Top- and mid-trophic level responses to ocean conditions off central California

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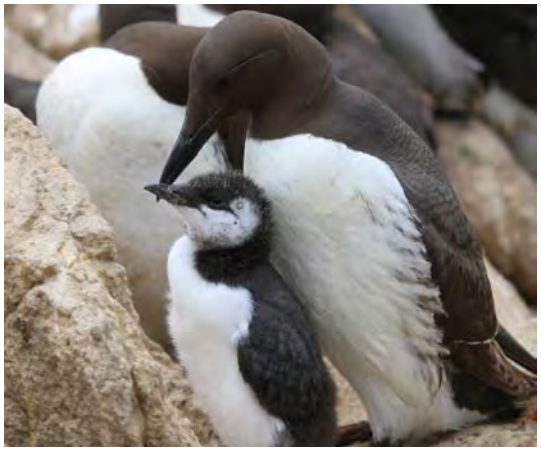

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Questions

How does physical forcing at the regional (e.g., UI and spring transition) and basin scale (e.g., the PDO, NPGO and ENSO) affect predators and prey off central California?

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Conclusions

Cold-productive conditions are best!

- **Early spring transition** and **La Niña-like (SOI) winters** were important for **early breeding**
- **Early breeding, high NPGO winters, strong spring upwelling,** and **Cool PDO springs** were important for **breeding success** and **prey availability**

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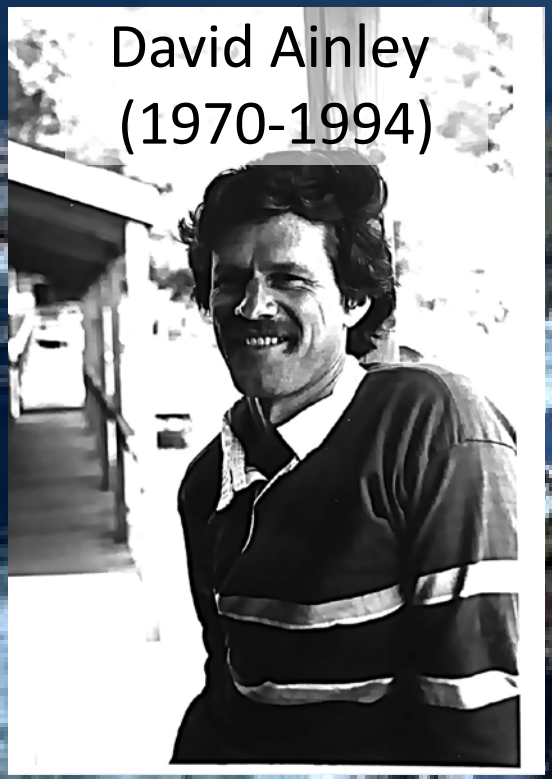
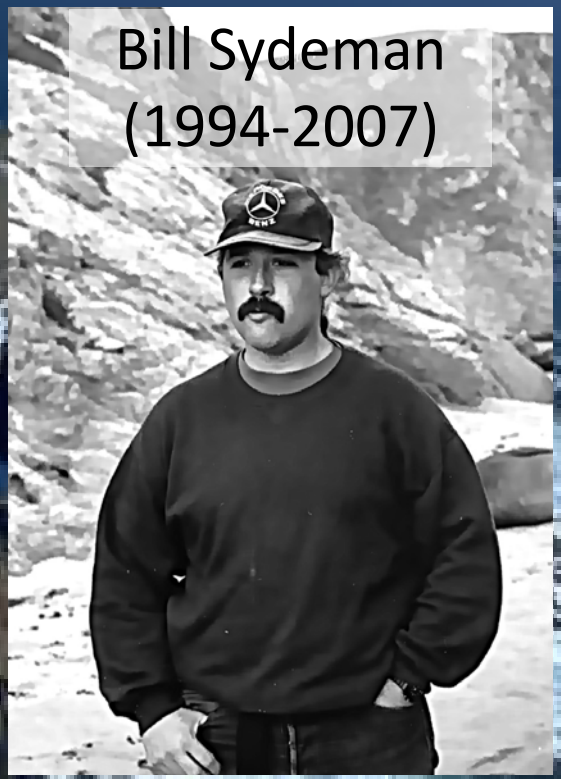
Research on Farallon Islands since 1968





