Zooplankton Time Series of the World Ocean: Pilot Results of a Global Comparison

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Goals

- To analyze the interannual zooplankton time series which, until recently, were unavailable to a broad audience of researchers.
- In doing that, to address the key questions already posed by international groups of experts (at SCOR/WG-125 and GLOBEC/WG-1), during recent workshops.

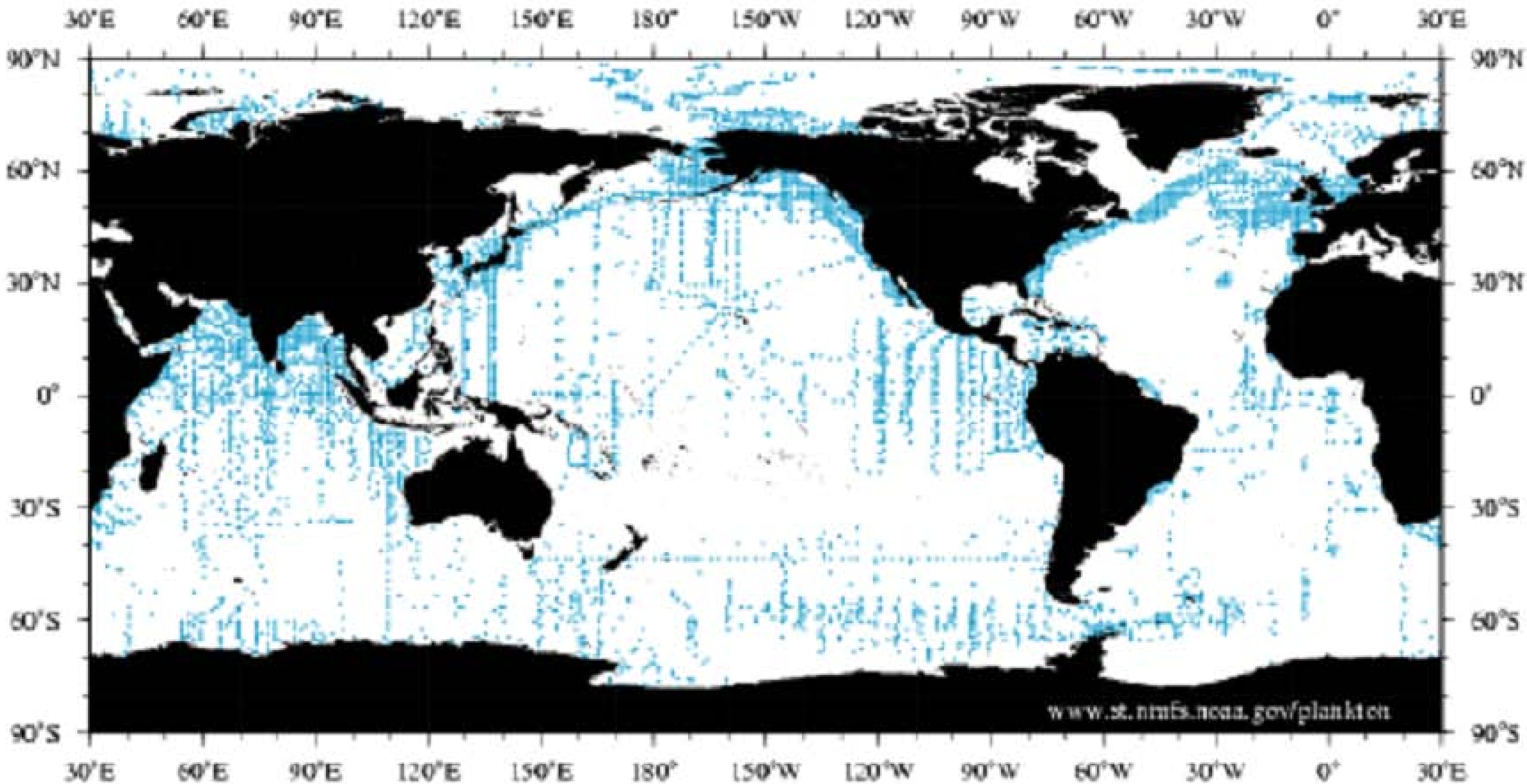
For example:

Are there any synchronies in timing of major fluctuations, of whatever form?

Are there any similarities in amplitude of variability, for total mesozooplankton biomass, abundance and for individual taxa?

What are types of relationships between global atmospheric anomalies and mesozooplankton?

(O'Brien, 2005)

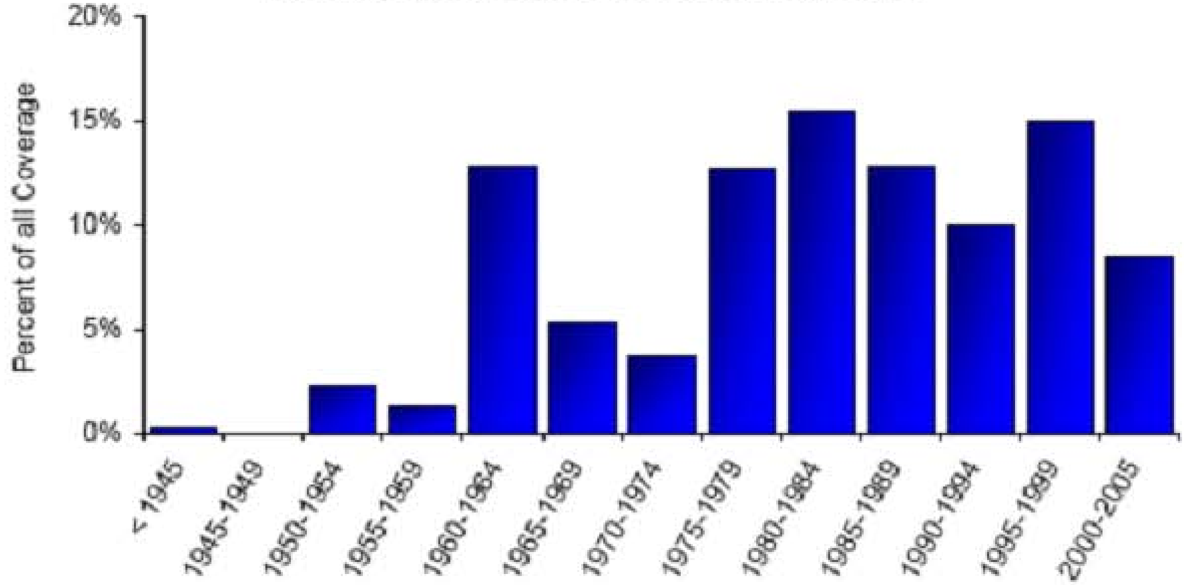


Distribution of all zooplankton observations

Content characteristics of all Zooplankton data

Number of Sampling Tows:	**47,298**
Number of Observations:	961,389

Temporal Coverage of Sampling Tows



(O'Brien, 2005)

Top Twenty most frequent Observations

Rank	# of OBS	ITIS-TSN	DESCRIPTION
1	32,616	85257	*Copepoda spp.*
2	28,734	158650	*Chaetognatha spp.*
3	23,077	85767	*Centropages typicus*
4	22,139	88802	*Oithona spp.*
5	20,585	85272	*Calanus finmarchicus*
6	19,841	95496	*Euphausiacea spp.*
7	19,546	85741	*Metridia lucens*
8	18,410	85371	*Pseudocalanus minutus*
9	16,440	64358	*Polychaeta spp.*
10	15,766	86084	*Acartia spp.*
11	15,091	95107	*Hyperiidea spp.*
12	14,774	76333	*Thecosomata spp.*
13	14,773	-5002	*Zooplankton spp.*
14	14,595	85766	*Centropages hamatus*
15	14,169	93294	*Amphipoda spp.*
16	14,092	158727	*Sagitta spp.*
17	14,071	84195	*Ostracoda spp.*
18	13,774	51268	*Siphonophora spp.*
19	13,700	159664	*Appendicularia (aka "larvacea")*
20	12,514	85263	*Calanus spp.*

(O'Brien, 2005)

GLOBEC Focus 1 working group: retrospective analysis and time series studies

Preservation of existing long time series
Analysis of existing retrospective data
Creation of new, retrospective, data sets

