Decadal Symposium - Keynote Speaker abstracts

Name and Keynote Title Please check your name and title on the website linked below and let us know if you would like to make any updates https://decadal2022.imr.no/en/projects/ices-decadal-2021/keynote-speakers
Antonio Bode. Plankton in the new millennium: synchronic multidecadal trends and regime shifts

Abstract (max 250 words)
Recent changes in oceanic plankton are being reported at unprecedented rates. Most changes are related to environmental factors and many were identified as driven by climate, either through natural cycles or by anthropogenic effects. However, the separation of both effects is difficult because of the small size of most observational series. Moreover, some changes are related to trends and cycles while others were perceived as system shifts, often synchronized over large spatial scales. Here, studies on observational series of plankton, with the focus in the N Atlantic, are reviewed. Two main quasi-synchronic shifts in species assemblages were identified: one in late 1980's and a most recent one in the first decade of the new millennium. While the origin and extent of most shifts vary locally, their synchronization seems to confirm the lagged response of plankton to changes in warming and in large-scale climatic factors. Changes in species abundance patterns are generally related to the strength of currents, but also to non-linear effects of warming, the latter particularly affecting species in regions near the limits of their thermal niche. Indeed, most of the changes are attributed to trade-offs between different biological strategies. Taken together, the reviewed case studies indicate a lagged biological response to variations in the local environment driven by large-scale climate forcing. The challenges for the interpretation of future changes include the consideration of local changes in a wider regional context, variations in species life-traits and possible top-down effects of plankton predators

Keywords (max 20)
phytoplankton, zooplankton, time series, abundance, biomass, regime shift, ocean, climate, life-traits

Tweet text for social media (max 267 characters)
Major reorganization of plankton assemblages lags behind climate change across ocean basins. Besides gradual changes, large discontinuities in the biomass and composition of plankton observed at different places are indicative of quasy-synchronous effects of climate.

Twitter name and any other tags you would like linked on Twitter such as your home institution (if applicable)
@IEOoceanografia @IEO_ACoruna

Dietary needs
none

Symposium on Decadal Variability of the North Atlantic and its Marine Ecosystems: 2010-2019
June 20-22nd, 2022
Bergen, Norway

Plankton in the new millennium: synchronic multidecadal trends and regime shifts

Antonio Bode

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Consejo Superior de Investigaciones Científicas

Instituto Español de Oceanografía 1914

ICES
CIEM

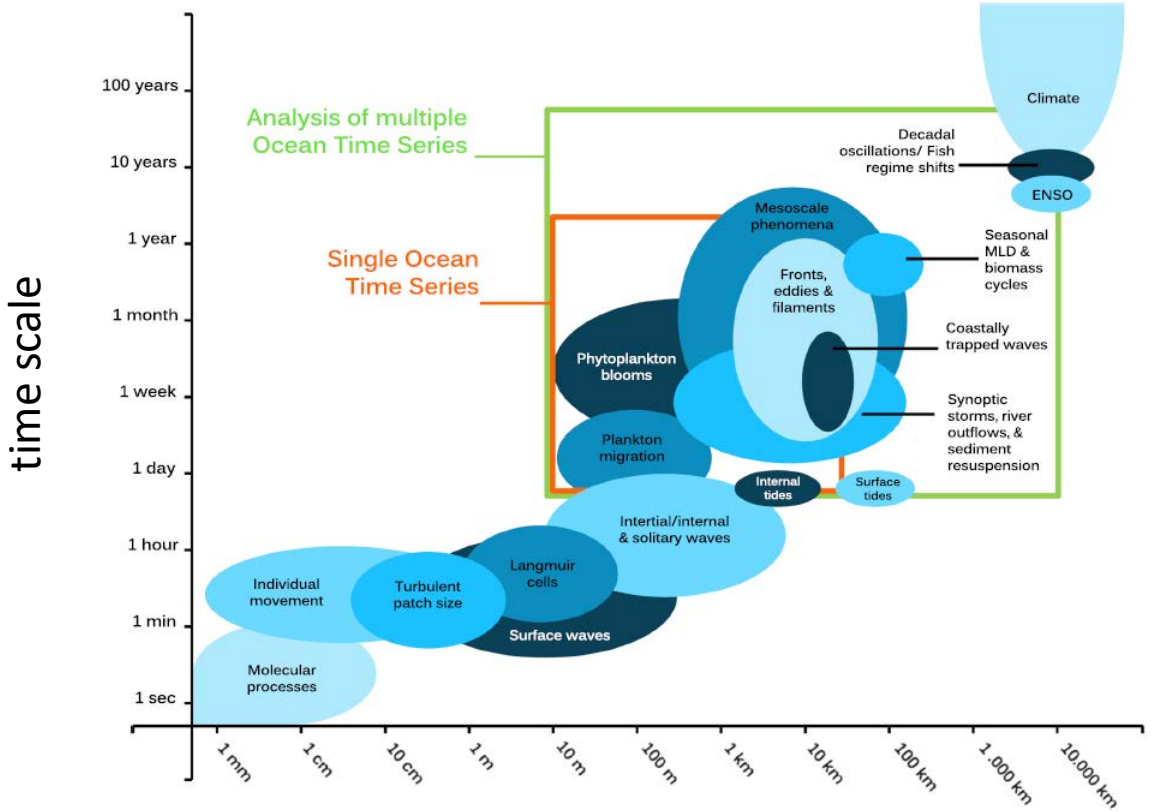
Content

- trends, cycles and shifts
- recent decadal variability: plankton in the N Atlantic
- synchronicity and time lags
- causes: climate, local environment, biological factors
- other modifiers: extreme events

Objective:

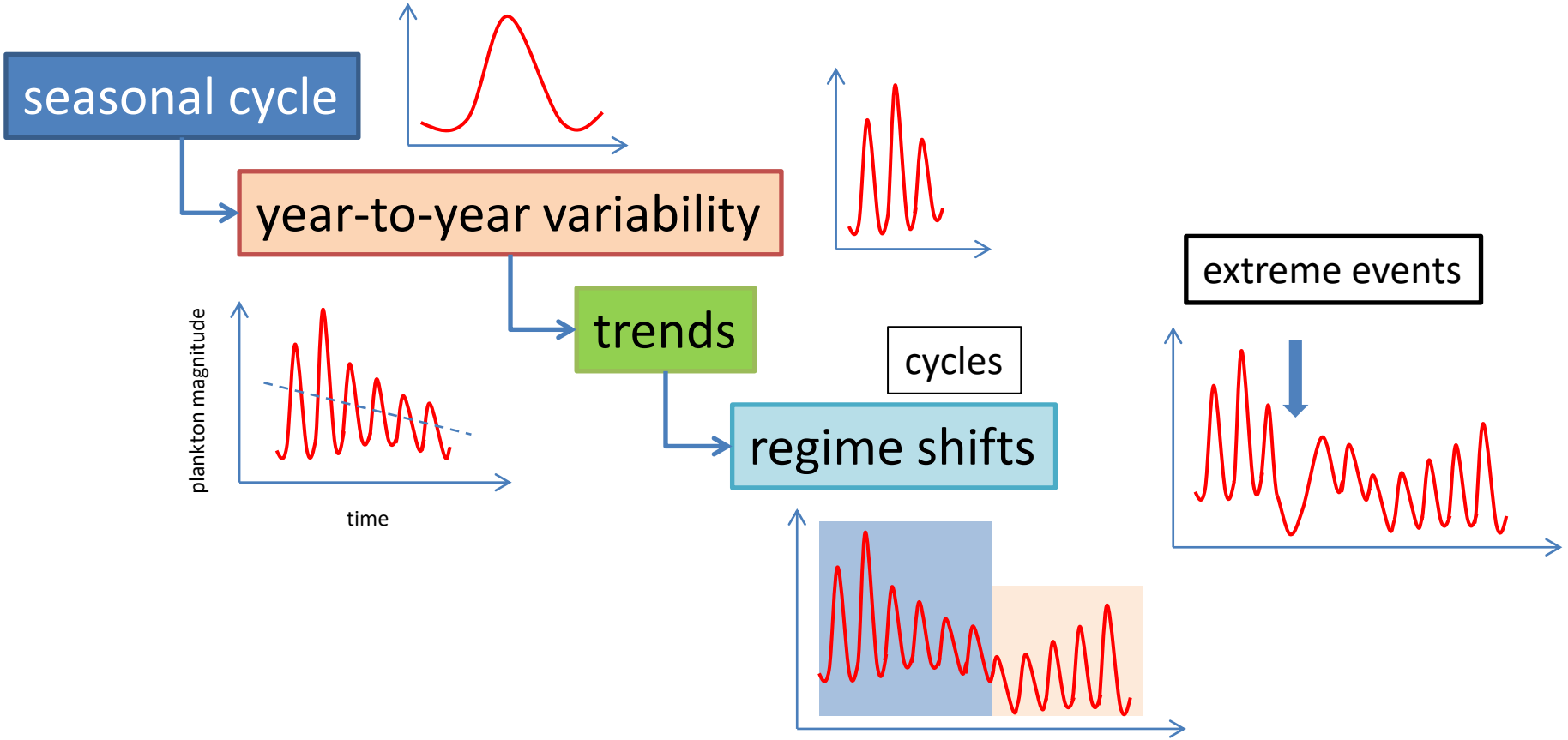
To review the current knowledge on multidecadal changes in plankton, with the focus in the N Atlantic

spatial and temporal variability:



Valdés et al. (2021) doi:10.1016/j.pocean.2021.102671
adapted from: Dickey (2002)

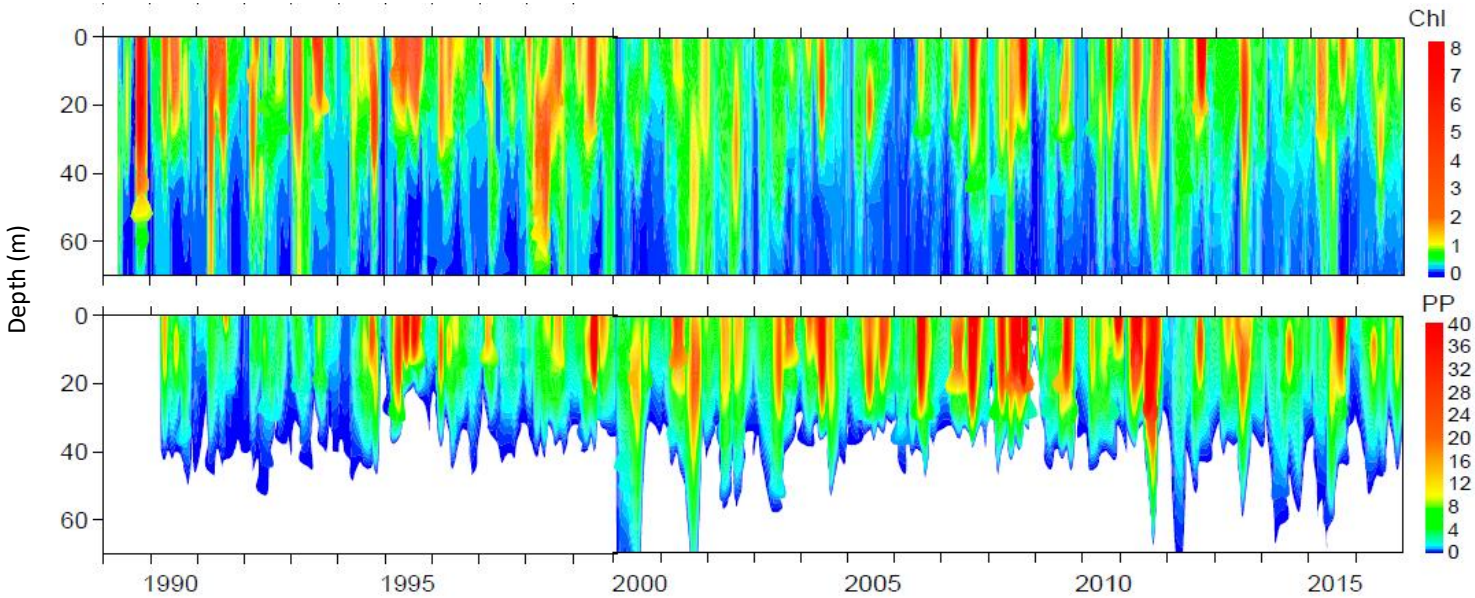
trends, cycles and shifts :



plankton series: examples

1989-2016 (28 yr)

Stn. E2CO
A Coruña

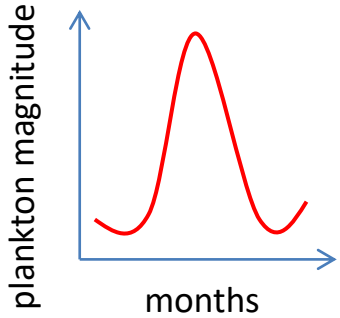


Chlorophyll
mg m^{-3}

Primary production
mg m^{-3} h^{-1}

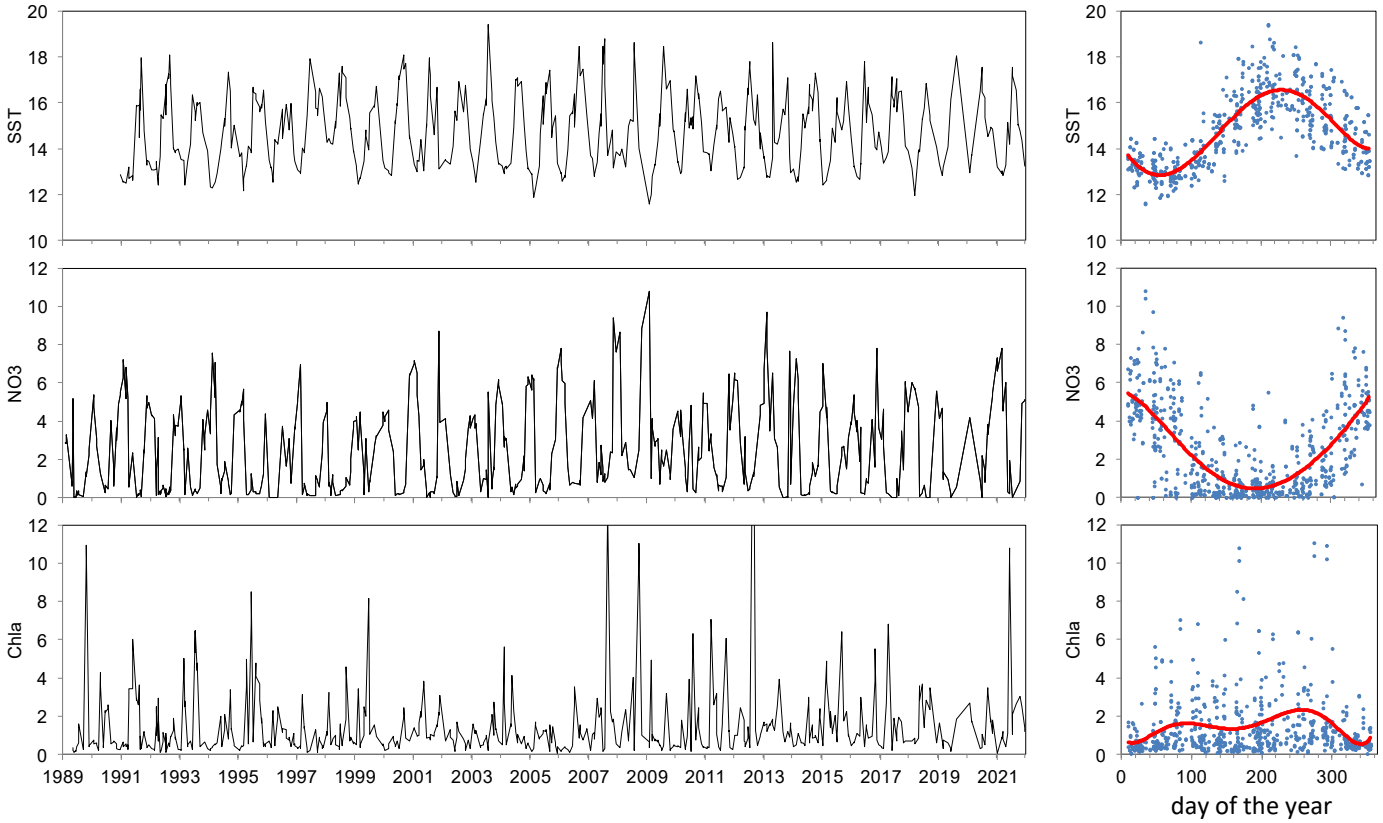
Bode et al. (2019) doi:10.1007/s10236-019-01278-y