>20 Farallon biologist led the fieldwork

>1,000 interns participated in data collection

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Cooperative agreement with USFWS

U.S. FISH & WILDLIFE SERVICE

Methods

Dependent variables: timing of breeding, breeding success, and main prey consumed by Farallon seabirds

Independent variables: spring transition, UI, PDO, NPGO and SOI

UI, SOI, PDO and NPGO were averaged for:

Winter	early	Nov-Dec
	late	Jan-Feb
Spring	early	Mar-Apr
	late	May-Jun

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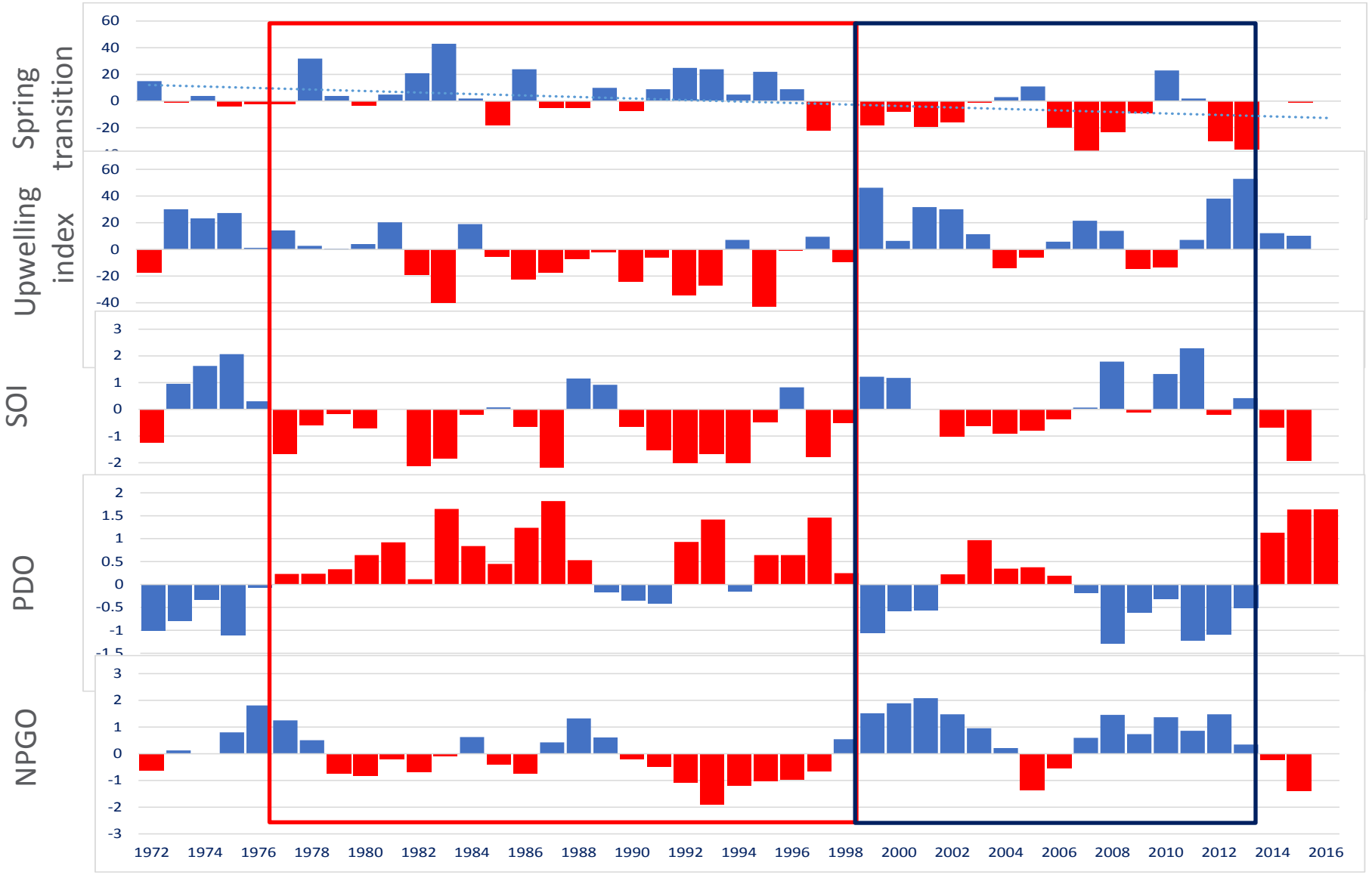
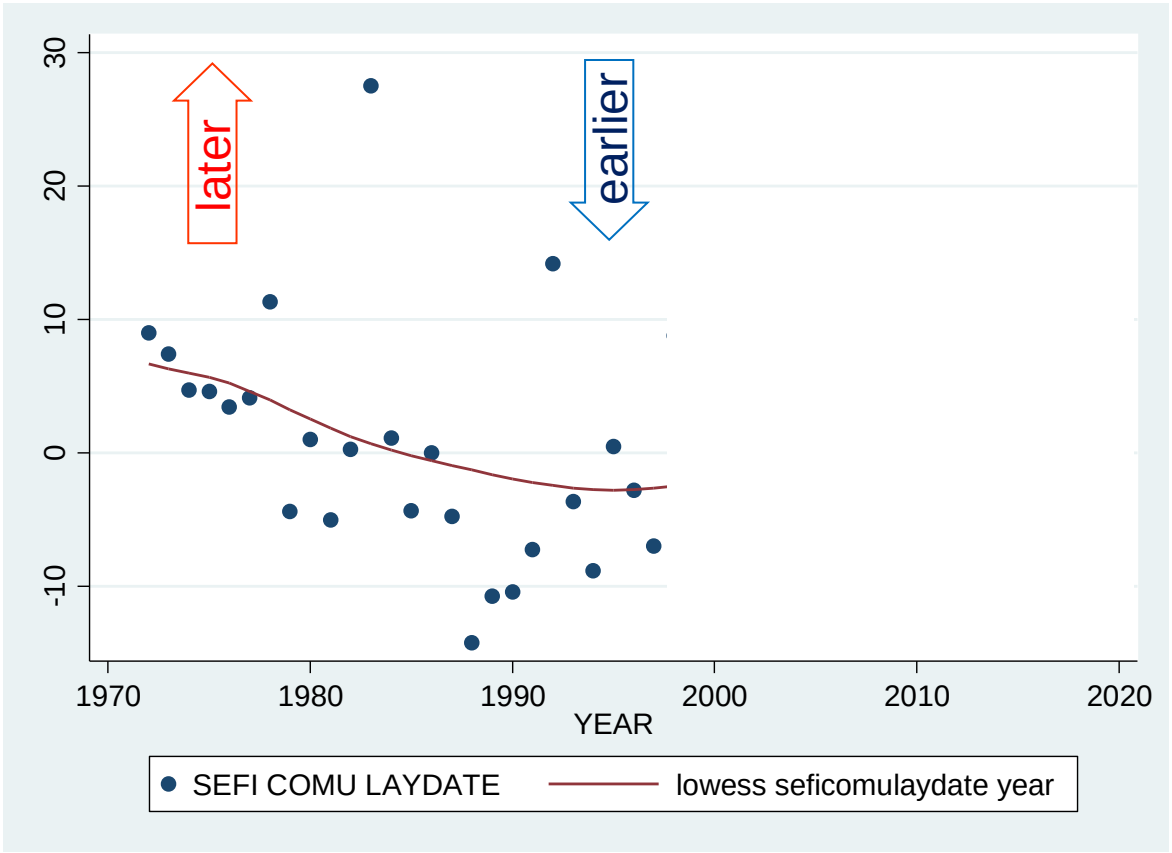
Climate related variables