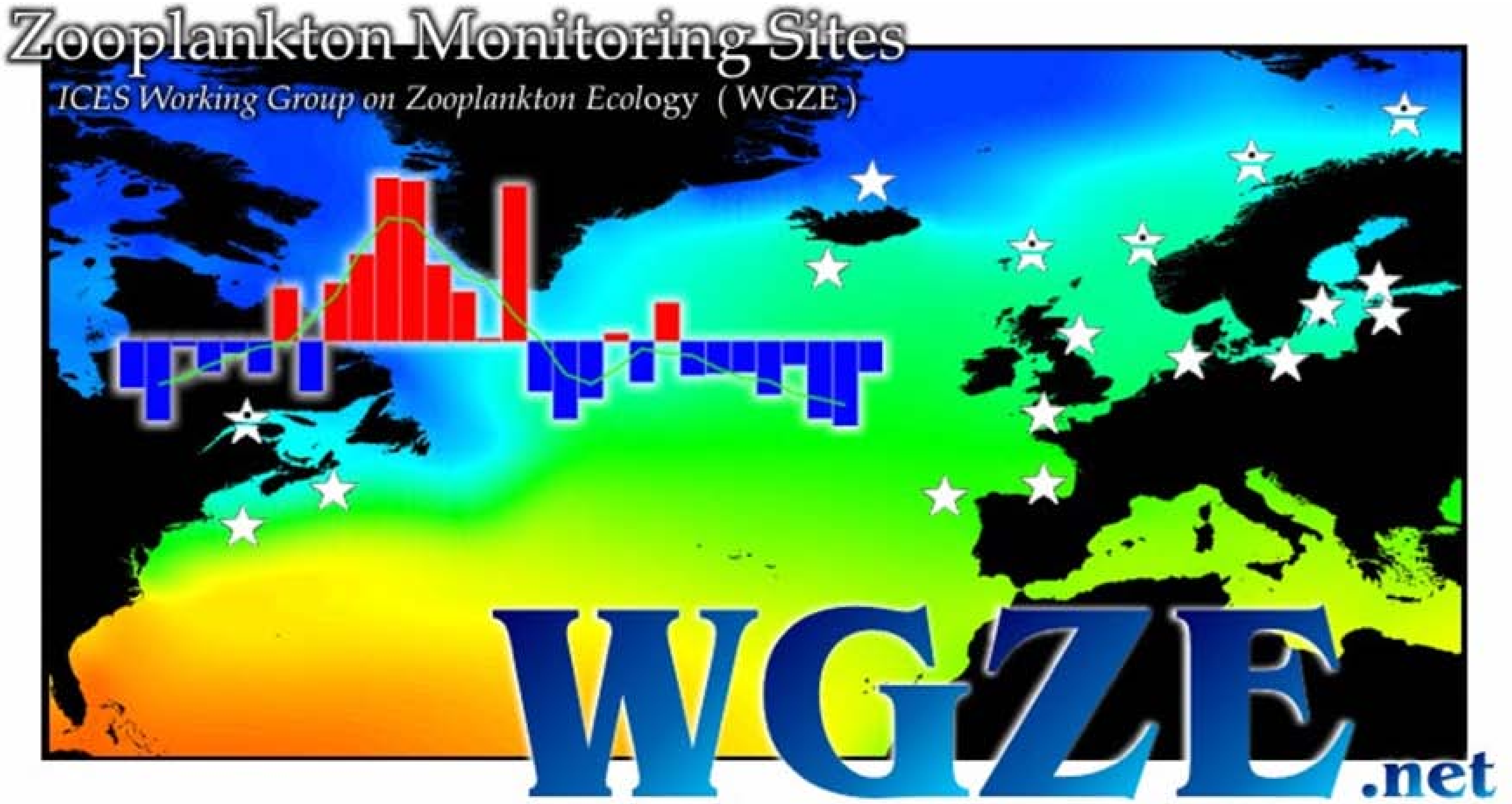
(1999)

T.Baumgartner, N.Ward, J.Alheit, S.Piontkovski, B.Planque, I.Perry, A.Bakun, and K.Drinkwater

IGBP Report 47

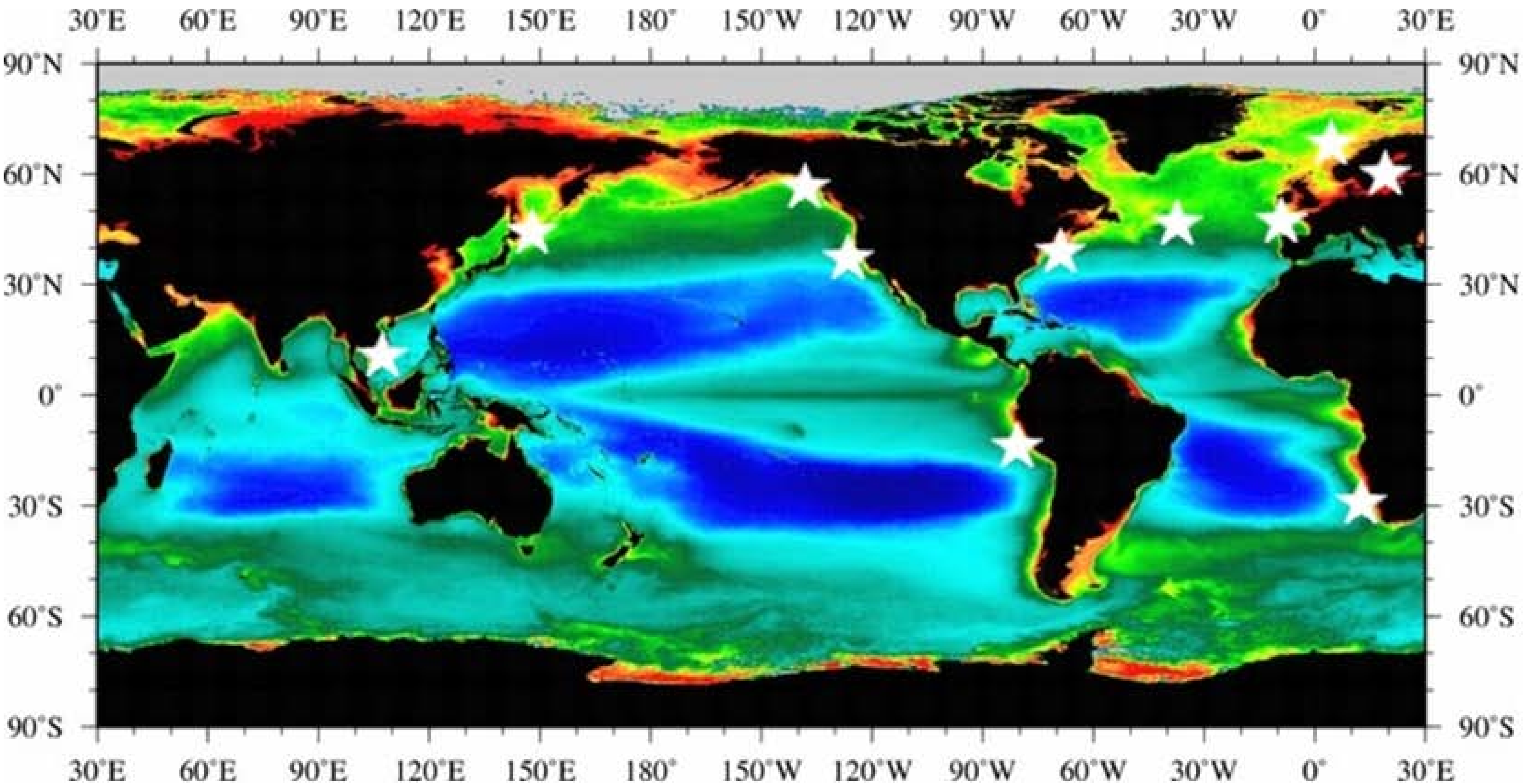
ICES working group on zooplankton ecology (WGZE)

(2003)



(2004)

