Seabird community composition and environmental relationships on Line P, 1996-2006

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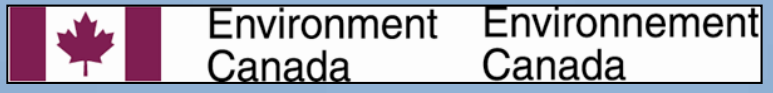
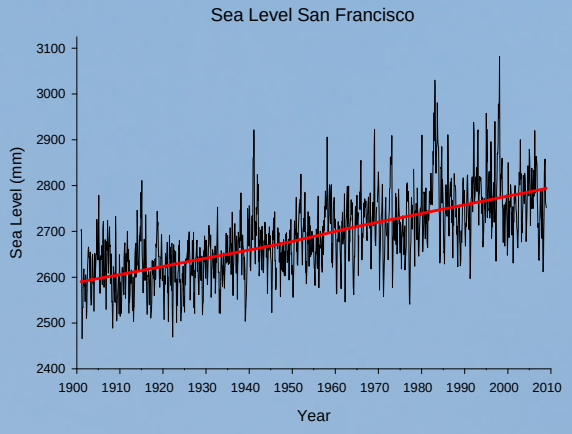
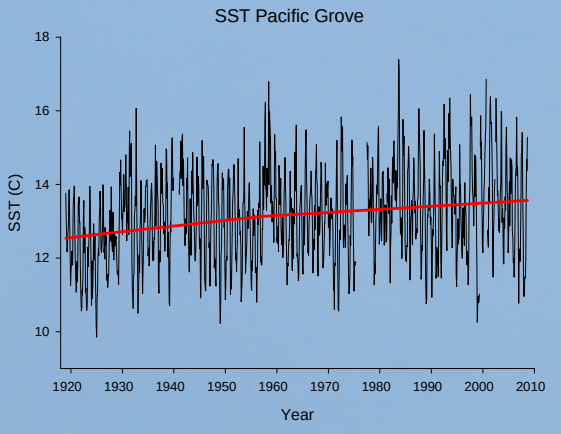


Climate change: marine manifestations

Plenty of evidence





Severely under-reported

- IPCC Fourth Assessment Report (2007)
  - 28,586 examples, 85 from aquatic systems (0.3%)**
- Focus on sexy habitats and charismatic megafauna

