Millennial to Decadal-scale Variability in the Bering Sea

Changes in the density seabird species in response to climate fluctuations

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Plan of Talk

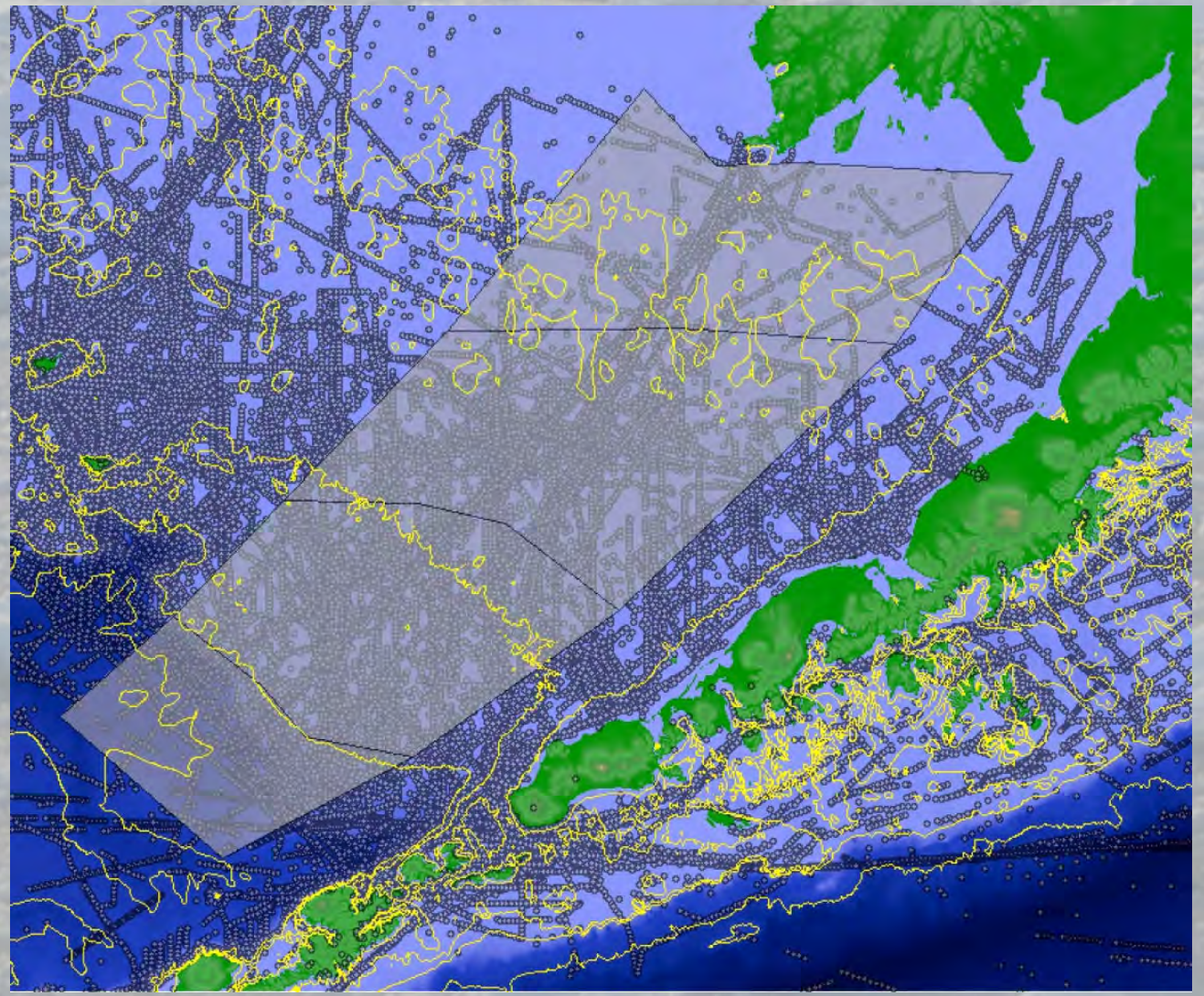
1. Evidence of seabird response to climate variability from Aleutian middens (10k years)
2. Decadal-scale changes in seabird abundance 1975-2014
3. Possible factors that might explain changes
    1. Changes in primary production
    2. Changes in the availability of prey
        1. Bottom-up production
        2. Top-down competition
    3. Changes elsewhere in their range at other seasons
4. Seabird Abundance in years with early and late sea-ice-retreat
5. Prey abundance in years with early and late sea-ice-retreat

The Archeological Record from the Aleutians

- Over three millennia, marine bird populations were **negatively correlated with temperature** and positively correlated with precipitation
- During periods of **increased temperatures and precipitation (e.g. 650–1100 yr BP), nearshore foragers such as cormorants and parakeet auklets increased in abundance**, but during periods of cooling (e.g. 1800– 2100 yr BP), piscivorous birds feeding offshore, such as murres and kittiwakes, predominated.

Causey et al., 2005. Fisheries Oceanography, Suppl.