Common murre timing of breeding

Murres breed early in years with cool late winter conditions and early spring transition



$P < 0.01$, $R^2 = 0.53$

Associations

Year (non linear)

Spring transition +

SOI (Jan-Feb) −

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Timing of breeding

Cold and productive conditions
Warm, poor, 'relaxed' conditions

	Cassin's auklets	Common murre	Brandt's cormorant	Western gull	Rhinoceros auklet	Pigeon guillemot
Transition		+	+	+		
Upwelling			+ **Early-winter**		+ **Early-winter**	
SOI	− **Late-winter**	− **Late-winter**			− **Late-winter**	− **Late-winter**
PDO			+ Late-winter	− **Early-spring**		
NPGO			+ **Early-winter**			− Late-spring

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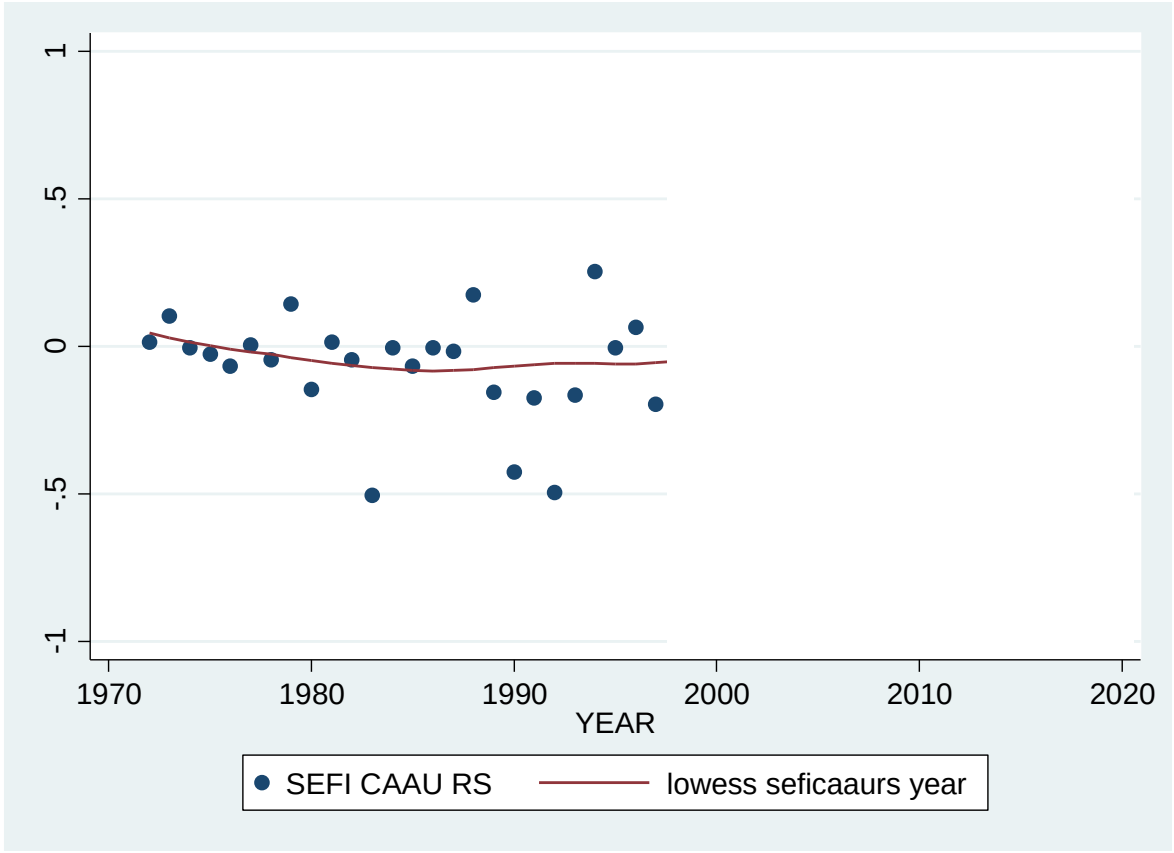
Cassin's auklet breeding success

Auklets breeding success is high during early lay date years, weak upwelling but productive ocean conditions in late winter



$P < 0.01$, $R^2 = 0.53$

Associations

Year (non linear)

Lay date −

UI (Jan-Feb) −

NPGO (Jan-Feb) +

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Breeding success

Cold and productive conditions
Warm, poor, 'relaxed' conditions

	Cassin's auklets	Common murre	Brandt's cormorant	Western gull	Rhinoceros auklet	Pigeon guillemot
Transition or Lay Date	−	+ −	−	−	−	−
Upwelling	− Late-winter	+ **Late-spring**			+ **Early-spring**	+ **Early-spring**
SOI						
PDO		− **Late-spring**				
NPGO	+ **Late-winter**		− Early-spring	− Early-spring		