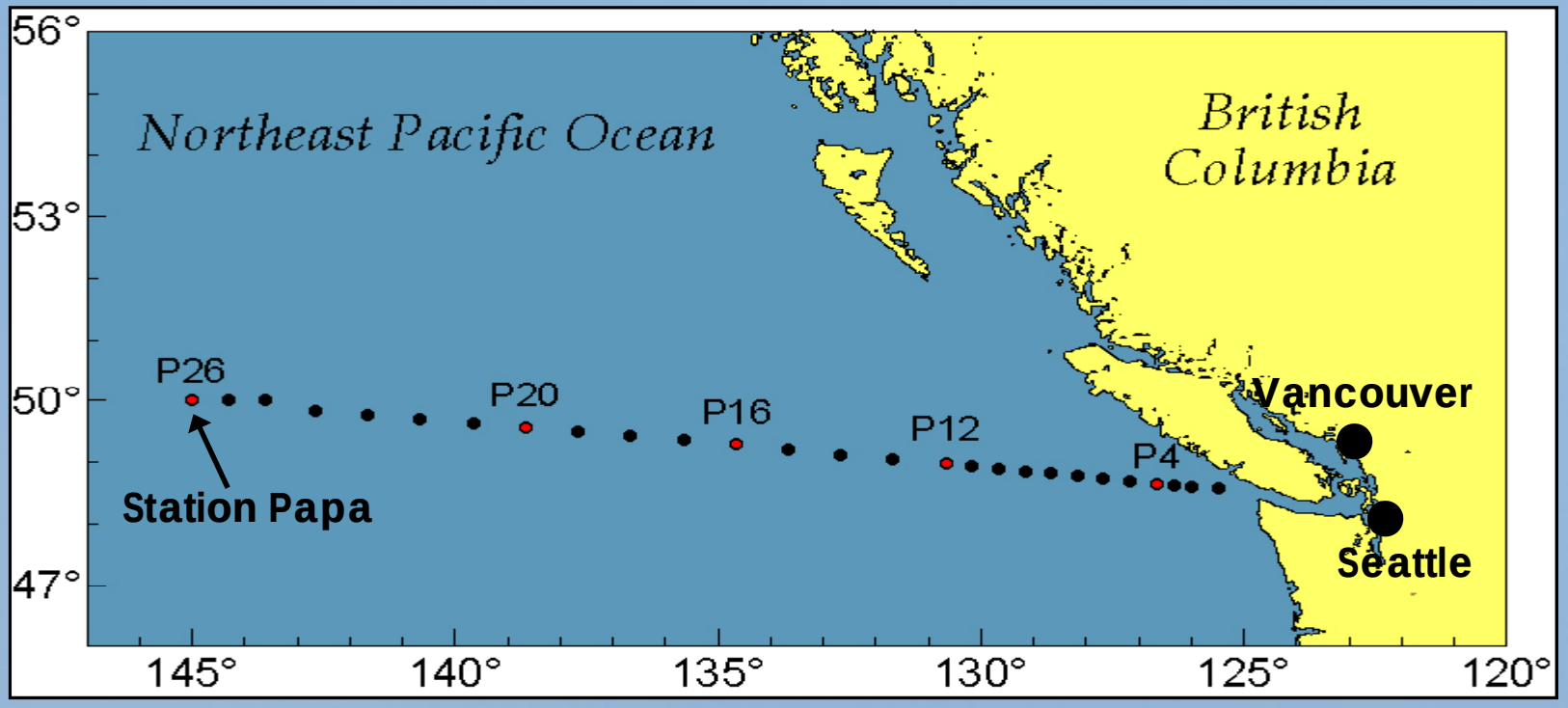
**Richardson and Poloczanska, *Science* 320:1294-1295

Hypotheses

1. Seabird communities are experiencing trends and interannual variability in seasonal density
2. Environmental parameters trend seasonally
3. Changes in environmental variables predict (precede) changes in seabird densities

Photo by Augusto Faustino

Line P—Institute of Ocean Sciences



- 26 sampling stations
- 1425 km, 120-4250 m depth
- 3 surveys/year
- CCGS *John P. Tully*

- Oceanography
- Ocean chemistry
- Seabird and mammal surveys (1996-2006)

Data

- Total seabird density (#/km^2)
- 24 species/groups:
  - 7 Alcids
  - 4 Gulls
  - 3 Petrels
  - 2 Shearwaters
  - 2 Albatross
  - 2 Storm-petrels
  - Phalaropes
  - Jaegers
  - Loons
  - Arctic Tern

Local physical variables:

- Ocean temperature
- Salinity
- Nitrates
- Sigma-t

Climate indices

- NPGO
- PDO

Data Analysis

- Bird data $\log_{10}$ transformed, daily averages and seasonal anomalies
- Oceanographic data averaged to season and across all stations

- Test for trends: Spearman rank correlation
- Test for interannual variability: 2-way ANOVA
- Seabird-environment relationship: principal component analysis and Spearman rank correlation

Seabird seasonal trends

Significant trends:

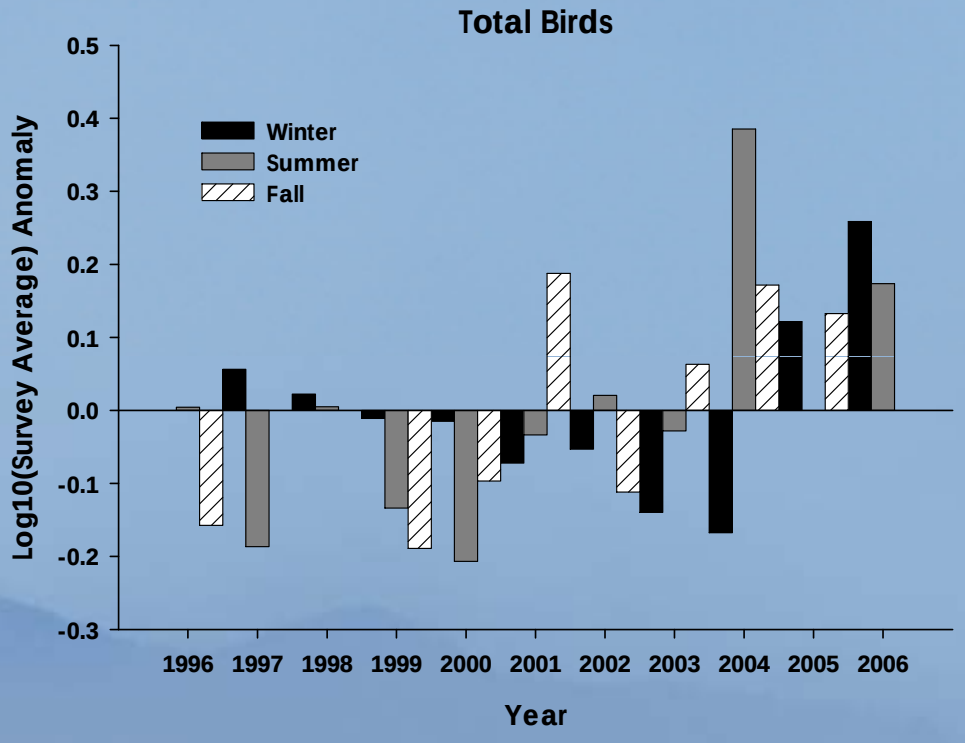
	# Increase	# Decrease
Winter (n=121)	5	2
Summer (n=159)	2	3
Fall (n=110)	11	1

Non-significant trends:

	# Increase	# Decrease
Winter	9	8
Summer	12	8
Fall	5	5

Seabird interannual variability

- Significant interannual variability by season
- 10 species in winter, 7 in summer, 9 in fall
- 5 species had no interannual variability
- Total birds and Common murre were significant in all three seasons



Seabird community structure

Winter:

Ranking	1997-2000	Percentage	2003-2006	Percentage
1	Northern Fulmar	19.6	Northern Fulmar	17.3
2	Black-legged Kittiwake	15.7	Black-legged Kittiwake	16.04
3	Common Murre	14.9	Glaucous-winged Gull	15.98
4	Laysan Albatross	11.3	Common Murre	15.8
5	Glaucous-winged Gull	11.1	Tufted Puffin	6.1
6	Herring Gull	6.9	Loons	5.0
7	Fork-tailed Storm-Petrel	3.7	Rhinoceros Auklet	4.4
	Total	83.2		80.6

Seabird community structure

Summer:

Ranking	1996-1999	Percentage	2002-2004, 2006	Percentage
1	Sooty Shearwater	32.2	Leach's Storm-Petrel	27.4
2	Leach's Storm-Petrel	19.9	Sooty Shearwater	26.5
3	Fork-tailed Storm-Petrel	10.3	Fork-tailed Storm-Petrel	9.2
4	Northern Fulmar	7.1	Cassin's Auklet	4.8
5	Black-footed Albatross	4.9	Common Murre	4.5
6	Rhinoceros Auklet	4.5	Rhinoceros Auklet	4.0
7	Cassin's Auklet	3.3	Black-footed Albatross	3.4
	Total	82.2		79.8

Seabird community structure

Fall:

Ranking	1996, 1999-2001	Percentage	2002-2005	Percentage
1	Leach's Storm-Petrel	32.7	Leach's Storm-Petrel	25.1
2	~~Northern Fulmar~~	12.1	Sooty Shearwater	14.8
3	~~Pink-footed Shearwater~~	9.1	Common Murre	9.5
4	Black-footed Albatross	8.9	Phalaropes	9.3
5	Sooty Shearwater	8.7	Black-footed Albatross	8.1
6	Cassin's Auklet	5.9	Glaucous-winged Gull	6.0
7	Fork-tailed Storm-Petrel	4.4	Rhinoceros Auklet	5.9
	Total	81.8		78.7

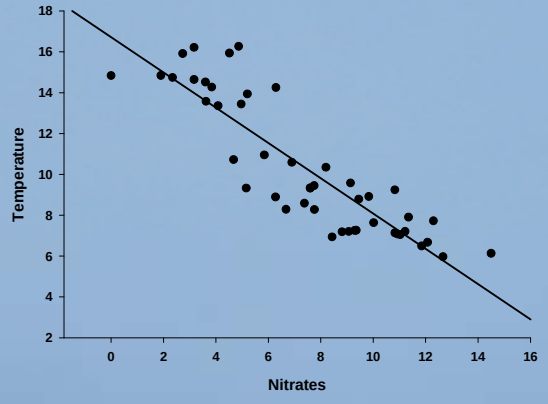
Physical parameters

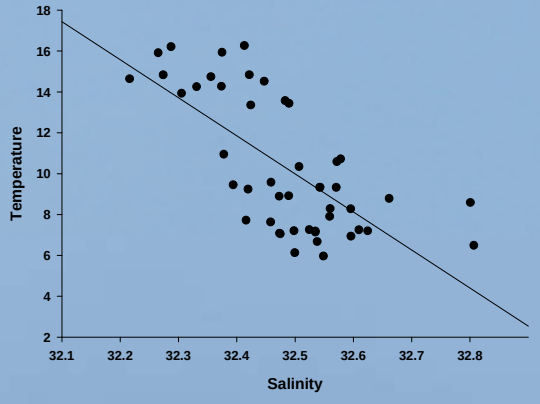
Trends over time (Spearman rank correlation)

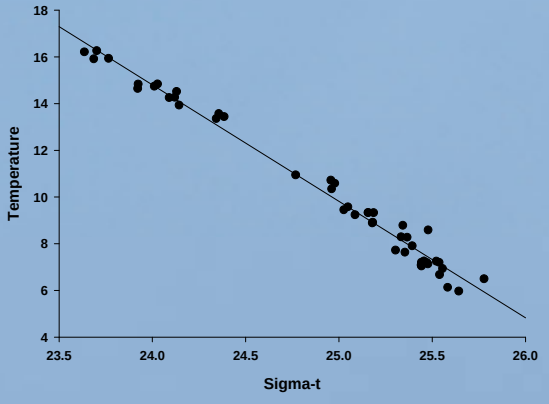
- **Increase in nitrates**

Cross-correlation between parameters

- **All significantly correlated with each other**
- **Negative relationships with temperature**







