

Food of Rhinoceros Auklets as an indicator of regional abundance and body size of forage fish

Yutaka Watanuki^{1*}, Jumpei Okado^{2,3}, Motohiro Ito⁴,
Kentaro Kazama⁵, Jean-Baptiste Thiebot¹

¹ Hokkaido University, ²Japan Fisheries Research and Education Agency, ³Nagoya University, ⁴Toyo University, ⁵Waseda University

*Acknowledgement: PICES supports travel expenses

Predatory fish, Seals,
Whales, **Seabirds**,
Fisheries

Puffins

nest in ground burrows;
easy to catch
bring multiple number
of whole (age-0) fish in
the bills; **easy to
measure**

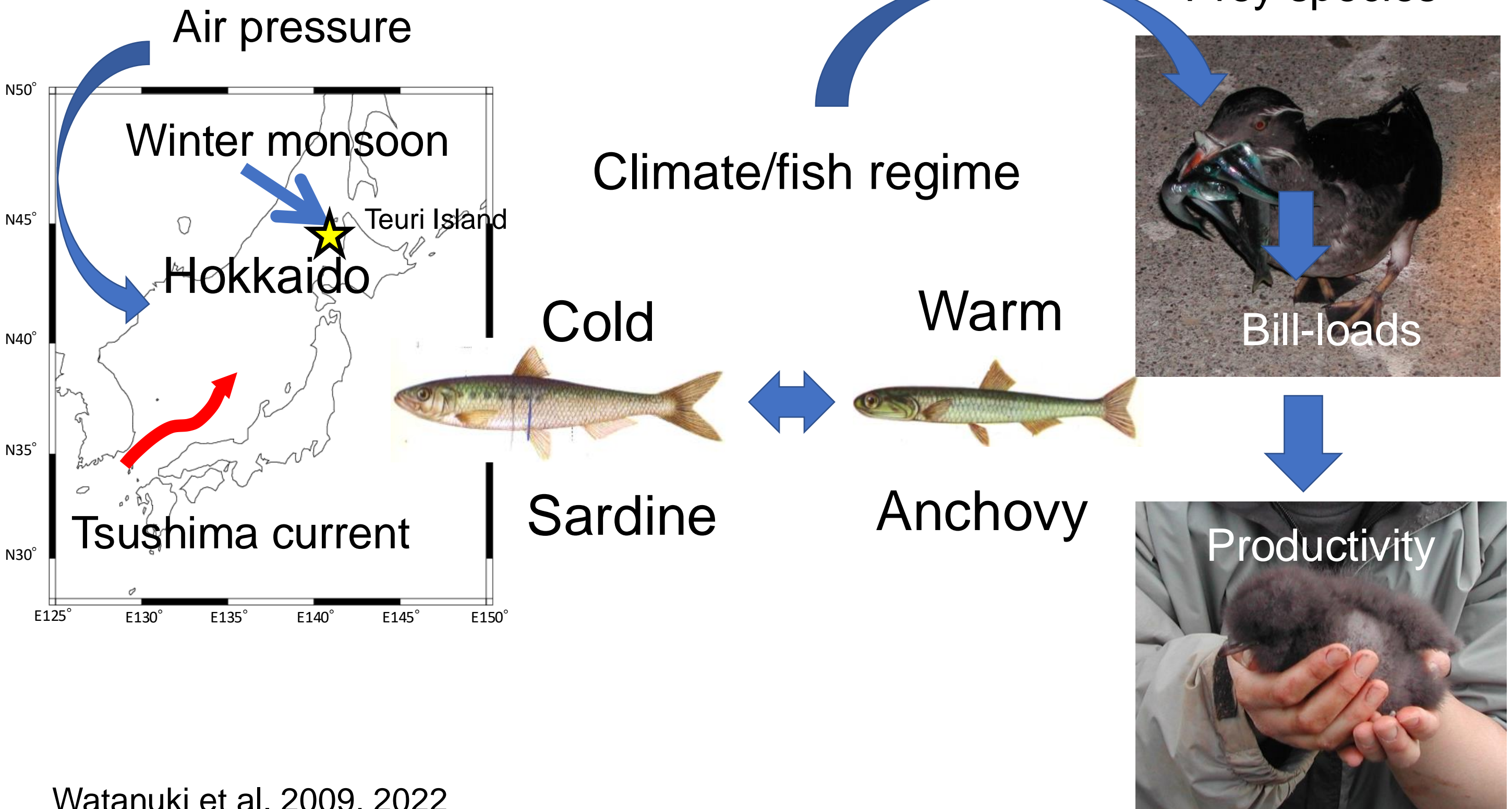
Forage
fish

Zooplankton
(Copepods)

Q1) Does **puffin prey composition** indicates regime shift?
Q2) and **fish abundance** ?
Q3) Does **size of fish in puffin diet** tell effects of environment on **age-0 growth**?

Our system

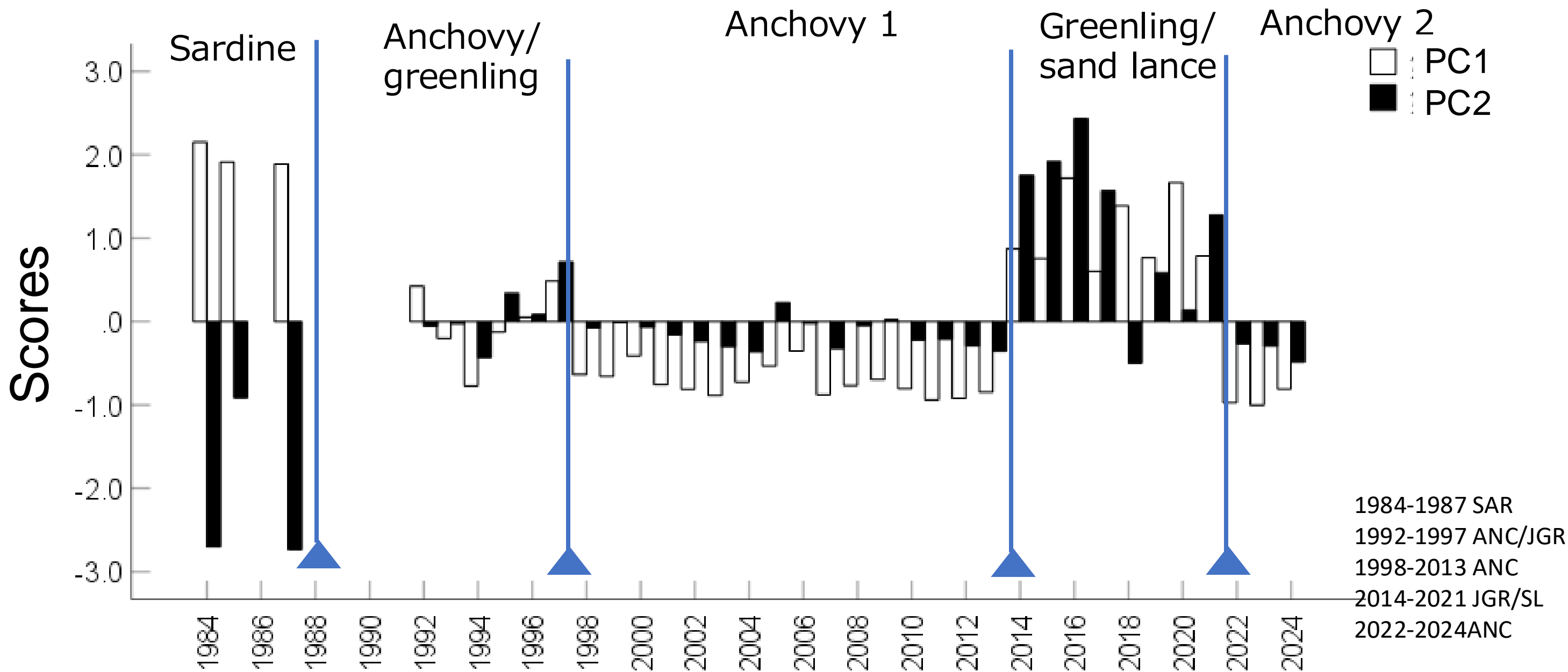
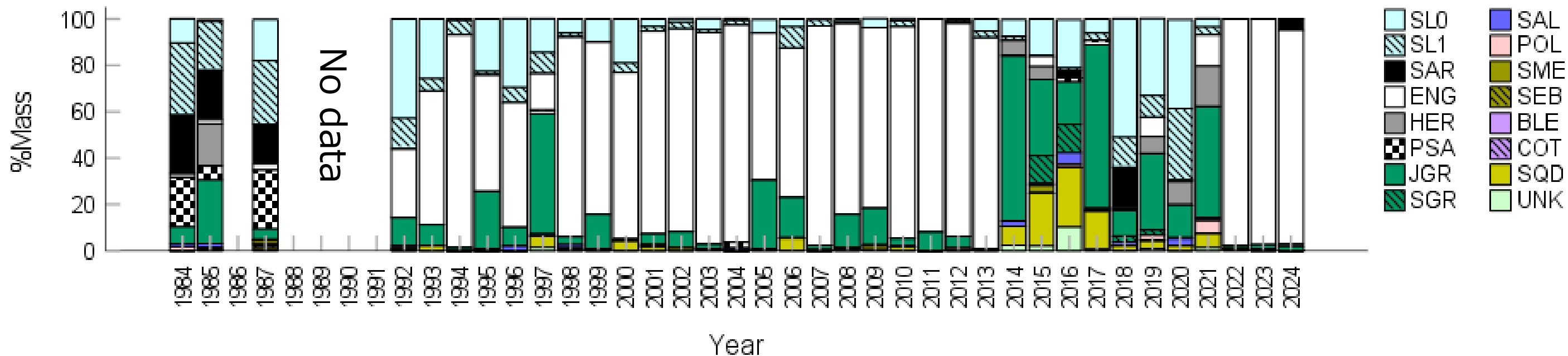
Climate, forage fish, prey and productivity of Rhinoceros Auklets (Puffins)



