Sixty years of water temperature data from Charleston Harbor

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Sixty years of water temperature data from Charleston Harbor

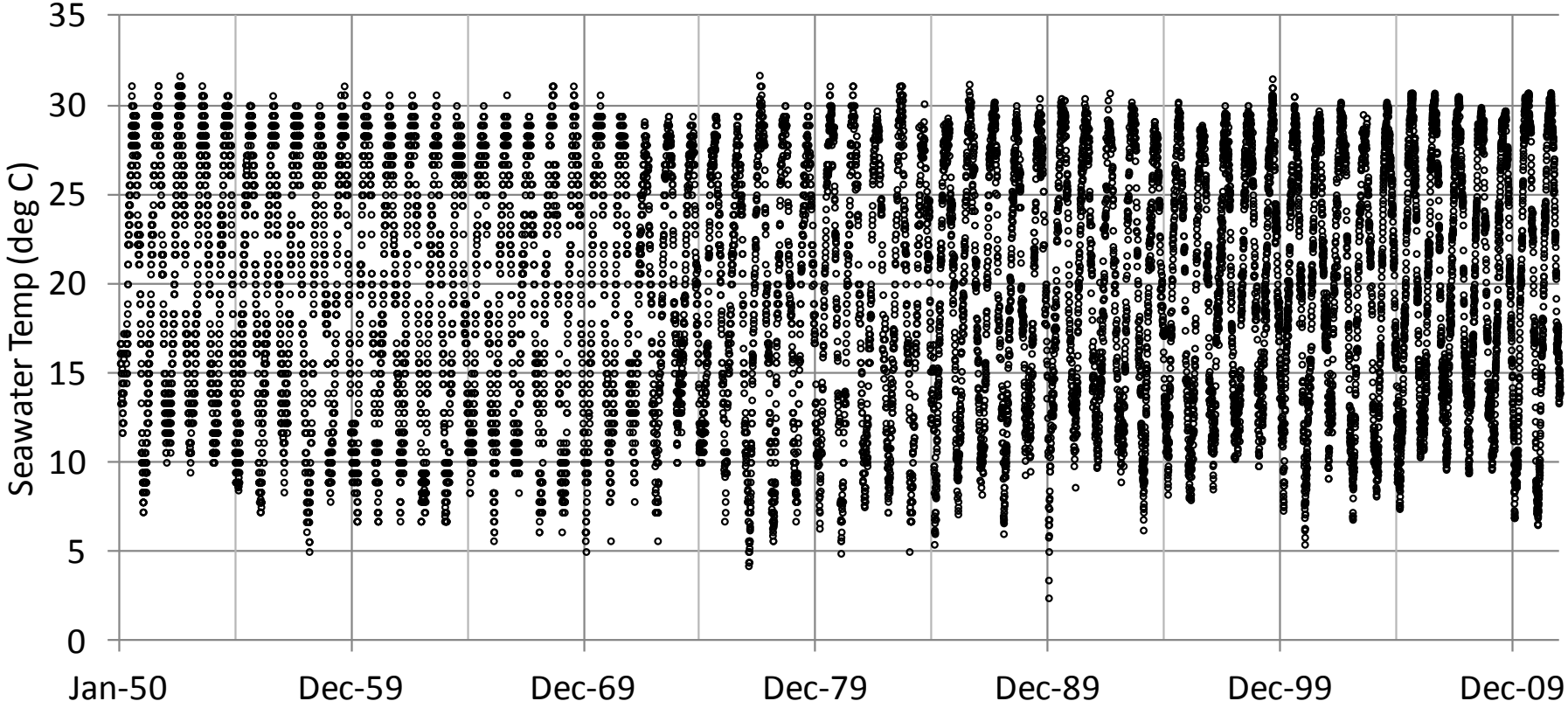
- Daily water temperature records from Charleston Harbor since 1950 – dataset compiled by David Whitaker

- What water temperature changes have occurred?

- How does Charleston Harbor water temperature relate with other climate-related parameters?

- How does Charleston Harbor water temperature affect estuarine fish populations?

Charleston Harbor Water Temperature
1 Jan 1950 - 31 Dec 2011



1950 – 2011 (62 yrs):	22,645 days
Temperature recordings:	16,741 days
Missing data:	5,904 days

Charleston Harbor Water Temperature
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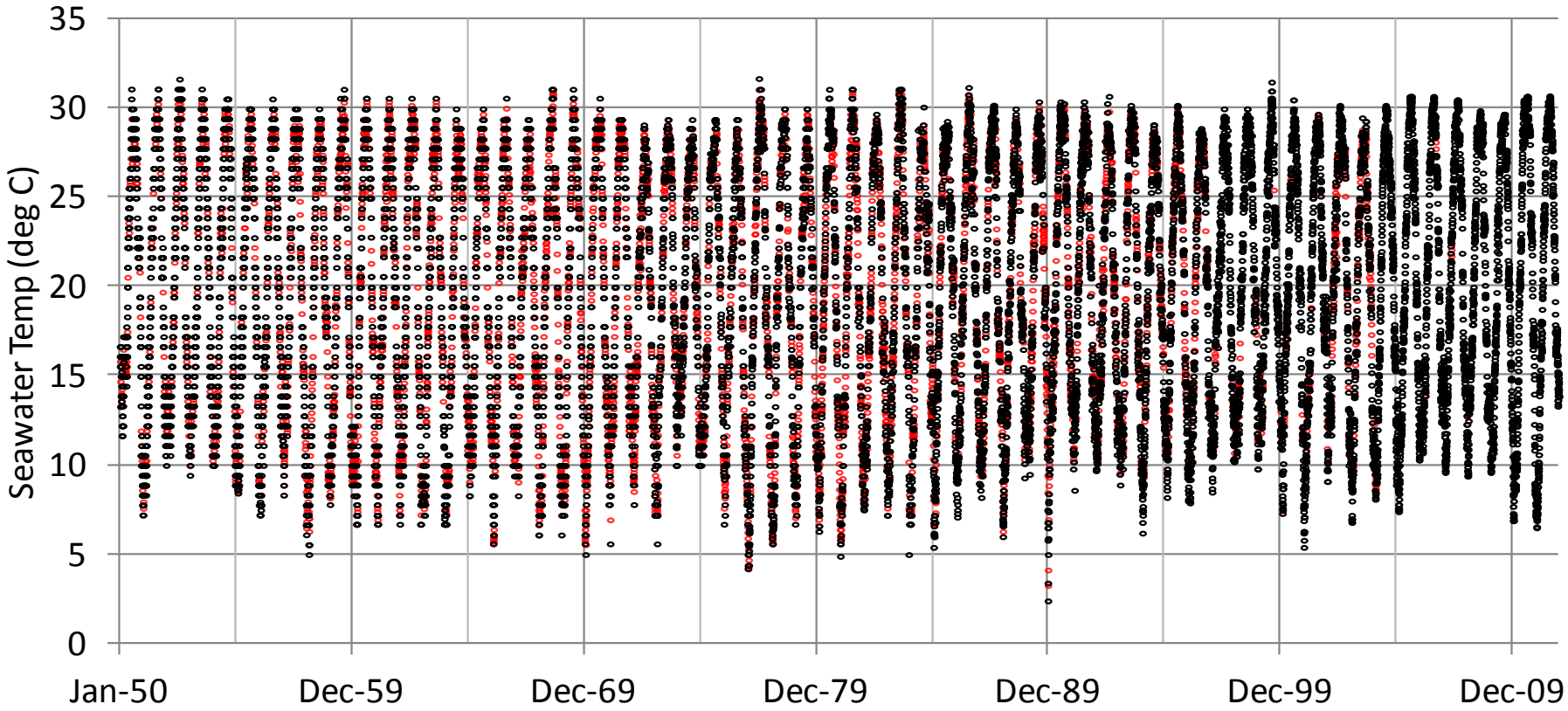
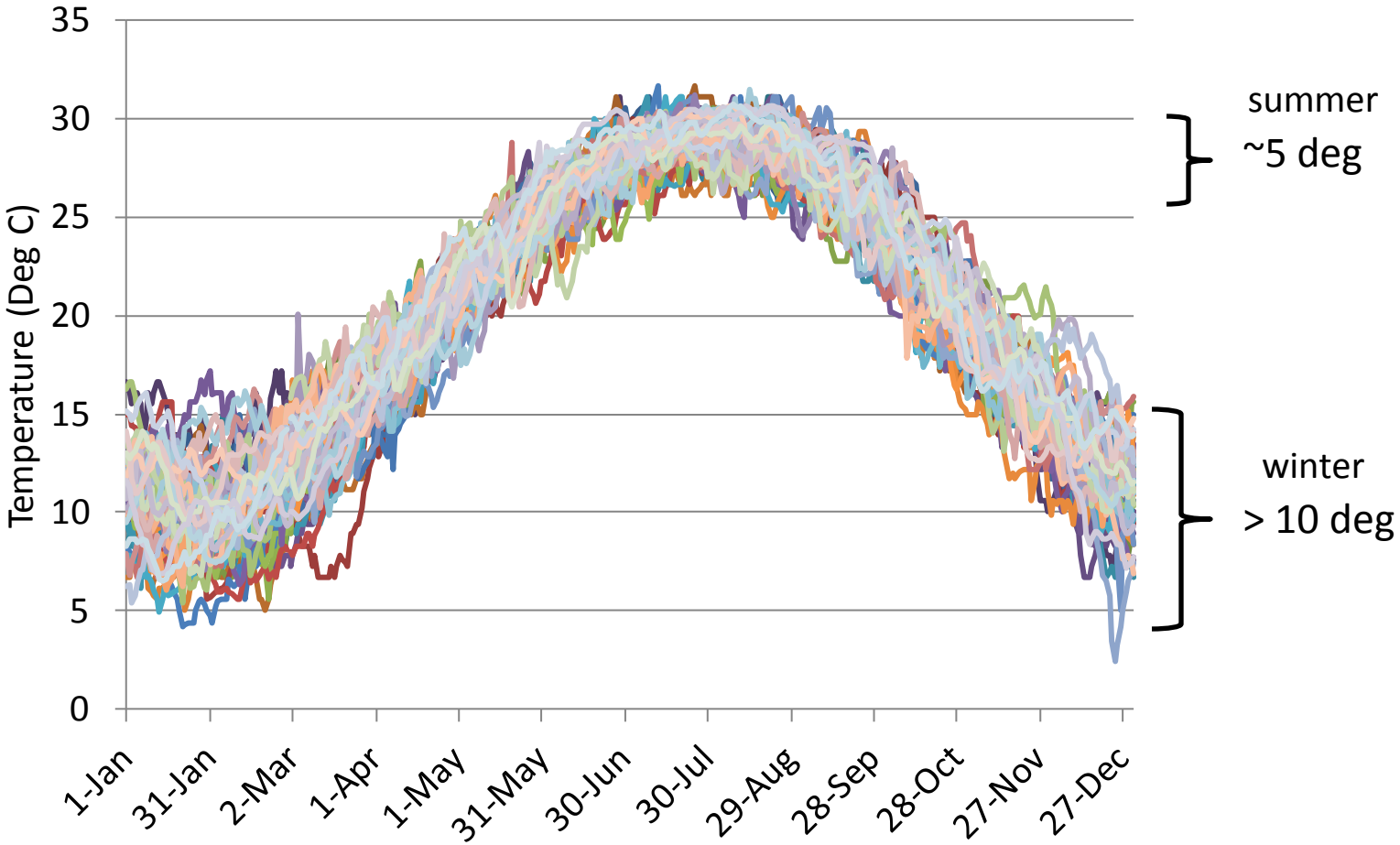
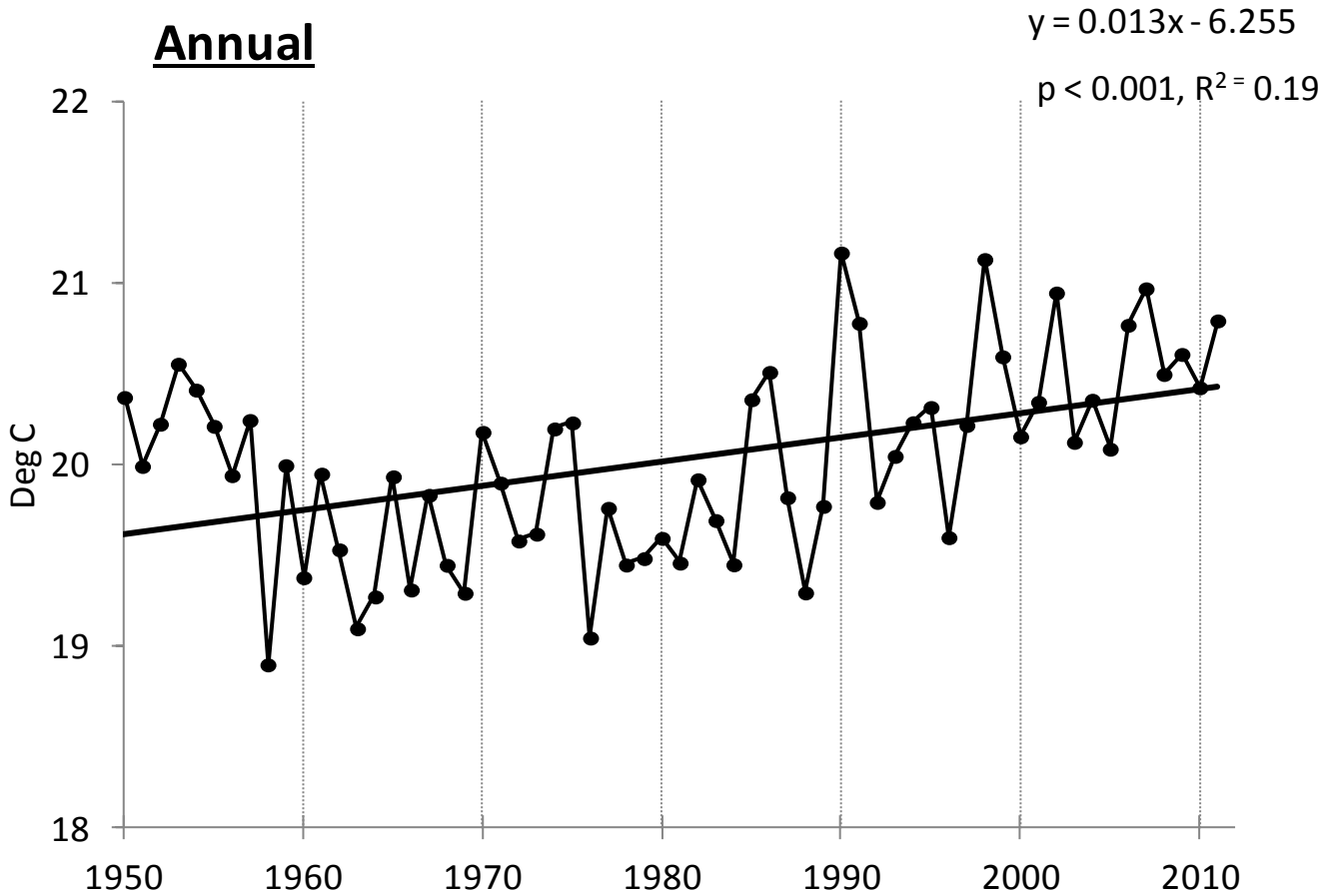


