Regional scale climatological forcing of *Calanus finmarchicus* dynamics in the Gulf of Maine and the Gulf of St. Lawrence

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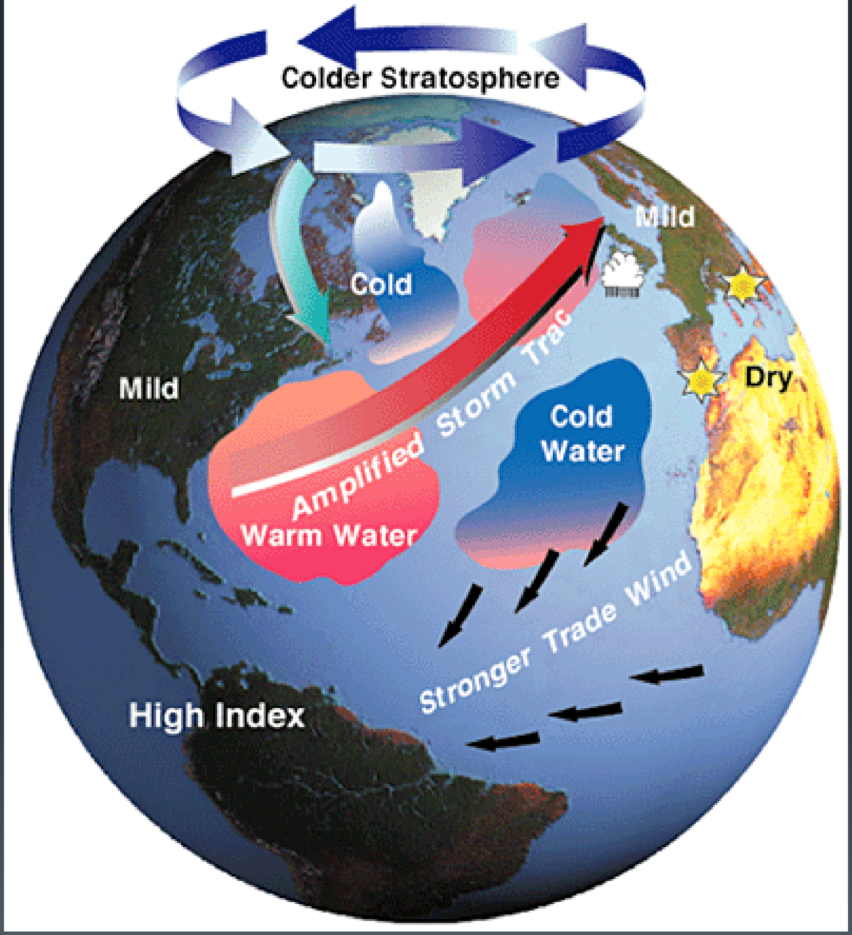
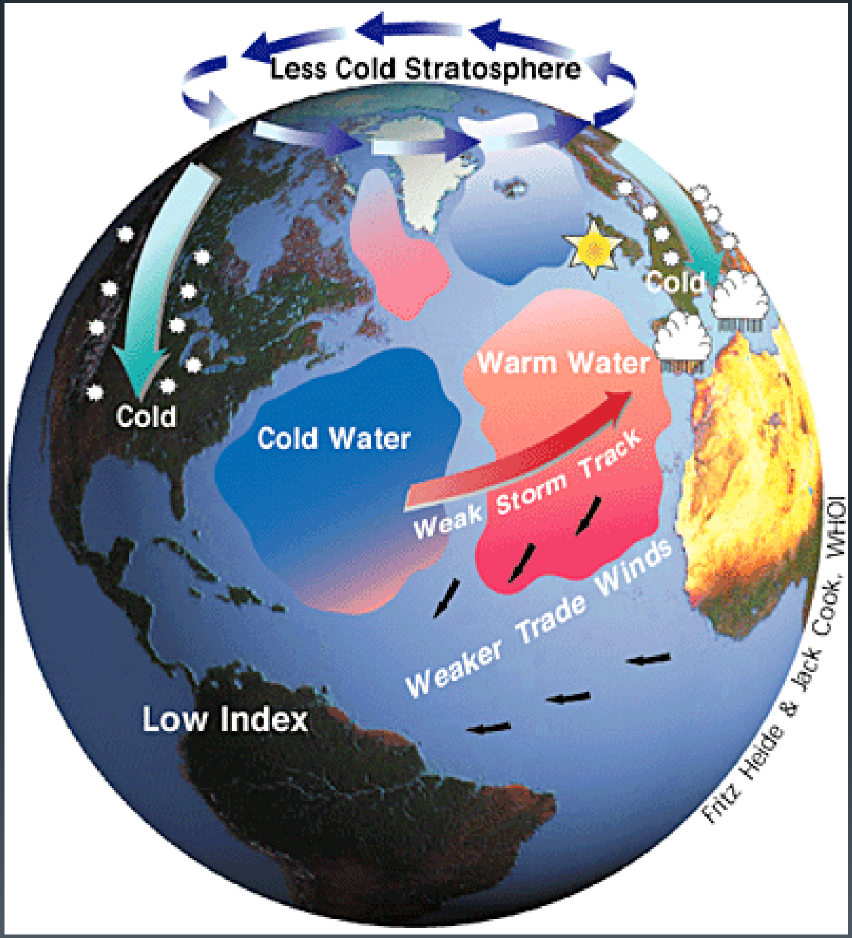
Outline

- The NAO and *Calanus finmarchicus* in the western North Atlantic Ocean
- Classifying regional scale weather variability in the western North Atlantic Ocean
- Downscaling weather patterns to surface conditions
  - The Gulf of Maine, Scotian Shelf, Newfoundland Shelf and Gulf of St. Lawrence
- A comparison of weather variability and *C. finmarchicus* abundance time-series

The North Atlantic Oscillation (NAO)



Positive NAO Index



Negative NAO Index

http://www.whoi.edu/page.do?pid=12455&tid=282&cid=1014
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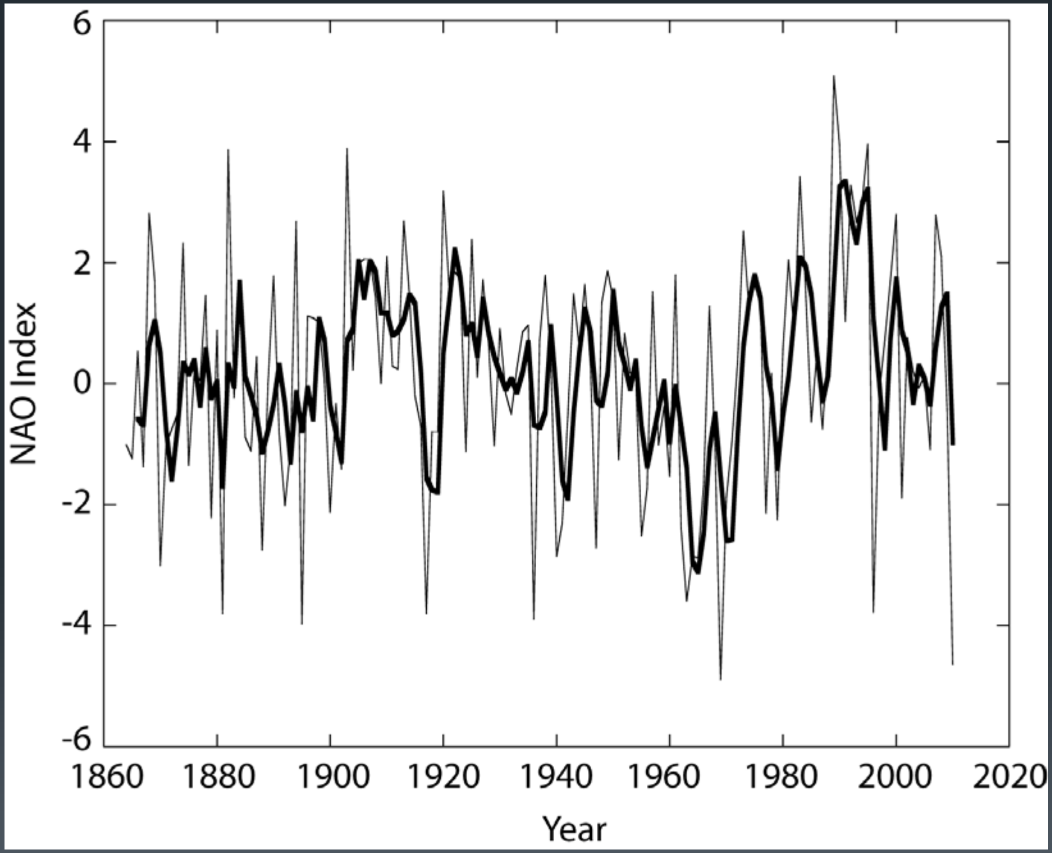
The NAO