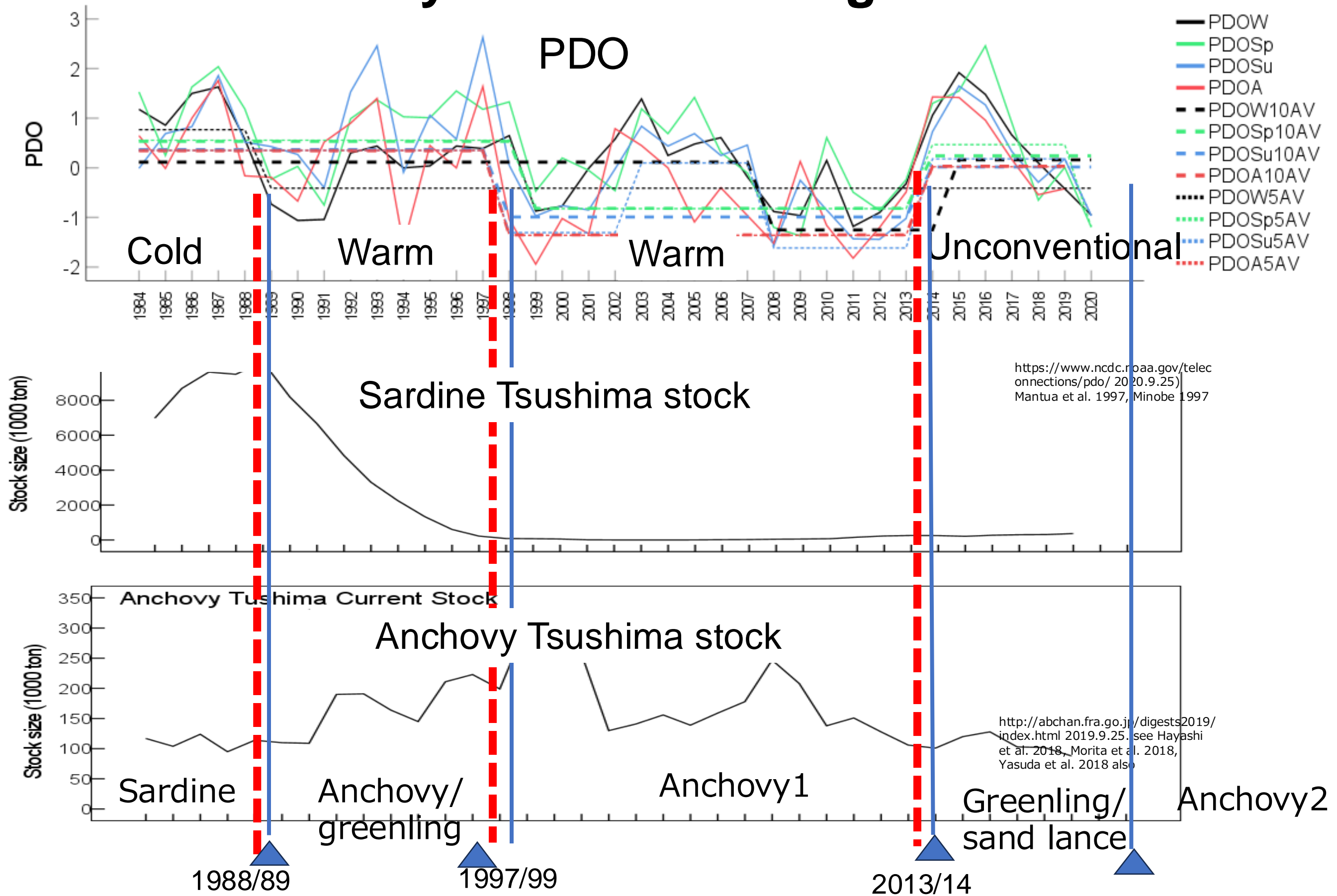
Prey shift at Teuri where longest time series data is available

Watanuki et al.2020 and continued

Teuri



Teuri: Prey shift reflects regime shift?

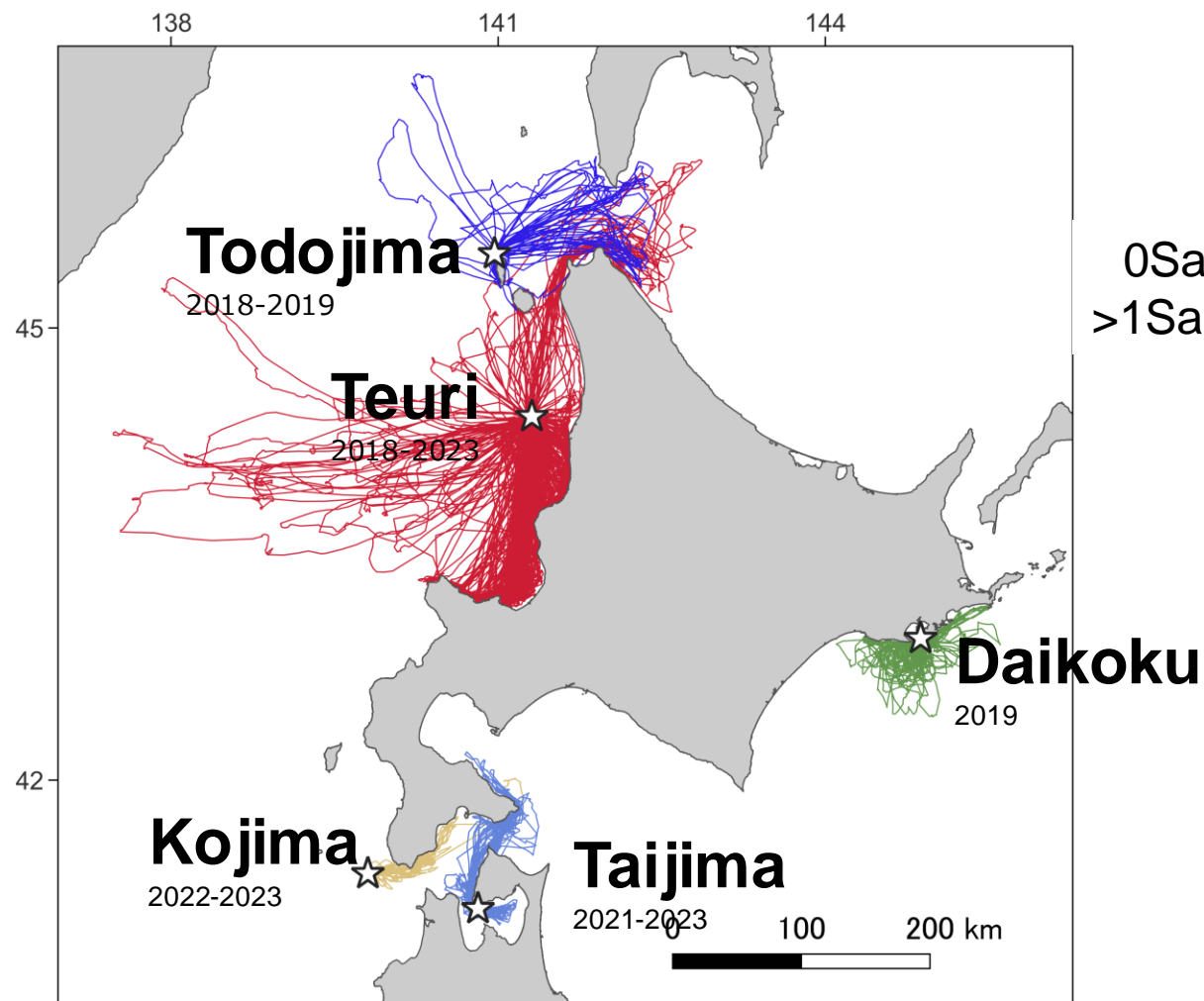


A1) Timings of three prey shifts matched with the climate/fish regime shifts but the latest one

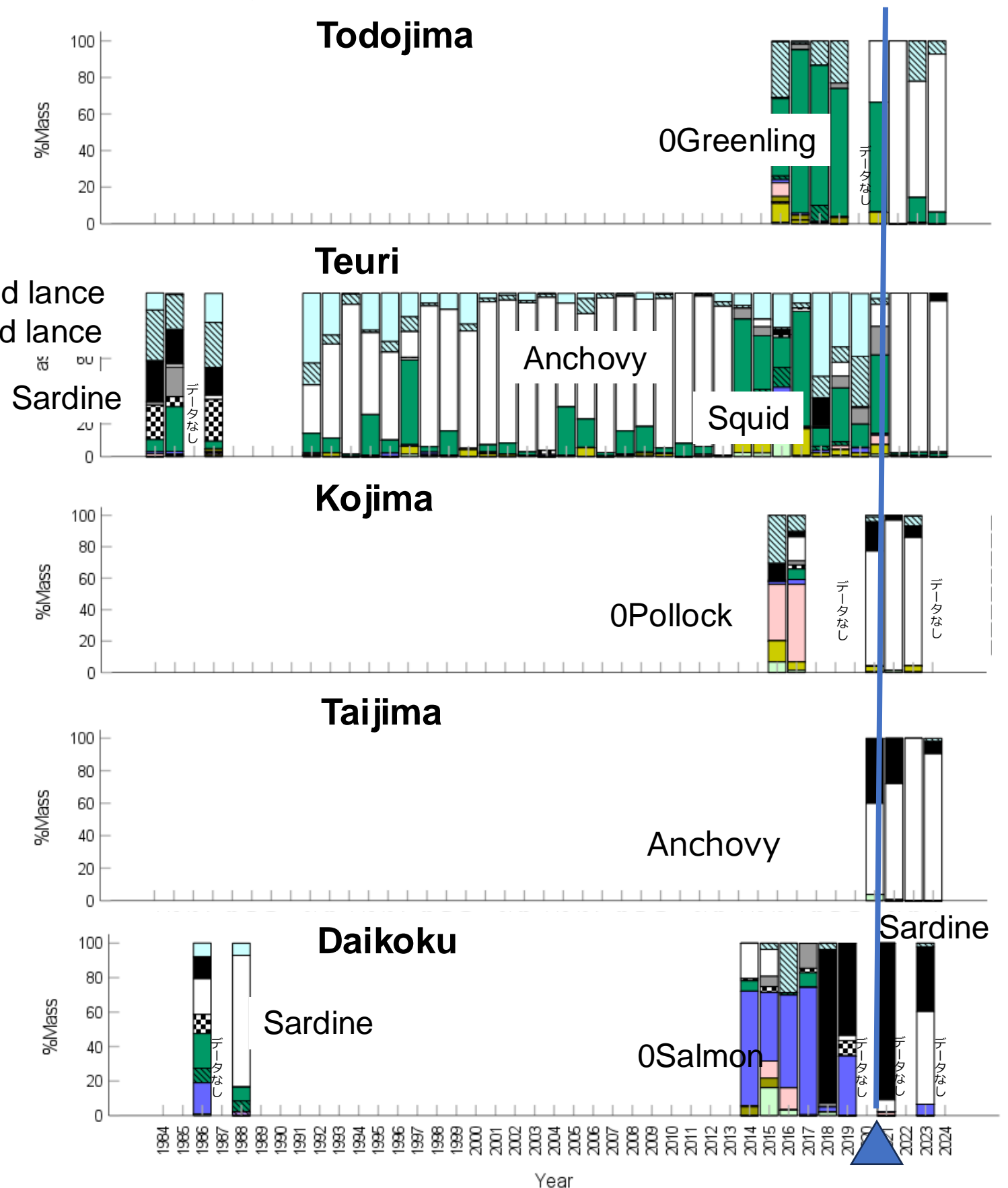
The prey composition in other islands

Colonies & GPS tracks

Okado and Watanuki 2023 Marine Ornithology, Okado 2022 PhD Thesisi, Sato et al. 2022 Zoological Science, Sakai et al. In Press, Ozawa et al. In Prep.