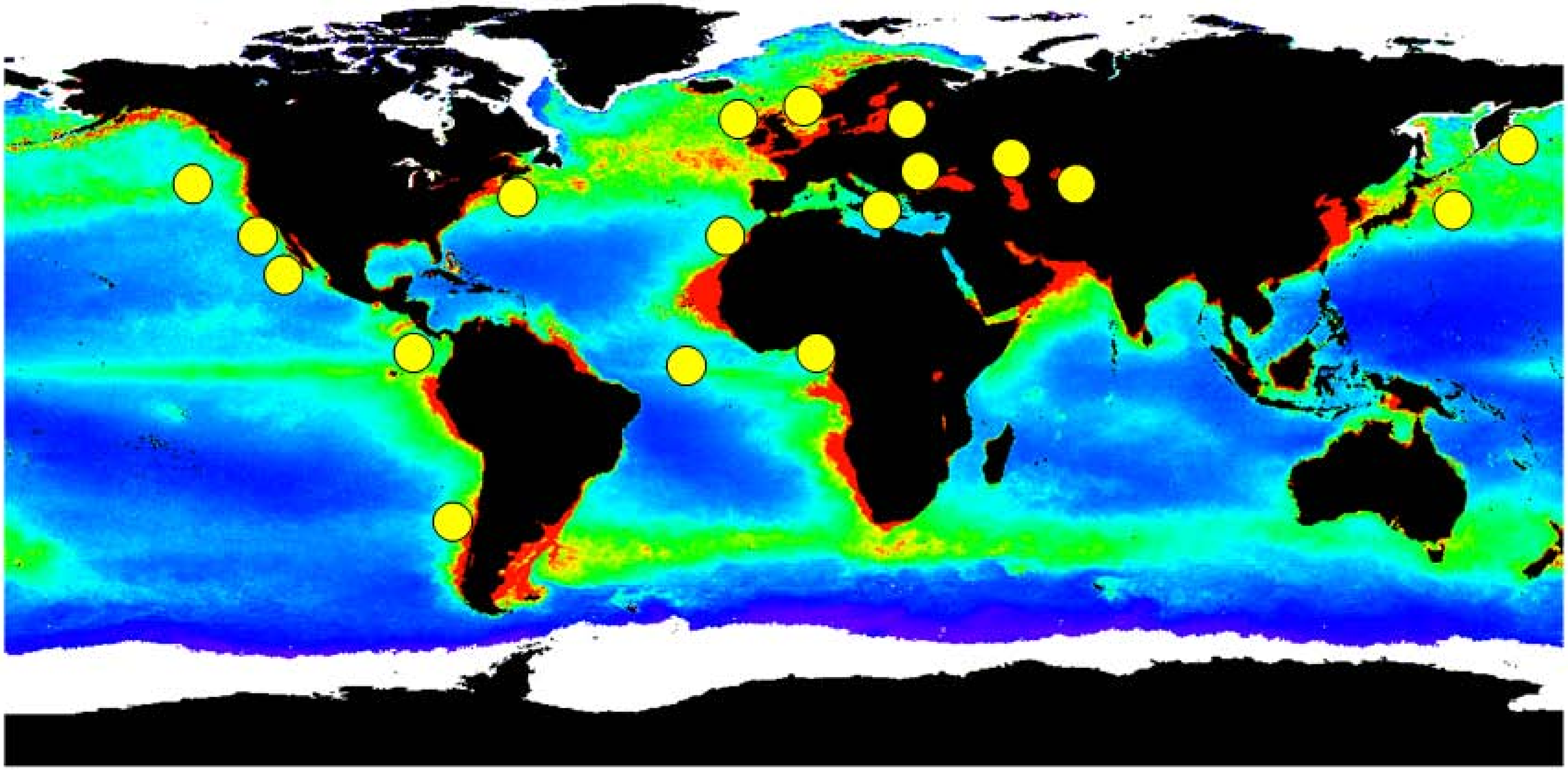
SCOR working group125: global comparisons of zooplankton time series
(http://scor.e-plankton.net/)



Zooplankton time series of the World Ocean

#	Region	Year of sampling	#	Region	Year of sampling
	Atlantic Ocean:		20	Adriatic Sea	1970-2007
1	The White Sea	1961-1995	21	Black Sea (western part)	1978-2007
2	Norwegian Sea	1961-2002	22	Black Sea (central part)	1959-1988
3	Barents Sea	1954-2007	23	Caspian Sea	1938-1980
4	Iceland	1961-2003	24	Aral Sea	1969-2004
5	Northern Atlantic/CPR	1938-2007		*Pacific Ocean:*	
6	Gulf of Maine	1961-2007	25	Gulf of Alaska/St."P"	1956-2007
7	North Sea coastal region ("Helgoland Roads")	1974-2007	26	Vancouver Island	1951-2007
8	Biscay Bay	1994-2007	27	Sakhalin coastal zone	1987-2007
9	Bermuda Time series	1994-2007	28	Western North Pacific	1951-2007
10	Central Tropical Atlantic	1950-1989	29	Central Subarctic and Bering Sea	1953-2001
11	Abidjan coastal zone	1969-1981	30	Western Subarctic region	1987-2007
12	Namibian Coast	1972-1989	31	Western Subtropical region	1971-2007
13	Cape coast of South Africa	1951-1967	32	California Current	1949-2007
14	*Enclosed Seas:*		33	South California Current	
15	Baltic Sea	1957-2005	34	Central Tropical region (HOT)	1994-2007
16	Ligurian Sea	1985-1995	35	Peruvian coastal region	1964-2007
17	Ligurian Sea ("Point B")	1957-2005		*Indian Ocean:*	
18	Aegean Sea	1989-2007	36	Kenyan coast (Mombasa)	1993-2007
19	Tyrrhenian Sea	1984-2007	37	Antarctic region (Elephant Island)	1977-2007

Zooplantkon time series used for the analysis



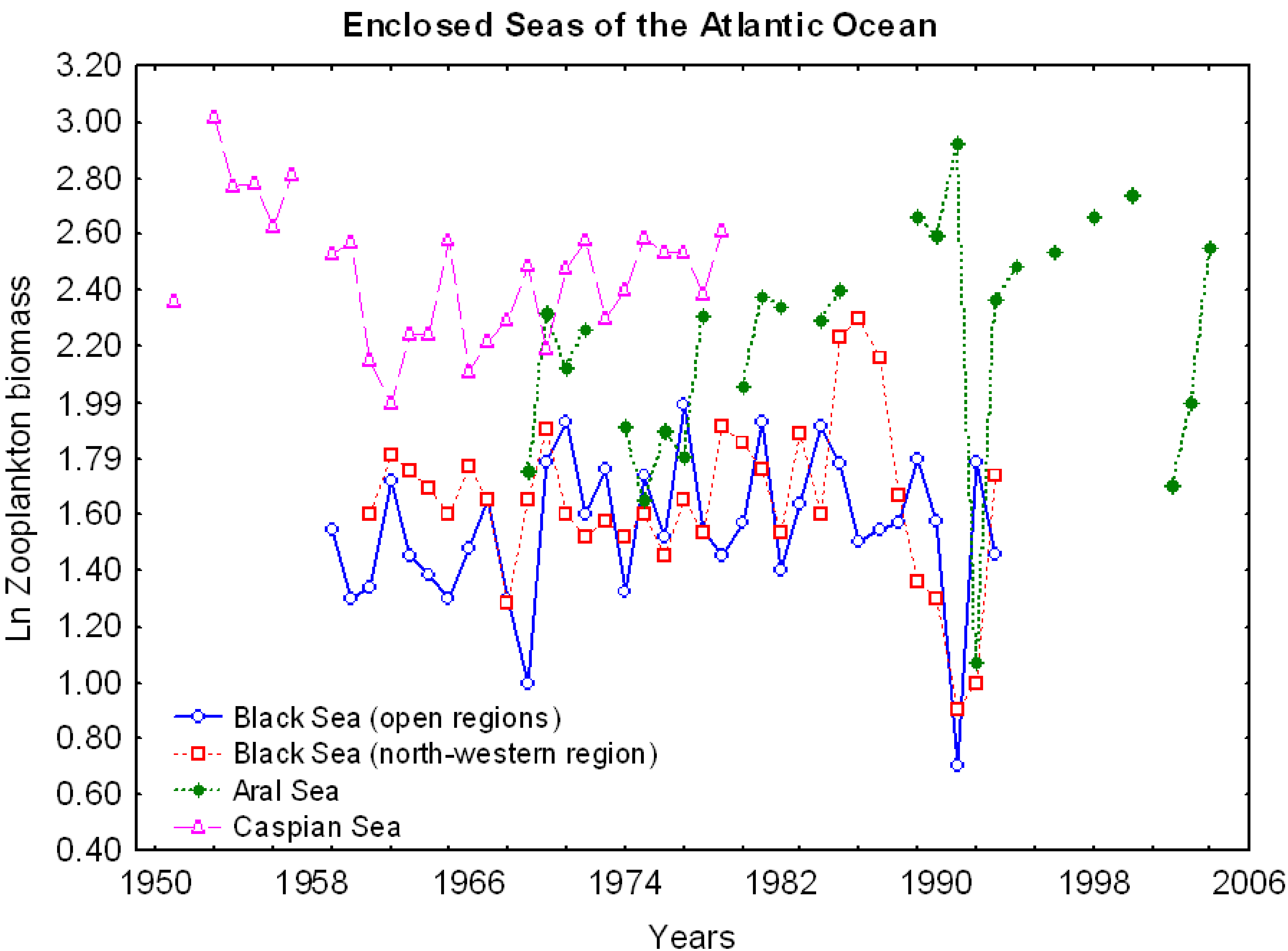
SeaWIFS chlorophyll "a"