1950 – 2011 (62 yrs):	22,645 days
Temperature recordings:	16,741 days
Interpolated data:	5,904 days

Superimposed Charleston Harbor water temperature data: 1950-2011



Mean annual water temperature



How are these changes associated with global atmospheric and ocean processes?

Atlantic Multidecadal Oscillation (AMO)

- Related to long-term shifts in atmospheric/oceanic heat exchange.

- Associated with small changes in the North Atlantic branch of the thermohaline circulation ('ocean conveyer belt').

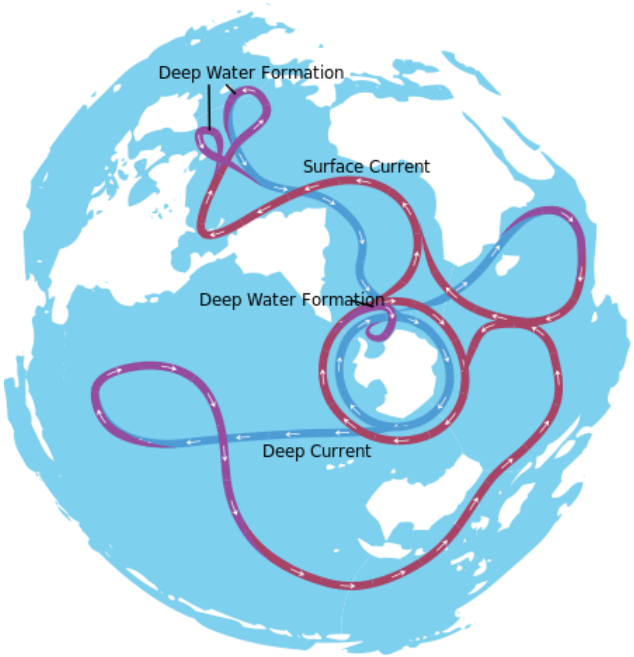
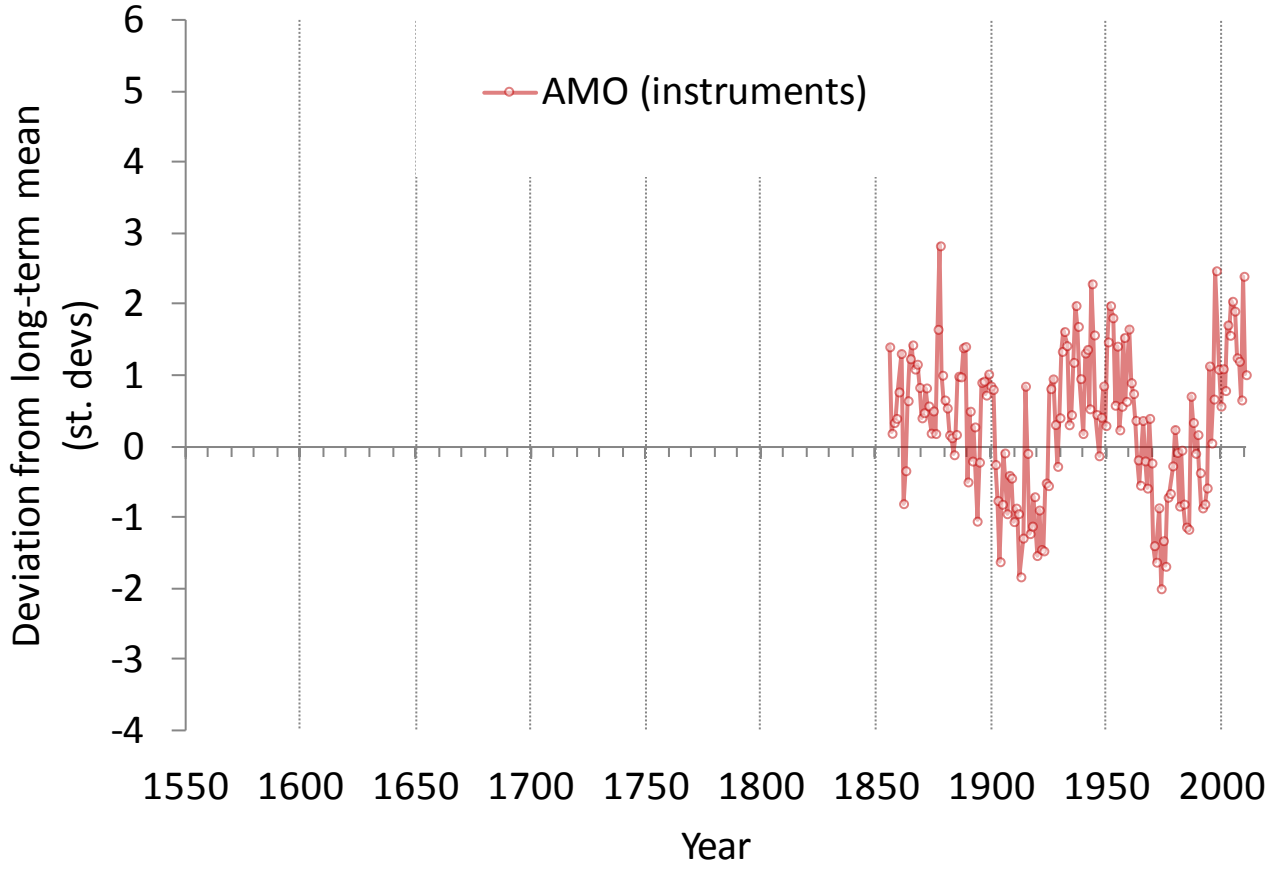


Image : http://en.wikipedia.org/wiki/File:Conveyor_belt.svg

Relationship between water temperature & Atlantic Multidecadal Oscillation (AMO)

(All data standardized to 1950-2011 mean and SD)



AMO, Instruments: Enfield et al 2001. http://www.esrl.noaa.gov/psd/data/timeseries/AMO/

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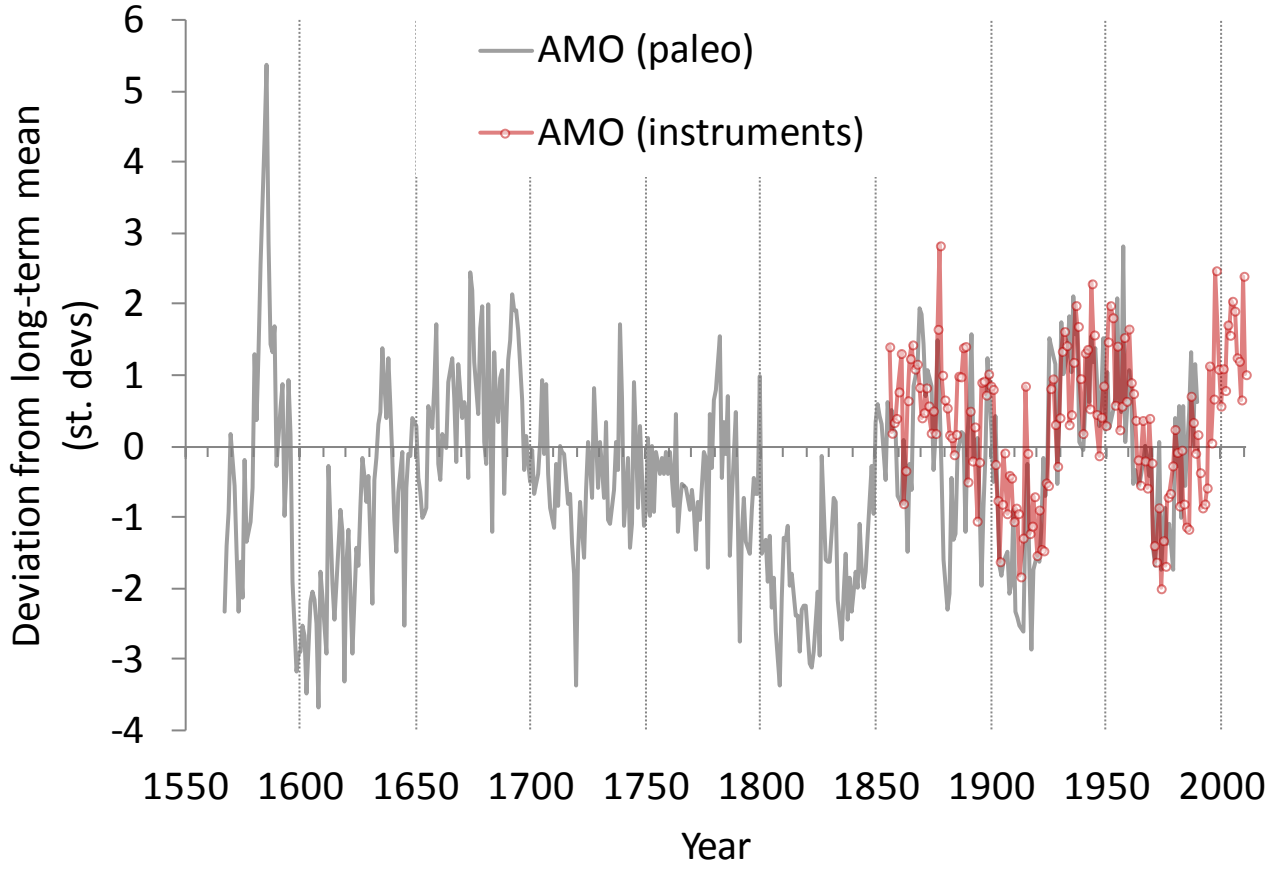

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AMO, Paleoclimatology: Gray et al, 2004 ftp://ftp.ncdc.noaa.gov/pub/data/paleo/treering/reconstructions/amo-gray2004.txt