seasonality



seasonality: hydrography & plankton

Stn. E2CO
A Coruña



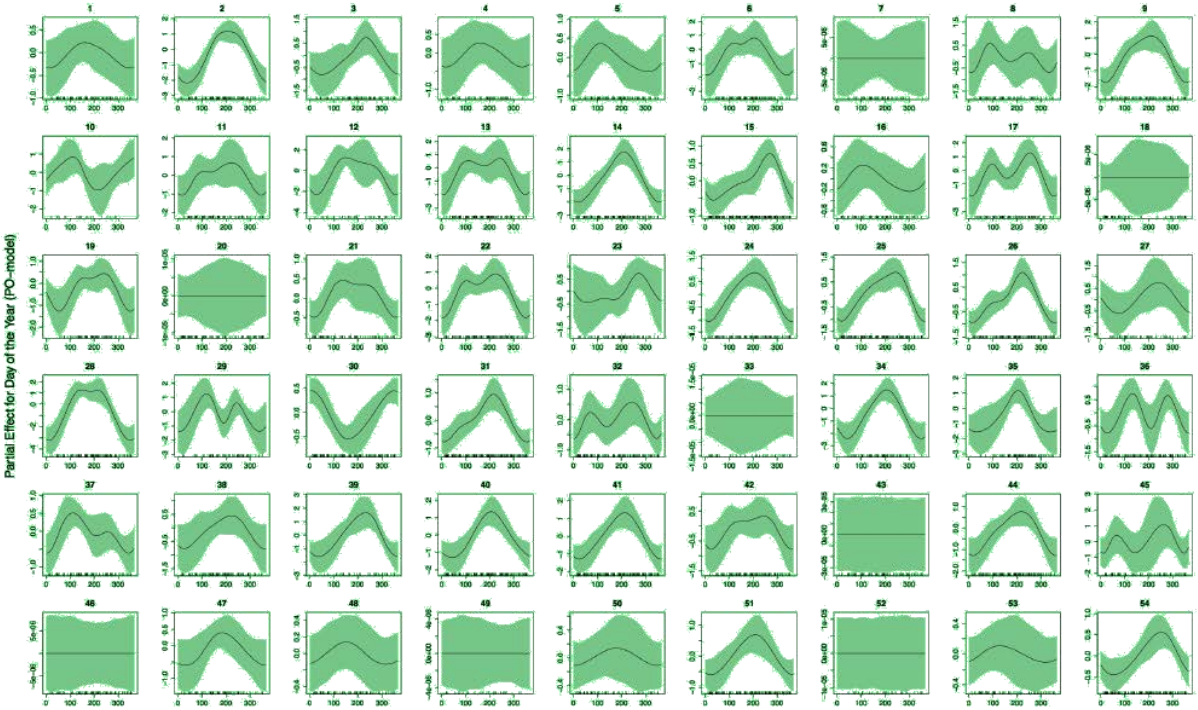
1989-2021 (33 yr)

seasonality: plankton spp.

Stn. E2CO
A Coruña

phytoplankton

54 spp.



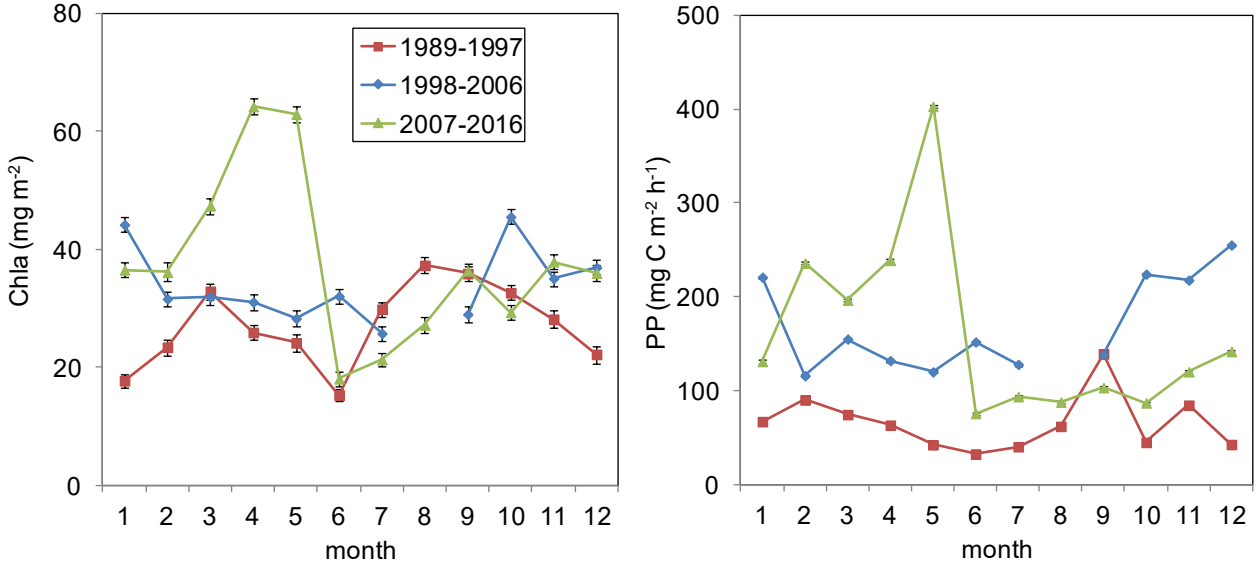
1989-2010 (22 yr)

Otero et al. (2018) doi:10.3354/meps12542

seasonality: phenological changes

Stn. E2CO
A Coruña

phytoplankton

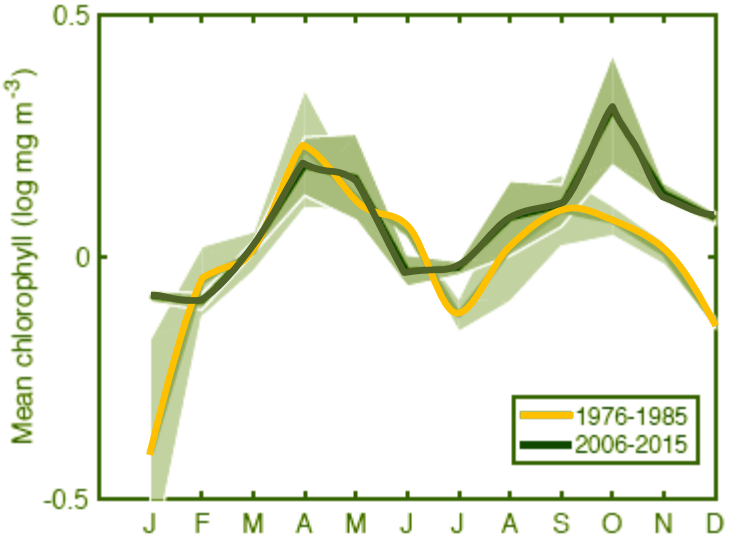


1989-2016 (28 yr)

Bode et al. (2019) doi:10.1007/s10236-019-01278-y

seasonality: phenological changes

Gulf of Maine



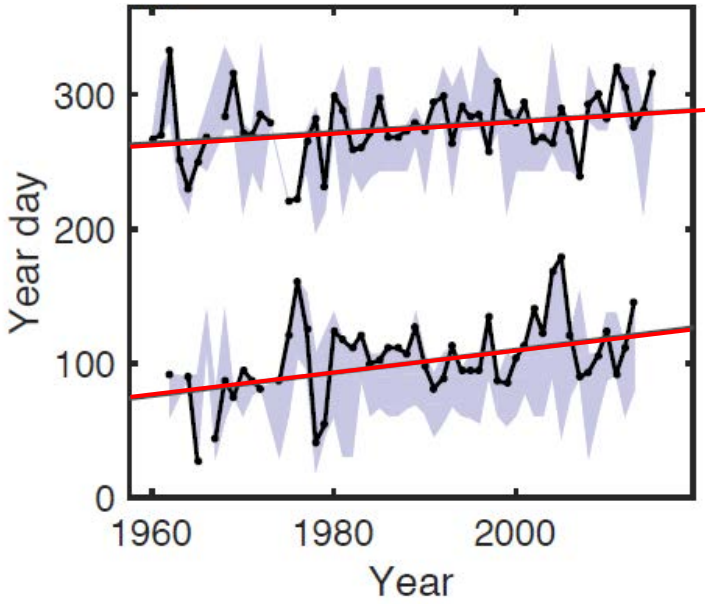
1976-2015 (40 yr)

Record et al. (2019) doi:10.7717/peerj.6735

seasonality: phenological changes

Gulf of Maine

phytoplankton bloom timing



autumn bloom

spring bloom

1960-2015 (56 yr)

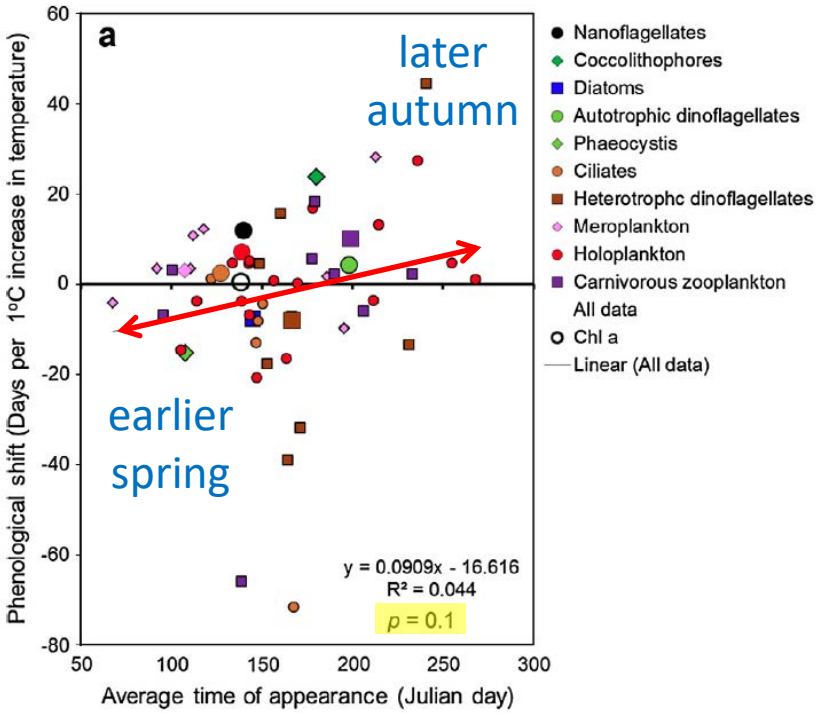
Record et al. (2019) doi:10.7717/peerj.6735

phenological changes

warming

widening of productive season

1988-2012 (25 yr)



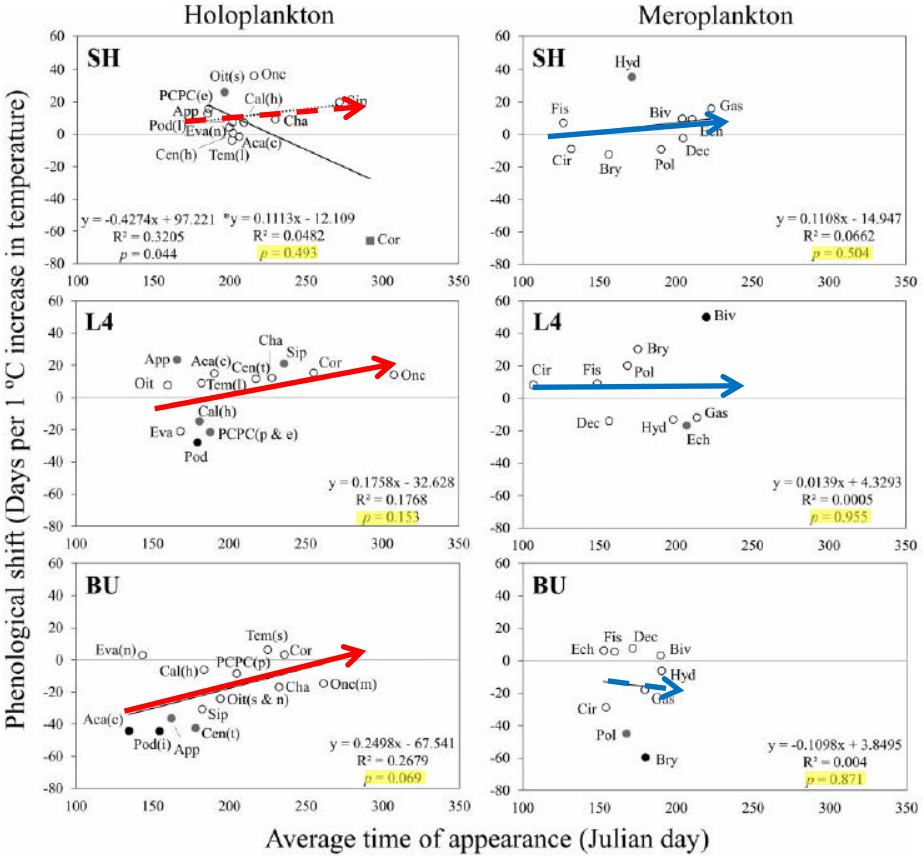
Stn. L4
Plymouth

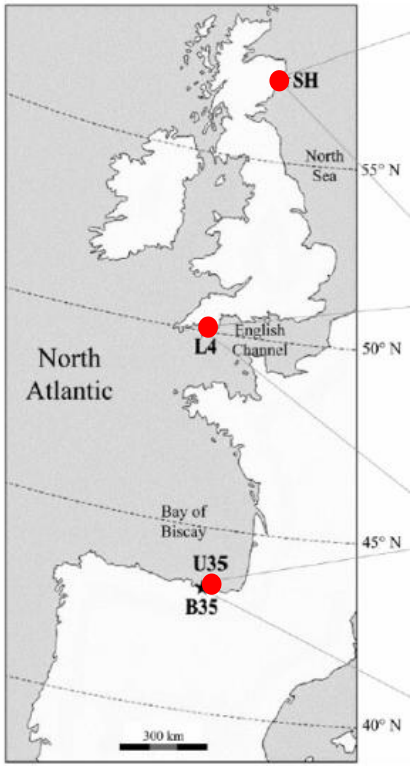
Atkinson et al. (2015) doi:10.1016/j.pocean.2015.04.023

phenological changes

zooplankton

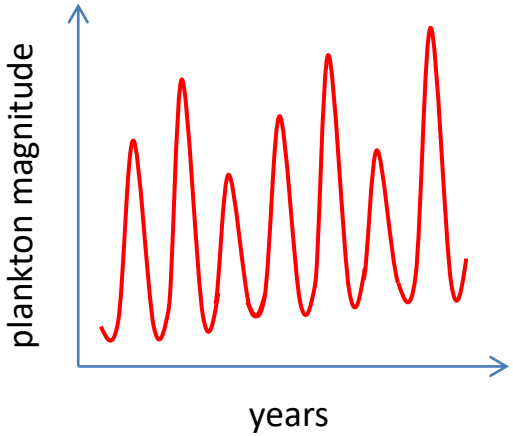
1999-2013 (14 yr)