Prey composition



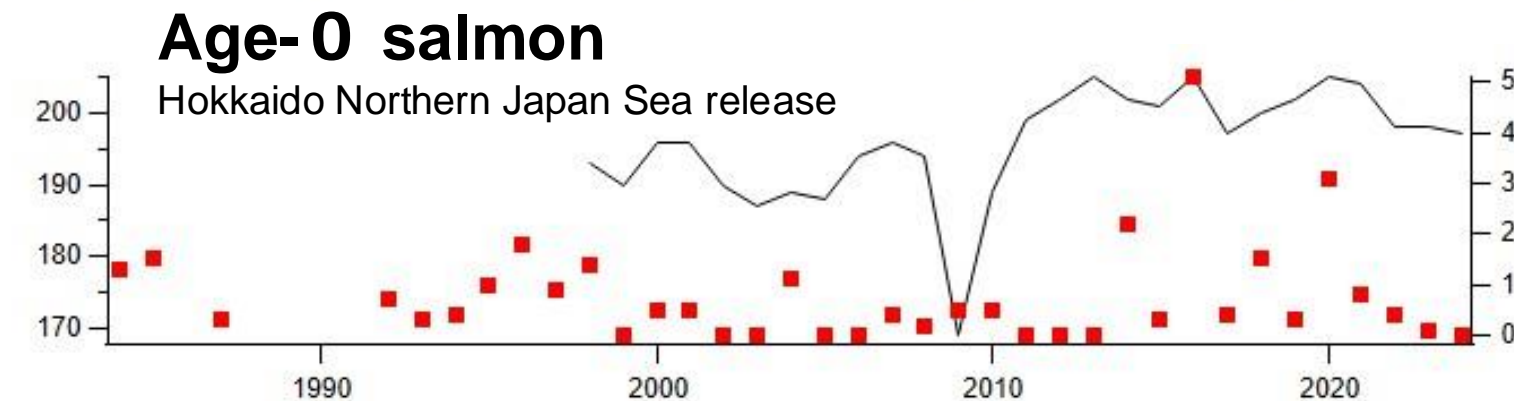
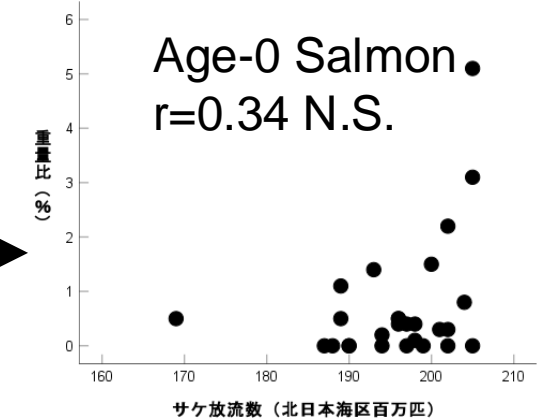
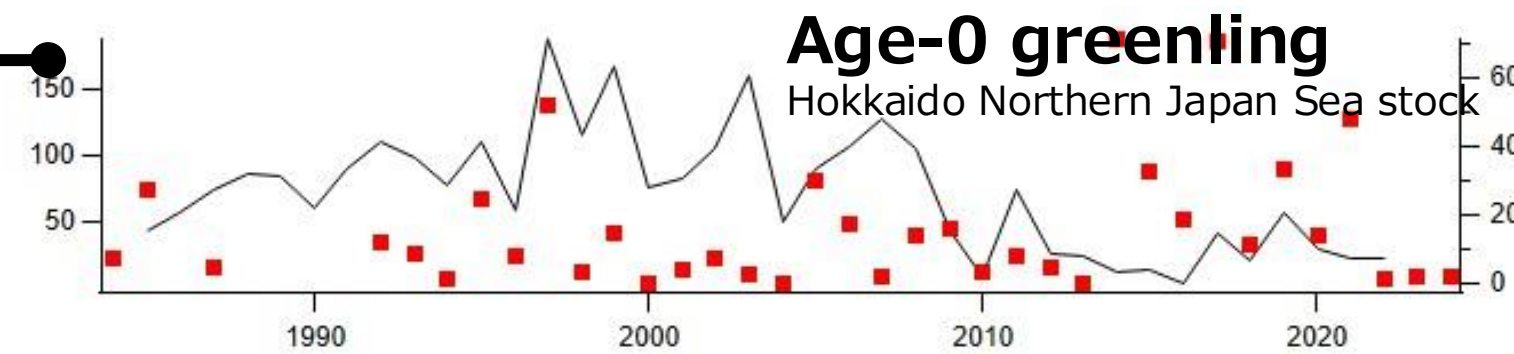
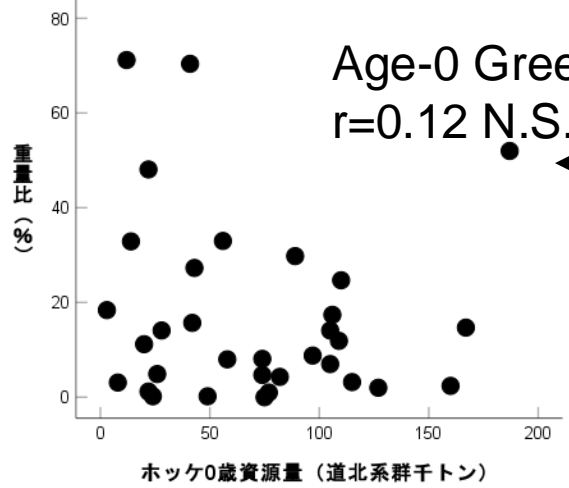
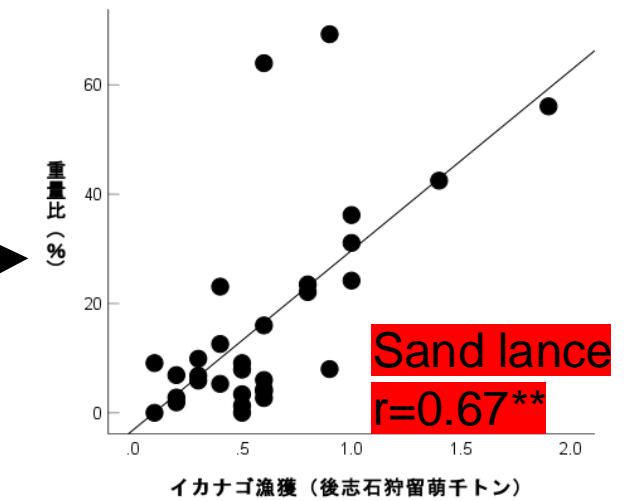
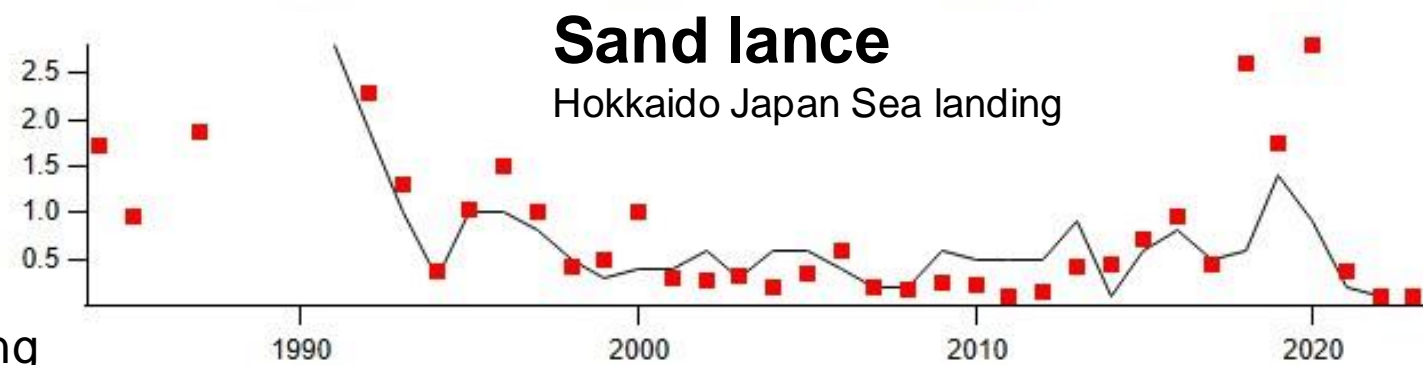
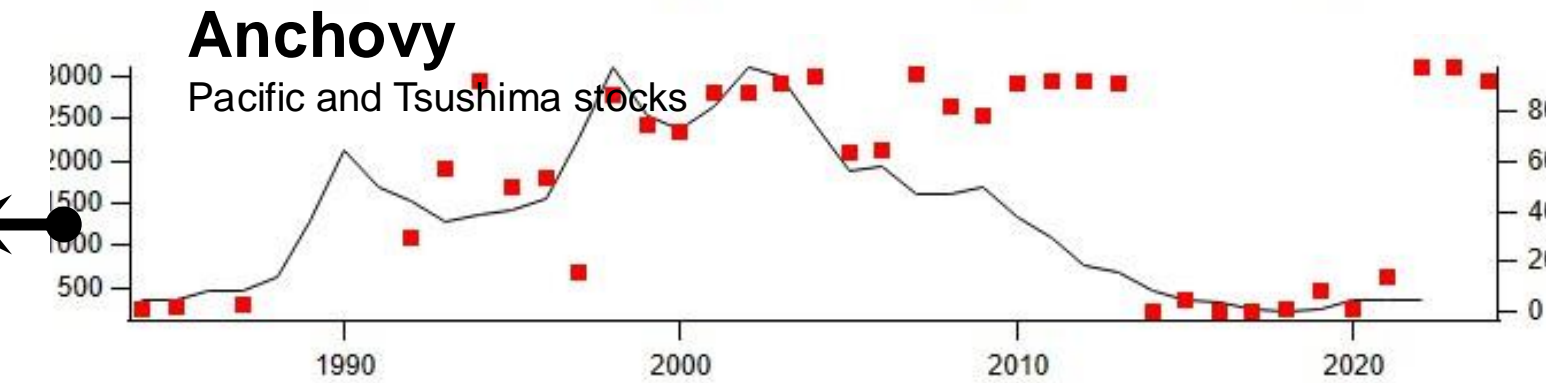
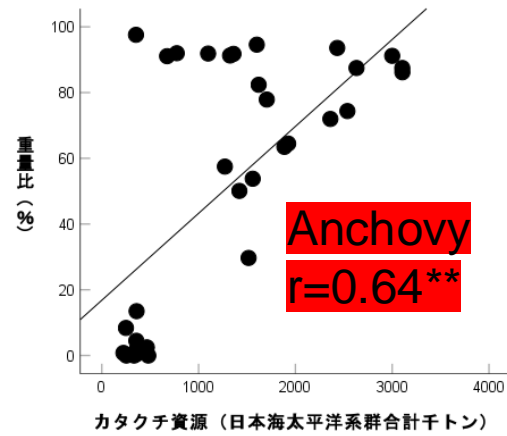
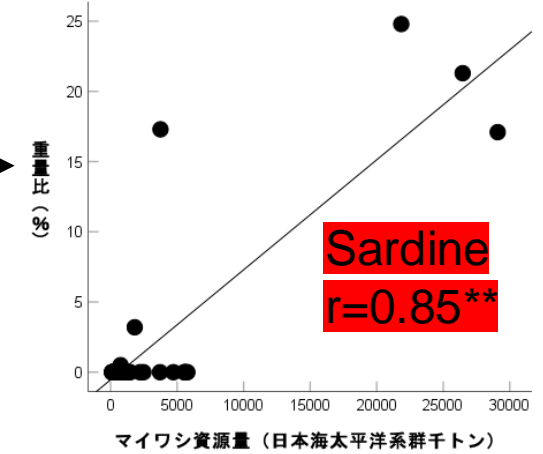
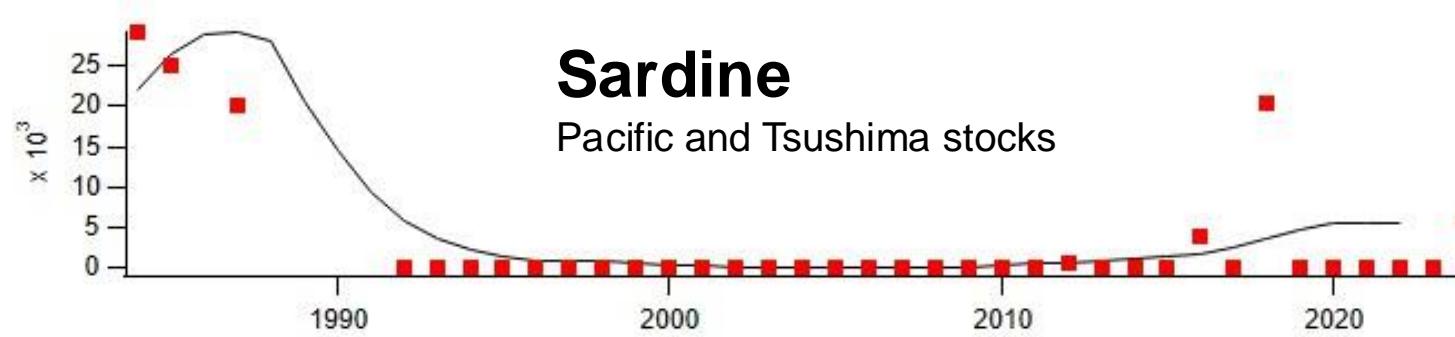
Correlation of %Mass anchovy