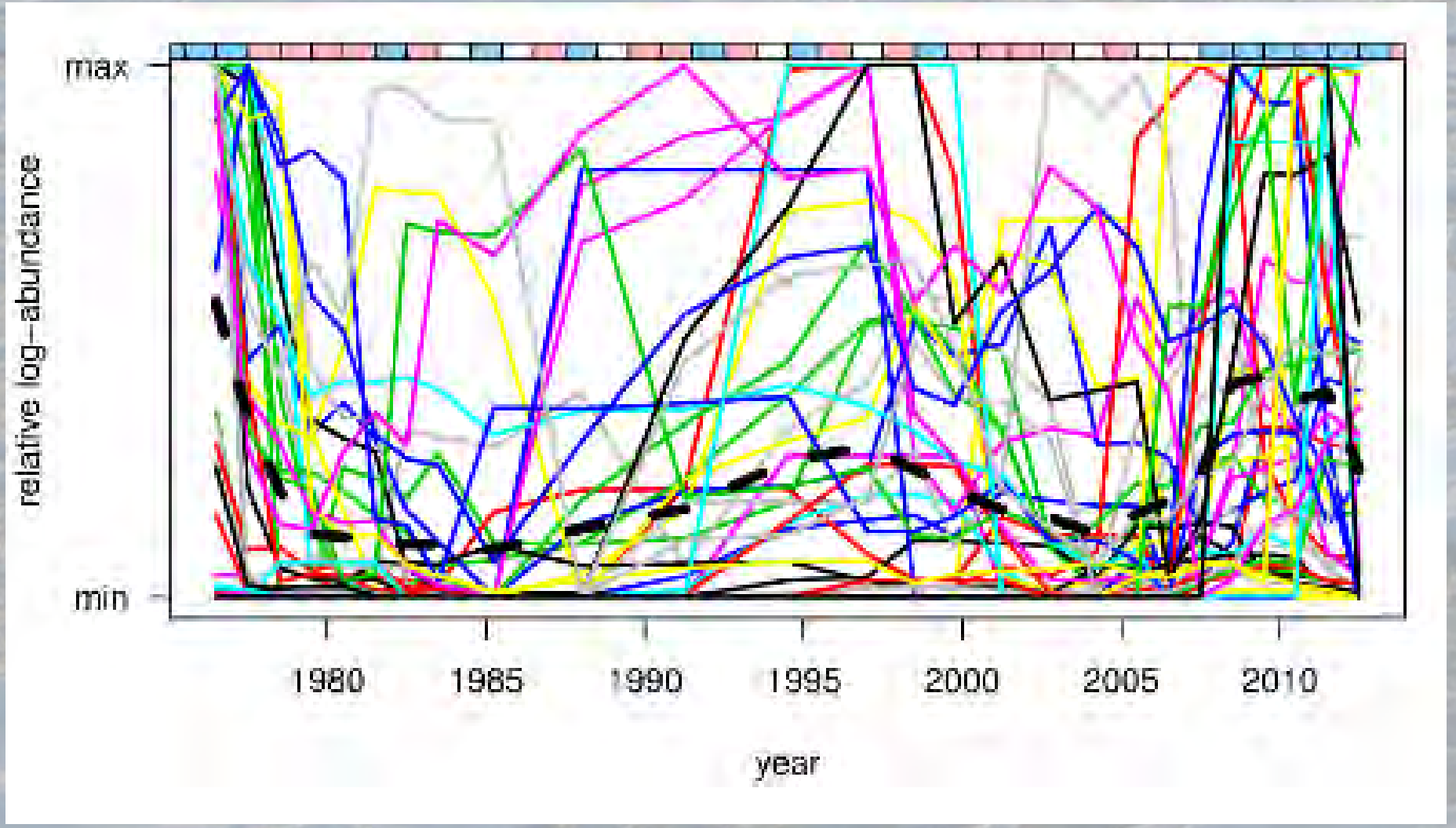
Focal Study Area
1975 – 2012
with individual transects marked as circles