Uriarte et al. (2021) doi:10.1093/icesjms/fsab008

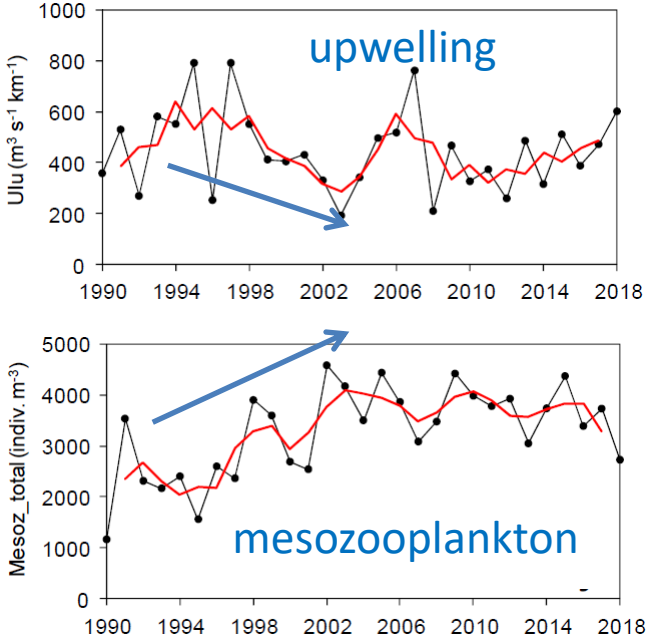
year-to-year variability



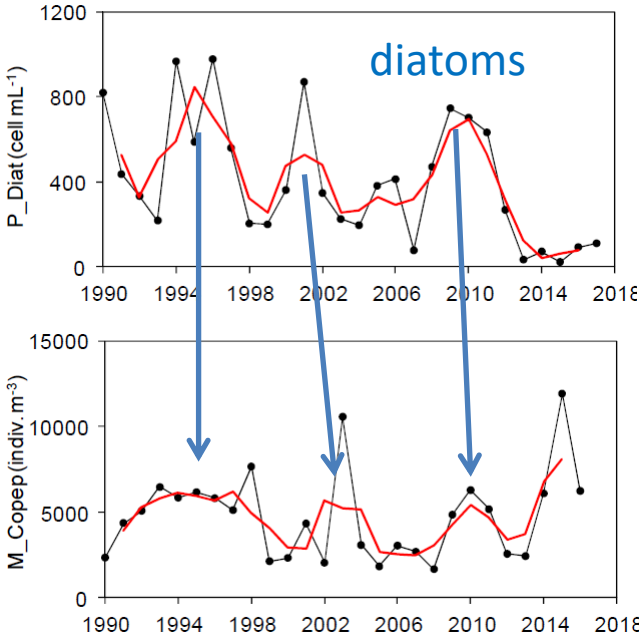
year-to-year variability: example

Stn. E2CO
A Coruña

trends



cycles

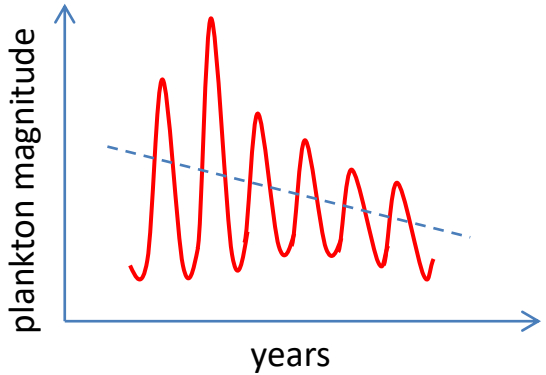


microzooplankton

1990-2016 (27 yr)

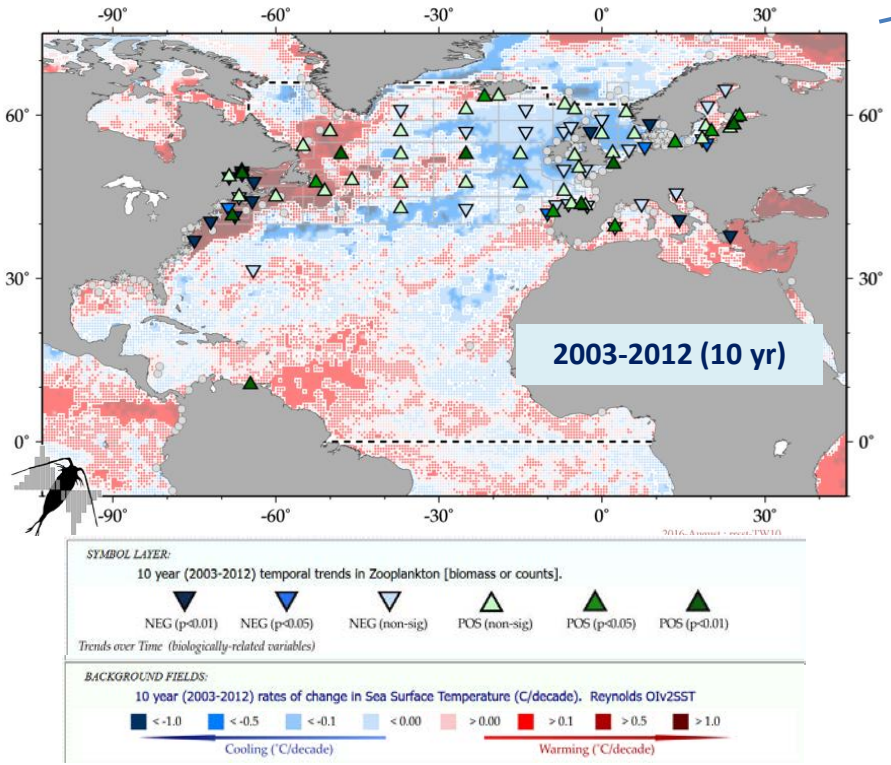
Bode et al. (2020) doi:10.3390/oceans1040014

trends

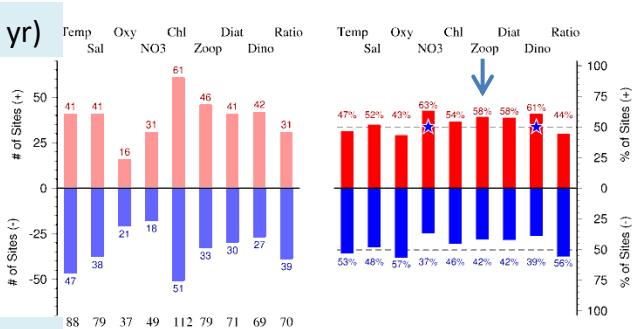


trends:

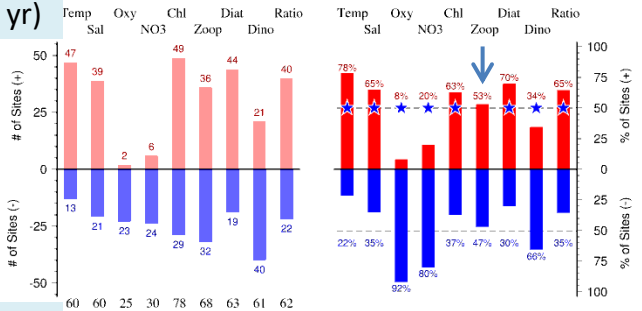
zooplankton



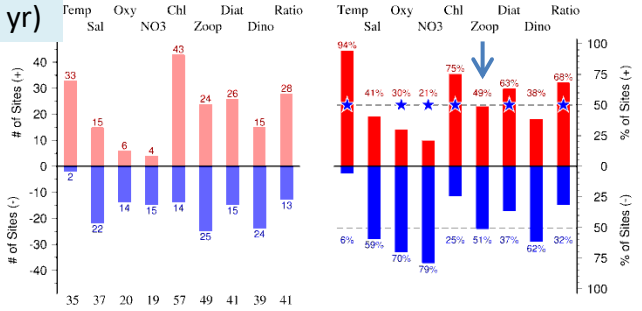
2003-2012 (10 yr)



1993-2012 (20 yr)



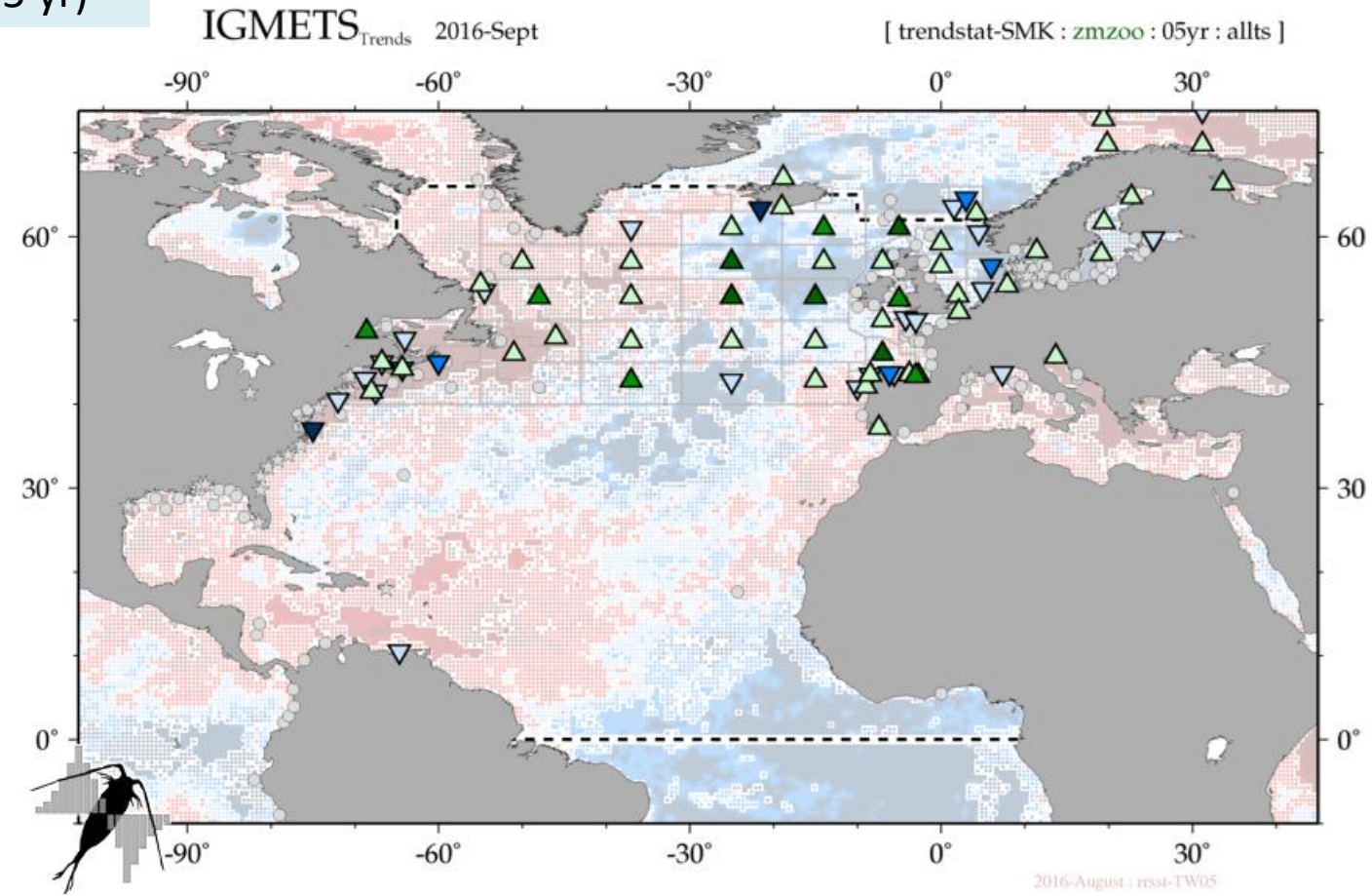
1983-2012 (30 yr)



https://igmets.net/explorer

2008-2012 (5 yr)

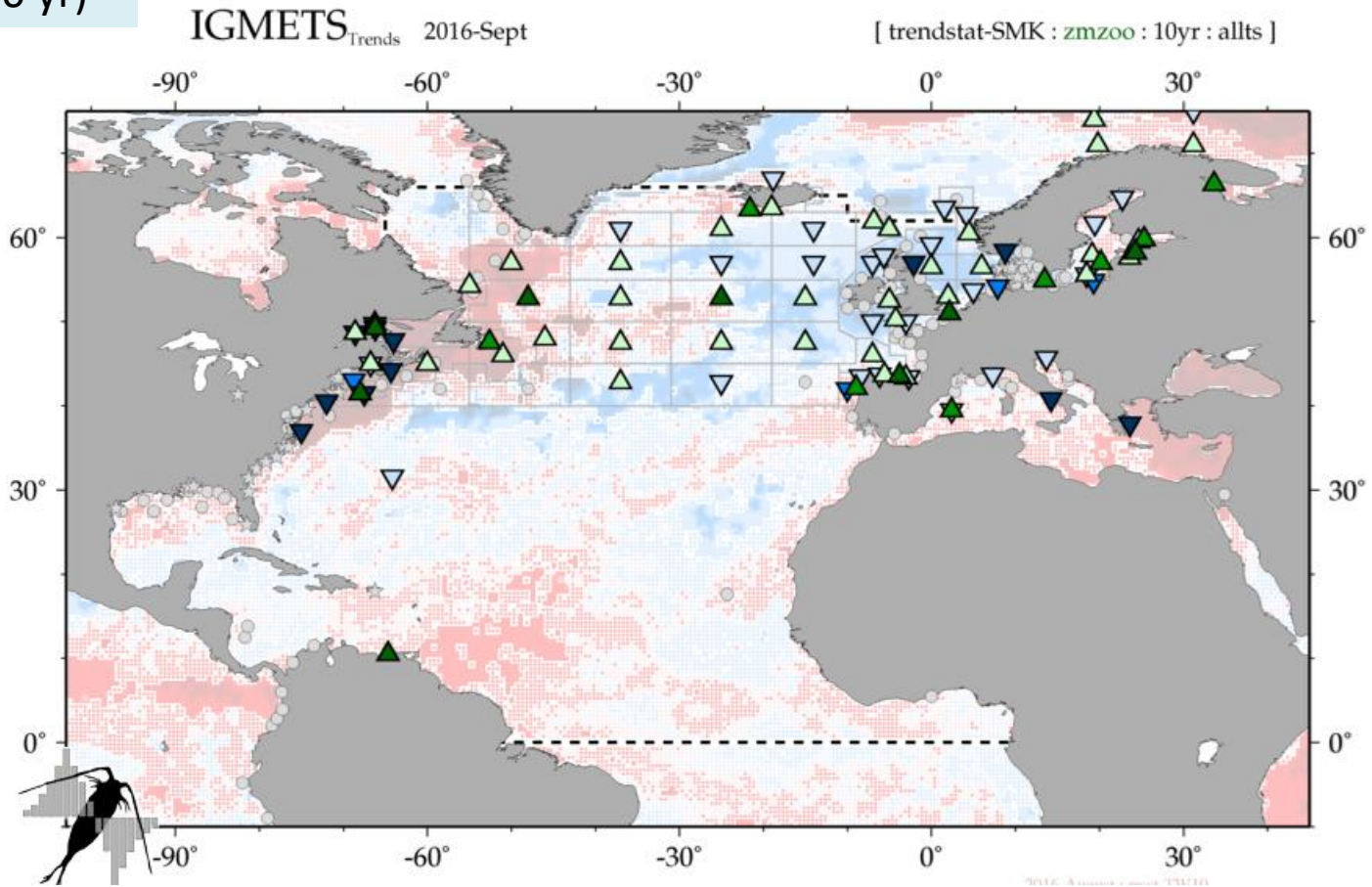
zooplankton



https://igmets.net/explorer

2003-2012 (10 yr)

