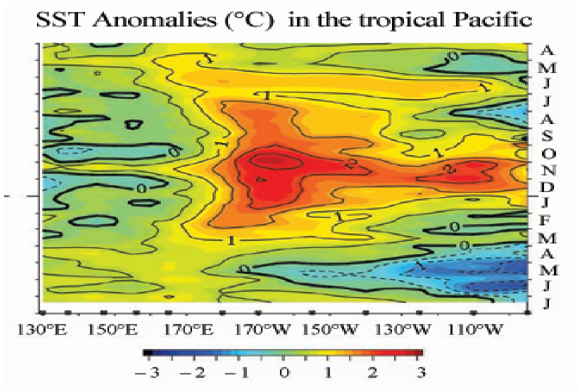

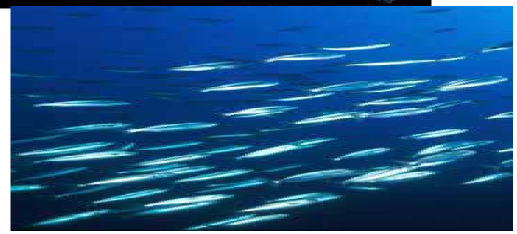

Marine Birds and Climate Change in the North Pacific: A Meta-Analysis

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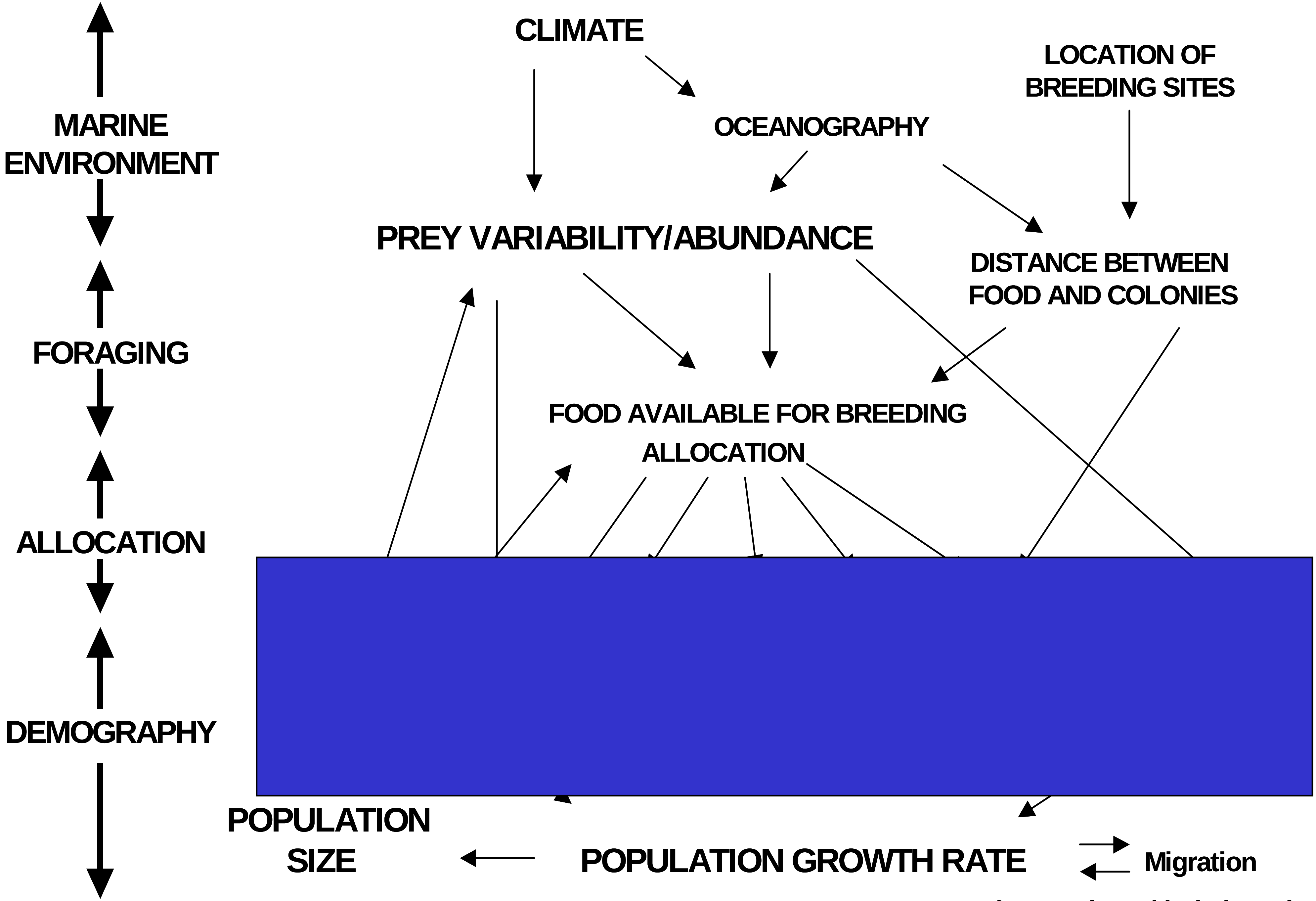
Marine Top Predators and Climate Change

- Population dynamics determined by 7 demographic processes: (1) fecundity (reproductive success), (2) adult survival, (3/4) dispersal (immigration/emigration), (5) recruitment, (6) age-at-first breeding, (7) breeding propensity (Nur and Sydeman 1999).

- Intrinsic (e.g., age-structure, density-dependence) and extrinsic factors (e.g., climate) modify demographic responses…

- Therefore, to advance understanding of climate change on top predators, knowledge of spatio-temporal co-variation in ocean climate and demographic attributes is required…abundance and biomass is not enough…

….we have seen some of this in this CCCC symposium (e.g.,Pacific Hake, V. Agostini et al.; Monk Seals, J. Baker et al.), but more is needed



After Weimerskirch (2001)

Two Basic Questions*

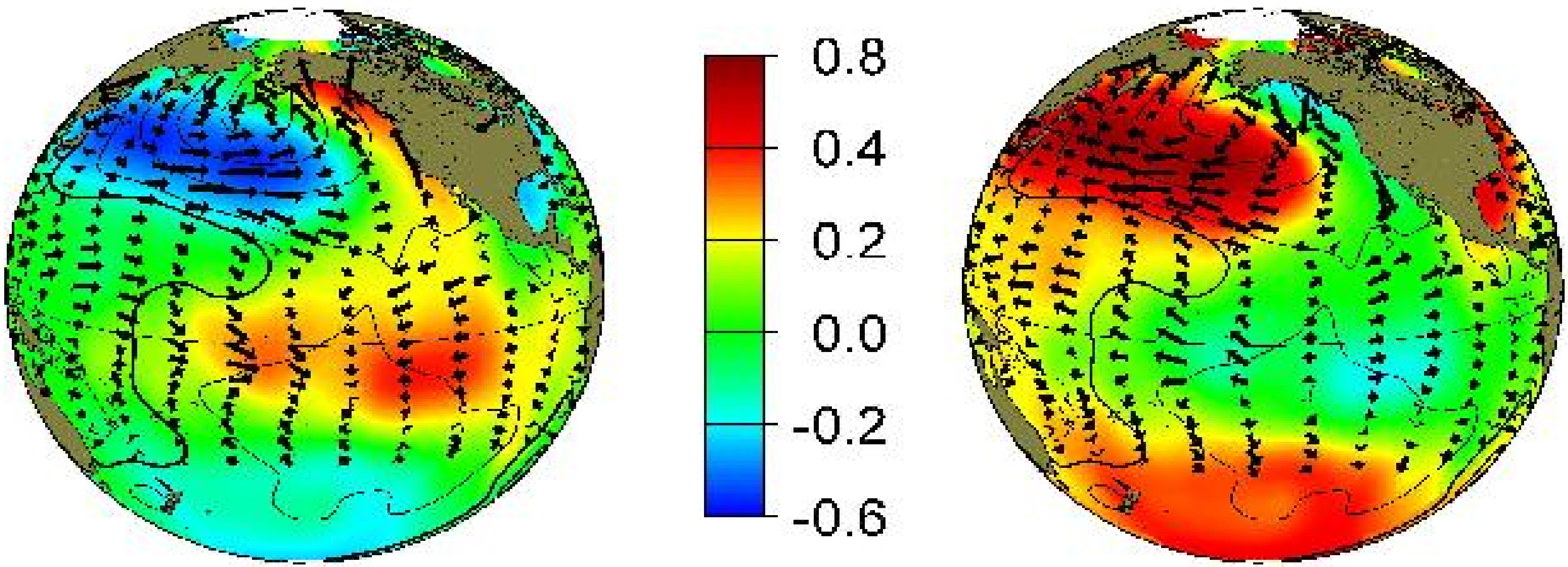
- Do planktivorous and piscivorous seabirds respond similarly to climate variation in different North Pacific marine systems (coastal CCS, Okhotsk, Japan Sea)?

- Are correlations and pathways of response between climate (local [SST] and remote (atmospheric forcing) and breeding success similar or dissimilar between systems?

*pertaining to Pan Pacific comparisons

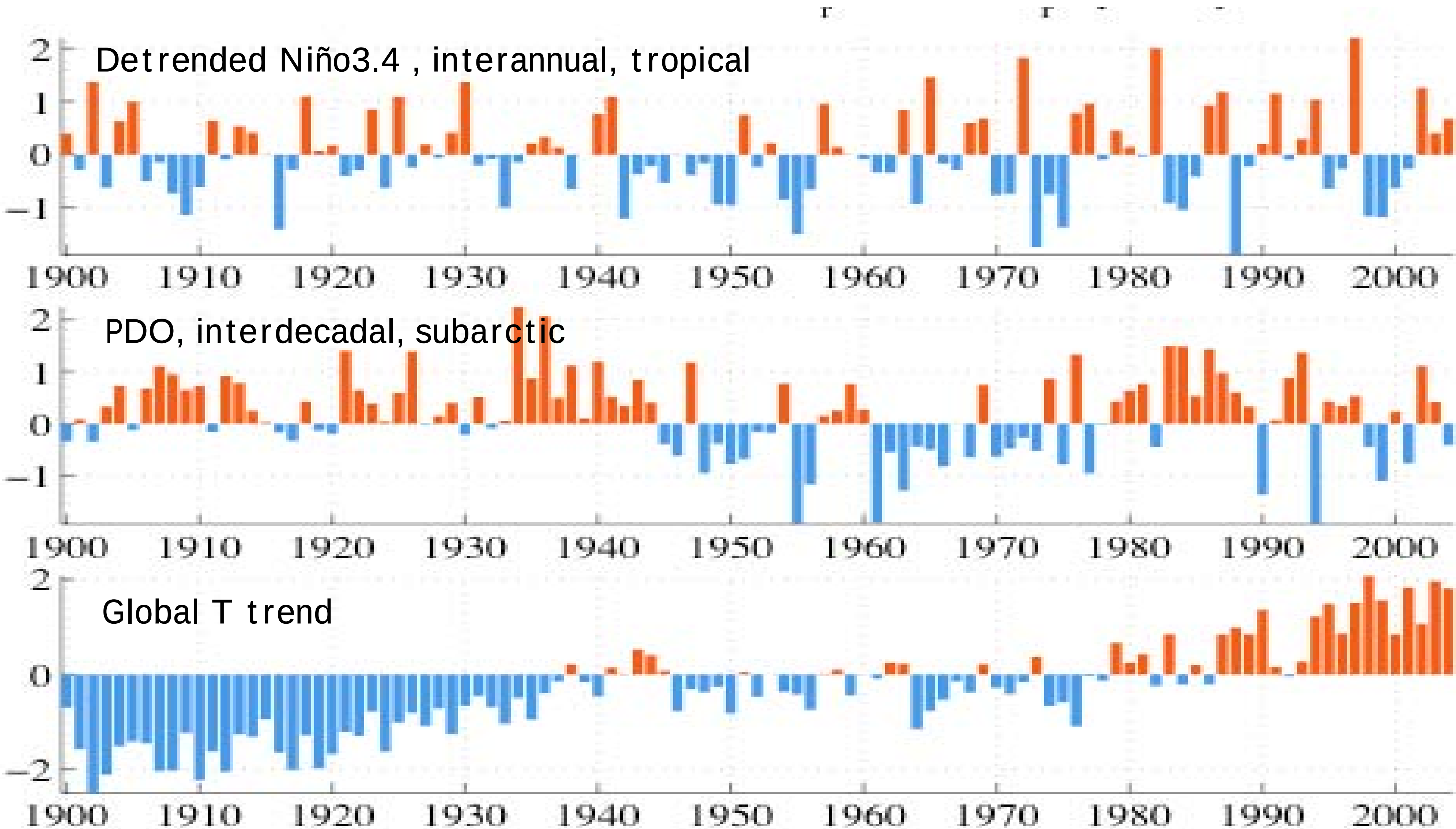
Spatial Covariation in SST Between Eastern and Western North Pacific, illustrated by PDO

