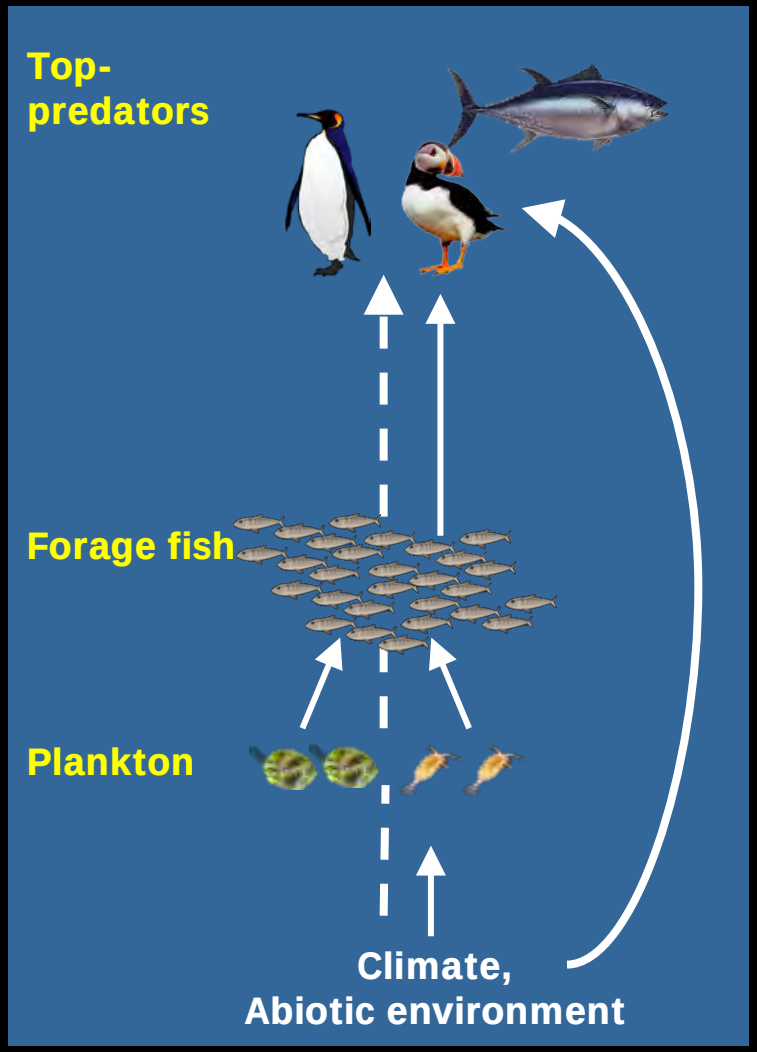
Functional responses of marine birds to local and global changes in climate and small pelagic fish availability

Claire Saraux, R. Crawford, N. Courbin, A. Chiaradia and W. Sydeman



Ecosystems under pressure

Use of top-predators as bio-indicators

Prey dynamics = missing link

PhD

Penguins

Climate,
Abiotic factors

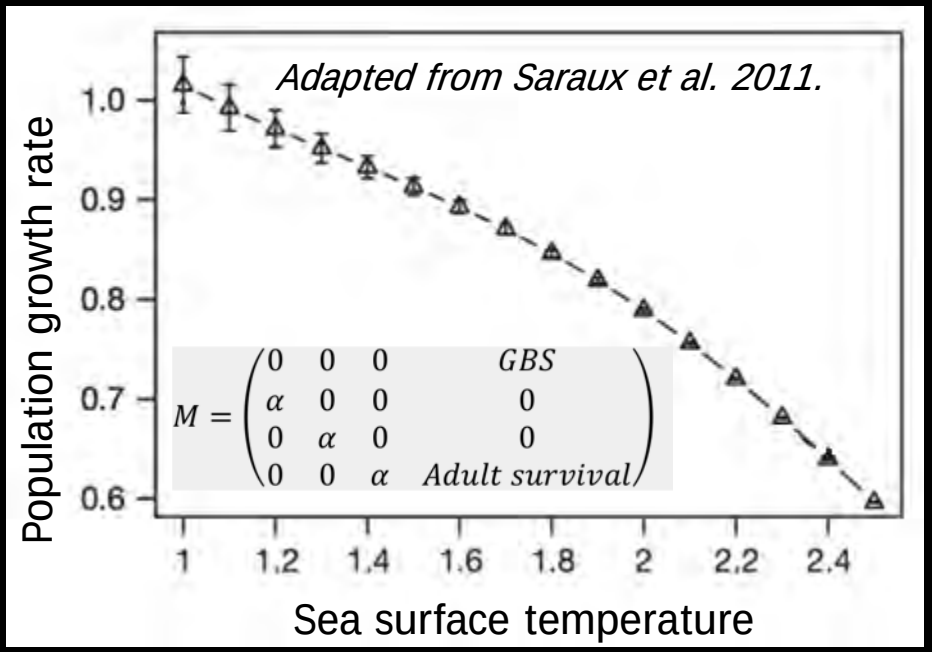
PhD

King penguin

Climate,
Abiotic factors

Saraux et al. 2011. Nature

→ Survival & Breeding **ADULTS**



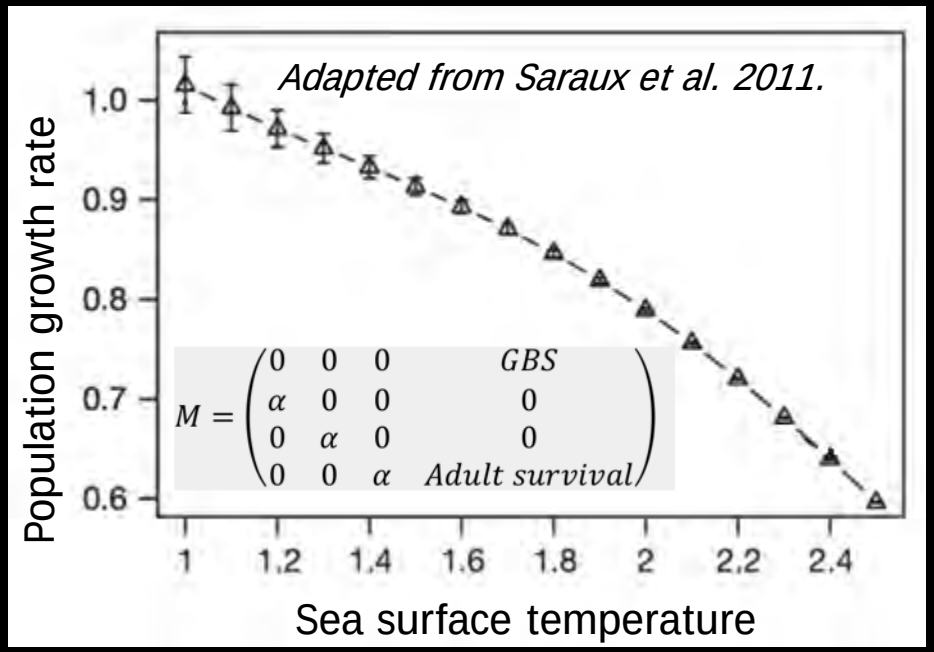
PhD

King penguin

Climate,
Abiotic factors

→ Survival & Breeding **ADULTS**

→ Recruitment **JUVENILES**



≠ effect of temperature within species depending on life-history traits

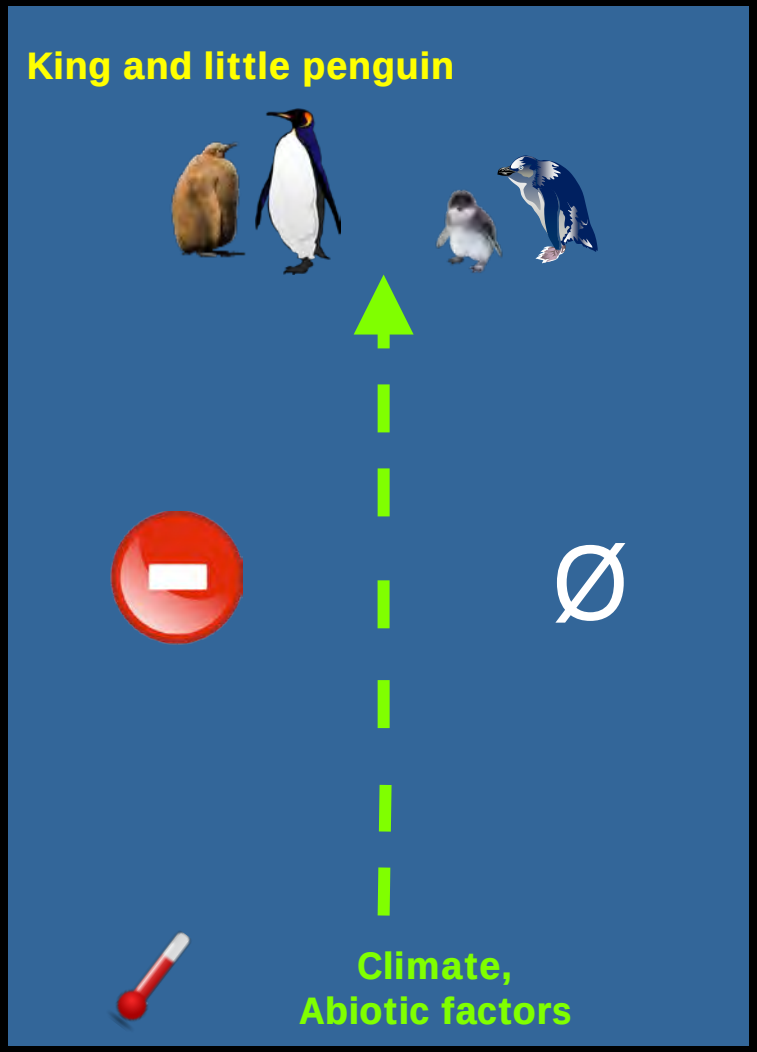
Saraux et al. 2011. Nature
Saraux et al. 2011. Plos One

PhD

King and little penguin

Climate,
Abiotic factors

PhD



≠ effect of temperature on breeding success depending on species

PhD

King and little penguin

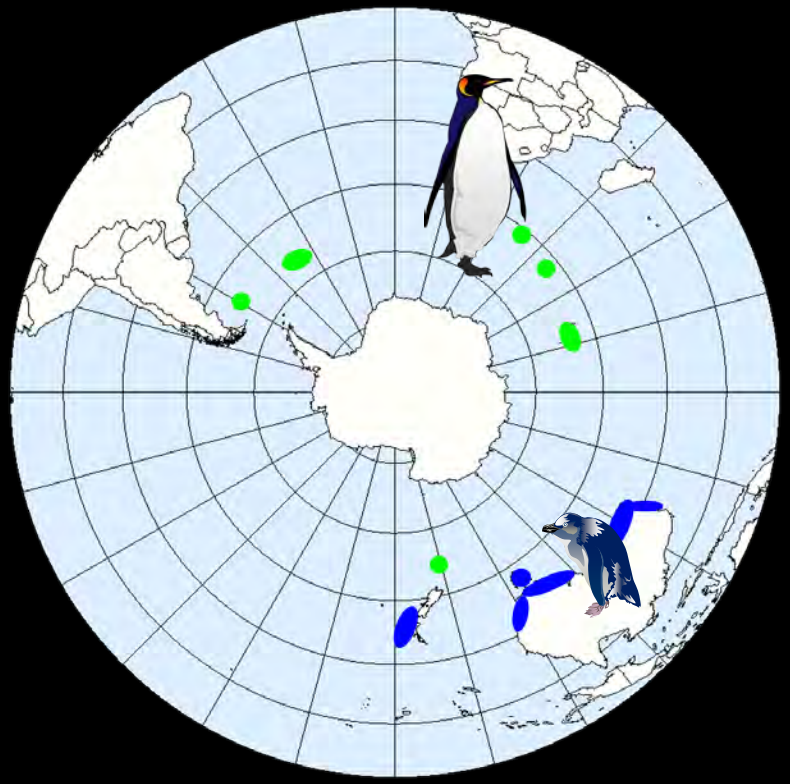
Ø

Climate,
Abiotic factors

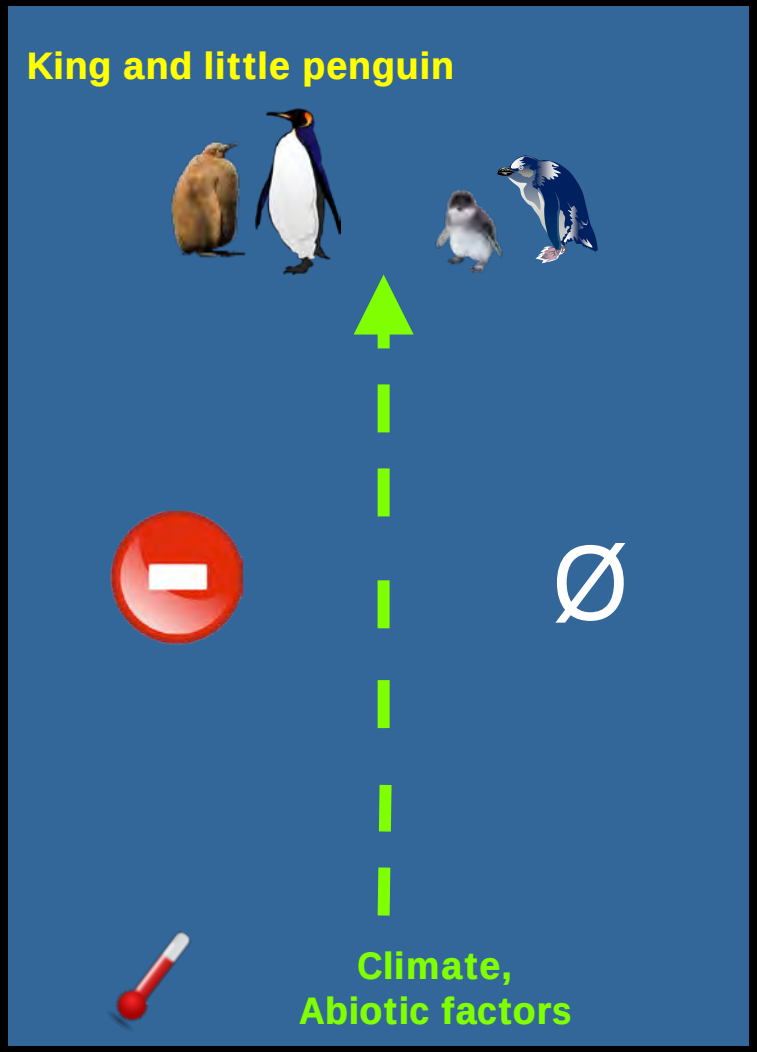
≠ effect of temperature on breeding success depending on species

Due to:

- ≠ in latitudes?



PhD



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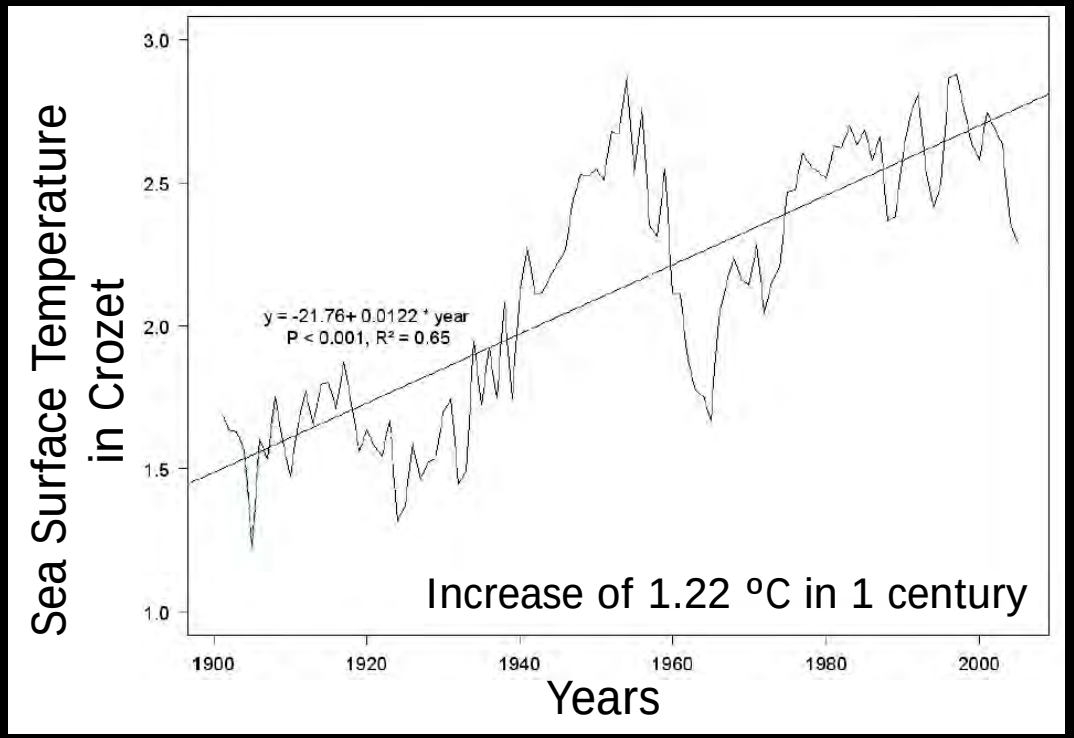

PhD

King and little penguin

Ø

Climate, Abiotic factors

≠ effect of temperature on breeding success depending on species

Due to:

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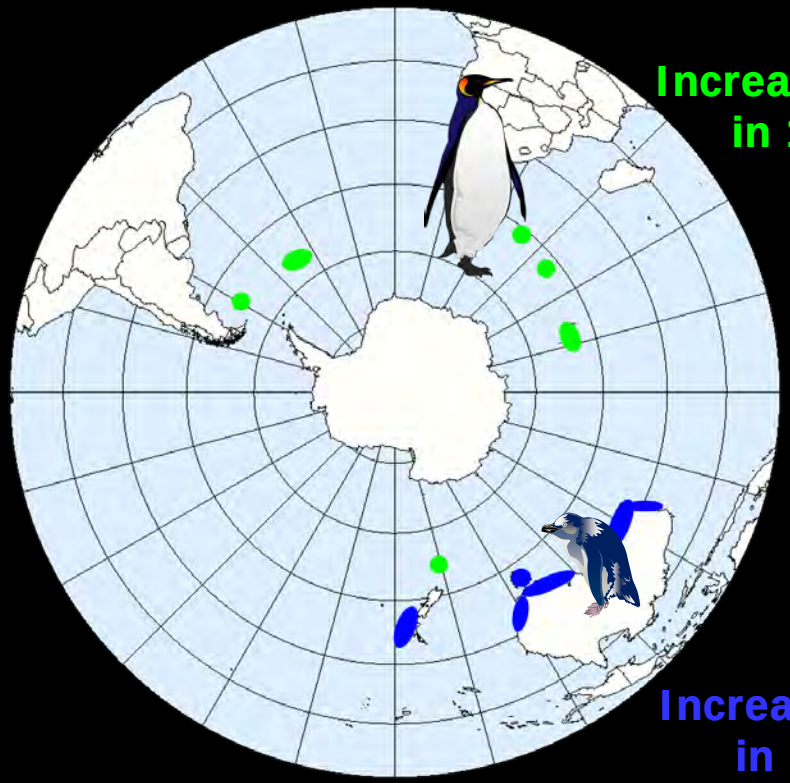
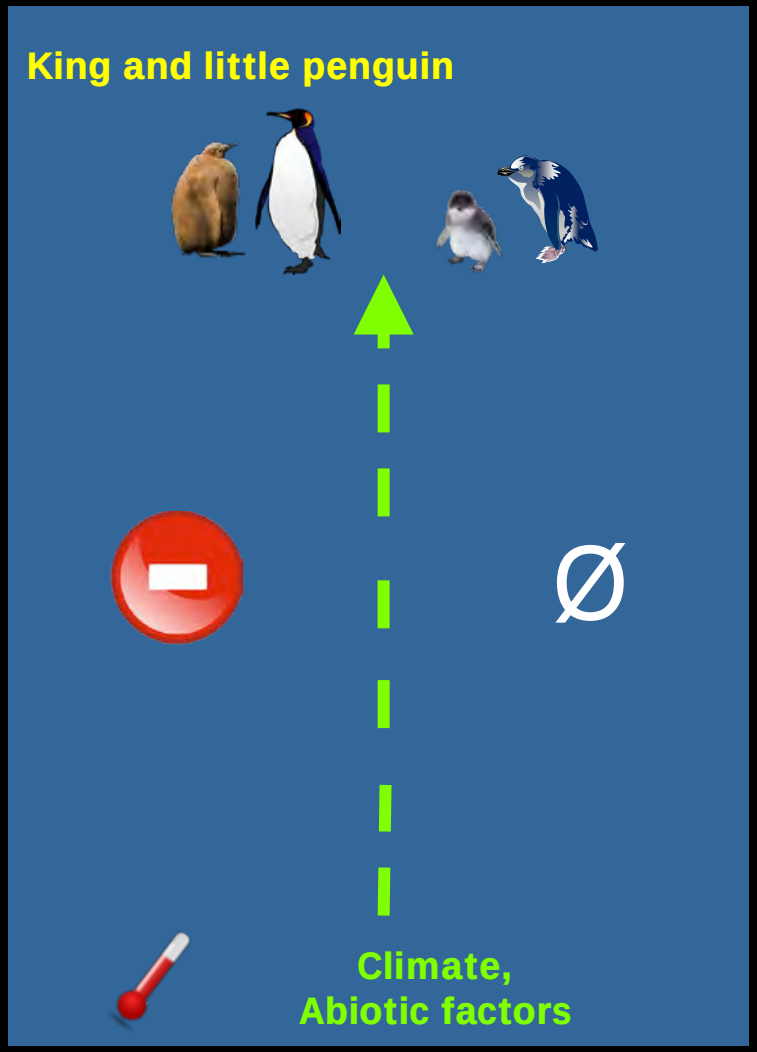


Increase of 1.22 °C in 1 century

Increase of 1.25 °C in 1 century

PhD



≠ effect of temperature on breeding success depending on species

Due to:

- ≠ in biology?