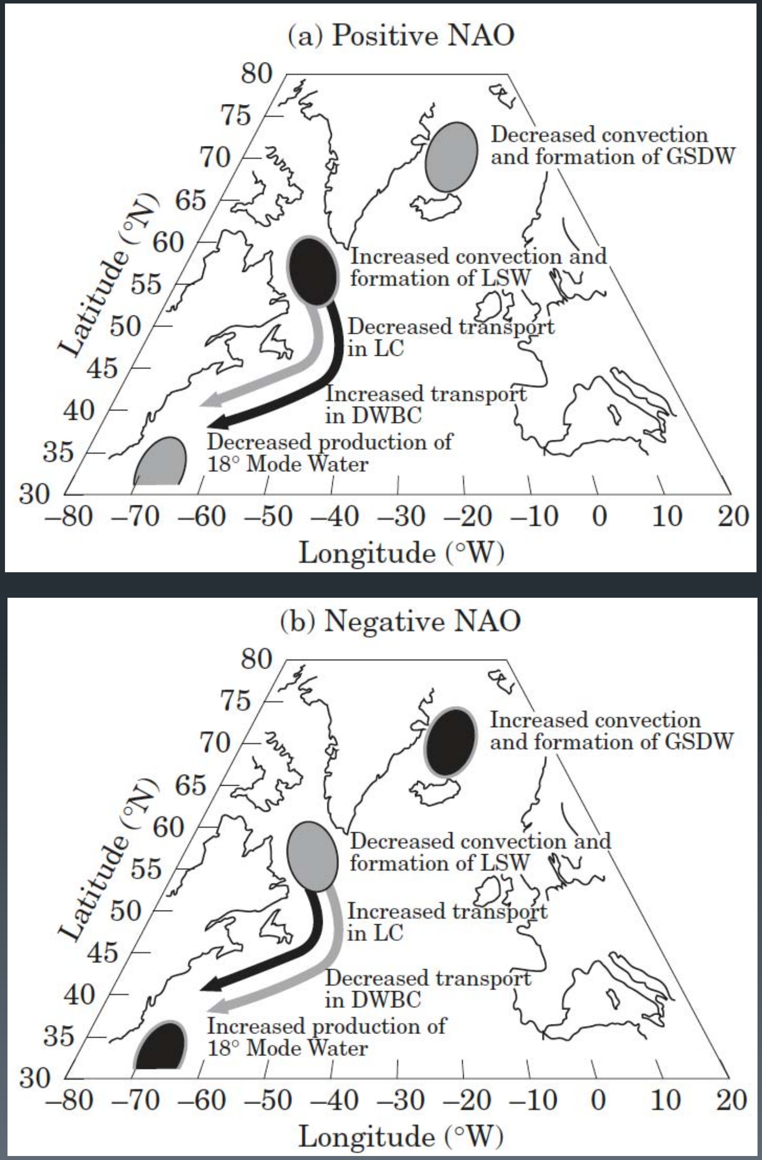
- **Advantages** as a forcing function
  - Works on larger (basin) spatial scales
  - Works on longer (decadal) temporal scales
- **Disadvantages** as a forcing function
  - Phenomena on smaller spatial and temporal scales do not correlate well with NAO
  - Winter only



The NAO and *C. finmarchicus*

Value	Location	Lag (y)	Mechanism	Reference
+	Gulf of Maine	4	SST, advection	Conversi et al. 2001
+	Northwest Atlantic basin	4	Advection	Greene et al. 2003
+[1]	Gulf of Maine	3	Advection	Piontkovski et al. 2006
-	Eastern Scotian Shelf	2	Temperature effect	Head and Sameoto 2007

1. Total copepod index

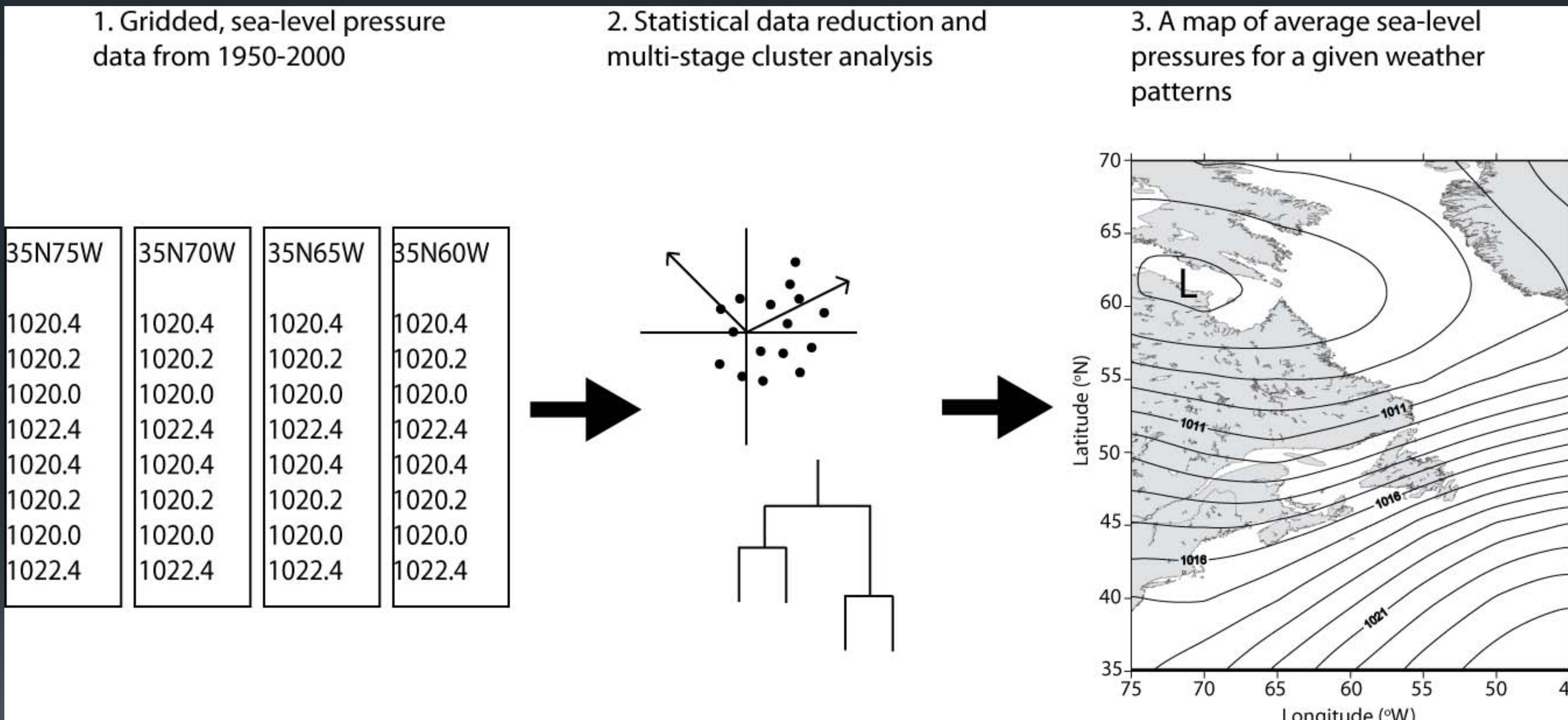


Greene and Pershing 2000

Research question

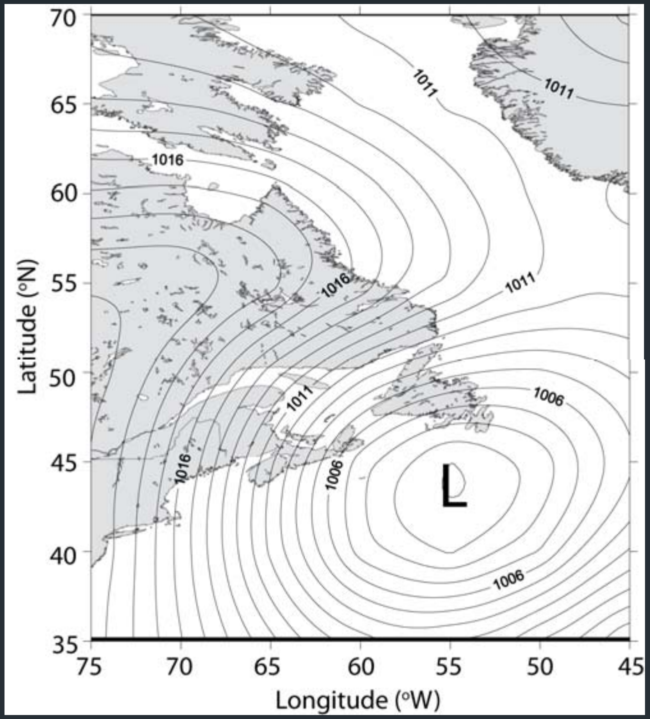
- Can we classify climate variability over shorter time scales?
- Can we relate these classifications to surface conditions?
- Can we relate classified climate and surface condition variability to *C. finmarchicus* abundance?