"Phase A" "Phase B"



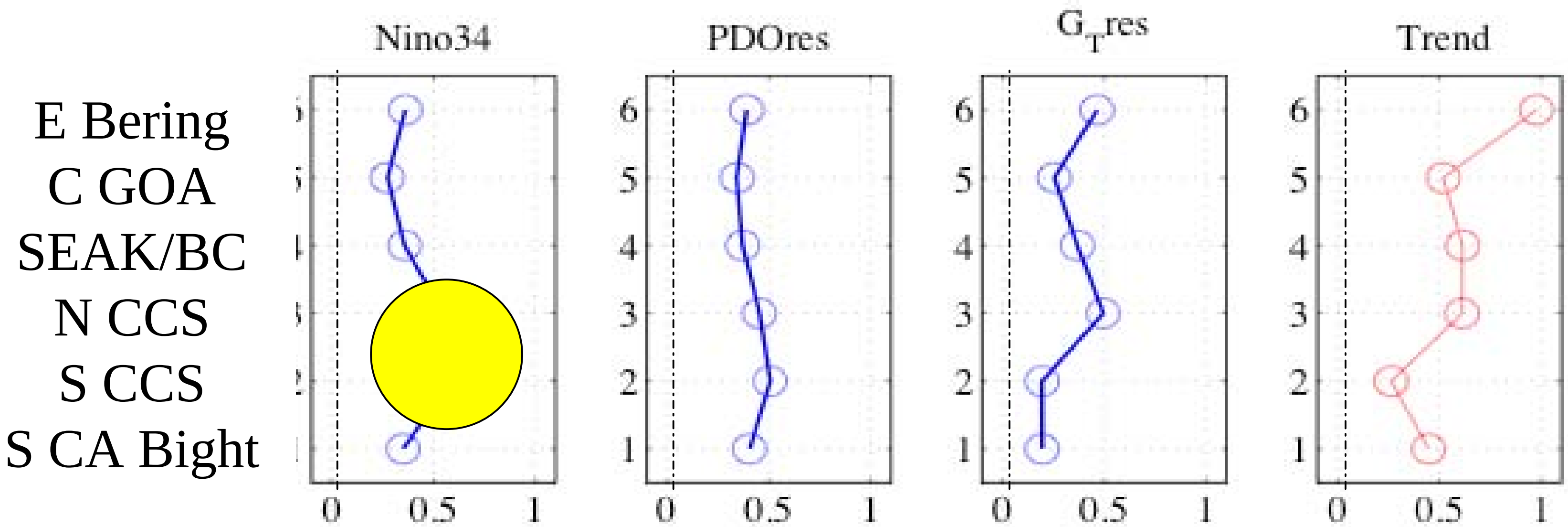
N. Mantua

Temporal Modes of Climate Variability



Mantua, Meuter, and Schwing, manuscript

Example: Determining AMJ SST (1900-2004) relative to large-scale forces



- Largest Nino3.4 SST regression coefficients are for CCS; PDO effects are nearly uniform; G_T regressions are largest in N CCS and EBS.
- SST trends from 1900-2004 are greatest in the Eastern Bering Sea, smallest in S CCS.

Mantua, Meuter, and Schwing, manuscript

Seabirds: Secondary and Tertiary Consumers

Planktivores (e.g, auklets): copepods, euphausiids, mysids, larval fish and squid

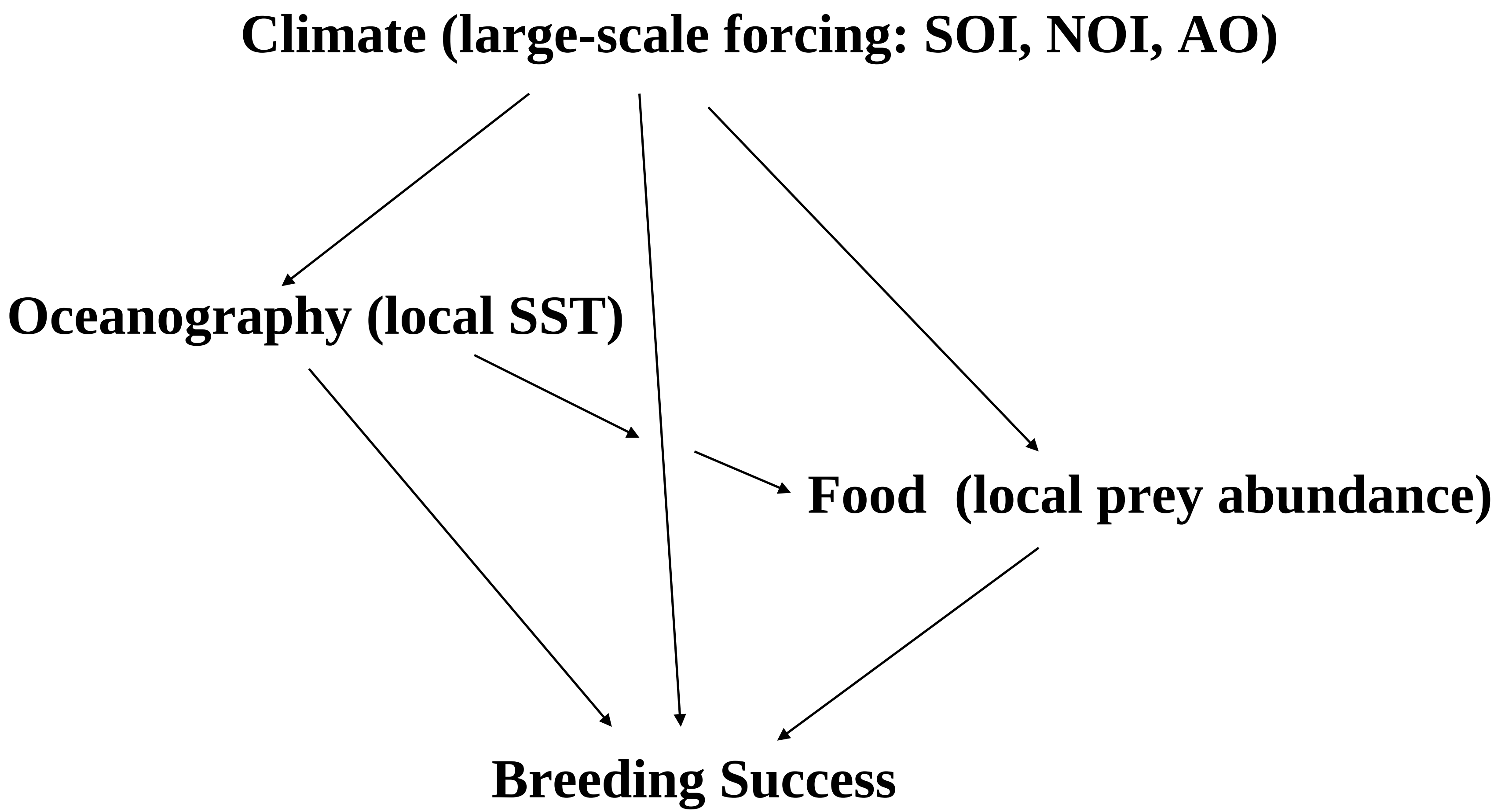
Piscivores (e.g., murres, puffins): 0 age-class predatory fish, coastal pelagics [anchovy, sardine], forage fish [sandlance], squids

…effects of climate change are, mostly indirect, operating through predator-prey relationships…

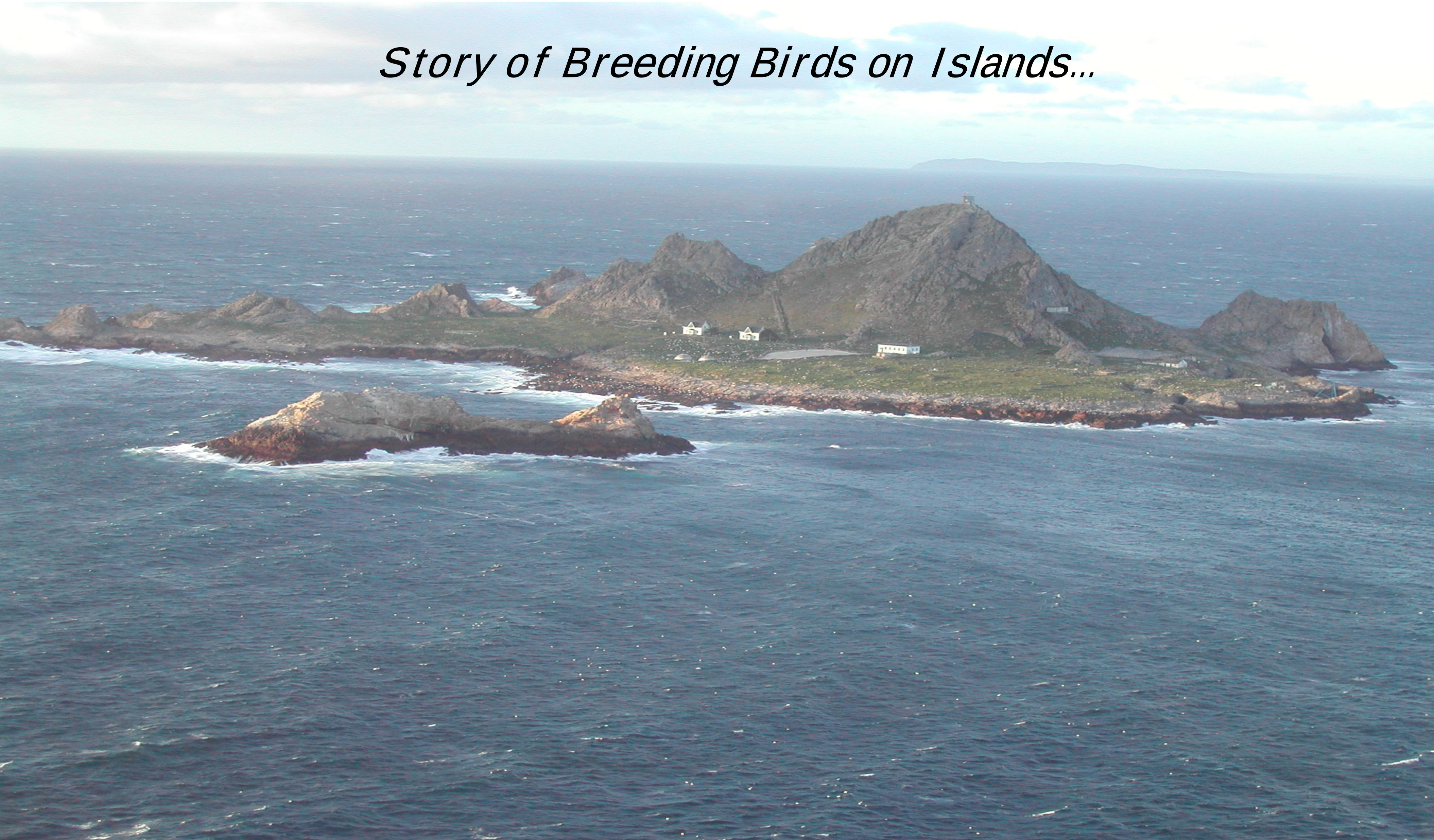
Climate to Seabirds, Some Life History Considerations