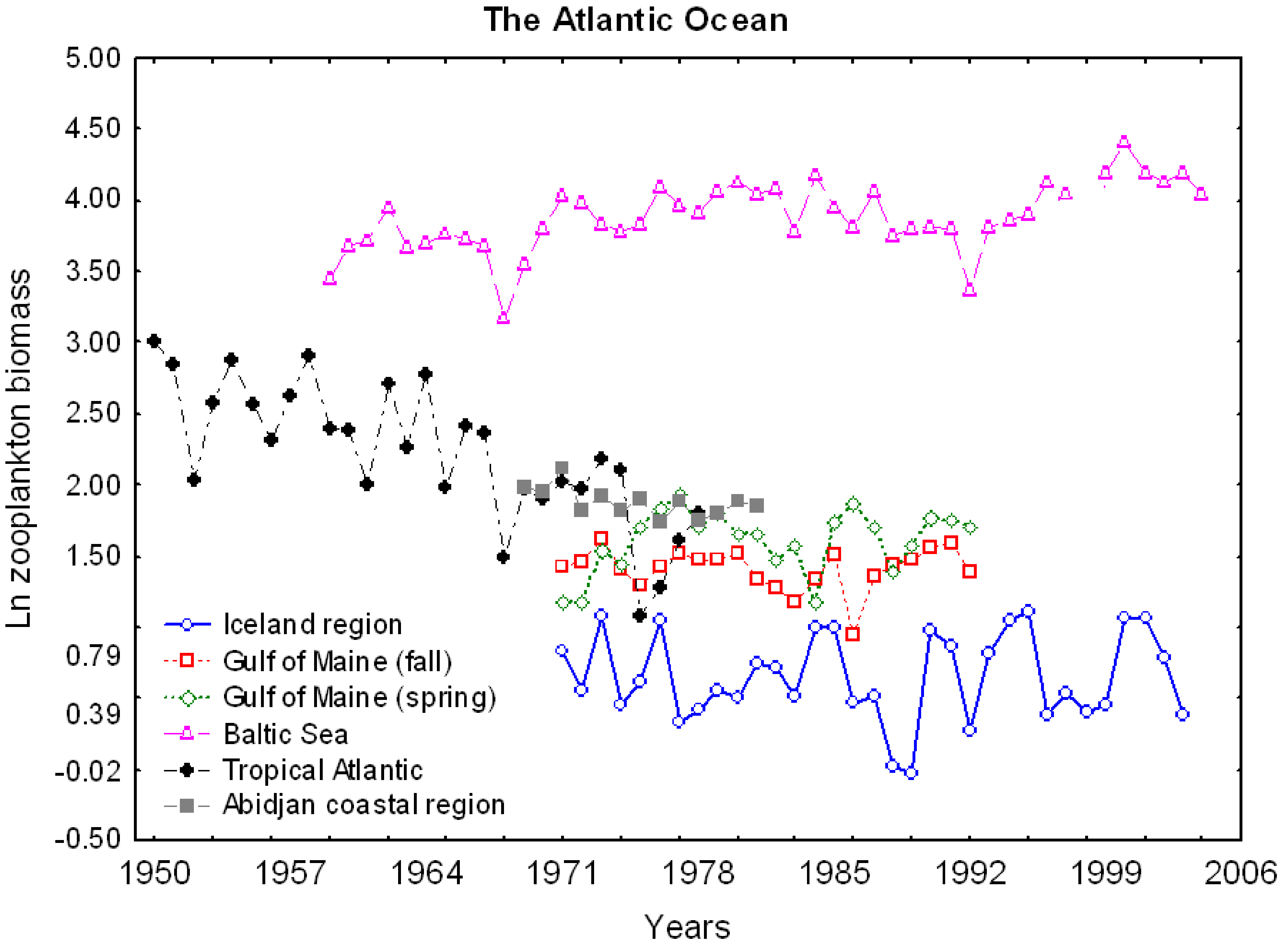
Time series and data sources

Region	Data source	Region	Data source
Iceland	COPEPOD database	Caspian Sea	FSU database
Gulf of Maine	J.Jossi	Aral Sea	FSU database
North Sea	SAHFOS	Gulf of Alaska	Fulton, 1983 Frost, 1983
Baltic Sea	Möllmann et al., 2000	California Current	Chelton et al., 1982 McGowan et al., 1995; Lorenzo, 2003
Bermuda Time Series	Madin et al., 2001	Bering Sea	I.Bragina
Tropical Atlantic	FSU database	Oyashio Current	ODATE database
Abidjan region	R.LeBorne	Hawaii Ocean Time Series	Landry and Hanniedes, 2006
Black Sea	IBSS database Kamburska et al., 2003	Peruvian region	COPEPOD database
Adriatic Sea	Umani et al., 1996	Panamanian region	L.D'Croz

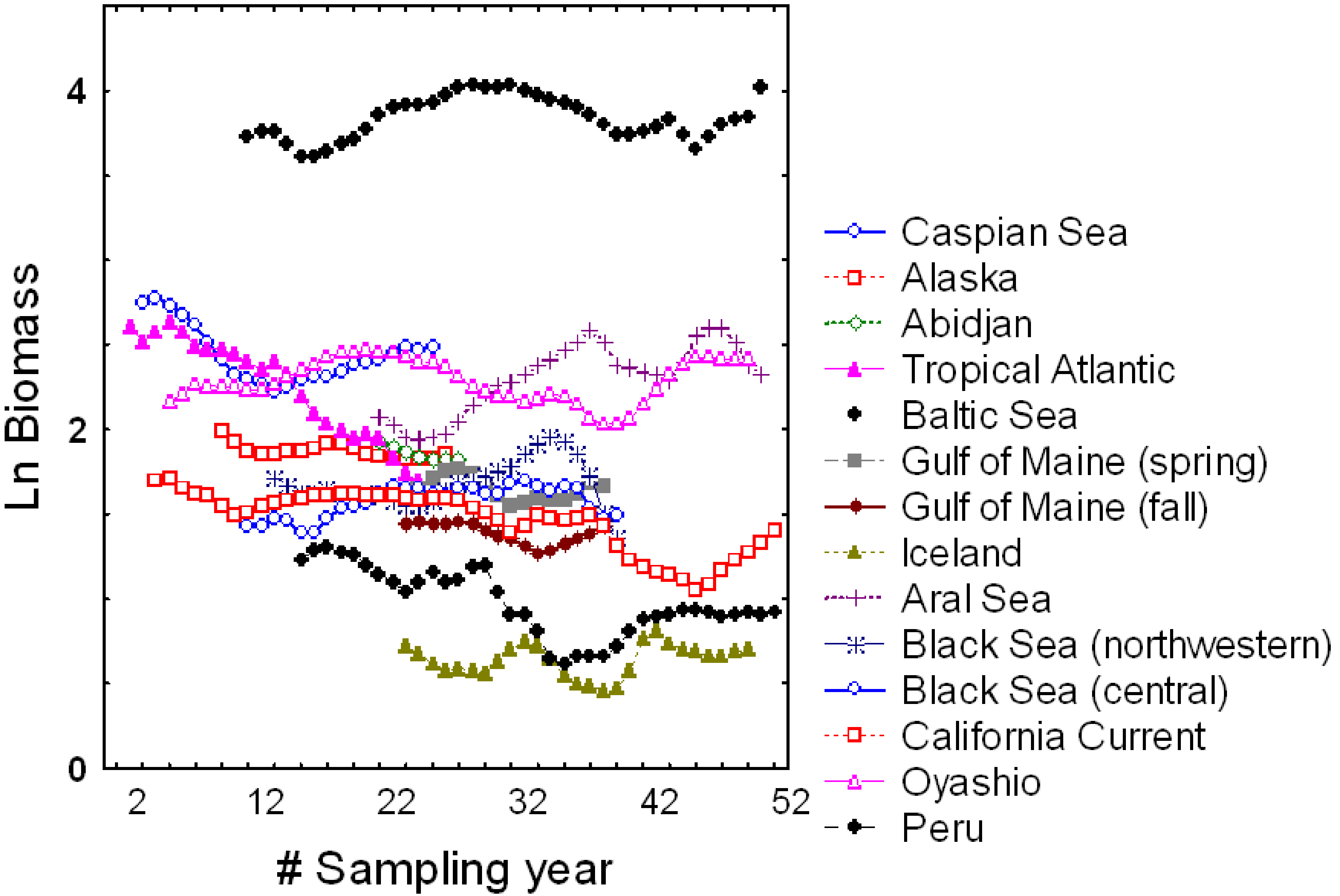
Pilot results of global comparative analysis:

- Diverse types of interannual trends
- Time lags in a response to global atmospheric anomalies
- No synchrony in timing of major fluctuations over regions
- No similarity in the amplitude of variability, for total mesozooplankton biomass

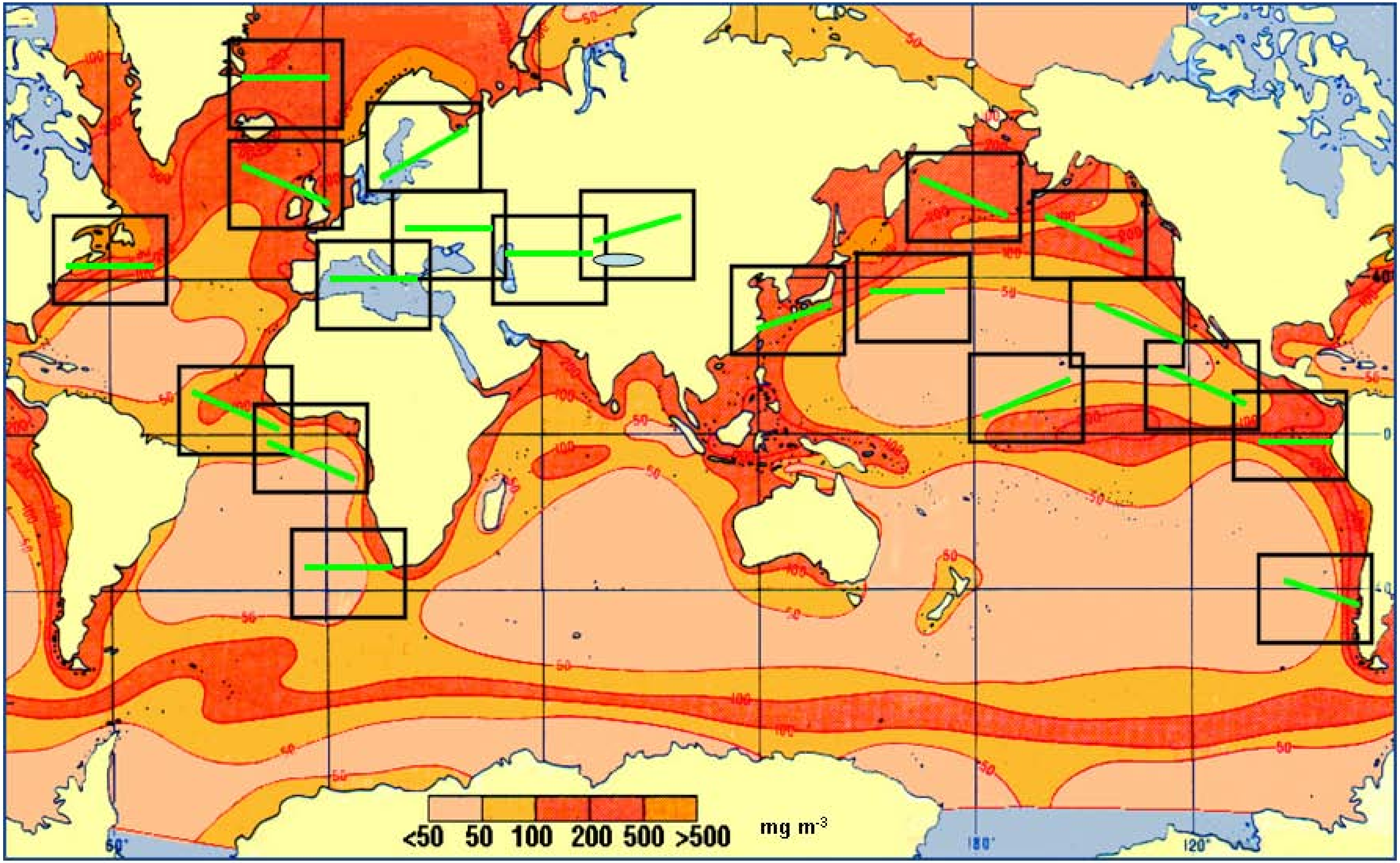

Enclosed Seas of the Atlantic Ocean
3.20
3.00
2.80
2.60
2.40
2.20
1.99
1.79
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ln Zooplankton biomass
1950
1958
1966
1974
1982
1990
1998
2006
Years
Black Sea (open regions)
Black Sea (north-western region)
Aral Sea
Caspian Sea


The Atlantic Ocean
Ln zooplankton biomass
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
0.79
0.39
-0.02
-0.50
1950
1957
1964
1971
1978
1985
1992
1999
2006
Years
Iceland region
Gulf of Maine (fall)
Gulf of Maine (spring)
Baltic Sea
Tropical Atlantic
Abidjan coastal region

Smoothed time series: 6 year running mean



Spatial-temporal trends of zooplankton biomass (1950-2005)



www.oceansatlas.org/unatlas

In the California Current, "zooplankton community shifts appear to coincide with variations in the Pacific Decadal Oscillation, a quasi-periodic variation in sea surface temperature with a time scale of about 15-25 years" http://www.siograddept.ucsd.edu/curricular_groups/BO/rch/pe1.htm

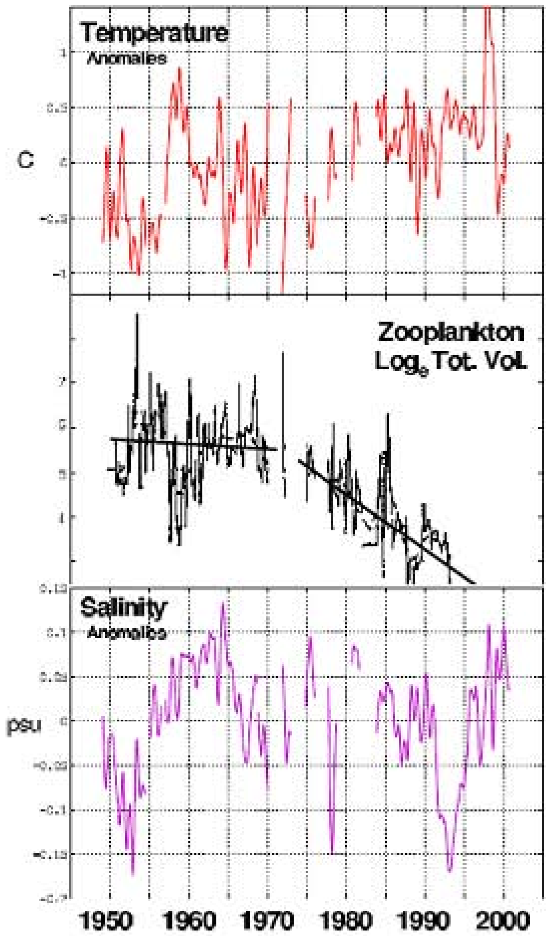
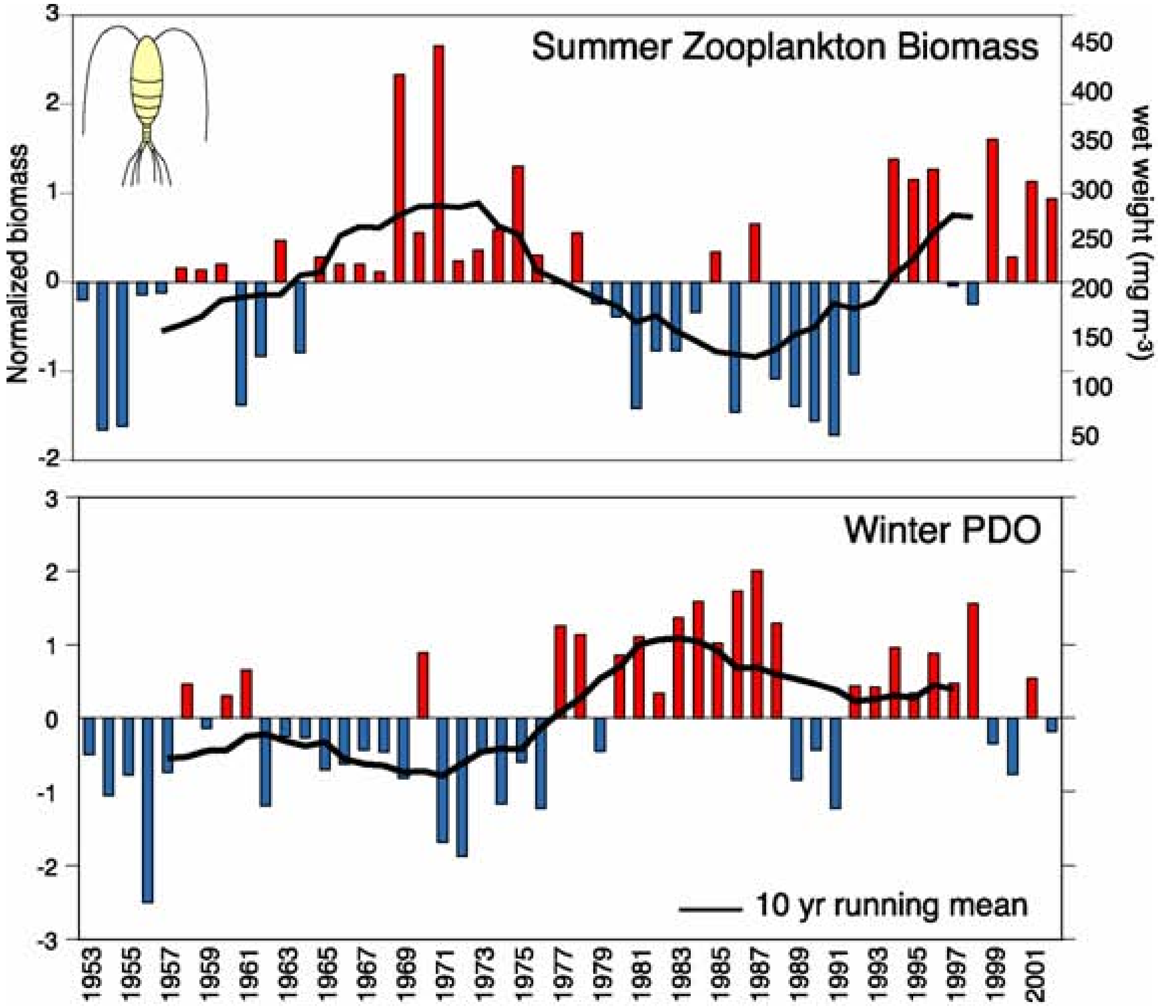


