Beyond Earlier, Poleward, and "Worse": Global Meta-Analysis of Seabird-Climate Relationships

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Some Fundamental Hypotheses in "Climate Change Ecology"

1. Earlier phenology with increasing T and lengthening of growing seasons

2. Decreasing and/or more variable productivity or survivorship (…abundance/biomass) with increasing T, lengthening of food chains and less efficient trophic transfer

3. Poleward shifts in distribution and range with increasing T and poleward isotherm displacements

   - Today: Are these generalized expectations (focus on 1,2) supported by seabird-climate studies at the global scale?

   - Seabirds have been put forth as reliable real-time indicators of coupled climate – ecosystem change. Is it reasonable to support this claim?




Working Group on Marine Climate Impacts

(Richardson and Poloczanska, PIs)

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Focal question OF NCEAS WG

Which marine species, groups and systems are most sensitive to climate change?

- **Are seabirds good indicators? Are they amplifiers or are they buffered relative to other taxa?**

Literature Search: Seabird-Climate Studies

ISI Web of Knowledge

Search terms:

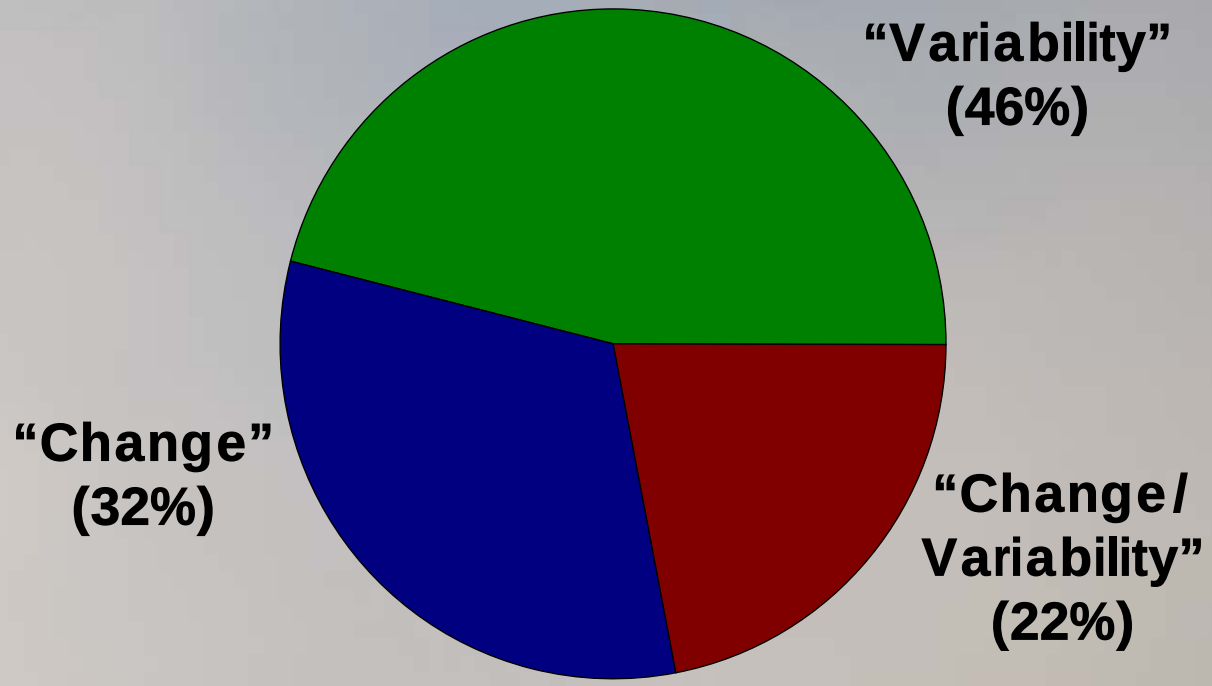
1. Seabirds climate change
2. Seabirds climate variability
3. Prominent authors found in results from 1. and 2.
4. Seabird climate trends
5. Seabird climate food availability
6. Seabird climate variation
7. Seabirds climate
8. Prominent authors (searched again)