Hunt et al. ms

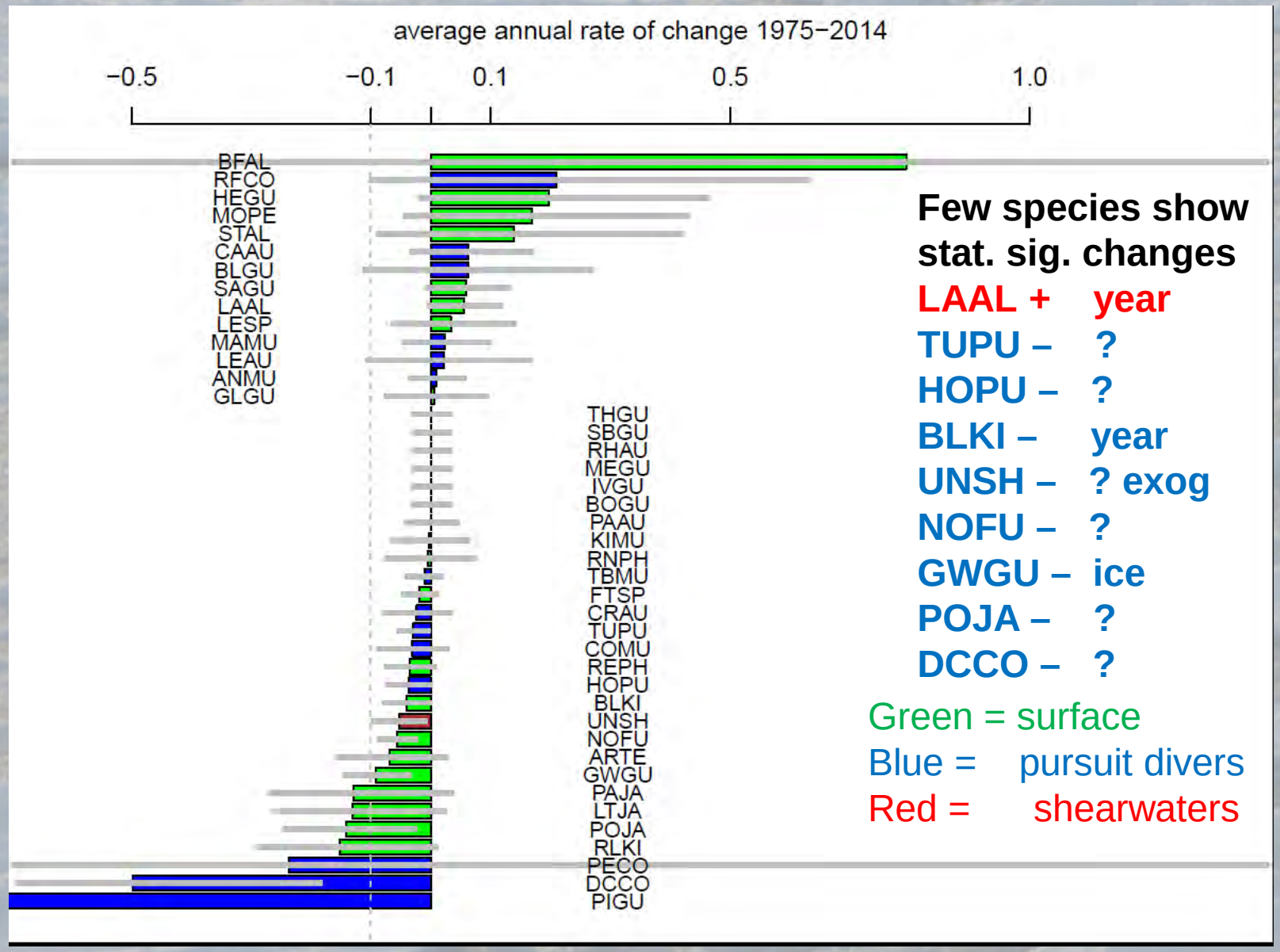
Relative Abundance of Seabird Species

SE Bering Sea, 1975 - 2012



From Renner et al., In Prep

Average Annual Rate of Change 1975 - 2014



Few species show stat. sig. changes

LAAL + year

TUPU – ?

HOPU – ?

BLKI – year

UNSH – ? exog

NOFU – ?

GWGU – ice

POJA – ?

DCCO – ?

Green = surface

Blue = pursuit divers

Red = shearwaters

From: Renner et al., In Prep.

Hypotheses

- Year- unknown long term trend
- Timing of sea ice retreat in spring and prey availability
- Abundance of age-1 walleye pollock
- Competition from adult walleye pollock
- Competition with western Alaska pink salmon
- Competition with Russian pink salmon
- Frequency of storms

