Seabirds, fish prey and ocean climate: Patterns of Synchrony in the N Pacific

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Introduction

- Inter-annual to inter-decadal changes in the environment are evident in the N. Pacific
- Influence of these factors on marine top predators has not been adequately quantified
- Important to examine synchrony in responses by these taxa to climate variability, describing and testing mechanisms of environmental forcing from physics to prey

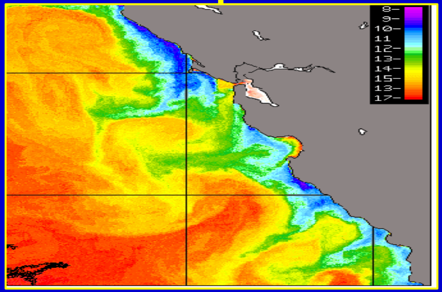
Marine Top Predators and Climate Change

- Effects of climate change are mostly indirect, operating through predator-prey relationships
- Inverse abundances in GOA vs. CCS (zooplankton, salmon, groundfish, some pelagics)
  - **Linked to strength of Aleutian Low vs. Monterey High Pressure**
- Some synchrony between CCS & Japanese waters (sardine)
  - **May be related through basin-scale atmospheric teleconnections since both Kuroshio & California Currents driven by wind stress**
- Yet, large-scale climate signals may be altered by regional processes as well as temporal variability, leading to divergent and asynchronous ecosystem responses