	Daikoku	Todojima
Teuri	0.901**	0.950**
Daikoku		0.913*

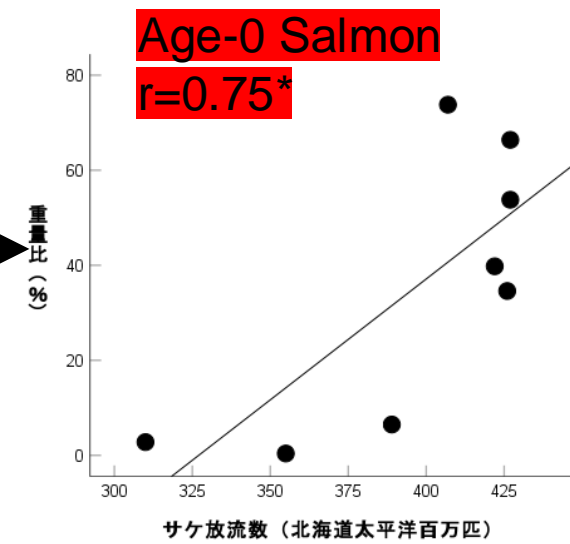
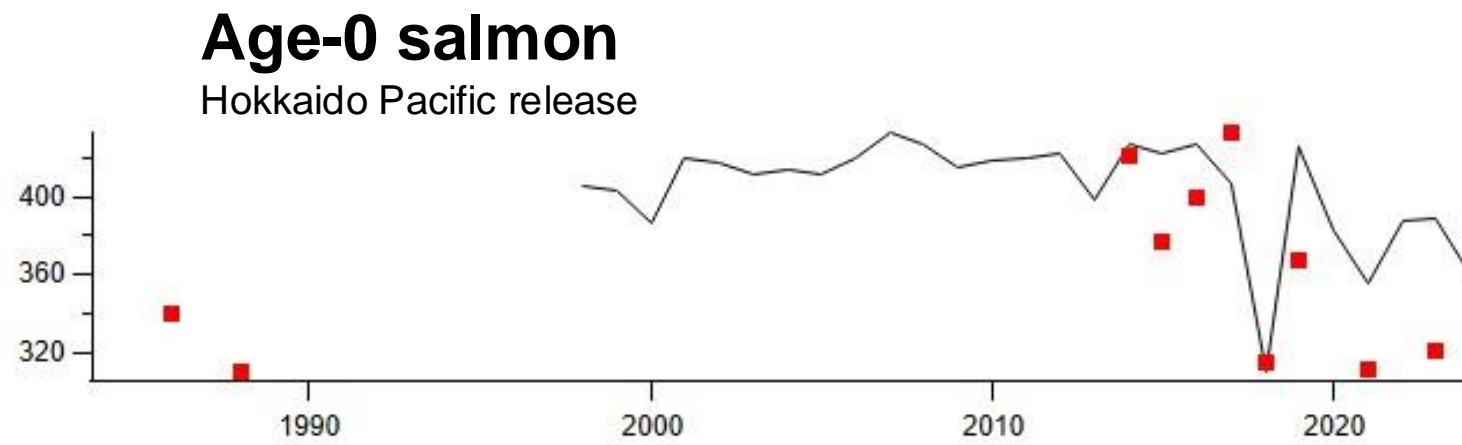
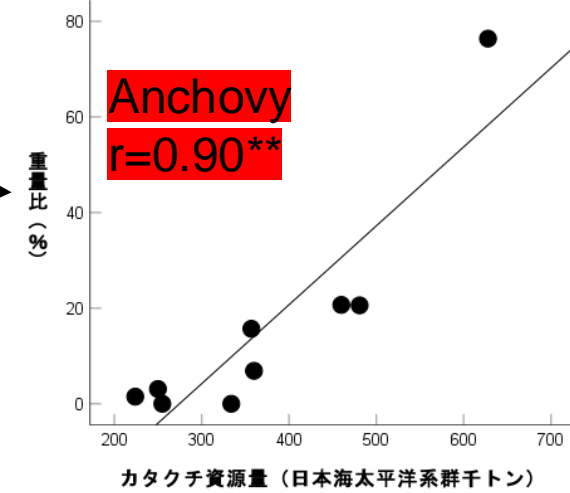
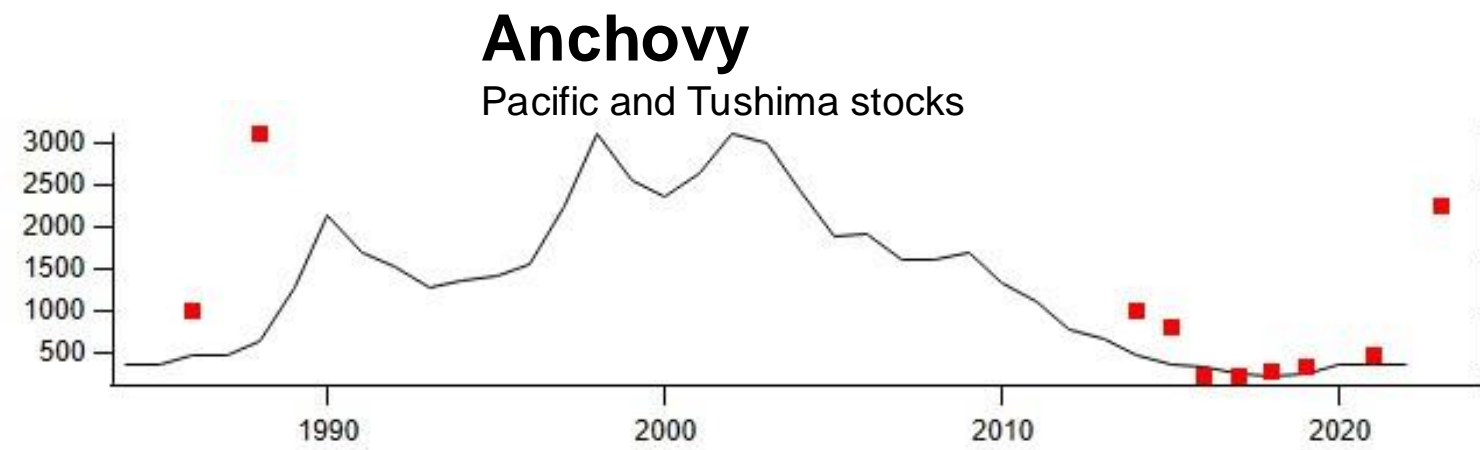
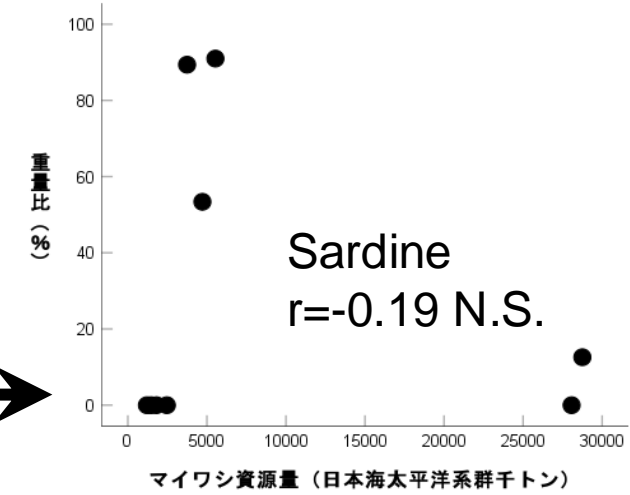
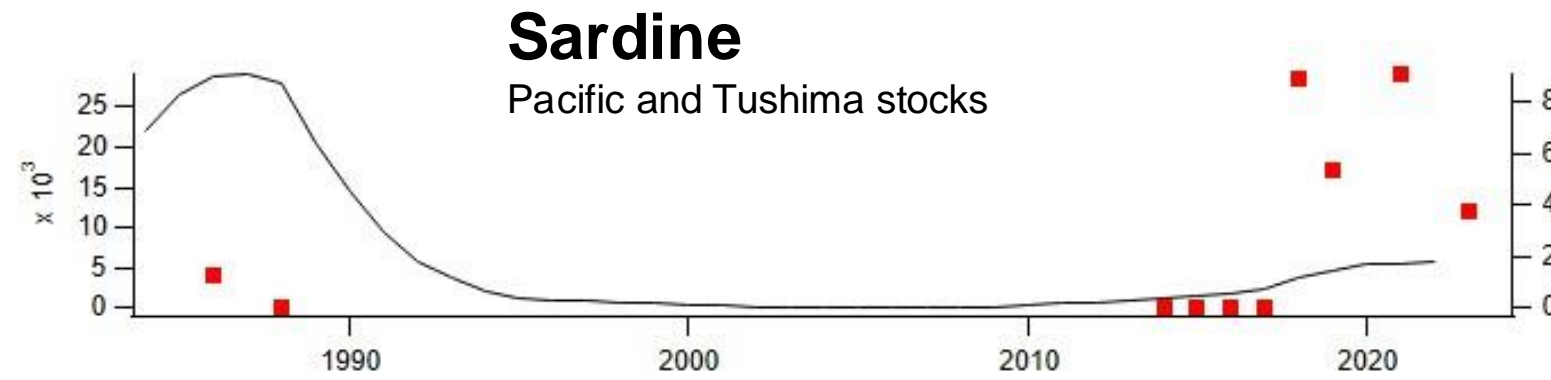
The latest prey shift was observed in all populations around Hokkaido

Prey abundance index and %mass in diet : Teuri

■ %Mass prey
— Abundance index



Prey abundance index and %mass in diet : Daikoku



%Mass of prey reflects fish abundance ?