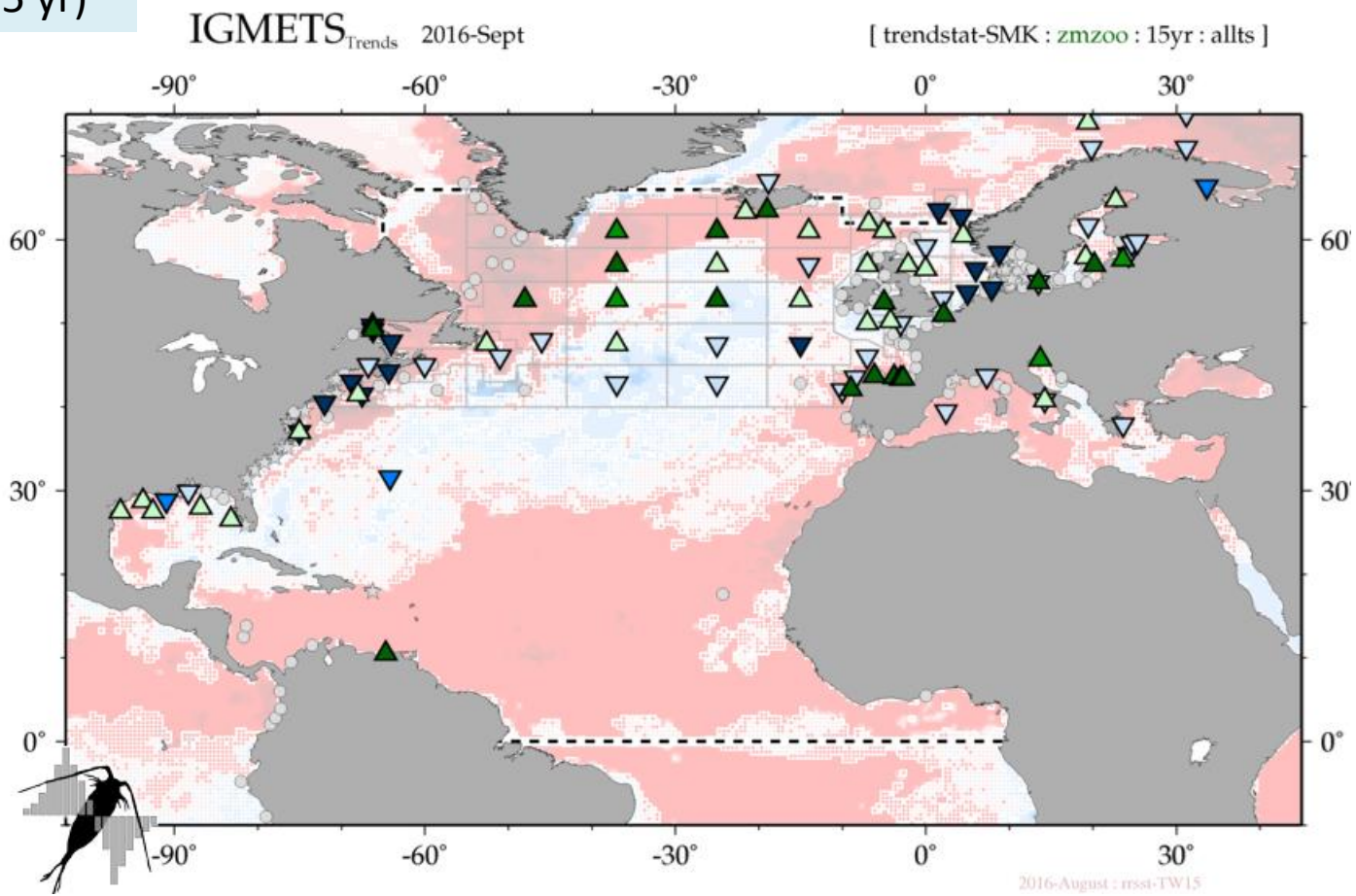
zooplankton



https://igmets.net/explorer

1998-2012 (15 yr)

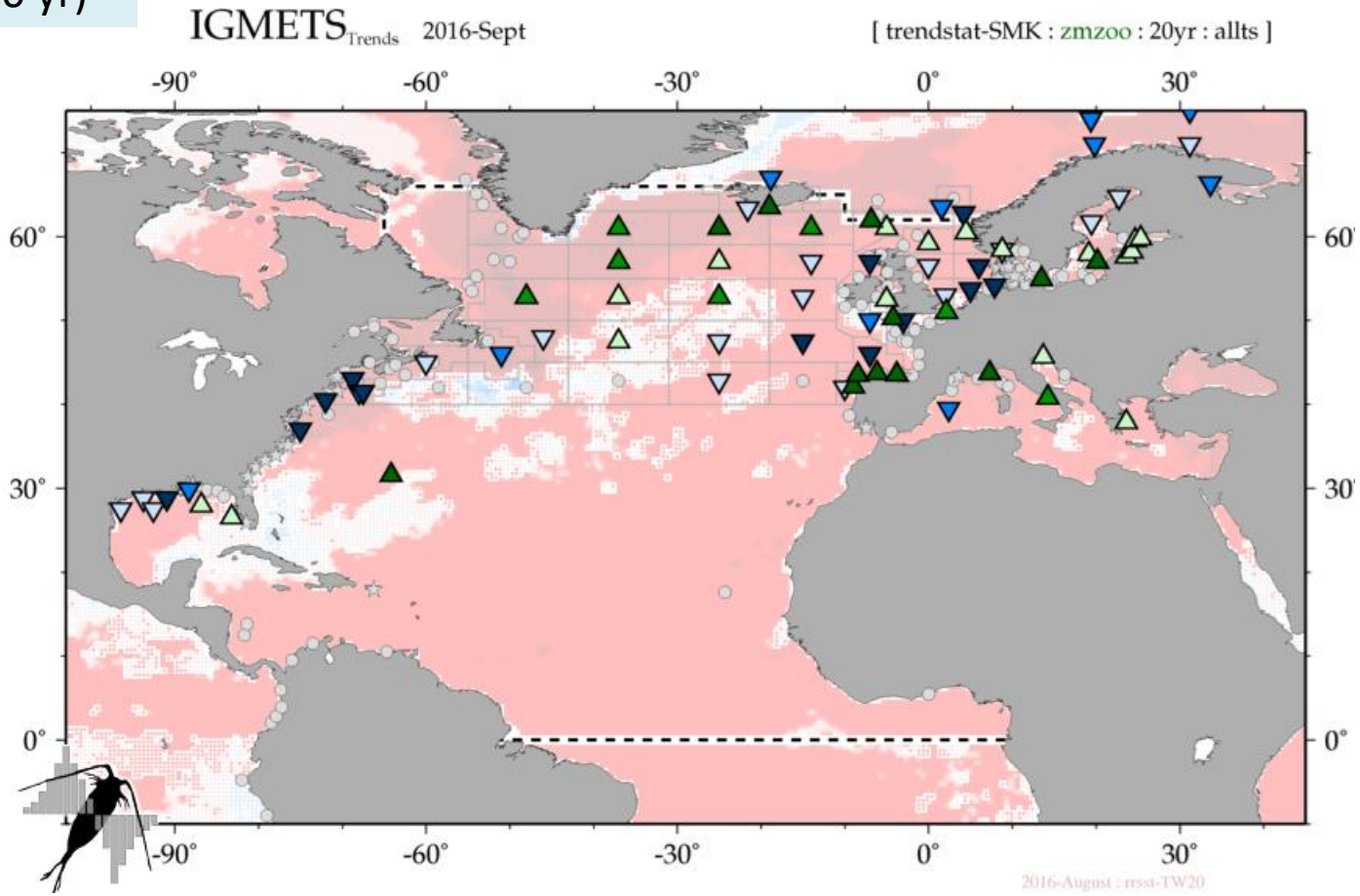
zooplankton



https://igmets.net/explorer

1993-2012 (20 yr)

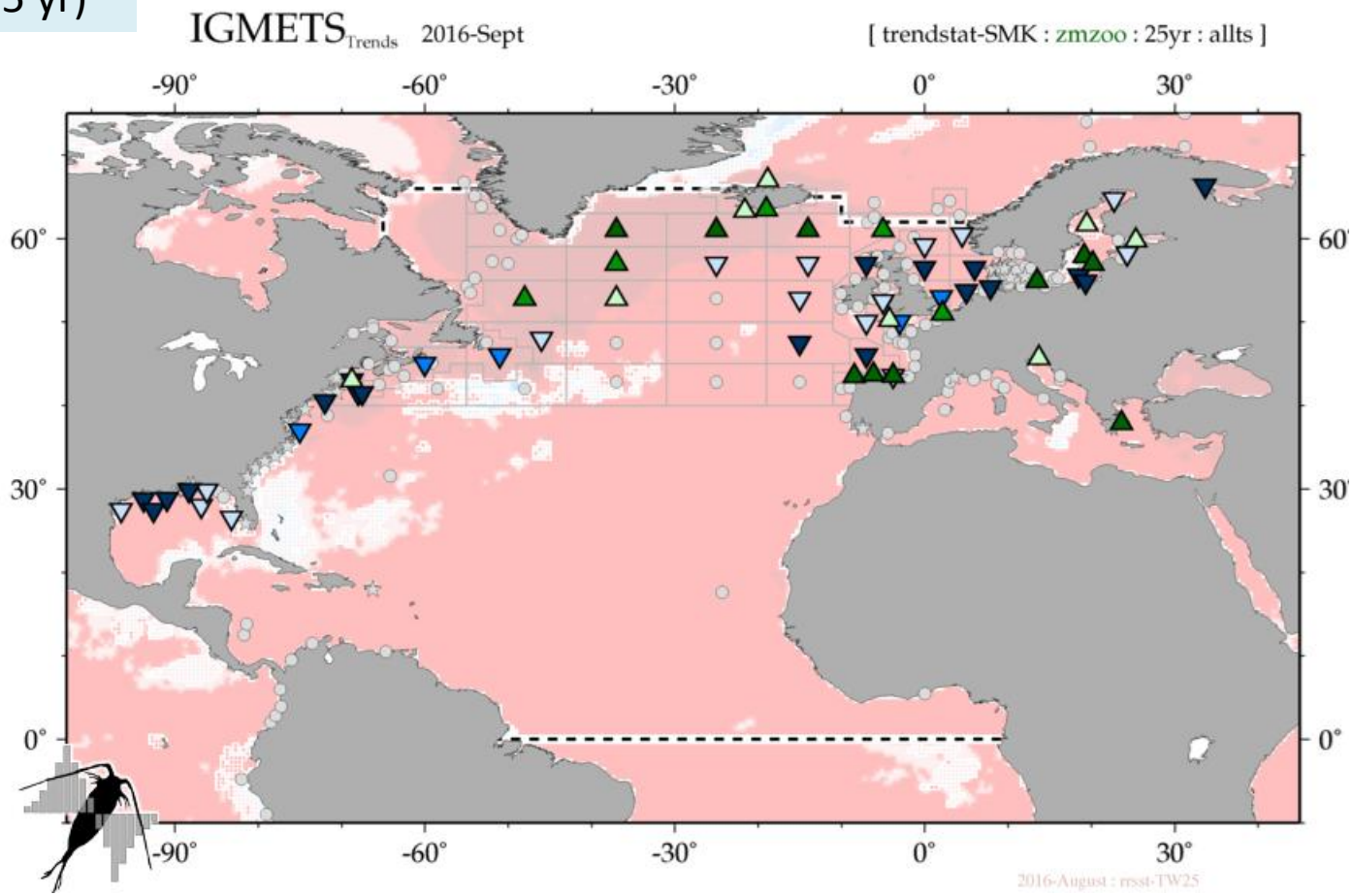
zooplankton



https://igmets.net/explorer

1988-2012 (25 yr)

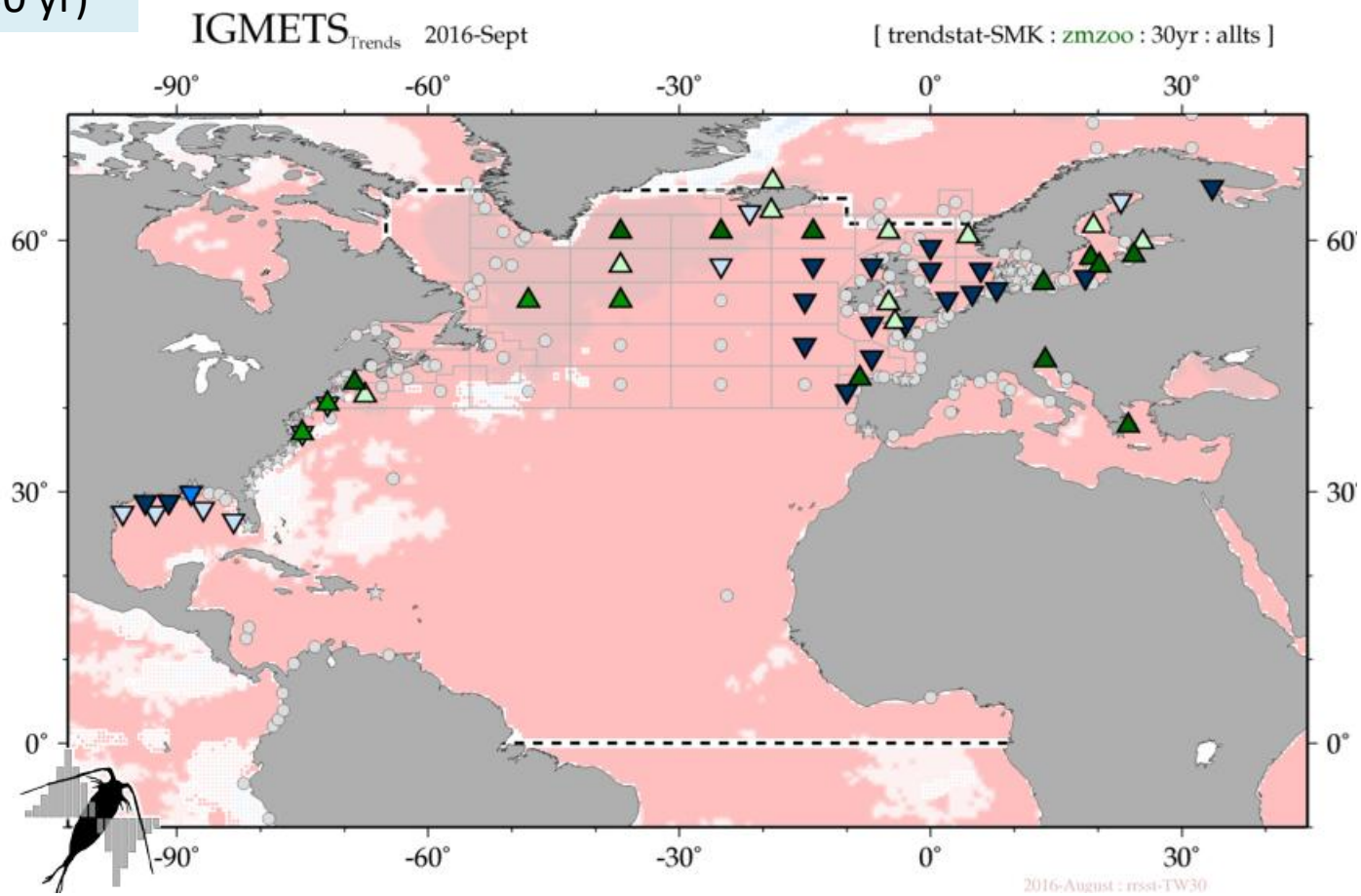
zooplankton



https://igmets.net/explorer

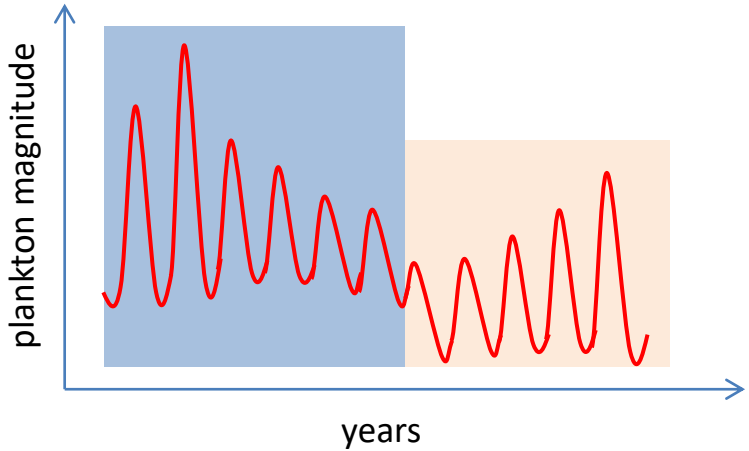
1993-2012 (30 yr)