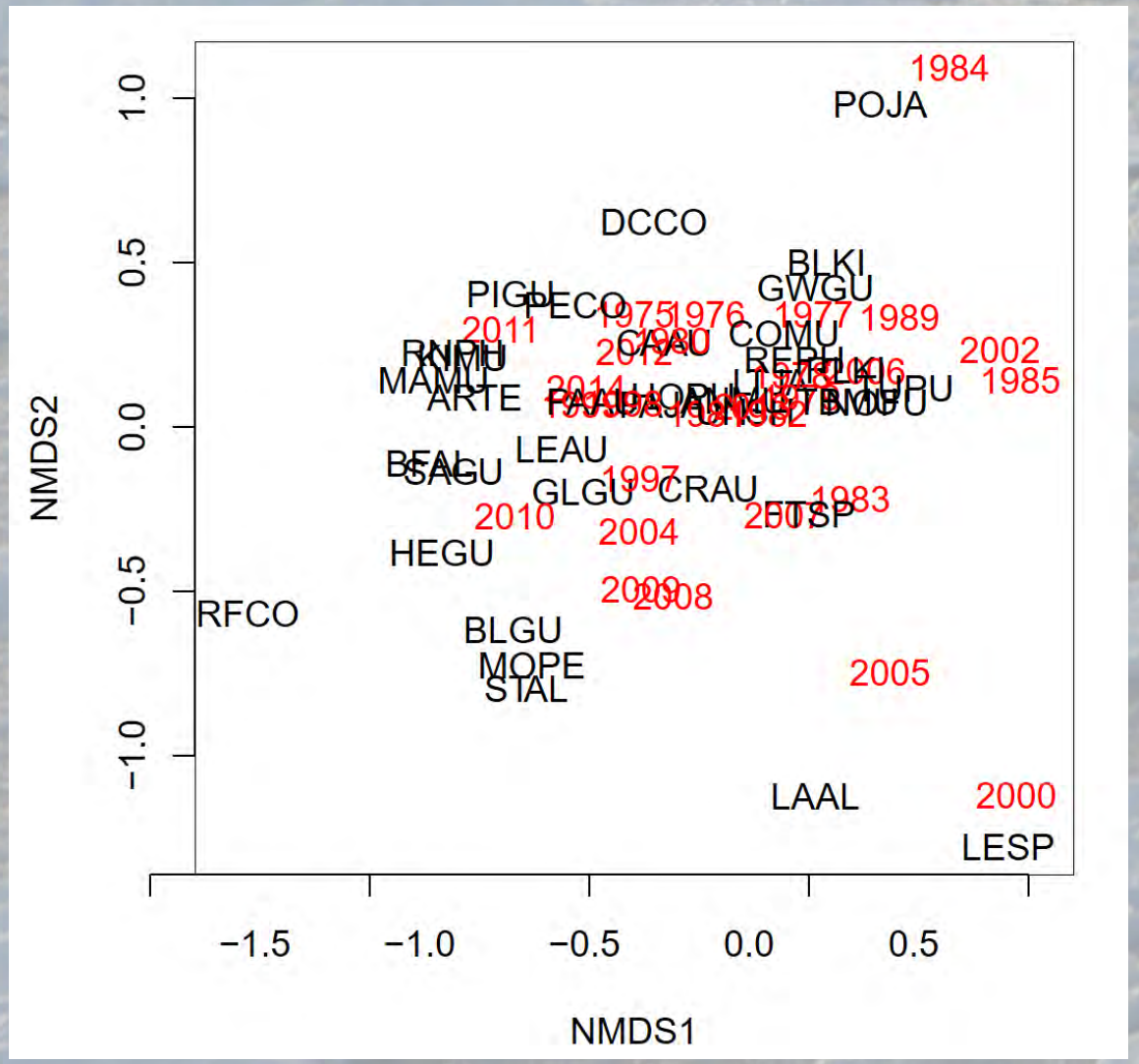
Approach

1) non-metric Multi-Dimensional scaling of all seabird species to reduce the need for multiple tests (38 seabird species)

2) AICc to examine the relative strength of alternative hypotheses

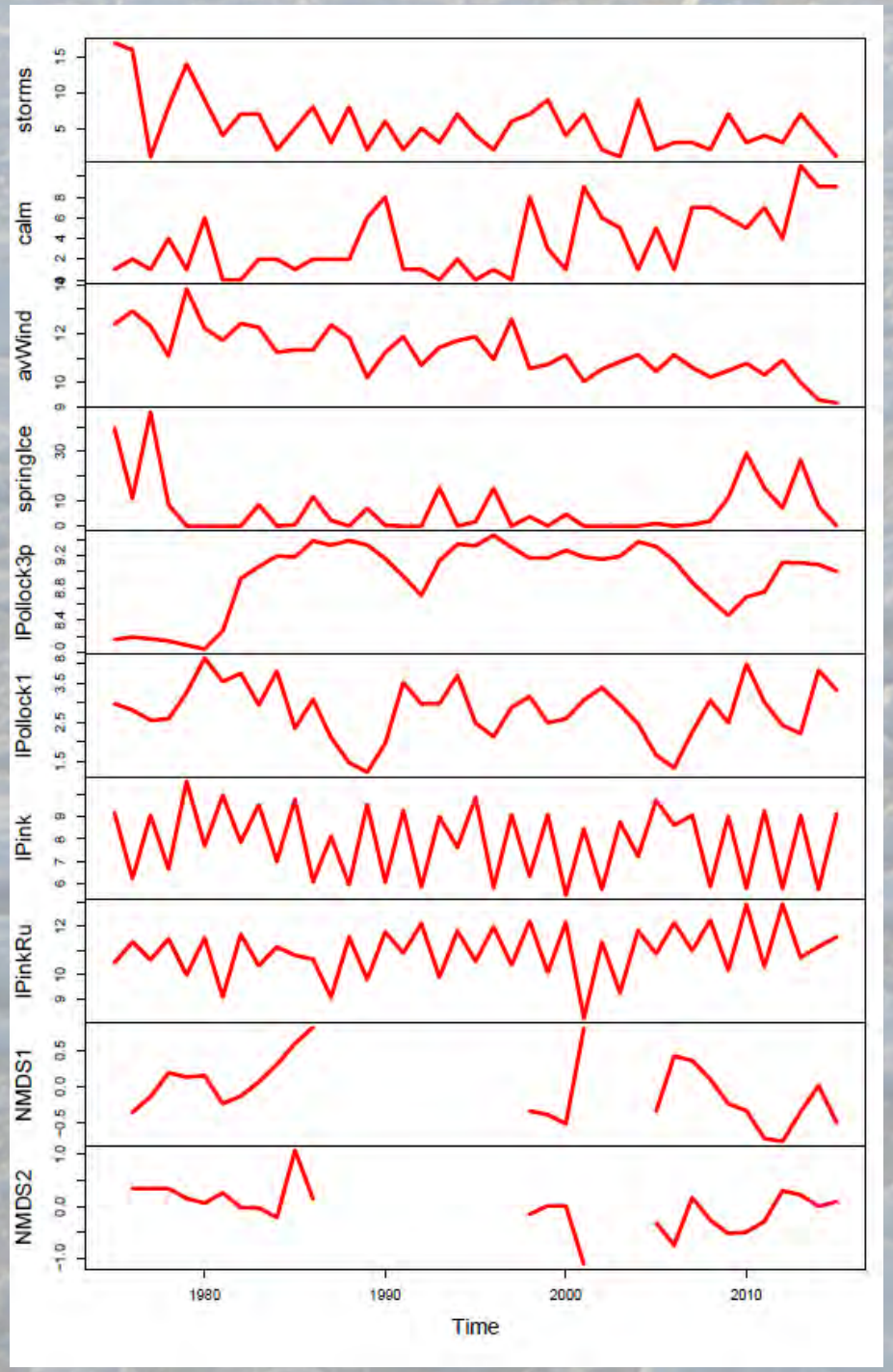
3) This is a work on progress!!!