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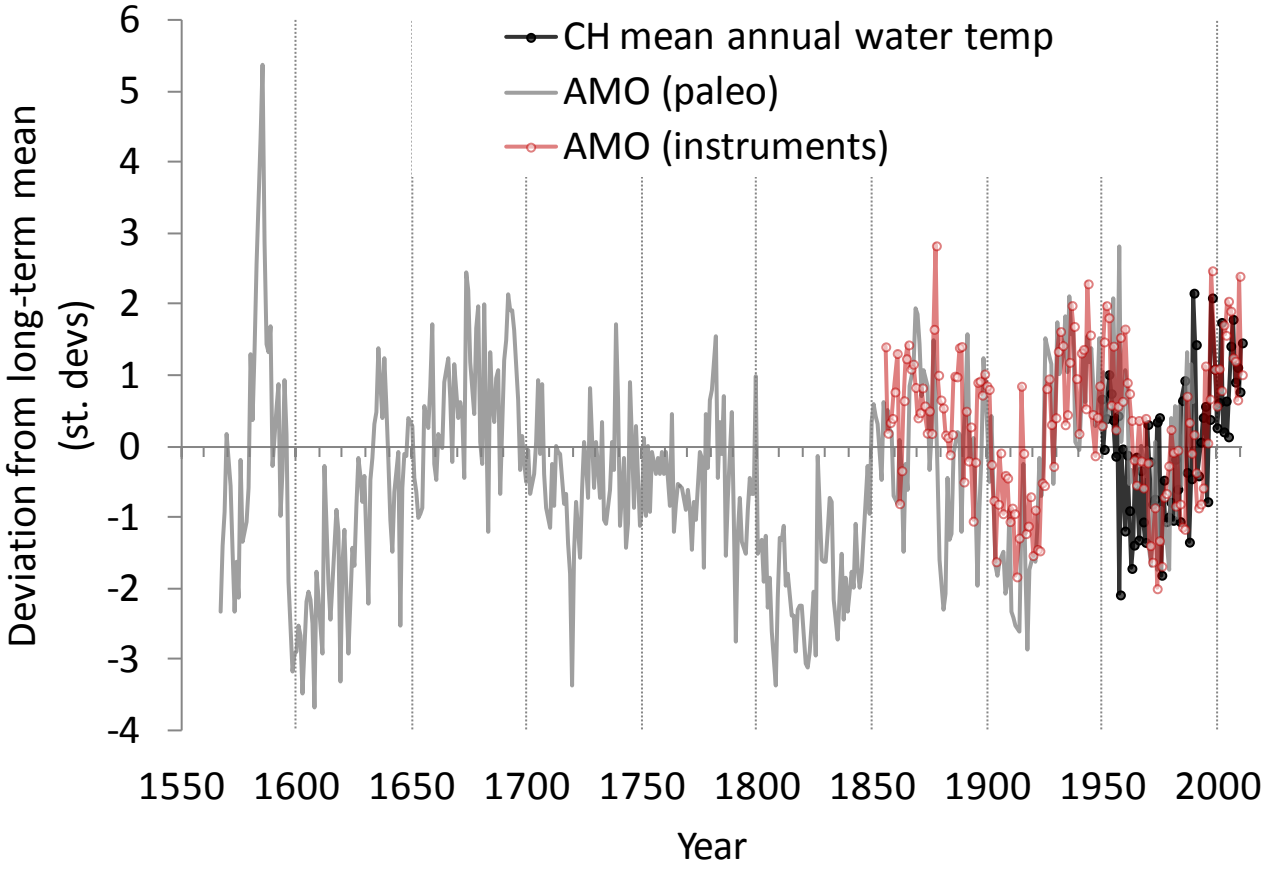

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Relationship between water temperature & Atlantic Multi-decadal Oscillation (AMO)

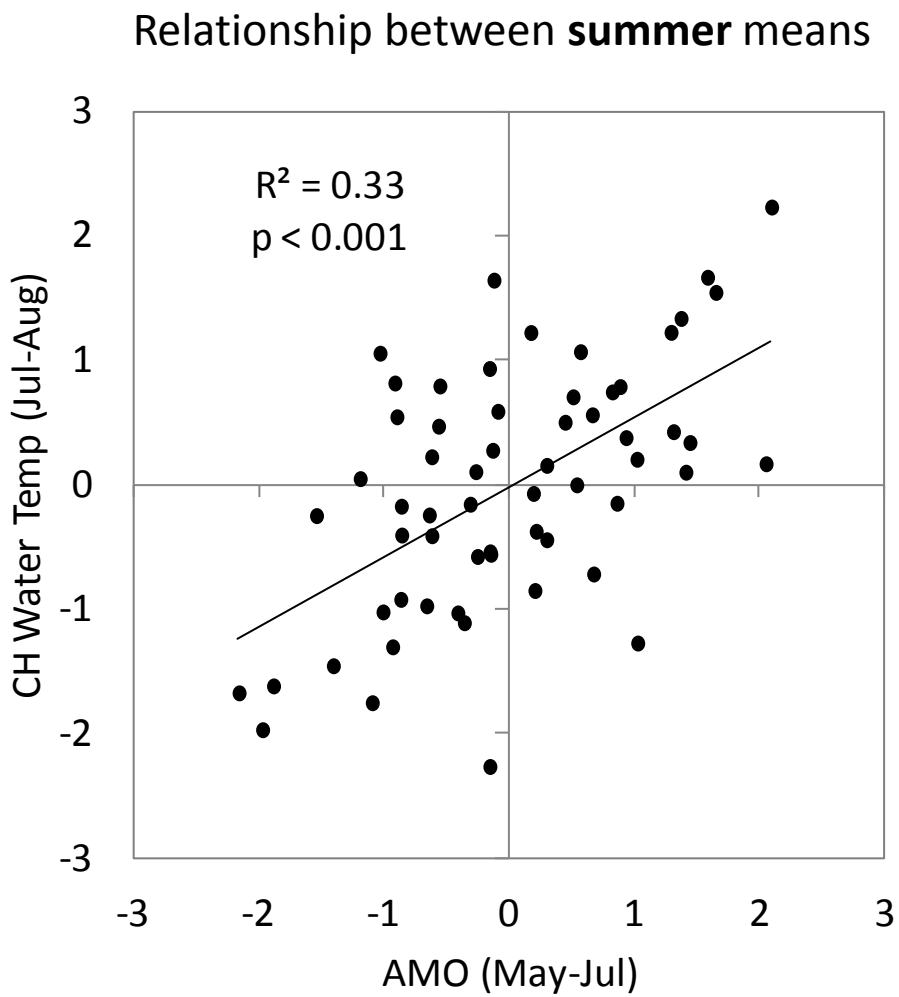
Cross-correlation matrix

Strongest AMO correlations are with summer water temperatures in Charleston Harbor

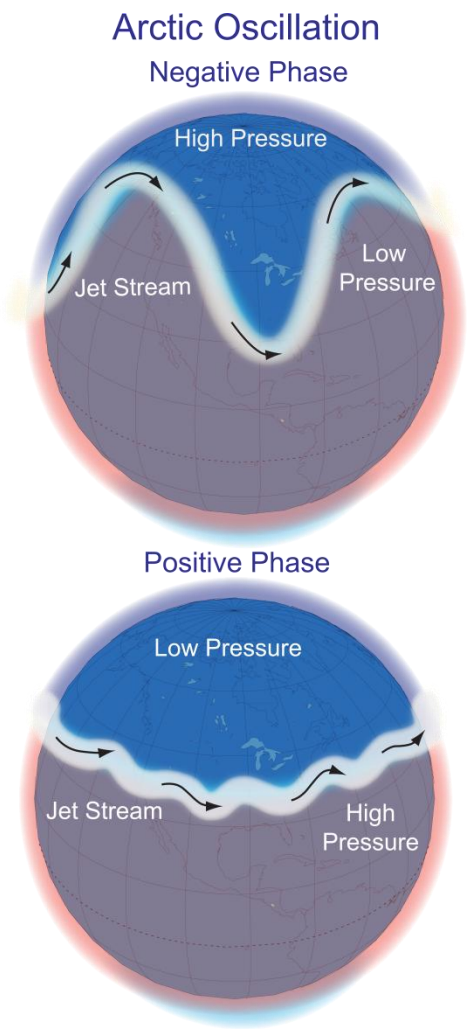
Charleston Harbor water temperature (monthly)	Atlantic Multidecadal Oscillation (monthly)											
	J	F	M	A	M	J	J	A	S	O	N	D
J	0.08	0.06	-0.05	-0.03	0.03	0.15	0.16	0.18	0.14	0.16	0.13	0.07
F	0.13	0.09	-0.01	-0.06	-0.01	0.05	0.08	0.16	0.17	0.12	0.03	0.07
M	-0.01	-0									02	0.00
A	0.18	0									.9	0.09
M	0.20	0.18	0.15	0.14	0.15	0.14	0.13	0.20	0.24	0.18	0.17	0.17
J	0.31	0.34	0.36	0.29	0.37	0.43	0.39	0.41	0.41	0.33	0.33	0.32
J	0.28	0.37	0.44	0.47	0.46	0.46	0.50	0.45	0.47	0.42	0.40	0.41
A	0.34	0.35	0.36	0.43	0.48	0.46	0.46	0.43	0.39	0.41	0.40	0.39
S	0.01	0.03	0.12	0.16	0.22	0.19	0.15	0.17	0.18	0.19	0.19	0.14
O	0.25	0.27	0.16	0.19	0.23	0.17	0.21	0.22	0.24	0.31	0.27	0.19
N	-0.10	-0.05	0.01	-0.03	0.05	0.13	0.10	0.12	0.08	0.12	0.13	0.08
D	-0.06	-0.02	-0.03	-0.03	-0.02	0.01	-0.01	-0.01	0.05	0.03	-0.03	-0.02

Scale (correlation coeff):	-1.00	-0.80	-0.60	-0.40	-0.20	0.00	0.20	0.40	0.60	0.80	1.00

Relationship between water temperature & Atlantic Multi-decadal Oscillation (AMO)



Arctic Oscillation (AO)



- Index of difference between atmospheric pressures: High *versus* Mid-latitudes

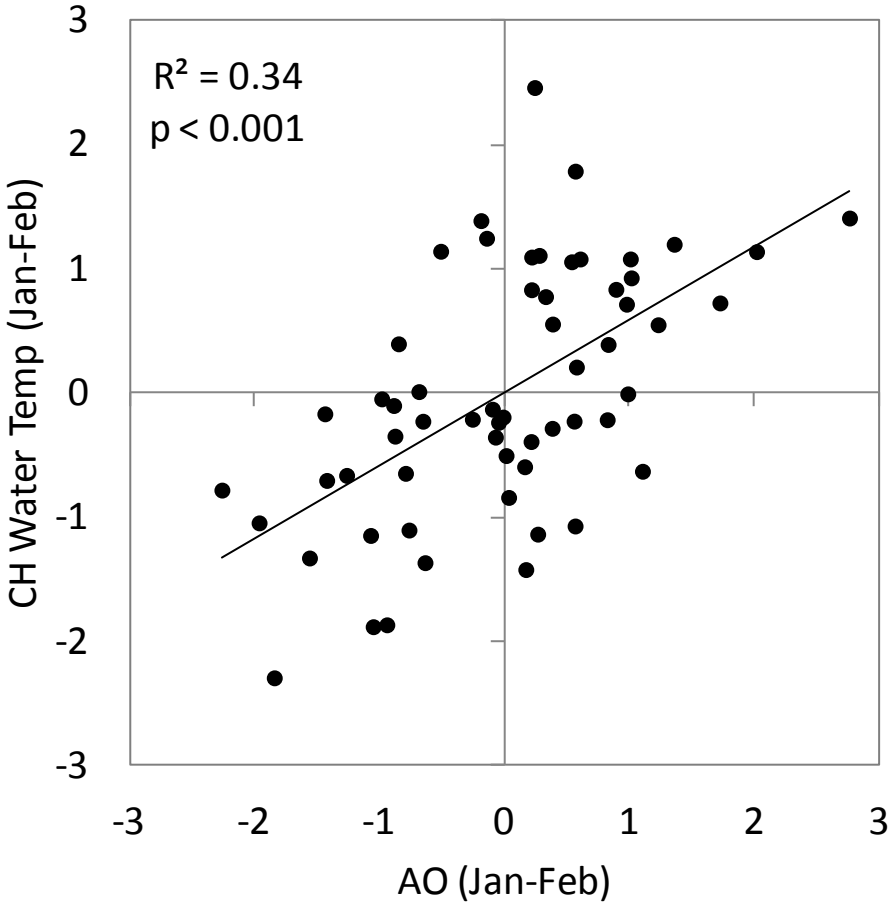
- During episodes of high pressure in the Arctic, cold Arctic air penetrates into mid-latitudes.