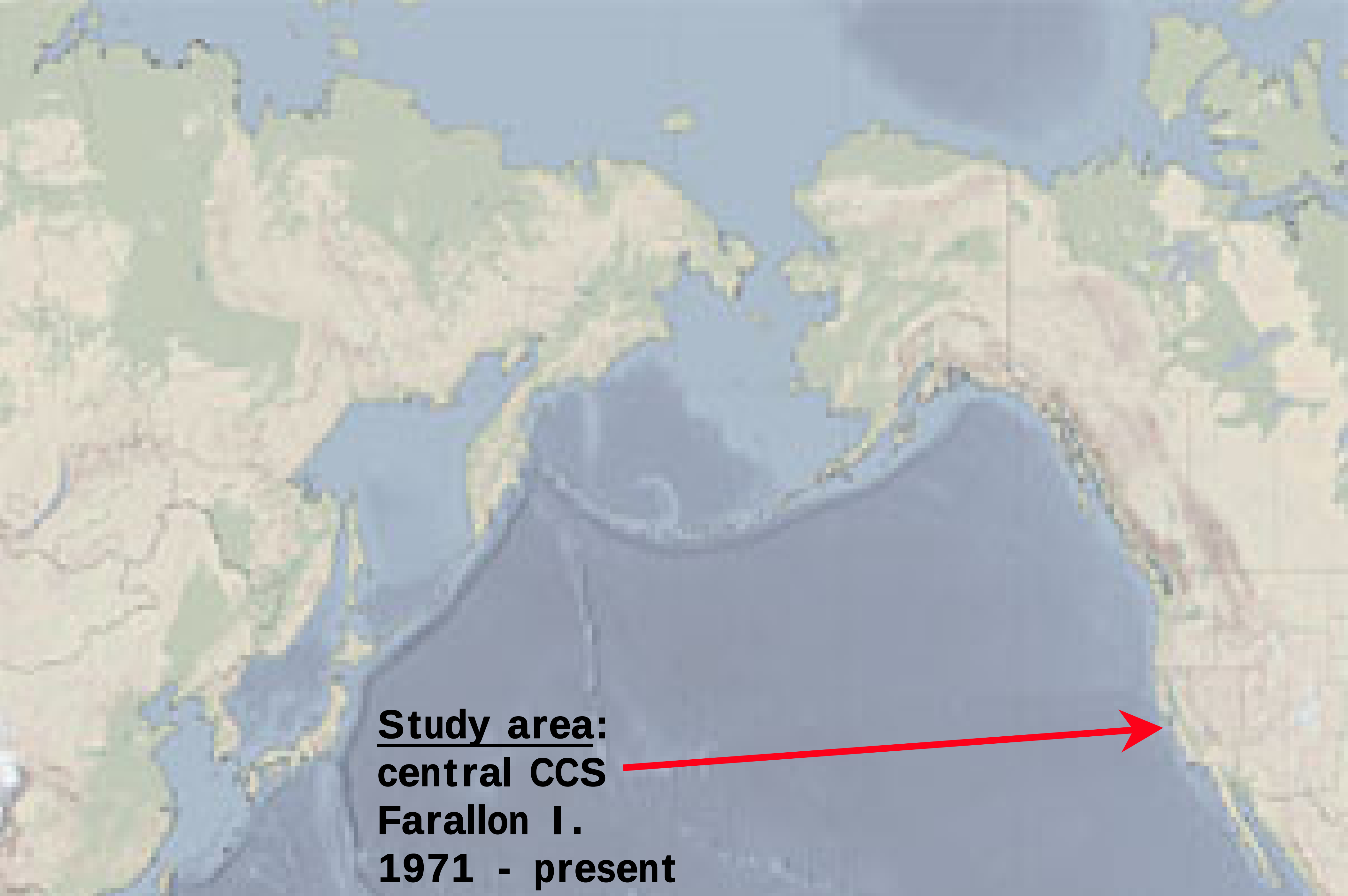
- Highly mobile = population abundance at sea is difficult to interpret, climate-ecosystem time lags (Hyrenbach and Veit 2003), move to food
  - Answer: focus on colonies; limited by central place foraging
- Deferred maturity (age first reproduction = 3-10 year) = extensive time lags, population responses to climate difficult to interpret
  - Answer: focus on sub-population parameters (e.g, breeding success), time scale (March – August)

Note: seasonal reproduction timed to seasonal cycle of mid trophic level organisms… seasonal cycle key to North Pacific ecosystem dynamics, explains variance

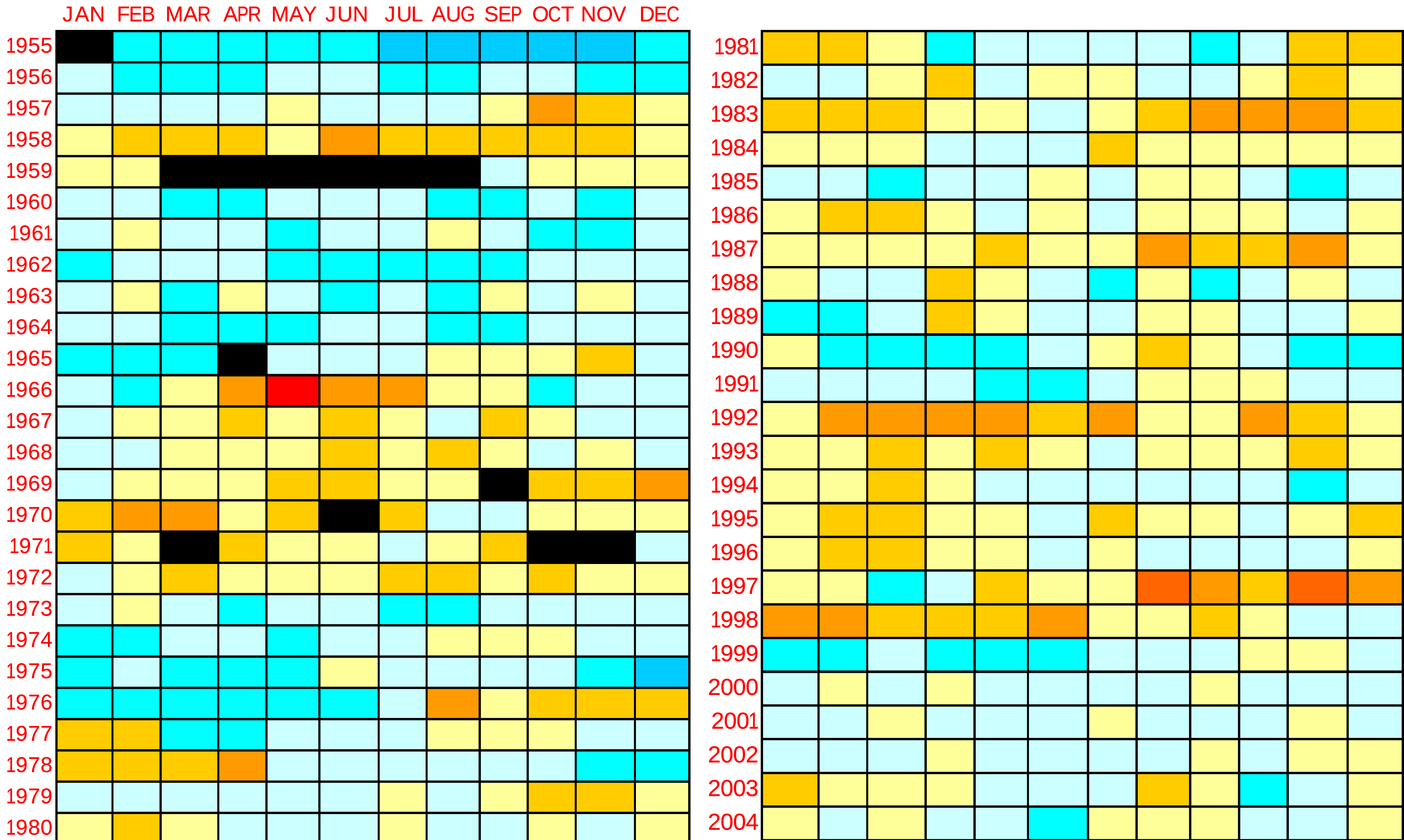


(…in this case, 4 colonies/systems)