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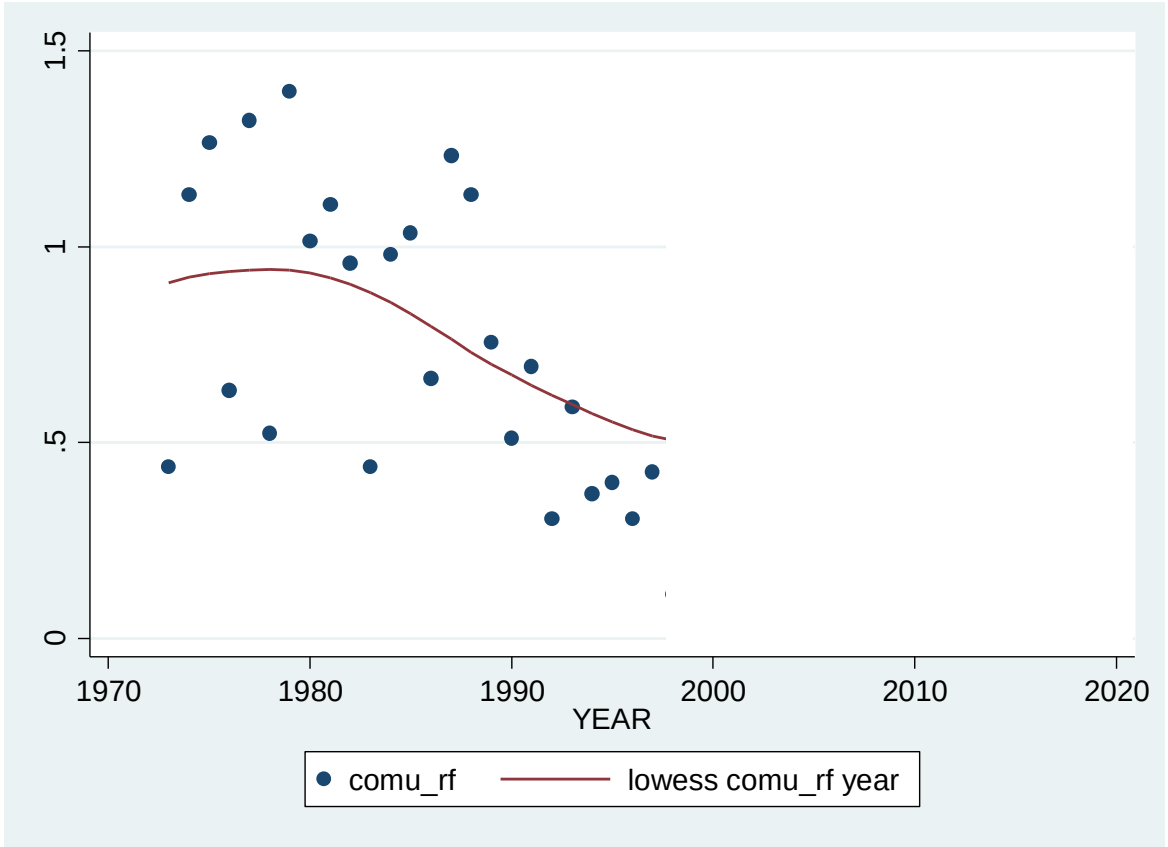
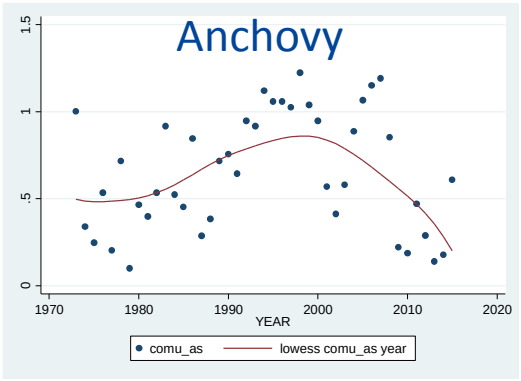
Common murre diet – Juv. Rockfish

Rockfish is high after productive late winter conditions
Anchovy is high after 'relaxed' early winter conditions





$P < 0.01$, $R^2 = 0.40$

Associations

Year (non linear)