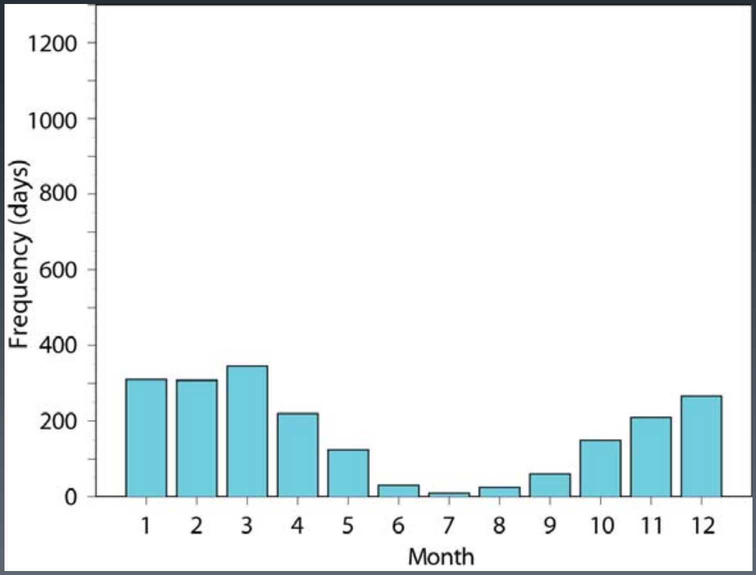
Synoptic climatology



Weather patterns

- Classified daily climate patterns over 1950-2009
- Identified 7 distinct weather patterns
- Weather patterns show seasonal variability