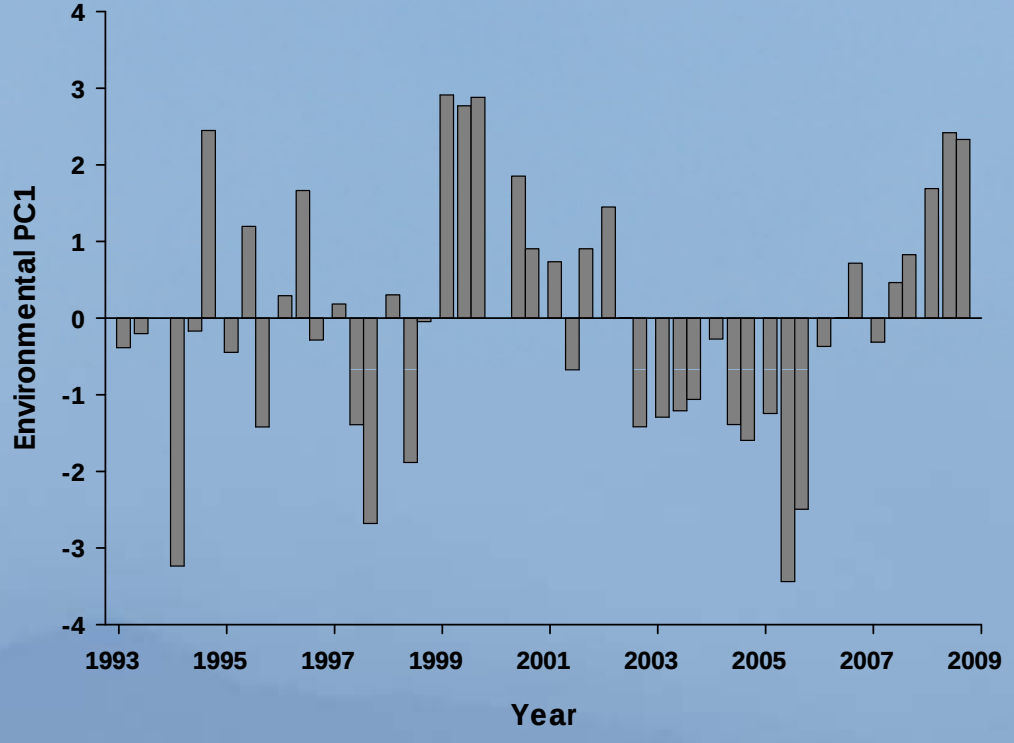
Environmental principal component analysis

Principal component analysis (“environmental pc”)

- **pc1 explained 62% of variation**
  - **Loaded heavily on temperature (-) and sigma-t (+)**

Temperature ↓
Salinity, nitrates, sigma-t ↑

Temperature ↑
Salinity, nitrates, sigma-t ↓



Seabird-environment relationships

Significant relationships:

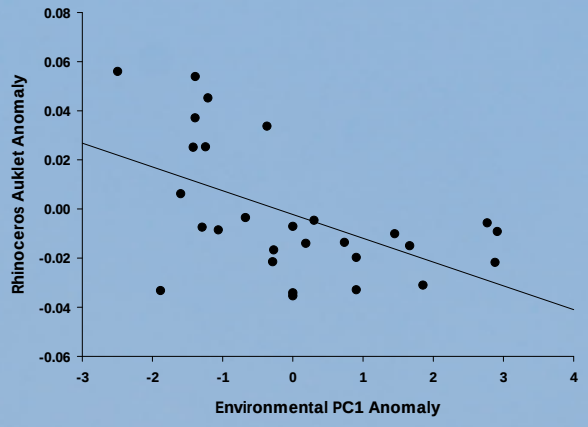
	# Positive	# Negative
Time 0	0	6
Lag 1 Season	0	8
Lag 2 Seasons	1	6

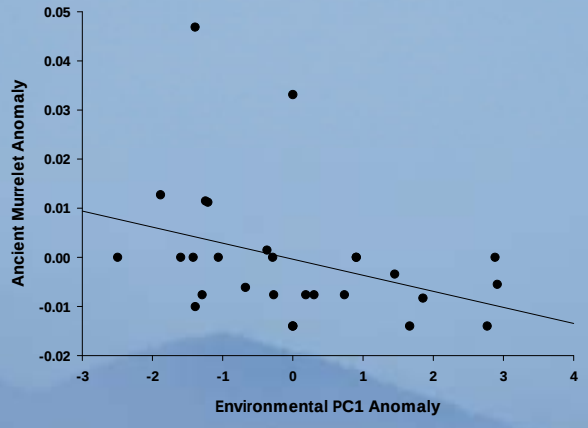
Non-significant relationships:

	# Positive	# Negative
Time 0	6	13
Lag 1 Season	4	13
Lag 2 Seasons	6	12

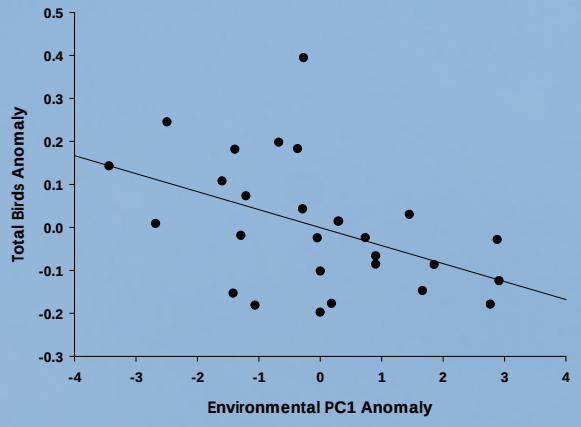
Seabird-environment relationships

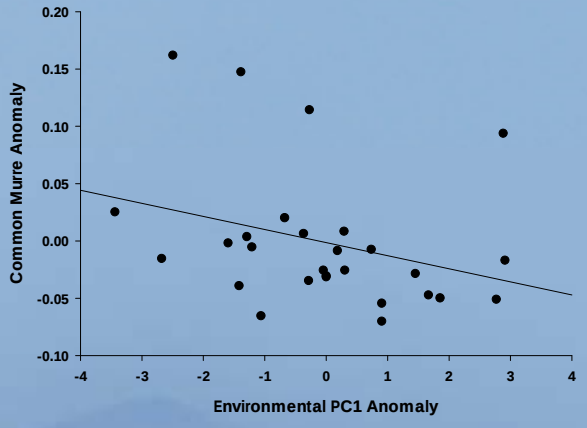
Time 0



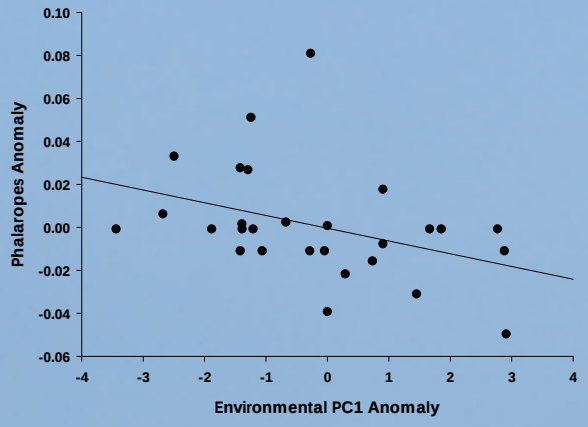


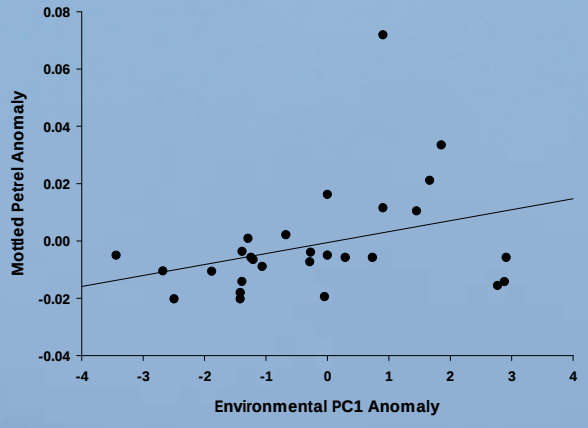
Lag 1





Lag 2





Seabird-environment relationships

- 13 species with significant relationships
- Most relationships for lag 1 season
- Total birds and Common murre significant at all times/lags
- Across all times, 21 total relationships, only 1 was positive

→Birds are decreasing with increasing environmental pc1

→Increasing environmental pc1 is decreasing temperature and increasing salinity, nitrates and sigma-t

Summary

- Seasonal and interannual variability in seabird abundance along Line P
- Changes in seasonal seabird community structure over the time series
- Little trending change in local environmental variables
- Patterns of abundance trends and relationships with environmental parameters are species-dependent
- Some relationships between seabird densities and the environmental pc1
    - All but one were negative—why??