Climate Change vs Climate Variability

91 papers, 2597 records/observations

(record: seabird response parameter – climate variable test)

- **mean = 28.5 tests/paper !**



Seabird-Climate Publications Database

(climate variability, climate change, variability/change)

- **95 seabird species (not comprehensive, but representative)**

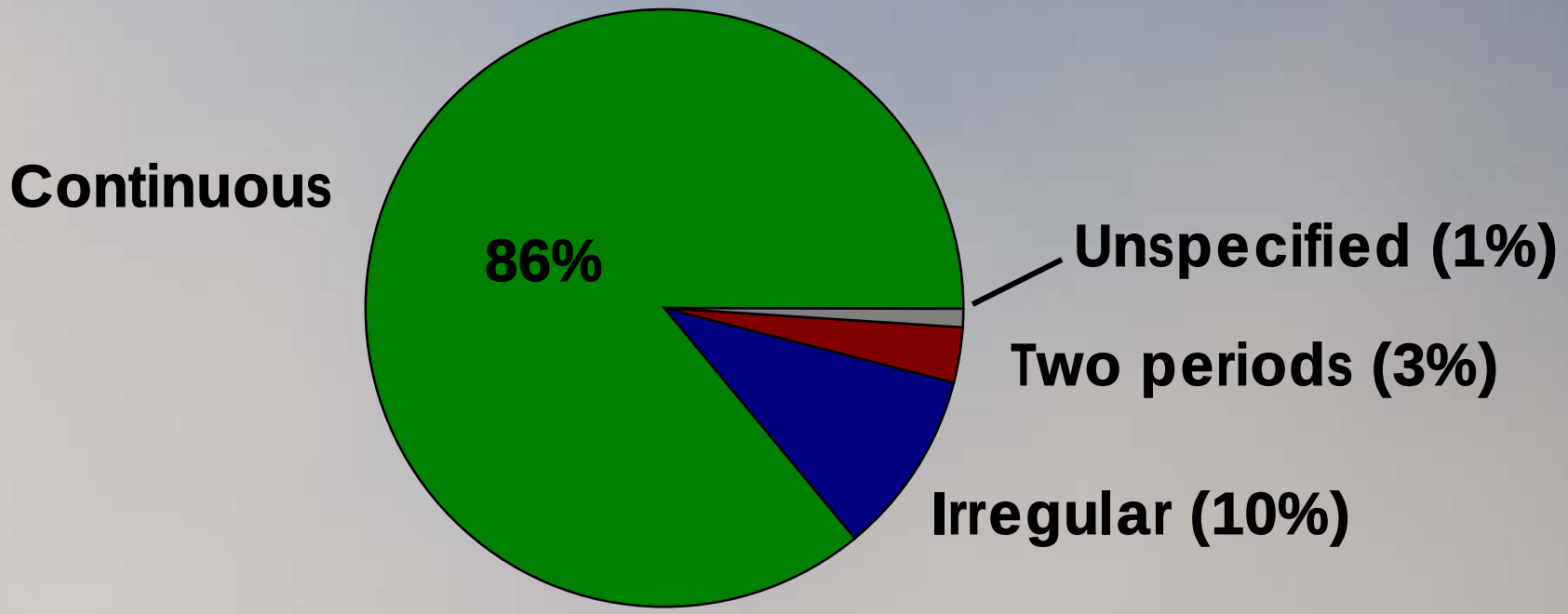
Number of species per paper:

- **71% papers included 1 species (publ. bias?)**
- **29% papers included >1 species**