Non-Metric Multi-Dimensional Scaling



Reduces degrees of freedom from 36 bird species to 2 dimensions

Data Used in the Analysis



Note: Breaks in NMDS1 and NMDS2 indicate where seabird data lacking

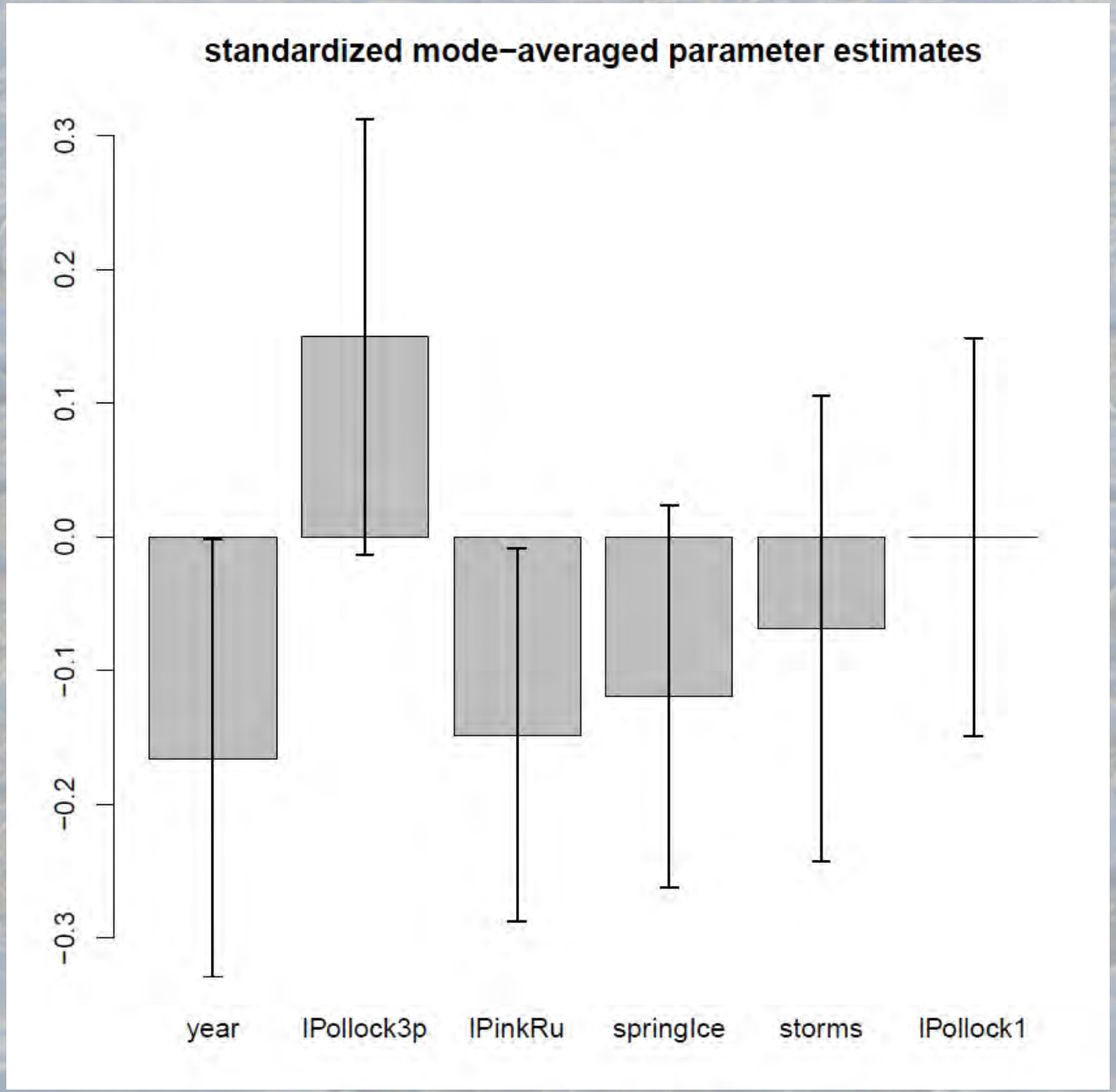
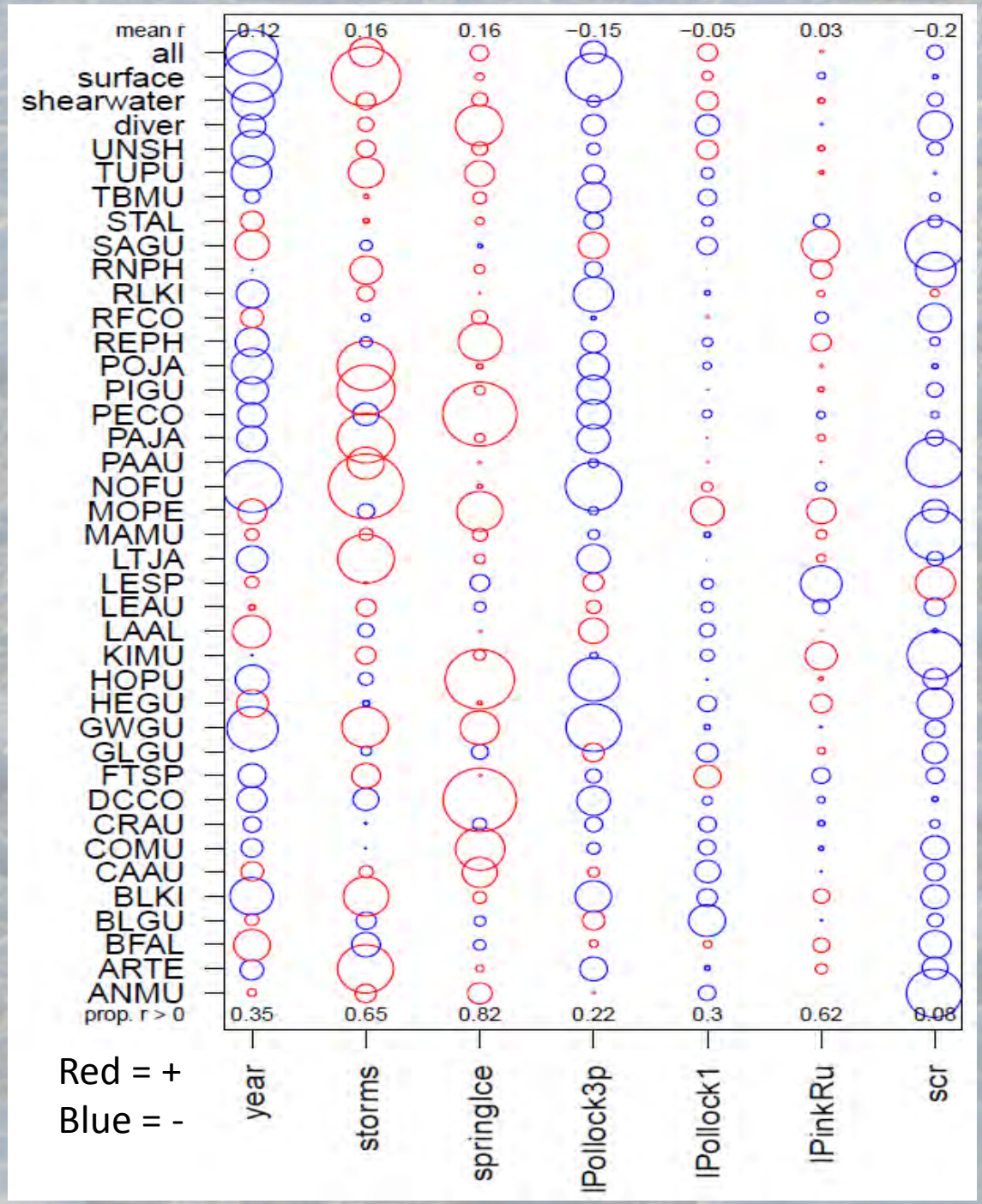