2 / month	Feeding events	1 / day
Up to 5 months	Fasting capacity	Few days

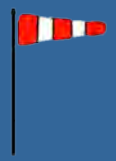
Importance of time scale at which events occur

Little penguin

(N = 17 363 trips, N = 222 ind)

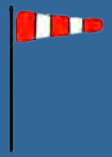
Climate,
Abiotic factors

Little penguin
(N = 17 363 trips, N = 222 ind)

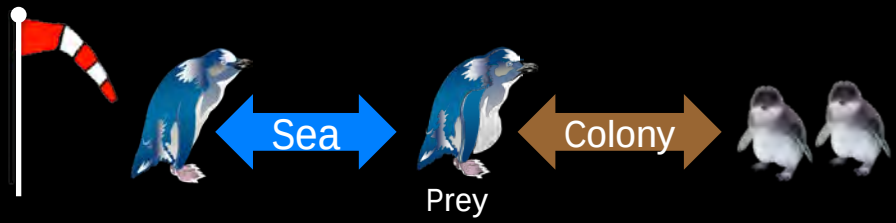


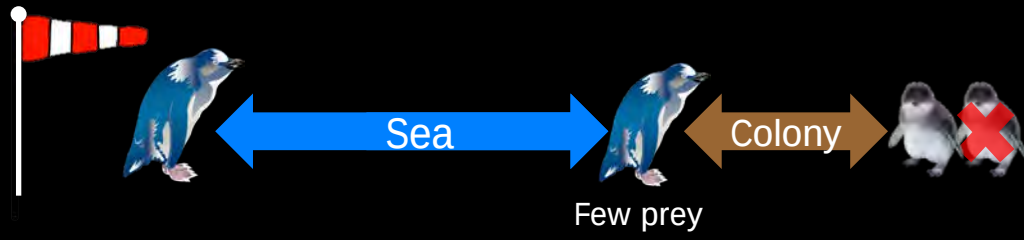
Climate, Abiotic factors

Saraux et al. 2016. Ecological Monographs

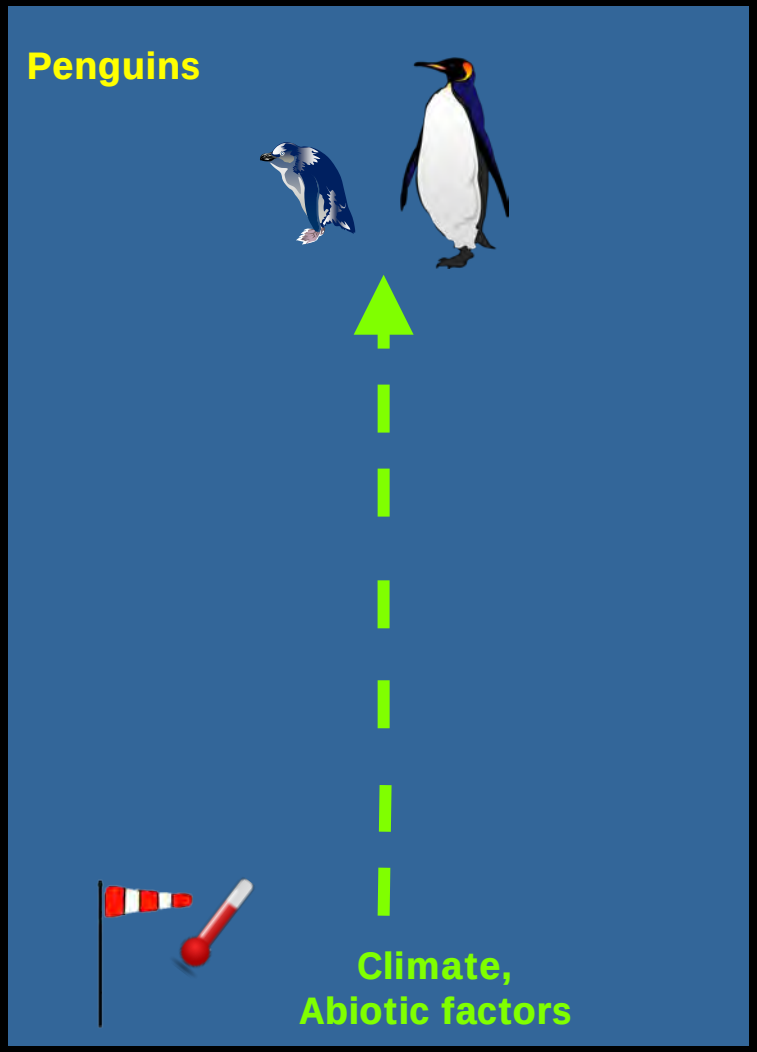


→ **ADULT** Body condition Ø
→ **CHICK** Survival

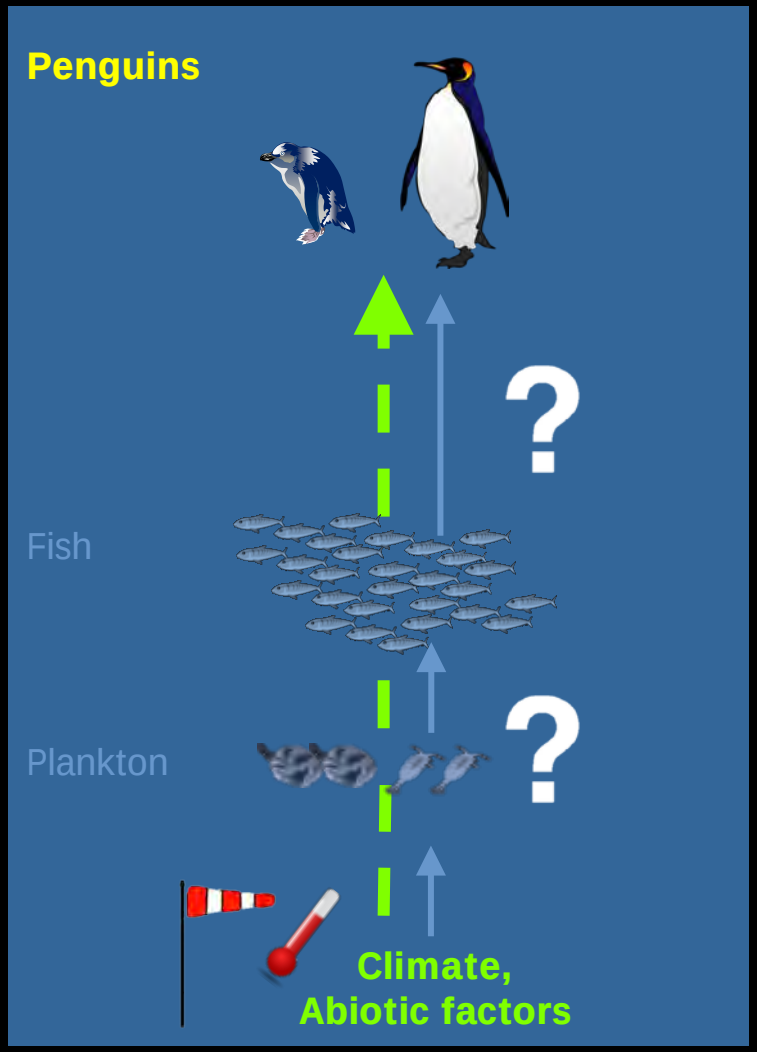




Effect of climate also mediated by life-history trade-offs



Climate effect differs depending species and life-history traits

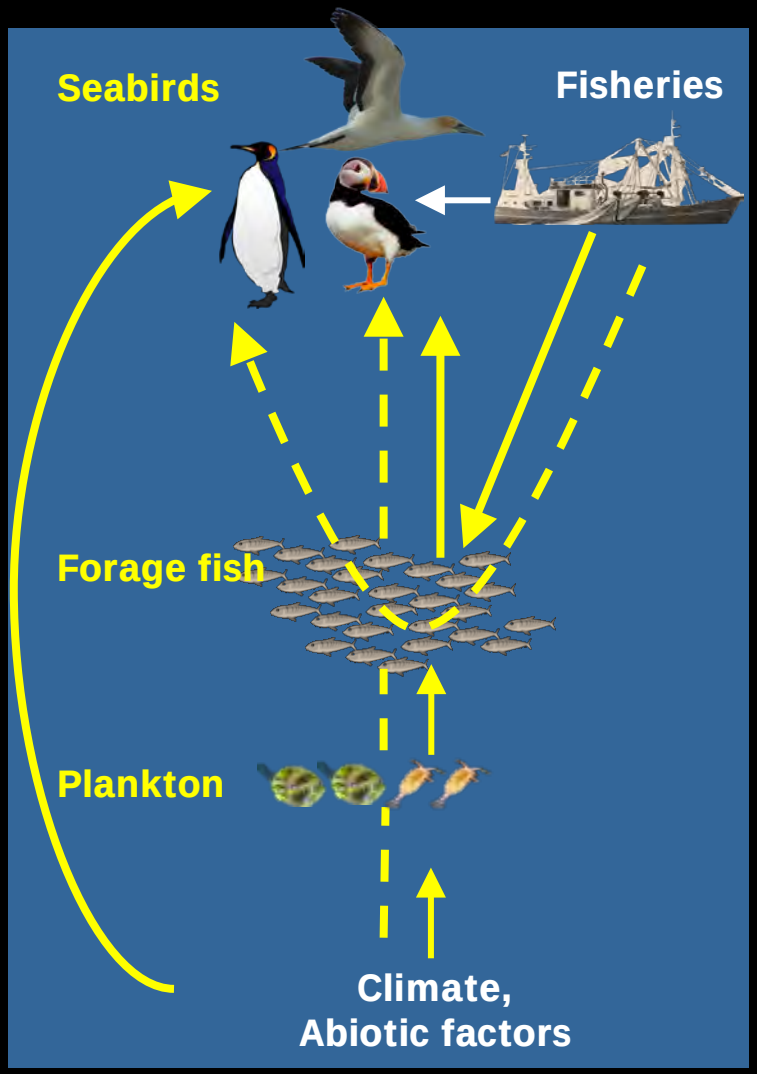


Climate effect differs depending species and life-history traits

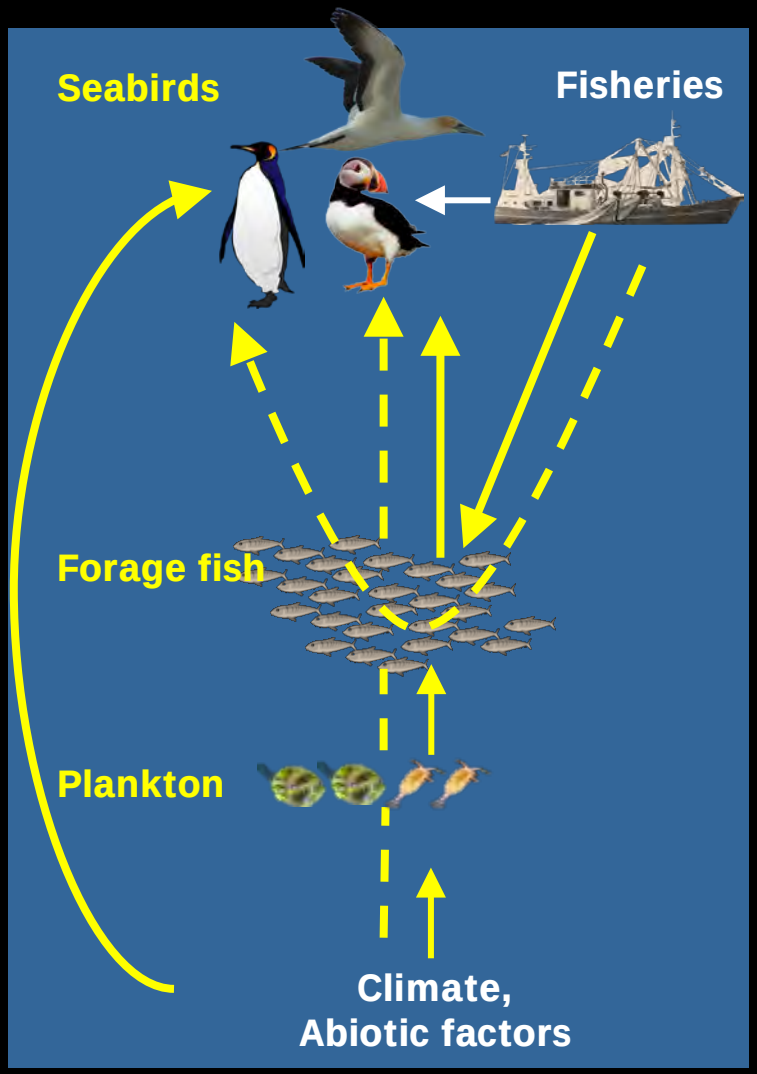
Mechanisms ?

Prey abundance?
Energetic quality?
Prey accessibility?

Seabird forage fish interactions?



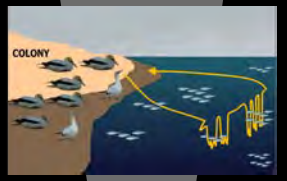
Seabird forage fish interactions?



Axis 1

Genericity of seabird-forage fish interactions

Axis 2

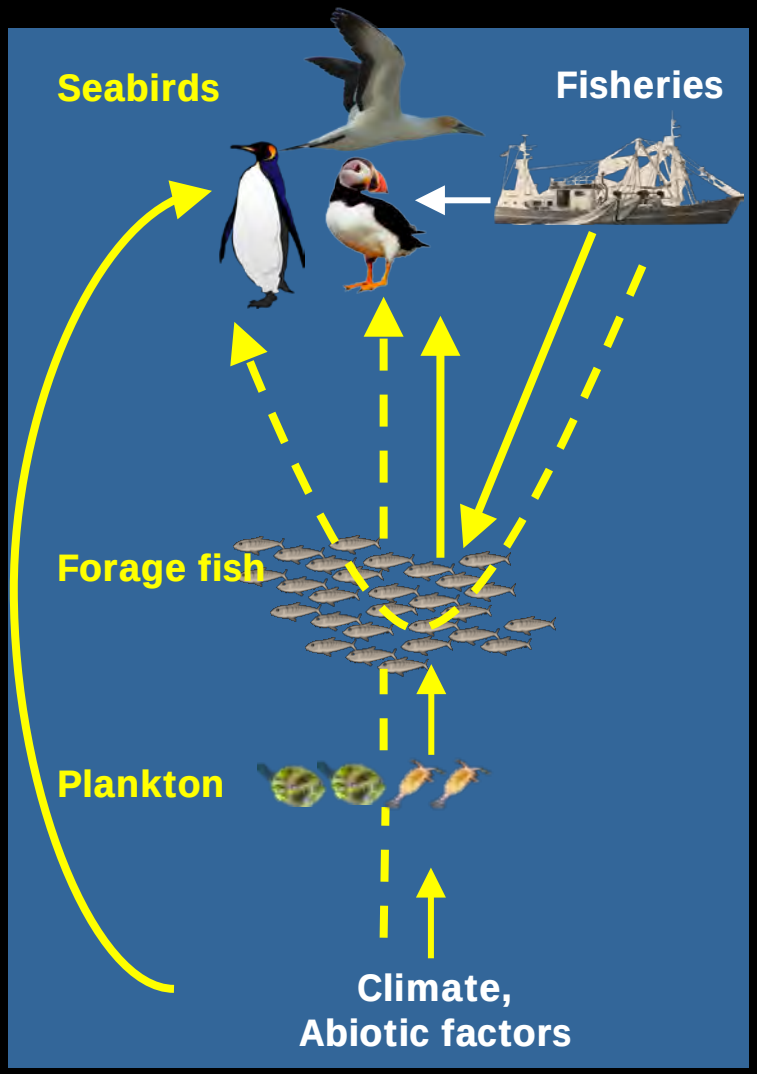


Mechanisms of bottom-up control

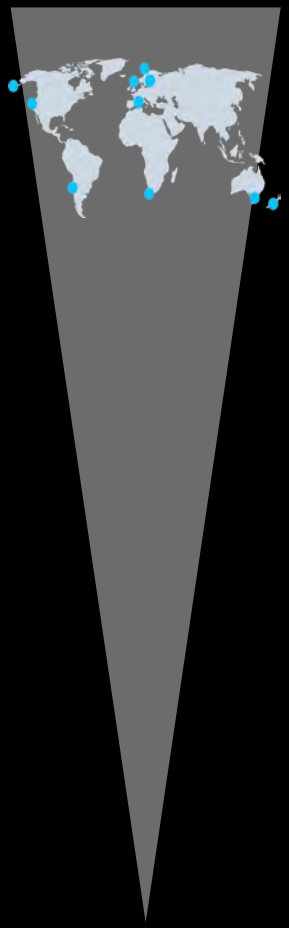
Axis 3

Interindividual differences and plasticity

Seabird forage fish interactions?



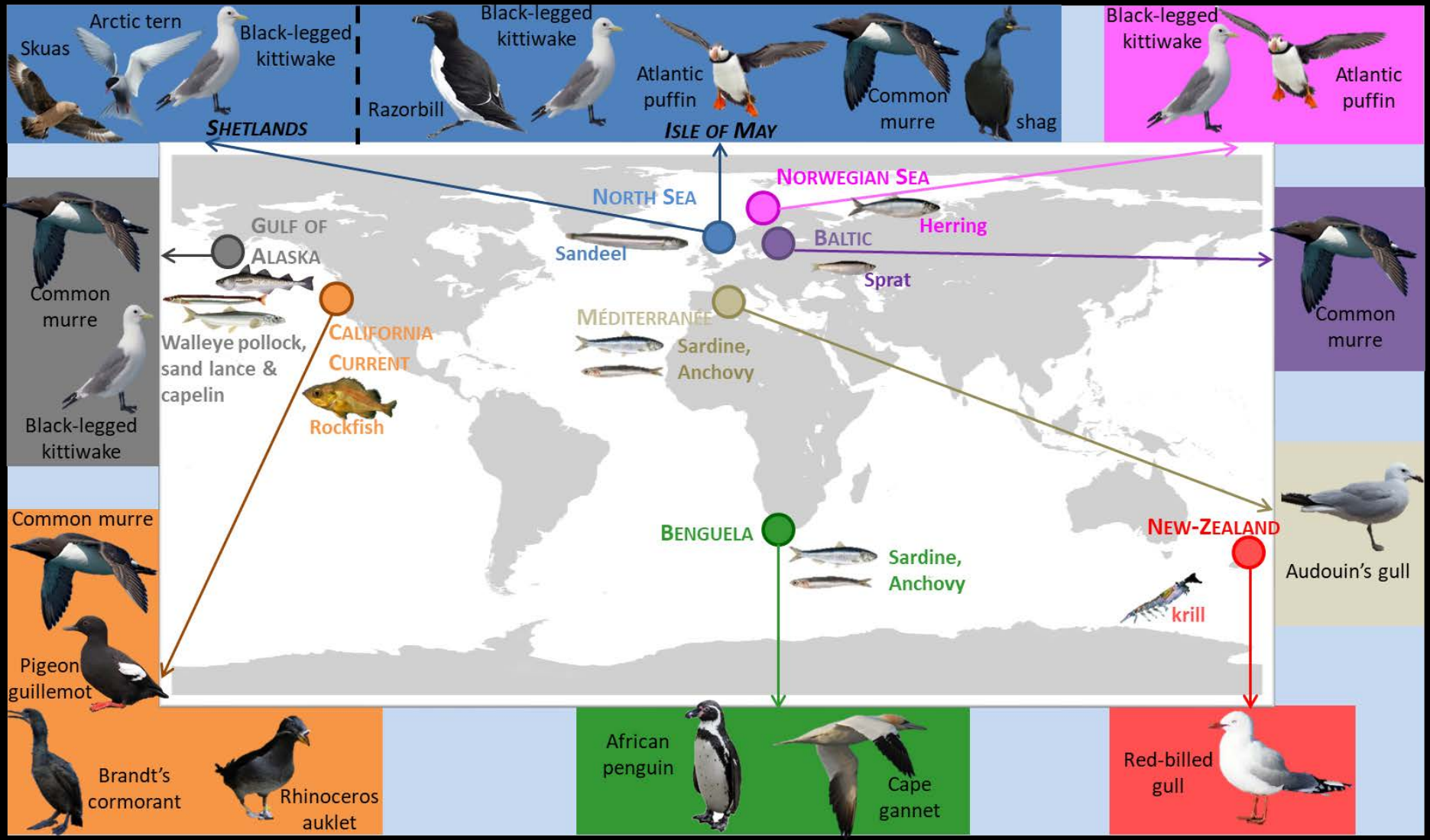
Axis 1



Genericity of seabird-forage fish interactions

Axis 1

Study species and ecosystems



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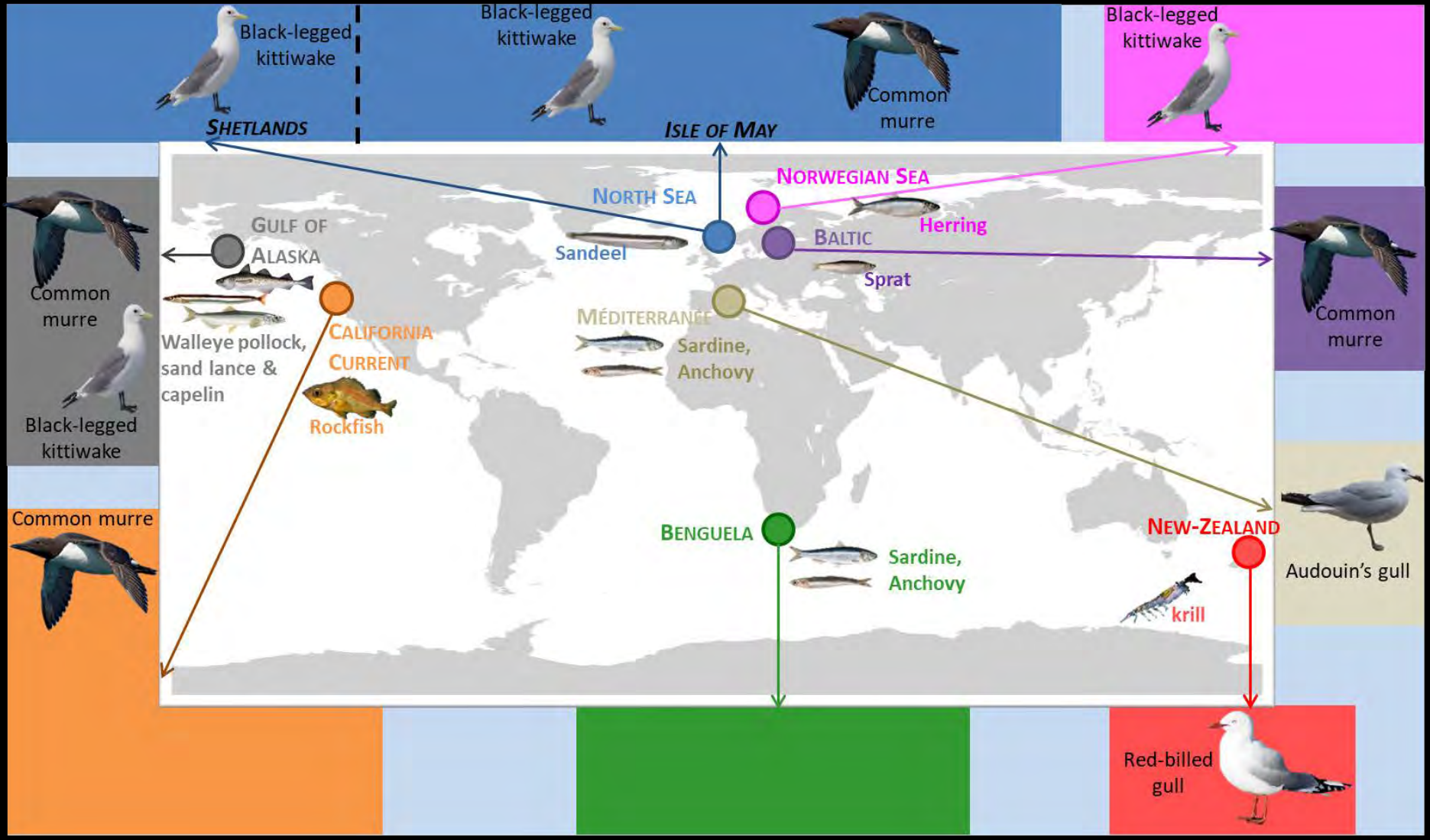
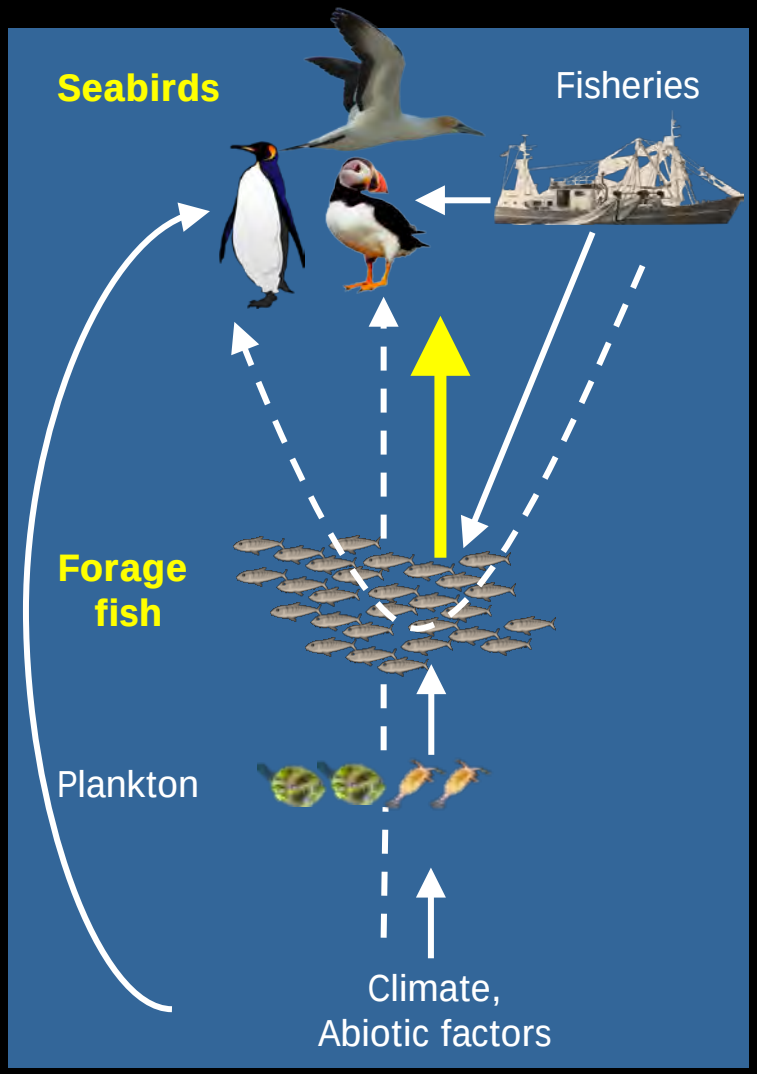
Study species and ecosystems

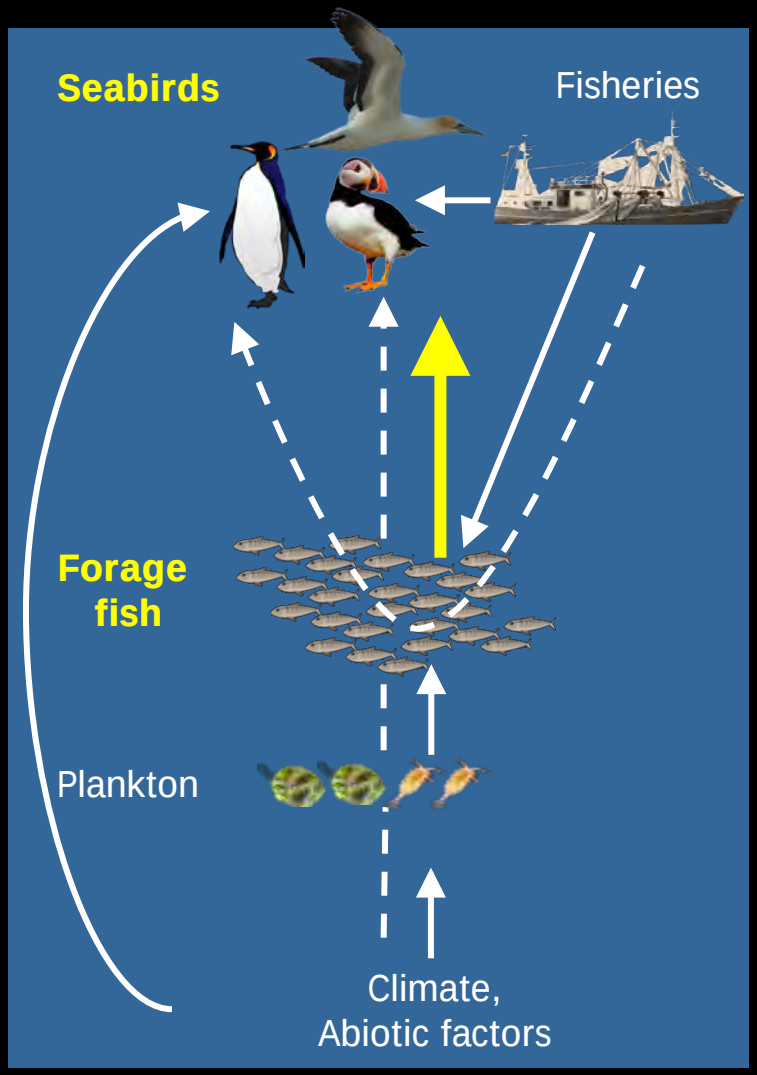




Axis 1

Genericity of seabird-forage fish interactions

Q1. Effect of fish biomass on seabird life-history traits ?