Anchovy and sand lance did, but age-0 greenling

Sardine did at Teuri but not at Daikoku

Age-0 salmon did at Daikoku but not at Teuri

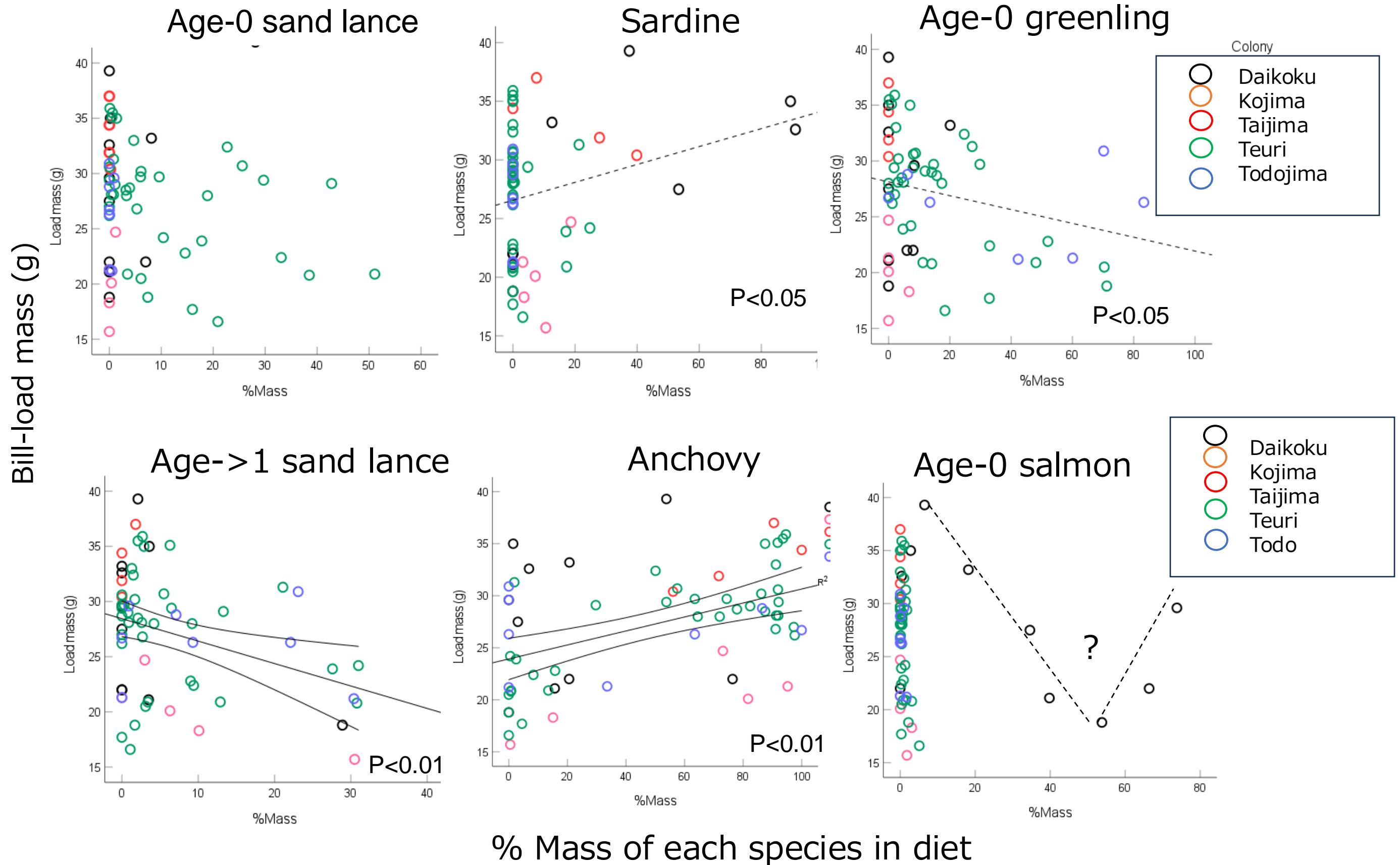
Profitable prey does but alternative prey ?

Profitable prey for chick production

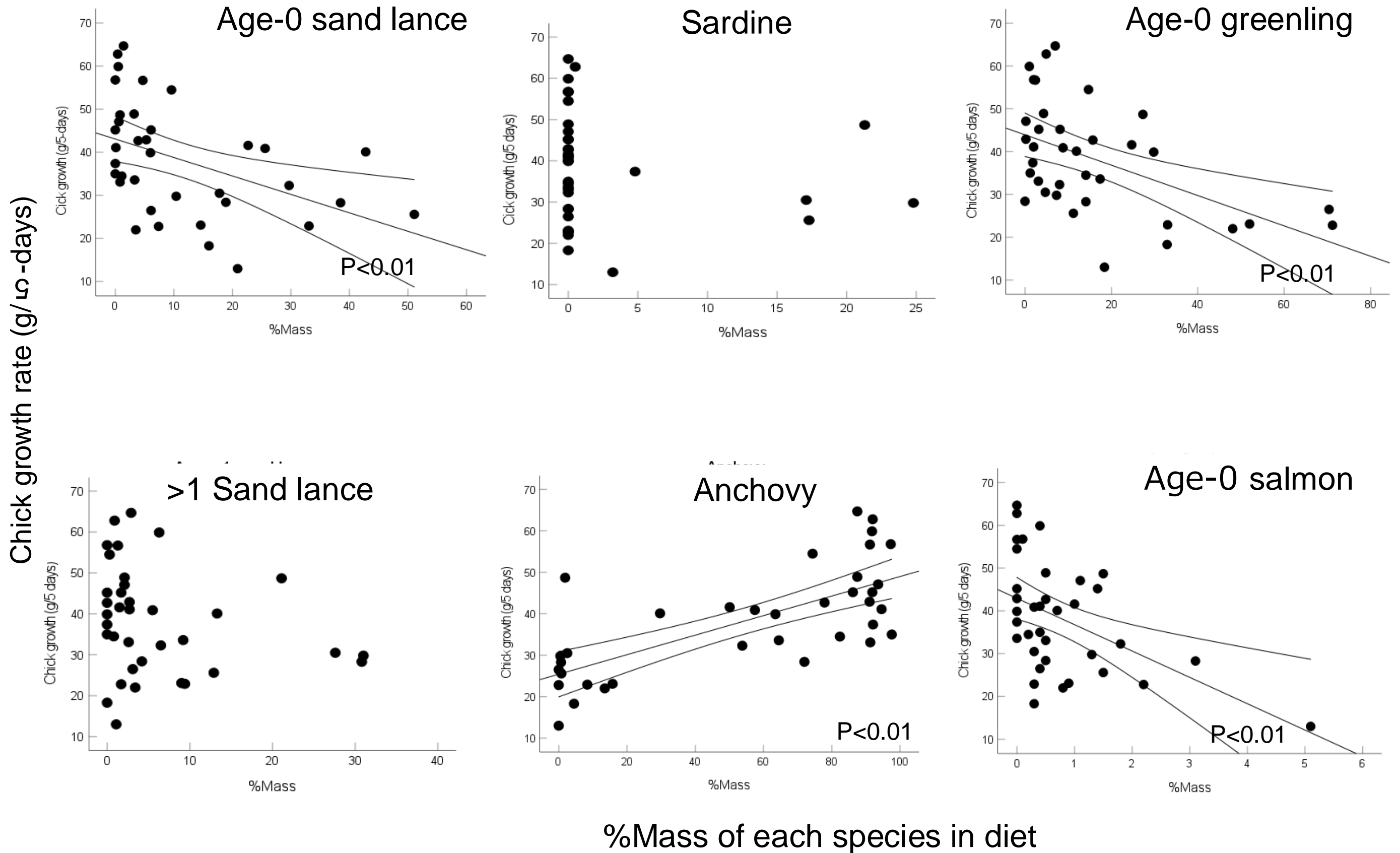
Heavy bill-load ?

Fast chick growth ?

%Mass and bill-load mass across all colonies-years



%Mass and chick growth rate on Teuri



Puffin prey composition indicates....

- 1) Three climate/fish regime shifts**
- 2) The latest prey shift to anchovy all around Hokkaido**
- 3) Different local forage fish as an alternative prey**
- 4) Abundance of profitable prey (anchovy) but alternative prey (age-0 greenling)**

Size of age-0 salmon:

Okado et al. In Prep.

A comparison between trawl and Rhinoceros Auklet....

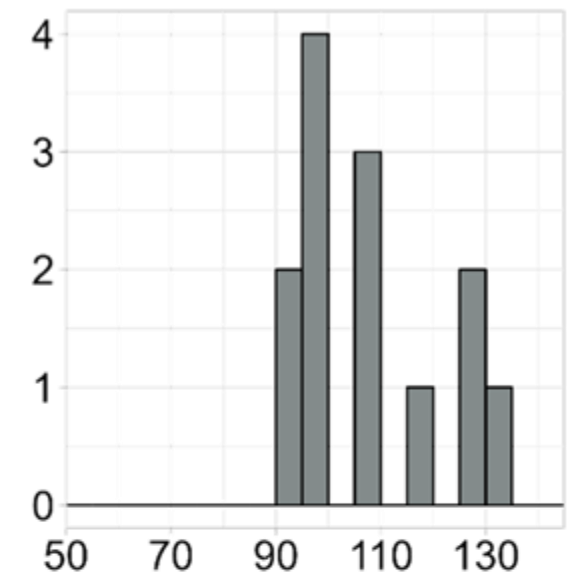
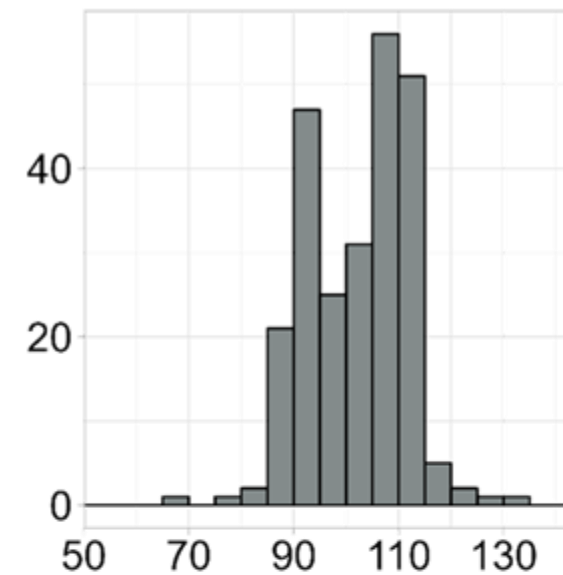
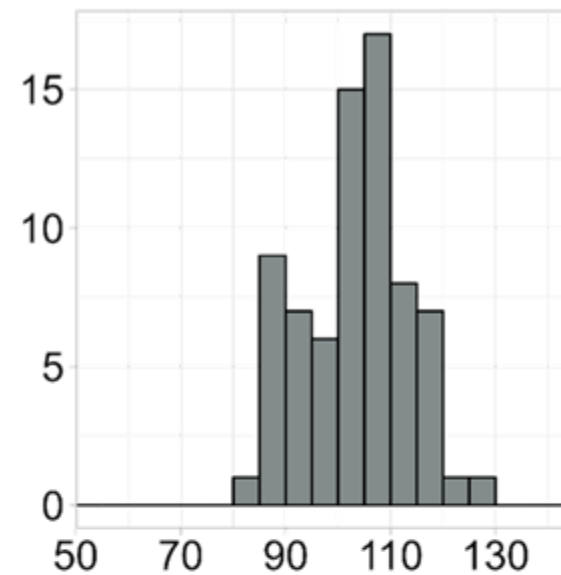
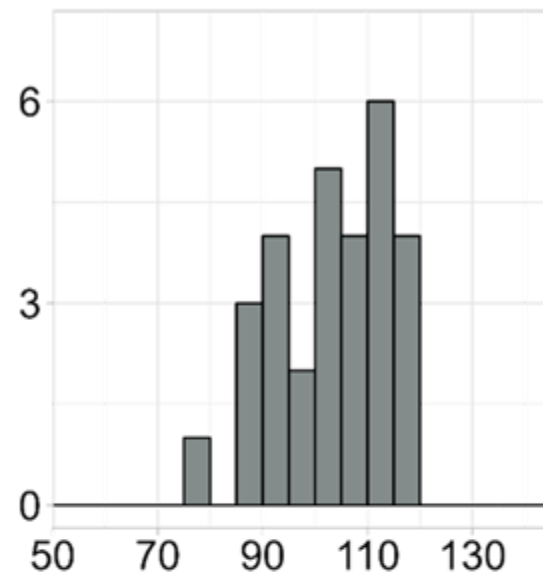
2014