- **mean = 2.4 species/paper**

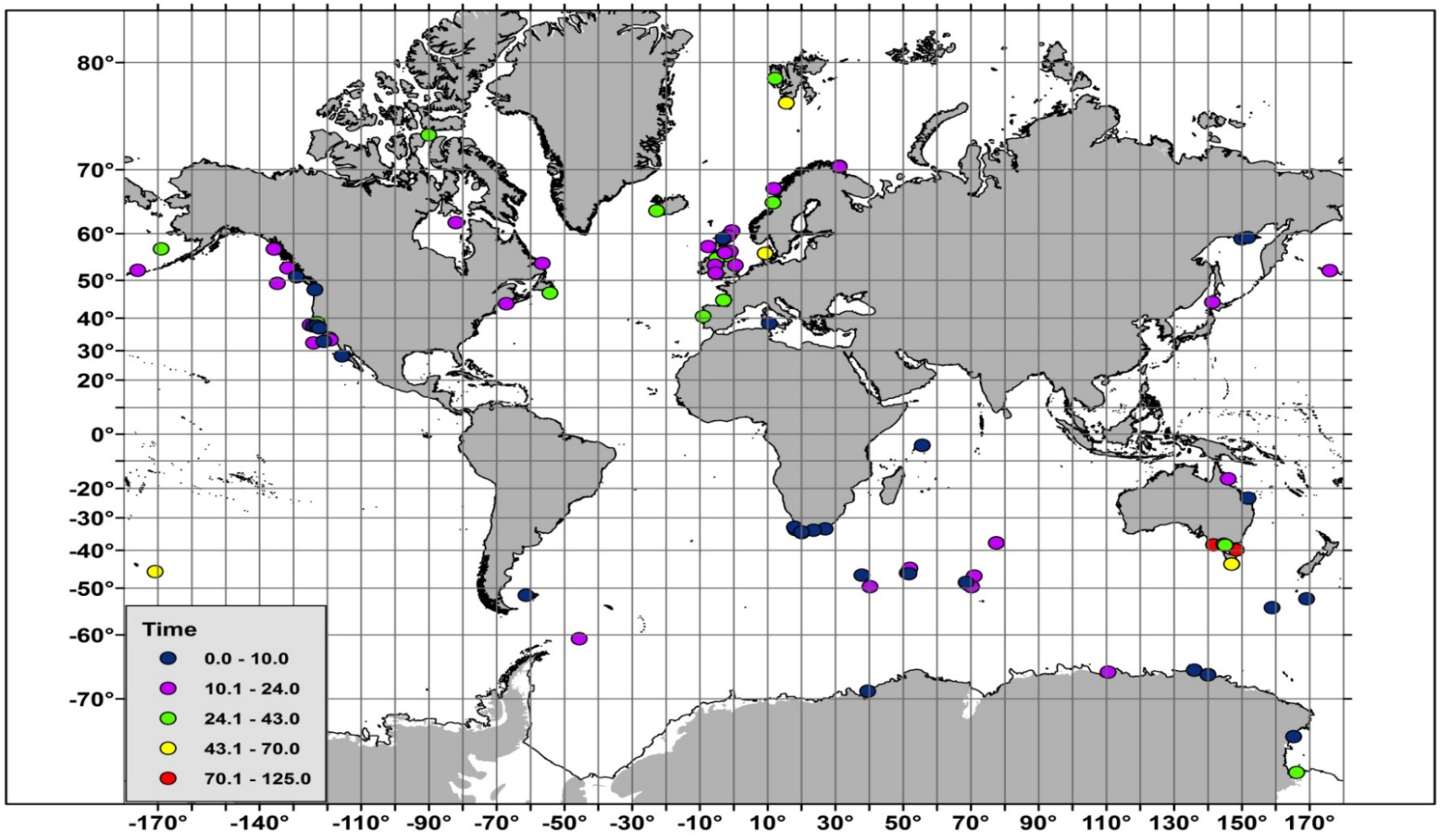
Temporal Characteristics of Seabird-Climate Studies (good news)

Continuity of data sets:

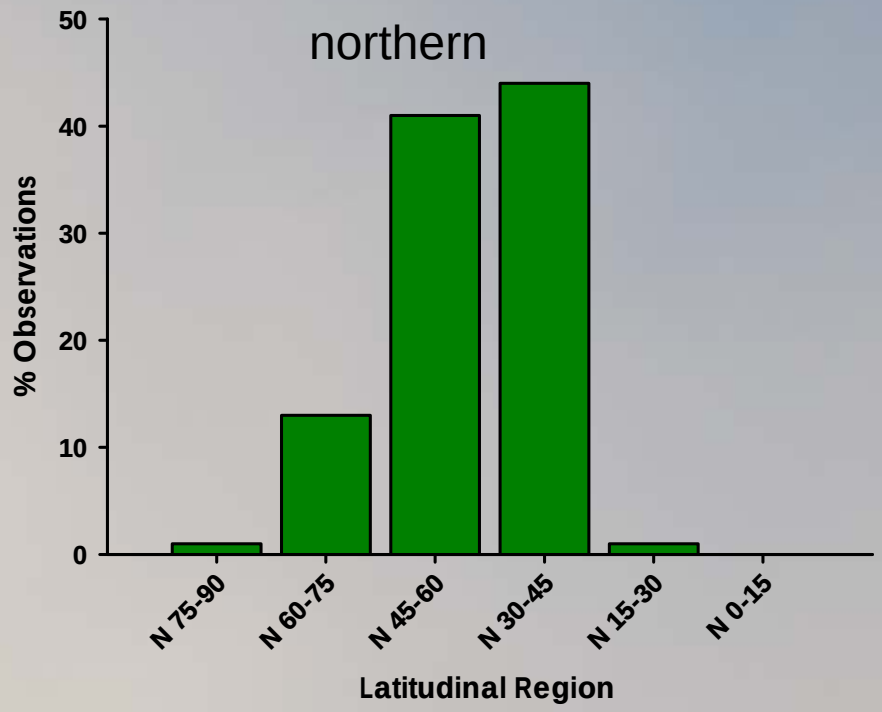


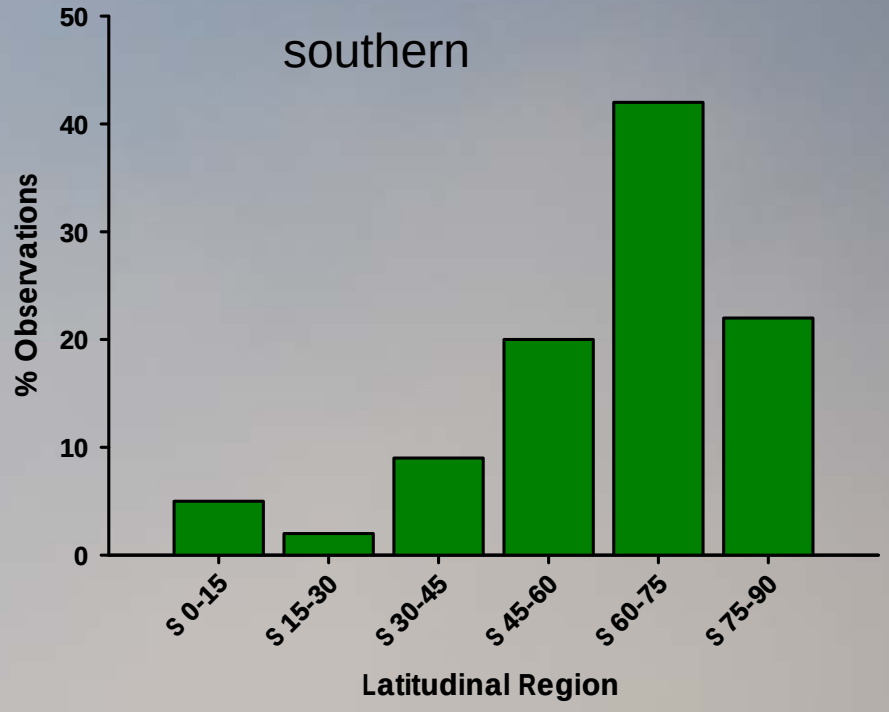
Average time span of studies: 23.4 y
Average number of years of data/study: 20.6 y