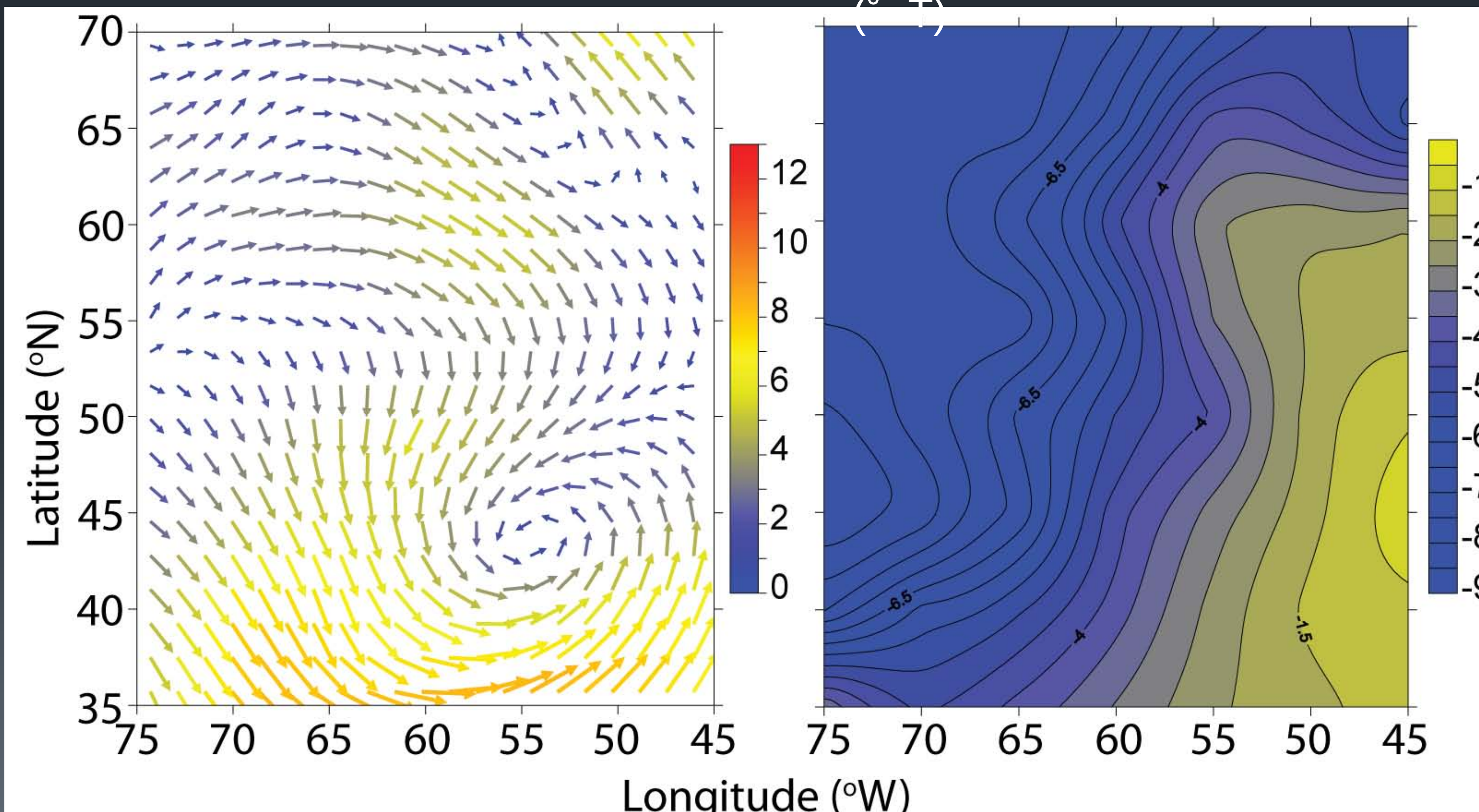




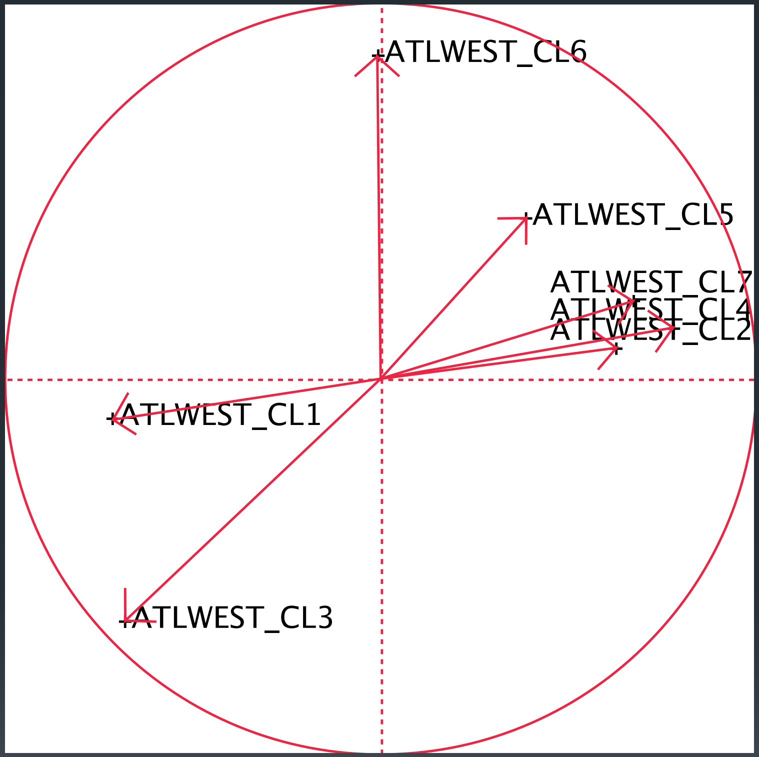
Weather patterns and surface conditions

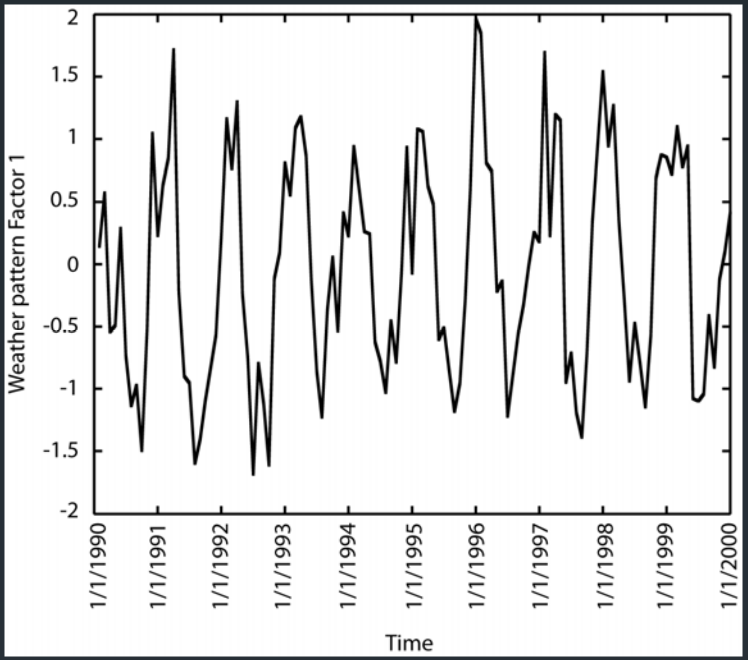
Average wind speed m s^{-1}

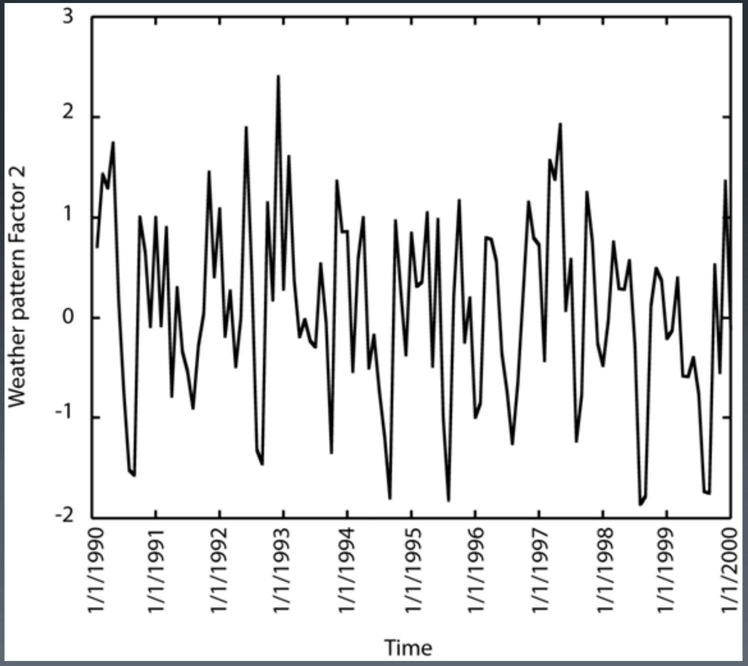
Air temperature anomaly (° T)