NPGO (Jan-Feb) +

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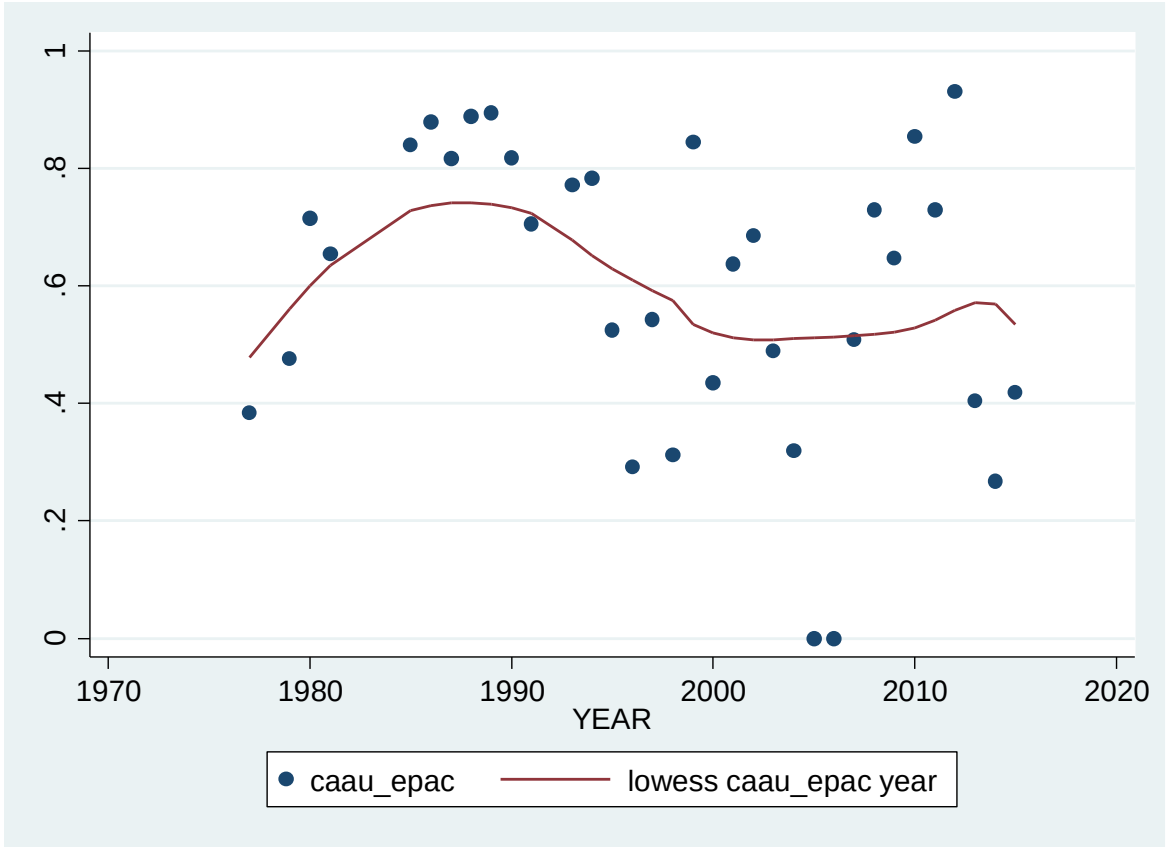
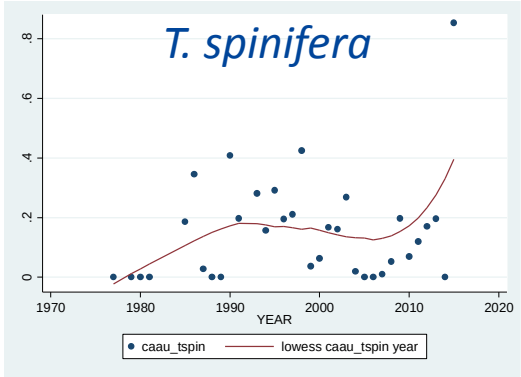
Cassin's auklet diet – *E. pacifica*

E. pac is high during cool and productive spring conditions

T. spin is high after productive early winter and 'relaxed' spring conditions





$P < 0.01$, $R^2 = 0.53$

Associations

Year (non linear)

PDO (Mar-Apr) −

NPGO (May-Jun) +

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Diet – Krill and rockfish

Cold and productive conditions
Warm, poor, 'relaxed' conditions

	Cassin's auklet E. pacifica	Common murre	Brandt's cormorant	Rhinoceros auklet	Western gull	Pigeon guillemot
Transition						
Upwelling		+ Late-spring		+ Late-spring		+ Late-spring
SOI						
PDO	– Early-spring	– Early-spring				+ Early-winter
NPGO	+ Late-spring	+ Late-winter	+ Late-winter – Late-spring			