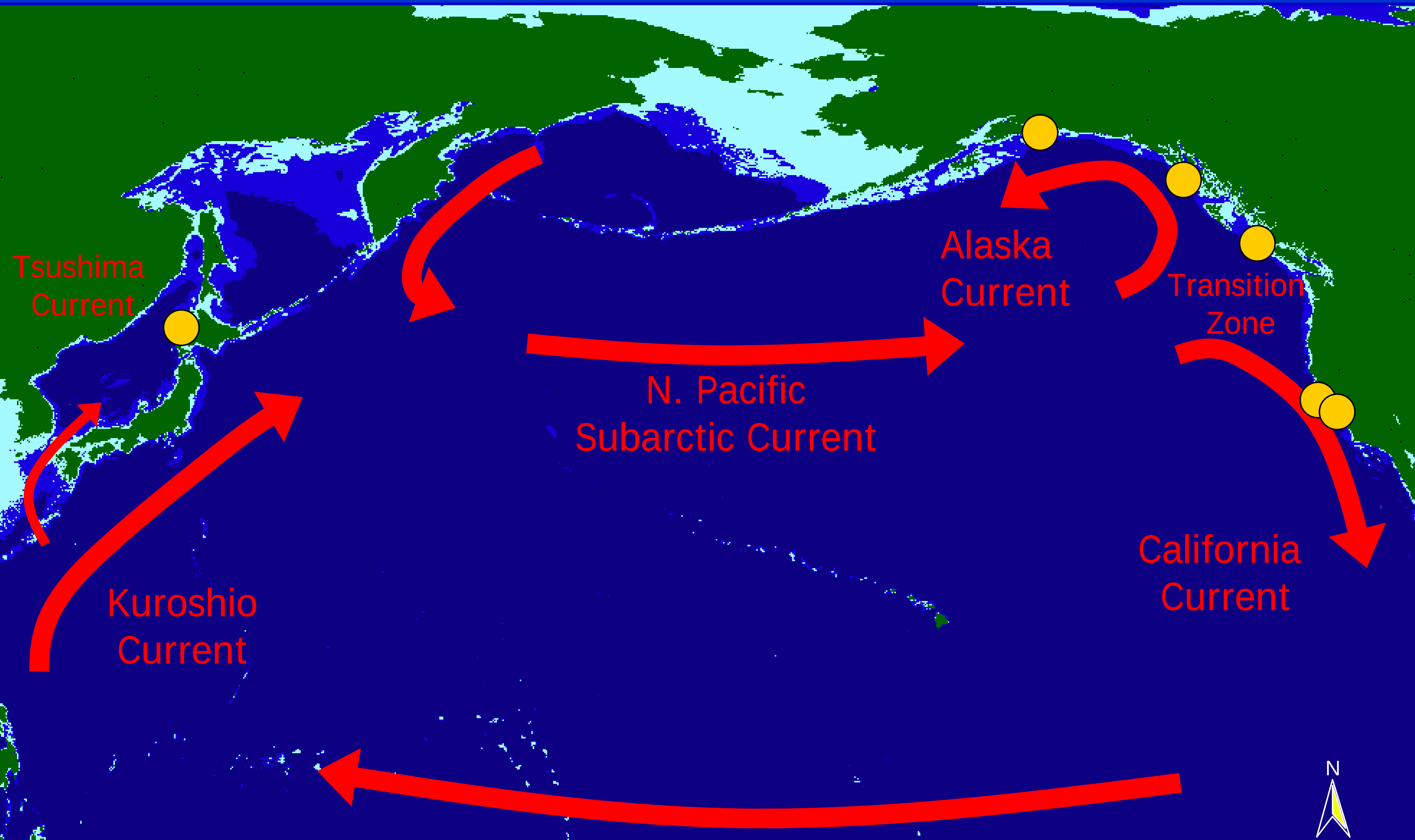
Questions

Are correlations and pathways of response between climate and top predators similar or dissimilar between coastal N Pacific marine systems (CCS, GOA, Japan Sea)?

- Does SST co-vary between regions (evidence of remote forcing)?
- Does forage fish prey co-vary?
- Do rhinoceros auklet reproductive responses co-vary?
- What are oceanography-fish-bird relationships within each region?