Story of Breeding Birds on Islands…

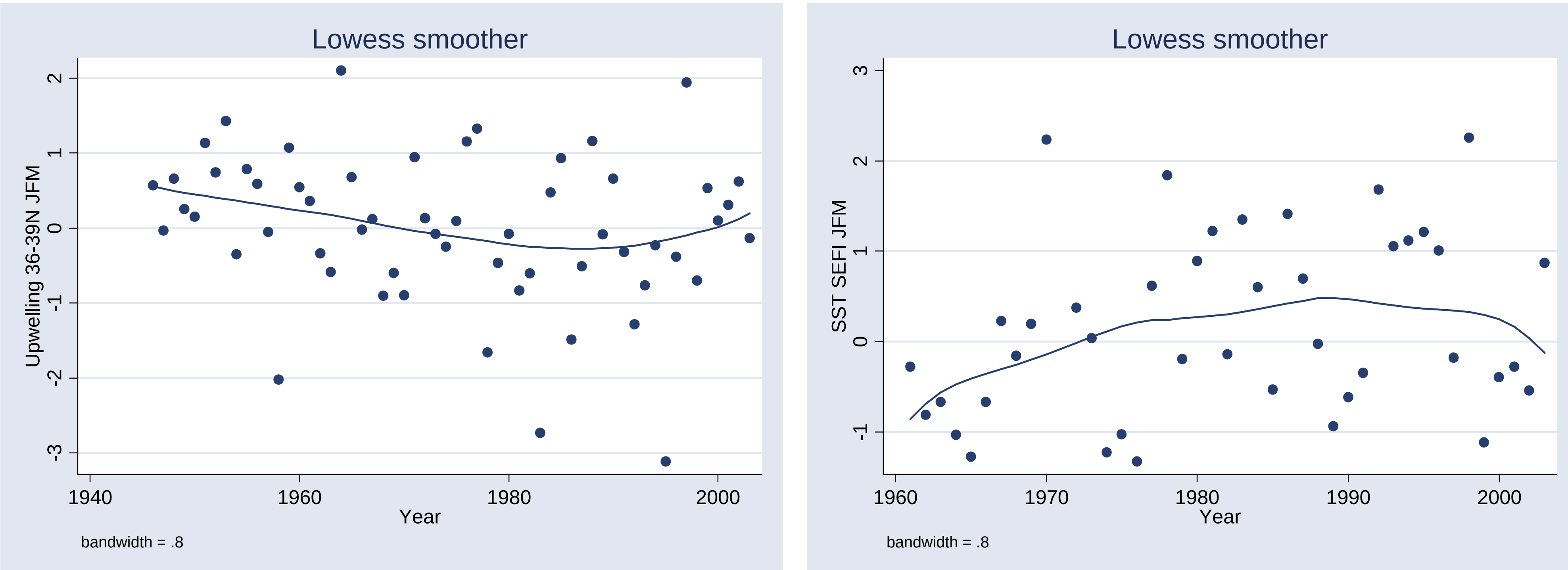

Study area:
central CCS
Farallon I.
1971 - present

Monthly SST Anomalies, California Current

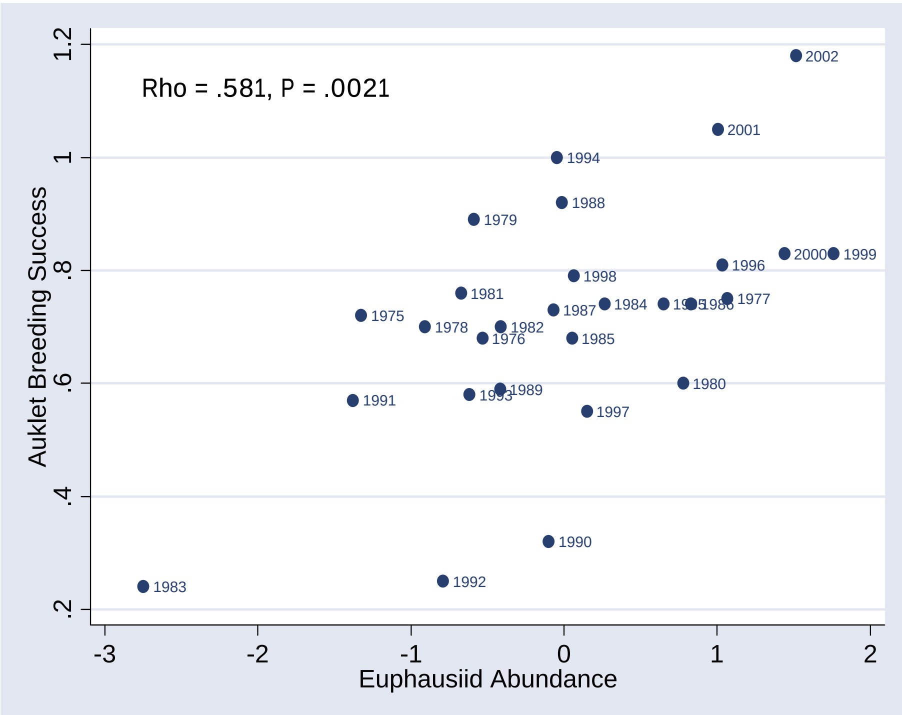


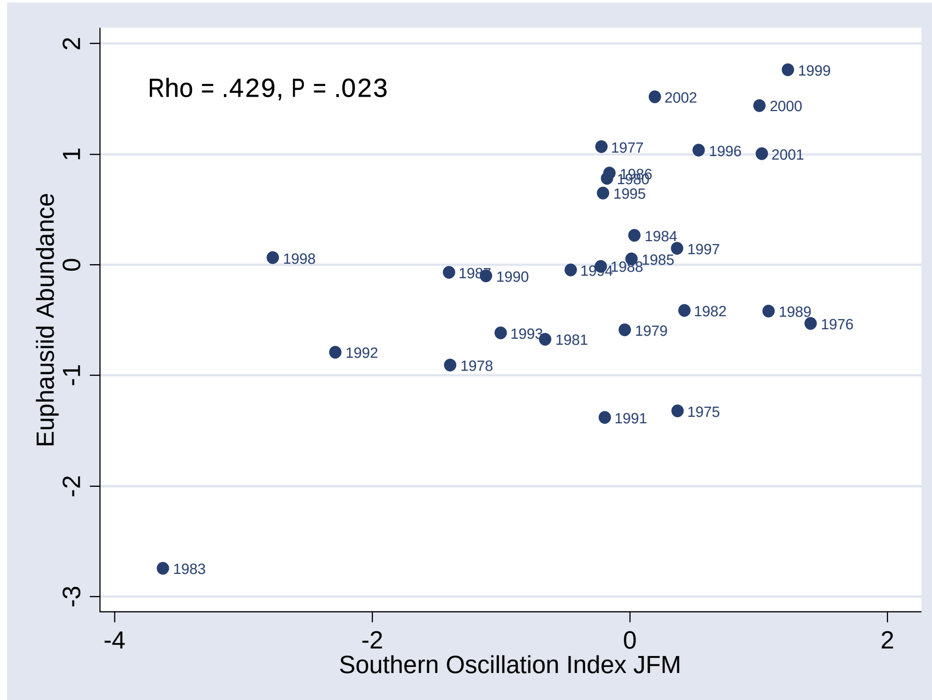
Upwelling & SST, Farallon I. (37º N),

(Rho = -0.638, P<<0.001, n=46)