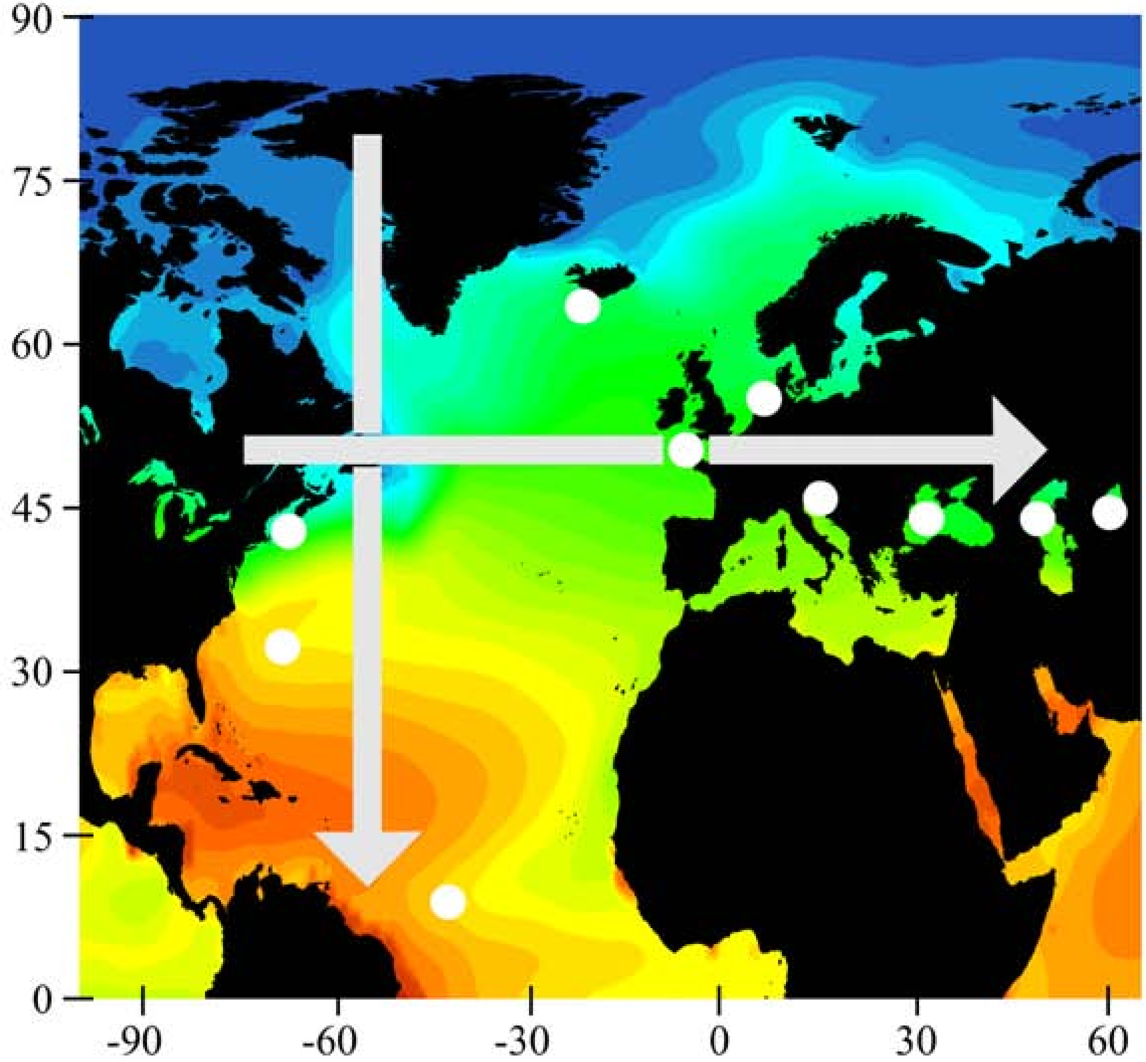
Figure 1.3. Timeseries of ocean temperature and salinity anomalies, and total volume zooplankton averaged over the Southern California domain. The source of the zooplankton plot is Roemmich and McGowan [1995].

Lorenzo, 2003



Time series of summertime total zooplankton wet weight in the Oyashio (upper), and wintertime PDO (http://tao.atmos.washington.edu/pdo/)(lower) **normalized for 1953-2002** (Chiba et al, 2006).