- Index is closely related to the North Atlantic Oscillation (Iceland vs Azores pressures differentials)

Image: http://en.wikipedia.org/wiki/File:Arctic_Oscillation.png

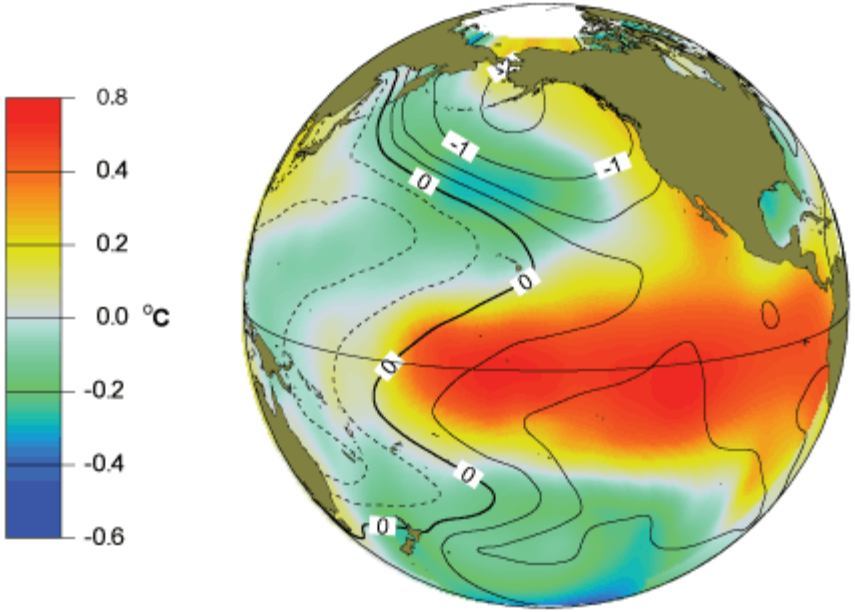
Arctic Oscillation (AO)

Relationship between **winter** AO and **winter** water temperature



(Similar relationship found with North Atlantic Oscillation)

El Niño–Southern Oscillation (ENSO)

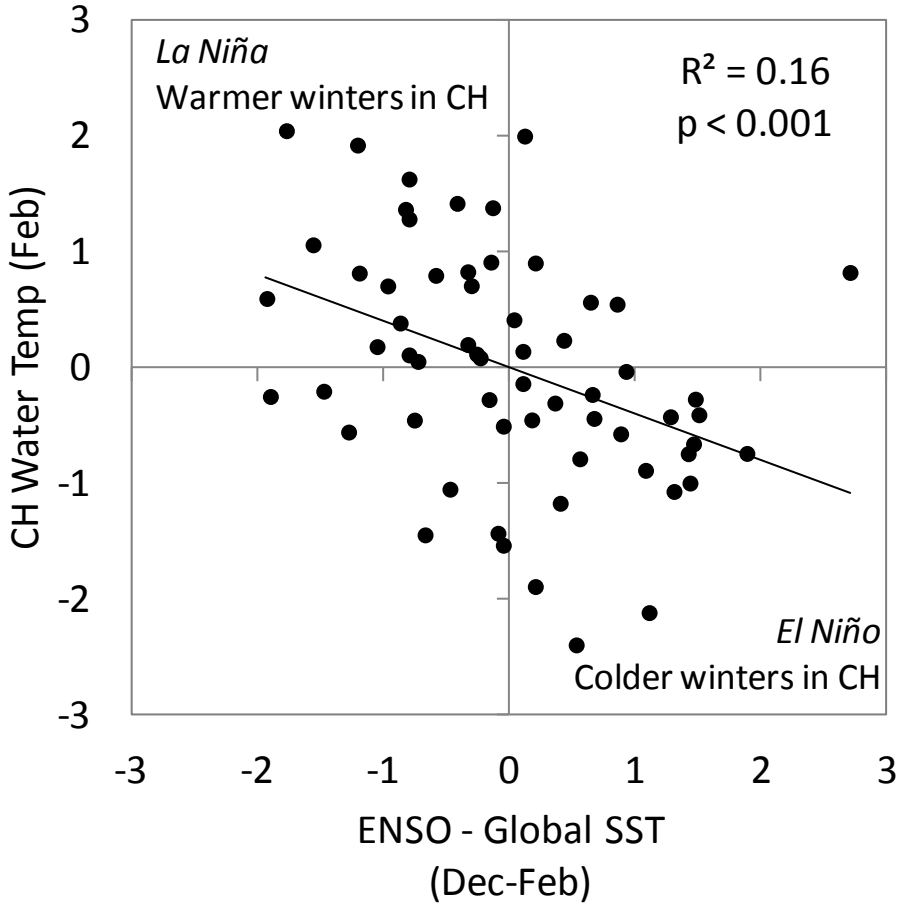


Warm Phase ENSO

Source: Climate Impacts Group, University of Washington
http://cses.washington.edu/cig/pnwc/aboutenso.shtml

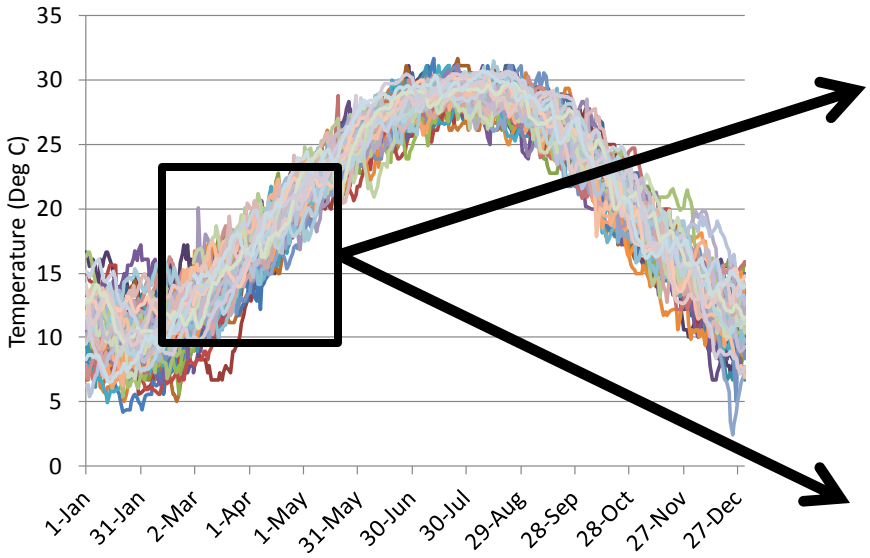
El Niño–Southern Oscillation (ENSO)

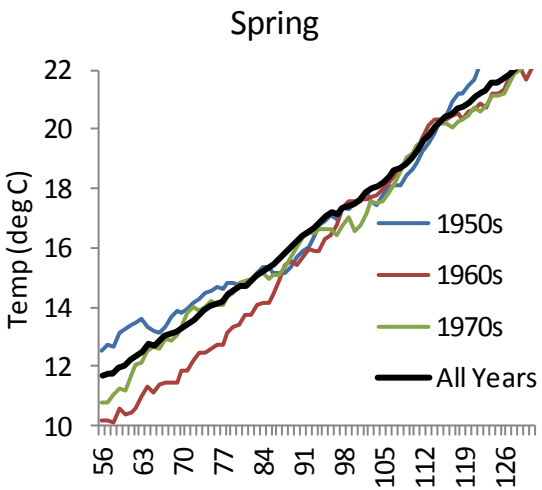
Relationship between winter ENSO and winter water temperature

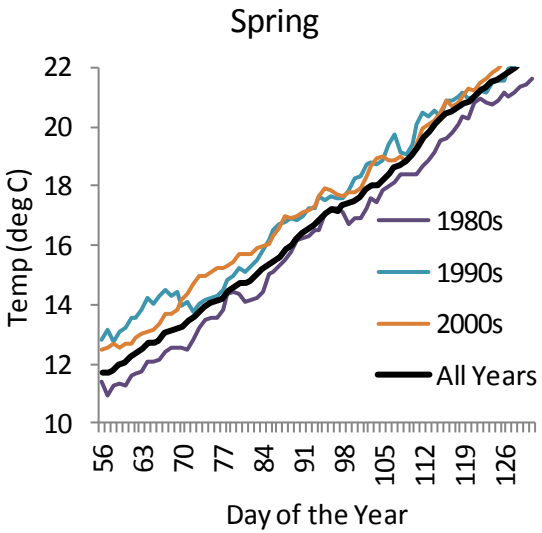


Global-SST ENSO Index data: http://jisao.washington.edu/data/globalsstenso/#digital_values

Timing of Spring Temperature Thresholds

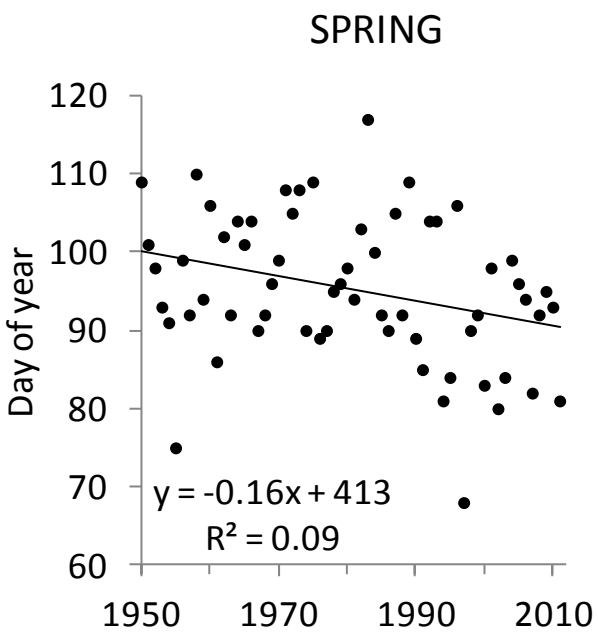




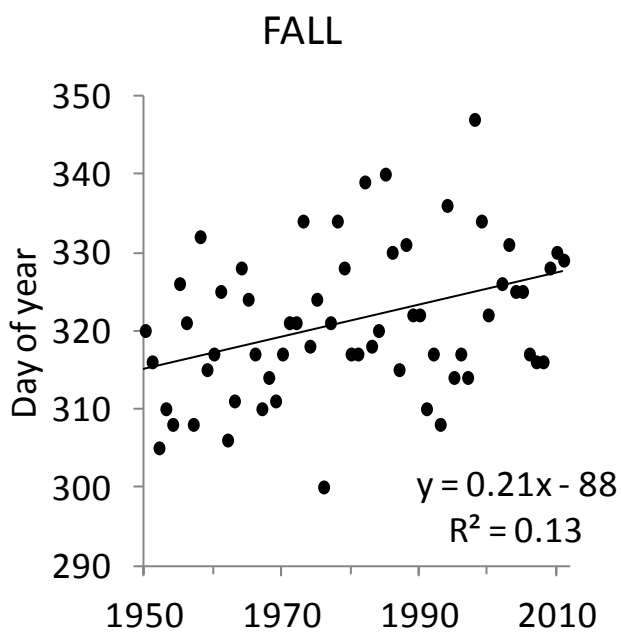


Timing of Spring and Fall Temperature Thresholds

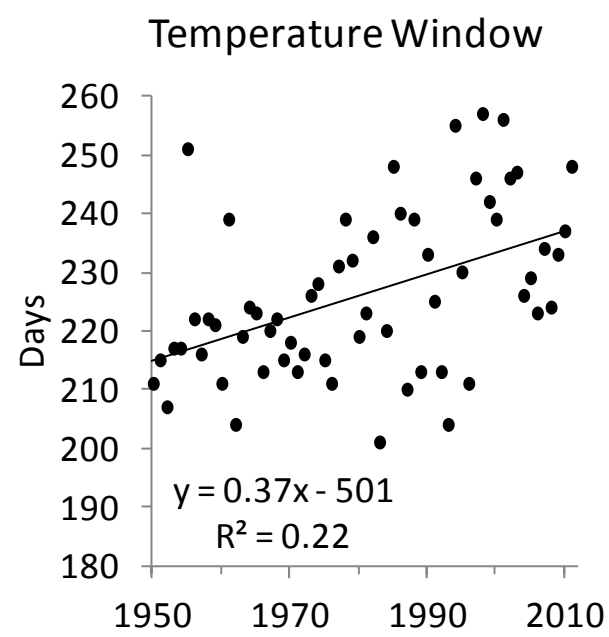
OCCURRENCE OF 17°C TEMPERATURE THRESHOLD