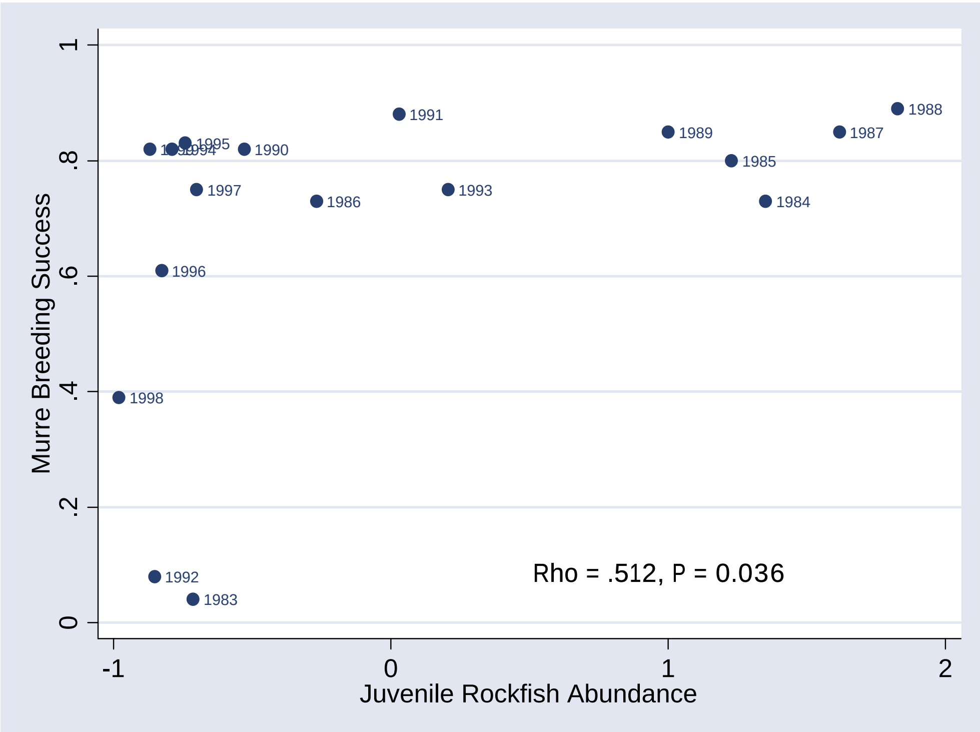
Planktivorous Auklets, Farallon I., CA

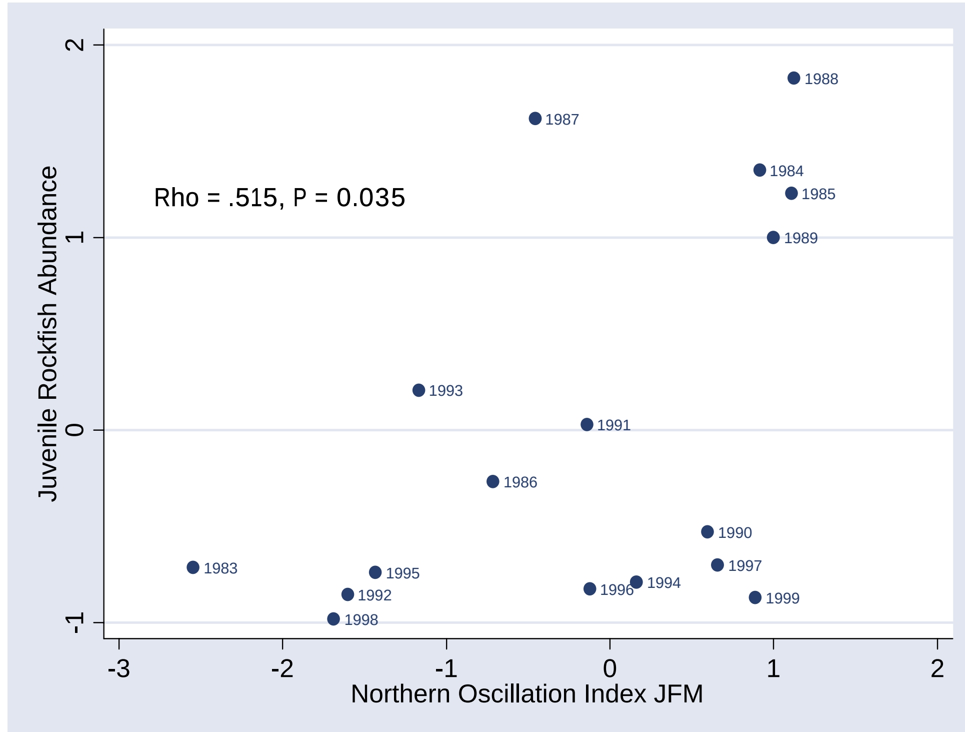




1. **SOI JFM – UI3969 JFM: rho=.339, P = .009**
2. **SOI JFM – SST JFM: rho =-.591, P<<0.001**

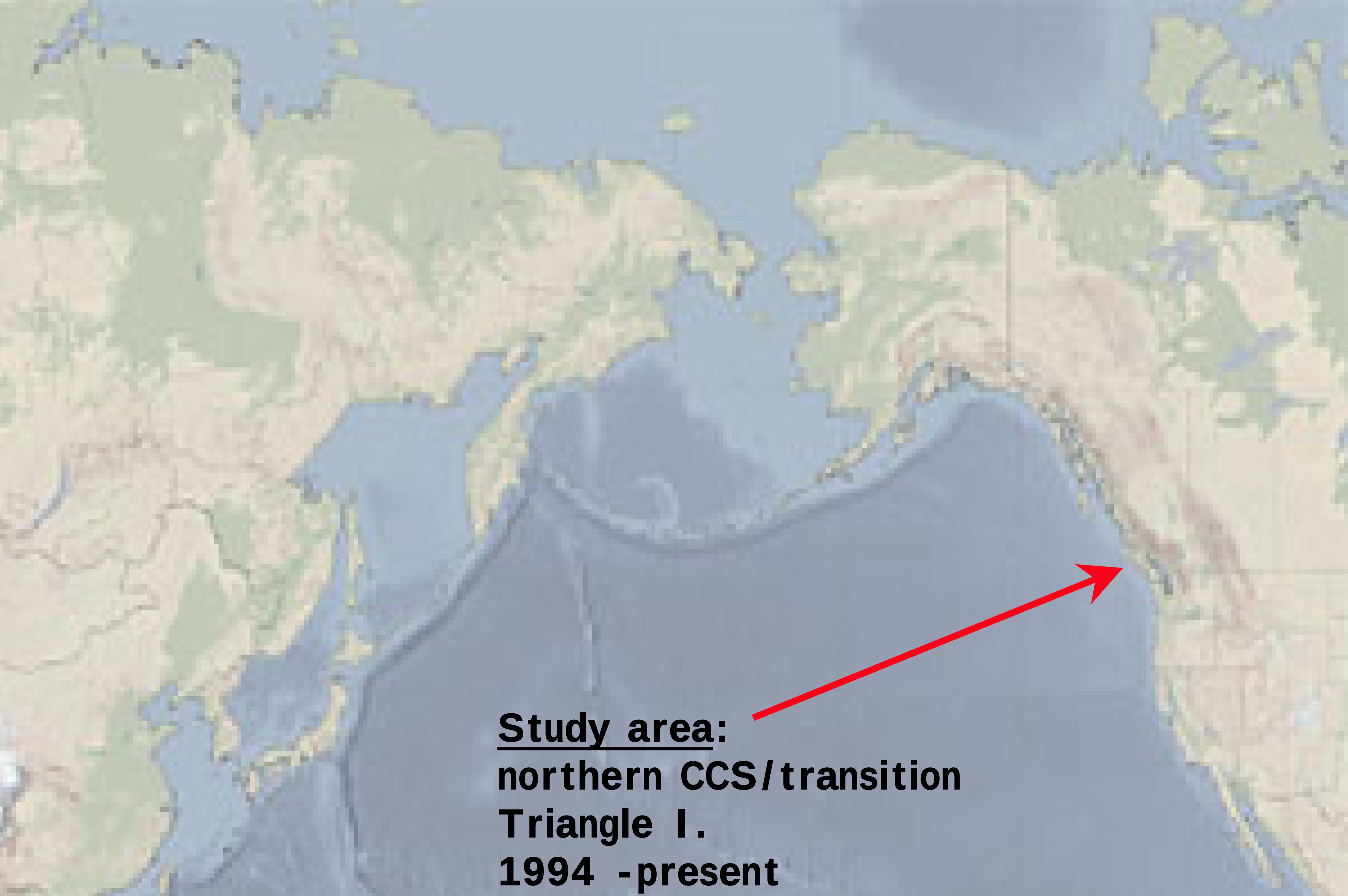
Piscivorous Murres, Farallon I., CA



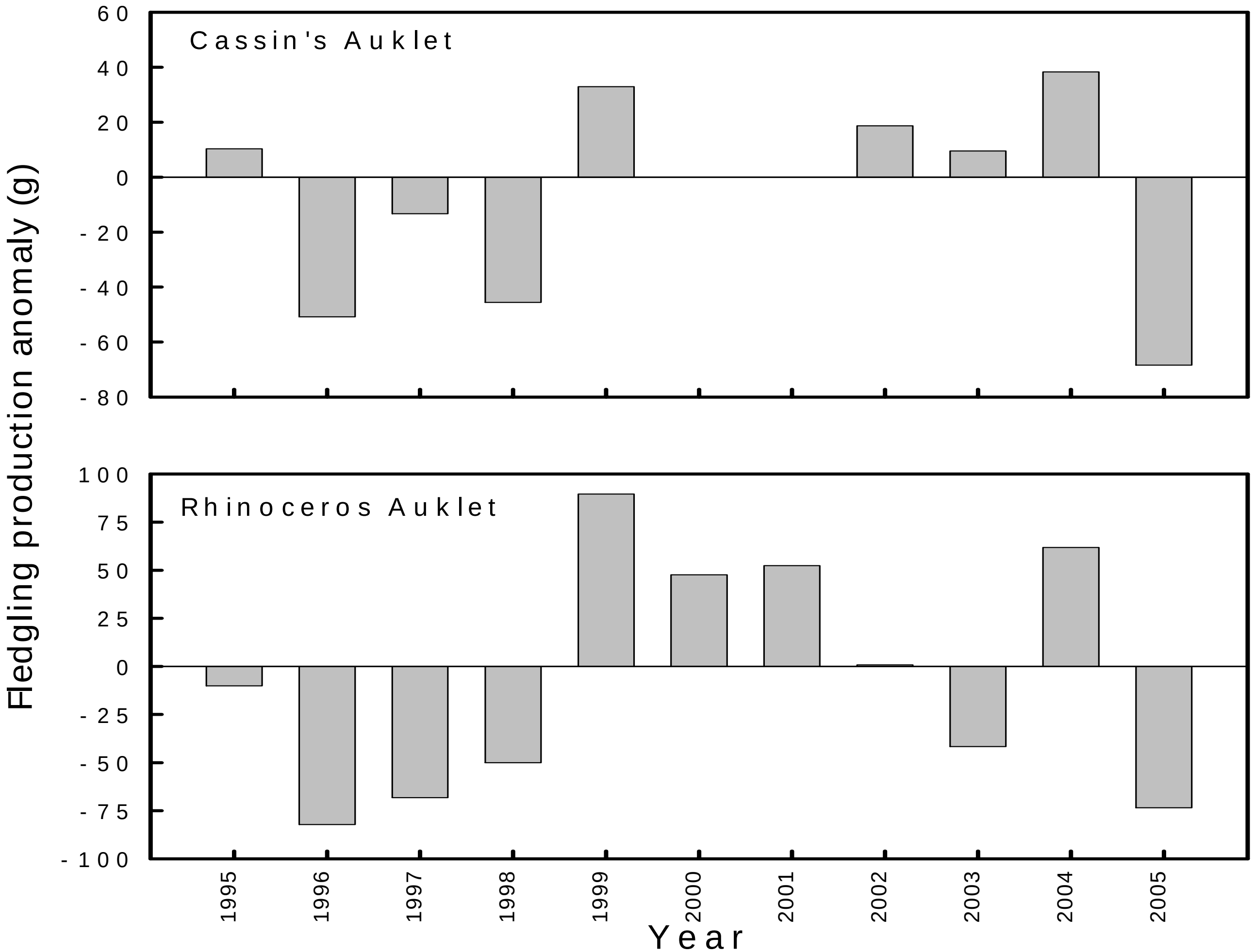


1. **NOI & UI: rho =~.9, P<<0.001**

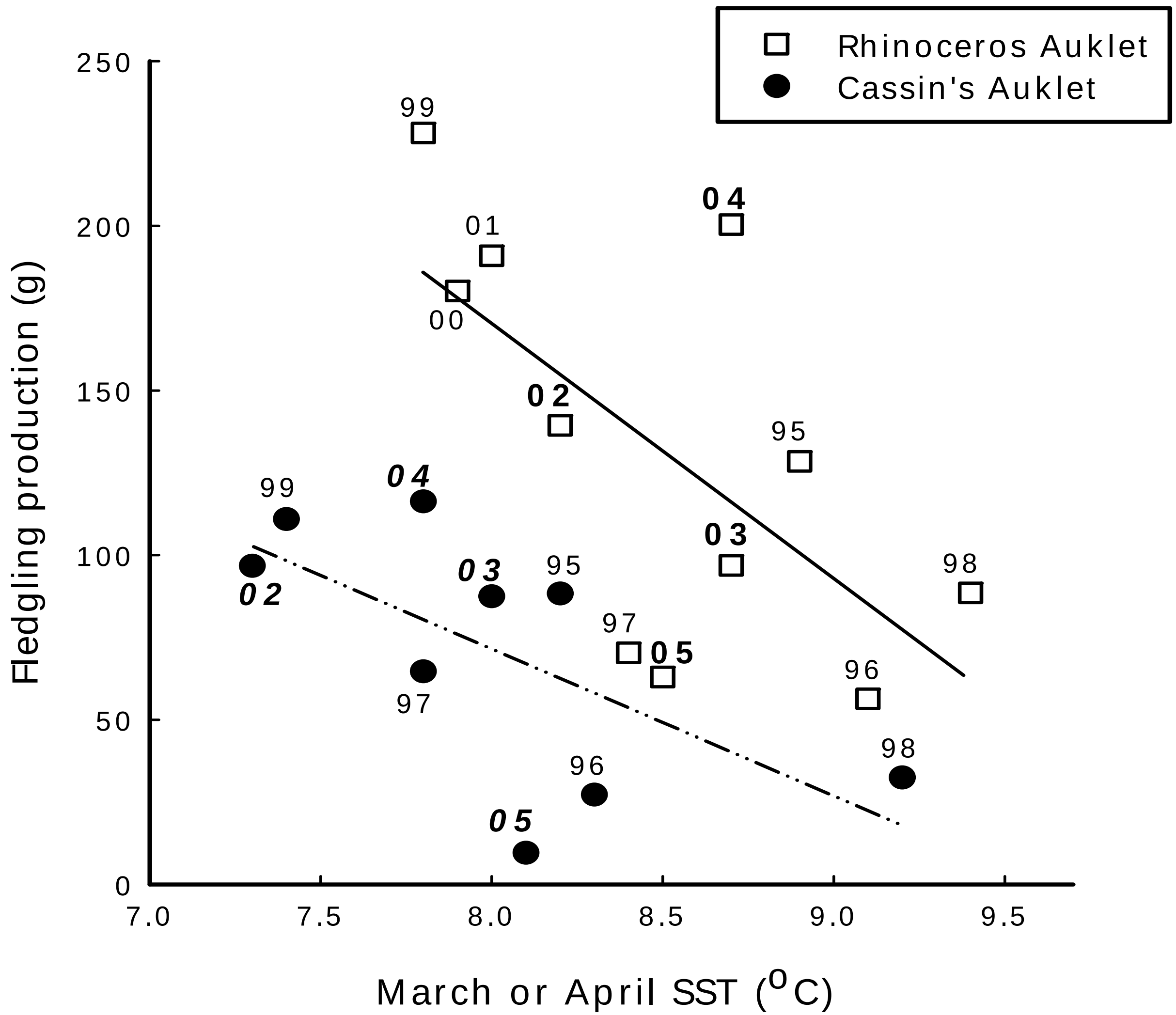
2. **Positive Covariance, Farallon auklets and murres: r2=.25**