zooplankton



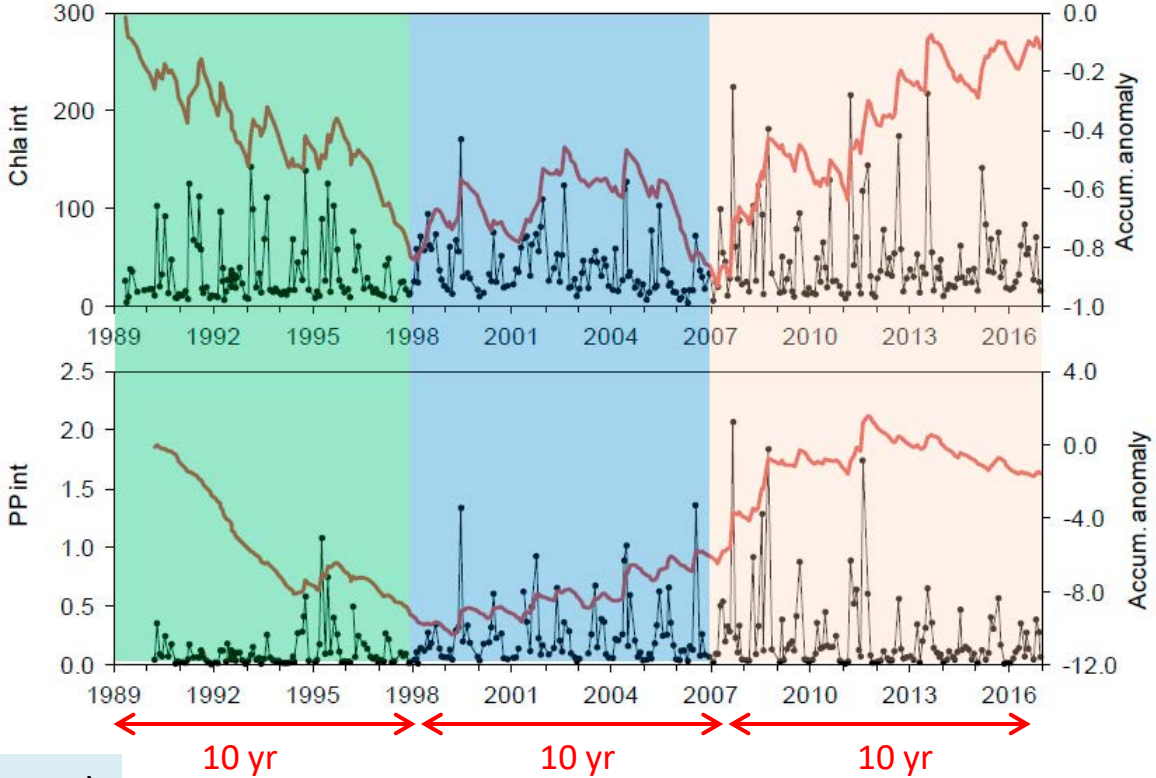
https://igmets.net/explorer

cycles & regime shifts



cycles: quasy-decadal examples

Stn. E2CO
A Coruña



1989-2016 (28 yr)

Bode et al. (2019) doi:10.1007/s10236-019-01278-y

regime shifts

Regime shifts are abrupt changes between contrasting, persistent states of any complex system.

DeYoung et al. (2008) doi:10.1016/j.tree.2008.03.008

→ Climate
→ Ocean
→ Biology

≅ alternation between stable states

Abrupt **C**ommunity **S**hifts (**ACS**)
Abrupt **E**cosystem **S**hifts (**AES**)

Beaugrand (2015) doi:10.1098/rstb.2013.0264

→ ecosystems

no stable states required

detecting regime shifts

Stn. E2CO
A Coruña

individual series

PCA

Sequential **T**-test **A**nalysis of **R**egime **S**hifts

(**STARS**)

Rodionov (2004) doi:10.1029/2004GL019448

1990-2016 (27 yr)

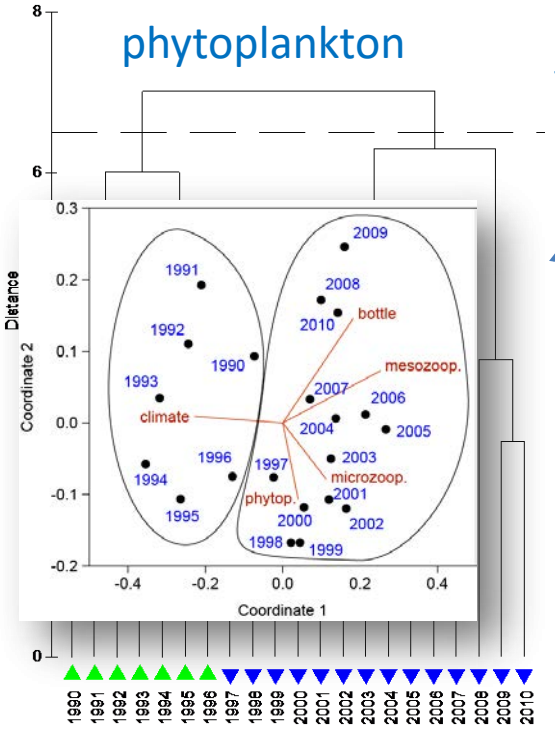
Bode et al. (2020) doi:10.3390/oceans1040014

detecting regime shifts

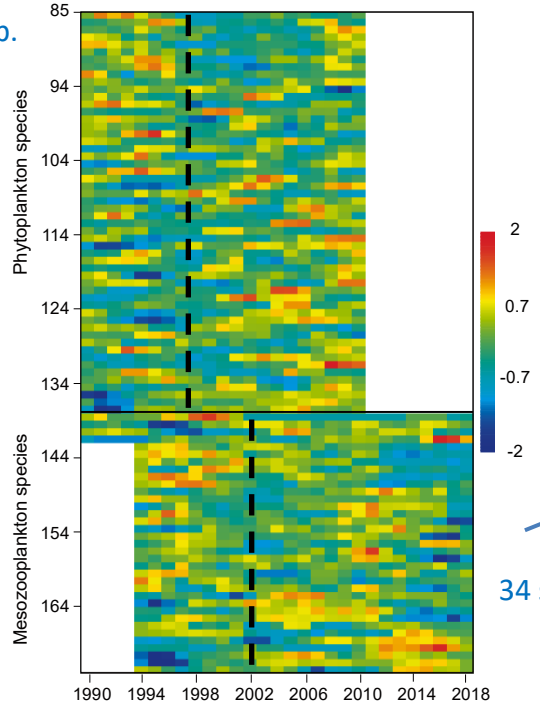
Stn. E2CO
A Coruña

non-metric **M**ulti**D**imensional **S**caling (**MDS**) and **C**luster **A**nalysis (**CA**)

phytoplankton

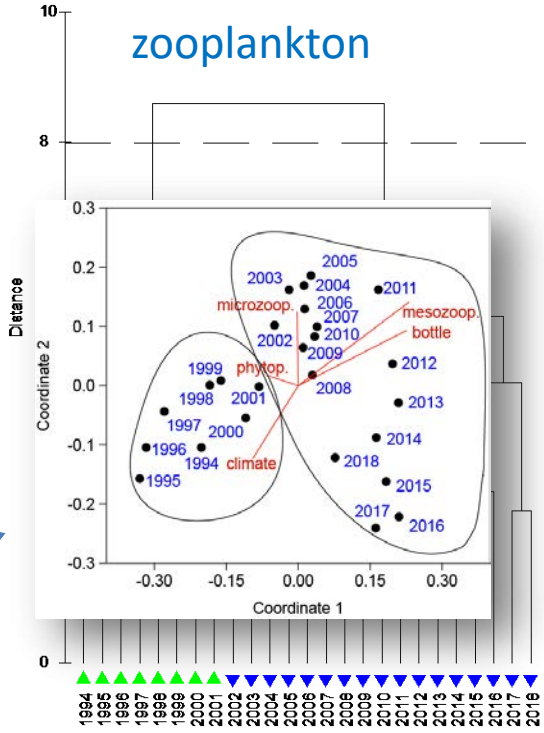


53 spp.



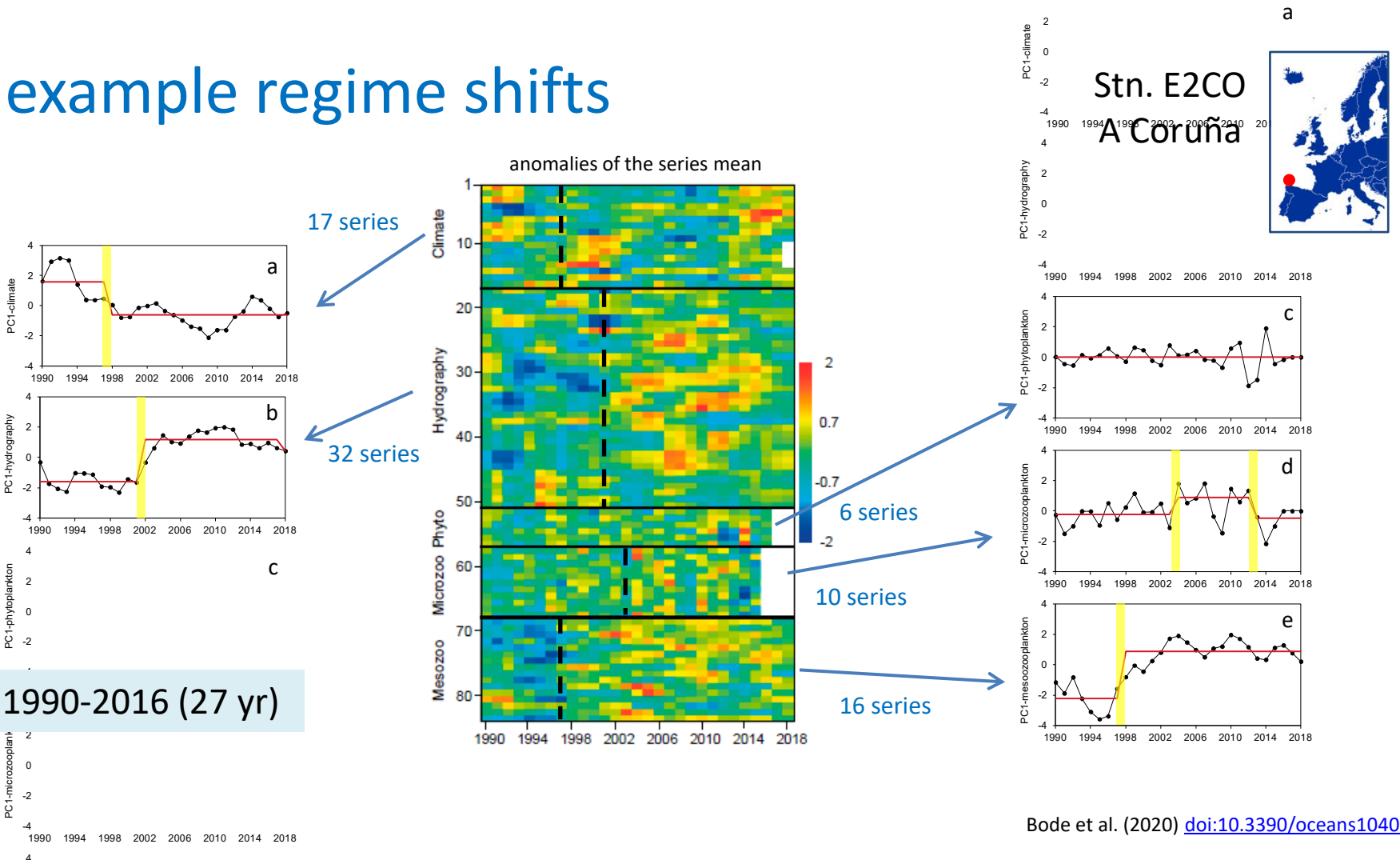
34 spp.

zooplankton



Bode et al. (2020) doi:10.3390/oceans1040014

example regime shifts



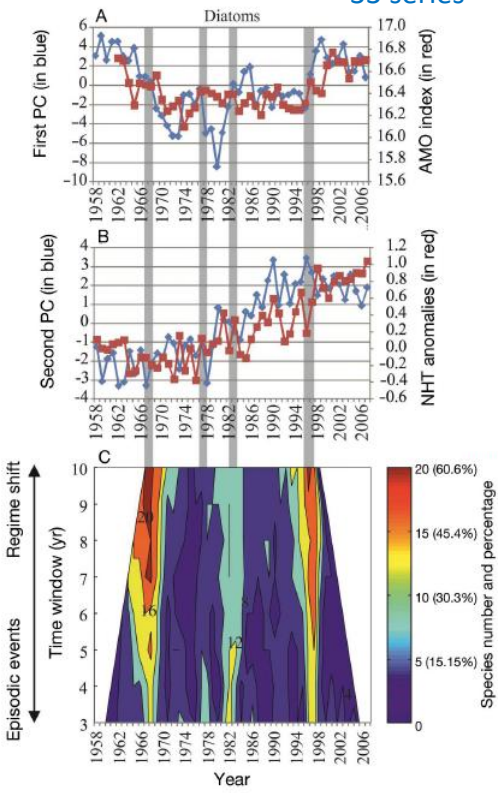
Bode et al. (2020) doi:10.3390/oceans1040014

example regime shifts

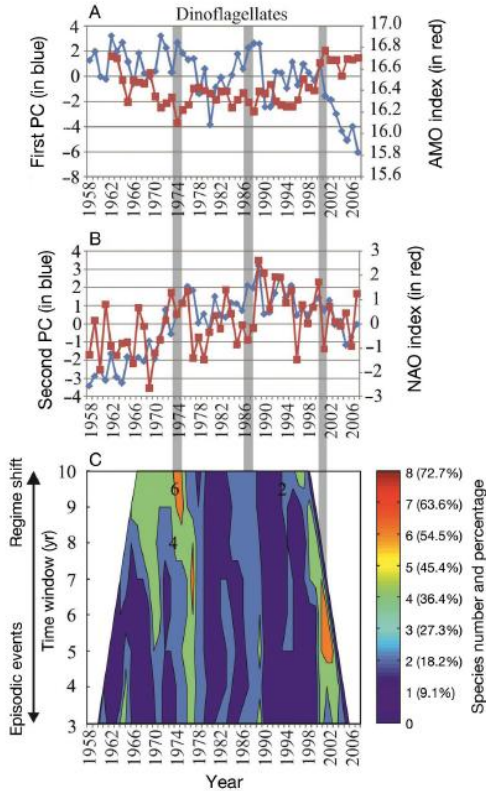
North Sea

1958-2007 (50 yr)