P = 0.015

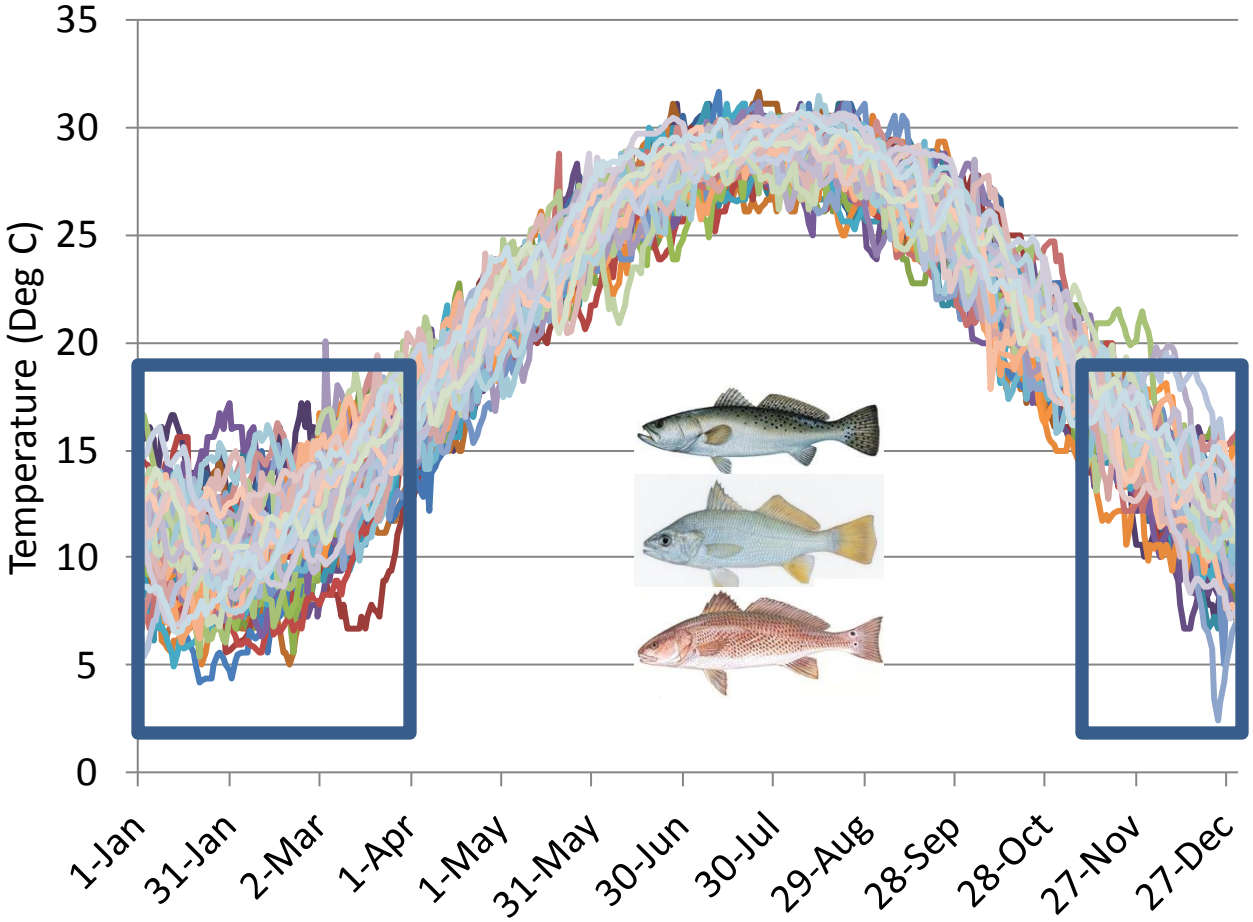


P = 0.004



P < 0.001

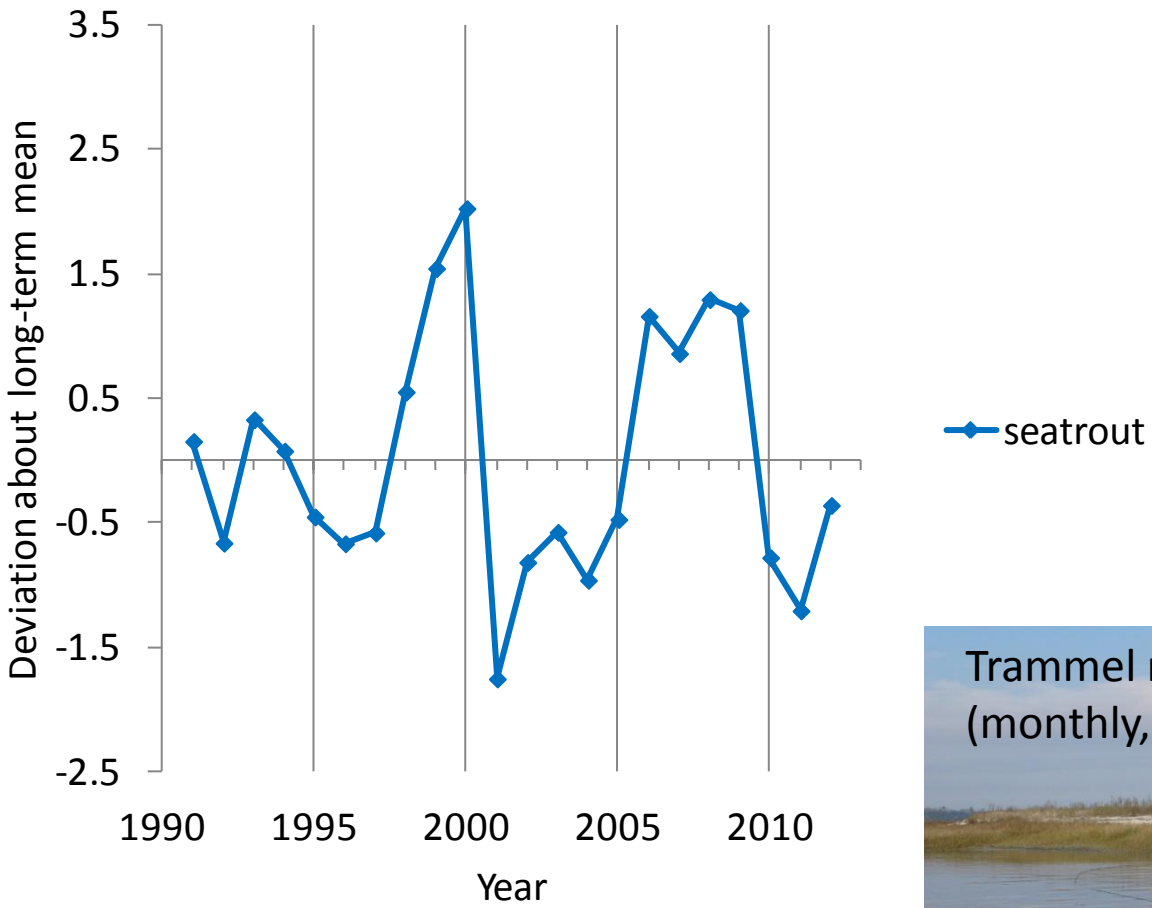
Superimposed Charleston Harbor water temperature data: 1950-2011



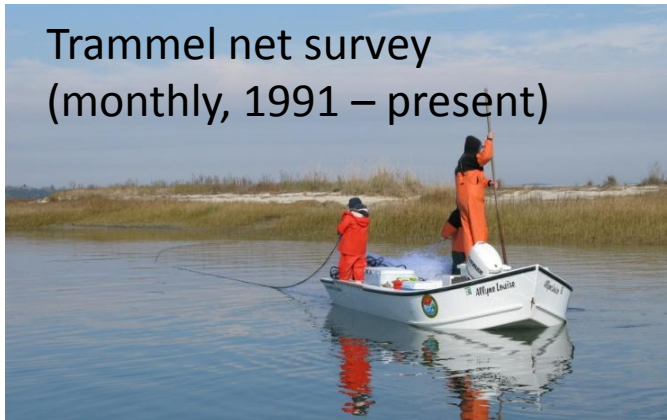
Winter: Most variable season.

How do winter temperatures affect estuarine fish populations?

Relationships between water temperature and estuarine fauna



Spotted seatrout
Cynoscion nebulosus



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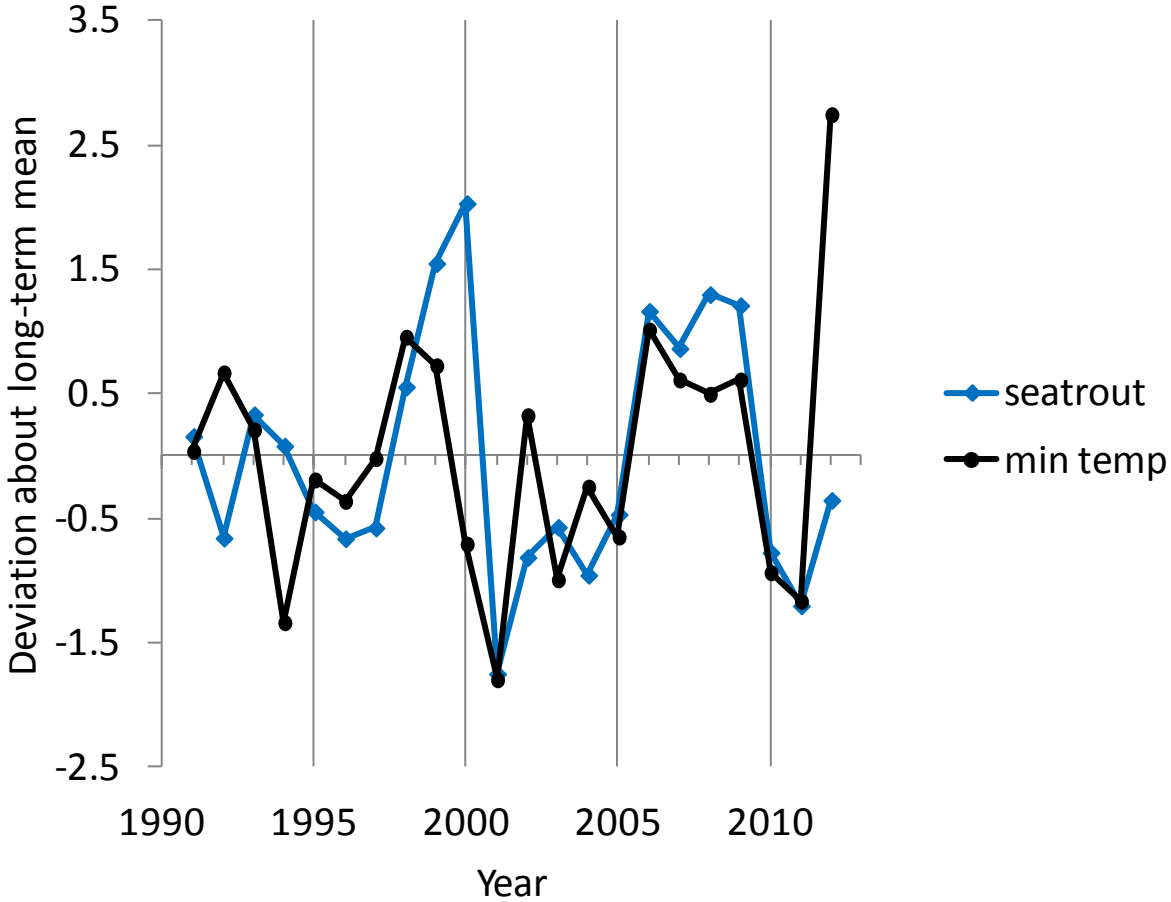

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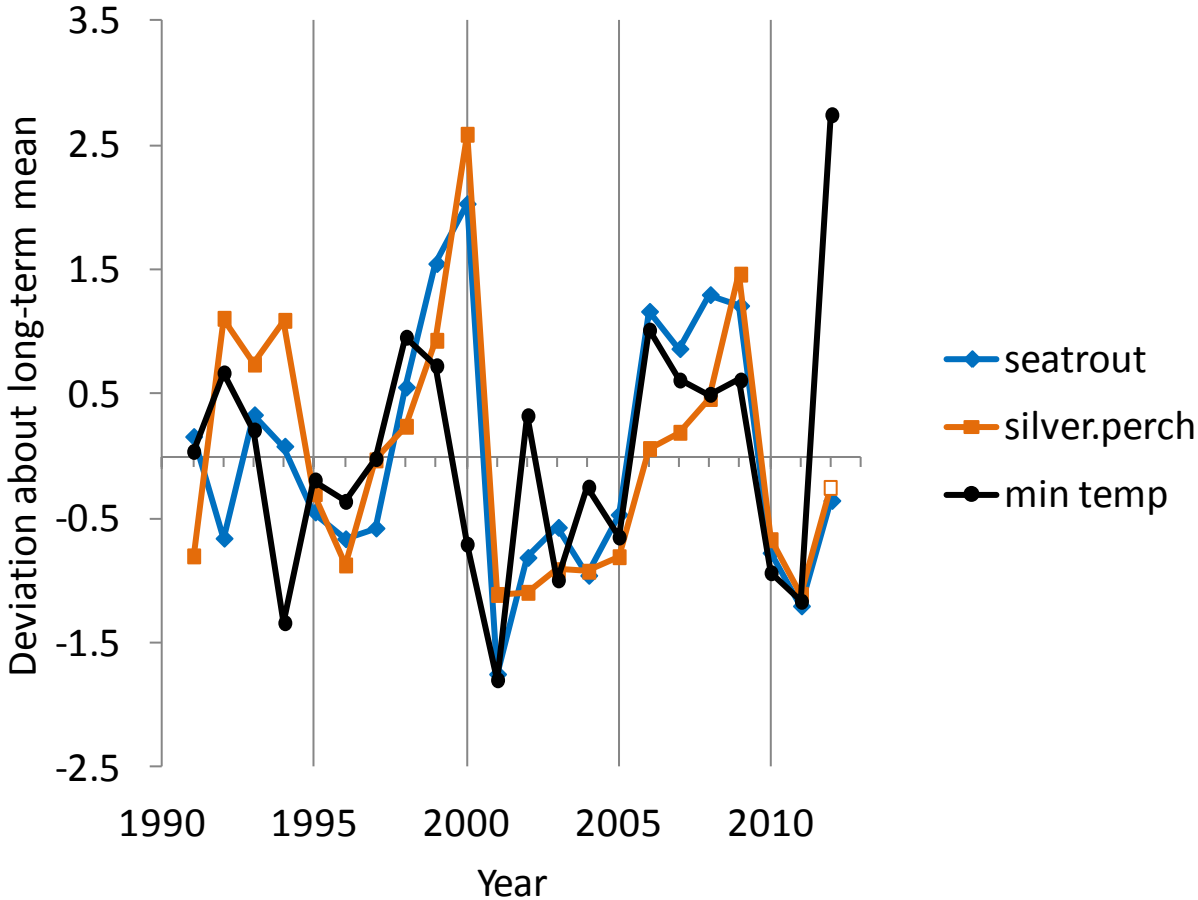
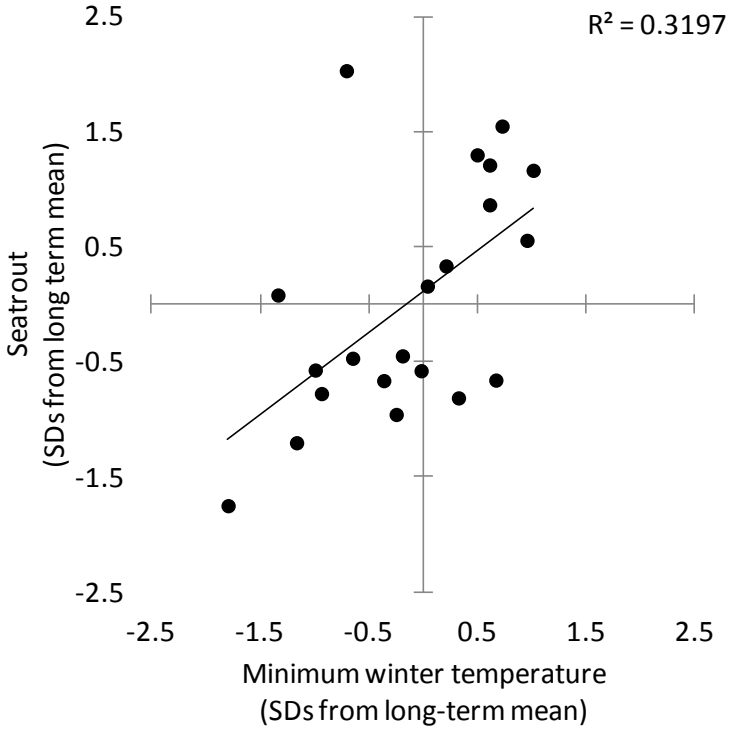