Study area:
northern CCS/transition
Triangle I.
1994 -present

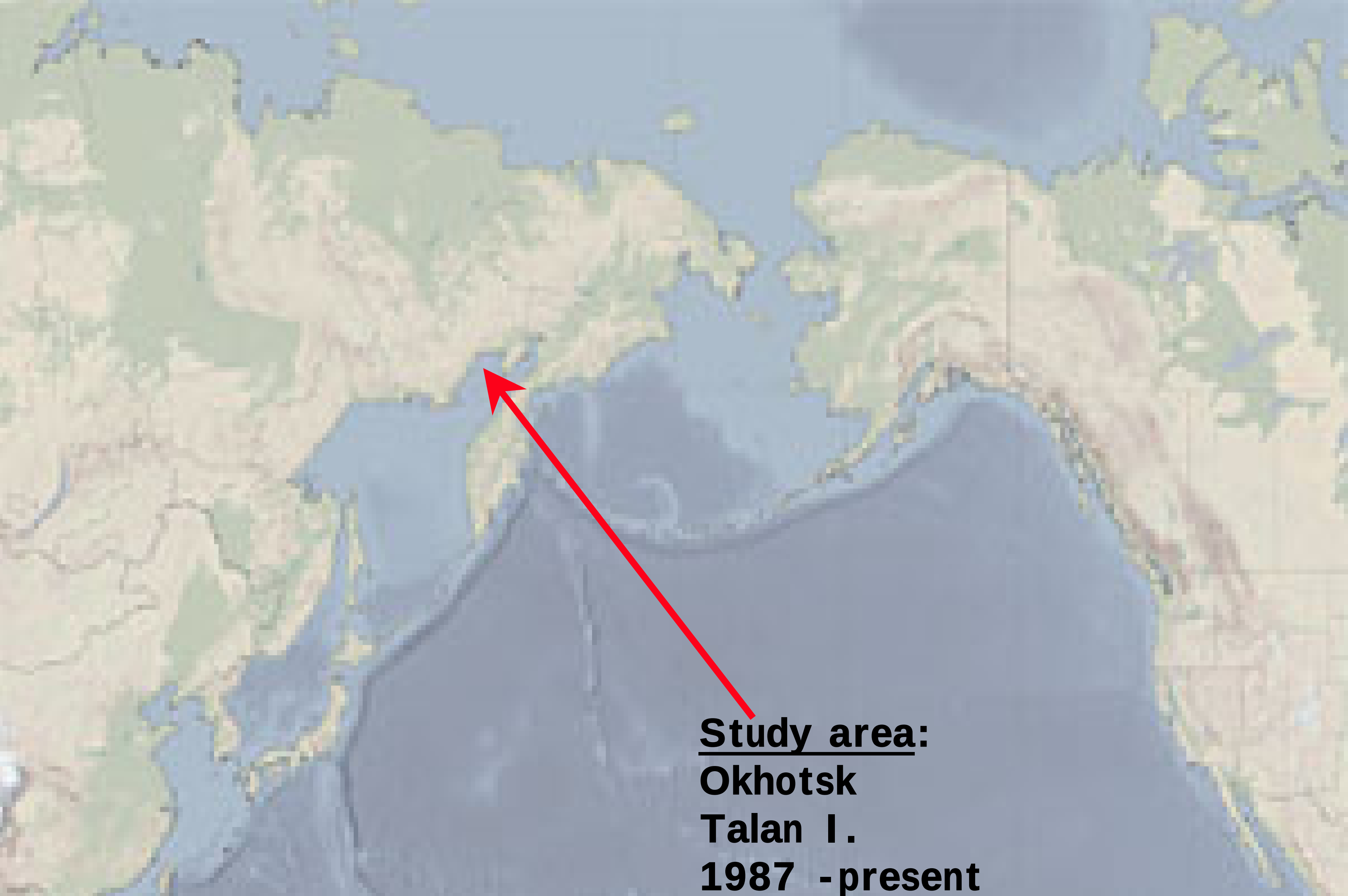
Planktivorous & Piscivorous Auklets, Triangle I.,



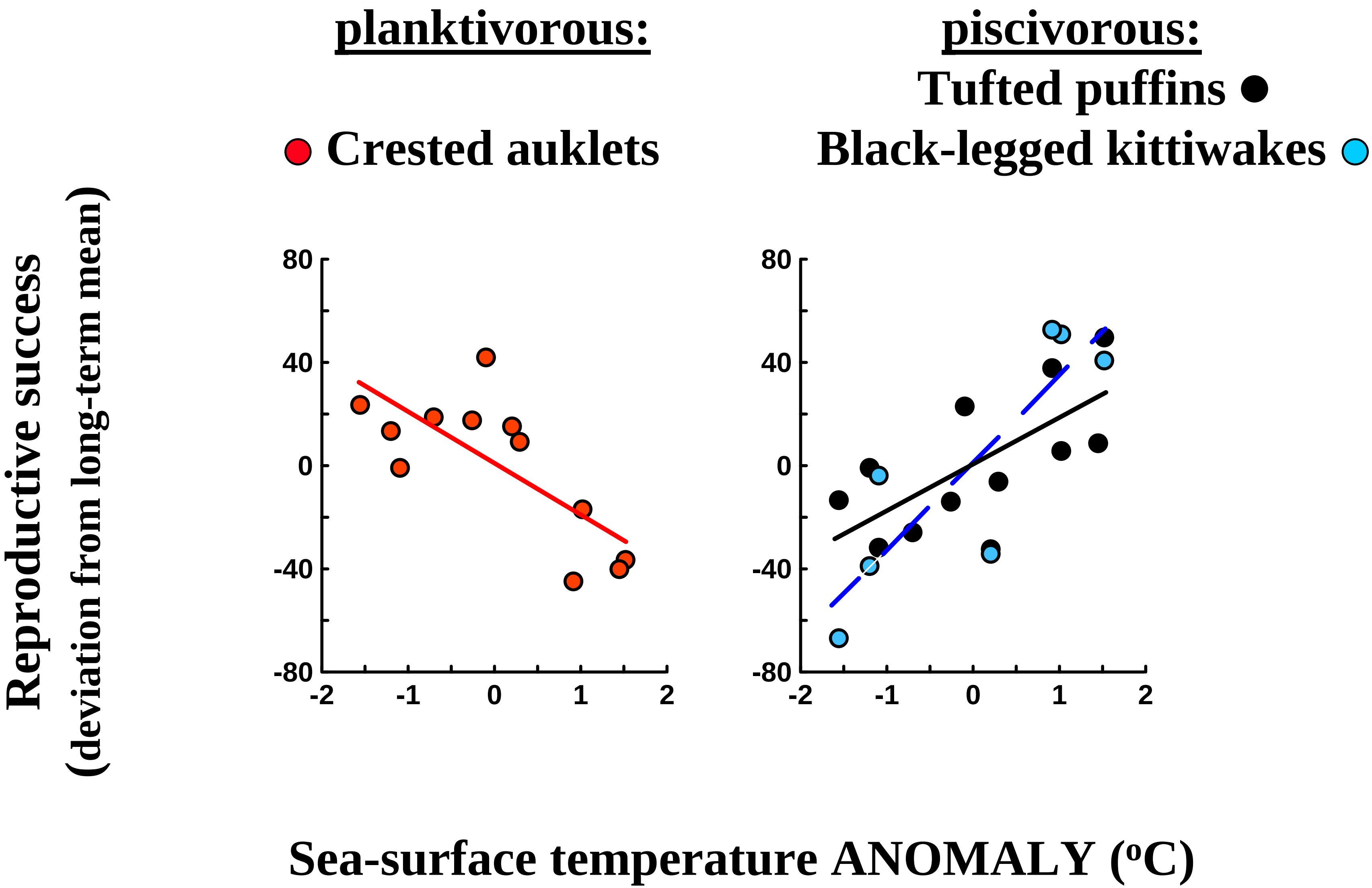
Positive Covariance,
R2 = .89



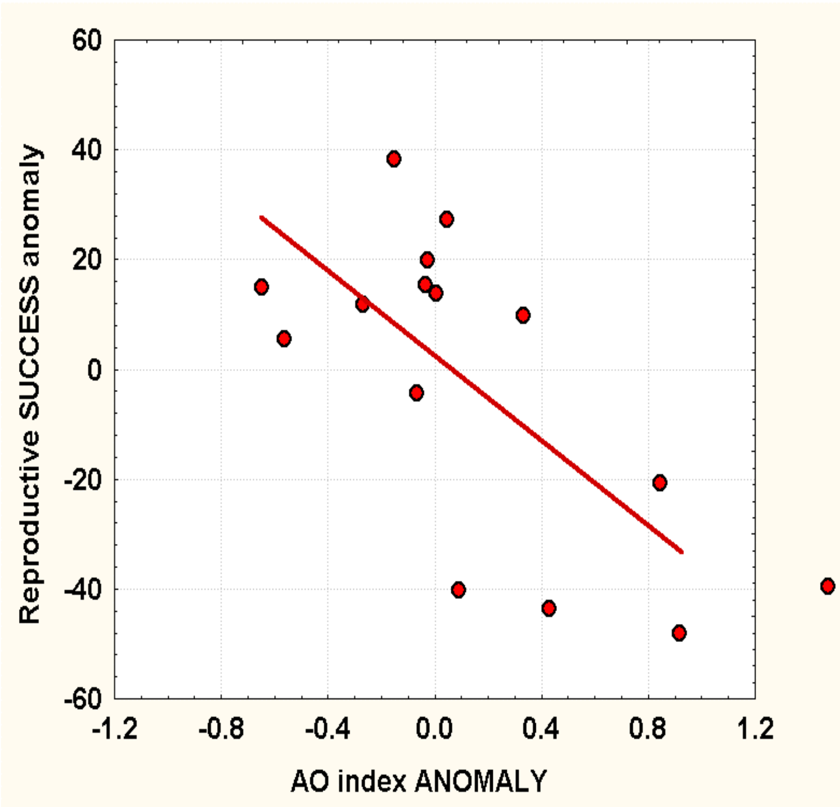
Rhinoceros Auklet
Cassin's Auklet
Fledgling production (g)
March or April SST (°C)
250
200
150
100
50
0
7.0
7.5
8.0
8.5
9.0
9.5
99
01
00
04
02
95
03
98
97
05
96
99
04
02
03
95
97
96
05
98