2015

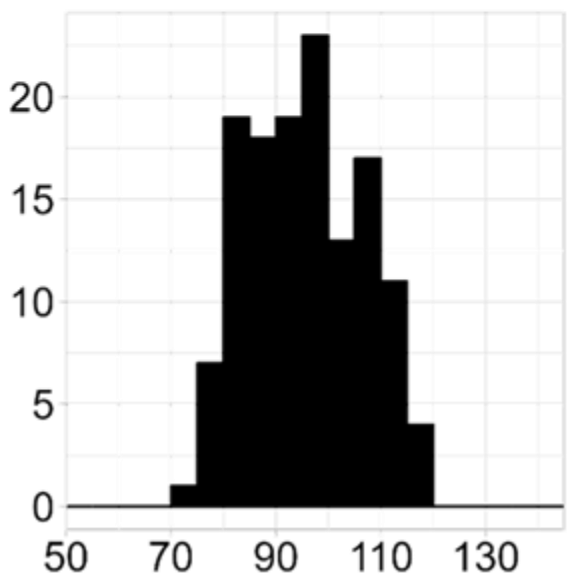
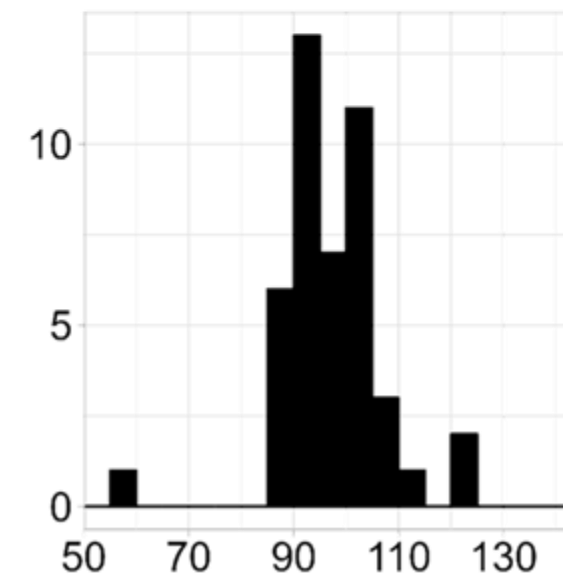
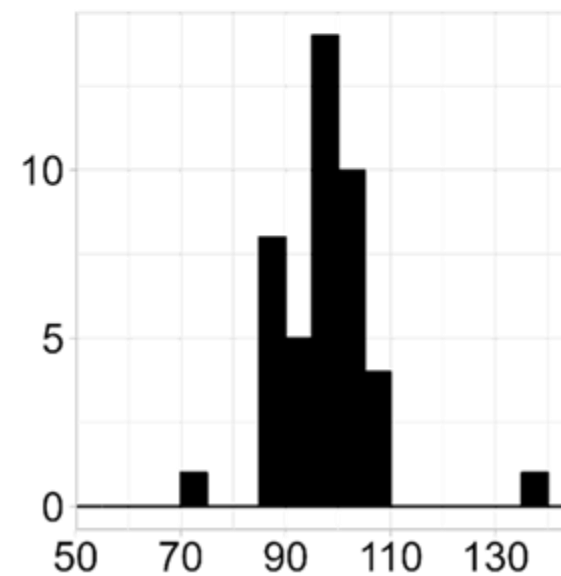
2016

2017

Trawl



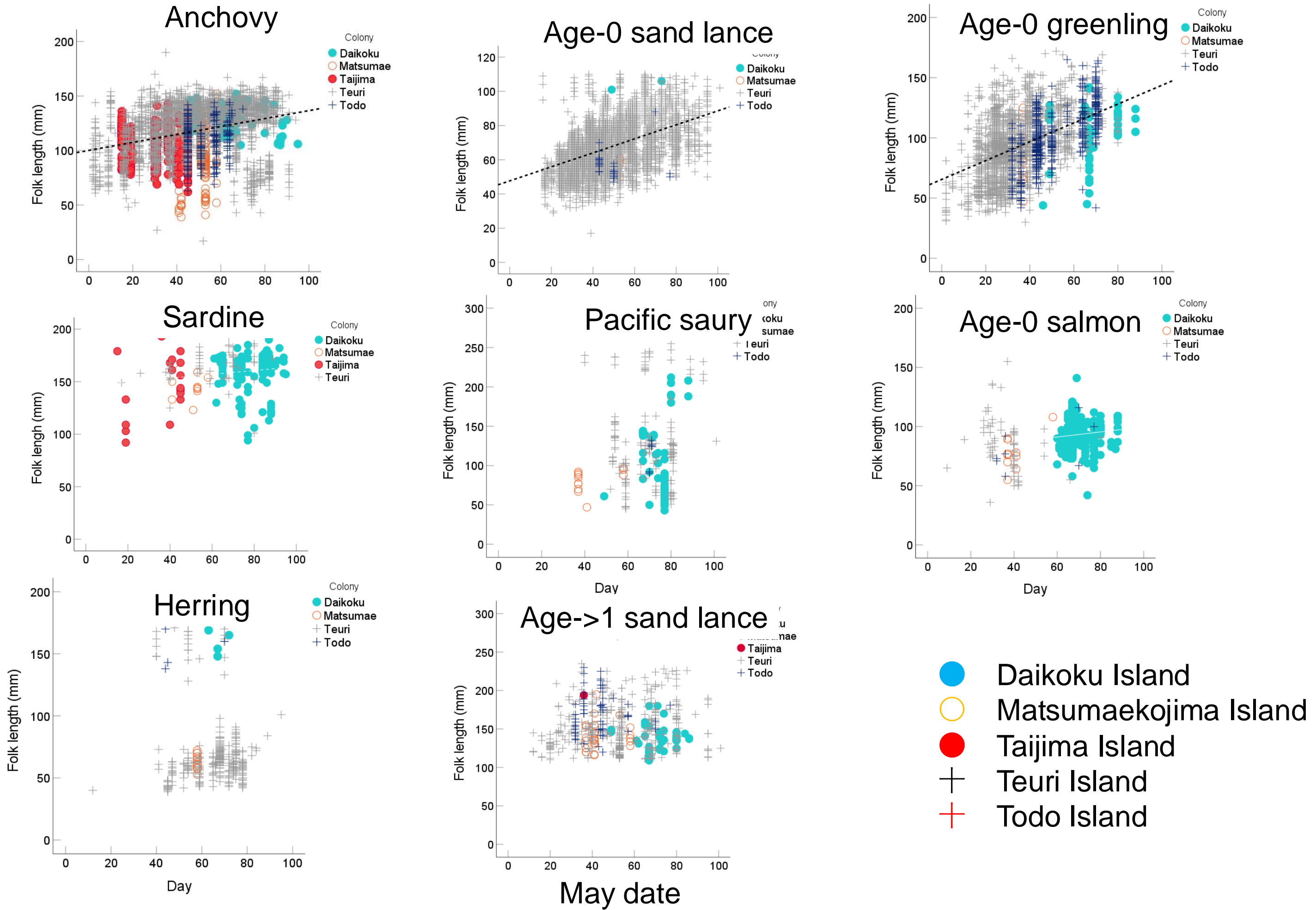
Diet



Folk length (mm)

shows negligible bias in the size of fish in diet of puffins

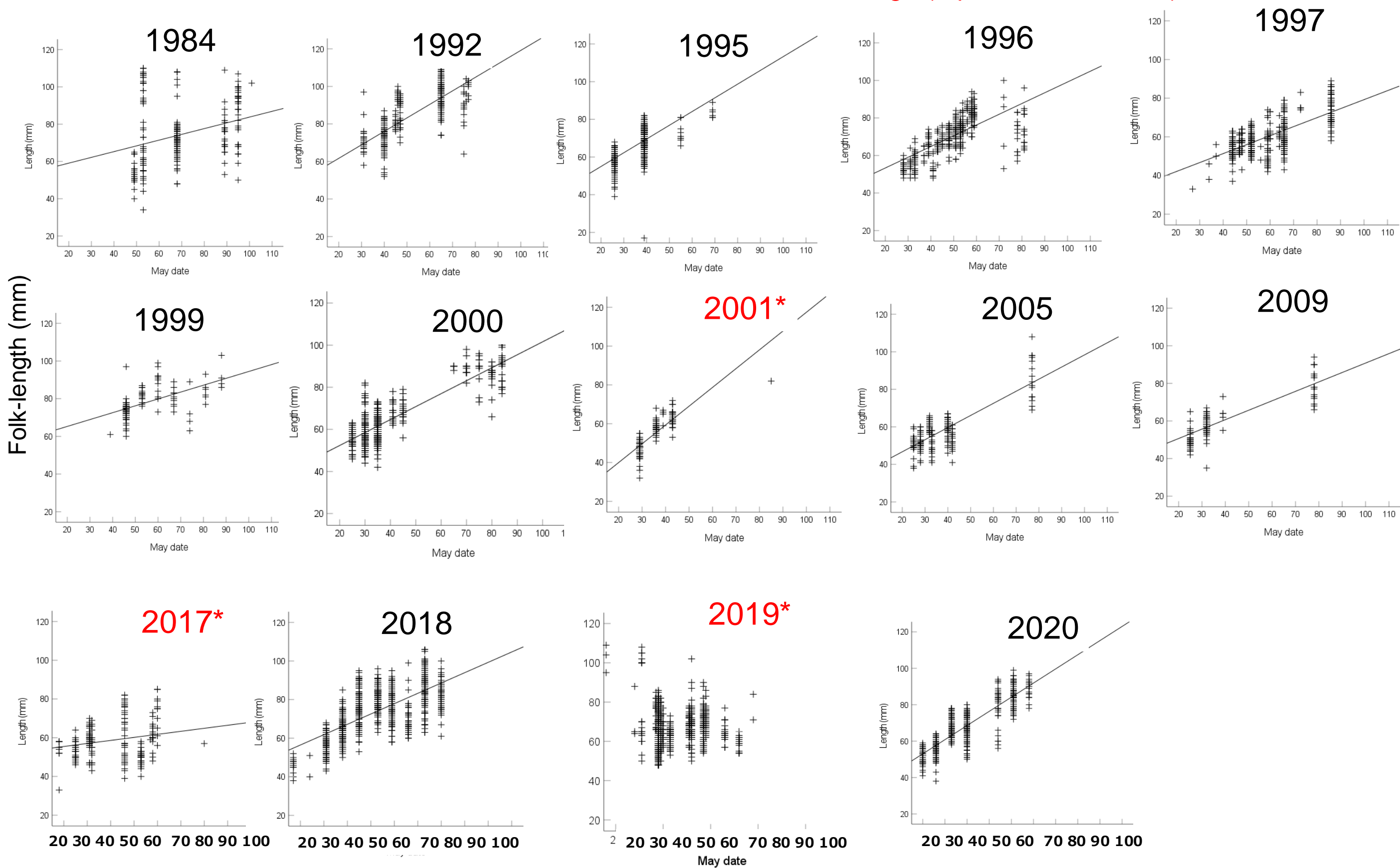
Seasonal increase of the size of forage fish in the diet