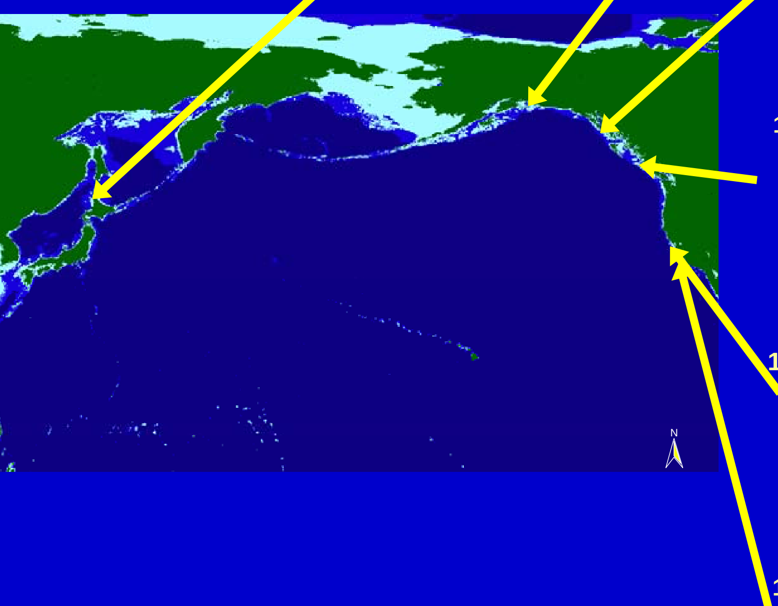
North Pacific Currents

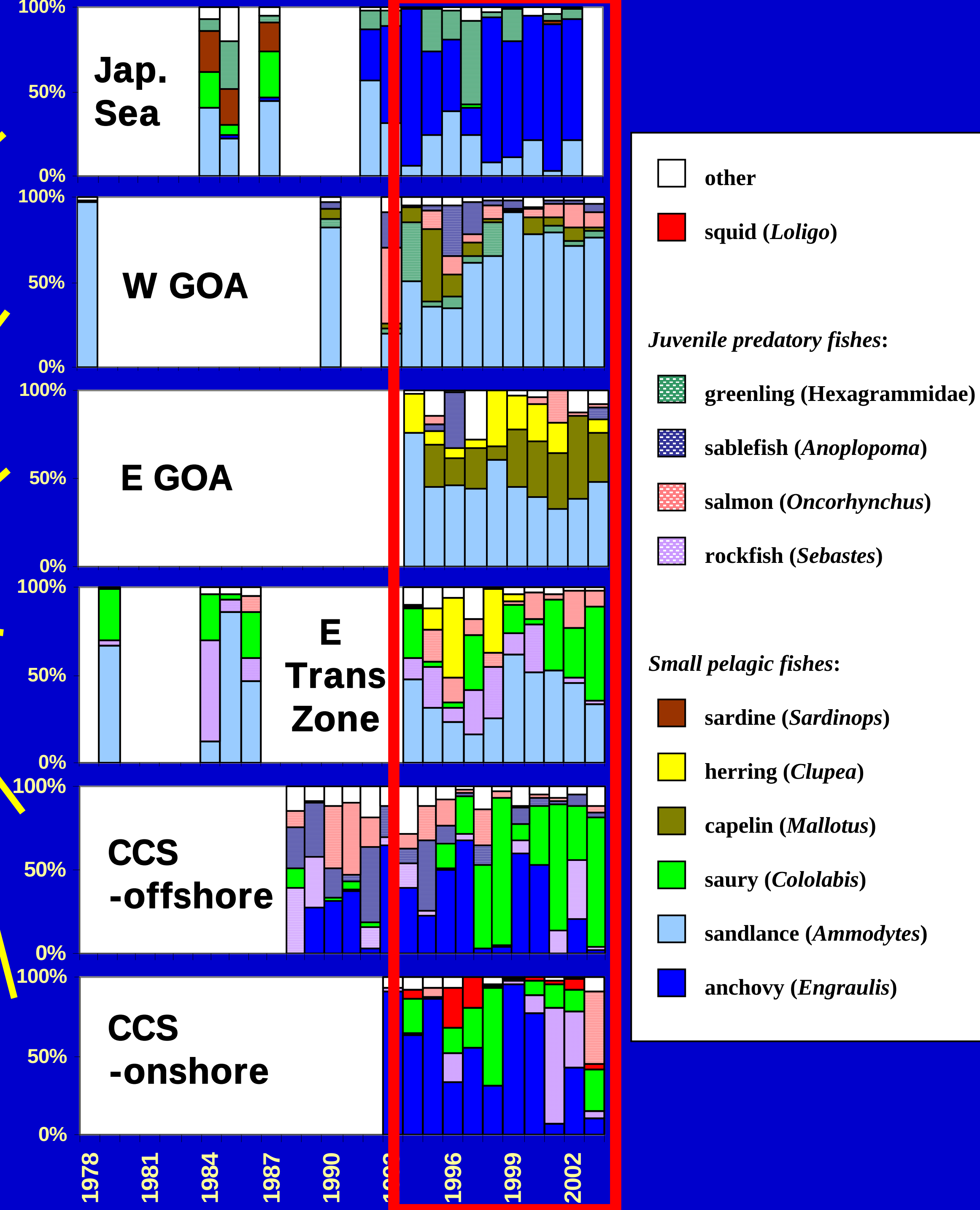


Tertiary Consumer: Rhinoceros Auklet (*Cerorhinca monocerata*)

- Ranges throughout N Pacific rim
- Diving seabird attains depths of 60m (avg 15m)
- Preys on mid-water schooling fishes
- Fishes sampled from auklets provisioning young in summer