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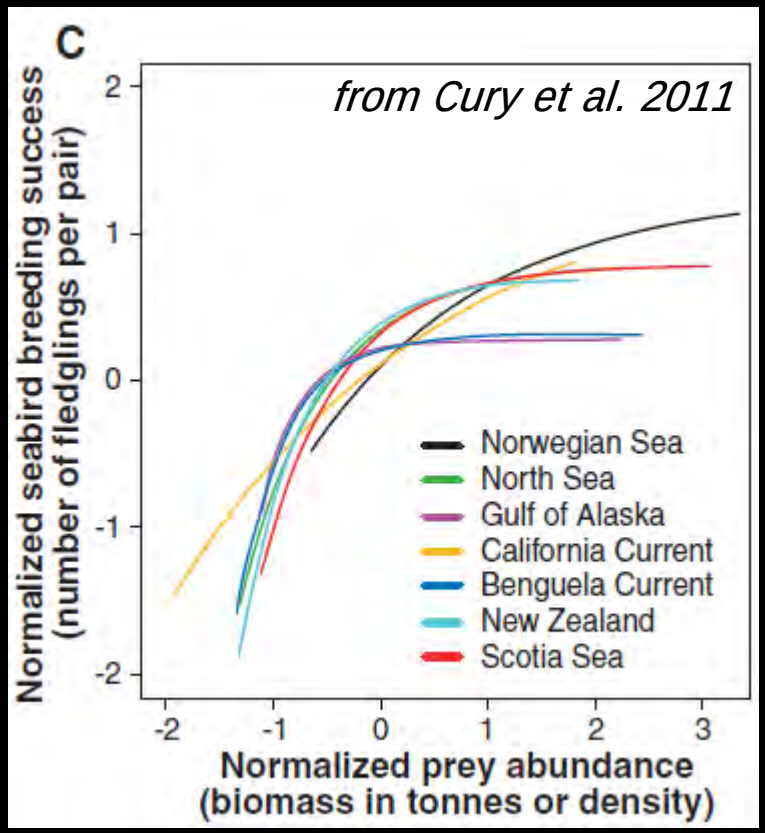

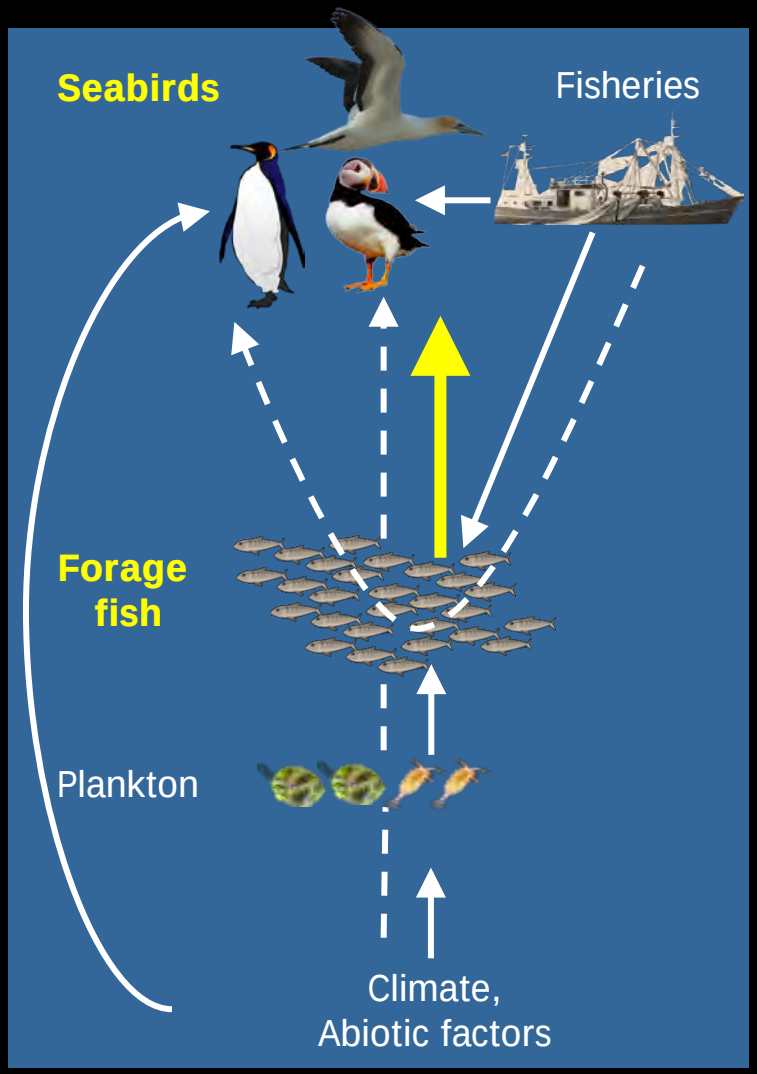

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Genericity of seabird-forage fish interactions

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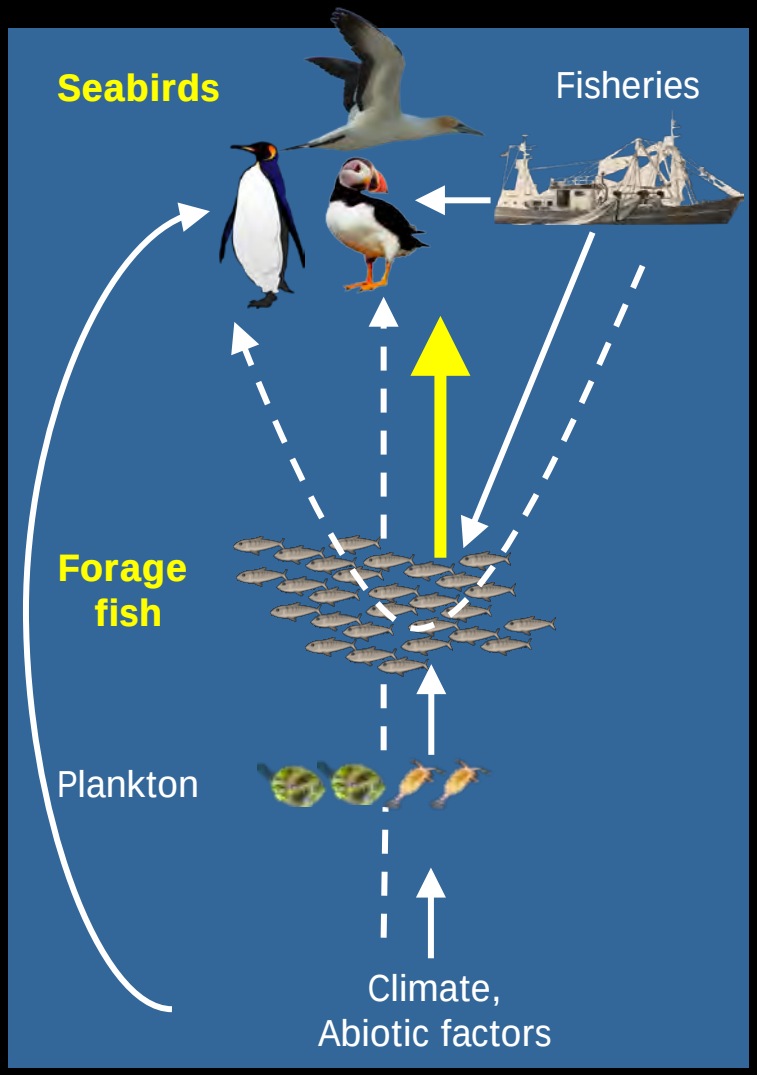
What about other traits?



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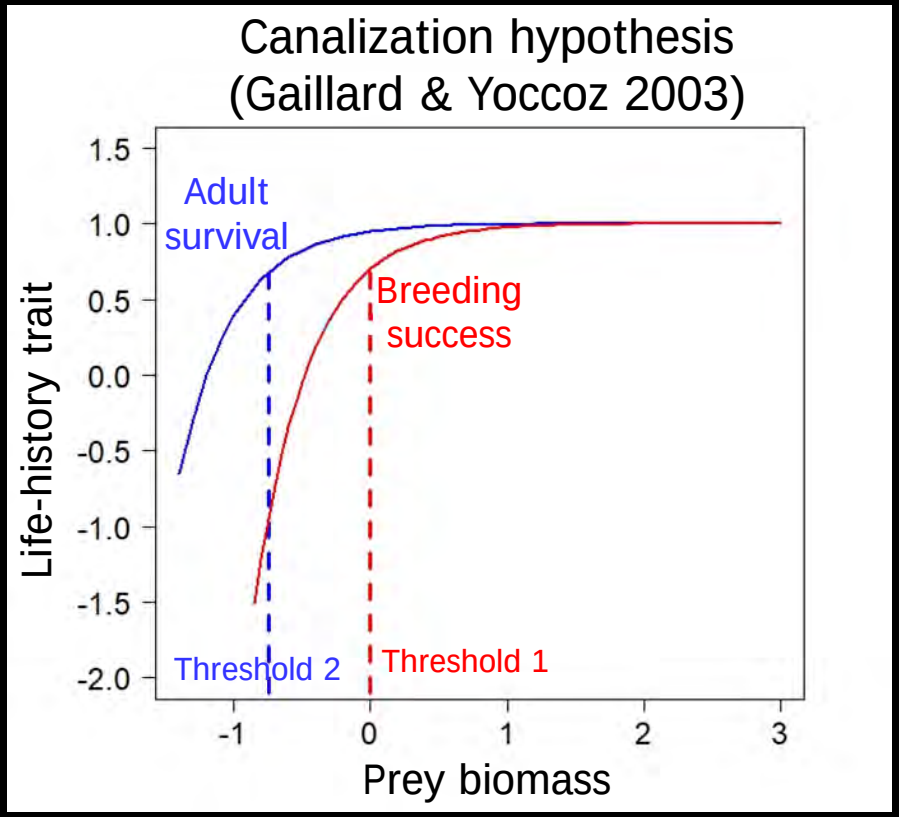

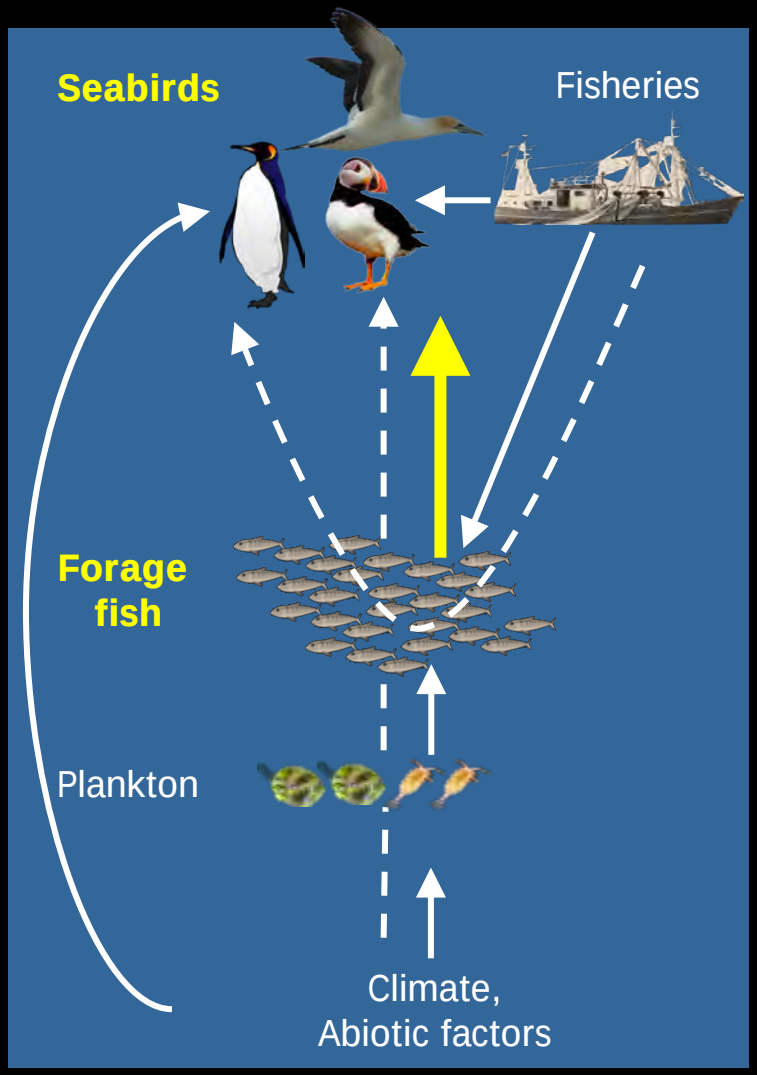

Sydeman et al. in prep.

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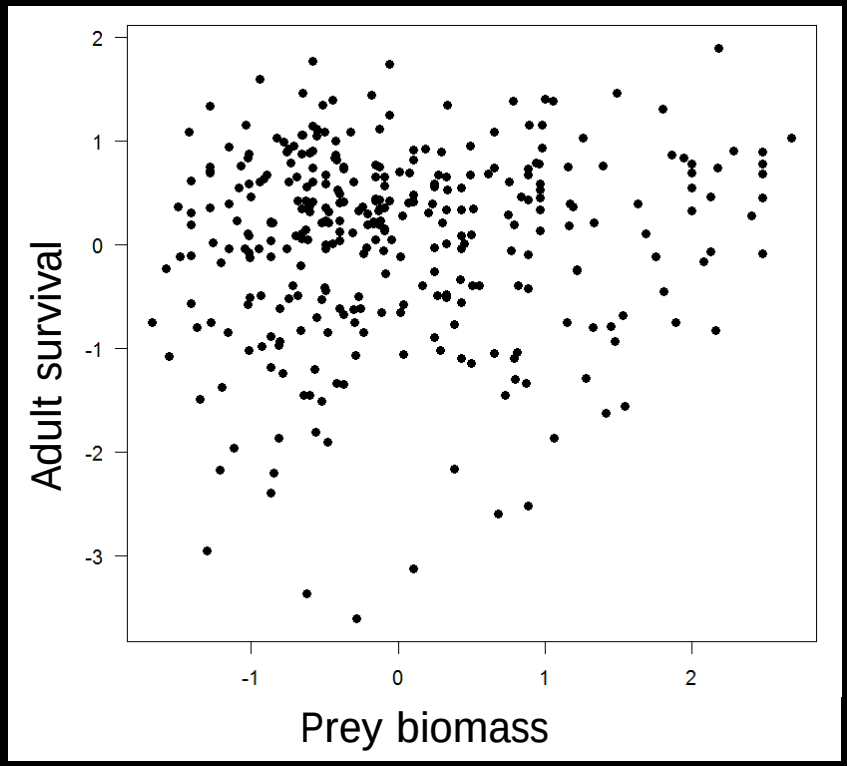

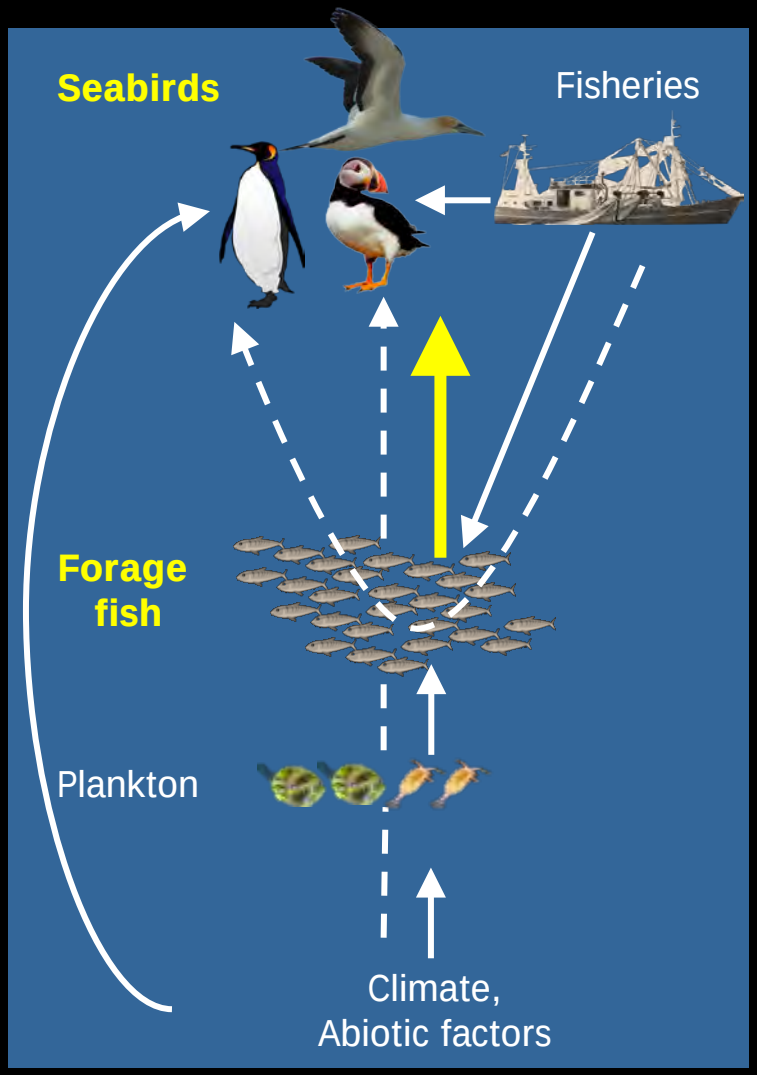

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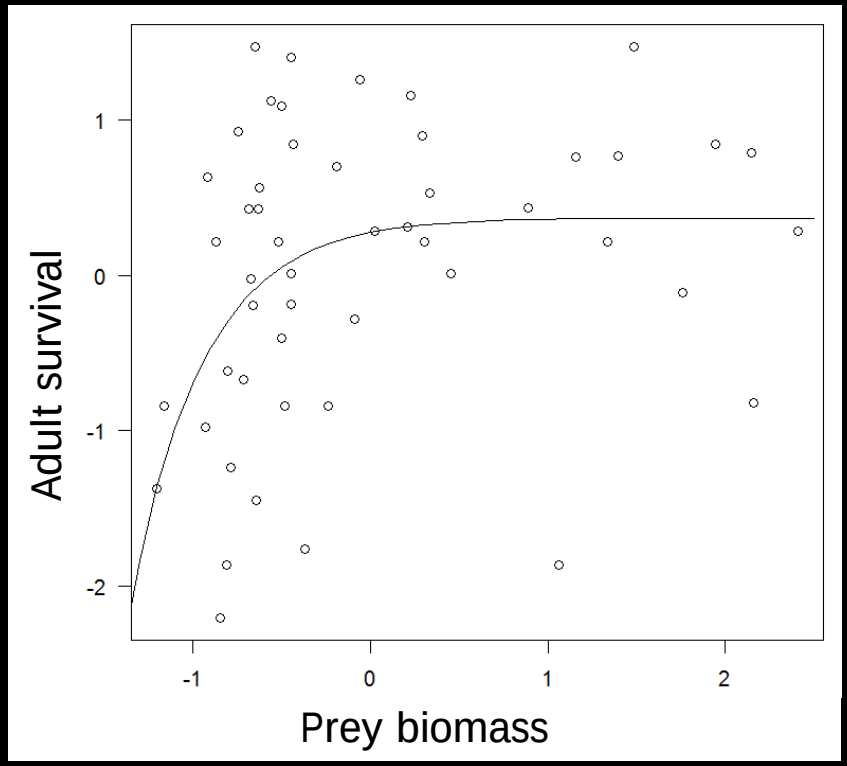

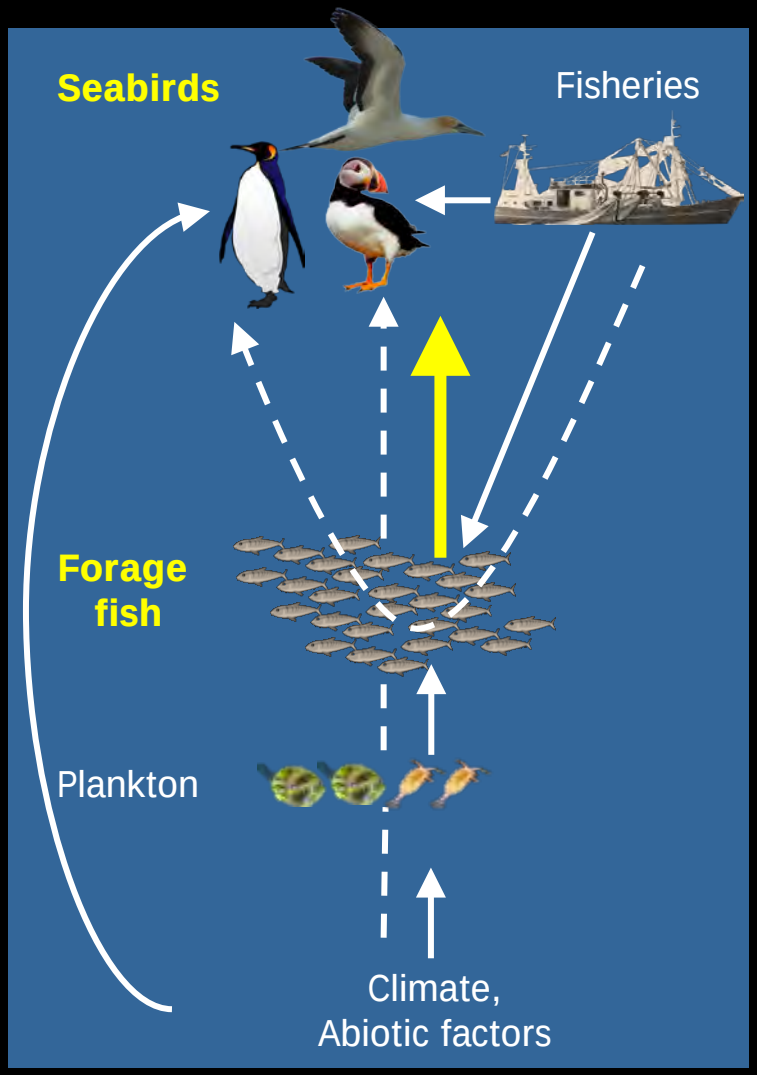

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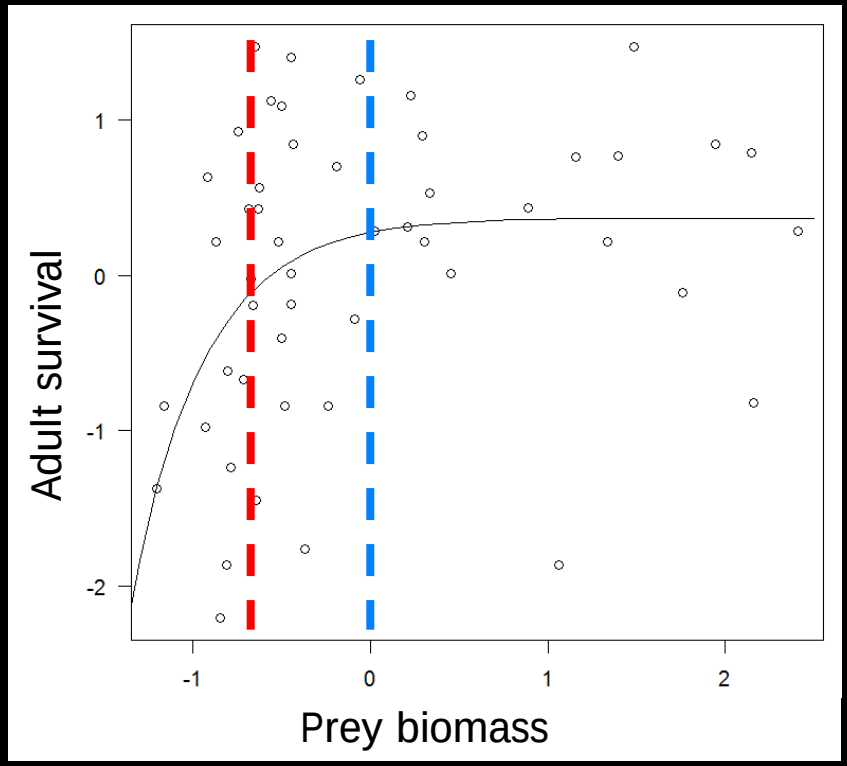