Age-0 sand lance at Teuri

Growth rate reported for age-0 sand lance **0.4 ~ 0.7 mm/d**
Robarts et al. 2002, Hoshino et al. 2009

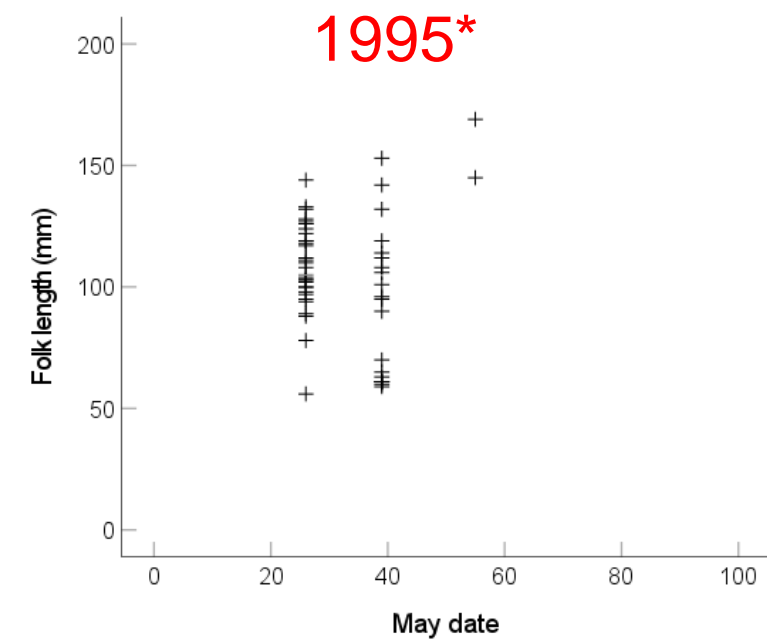
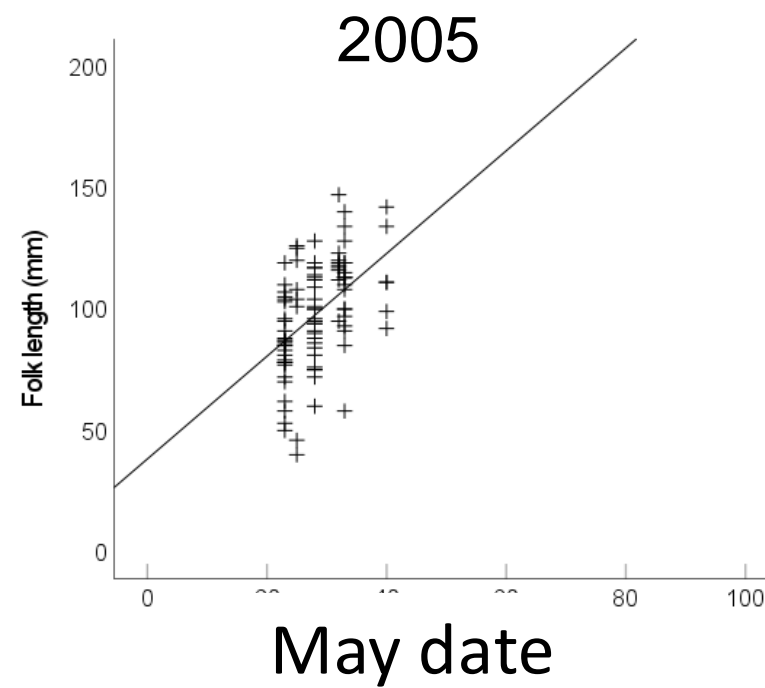
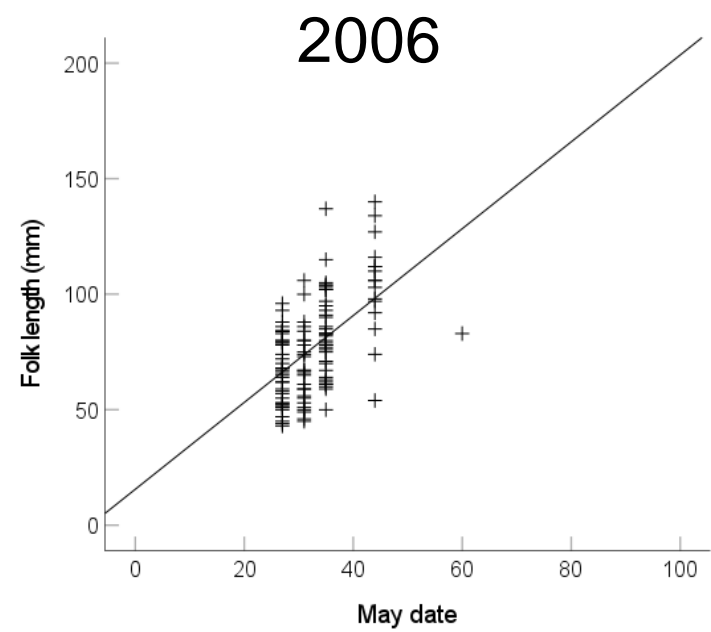
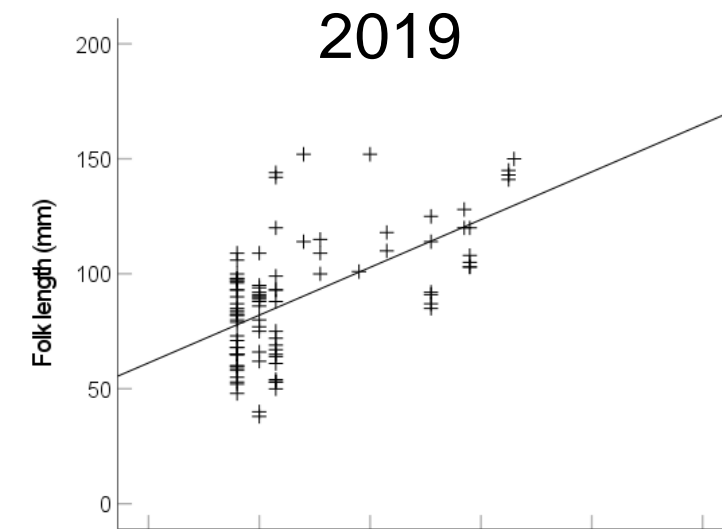
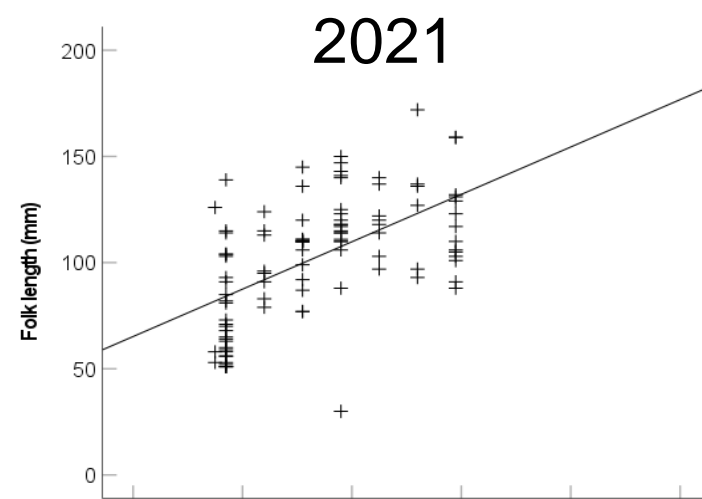
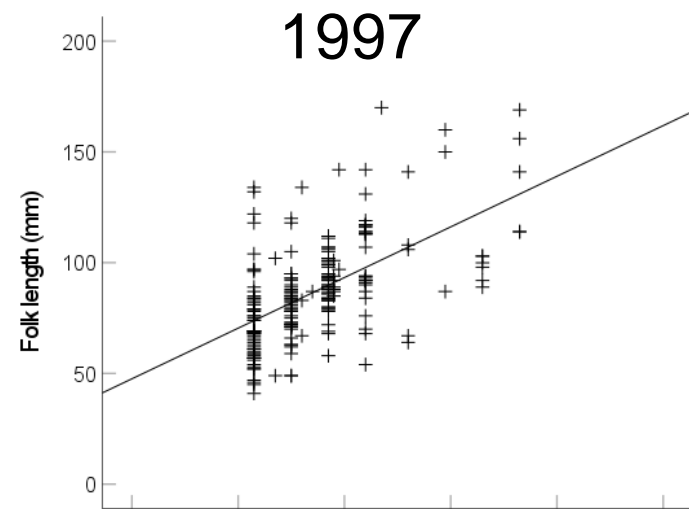
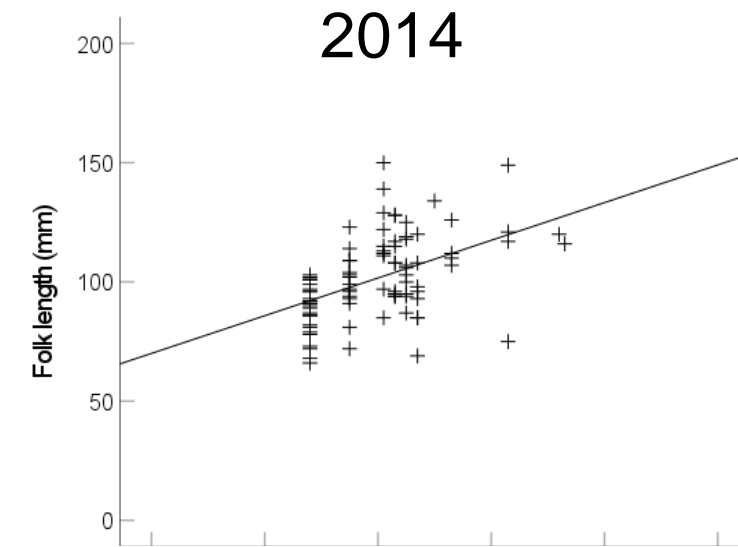
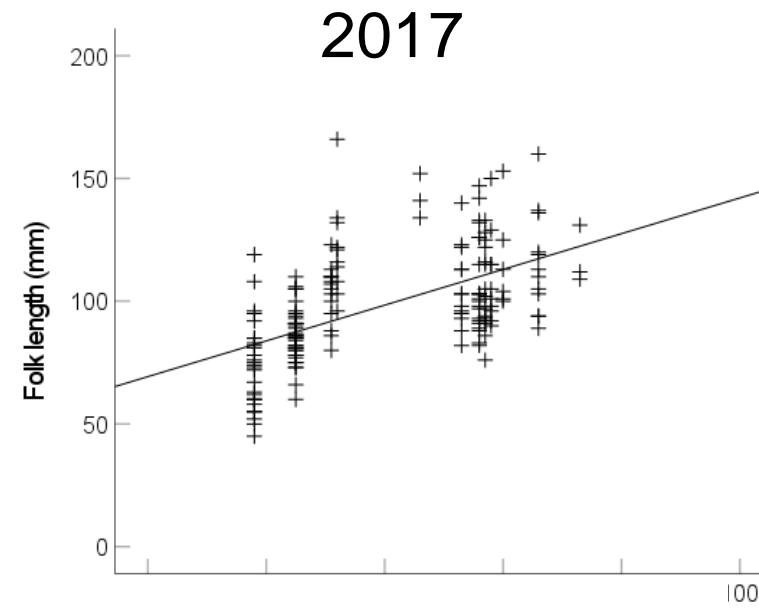
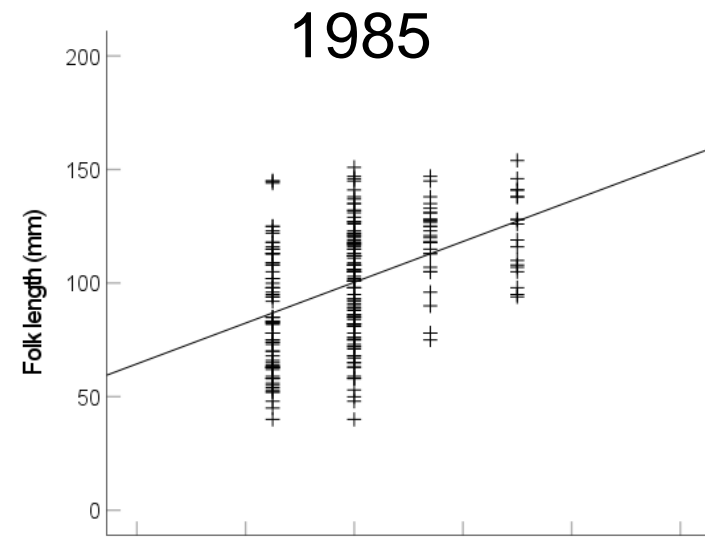
*Out of the range (reported ± 0.2 mm/d)