Spotted seatrout
Cynoscion nebulosus

Silver Perch
Bairdiella chrysoura

Relationships between water temperature and estuarine fauna



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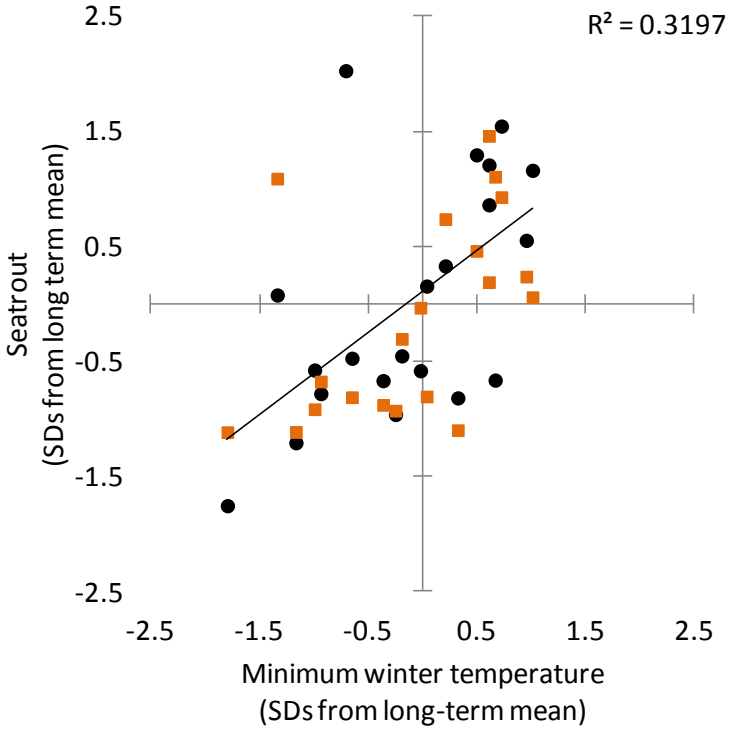

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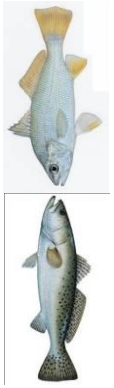
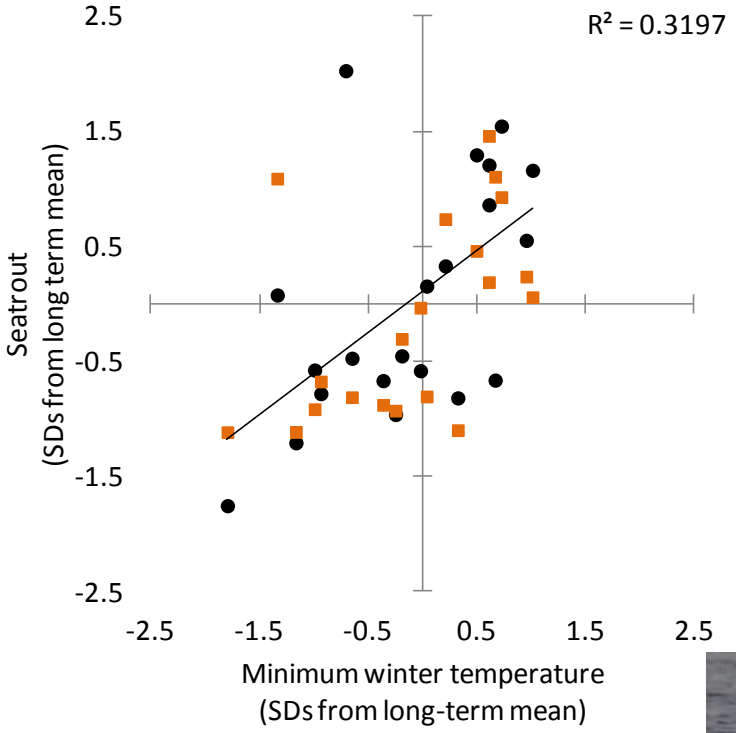
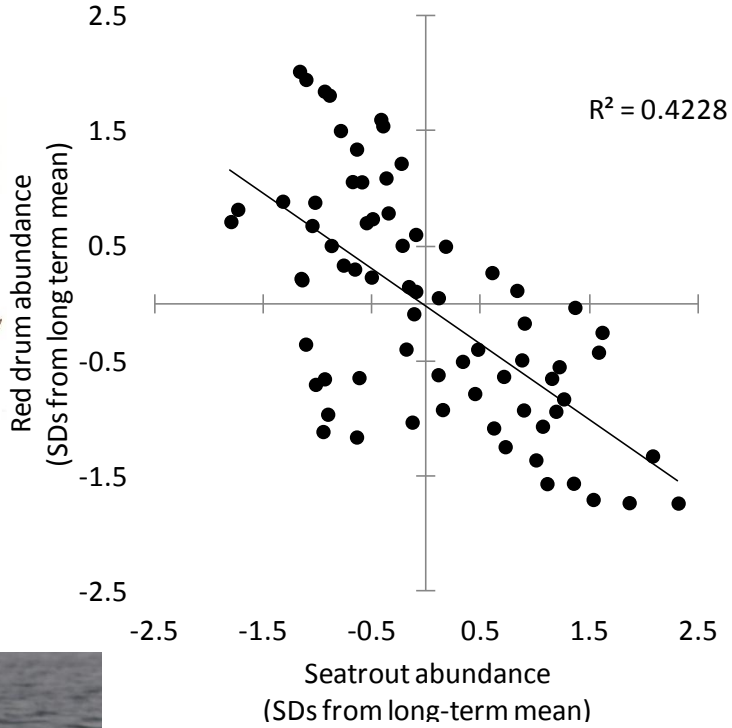




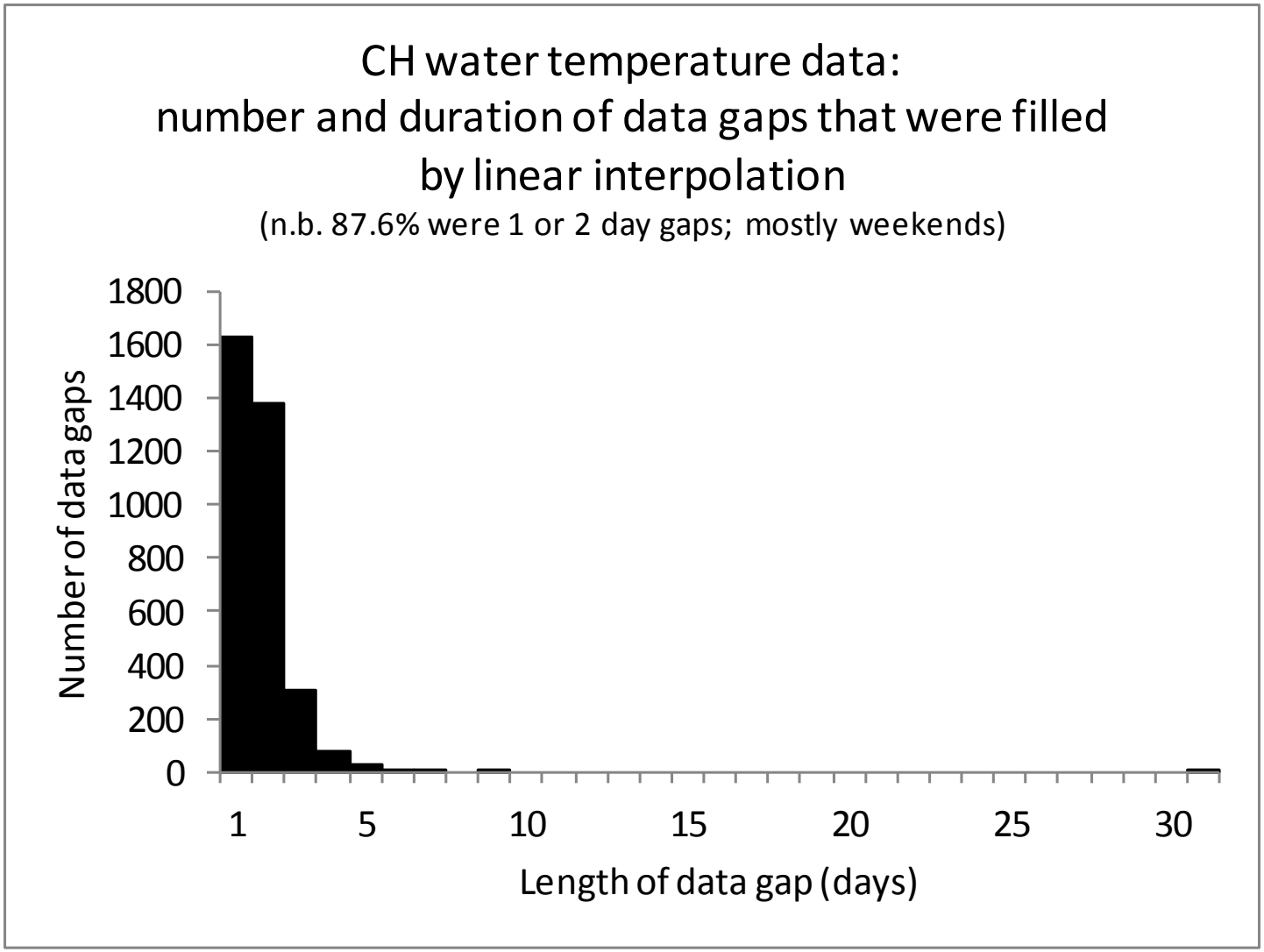


Cold winter effects on dolphin strandings:
Strandings more common following colder winters, especially when fish numbers are low (McFee & Arnott, unpublished data)

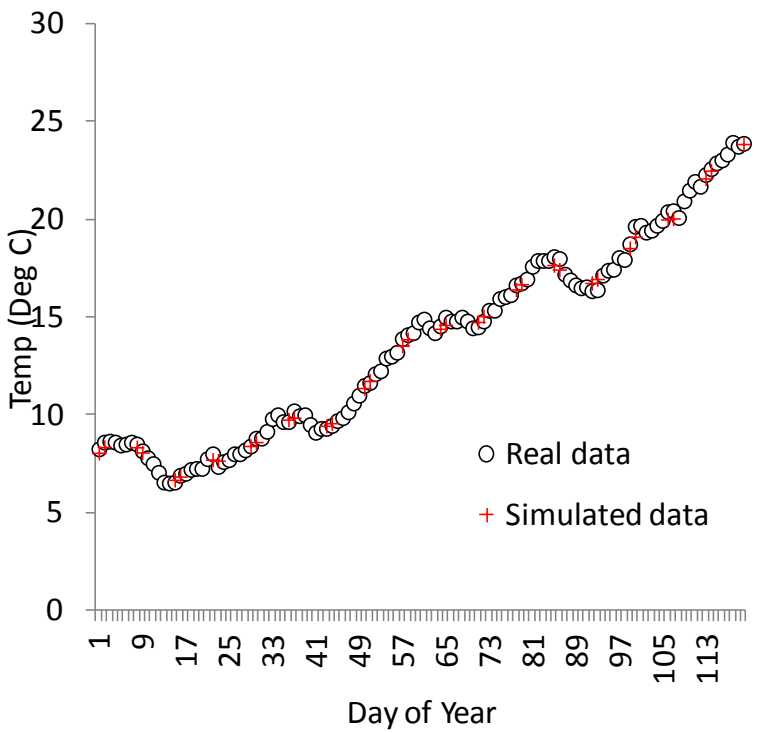
Conclusions

- Water temperatures have changed significantly with time
- General increase in temperatures, with spring arriving earlier and fall arriving later
- Many of the changes are linked with large-scale, climatic-related indices (AMO, AO, ENSO)
- Winter is the most variable season
- Winters affect resident fish, and probably other ecosystem-level processes
- Ongoing studies(e.g. seatrout temperature tolerance & genetic diversity)

Temperature Data Interpolation (i.e. filling in missing data)



Simulating the effects of data interpolation



Method

- Used data from 2011 (temperature recorded every day)
- Removed all week-end values and then interpolated them.
- Compared real versus simulated data.