Time series of the Atlantic Ocean basin

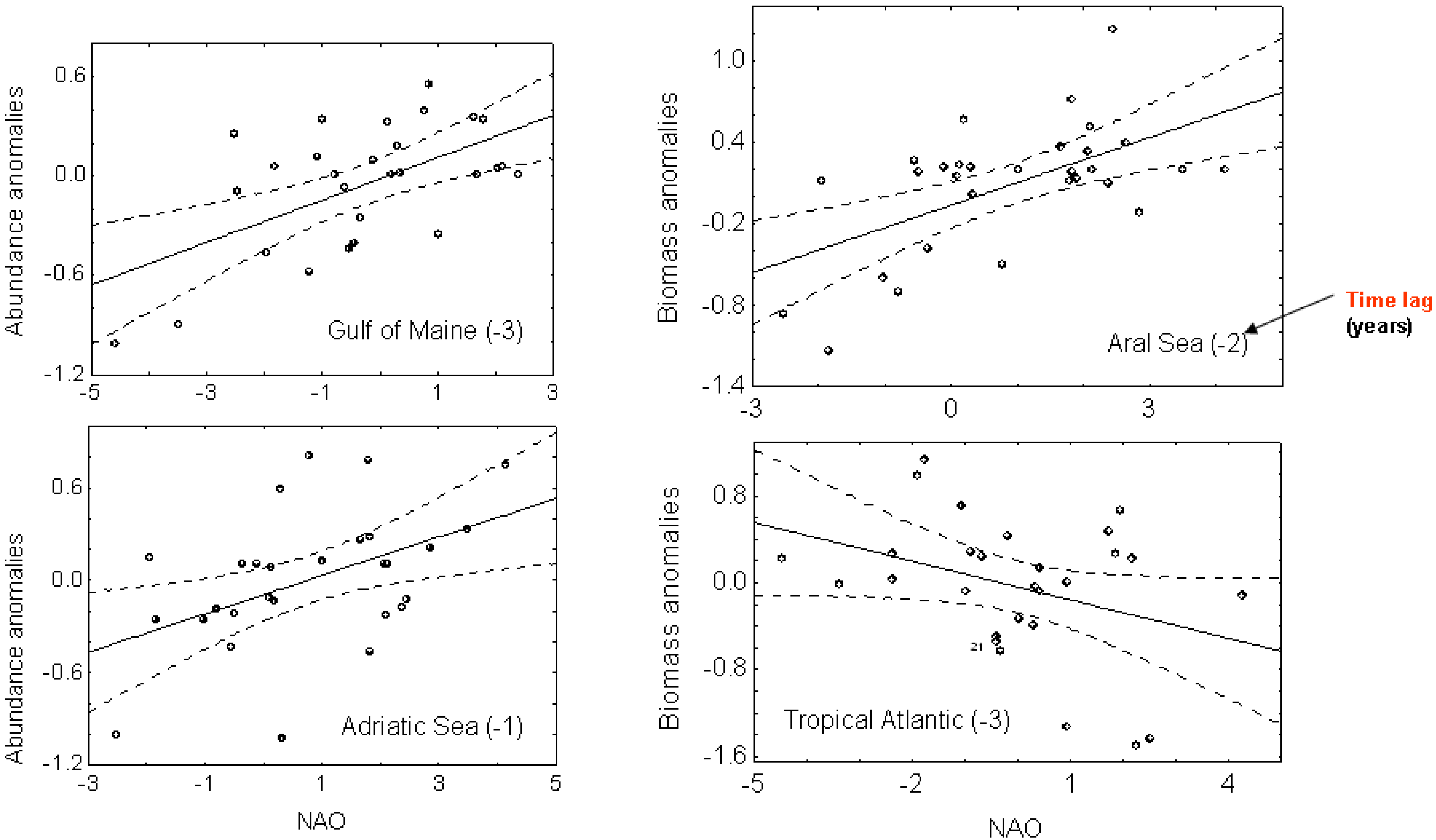


Background: Annual mean sea surface temperature (modified from Stephens et al, 1998). Arrows illustrate the latitudinal and longitudinal arrays analyzed in this talk.

(Piontkovski et al., 2006)

The relationship between mesozooplankton and NAO

(Piontkovski et al., 2006)

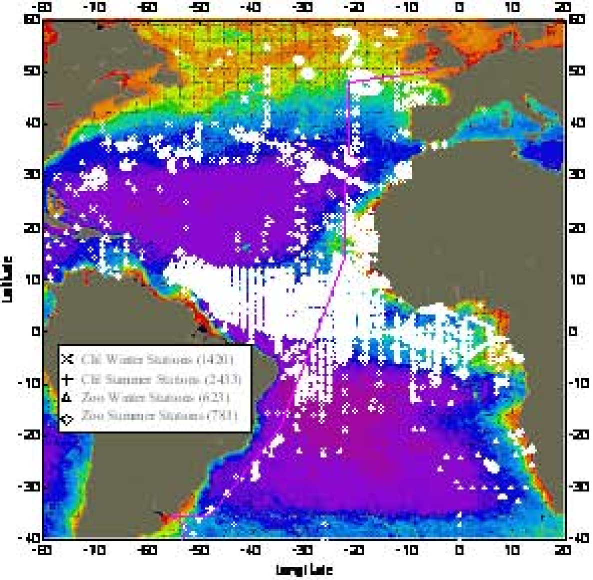


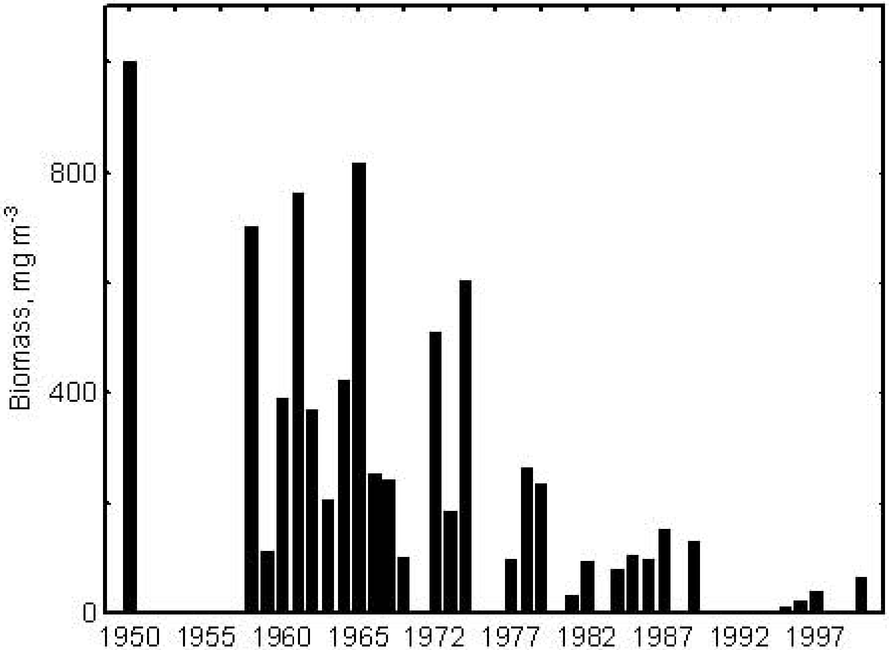
Time Lags

Piontkovski et al., 2006

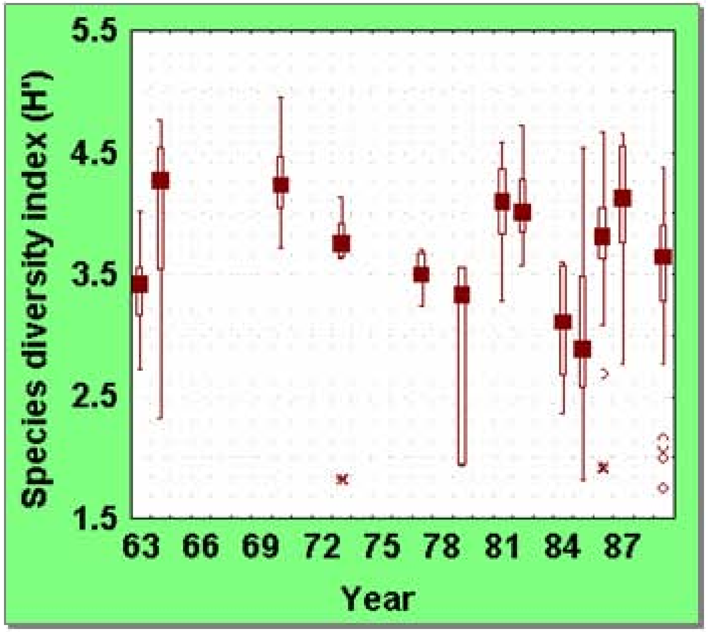
Region	"Plankton-NAO" time lag in years	Correlation (r)	Years of sampling	Sampled Parameter
North Atlantic (Iceland)	3-4	0.5	1961-2002	Zooplankton Biomass
Western Atlantic (Gulf of Maine)	3	0.6	1961-1991	Copepod Abundance
Eastern Atlantic ("Helgoland Roads")	3-4	0.6	1975-2003	Copepod Abundance
Eastern Atlantic (UK-L4)	3	0.4	1988-2002	Copepod Abundance
Adriatic Sea	0-1*	0.5*	1970-1999	Copepod Abundance
Black Sea	3	0.5	1959-1988	Zooplankton Biomass
Caspian Sea	3	0.4	1939-1980	Copepod Biomass
Aral Sea	2	0.6	1969-2004	Zooplankton Biomass
Subtropical Atlantic (BATS)	1 (lack of data)	-0.7	1994-1998	Zooplankton Biomass
Tropical Atlantic	3	-0.4	1950-1989	Zooplankton Biomass

Interannual variability of zooplankton biomass and copepod species diversity in the Tropical Atlantic Ocean