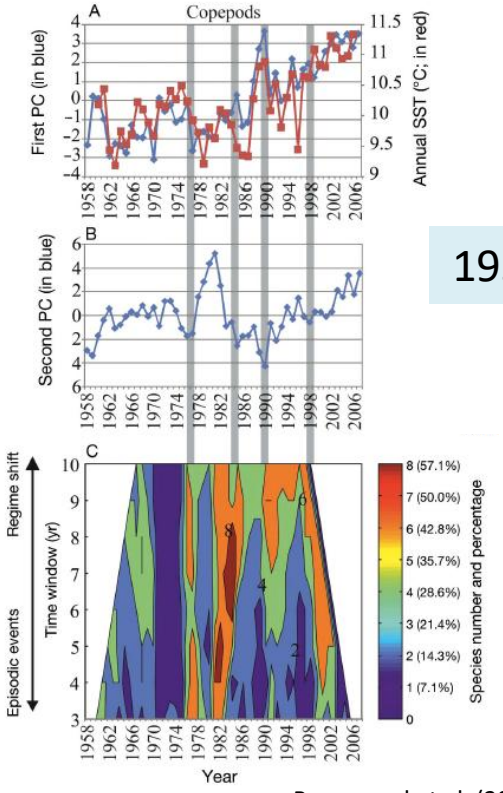
diatoms 33 series



dinoflagellates 11 series

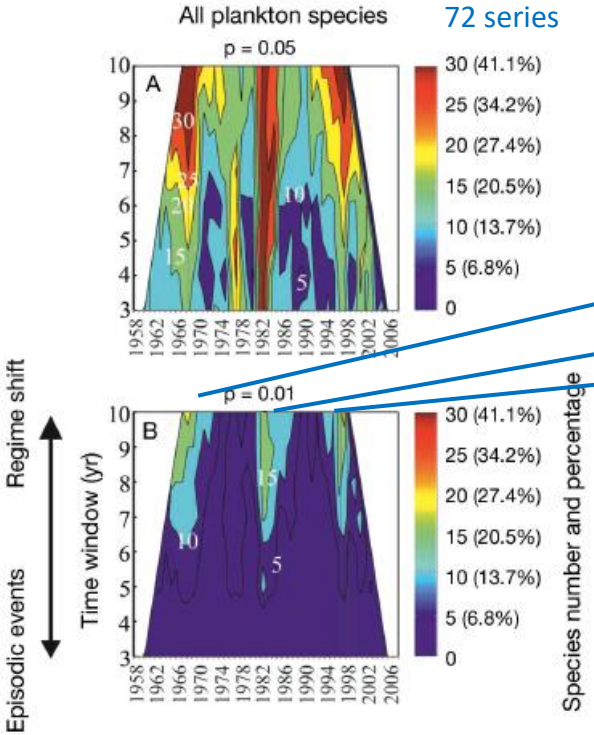


copepods 14 series



Beaugrand et al. (2014) doi: 10.3354/meps10693

example regime shifts



late-1960s
early-1980s
late-1990s

North Sea

1958-2007 (50 yr)

mainly related to temperature and NAO

Beaugrand et al. (2014) doi: 10.3354/meps10693

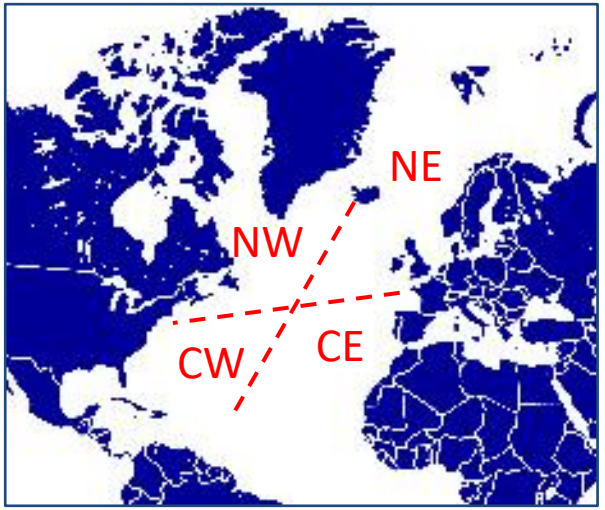
- How many regime shifts?
- Are they synchronized?

since 1960

N Atlantic plankton regime shifts

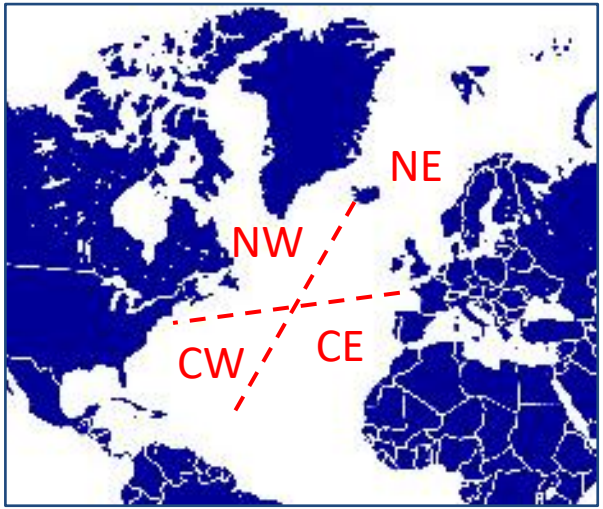
review

- plankton
- observational studies with continuous time-series ≥ 10 yr
- at least one major shift identified
- four major subregions:
  - North East
  - Central East
  - North West
  - Central West



N Atlantic plankton regime shifts

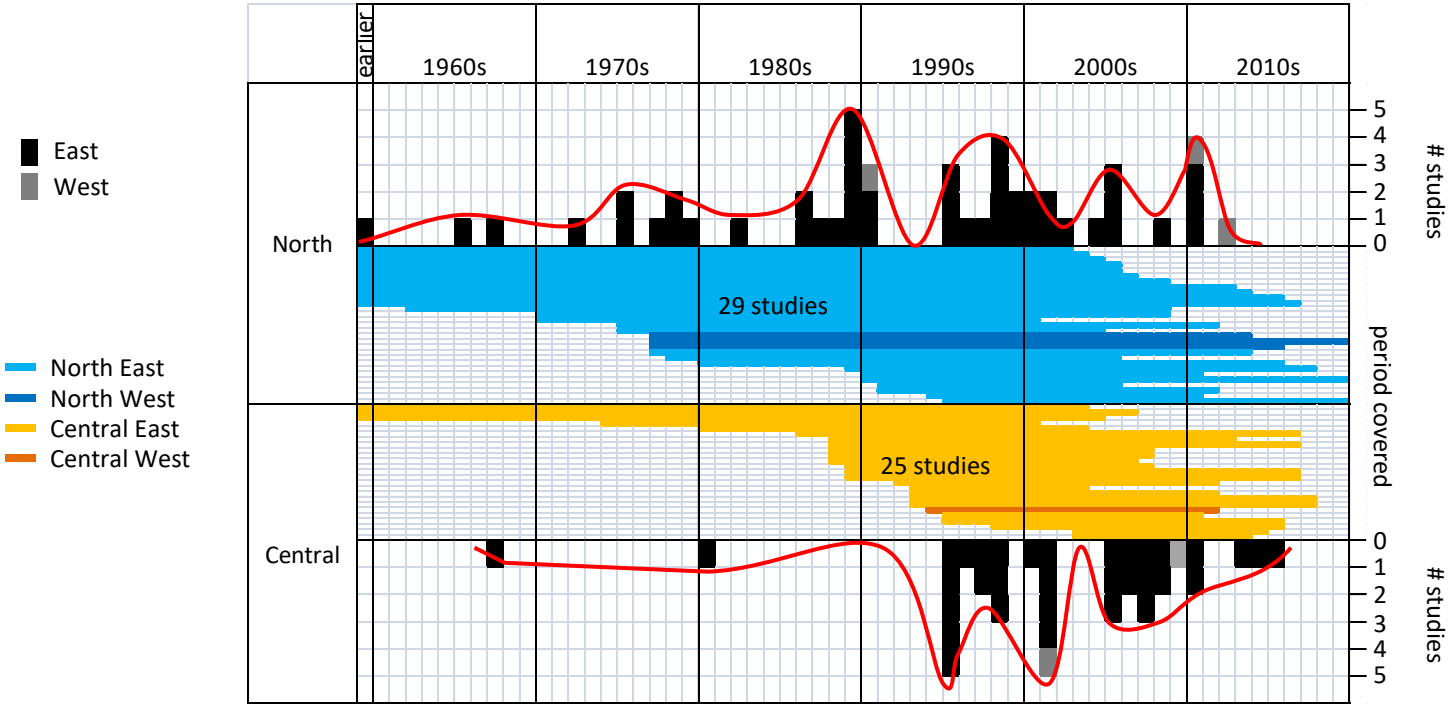
review



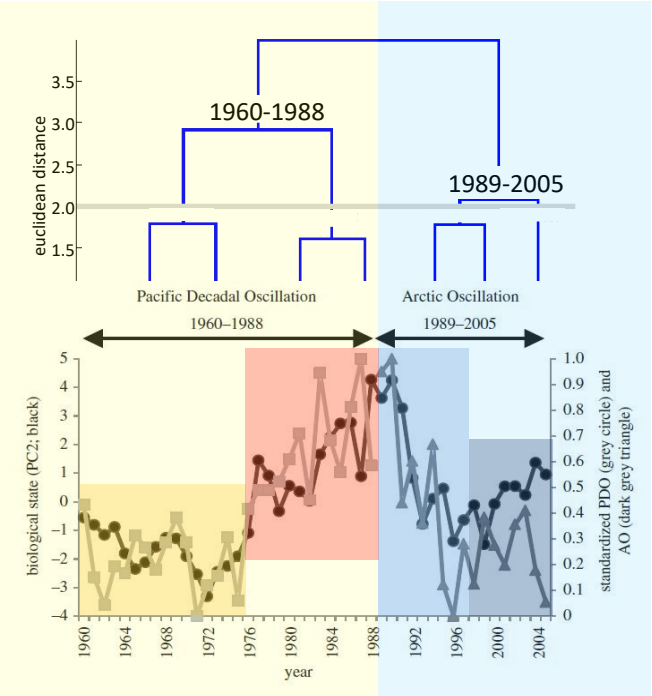
zone	subzone	# series
North East	Norwegian Sea	3
	Baltic Sea	4
	North Sea	14
	Celtic Sea	2
	English Channel	7
North West	Labrador Sea	1
	Scotian Shelf	1
	Georges Bank	3
	Gulf of Maine	3
	Mid Atlantic Bight	1
	Total North	**39**
Central East	Bay of Biscay	7
	Iberian Atlantic	5
	Canary Current	1
	Mediterranean Sea	2
Central West	Sargasso Sea	1
	Total Central	**16**

N Atlantic plankton regime shifts

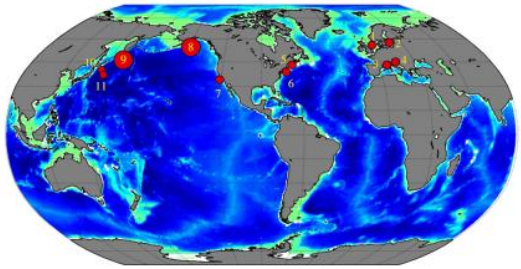
review



synchronicity:



Northern hemisphere

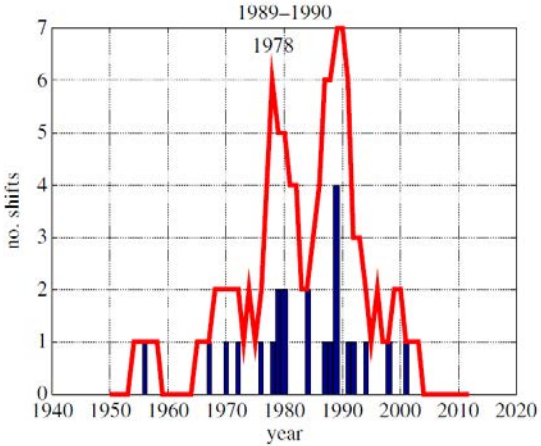


reanalysis

33 time series

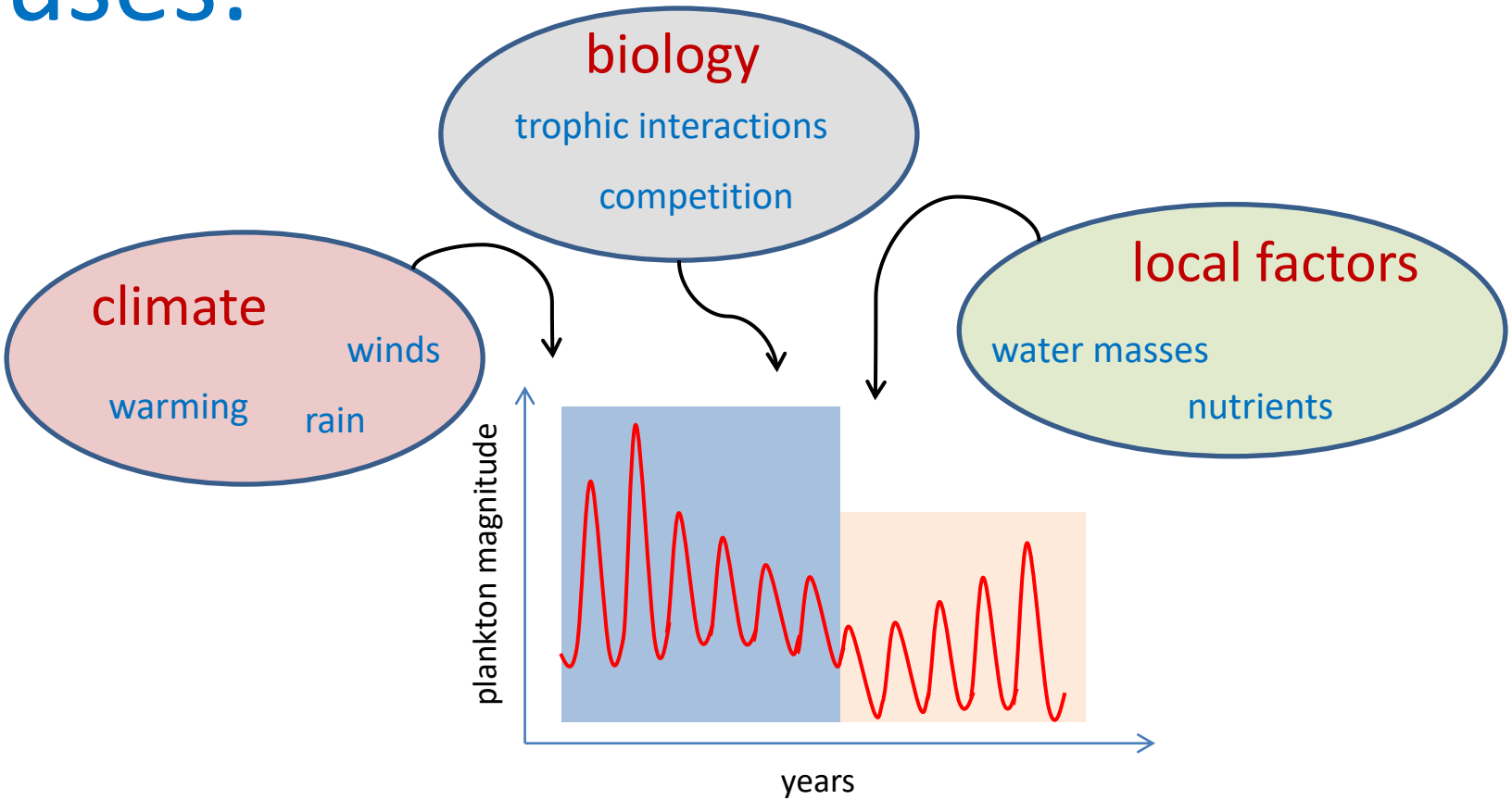
1960-2005 (46 yr)

shifts



Beaugrand et al. (2015) doi:10.1098/rstb.2013.0272

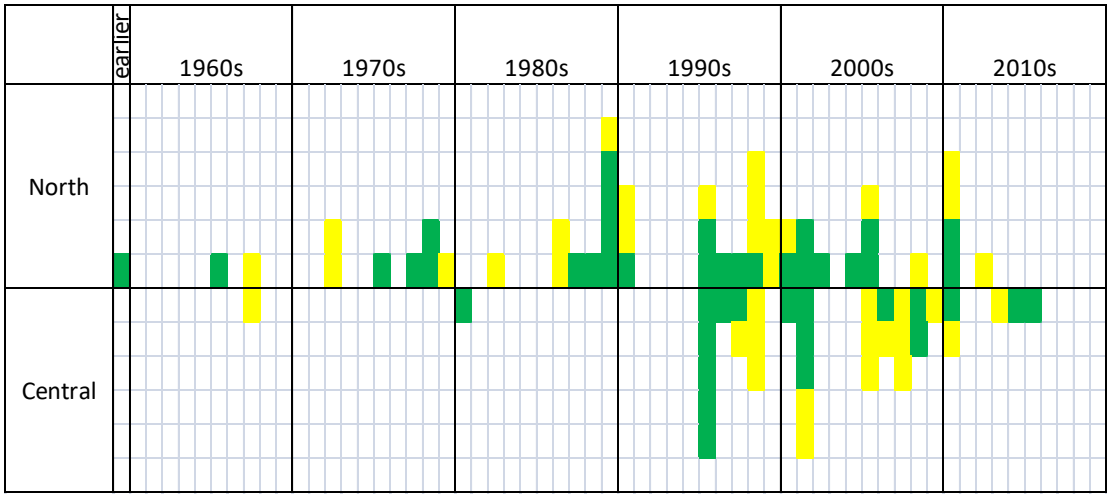
causes:


biology
trophic interactions
competition
climate
winds
warming
rain
local factors
water masses
nutrients
plankton magnitude
years