Results

Daily Temperature Values

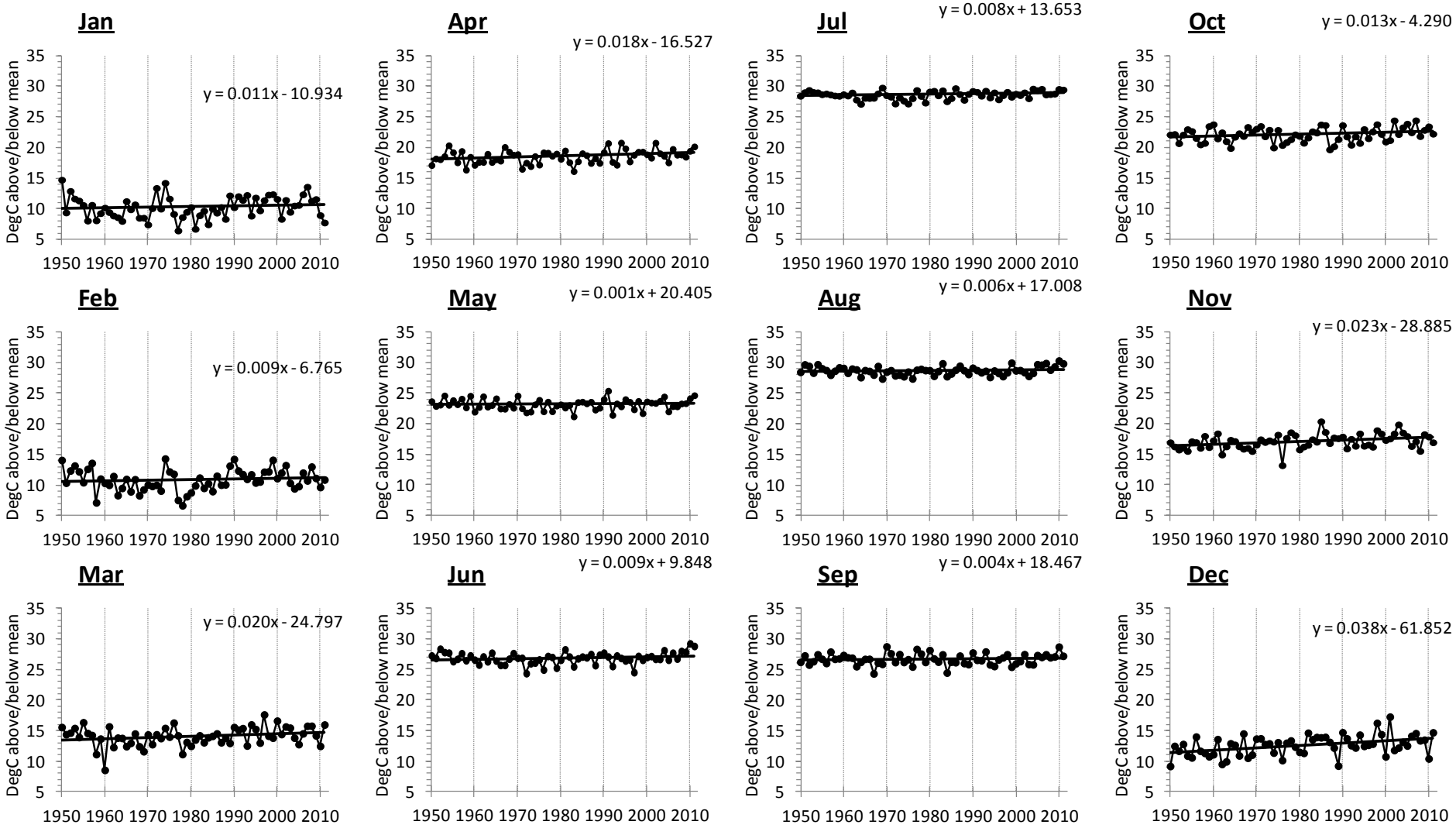
- Simulation error ranged from -0.6°C to +0.6°C
- Mean Error = 0.001°C (not sig. dif from zero, 1-sample t-test, p = 0.96)

Mean Monthly Temperatures

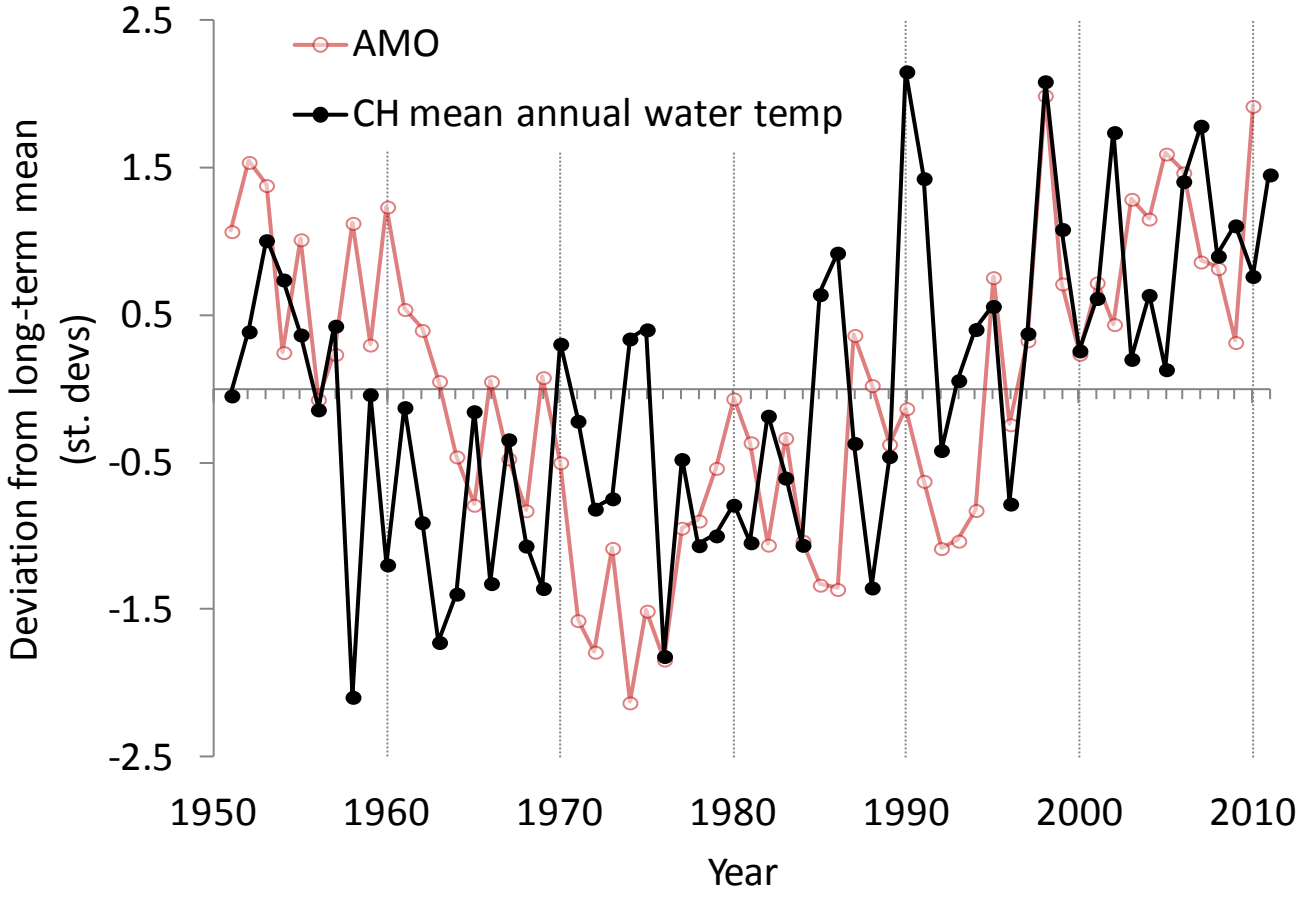
- Simulation error ranged from -0.1°C to +0.3°C

Error from data interpolation was negligible

Title

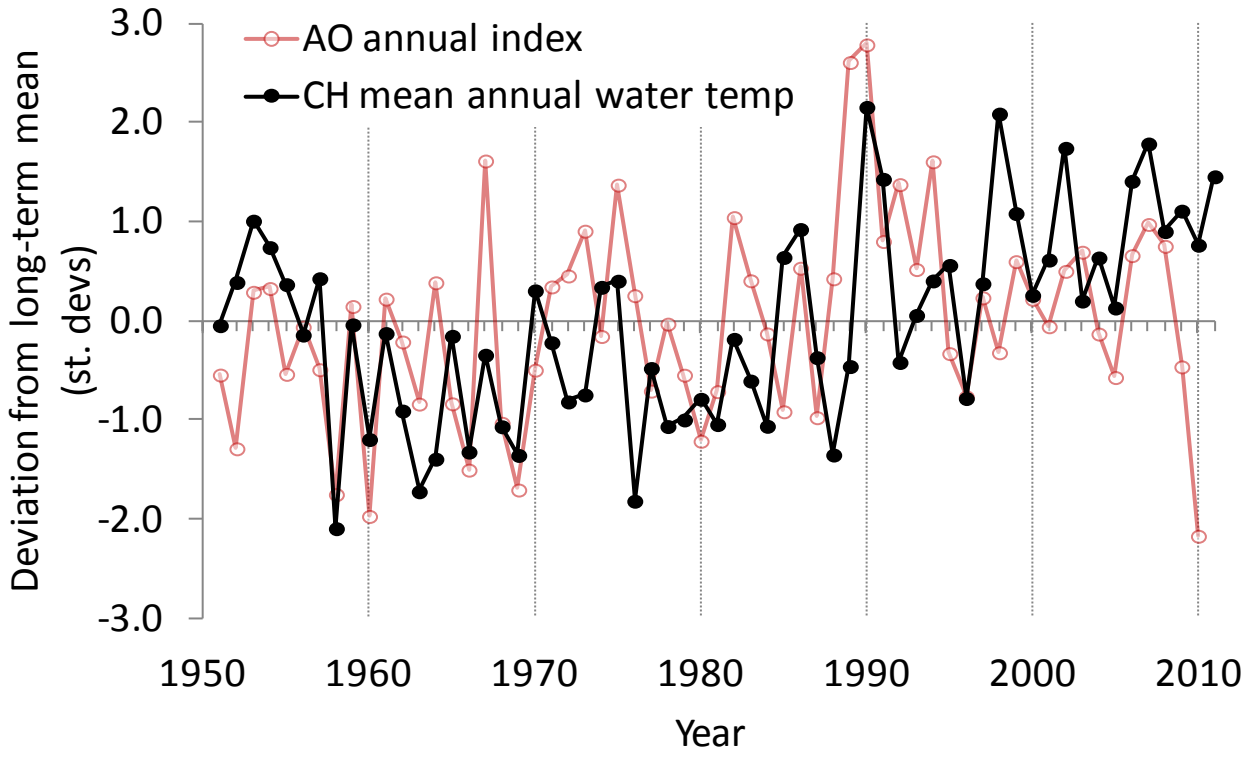

Jan
y = 0.011x - 10.934
Apr
y = 0.018x - 16.527
Jul
y = 0.008x + 13.653
Oct
y = 0.013x - 4.290
Feb
y = 0.009x - 6.765
May
y = 0.001x + 20.405
Aug
y = 0.006x + 17.008
Nov
y = 0.023x - 28.885
Mar
y = 0.020x - 24.797
Jun
y = 0.009x + 9.848
Sep
y = 0.004x + 18.467
Dec
y = 0.038x - 61.852
DegC above/below mean
35
30
25
20
15
10
5
1950 1960 1970 1980 1990 2000 2010