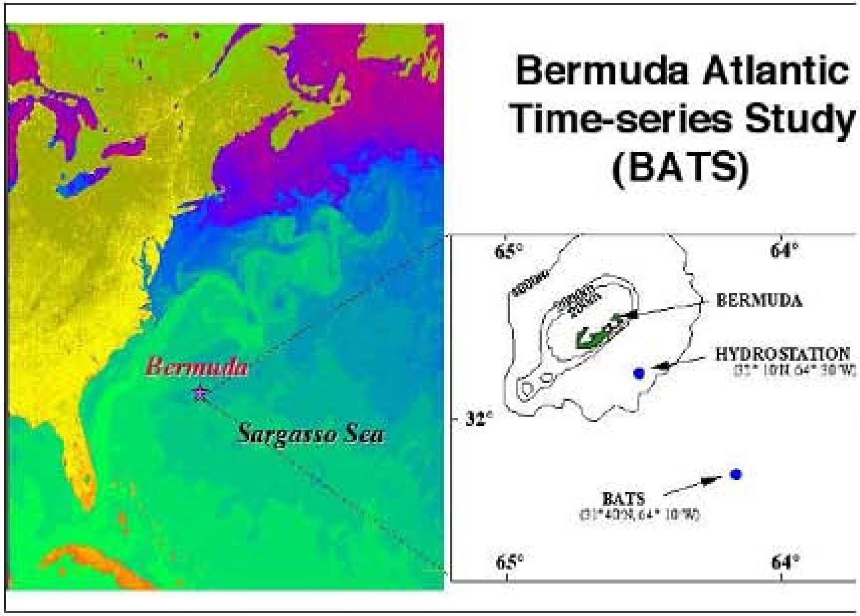


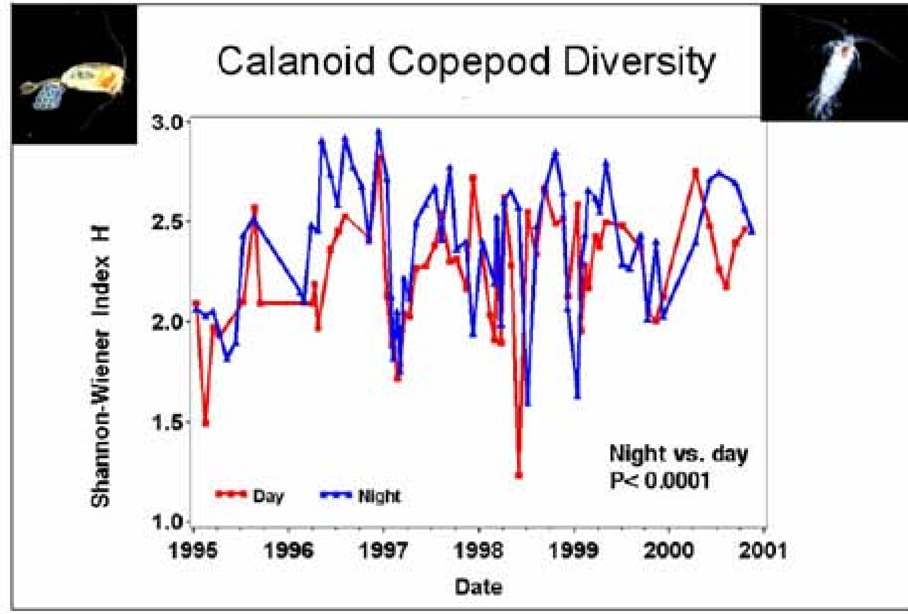


(Piontkovski and Castellani, in press)



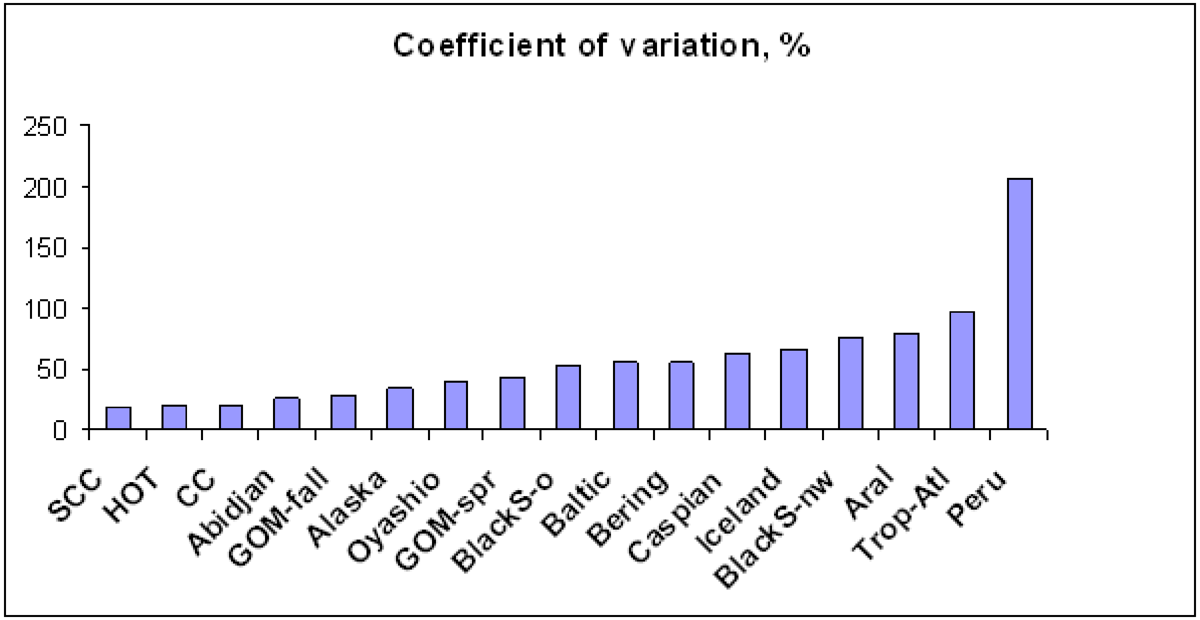
Piontkovski and Landry, 2003

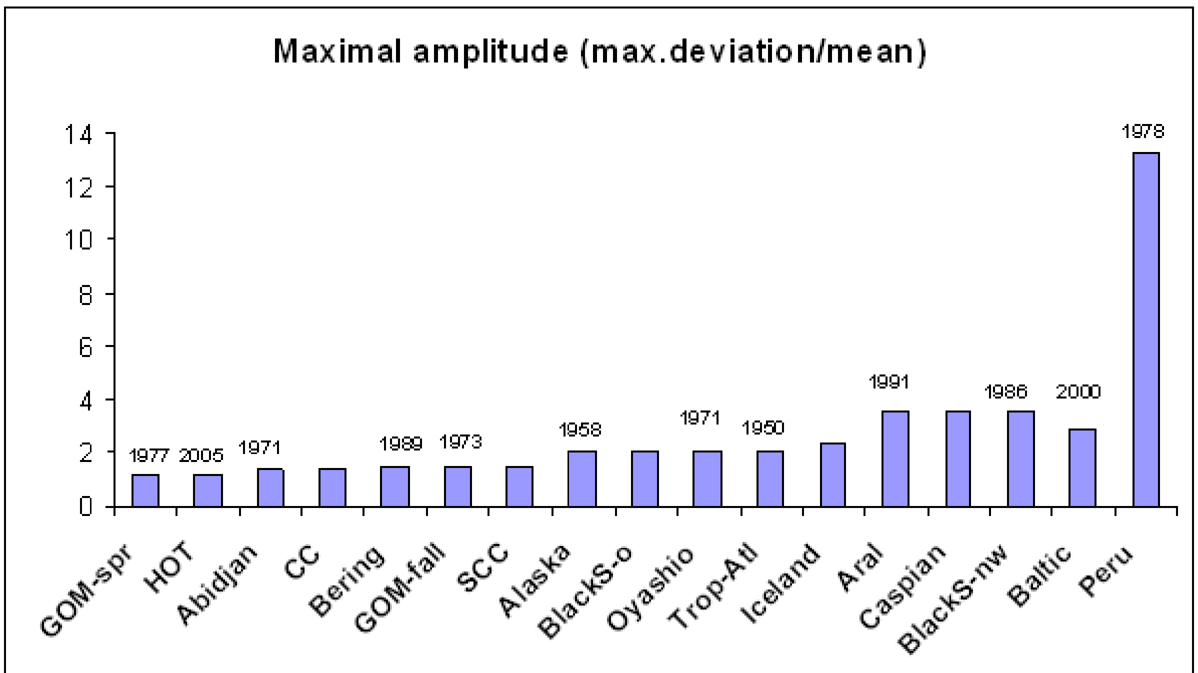




Steinberg and Madin- http://www.vims.edu/bio/zooplankton/BATS/index.html

Interannual variability in zooplankton time series (1950-2005)





This study examined zooplankton time series across coastal and oceanic waters of the Pacific Ocean, the Atlantic Ocean and its enclosed seas (the Mediterranean, Black, Caspian, and Aral seas).

The majority of these time series were twenty years in length or longer with samples starting as far back as the early 1950's. In general, the time series exhibited three obvious types of interannual trends (rising, declining, or relatively stable over the years).

A global or basin scale synchrony between interannual fluctuations was not obvious but correlation with atmospheric indices (ENSO,PDO, and/or NAO) were found in many sites.

Pilot results of global comparative analysis suggest that local atmospheric and water mass dynamics dominant the interannual fluctiations of zooplankton biomass, and contribute noise that makes it difficult to isolate the effects of larger or longer term events.