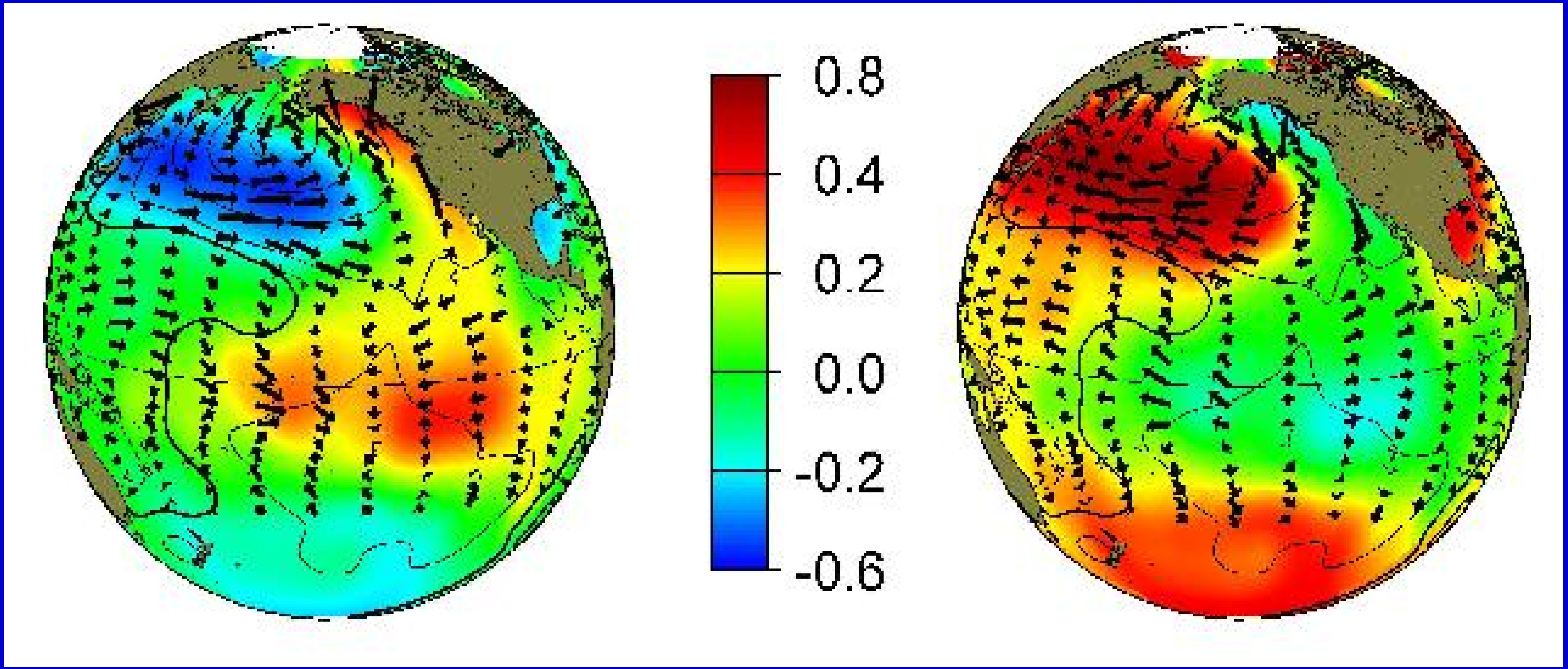
% Number Rhinoceros Auklet Diet





Spatial Covariation in SST between Eastern and Western N. Pacific, illustrated by PDO

“Positive” “Negative”



N. Mantua

Covariation in SST 1994-2003

p ≤ 0.10

Winter
(Dec-Feb)

		W Pacific	E Pacific			
Lat	Site	Jap Sea	WGOA	EGOA	Trans	CCS-off
59°	WGOA	-				
56°	EGOA	-	+			
50°	Trans	-	+	+		
37°	CCS-off	-	+	+	+	
37°	CCS-in	-	+	+	+	+

Spring
(Mar-May)

59°	WGOA	+				
56°	EGOA	+	+			
50°	Trans	+	+	+		
37°	CCS-off	+	+	+	+	
37°	CCS-in	+	+	+	+	+

Summer
(Jun-Aug)

59°	WGOA	-				
56°	EGOA	-	+			
50°	Trans	-	+	+		
37°	CCS-off	-	+	+	+	
37°	CCS-in	-	+	+	+	+

Covariation of main forage fish 94-03

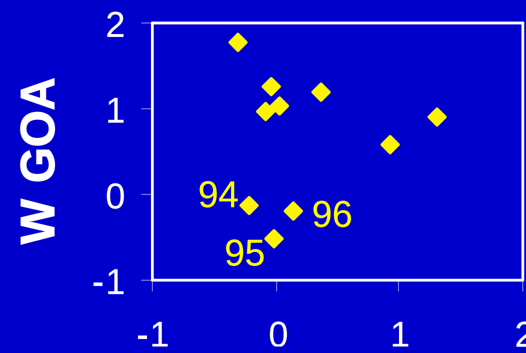
$p \leq 0.10$

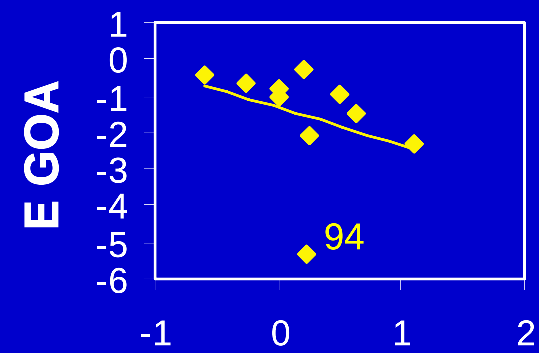
		W Pacific	E Pacific			
Lat	Loc	Jap Sea	WGOA	EGOA	Trans	CCS-off
59°	WGOA	0				
56°	EGOA	0	+			
50°	Trans	0.48	0.48	0.41		
37°	CCS-off	+	+	+	+	
37°	CCS-in	+	+	+	+	+