Creating a weather pattern index





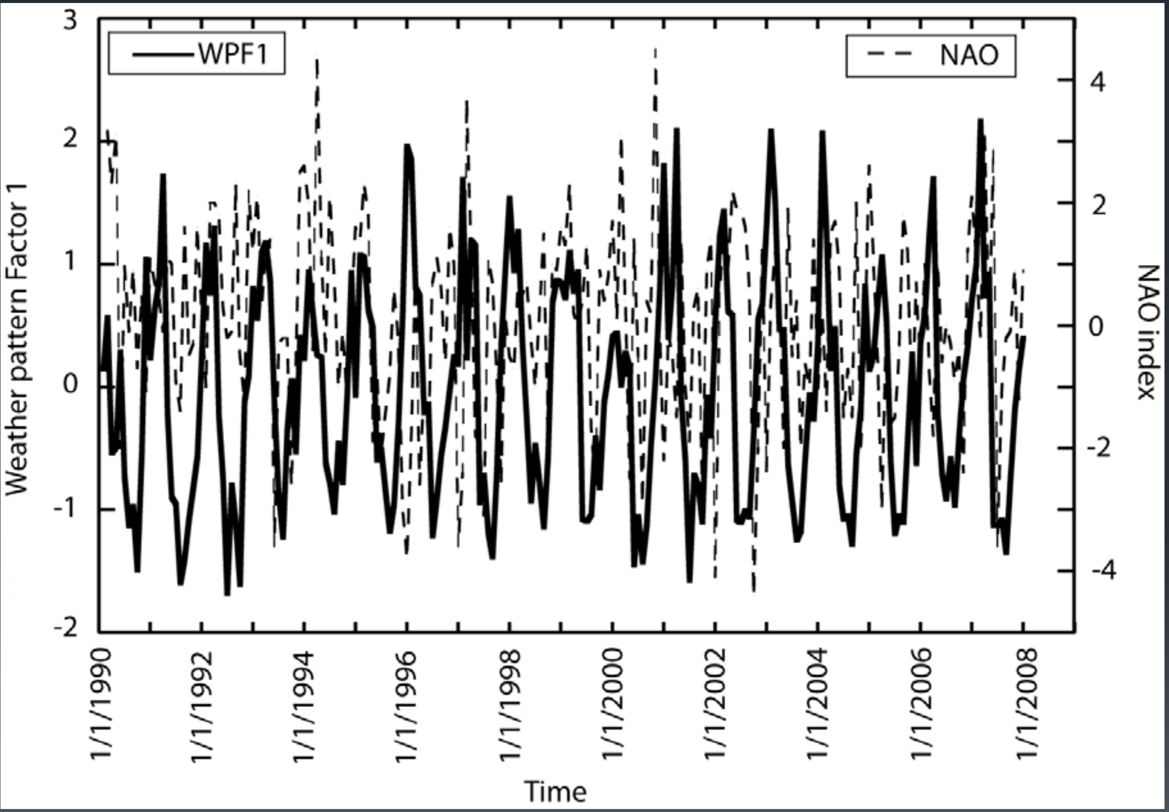


Weather pattern index is **+** : lower T, more storm driven

Weather pattern index is **-** : higher T, less storm driven

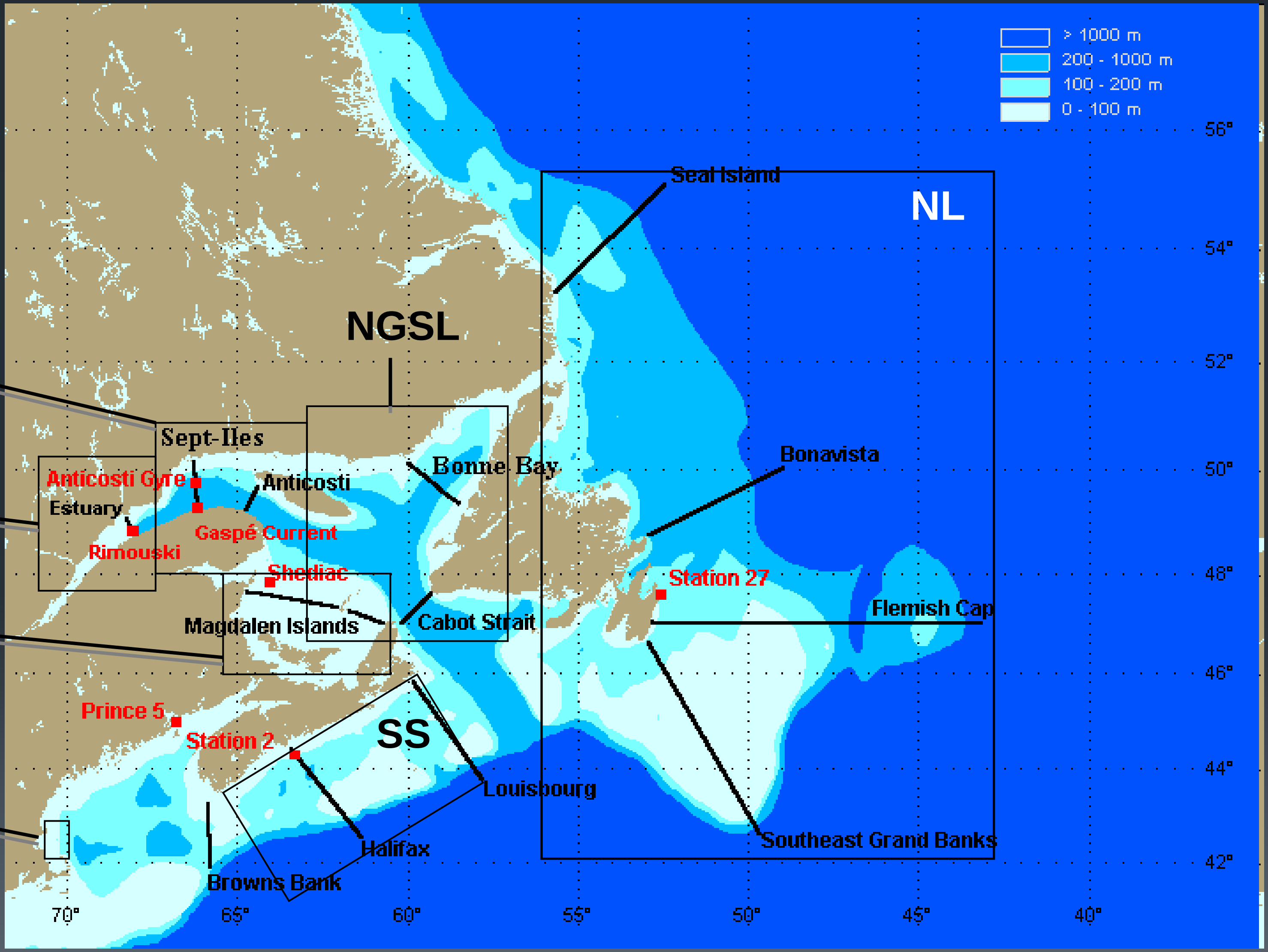
Weather pattern index and the NAO

- No relationship at any lag
- $R^2 = 0.01$



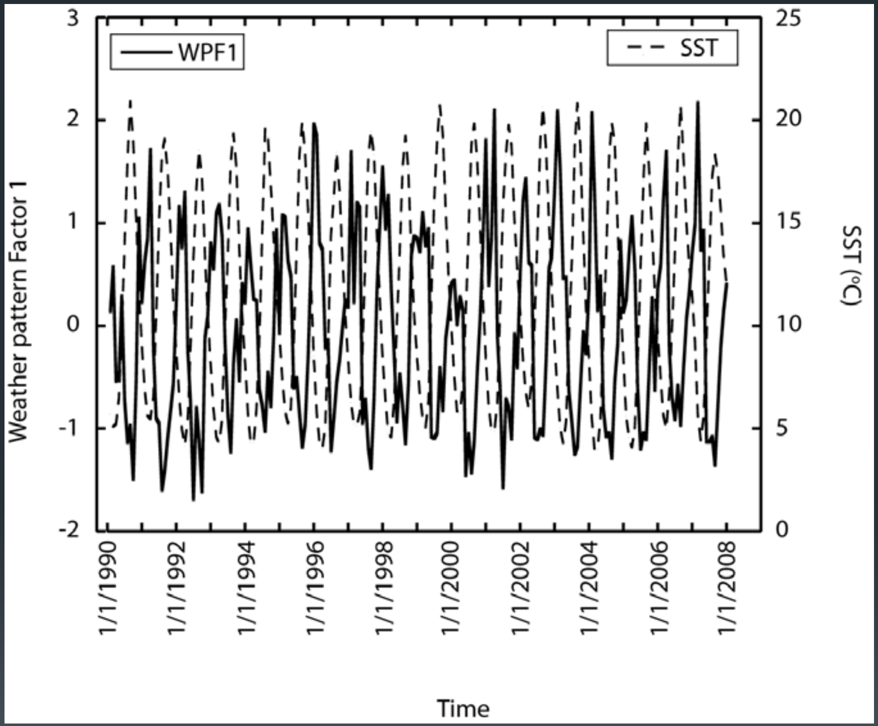
Downscaling to oceanographic conditions

NWGSL
LSLE
SWGSL
GOM coastal station



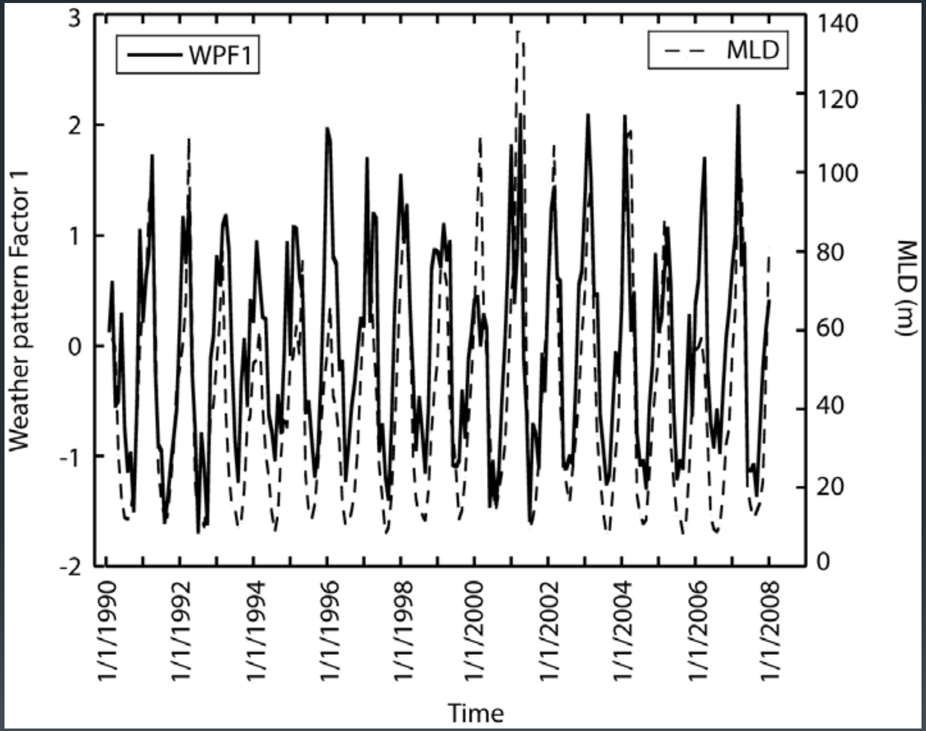
Downscaling to oceanographic conditions, Gulf of Maine

Sea Surface Temperature



Cross-correlation = r^2=0.63
Correlation is negative; 1 month lag

Mixed layer depth

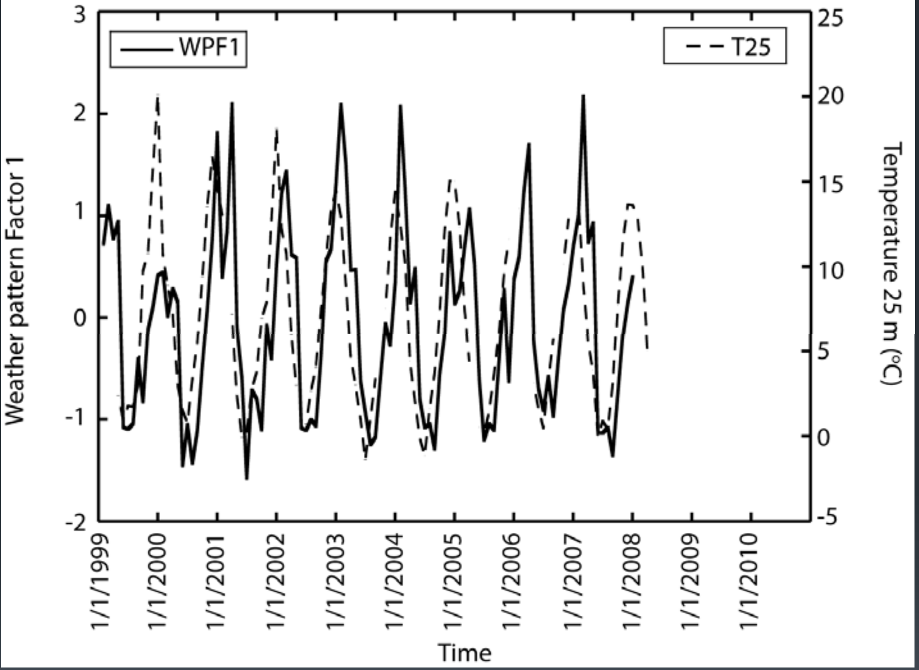


Cross-correlation = r^2=0.55
Correlation is positive

Colder patterns are negatively correlated to SST, at one month lag and positively correlated to MLD