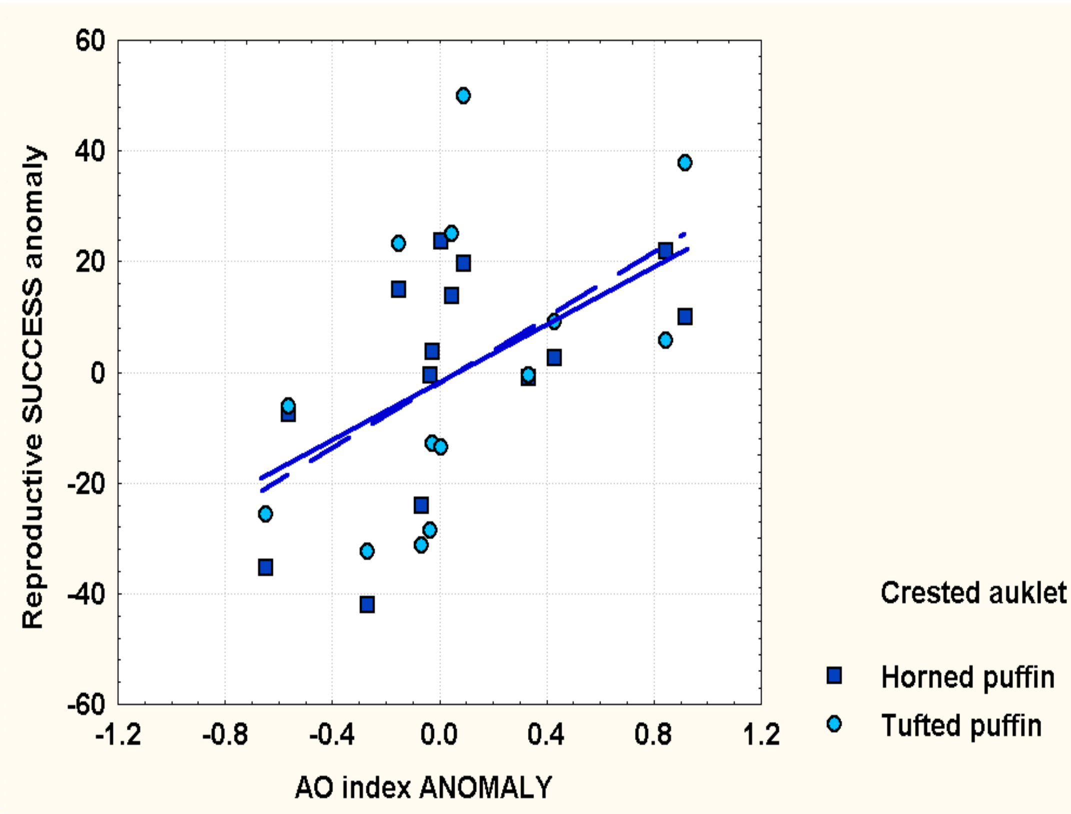

Study area:
Okhotsk
Talan I.
1987 -present

Talan I.
1987-2001



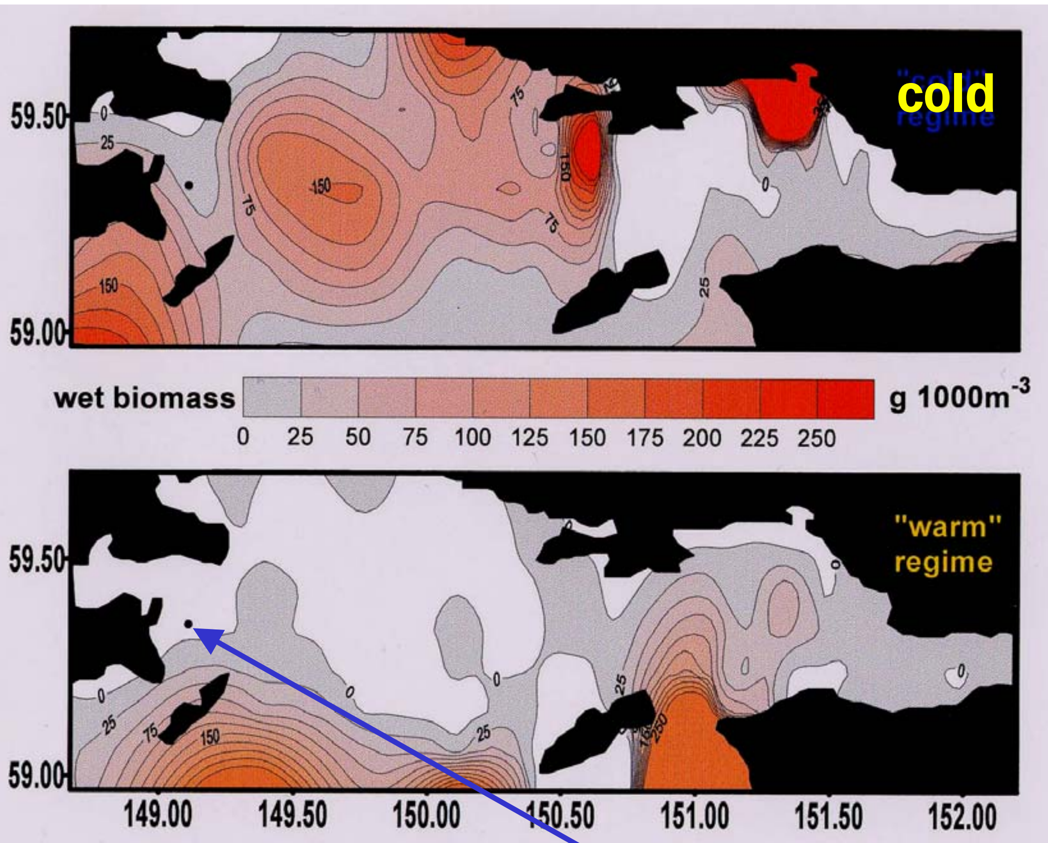
Talan I., 1987-2003 (Kitaysky and Globuva, unpubl.)



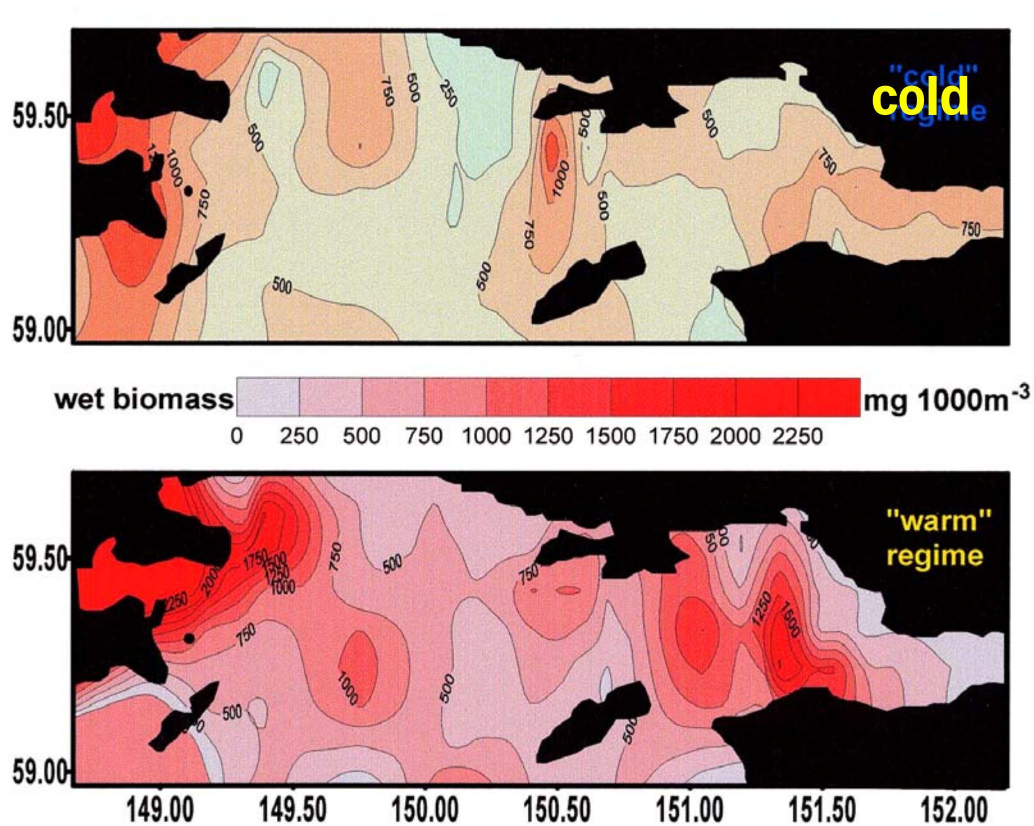


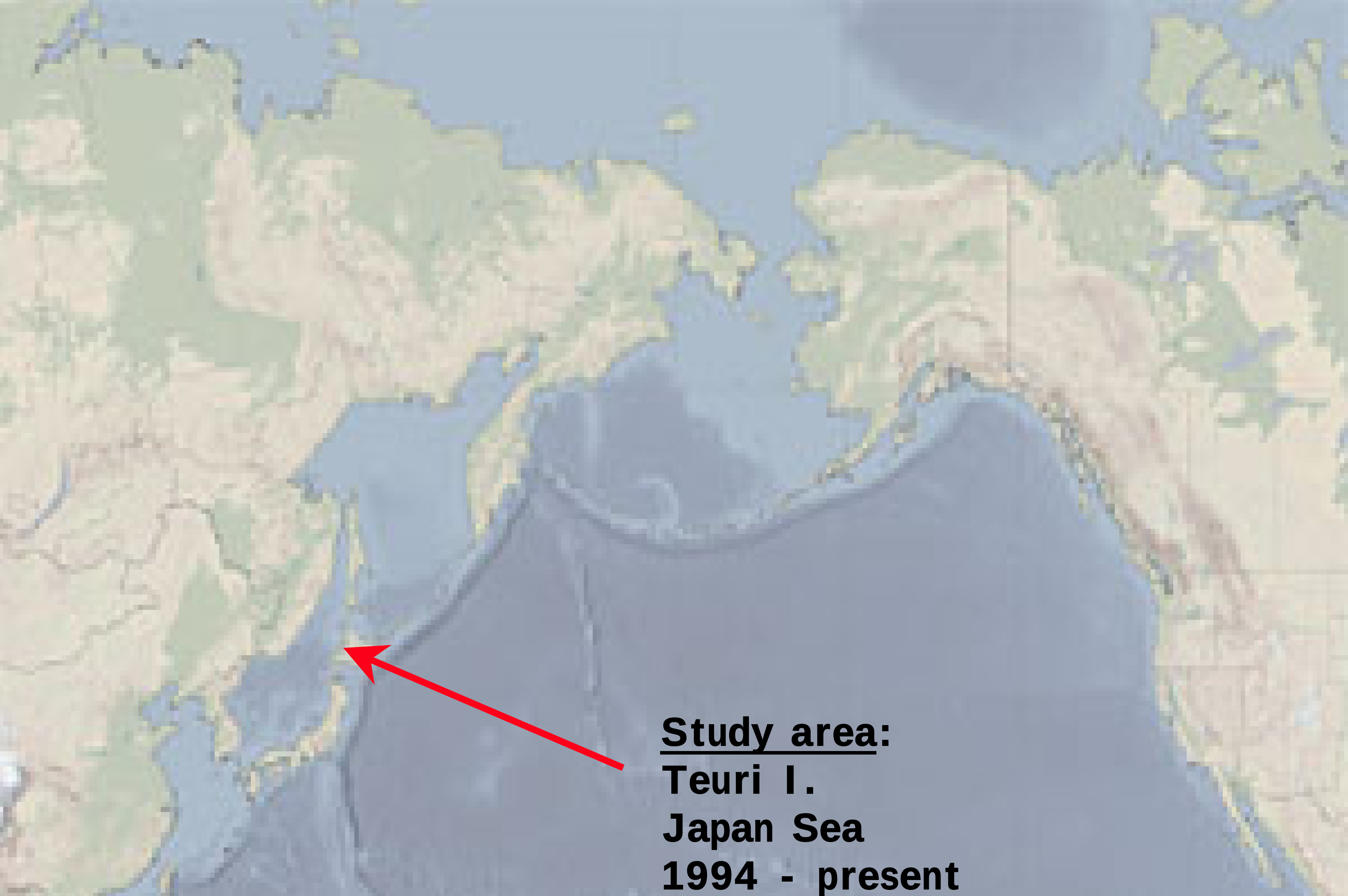
Zooplankton, Talan I., Russia (Kitaysky and Globuva 2000)