May date

Age-0 greenling at Teuri

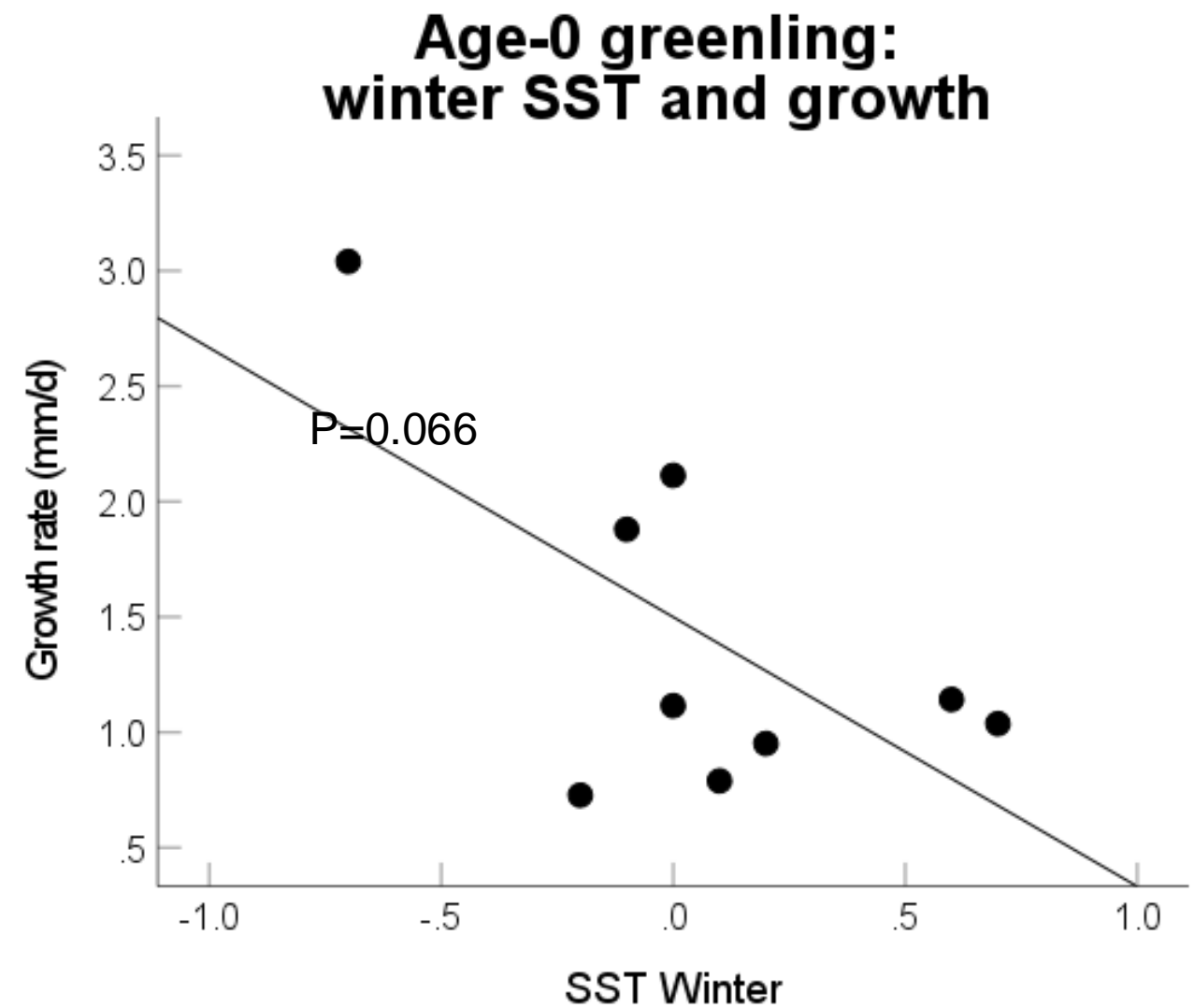
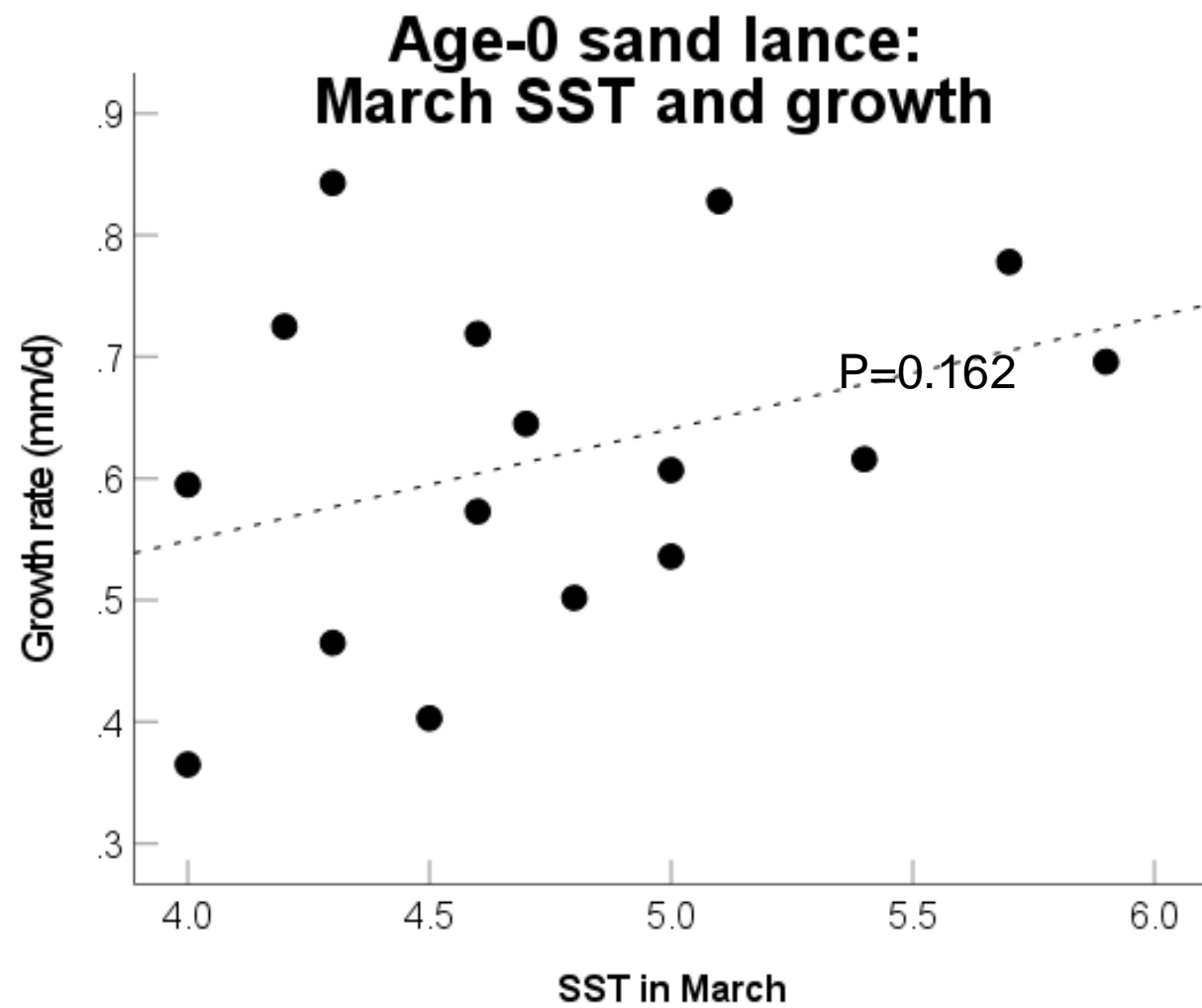
*Slope (growth rate) was not significant



SST and growth rate of age-0 forage fish

Interannula variation

Excluding non-significant and outlier growth



Puffin prey size suggests.....

- 1) Multiple age groups in anchovy, herring, Pacific saury
- 2) Immigration of different seasonal groups of age-0 salmon in the puffin foraging area
- 3) Different seasonal groups of age-0 sand lance and greenling in some years
- 4) Potential opposite effects of SST on the age-0 growth of sand lance and greenling

Conclusion

A1) **Puffin prey composition** is a real-time indicator of the marine ecosystem shift.

A2) and the abundance of profitable prey

A3) **Size of fish in puffin diet** may inform environmental effects on a demographic parameter; growth of age-0 forage fish

Our study

Supports the statement; **“Increased collaboration between seabird biology and fisheries science will benefit conservation of both birds and fish (Cairns 1992, Condor 94:811-824)”**.

Encourages future studies; making the most of information from fish samples (**body size, otolith, stomach contents, tissue SI etc**) in puffin diet.