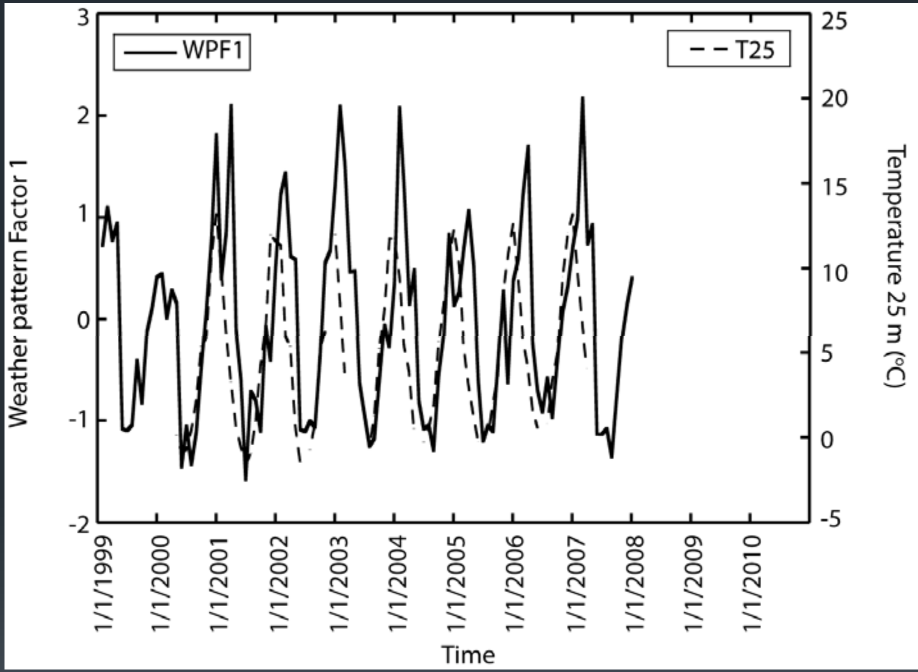
Downscaling to oceanographic conditions, Scotian Shelf, Newfoundland

Temperature (25 m)



Cross-correlation = r^2=0.43
Correlation is positive; 3 month lag

Temperature (25 m)

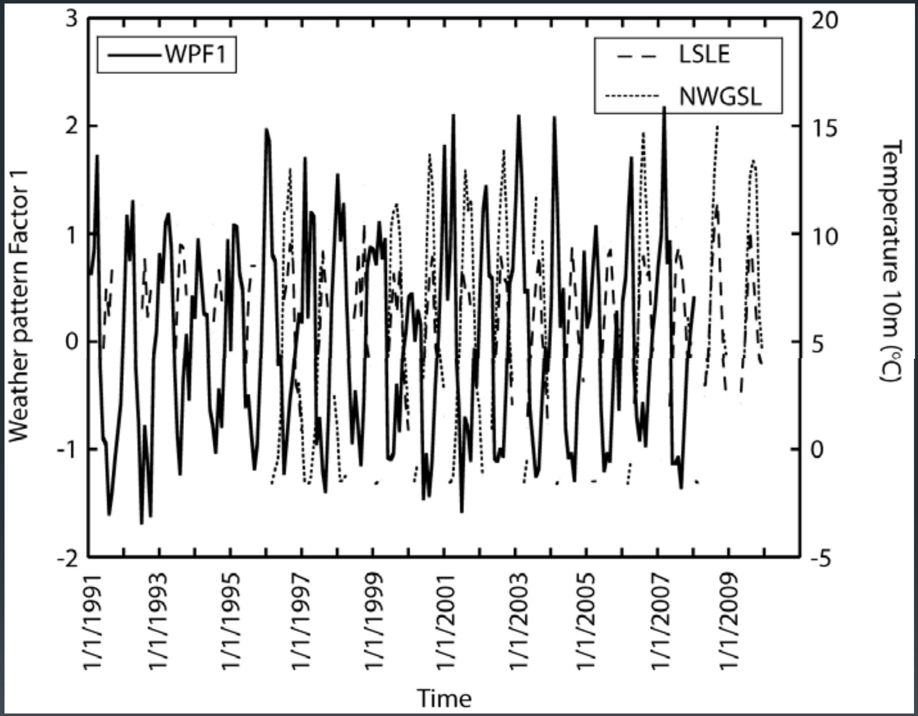


Cross-correlation = r^2=0.38
Correlation is positive; 3 month lag

Colder patterns are positively correlated to 25 m T, at 3 month lag

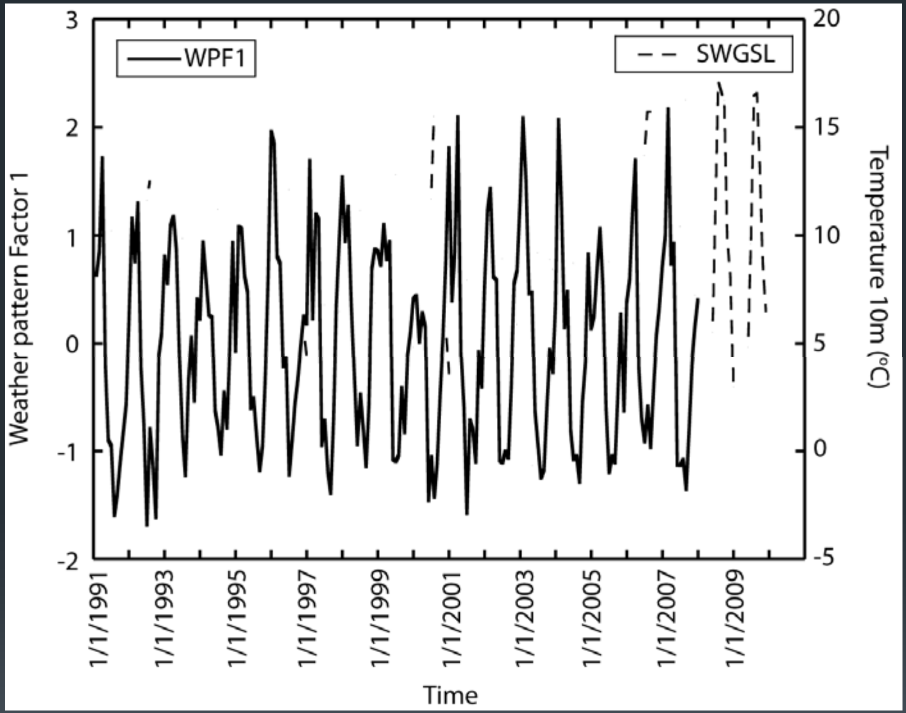
Downscaling to oceanographic conditions, Gulf of St. Lawrence

Temperature (10 m)



Cross-correlation r^2=0.53 (LSLE)
Cross-correlation r^2=0.73 (NWGSL)
Correlation is negative; no lag

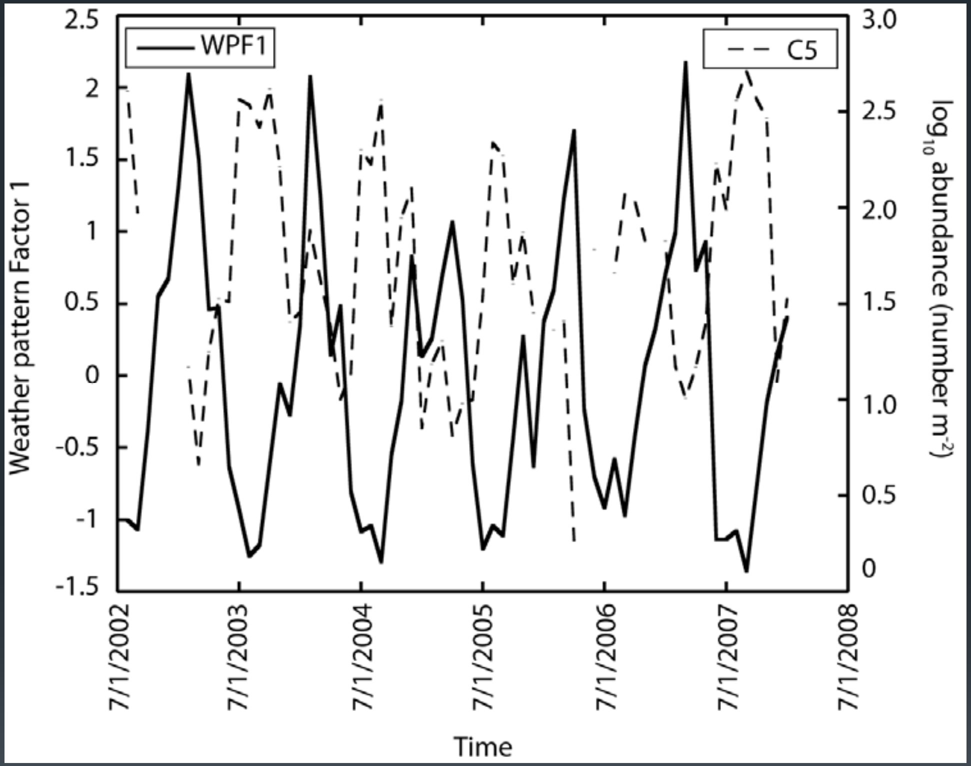
Temperature (10 m)