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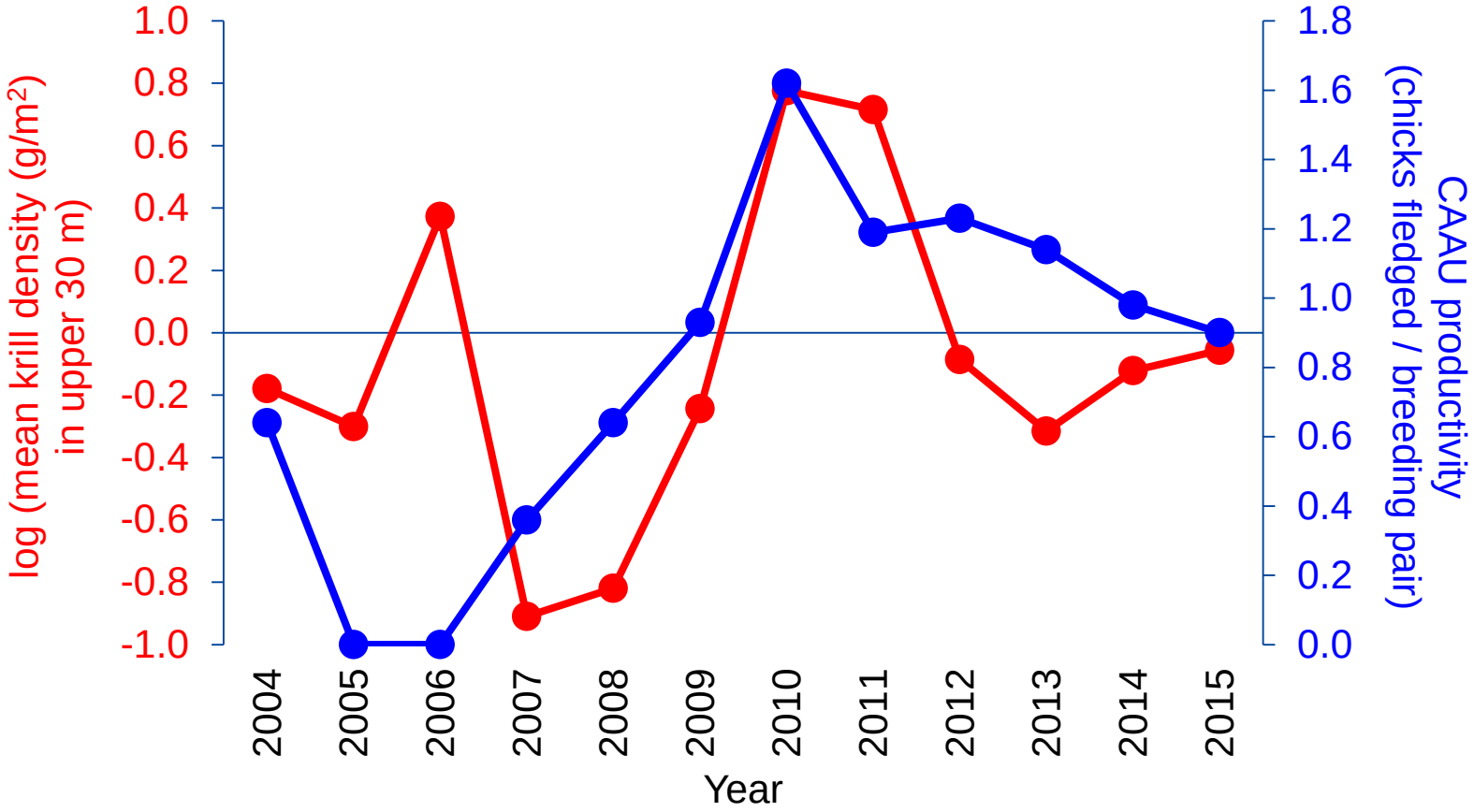
Krill acoustic biomass and auklets