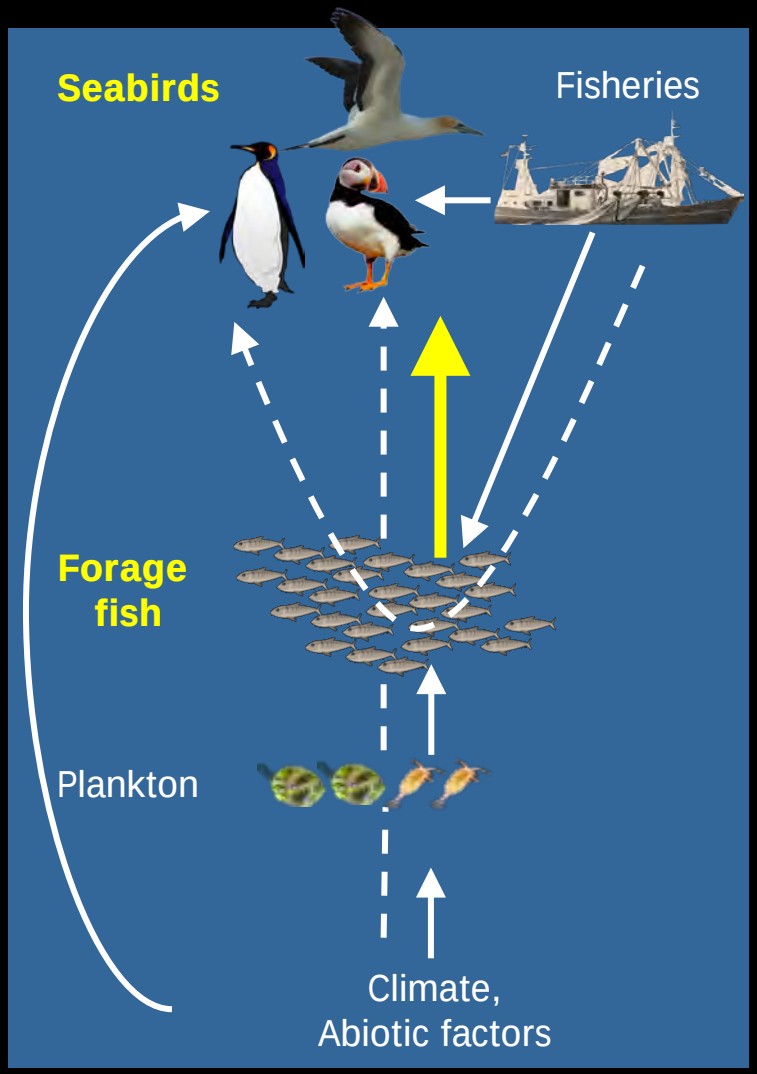

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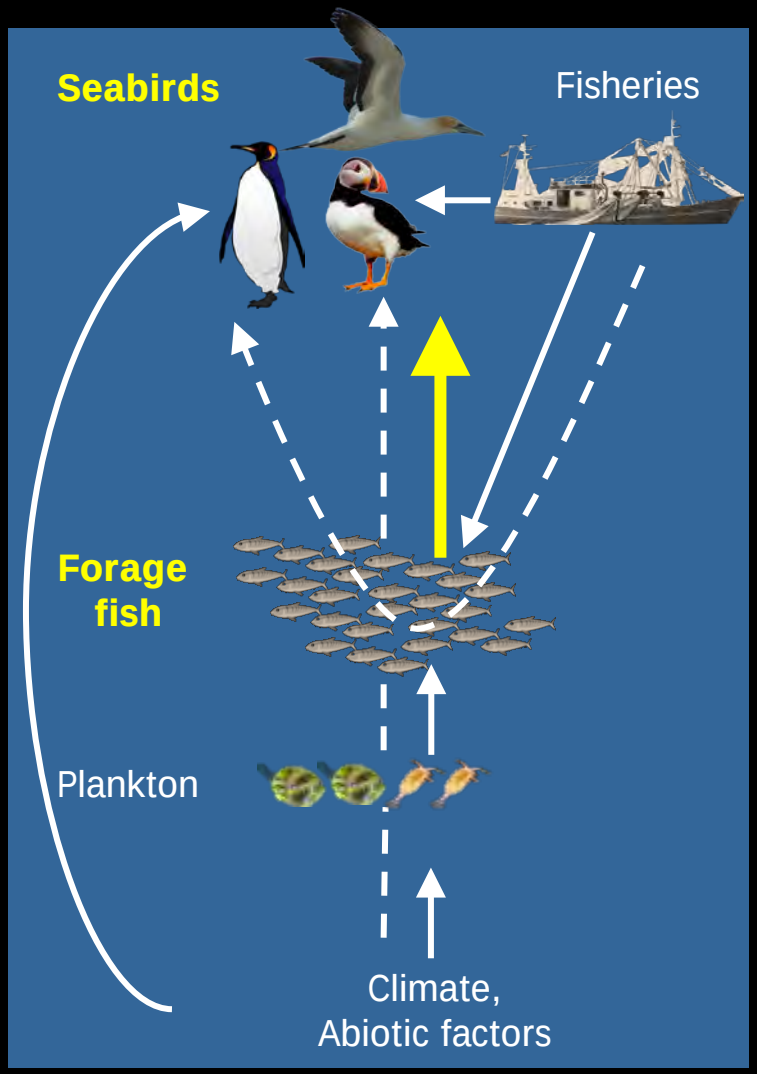
Genericity of seabird-forage fish interactions

Q1. Effect of fish biomass on seabird life-history traits ?

What about other traits?

- Adult survival
- Juvenile survival
- Breeding propensity



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Genericity of seabird-forage fish interactions

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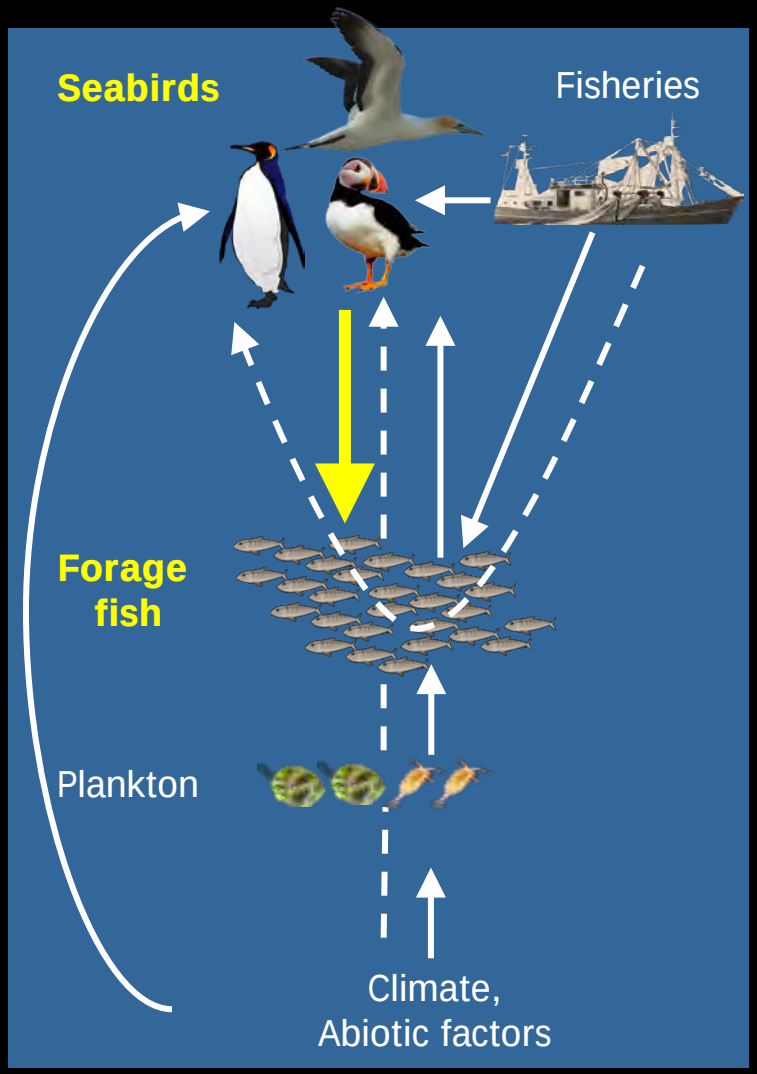
- Adult survival
- Juvenile survival
- Breeding propensity

Consequences on population dynamics

$$M = \begin{pmatrix} 0 & BS = f_1(prey\ biomass) \\ Surv_{juv} = f_3(prey\ biomass) & Surv_{adult} = f_2(prey\ biomass) \end{pmatrix}$$

$$\lambda = \pm Max\ (|e.v.(M)|)$$



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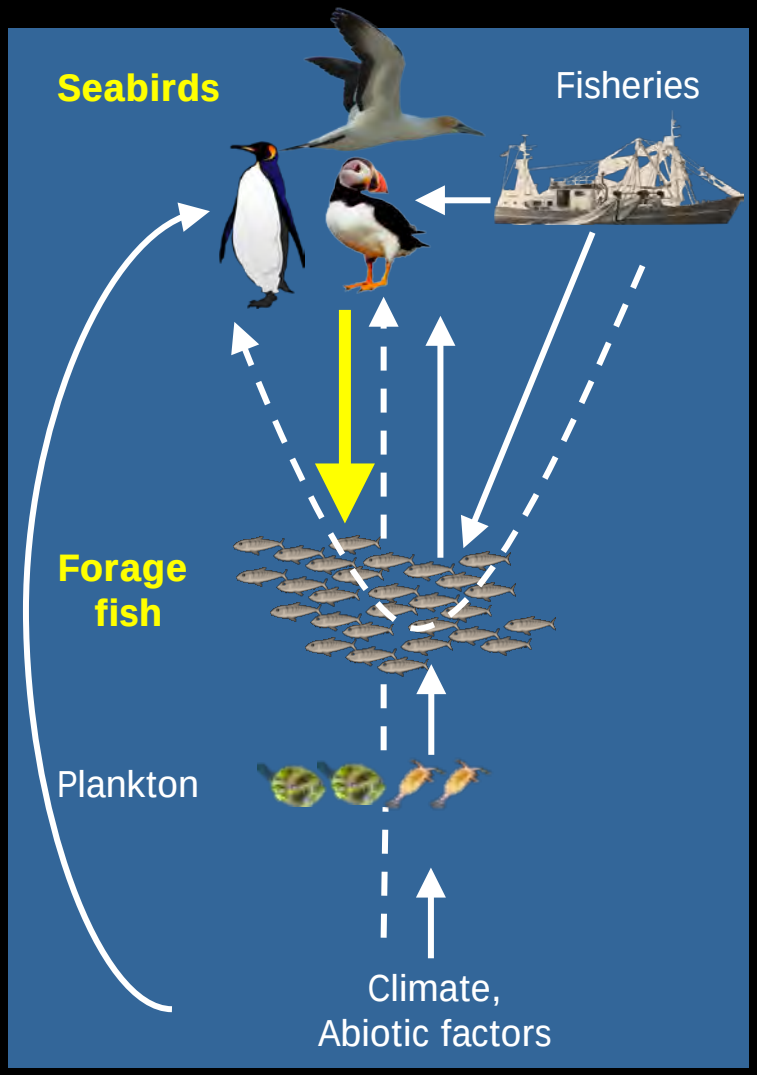
Genericity of seabird-forage fish interactions

Q2. Top-down effect of seabird on fish?



Saraux et al. in prep.

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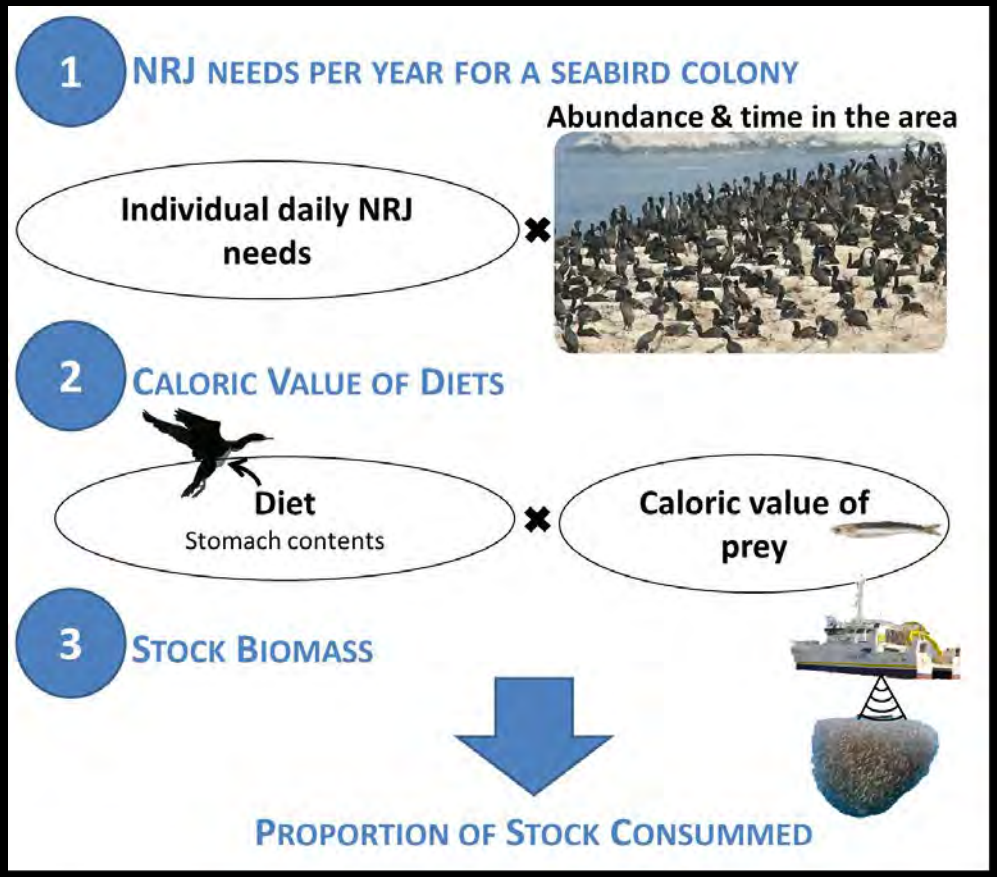
Genericity of seabird-forage fish interactions

Q2. Top-down effect of seabird on fish?

% of a fish stock consummed by seabird:



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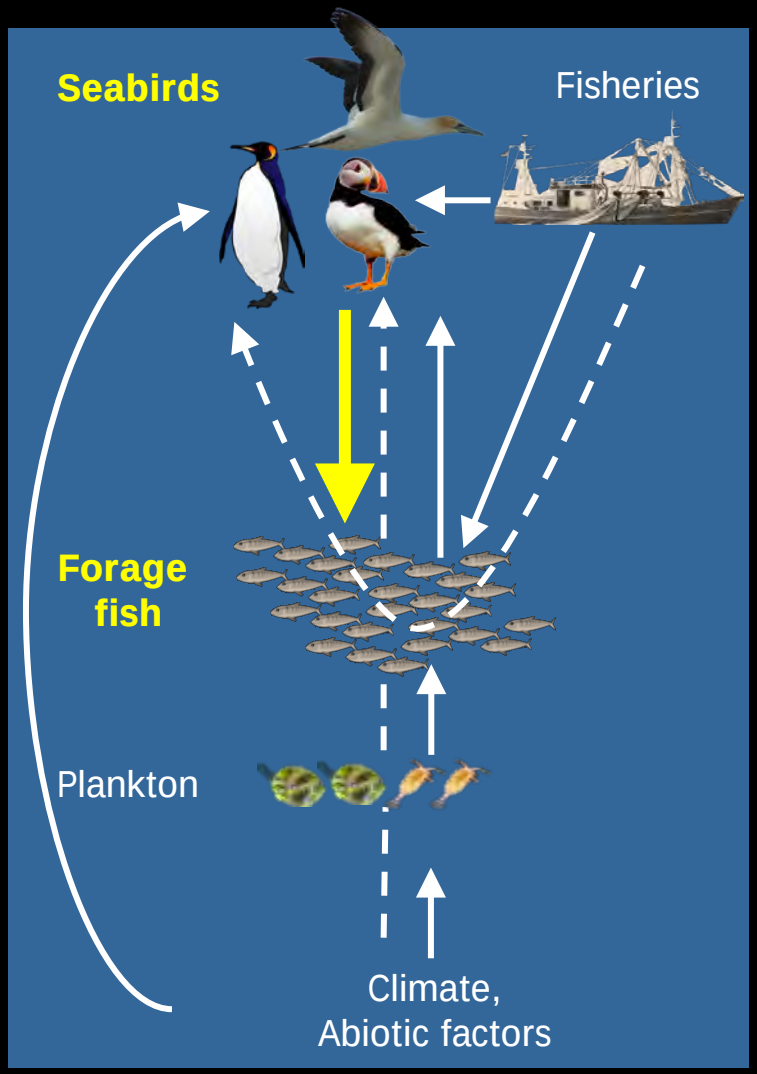

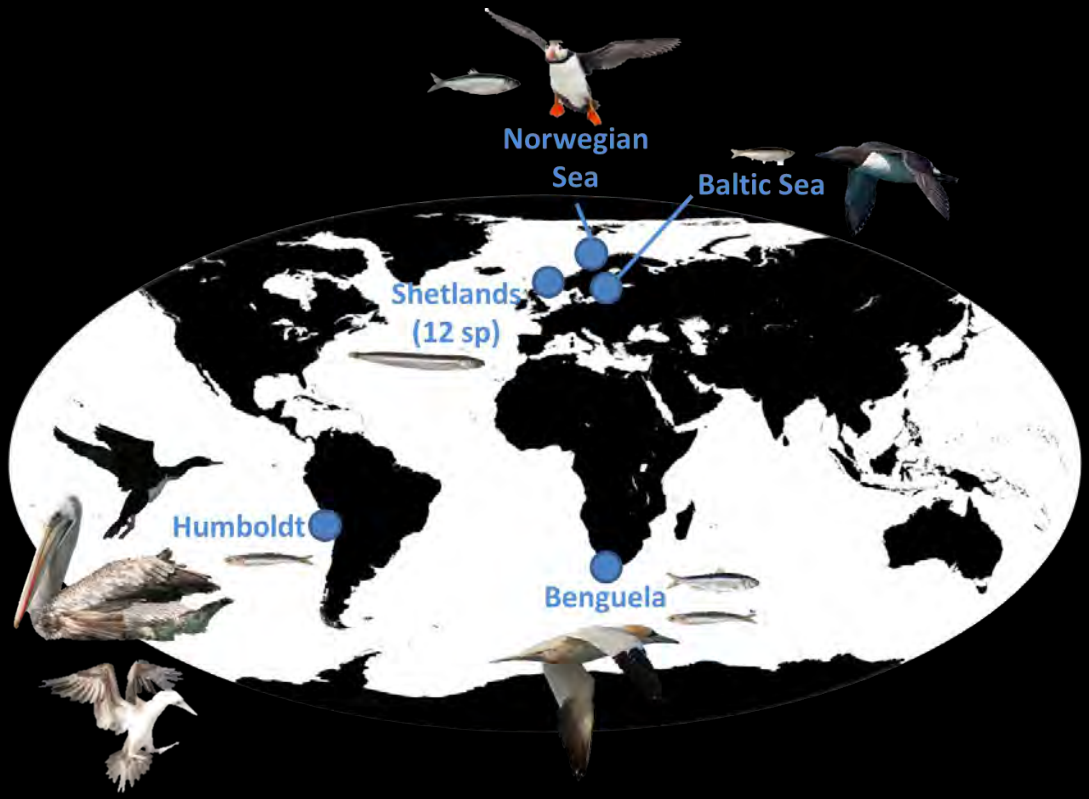

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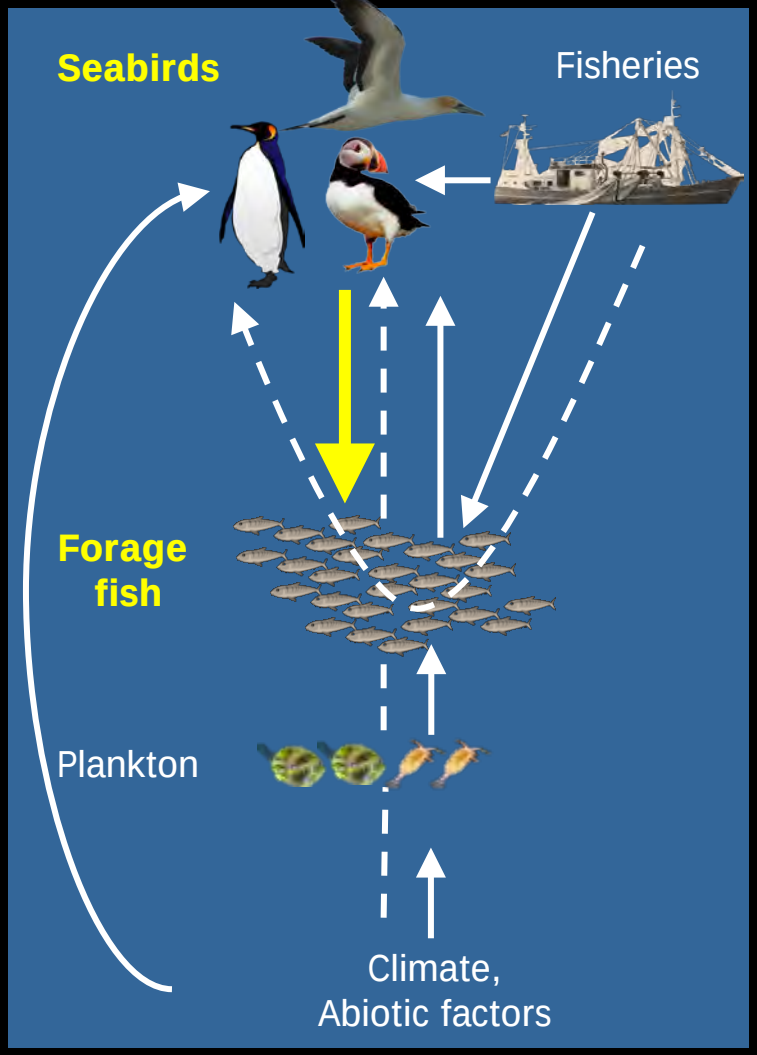


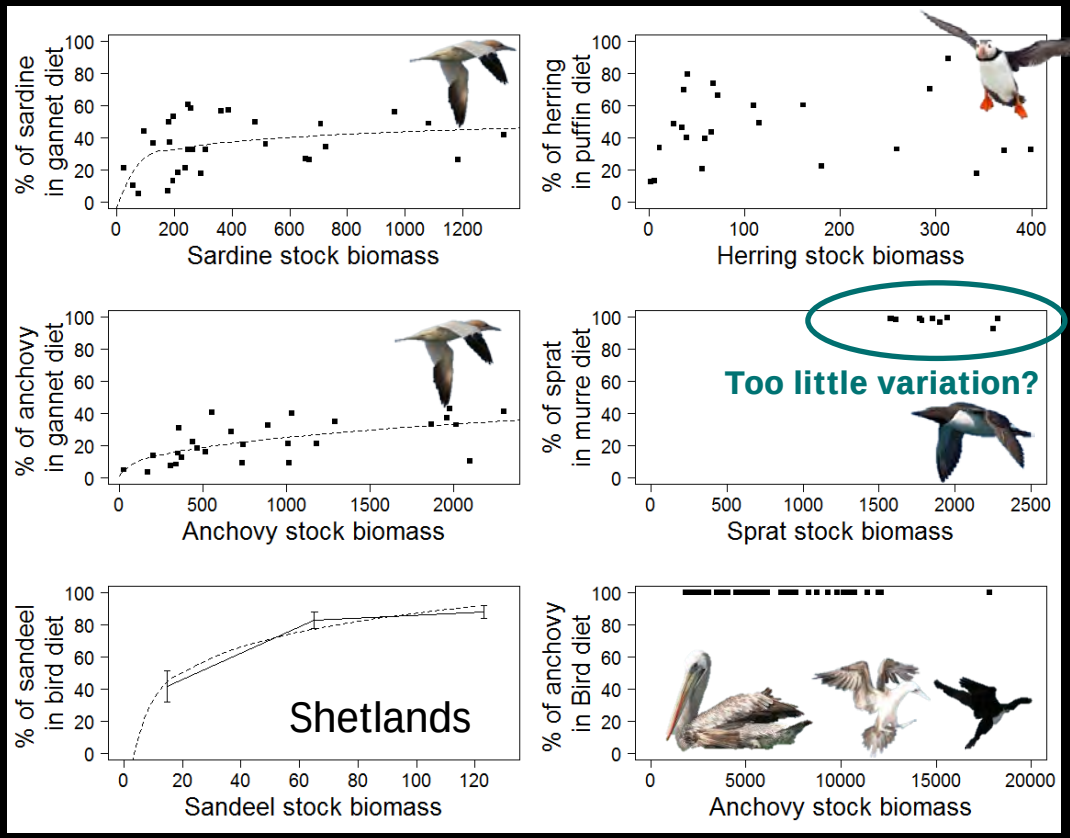
Saraux et al. in prep.