Relationship between water temperature & Atlantic Multi-decadal Oscillation (AMO)



Arctic Oscillation (AO)

Annual AO index and CH mean annual water temperature



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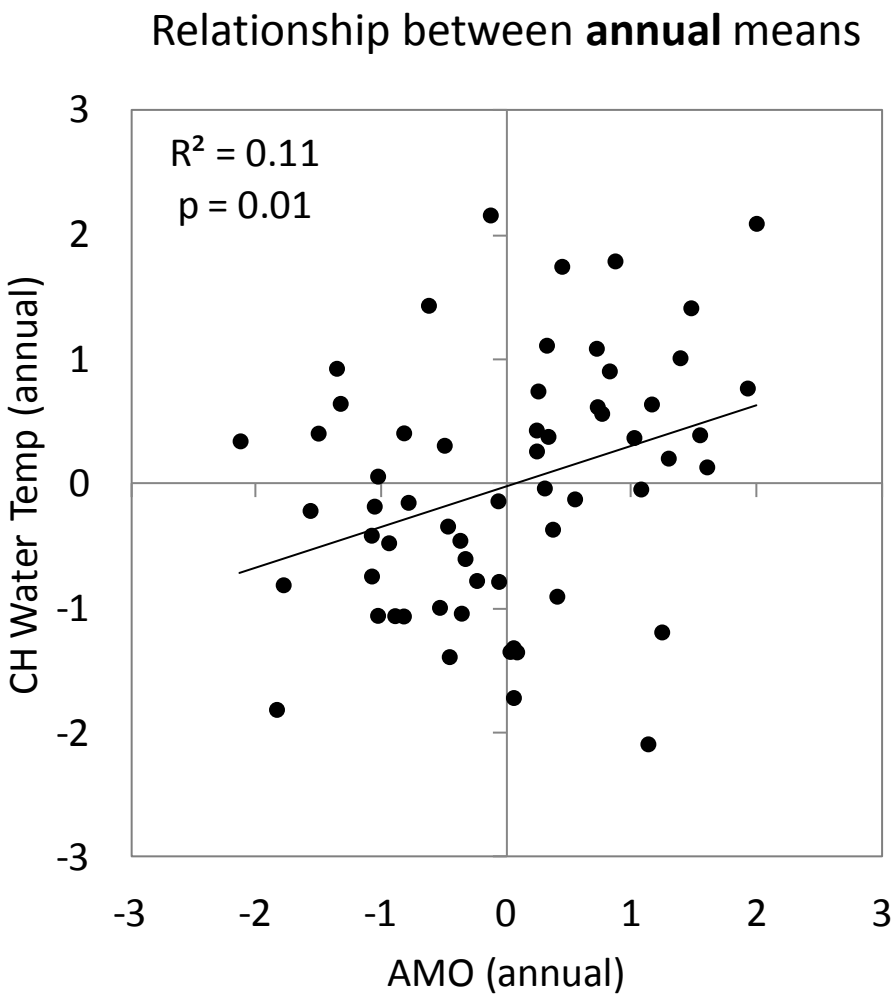
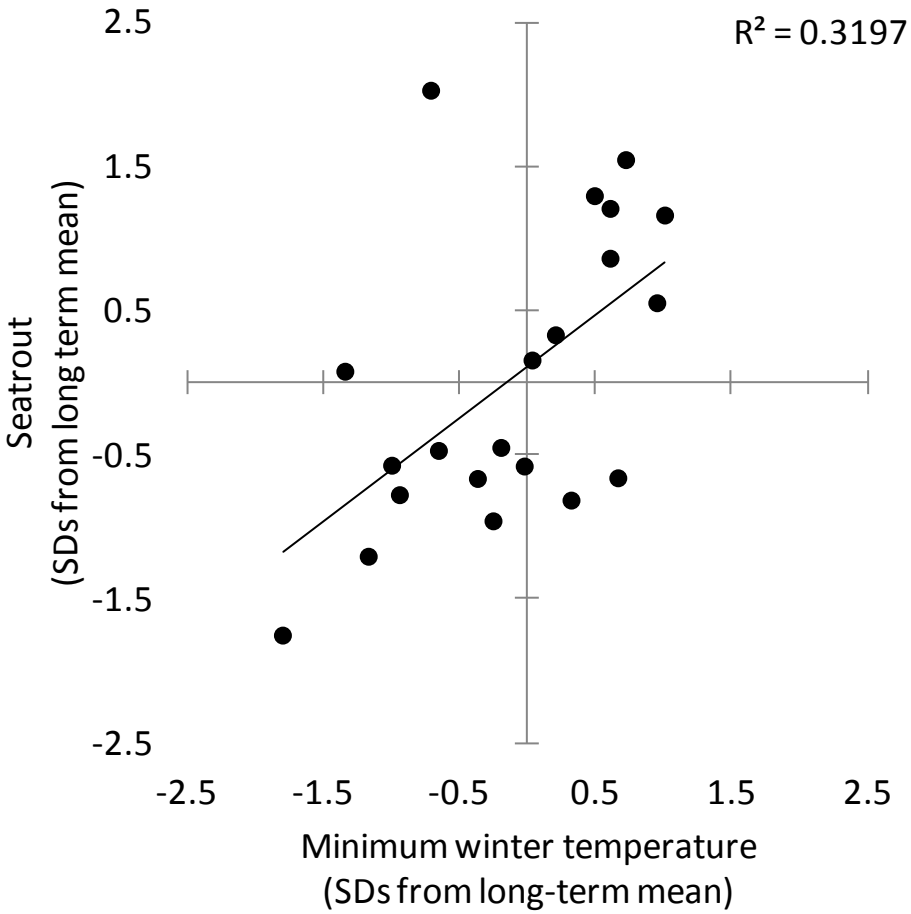


Relationships between water temperature and estuarine fauna



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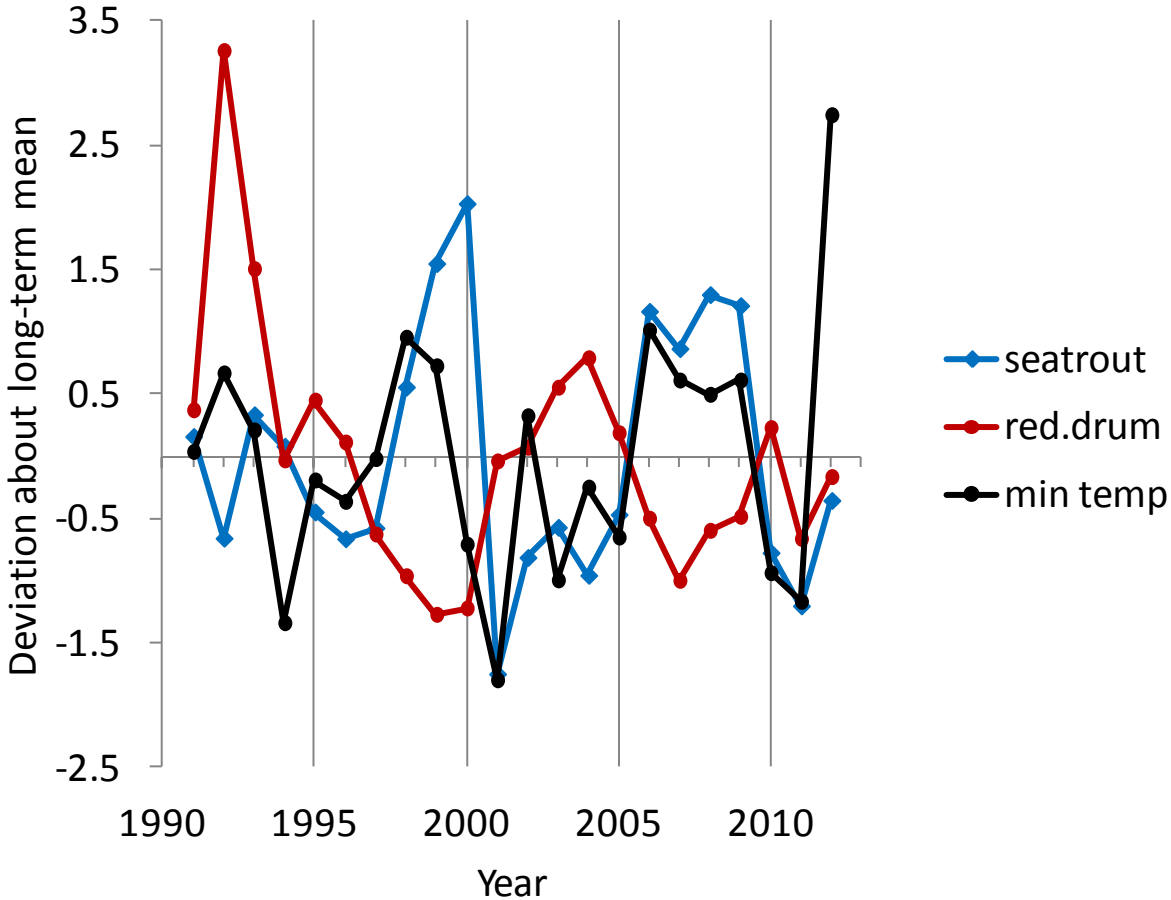

Spotted seatrout
Cynoscion nebulosus

Red Drum
Sciaenops ocellatus

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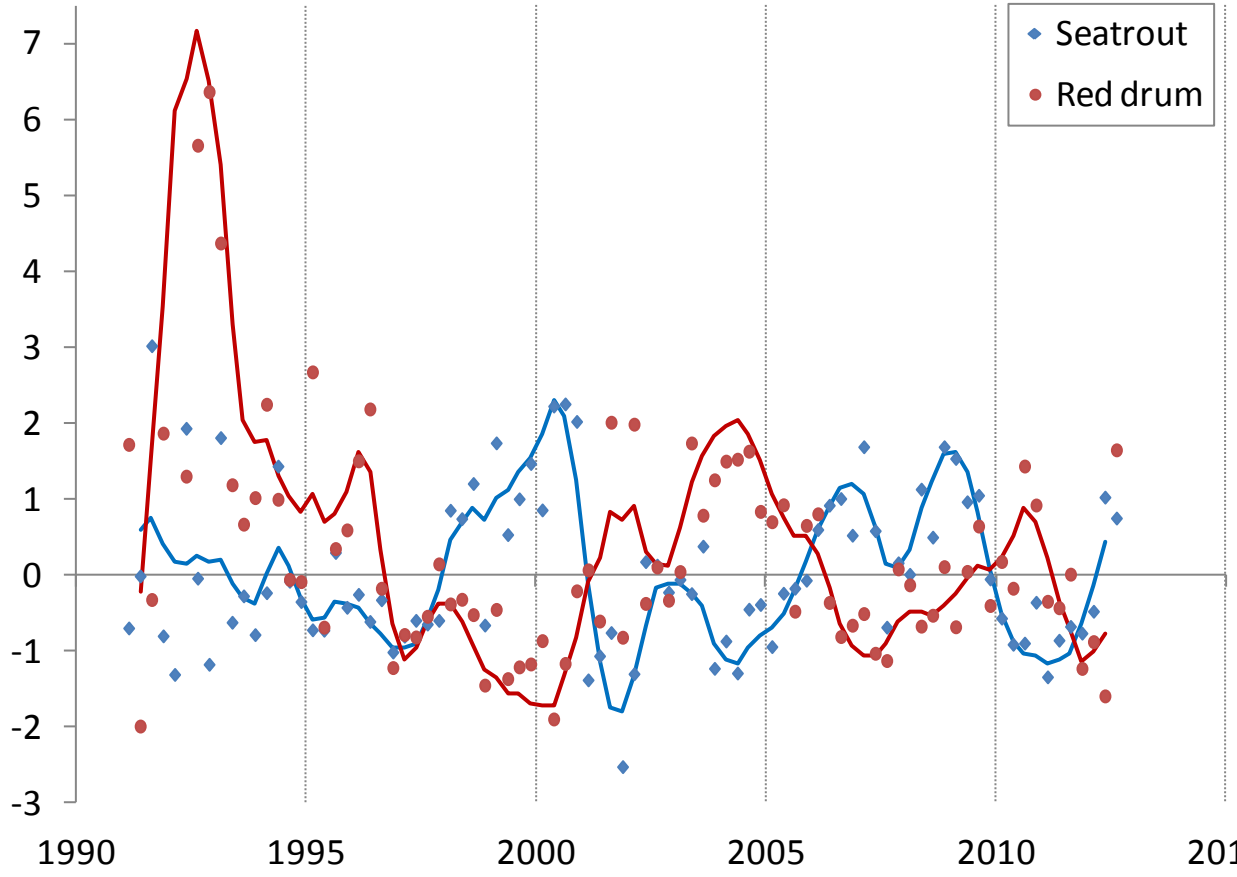

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