Cross-correlation r^2=0.67
Correlation is negative; no lag

Colder patterns are negatively correlated to 10 m T, no lag

C. finmarchicus Gulf of Maine



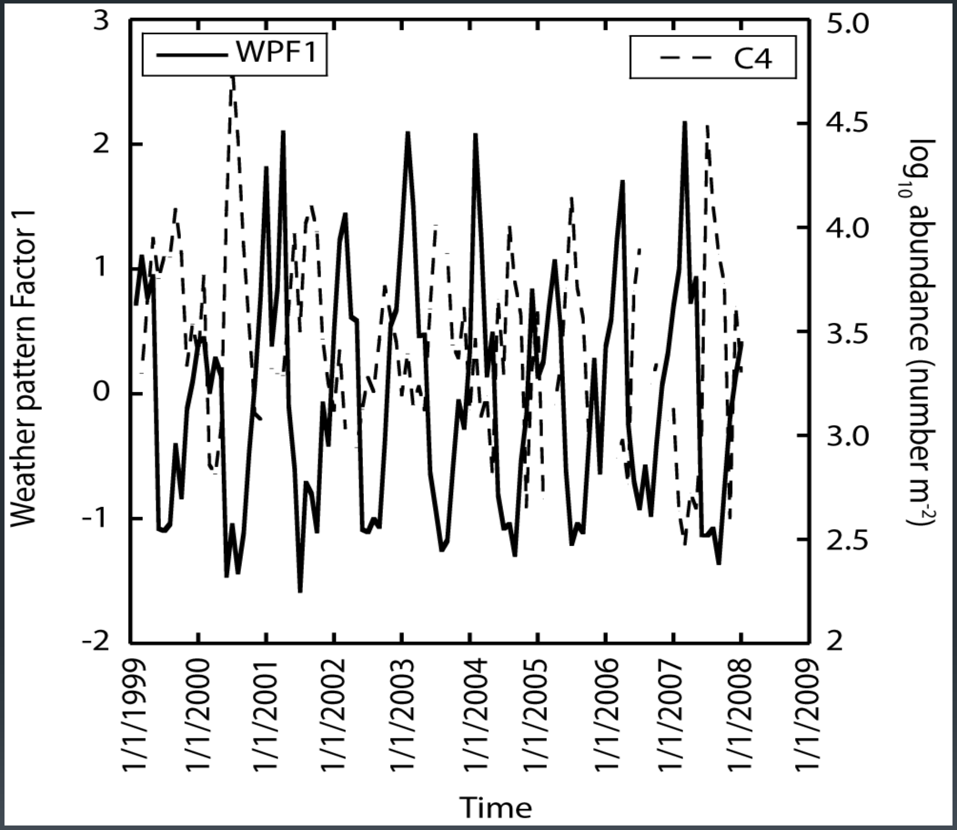
C. finmarchicus C5, no lag
Cross-correlation r^2=0.49
Correlation is ***negative***

Lag (month)

St.	0	1	2	3
C1	0	0.35	0.42	0.28
C2	0.26	0.50	0.45	0.18
C3	0.43	0.54	0.40	0.08
C4	0.60	0.47	0.49	0.02
C5	0.49	0.17	0.19	0.19
C6m	0.16	0	0	0.04
C6f	0	0	0.14	0.19

Colder patterns are negatively correlated to *C. finmarchicus*

C. finmarchicus Scotian Shelf



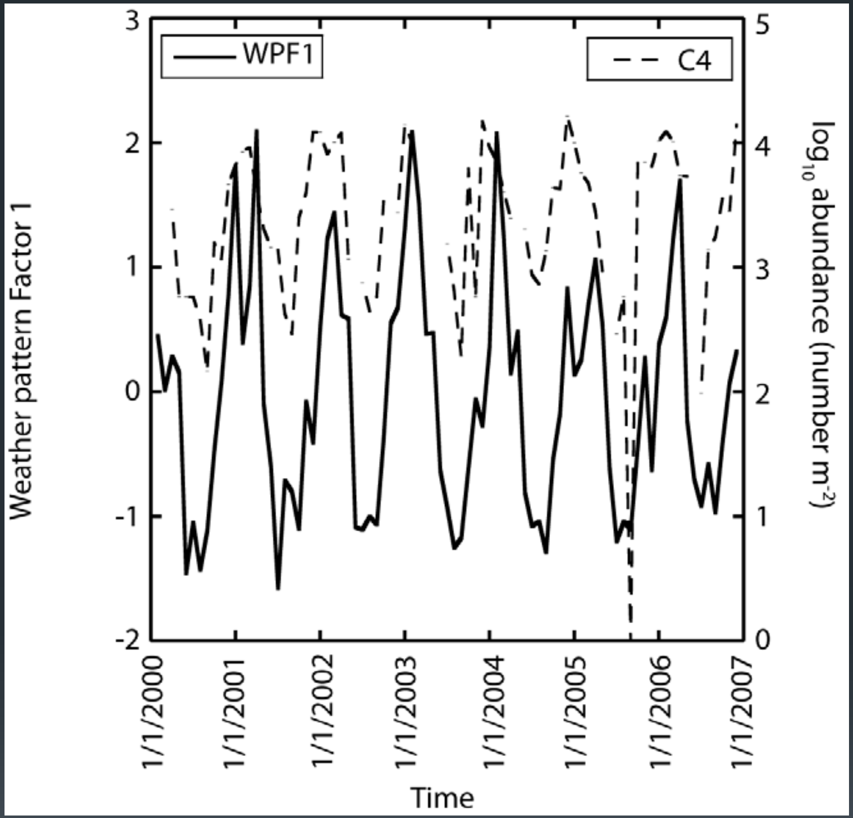
C. finmarchicus C4, 1 month lag
Cross-correlation r^2=0.39
Correlation is ***negative***

Lag (month)

St.	0	1	2	3
C1	0.04	0.38	0.57	0.44
C2	0.11	0.37	0.51	0.32
C3	0.10	0.34	0.43	0.26
C4	0.26	0.39	0.30	0.06
C5	0.23	0	0	0.14
C6m	0	0	0.04	0.05
C6f	0	0	0.11	0.20

Colder patterns are negatively correlated to *C. finmarchicus*, 1 month lag

C. finmarchicus Newfoundland Shelf



C. finmarchicus C5, 2 month lag
Cross-correlation r^2=0.47
Correlation is ***positive***

Lag (month)

St.	0	1	2	3	4
C1	0.35	0.29	0.08	0	0.17
C2	0.28	0.10	0	0.20	0.31
C3	0.23	0.04	0.07	0.34	0.31
C4	0.03	0.07	0.29	0.37	0.25
C5	0.07	0.25	0.47	0.38	0.18
C6m	0.19	0	0	0	
C6f	0	0	0	0.25	

Colder patterns are positively correlated to *C. finmarchicus*, 2 month lag

C. finmarchicus NW Gulf of St. Lawrence and SW Gulf of St. Lawrence estuary

Lag (month)

St.	0	1	2	3
C1	0.39	0.29	0	0
C2	0.33	0.18	0	0
C3	0.21	0.10	0	0.10
C4	0	0.10	0.17	0.10
C5	0.18	0.27	0.25	0.13
C6m	0	0	0.10	0.20
C6f	0	0.23	0.35	0.36