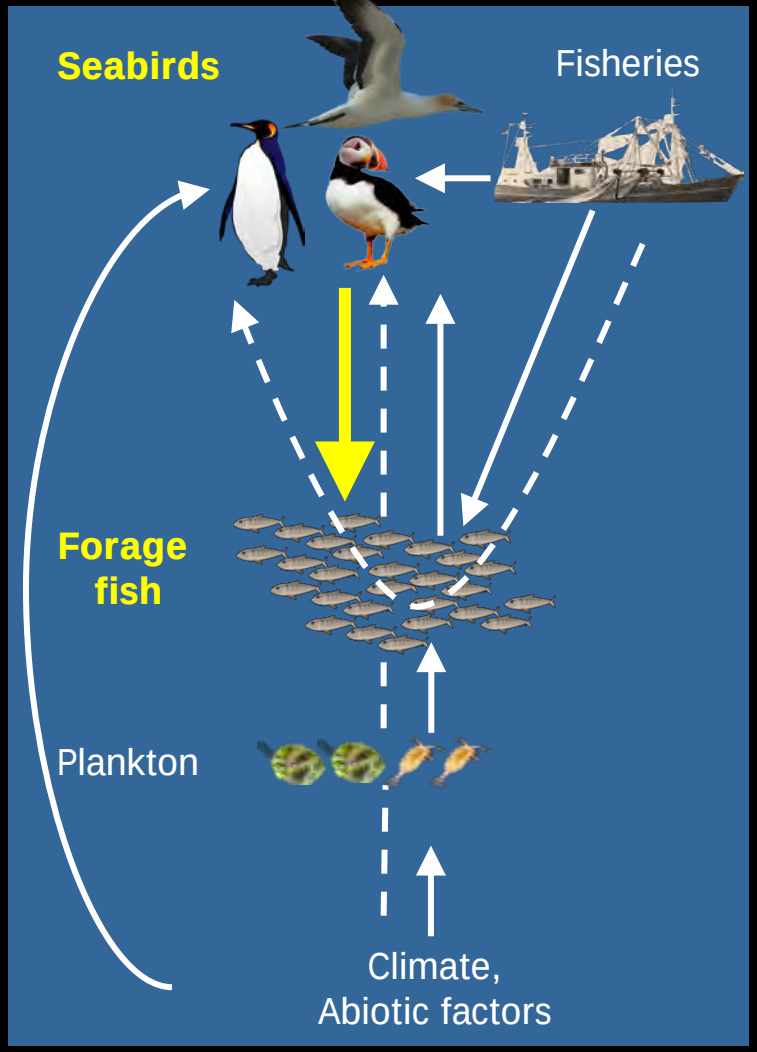
Axis 1

Genericity of seabird-forage fish interactions

Q2. Top-down effect of seabird on fish?

Redirection *vs.* diet independent from stock biomass





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Genericity of seabird-forage fish interactions

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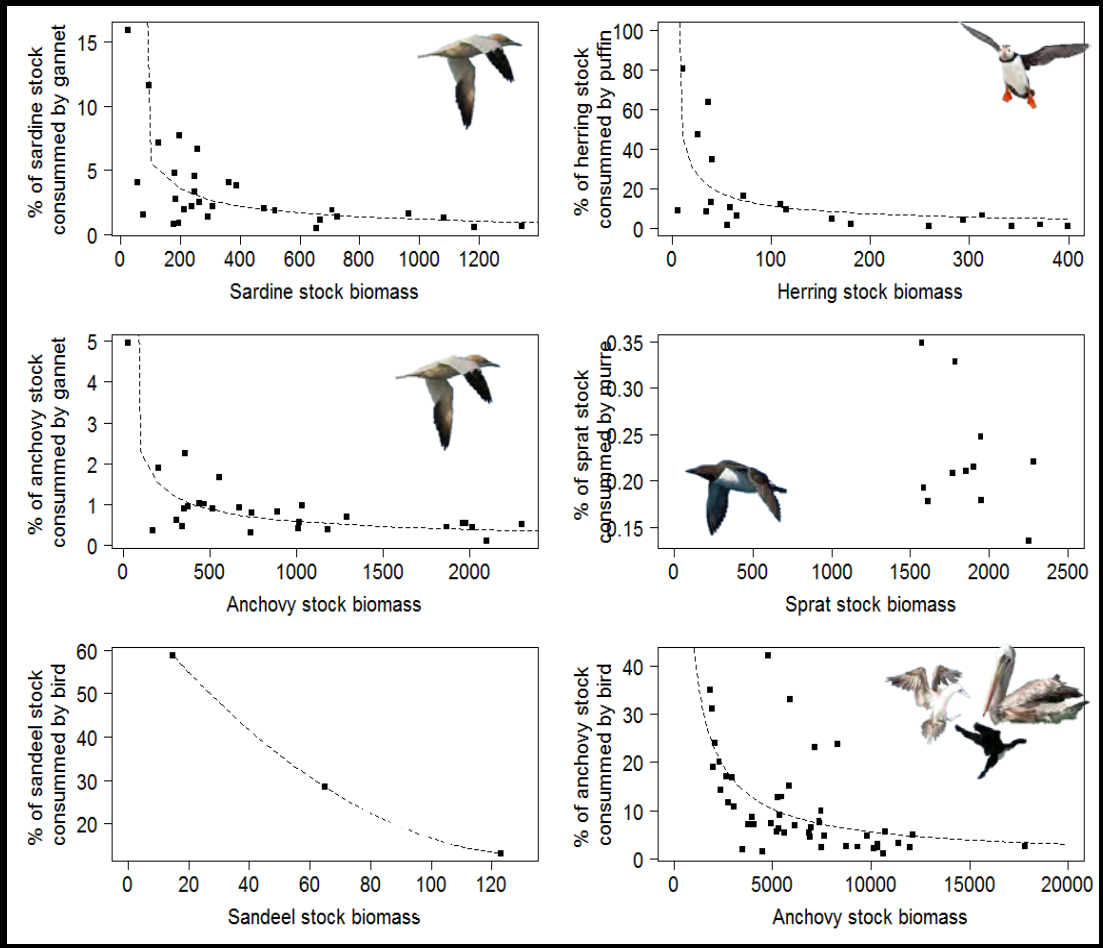

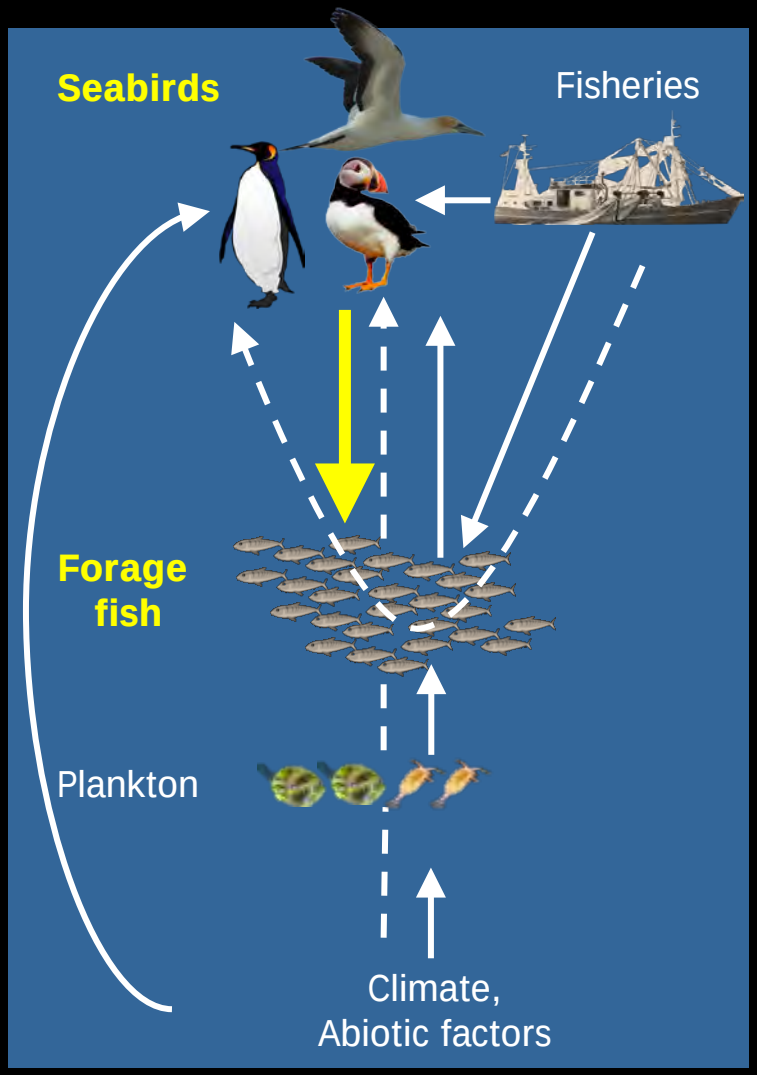

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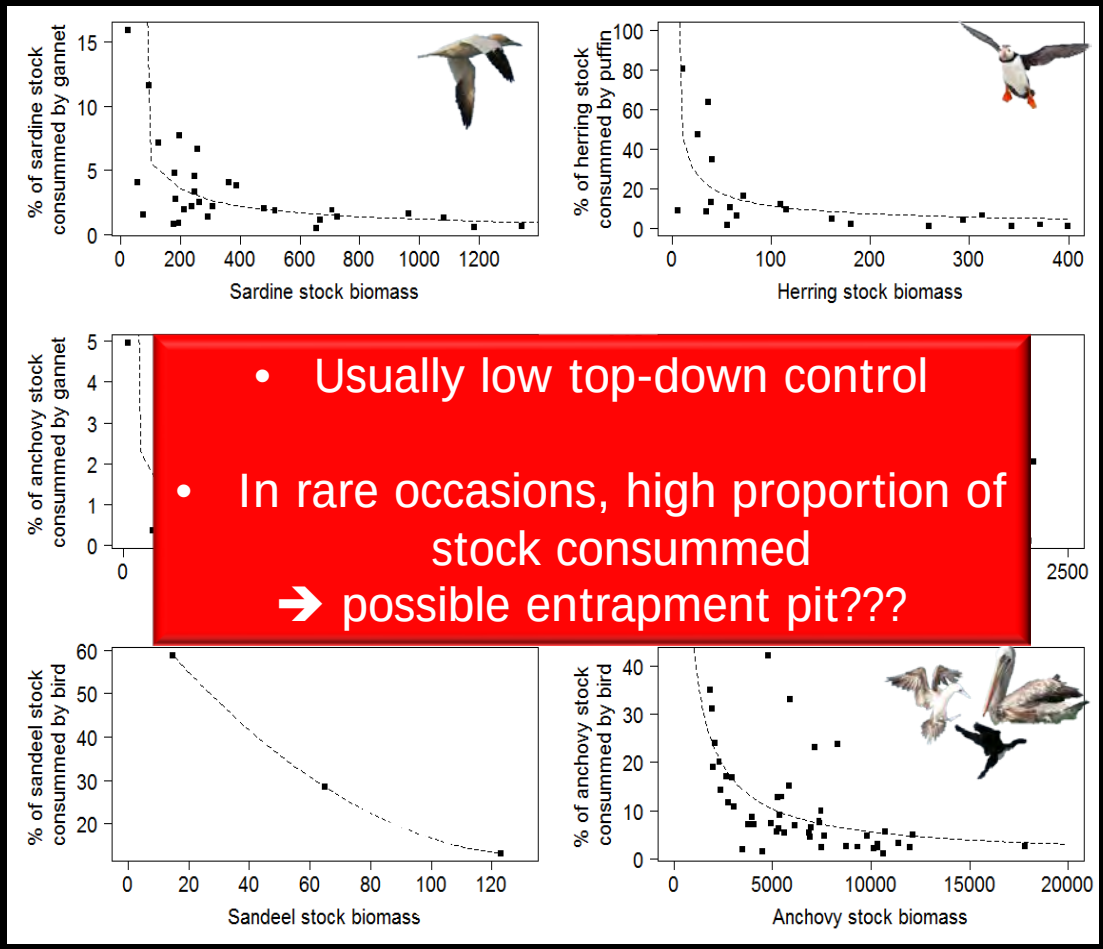
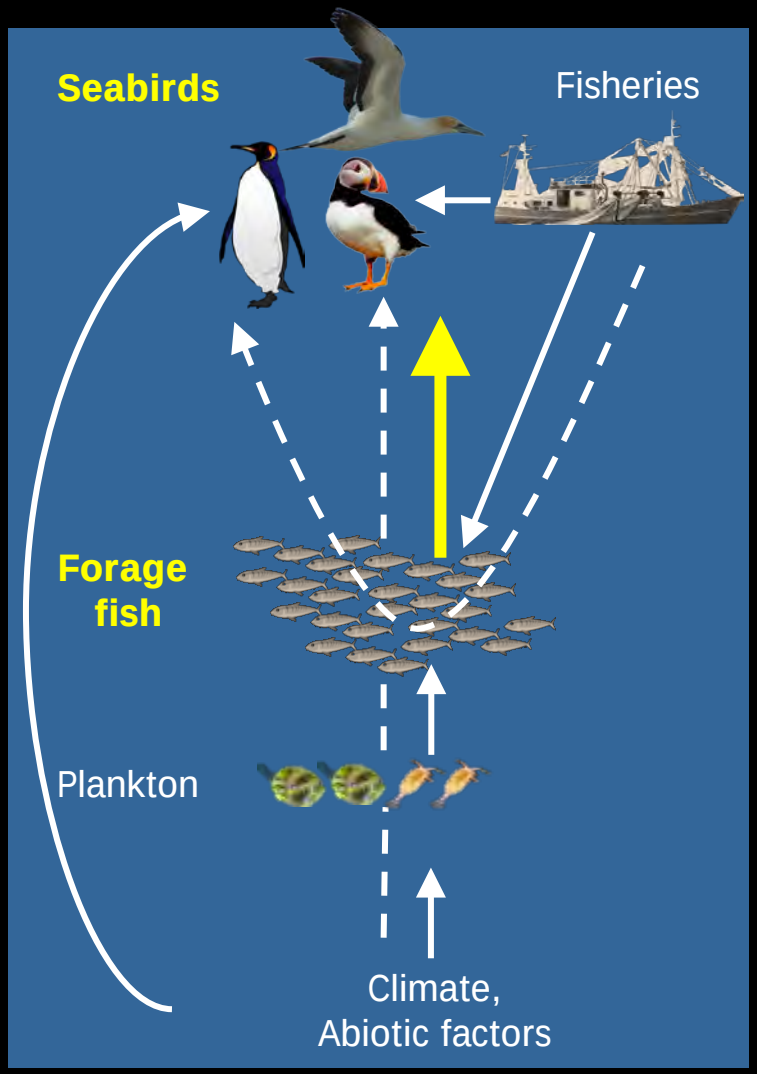


- Usually low top-down control
- In rare occasions, high proportion of stock consummed
  ➔ possible entrapment pit???

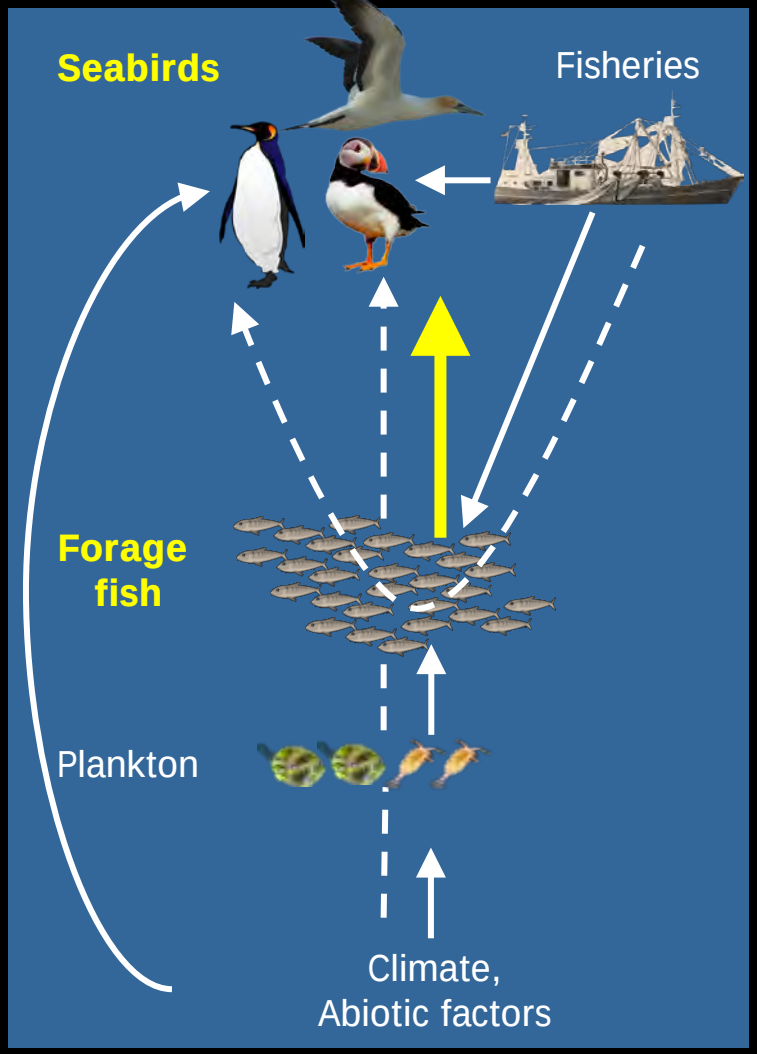


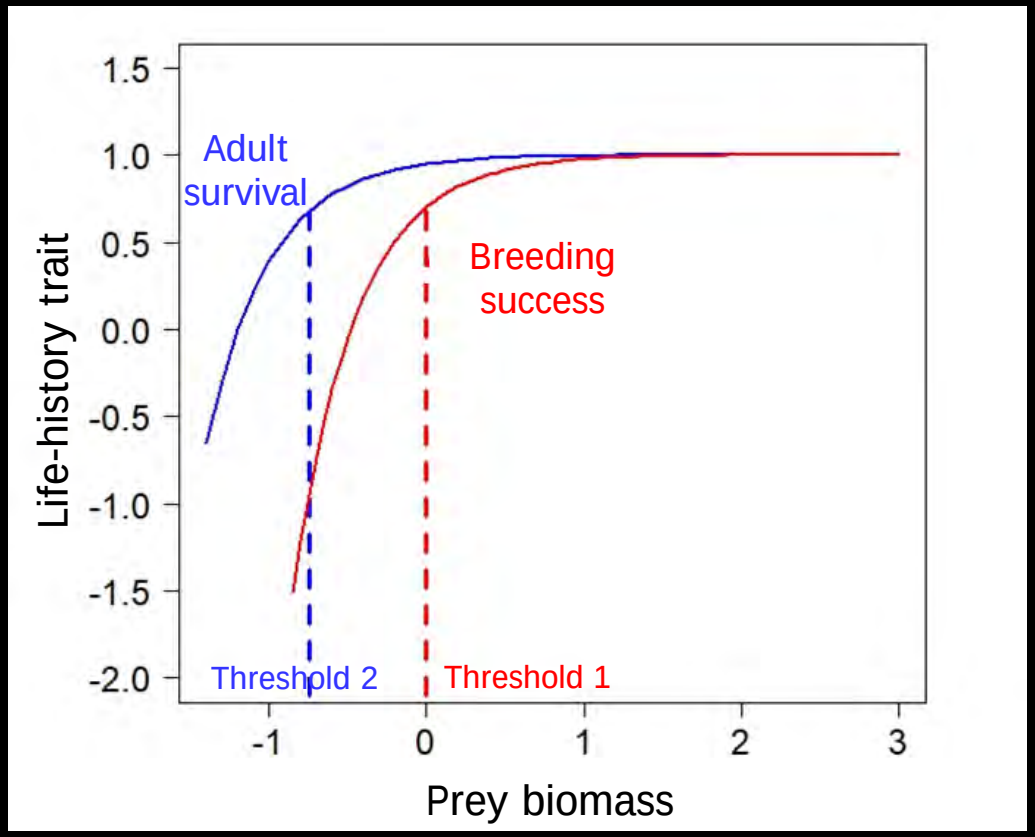
Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility

Axis 2

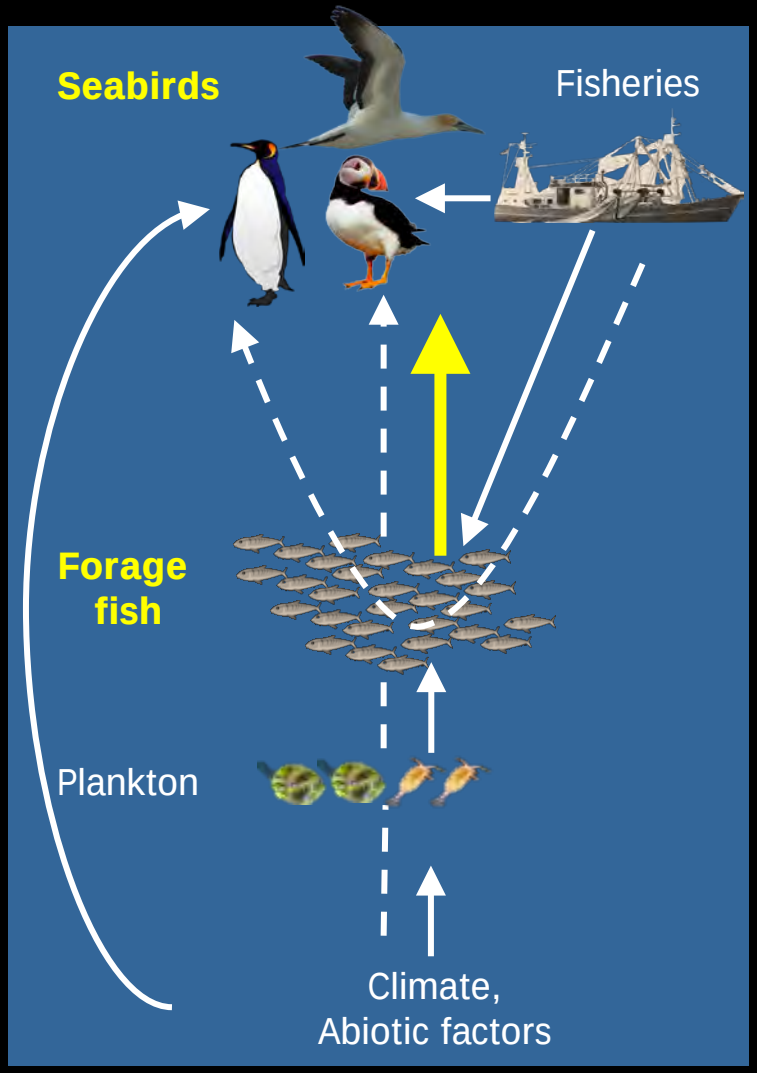
Mechanisms of bottom-up control?
Energy transfer & stock accessibility