W PACIFIC

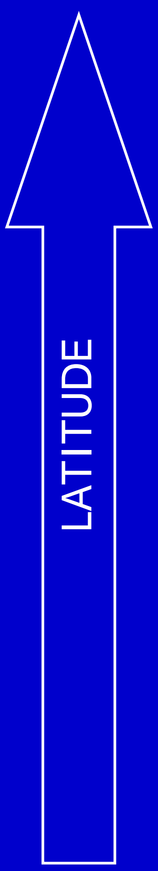
E PACIFIC

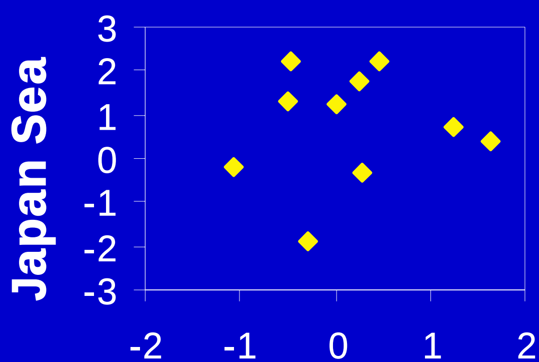
Forage fish – SST relationships 1994-2003

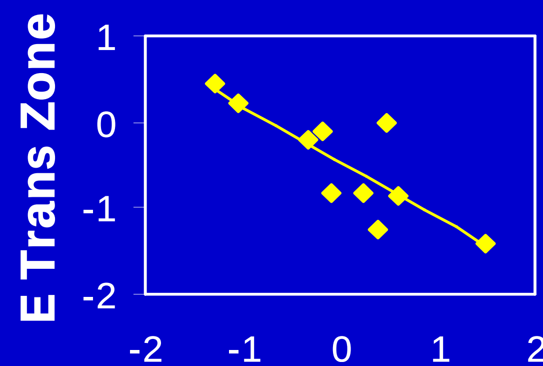


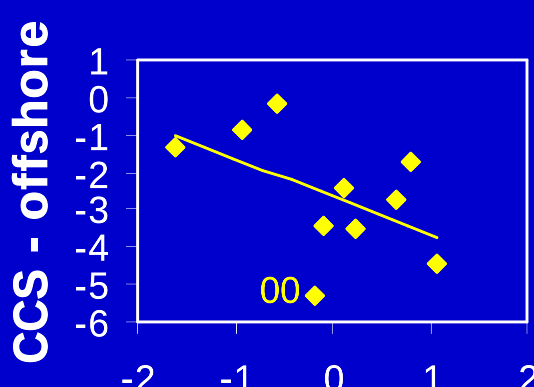