N Atlantic plankton regime shifts: drivers

review

decade	% climate	% local
1960's	33.3	66.7
1970's	57.1	42.9
1980's	63.6	36.4
1990's	52.0	48.0
2000's	51.9	48.1
2010's	50.0	50.0
total	**53.0**	**47.0**



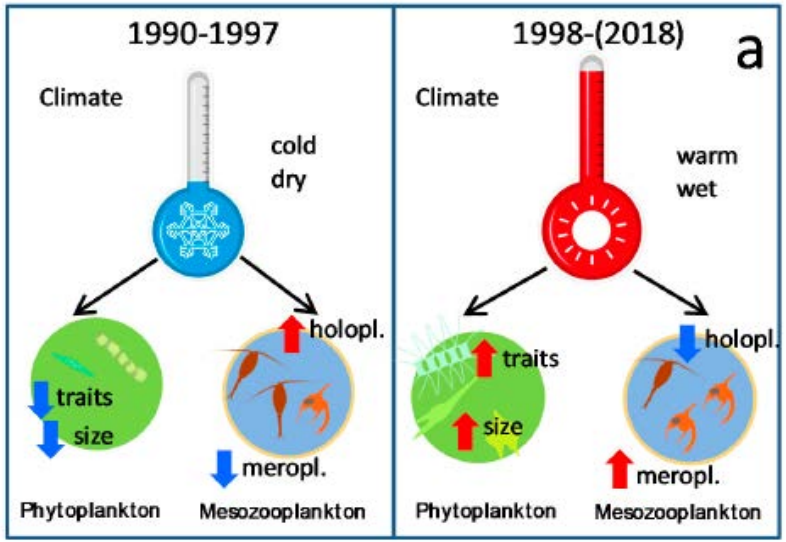
climate

local

53% climate : 47% local

life traits

climate-related shifts



Lauderia annulata
Skeletonema costatum
Bacteriastrum delicatulum
Chaetoceros decipiens
Chaetoceros socialis
Chaetoceros gracilis

diatoms

phytoplankton spp. & zooplankton groups

chain-forming diatoms
small cell sizes
cylindrical or oval cell shape

diatoms, dinoflagellates, …
large cell size
diverse cell shapes

holoplankton (copepods)

meroplankton (benthic larvae)

1990-2016 (27 yr)

Stn. E2CO
A Coruña

diatoms

Navicula transitans
Pseudo-nitzschia delicatissima
Chaetoceros spp.
Nitzschia spp.
Thalassiosira levanderi
Proboscia alata

Torodinium robustum
Heterocapsa niei
Prorocentrum balticum
Gyrodinium spirale

dinoflagellates

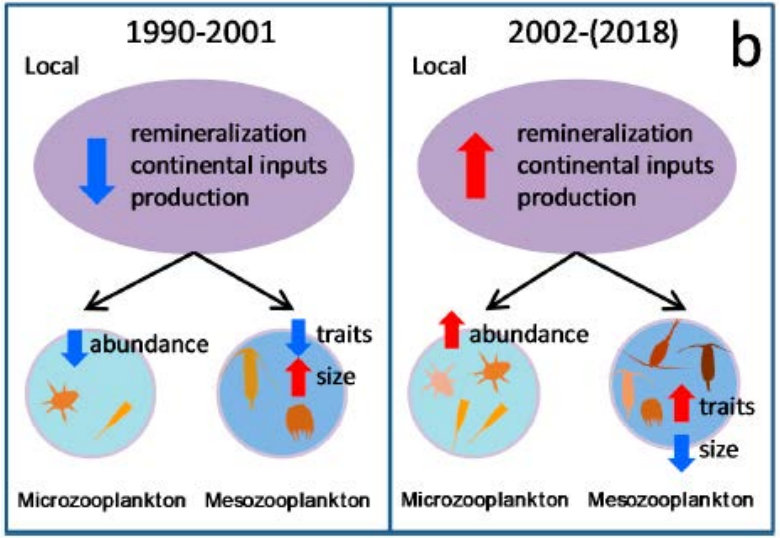
Dictyocha fibula

Dictyochophyceae

Bode et al. (2020) doi:10.3390/oceans1040014

life traits

locally-related shifts



Stn. E2CO
A Coruña

1990-2016 (27 yr)

cladocera

filter-feeding herbivores

Penilia avirostris
Temora spp.
Ctenocalanus vanus

omnivores

copepods

microzooplankton groups & mesozooplankton spp.

less feeding traits	more feeding traits
large size	small size
less microzooplankton	more microzooplankton

ambush-feeding omnivores

Oithona spp.
Pseudocalanus elongatus
Podon intermedius
Evadne nordmanni

filter-feeding herbivores

Centropages typicus

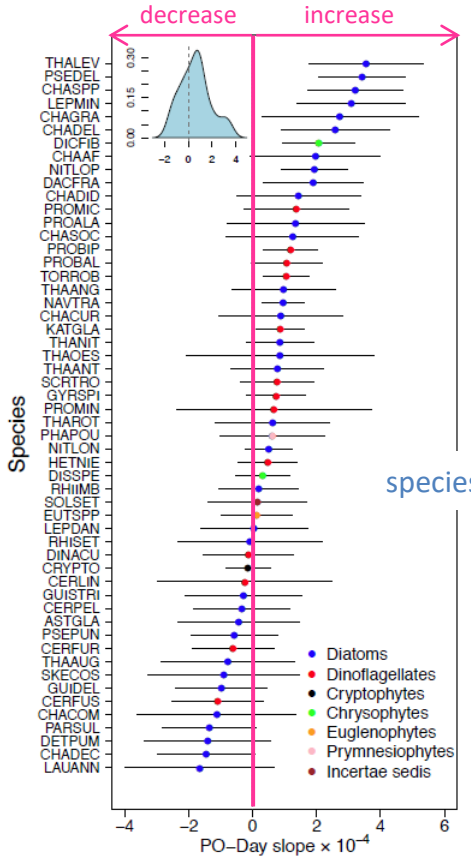
omnivores

Corycaeus spp.

ambush-feeding carnivores

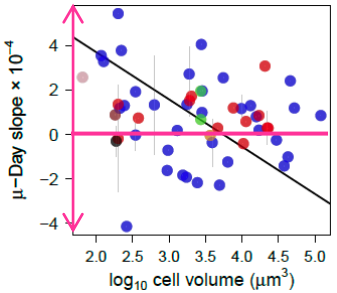
Bode et al. (2020) doi:10.3390/oceans1040014

life traits: size

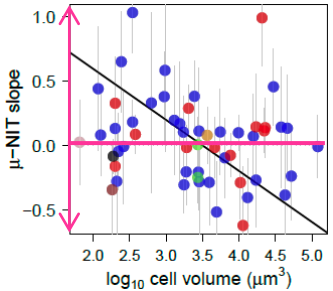


species vs. groups

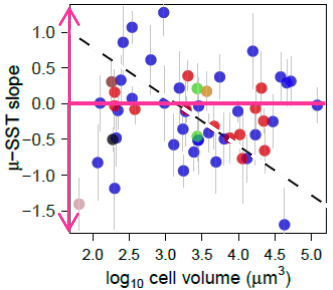
phytoplankton abundance



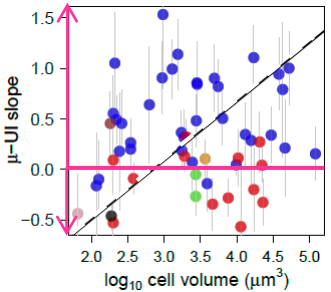
small species increase



small species favoured by high nutrients



weak effect of SST or upwelling



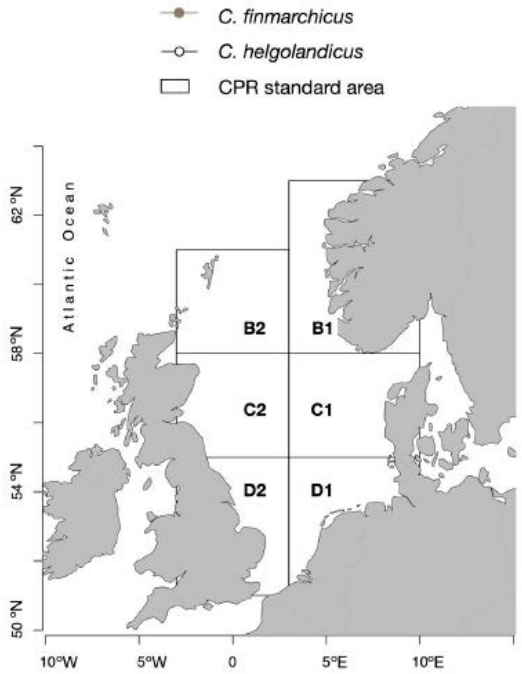
Stn. E2CO
A Coruña

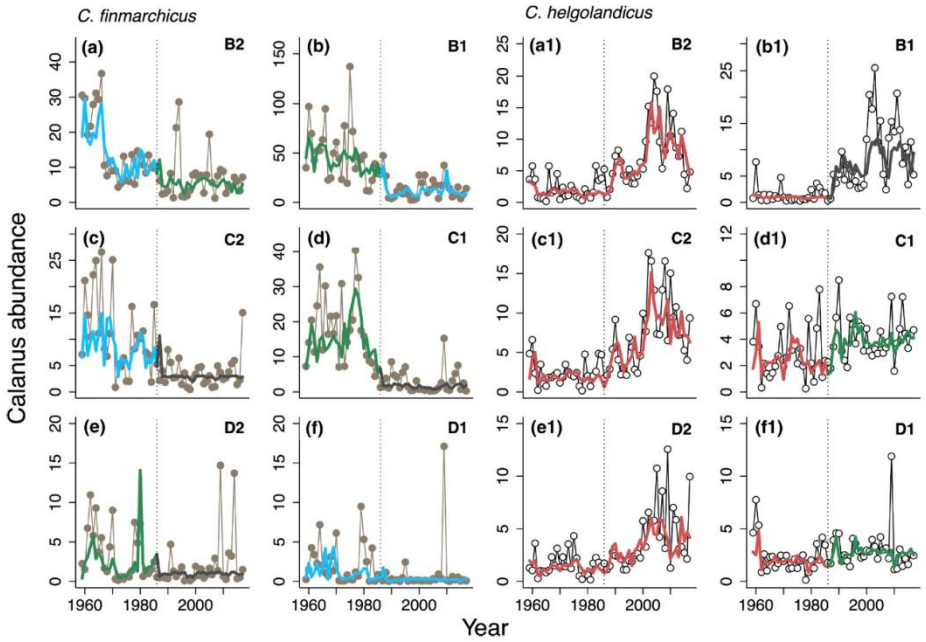
1989-2010 (22 yr)

Otero et al. (2018) doi:10.3354/meps12542

life traits & competition

North Sea





PCI = chlorophyll
NAO = climate
SST = warming
Ricker = competition

1958-2017 (60 yr)

Montero et al. (2021) doi:10.1111/gcb.15394

niche

Bay of Biscay

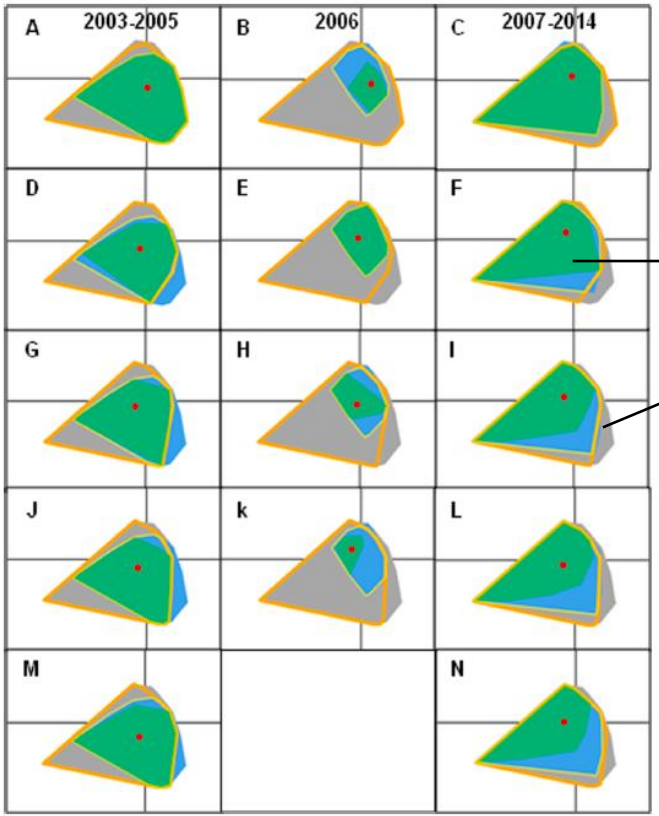
Gymnodinium spp. + Gyrodinium spp.

Pseudo-nitzschia spp.

Leptocylindrus danicus

Chaetoceros sp.