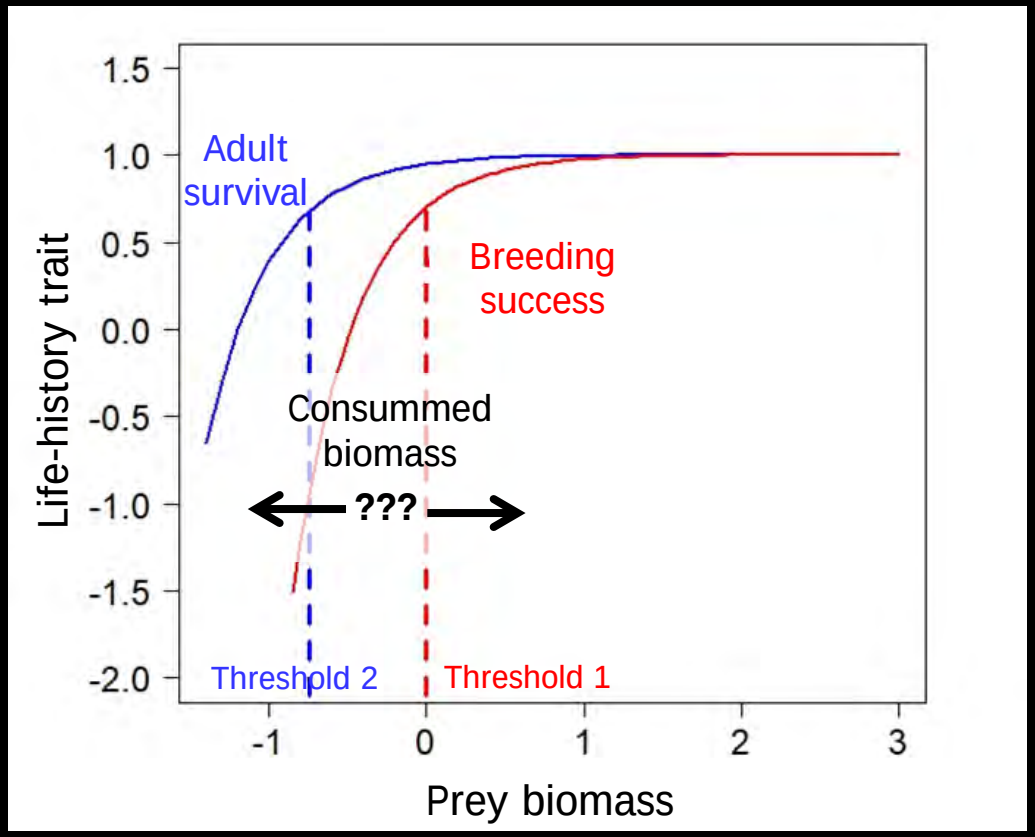




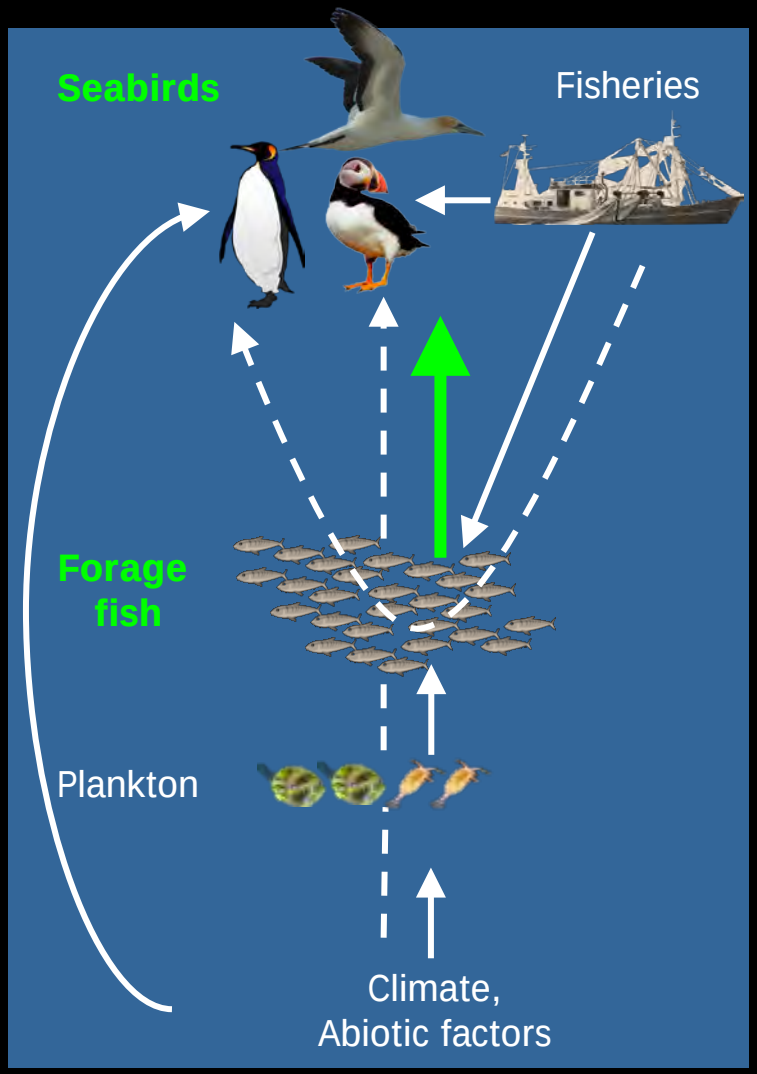
Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility





Piatt et al. in prep.



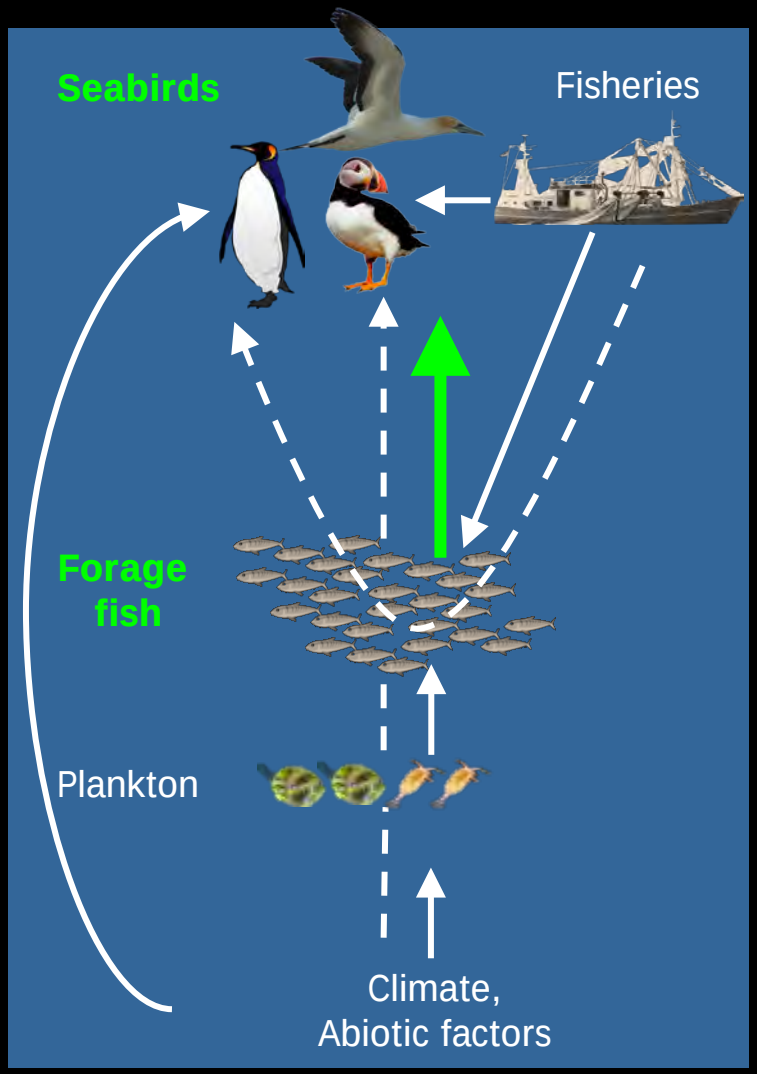
Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility

Which part of the stock is accessible for seabirds?

Q1. Spatial distribution of fish in 3D?

Q2. Ecophysiological constraints of seabirds?



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Mechanisms of bottom-up control?
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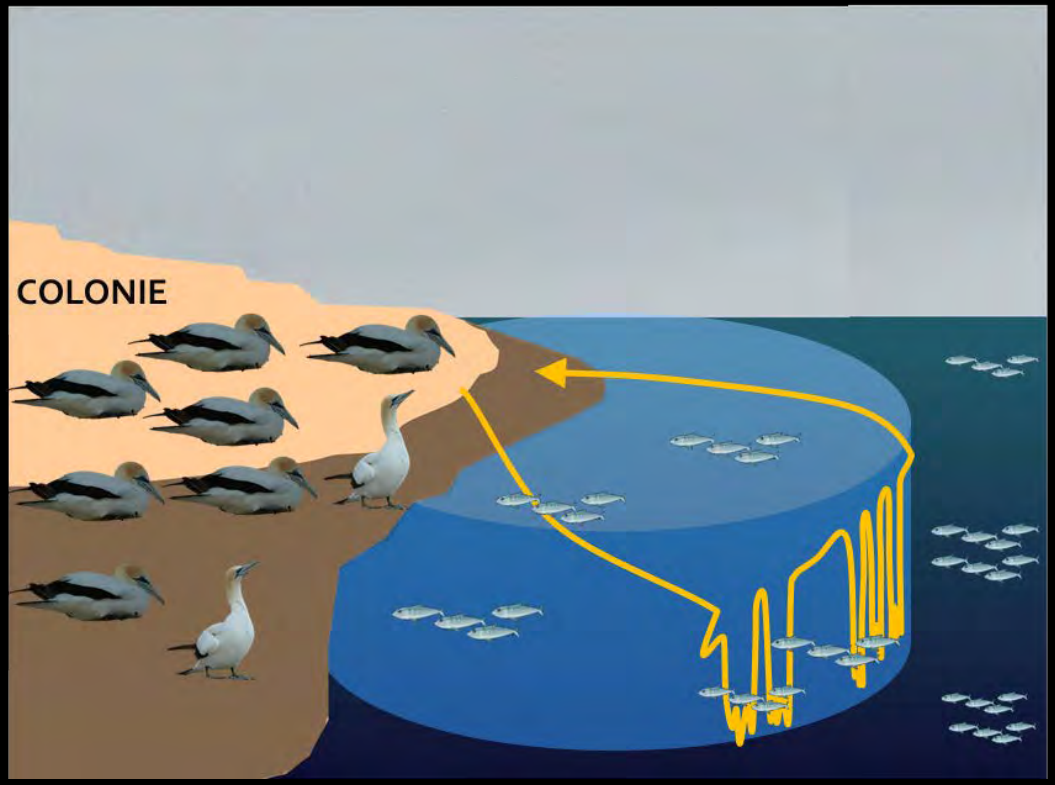
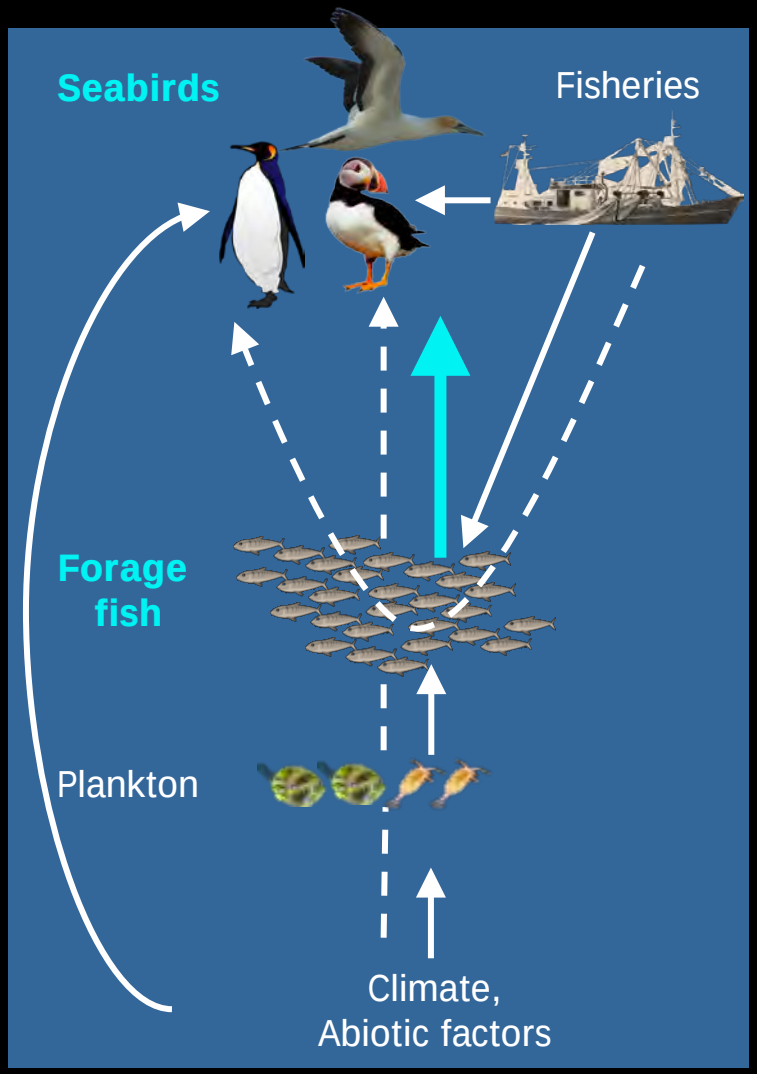
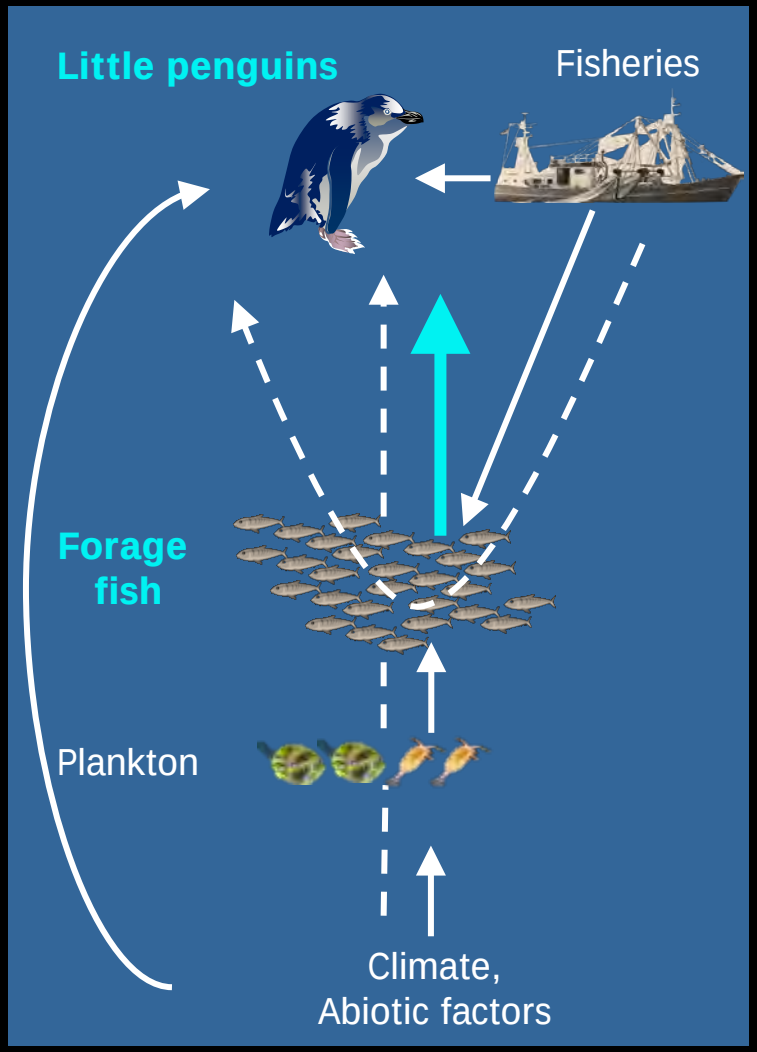




Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility

Q3. How does seabird NRJ balance vary with fish distribution and aggregation?

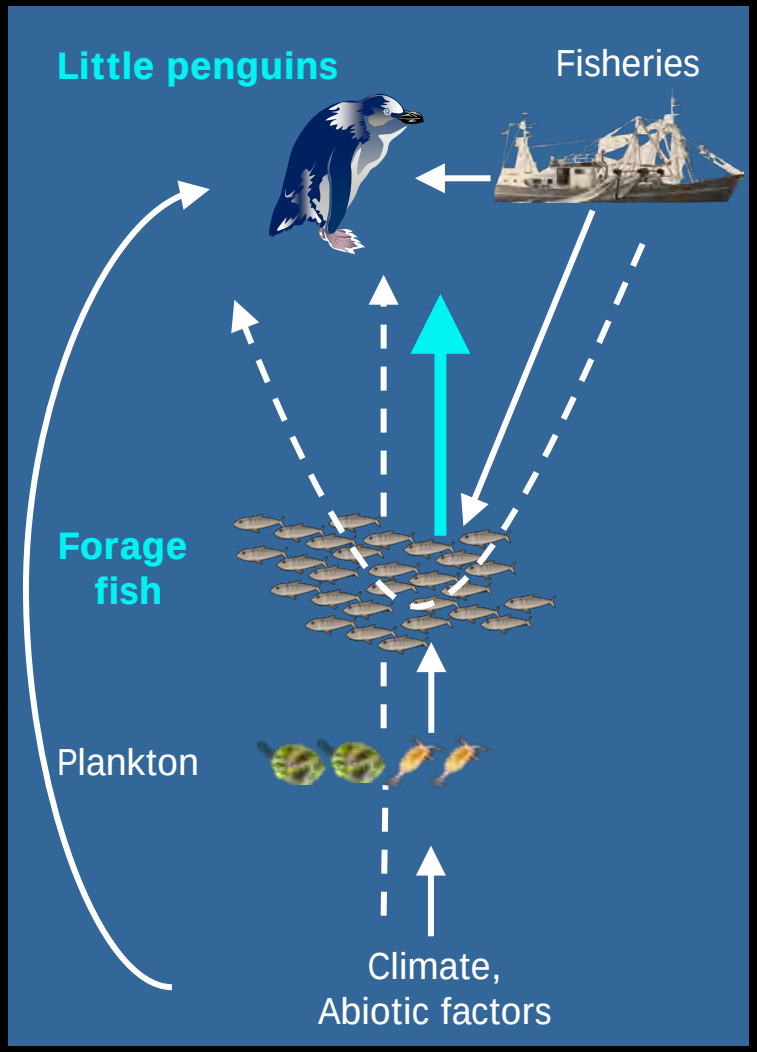


Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility

Q3. How does seabird NRJ balance vary with fish distribution and aggregation?

1. NRJ expenditure using accelerometers

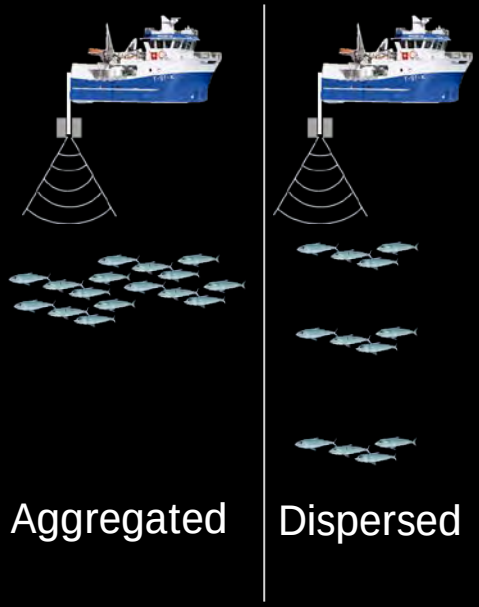


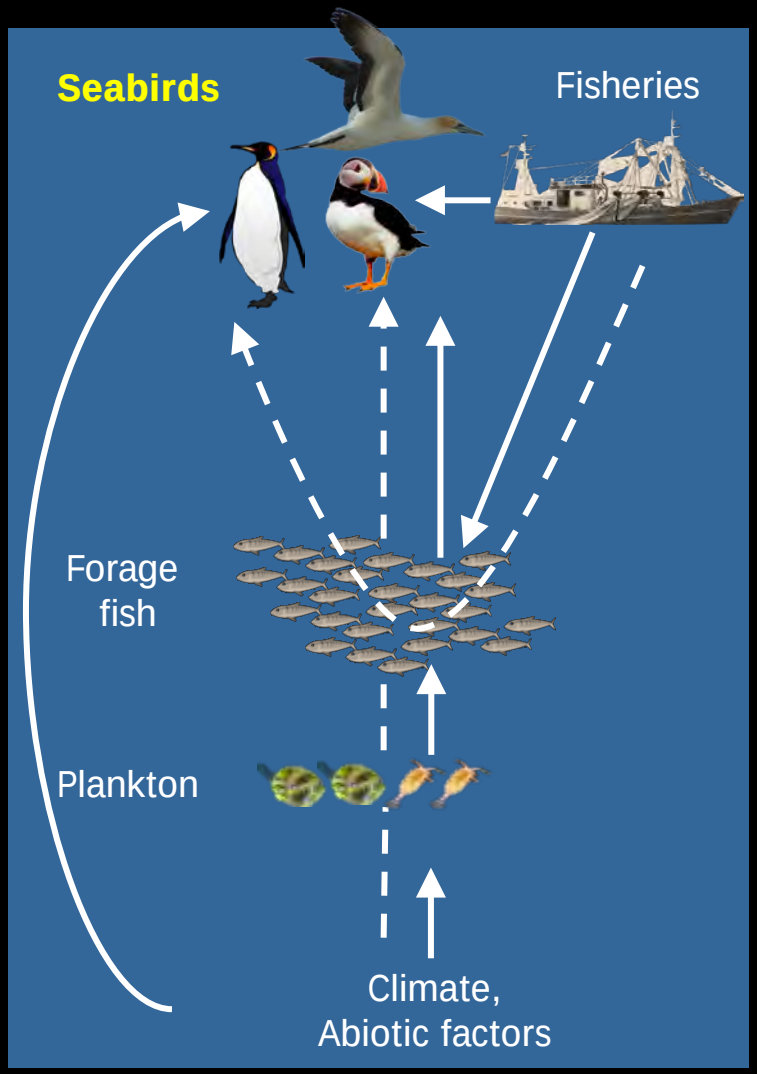
Axis 2

Mechanisms of bottom-up control?
Energy transfer & stock accessibility

Q3. How does seabird NRJ balance vary with fish distribution and aggregation?