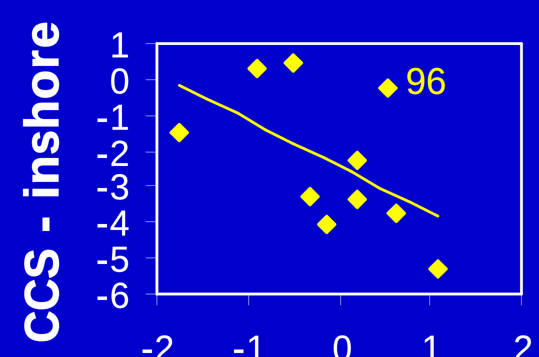
SST Spring











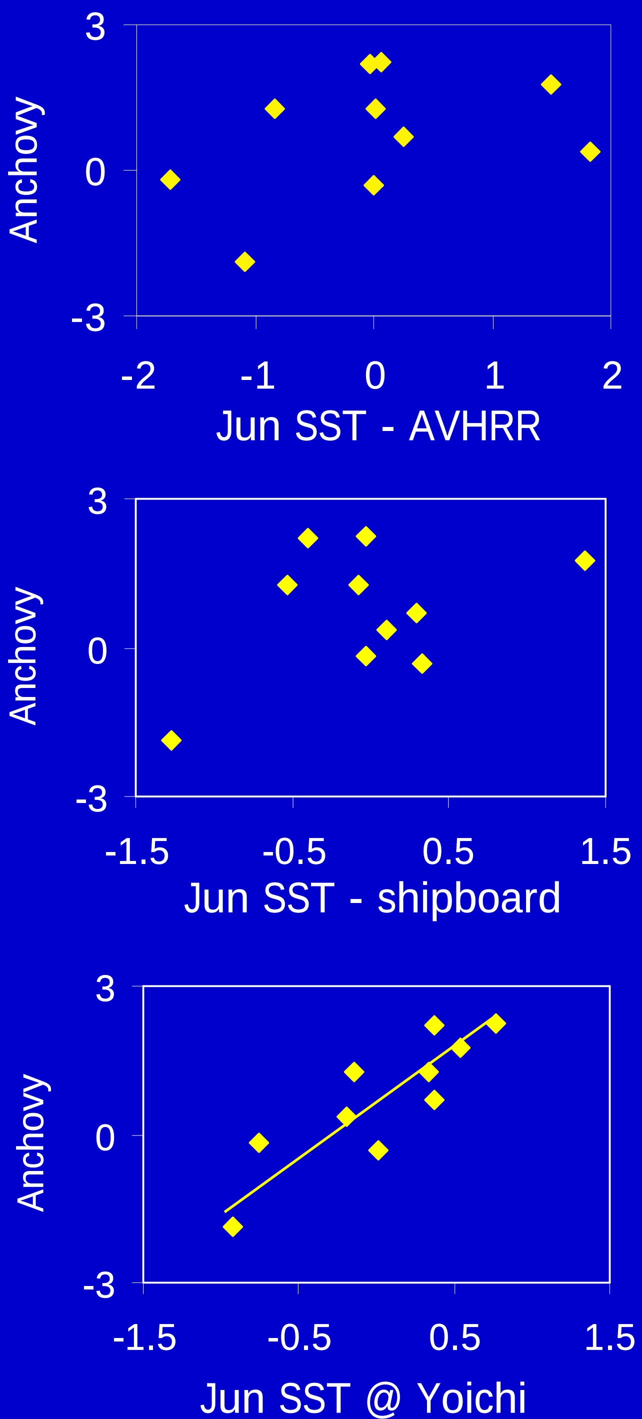
SST Summer

Japan Sea – Tsushima Warm Current

Deguchi et al. (2004) found regional influx of anchovy:

- higher with higher SST (shipboard measurements)