standardized mode−averaged parameter estimates
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
year
lPollock3p
lPinkRu
springIce
storms
lPollock1

Table 1: Comparisons of candidtate models using AICc.

	r^2-adj	K	△AICc	ω	ω-ratio
year+lPollock3p+lPinkRu	0.215	5	0	0.151	1
lPinkRu	0.0983	3	0.399	0.124	1.22
year+lPollock3p	0.147	4	0.479	0.119	1.27
year+lPinkRu	0.121	4	1.32	0.0779	1.94
year	0.0532	3	1.77	0.0623	2.42
year+springIce	0.106	4	1.81	0.0611	2.47
1	0	2	1.83	0.0603	2.5
springIce	0.0507	3	1.84	0.0601	2.51
year+springIce+lPinkRu	0.16	5	1.91	0.0581	2.6
lPollock3p+lPinkRu	0.102	4	1.92	0.0577	2.61
year+springIce+lPollock3p	0.152	5	2.17	0.051	2.96
lPollock3p	-0.00881	3	3.54	0.0257	5.88
year+springIce+storms+lPinkRu	0.169	6	3.68	0.024	6.28
year+springIce+storms	0.105	5	3.69	0.0239	6.32
storms	-0.038	3	4.34	0.0172	8.77
lPollock3p+lPinkRu+lPollock1	0.0648	5	4.91	0.013	11.6
year+springIce+storms+lPollock3p	0.13	6	4.95	0.0127	11.9
full model	0.161	8	8.98	0.0017	88.9

Pearson's r for all bird species with respect to environmental variables and the nMSD1 score