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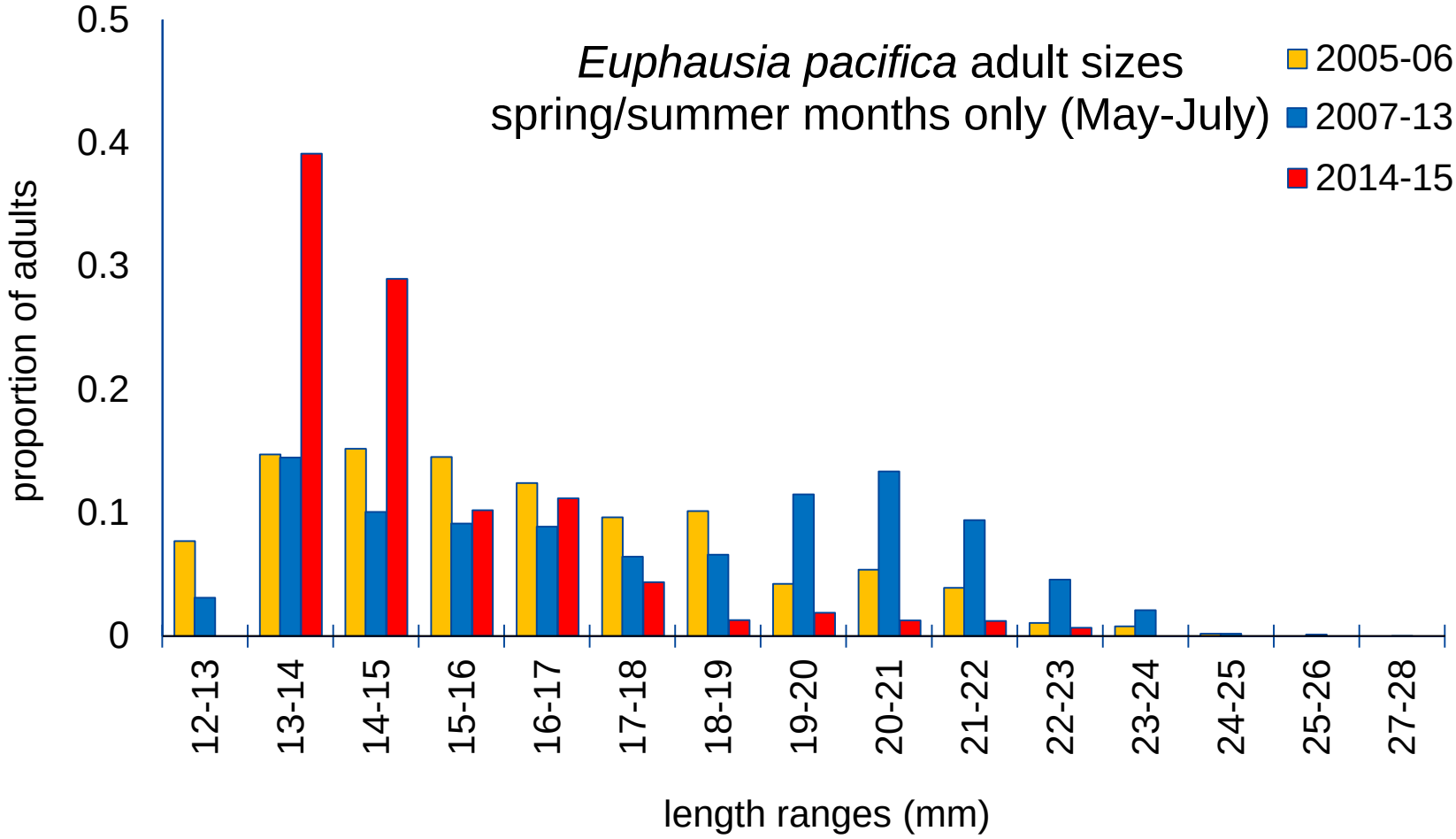
Krill is larger in cold productive years



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Cold-productive conditions are best!

- **Early spring transition** was important for **early breeding** and both were important for **high breeding success**
- **La Niña-like (SOI) winters** were important for **early breeding**
- **High NPGO winters** were important for high **breeding success** for C. auklets and **high prey availability**
- **Strong spring upwelling** important for high **breeding success** for cormorants and R. auklets and **rockfish availability**
- **Cool PDO springs** were important for high **breeding success** for murres and **high prey availability**

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Conclusions

- **Seasonal variability (UI)** and **Interannual variability (SOI)** important for timing of breeding
- **Interdecadal variability (PDO and NPGO)** important for breeding success and prey availability
- While we see increased variability, “old-known” relationships between climate, predator and prey still hold
- Increased frequency of El Niño, changes in the onset and productivity of upwelling will have the most effect on seabirds

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Thank you!

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