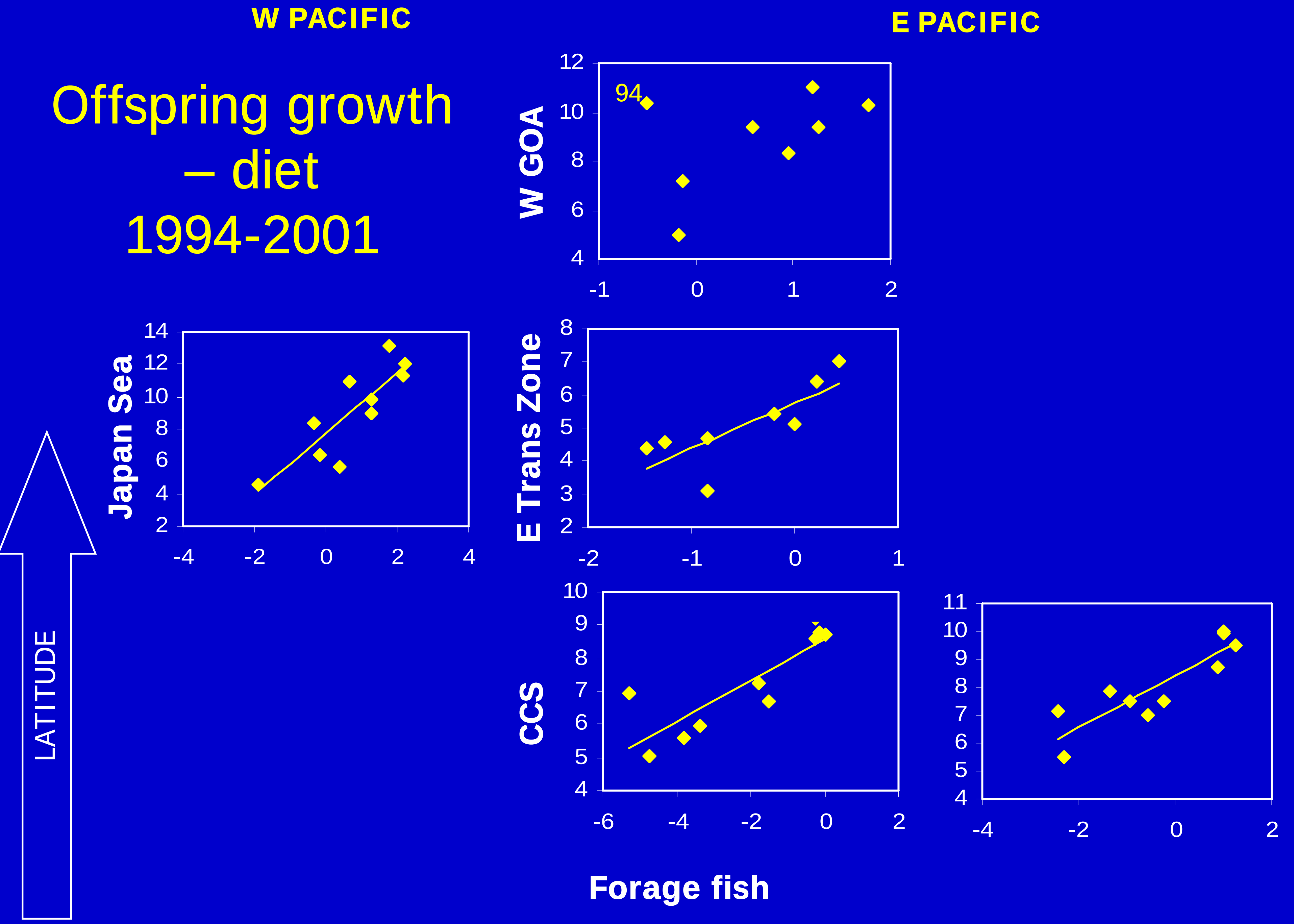
- higher with stronger Tsushima Warm Current flow in summer



Covariation of auklet offspring growth 1994-2001

$p \leq 0.10$

		W Pacific	E Pacific			
Lat	Loc	Jap Sea	WGOA	EGOA	Trans	CCS-off
59°	WGOA	+				
56°	EGOA		*data not yet available*			
50°	Trans	+	+			
37°	CCS-off	+	+		+	
37°	CCS-in	+	+		0.40	+


W PACIFIC
E PACIFIC
Offspring growth – diet 1994-2001
W GOA
12
10
8
6
4
-1
0
1
2
94
Japan Sea
14
12
10
8
6
4
2
-4
-2
0
2
4
E Trans Zone
8
7
6
5
4
3
2
-2
-1
0
1
CCS
10
9
8
7
6
5
4
-6
-4
-2
0
2
11
10
9
8
7
6
5
4
-4
-2
0
2
LATITUDE
Forage fish

Diet-growth-productivity relationships

Confounding factors:

- 2 different-sized preferred prey spp. in CCS
- Rockfish available early in season, anchovy eaten later

Growth – productivity relationship not significant in CCS

Summary: E-W relationships

		no lag	
SST		- (sig)	all sites (depending on season)

Fish		0	GOA
		+ (almost sig)	E Trans Zone
		+	CCS

Bird offspring growth		+	GOA
		+ (sig)	E Trans Zone
		+	CCS

Conclusions

Synchrony in SST, forage fishes, seabird responses?

- SST: regional synchrony in East, E-W out of phase
- Fish: regional synchrony in East, E-W in-phase for CCS
- Bird offspring growth: regional synchrony in East (although less), West positively linked w/ E Trans. Zone

Marine climate (SST) influences top predator responses, although mechanisms by which this occurs may be different between regions

Relationships of physics to predators need to be examined *within* regions to give insight into large scale covariation