AIC Model & Summary of Pearson's r

for all 36 Seabird Species with respect to nMSD1

AIC Best Model

Year + Age-3+pollock + Russian Pink Salmon

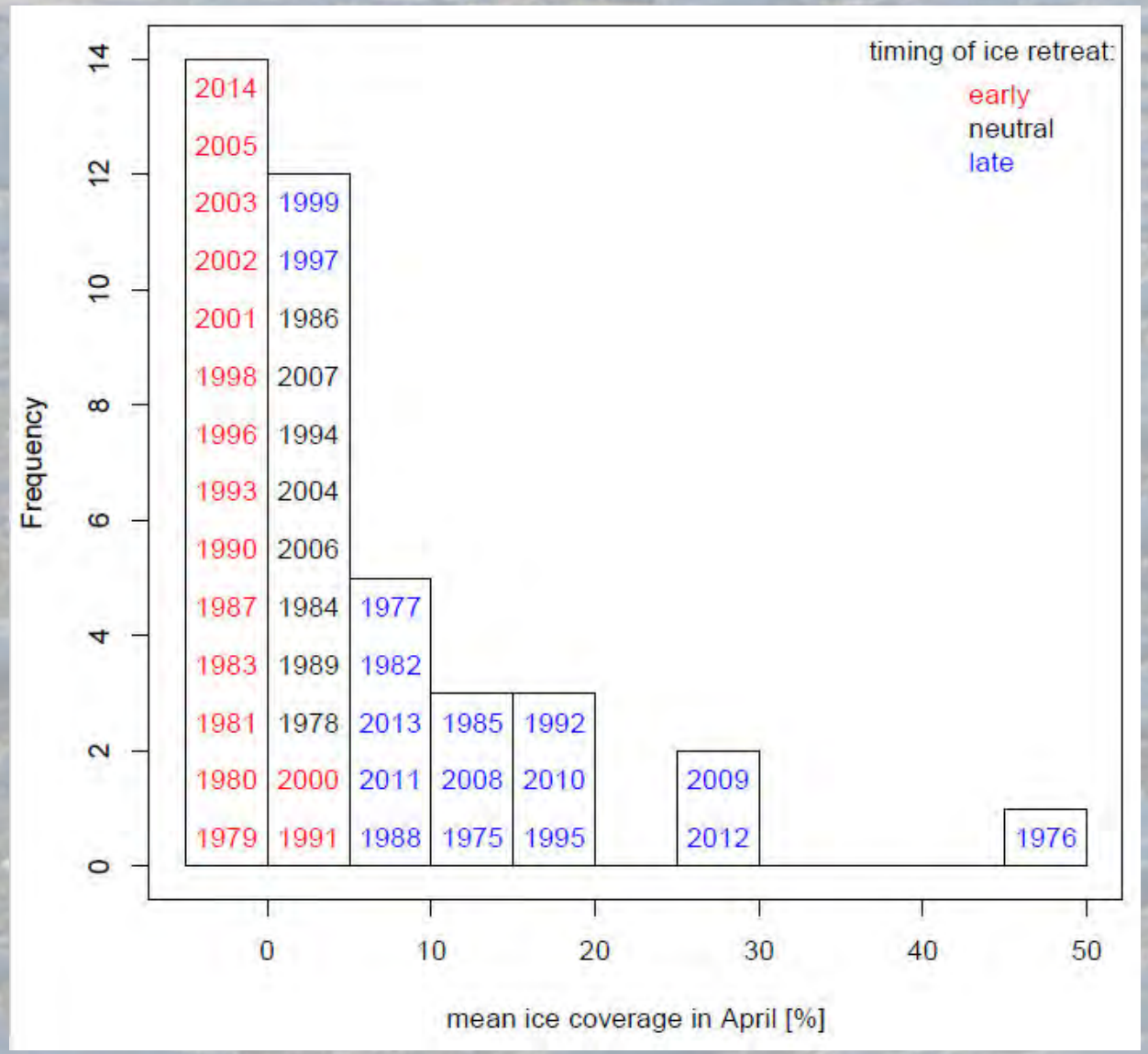
$r^2 = 0.215$

Mean Pearson's r	r
STORMS	0.16
SPRING SEA ICE COVER (April)	0.16
AGE-3+ POLLOCK	-0.15
YEAR	-0.12
AGE-1 POLLOCK	-0.05
RUSSIAN PINK SALMON RETURNS	0.03

Proportion species with Pearson's r > 0	r
SPRING SEA ICE COVER	0.82
STORMS	0.65
RUSSIAN PINK SALMON	0.62
YEAR	0.35
AGE-1 POLLOCK	0.30
AGE-3+ POLLOCK	0.22