NWGSL

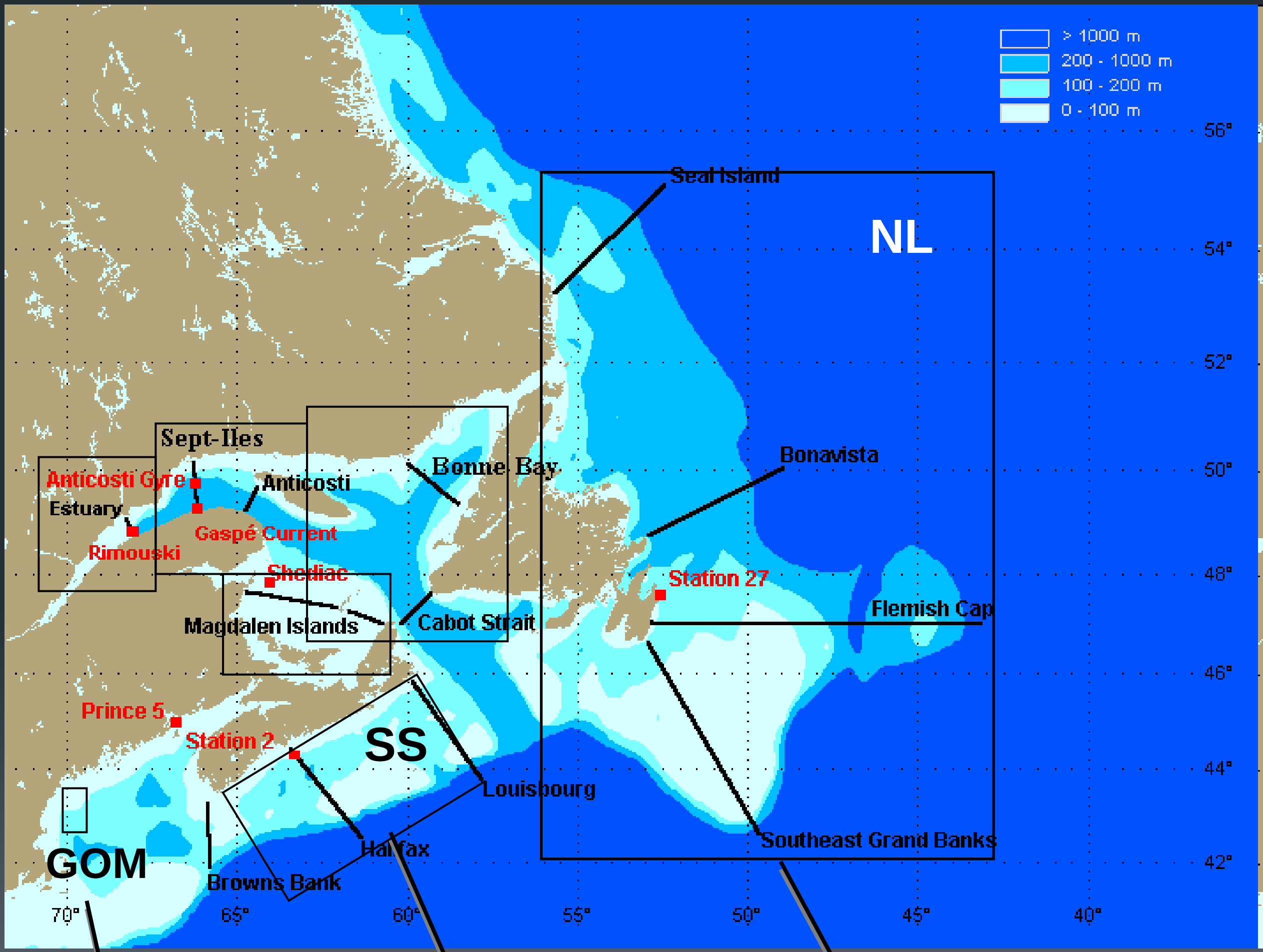
Lag (month)

St.	0	1	2	3
C1	0.10	0	0.13	0.27
C2	0.10	0	0.16	0.31
C3	0.19	0.07	0	0
C4	0.08	0	0	0
C5	0	0	0	0
C6m	0	0	0	0
C6f	0.10	0	0	0

SWGSL

Oceanic stations

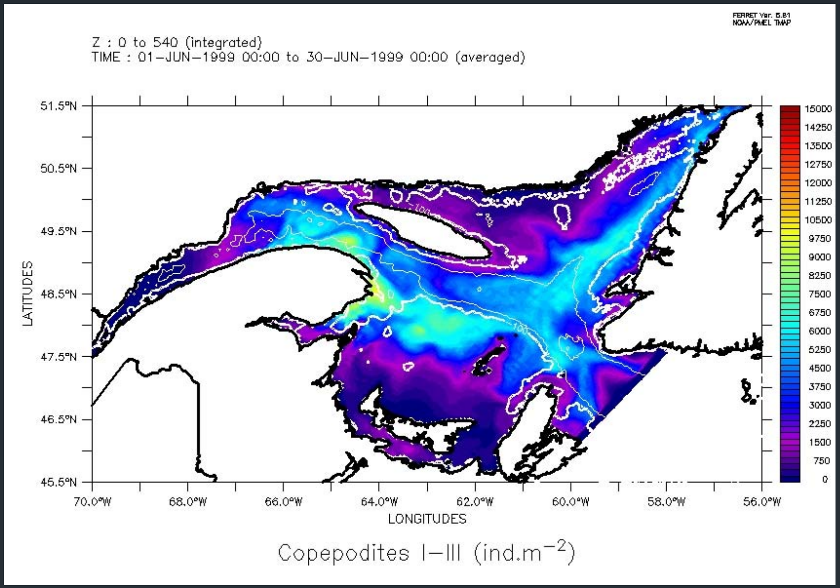
- Driven primarily by atmospheric-oceanic interaction
- *C. finmarchicus* 4-5 abundance is correlated to weather pattern variability in the oceanic stations with increasing time lag for more northern stations

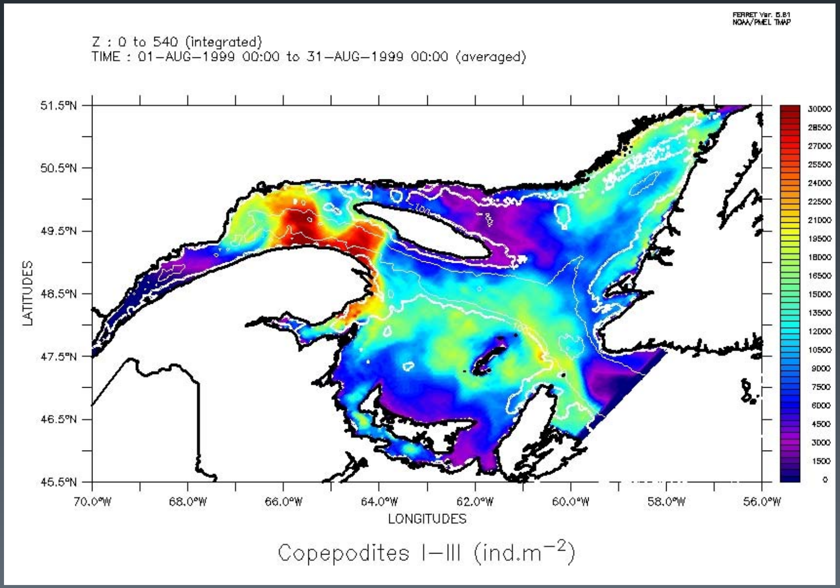


0-1 month lag 1-2 month lag 2-3 month lag

Gulf of St. Lawrence stations

- *C. finmarchicus* abundance changes are not related to weather pattern variability within the Gulf of St. Lawrence
- Most likely mechanism for changes in *C. finmarchicus* abudances are local biological interactions





Conclusions

- Synoptic climatology approach successfully classifies short-term climate variability
  - The NAO shows no relationship to oceanic surface conditions or *C. finmarchicus* dynamics on a monthly time scale

- Weather pattern variability correlates to SST and MLD in both the oceanic stations (GOM, SS, NL) and SST within the Gulf of St. Lawrence
  - May allow short-term predictions of surface conditions

- Short-term *C. finmarchicus* abundance changes are linked to weather variability in oceanic stations and likely driven by local dynamics in the Gulf of St. Lawrence
  - Synoptic climatologies may be used at even shorter time scales (within season) to explain conditions leading to exit or entry into dormancy