1. NRJ expenditure using accelerometers
2. Spatial distribution of fish using acoustic survey





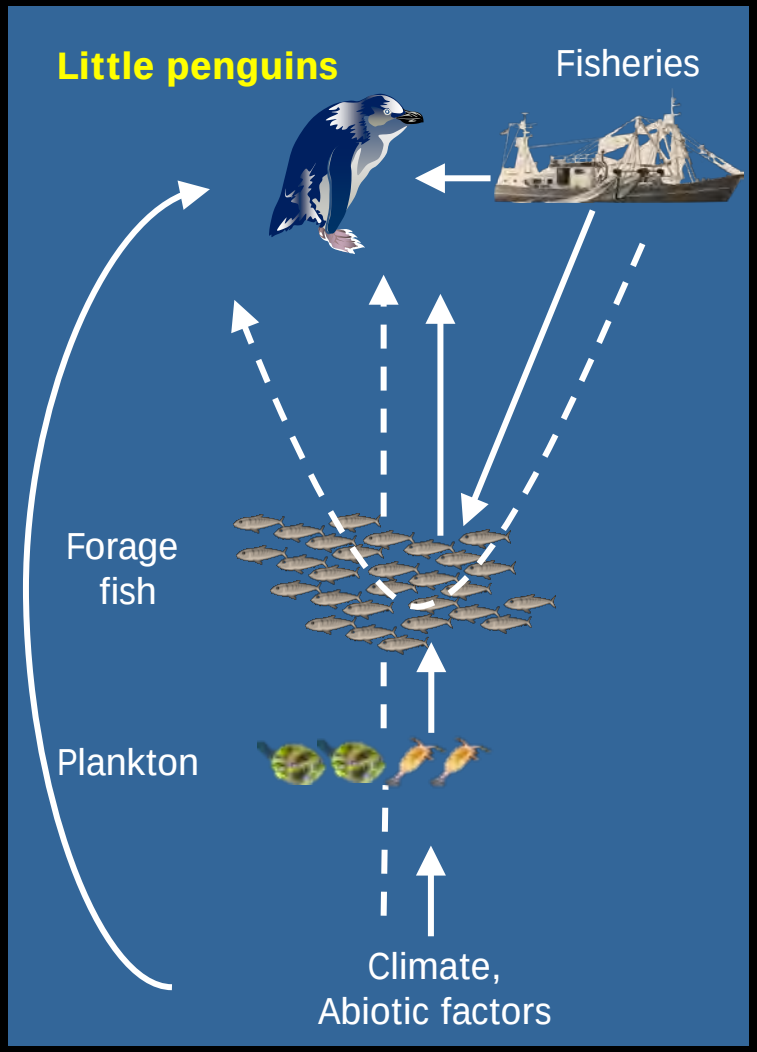
Axis 3

Interindividual differences & plasticity

$$M = \begin{pmatrix} 0 & BS = f_1(prey\ biomass) \\ Surv_{juv} = f_3(prey\ biomass) & Surv_{adult} = f_2(prey\ biomass) \end{pmatrix}$$

Assumptions:

- All individuals react the same in a given category
- Individuals always react the same way

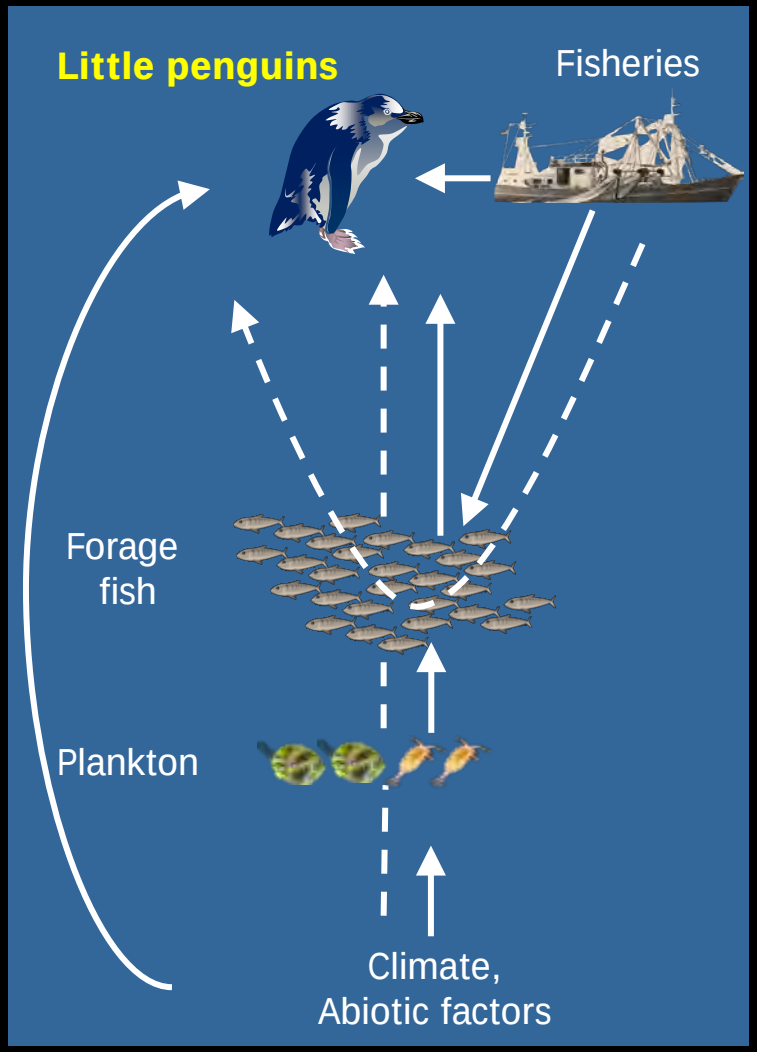


Saraux et al. 2011. Beh Ecol

Axis 3

Interindividual differences & plasticity

Assumption 1: All individuals react the same in a given category



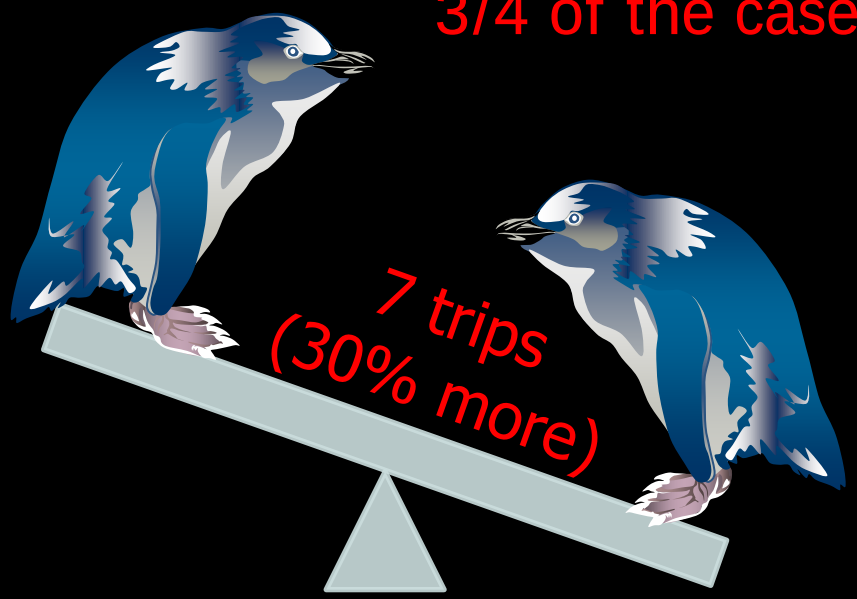
Saraux et al. 2011. Beh Ecol

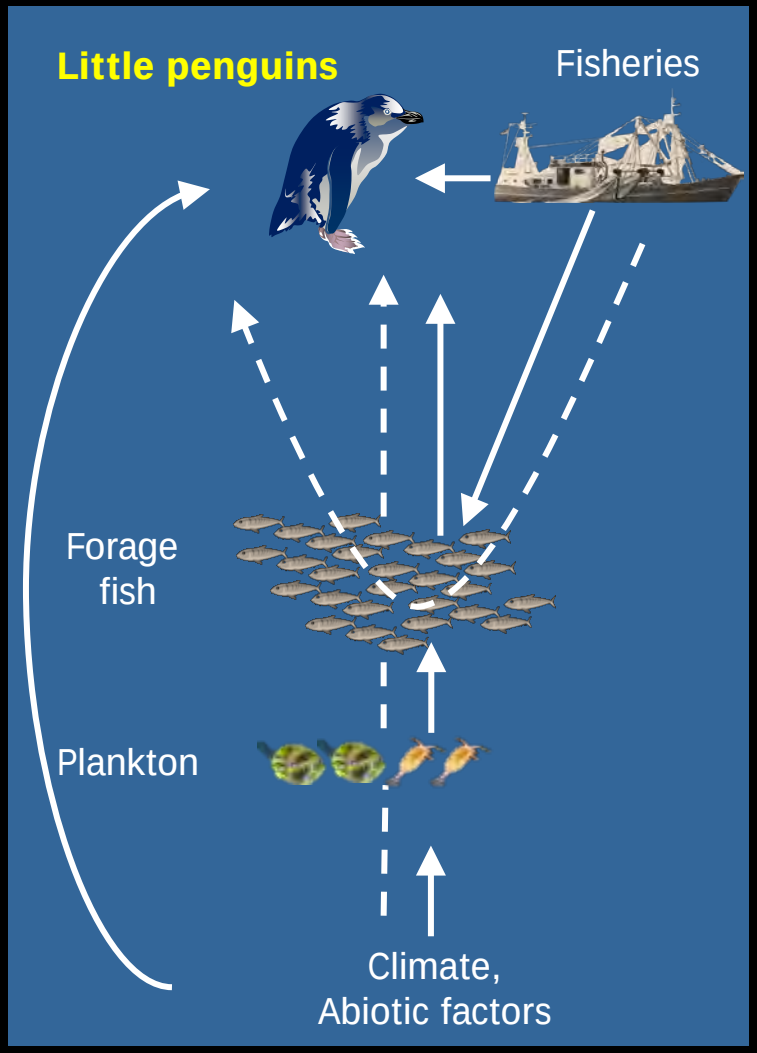
Axis 3

Interindividual differences & plasticity

Assumption 1: All individuals react the same in a given category

Parental care





Saraux et al. 2011. Beh Ecol

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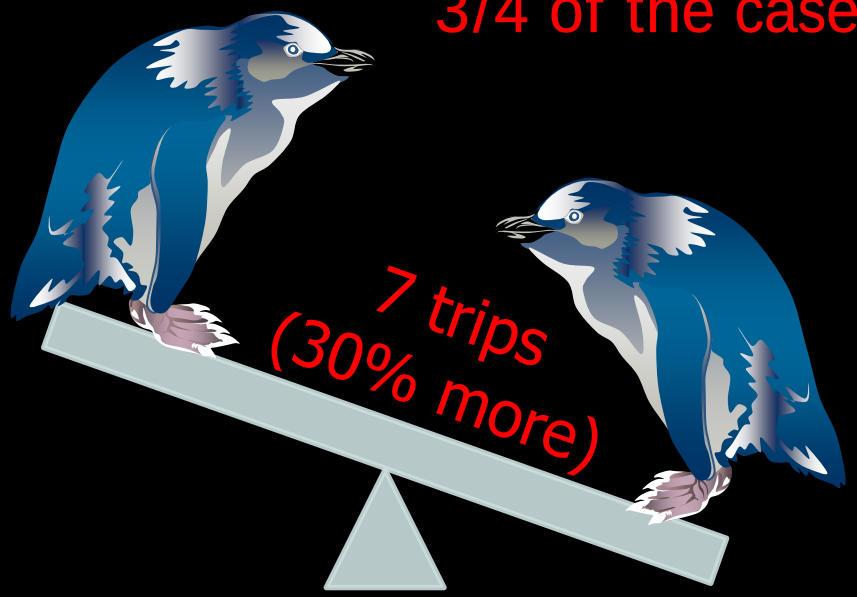
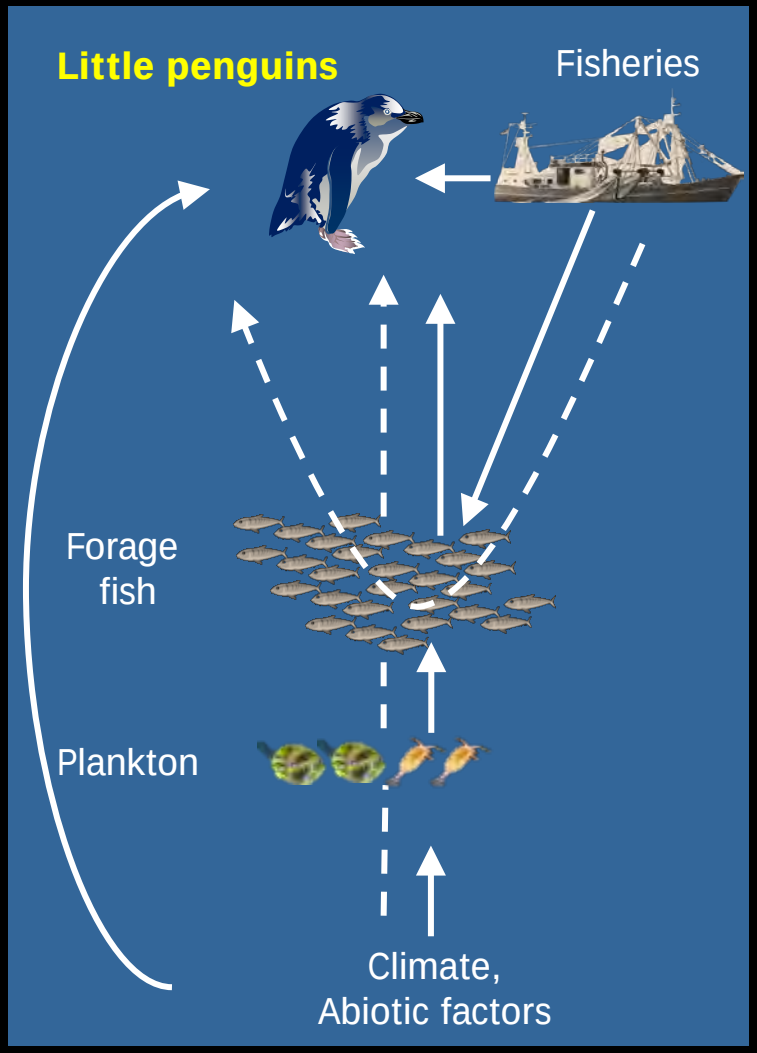


Explained by Sex or Age?



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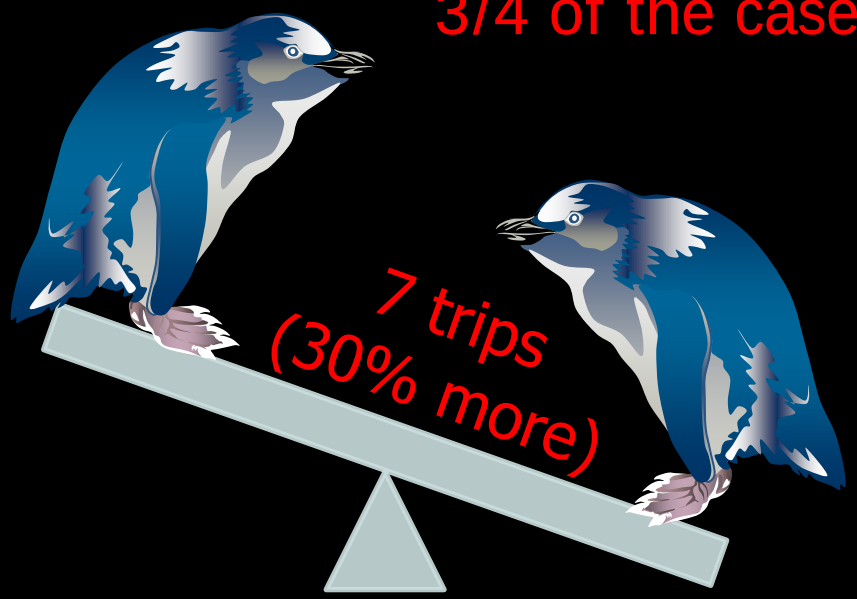
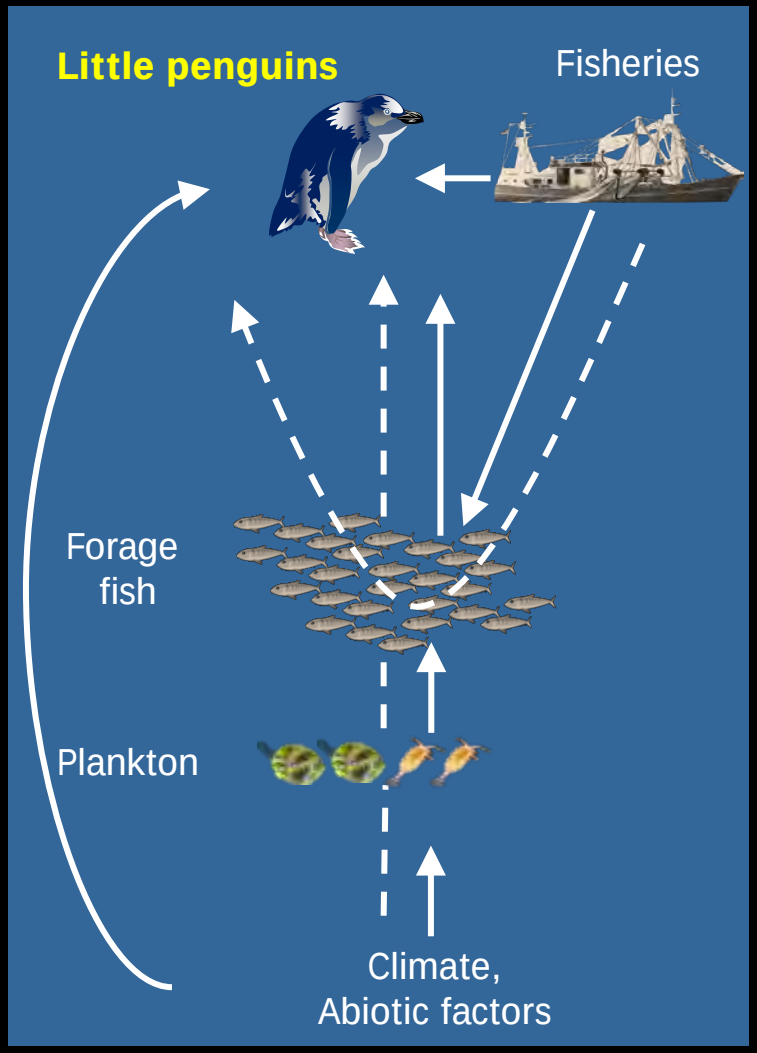


Explained by ~~Sex or Age?~~



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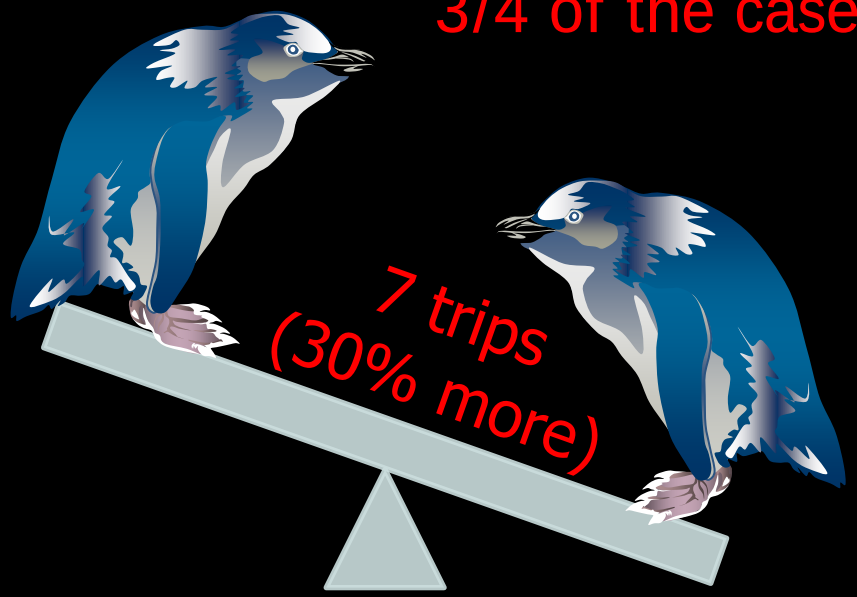
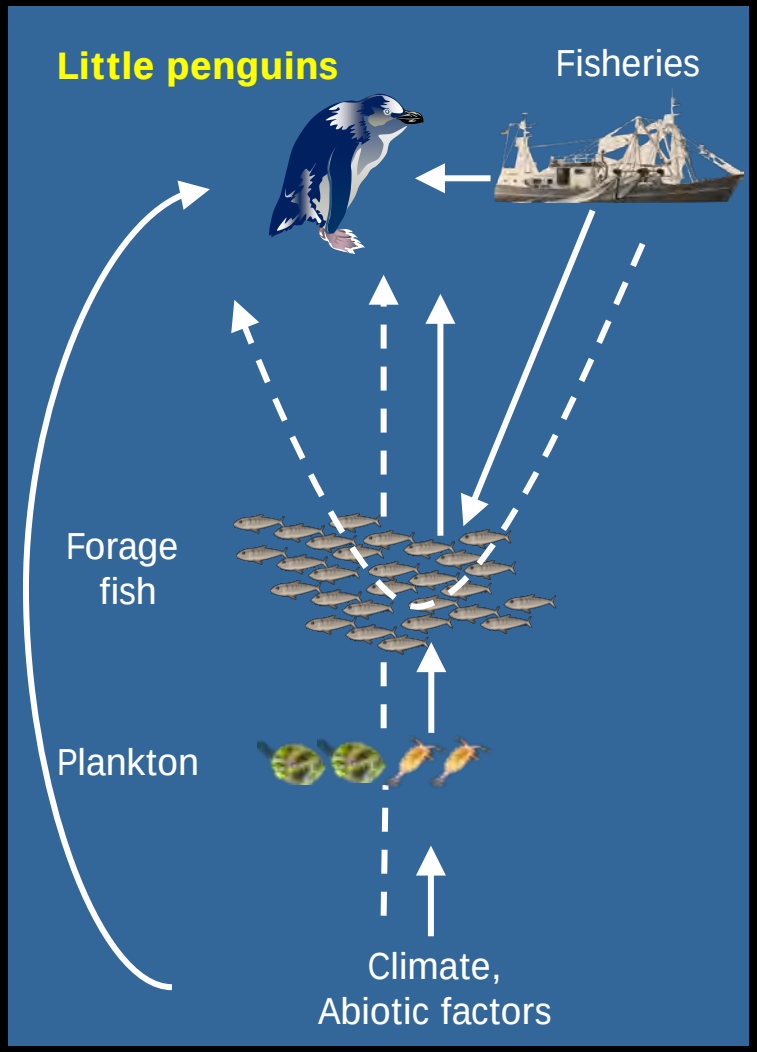