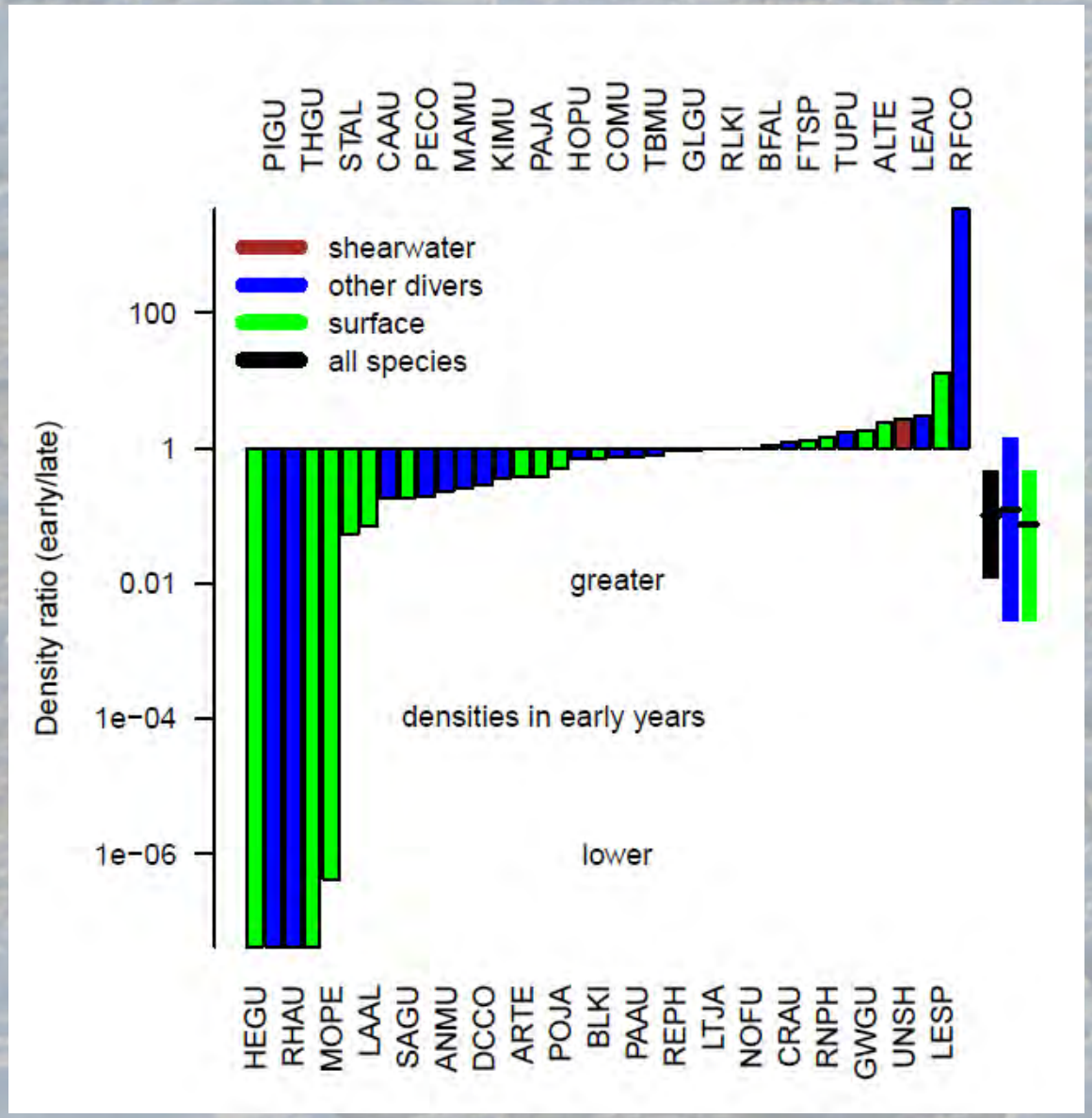

Timing of Sea-Ice Retreat

Classification of years as Early or Late with respect to ice retreat in the study area



From: Renner et al., 2016

Changes in Seabird Abundance
Early – Late ice-retreat-years



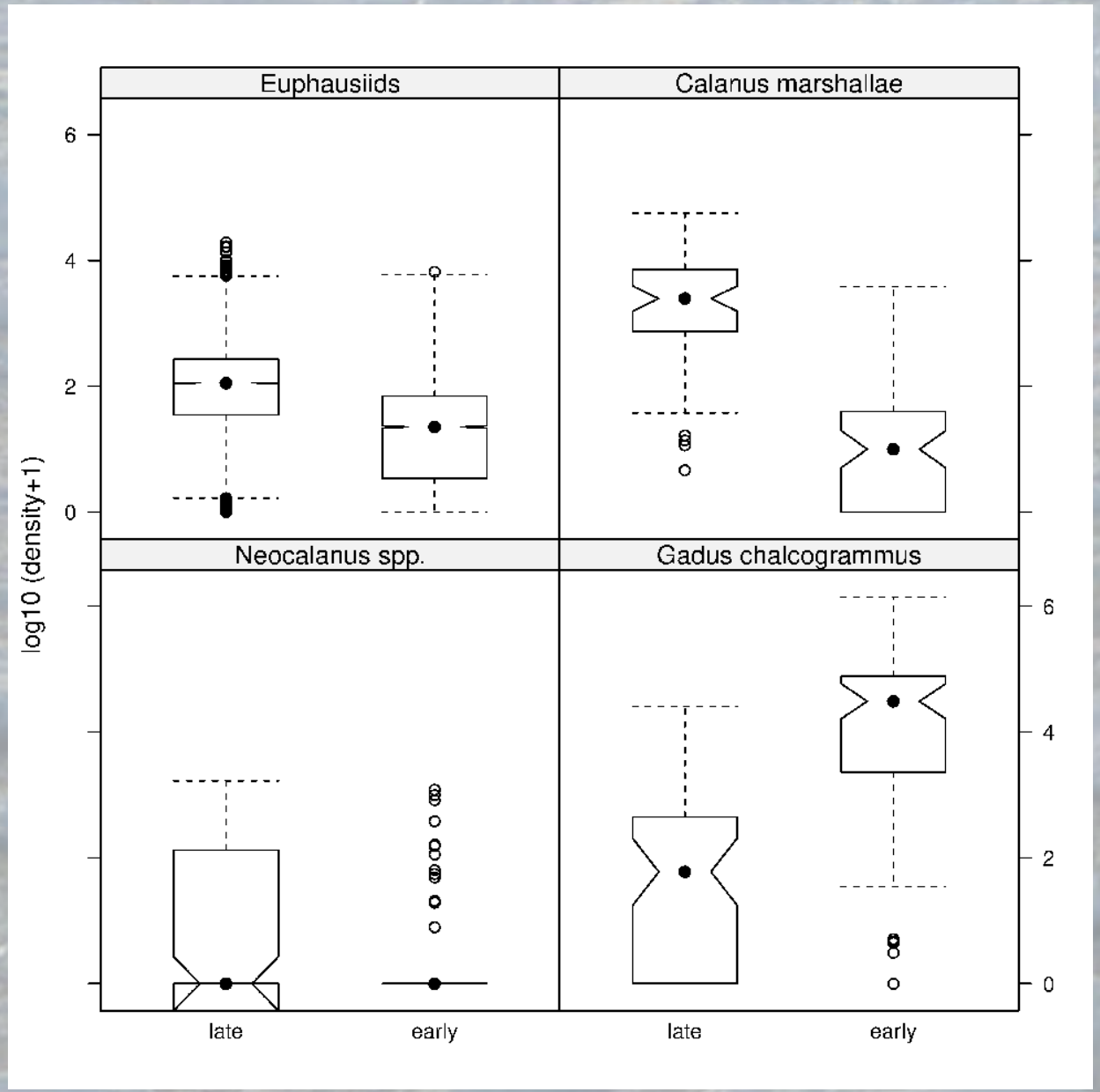
Averaged over all species, densities in early ice-retreat-years were 10.1% (95% CI: 1.1–47.9%) of those in late ice-retreat-years.

Surface-foragers decrease in early years

Renner et al., 2016

What we Know about Prey

Changes in Zooplankton & age-0 pollock in Late (cold) vs. Early (warm) years (2001 – 2012)



From: Renner et al., 2016

Summary

- **Overall, declines in seabird densities greater than increases for period 1975 – 2014**
- **More species show declines in years with early sea-ice-retreat than in years with late sea-ice-retreat**
- **More species show a negative trend with respect to age-3+ walleye pollock**
- **Surface-foragers seem more sensitive than divers**
- **Patterns of decline or increase depend on species**

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