Distribution of adult euphausiids
Thysanoessa rashii
(major prey of planktivorous auklets)

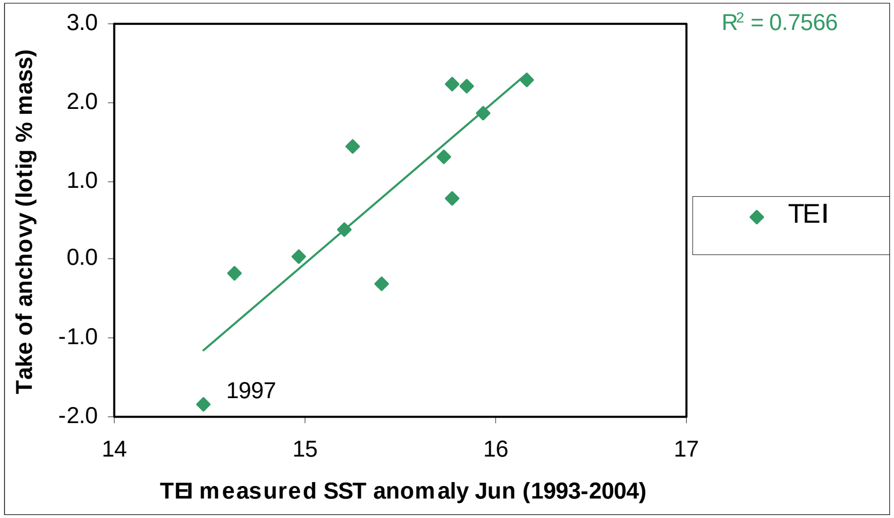


Distribution of *Acartia* and calanoid copepods (major prey of forage fish)

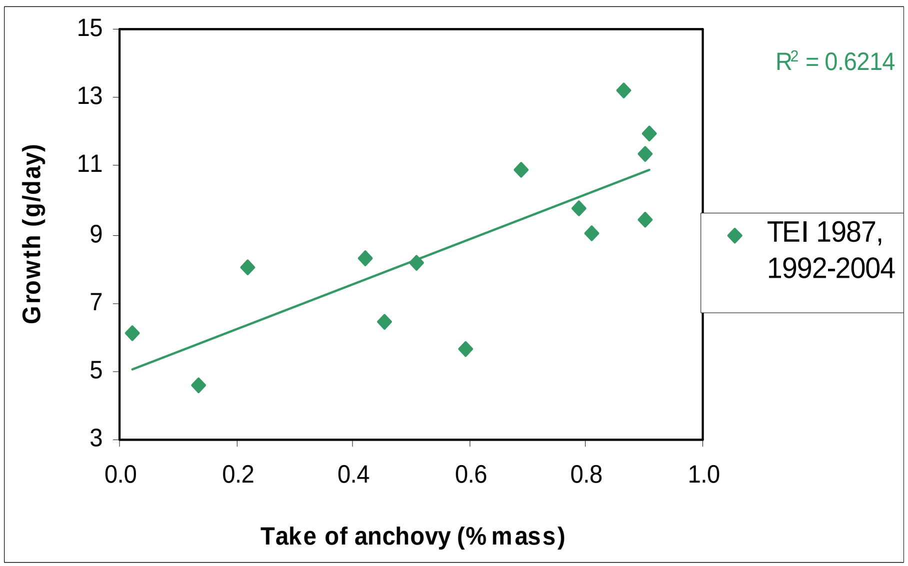


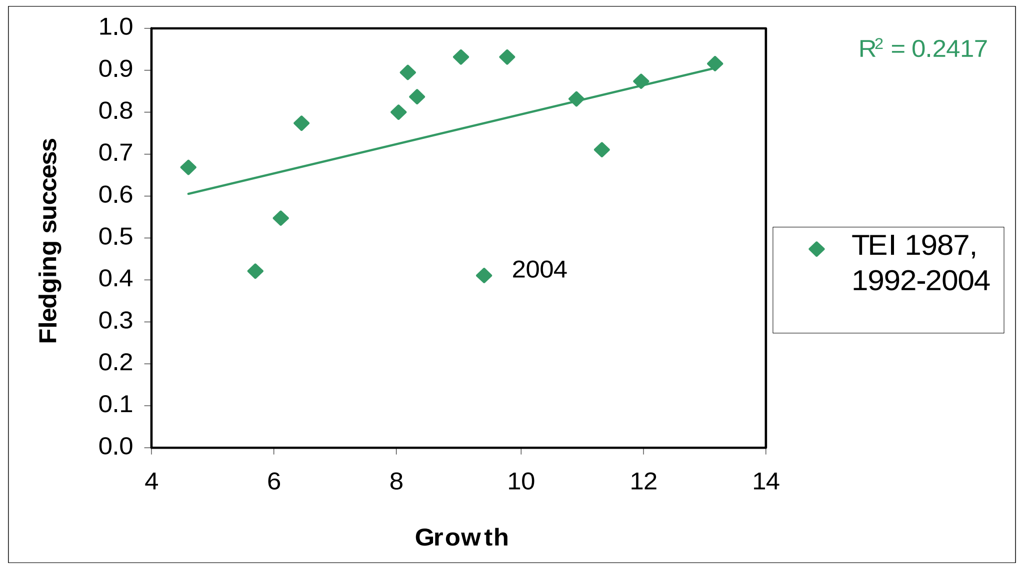

Study area:
Teuri I.
Japan Sea
1994 - present

Japan Sea, Teuri I. (Deguchi et al. 2004, Watanuki unpubl.)



...and anchovy abundance related to strength and inflow of the Tsushima warm current in Japan Sea





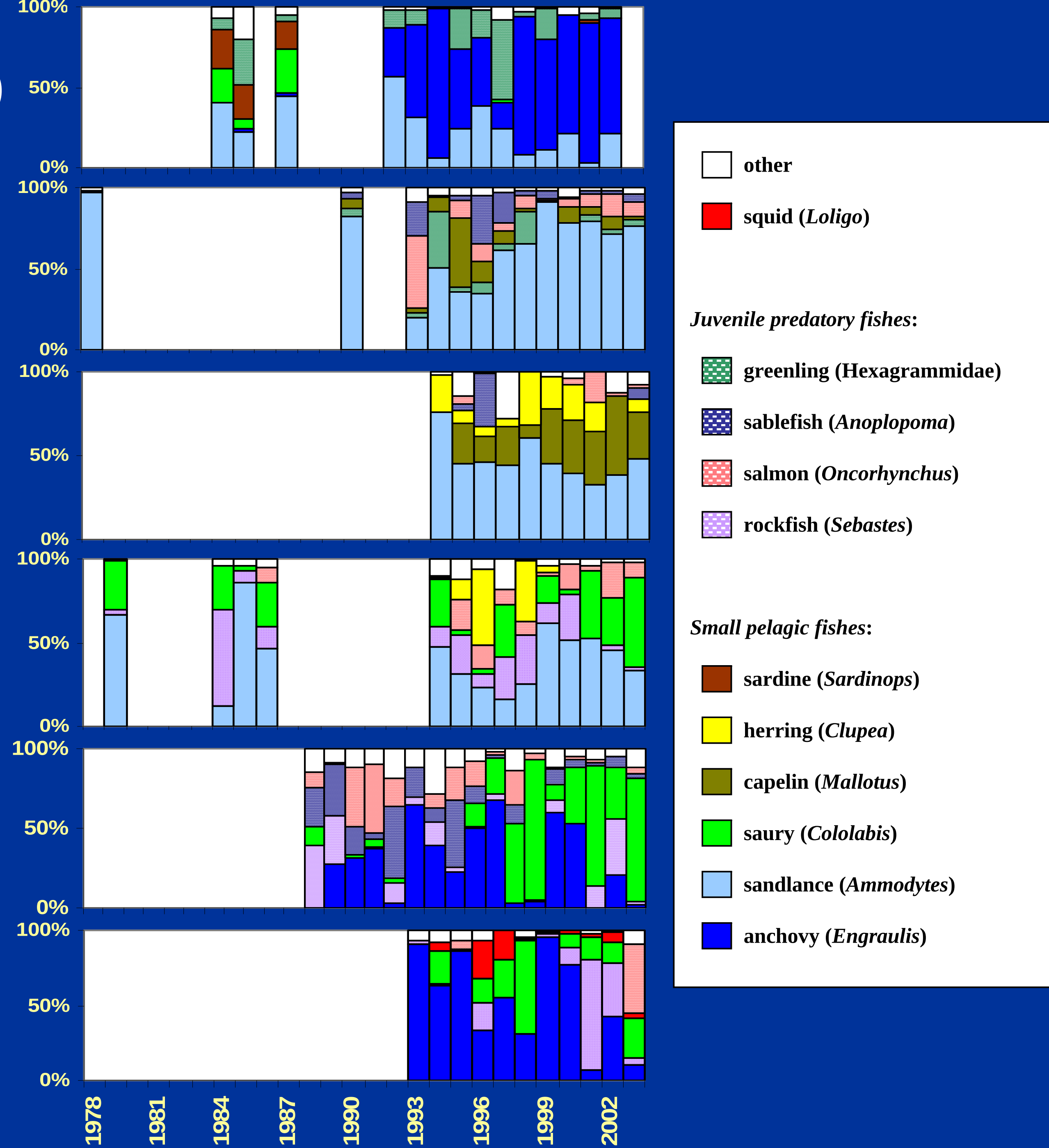
Japan Sea (increase anchovy)

w GOA (increase sandlance)

e GOA (decrease sandlance)

n CCS (variable sandlance, increase saury)

central CCS (decrease rockfish, decrease anchovy, increase saury)



(Thayer et al. unpubl.)

Summary and Conclusions – Seabirds and Climate Change

1. Planktivores and piscivores? East, positive co-variation; West, negative co-variation (Talan I.).
2. Effects of local SST on breeding success? Yes, negative in CCS and Okhotsk, but positive in Japan (depends on mechanism); generally, relationships are negative.
3. Effects of remote forcing? Yes, sometimes better correlations than with local indices (e.g., Farallones).
4. Functional relationships with food? Yes, some linear, some not.
5. Diet. As $2^{o}/3^{o}$ consumers, seabirds reveal climate-driven forage fish variability, which is important to seabirds, but other “upper trophs” as well.
6. This “mini” meta-analysis is reflective of only 1 demographic process (fecundity) and one scale (interannual)…