Explained by ~~Sex or Age?~~

Consistency through life

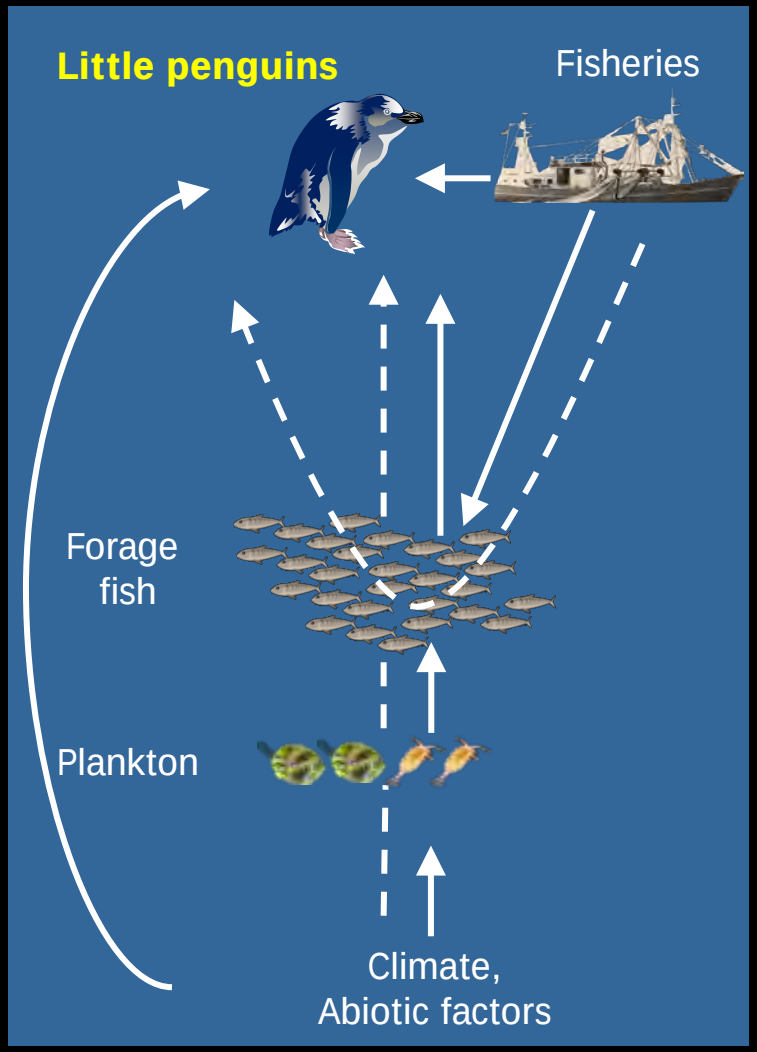


Saraux et al. 2011. Ecology

Axis 3

Interindividual differences & plasticity

Assumption 2: Individuals always react the same way



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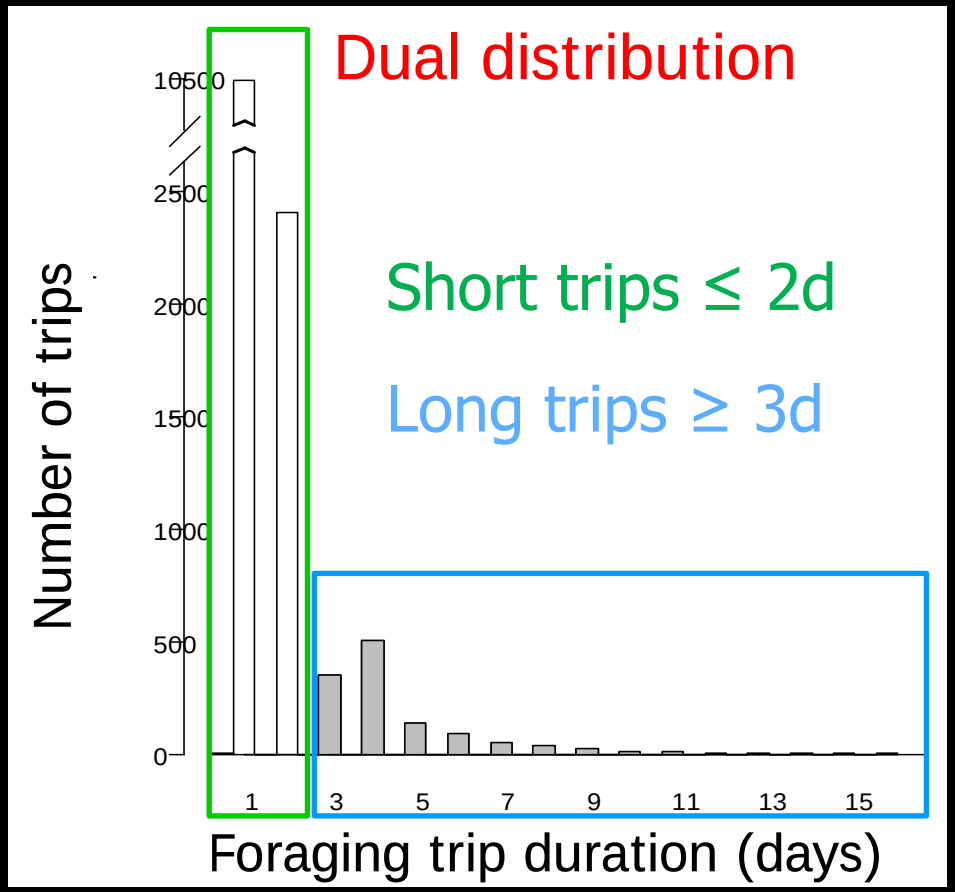
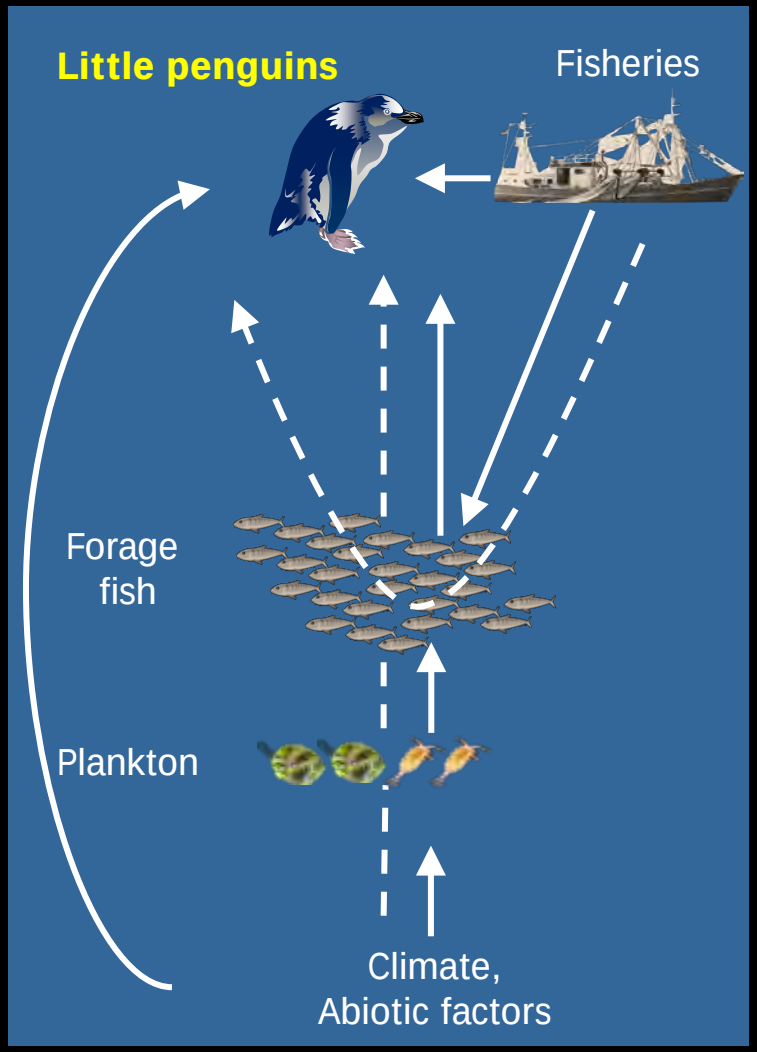




Saraux et al. 2011. Ecology

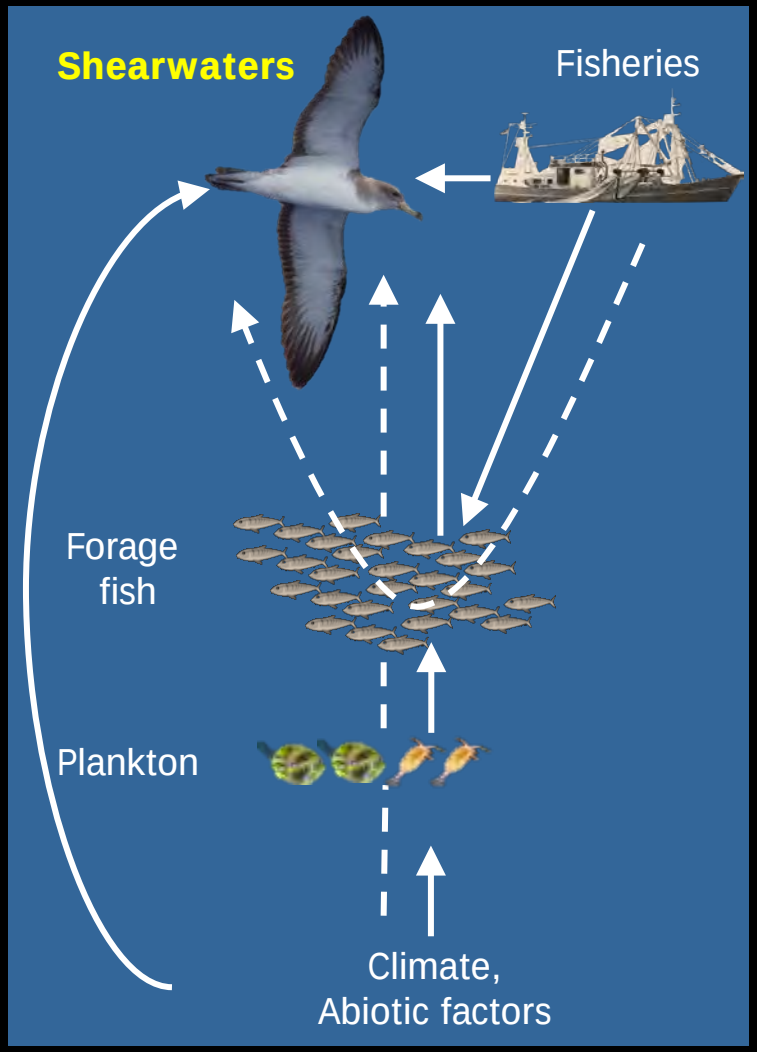
Axis 3

Interindividual differences & plasticity

Assumption 2: Individuals always react the same way

Alternate between short and long trips depending on their own condition & environment

➔ Plasticity in foraging



Courbin et al. 2018. Ecol letters

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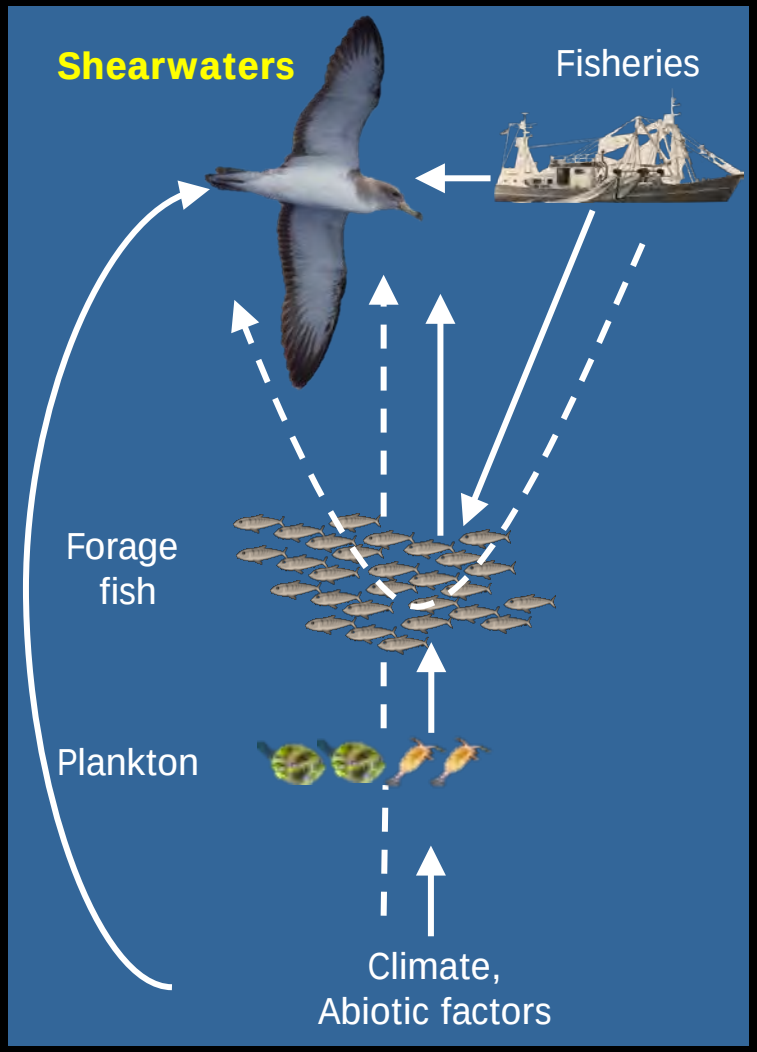

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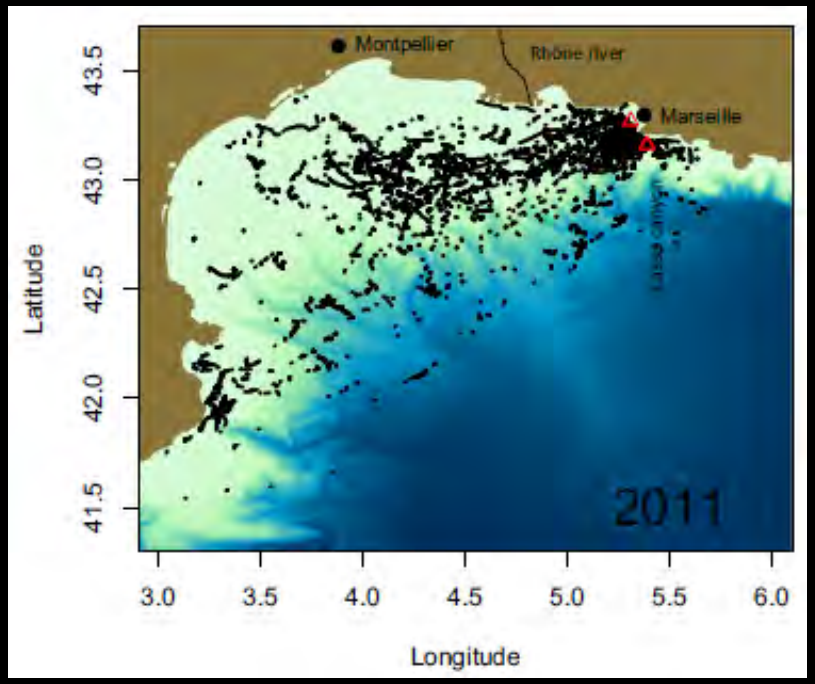
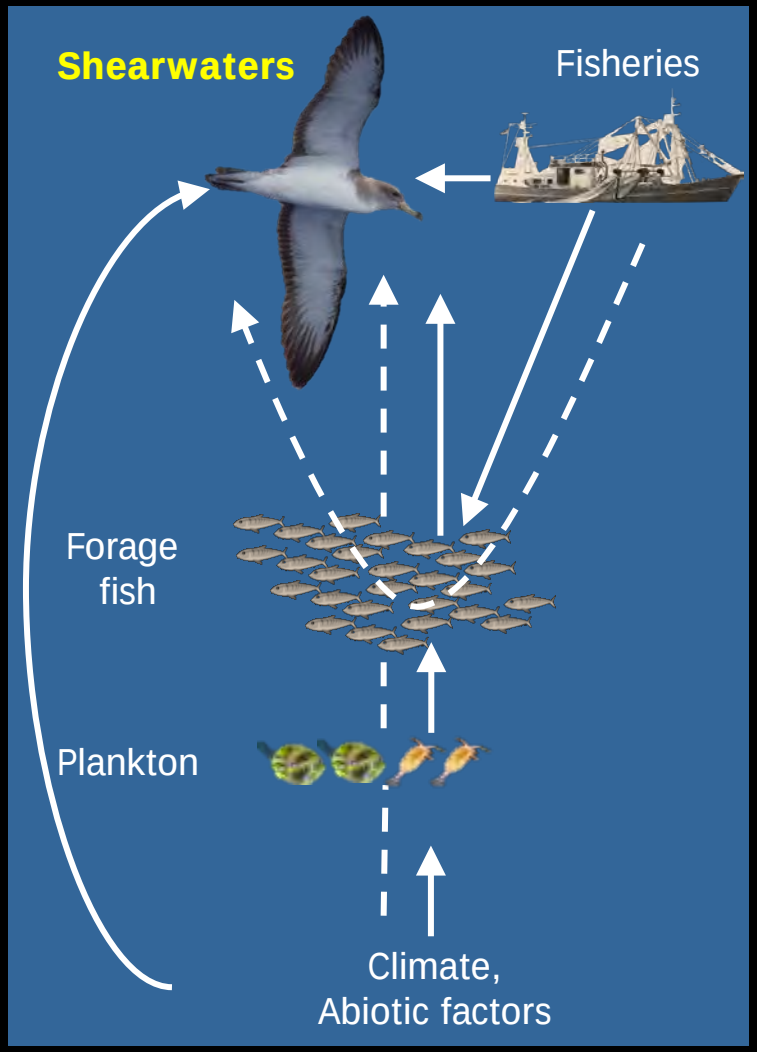


Site fidelity?
Resource selection?
Diet specialization?



Courbin et al. 2018. Ecol letters

Axis 3

Interindividual differences & plasticity

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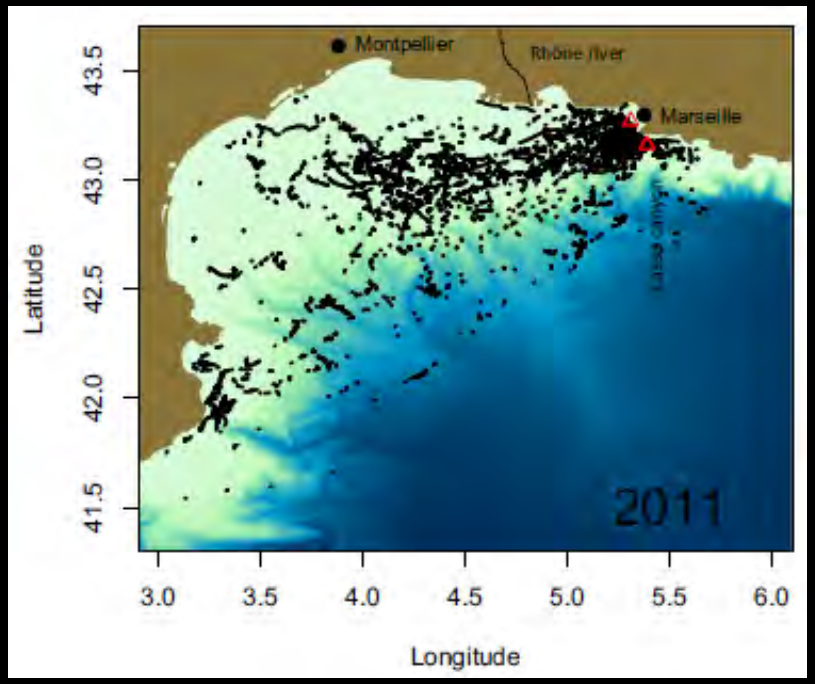
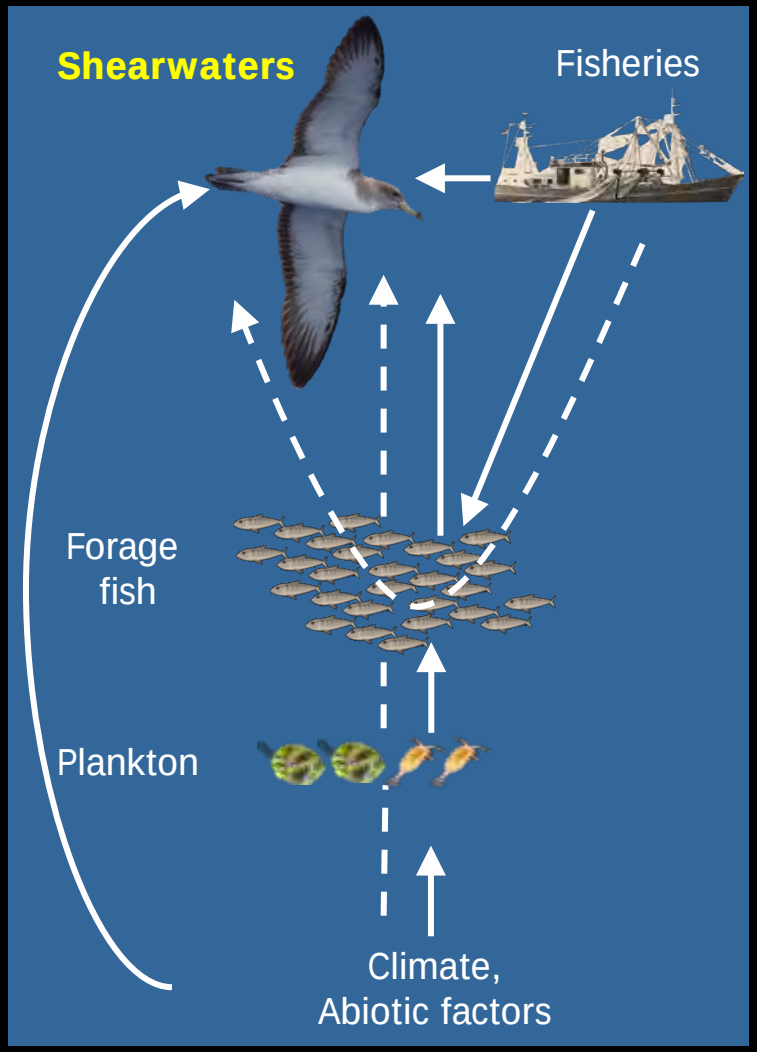


Site fidelity? X

Resource selection? X

Diet specialization? X



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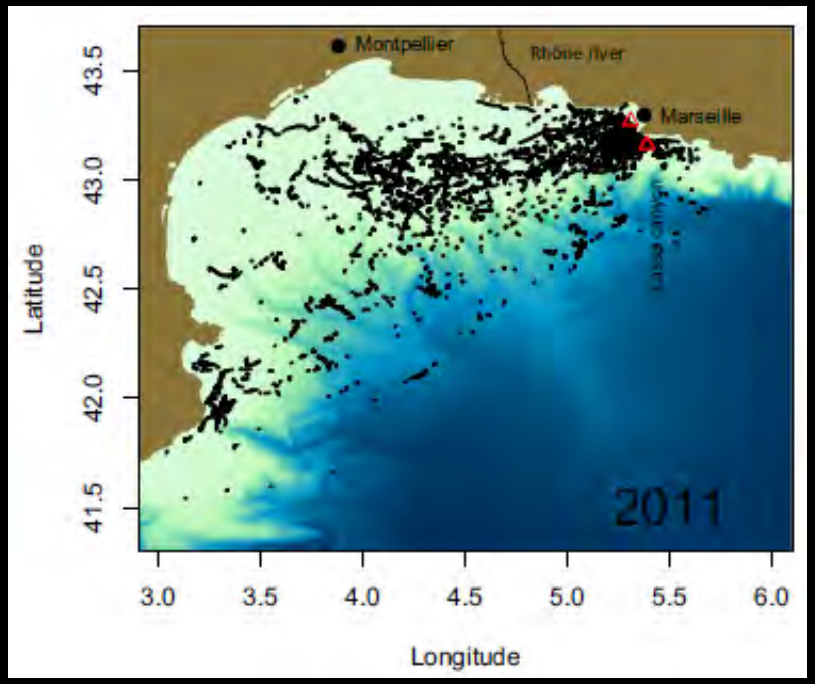
Axis 3

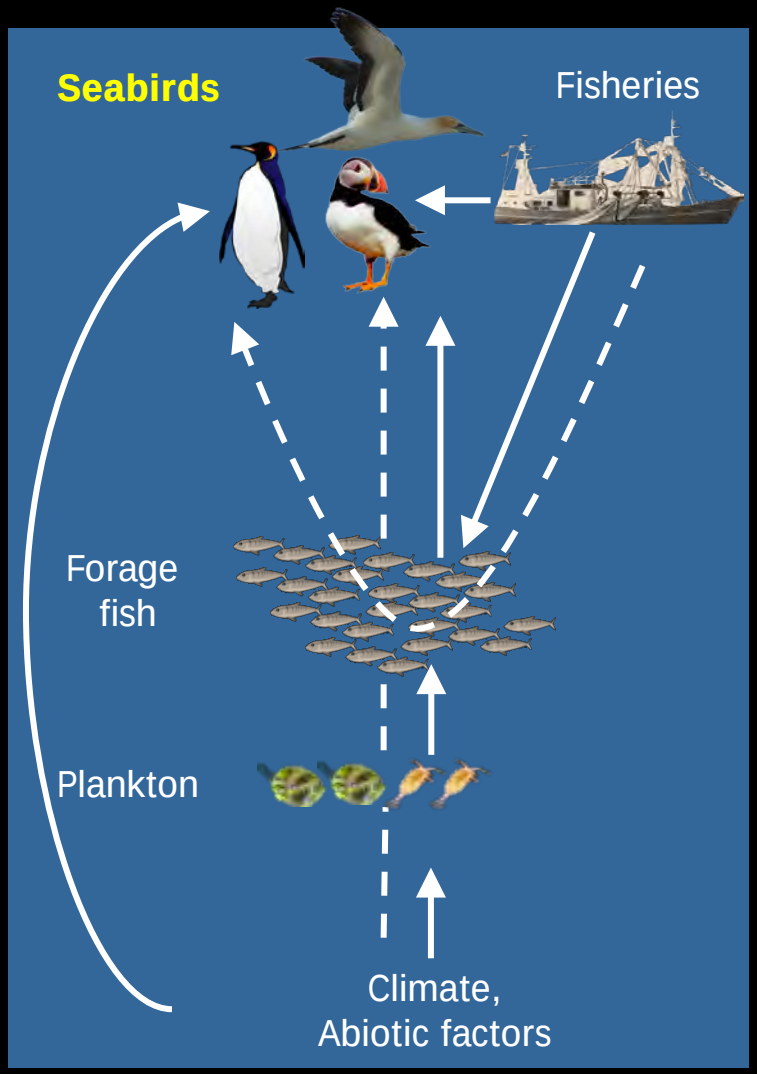
Interindividual differences & plasticity

Assumption 2: Individuals always react the same way



Site fidelity? ✗
Resource selection? ✗
Diet specialization? ✗

High plasticity, daily foraging tactics



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$$M = \begin{pmatrix} 0 & BS = f_1(prey\ biomass) \\ Surv_{juv} = f_3(prey\ biomass) & Surv_{adult} = f_2(prey\ biomass) \end{pmatrix}$$

Needs:

- Incorporate individual heterogeneity
- Incorporate plasticity

Many thanks to all collaborators!

‘1/3 for the birds’

Thank you for your attention!