Leptocylindrus minimus



realized niche

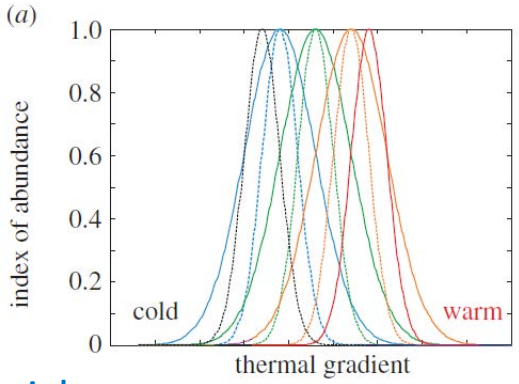
environmental space

2003-2014 (12 yr)

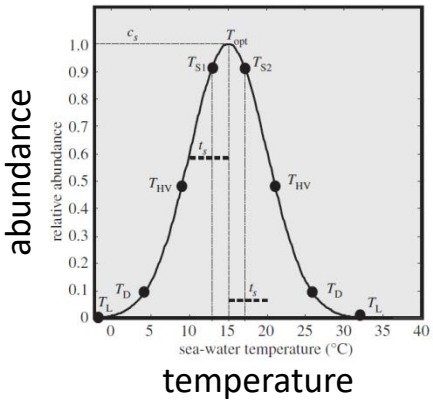
Houliez et al. (2021) doi:10.1016/j.pocean.2021.102558

thermal effects:

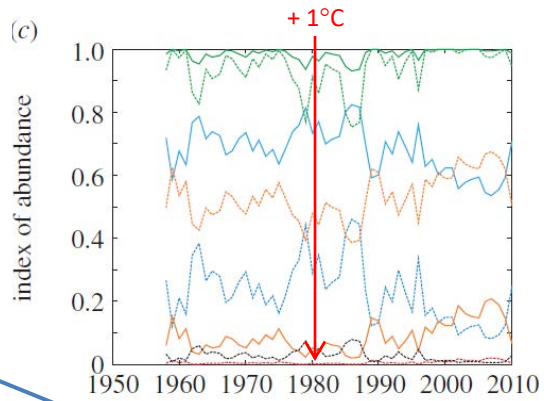
simulation

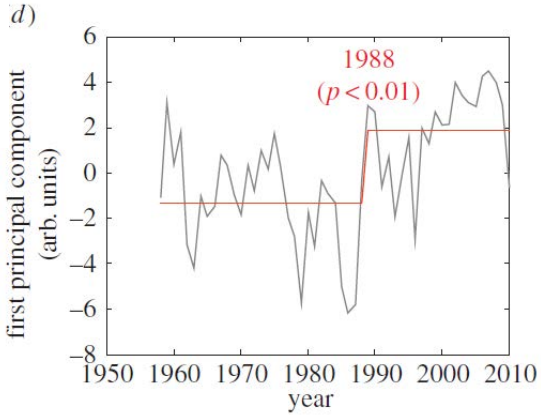


thermal niche



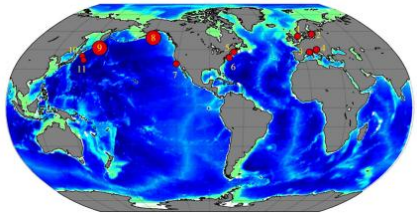
temperature increase



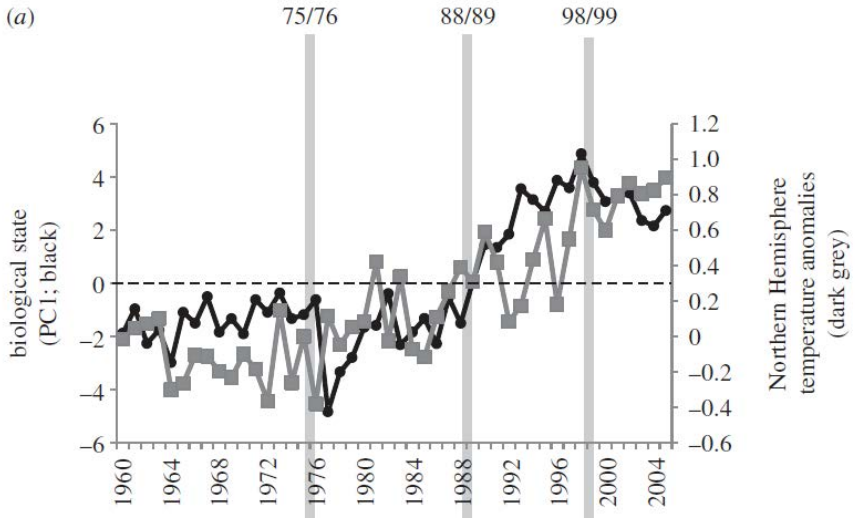


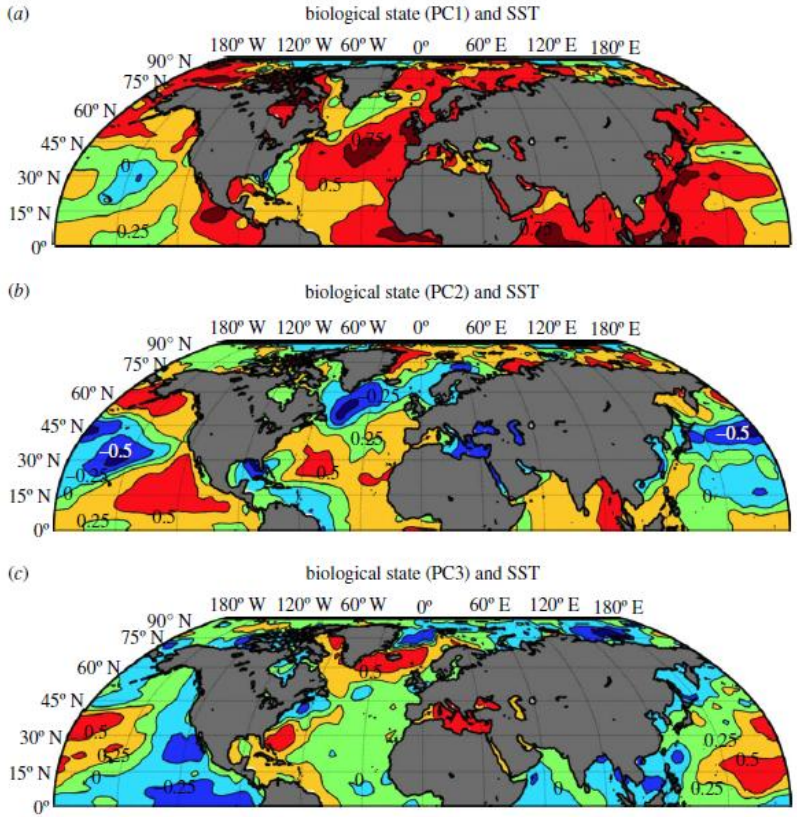
Beaugrand (2015) doi:10.1098/rstb.2013.0264

warming and synchronicity:



correlations with SST

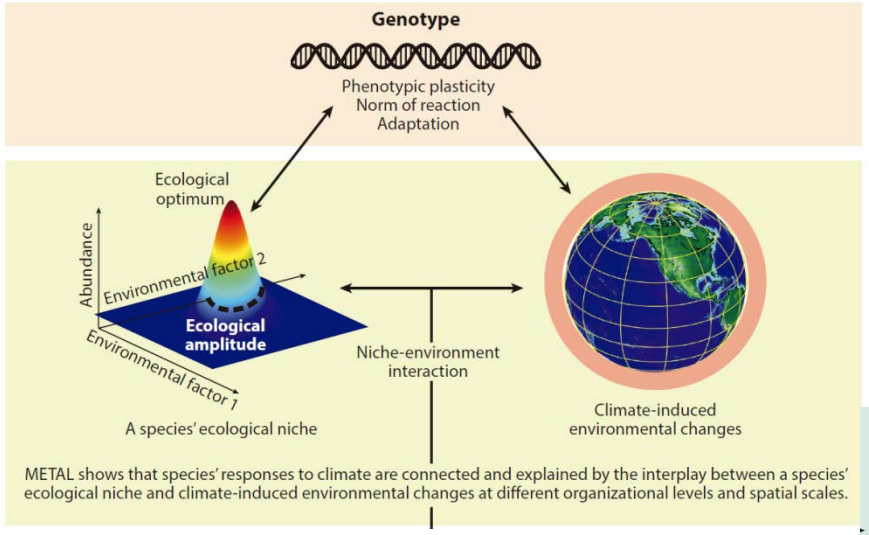


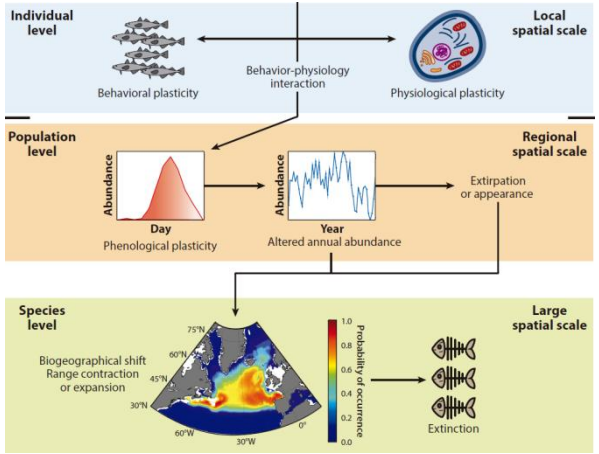


Beaugrand et al. (2015) doi:10.1098/rstb.2013.0272

predicting shifts:

Macro**E**cological **T**heory on the **A**rrangement of **L**ife





Beaugrand & Kirby (2018) doi:10.1146/annurev-marine-121916-063304

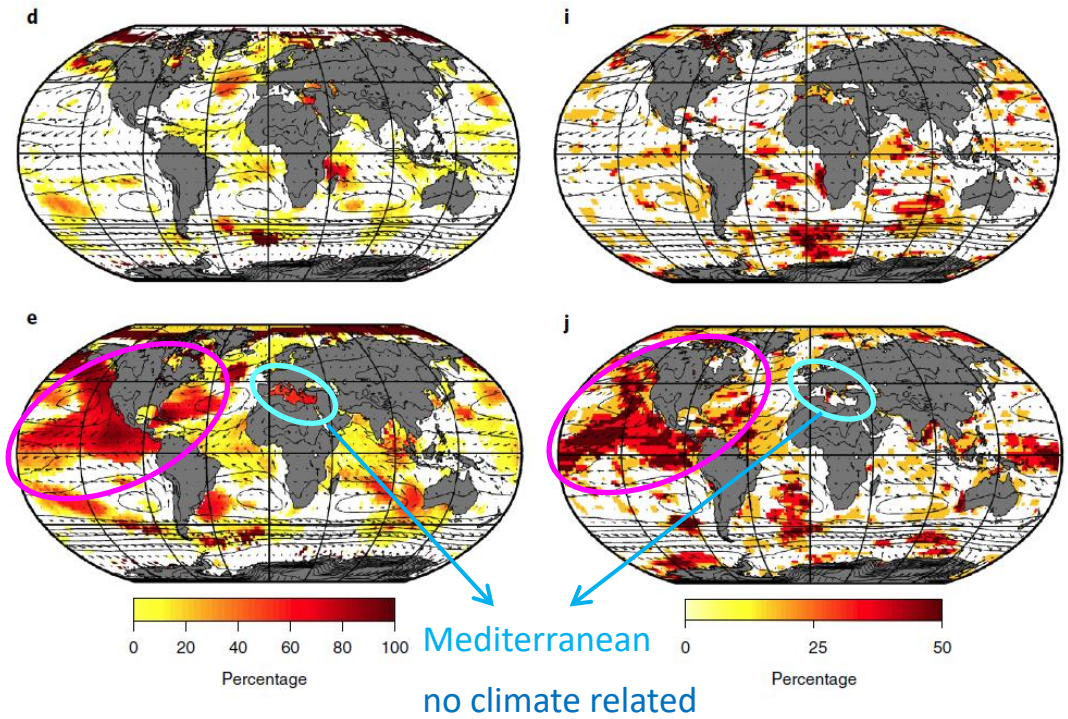
predicting shifts:

species shift

climatic shift

2005-2009 (5 yr)

2010-2014 (5 yr)



NE Pacific
NW Atlantic

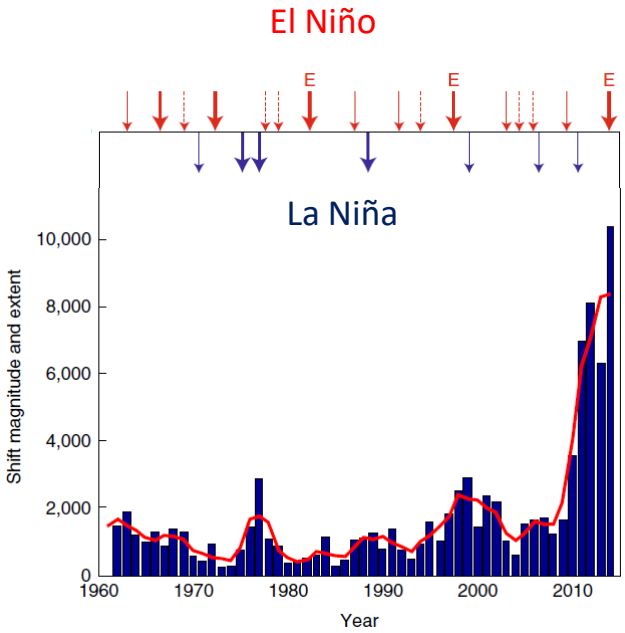
climate related

Mediterranean

no climate related

Beaugrand et al. (2019) doi:10.1038/s41558-019-0420-1

extreme events:

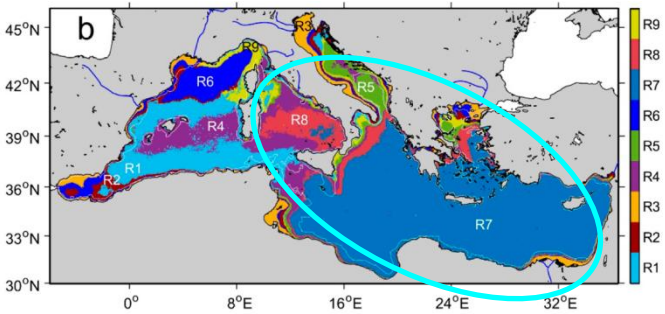


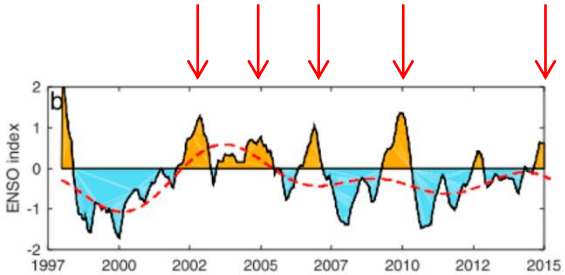
Global ocean: predicted shifts

- relationship with ENSO events?
- no global signal of late 1980s shift
- unprecedent shift ca. 2014

Beaugrand et al. (2019) doi:10.1038/s41558-019-0420-1

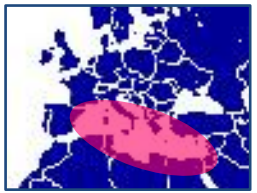
extreme events: El Niño



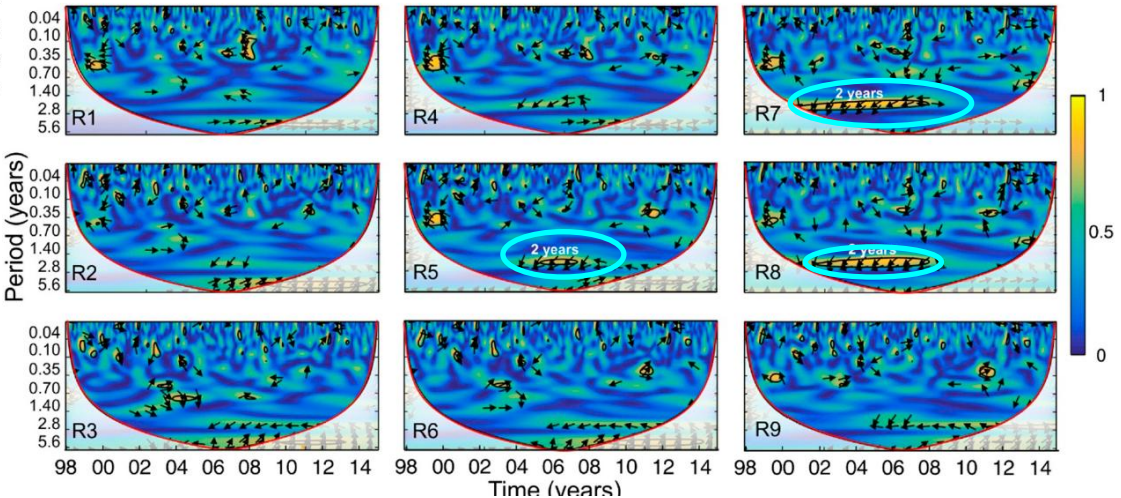


1998-2015 (18 yr)

Mediterranean Sea



satellite-chlorophyll



Saharan dust fertilization?

Basterretxea et al. (2018) doi:10.1016/j.rse.2018.05.027

new approaches

examples

- predictions from macroecological theory: warming
- functional traits & niche vs. species
- multi-trophic trait dynamics
- direct anthropogenic impacts: e.g. fisheries
- extreme event impacts: e.g. teleconnections, heatwaves

Beaugrand & Kirby (2018) doi:10.1146/annurev-marine-121916-063304

Houliez et al. (2021) doi:10.1016/j.pocean.2021.102558

Pecuchet et al. (2020) doi: 10.1111/ecog.04643

Perala et al. (2020) doi:10.1371/journal.pone.0237414

Basterretxea et al. (2018) doi:10.1016/j.rse.2018.05.027

Symposium on Decadal Variability of the North Atlantic and its Marine Ecosystems: 2010-2019

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

The Research Council of Norway

Marine Institute
Foras na Mara

NAFO
Northwest Atlantic Fisheries Organization

2021 2030 United Nations Decade of Ocean Science for Sustainable Development