Location and Time Span of Seabird Studies

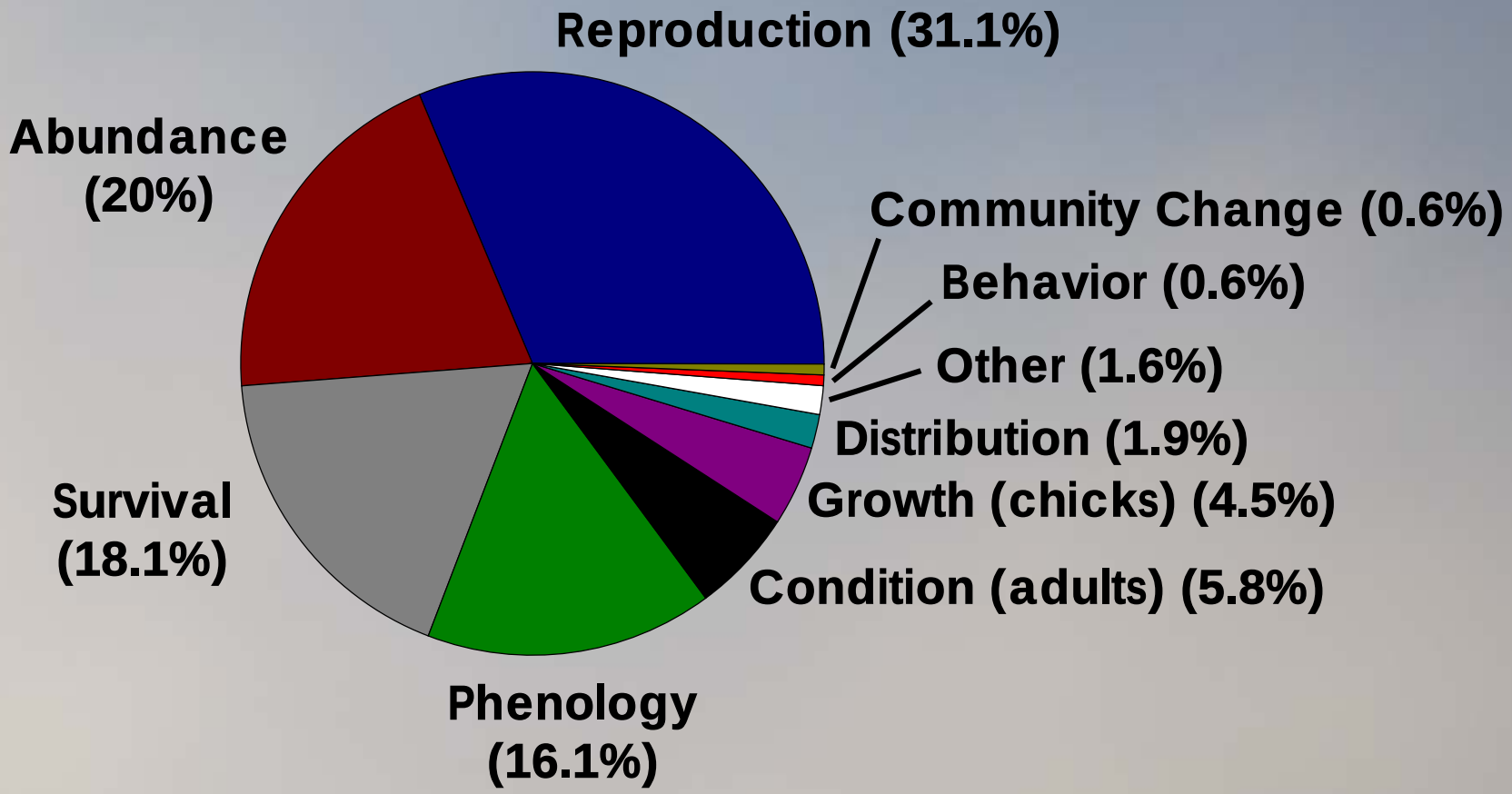


Location of Seabird Studies by Hemisphere and Latitude



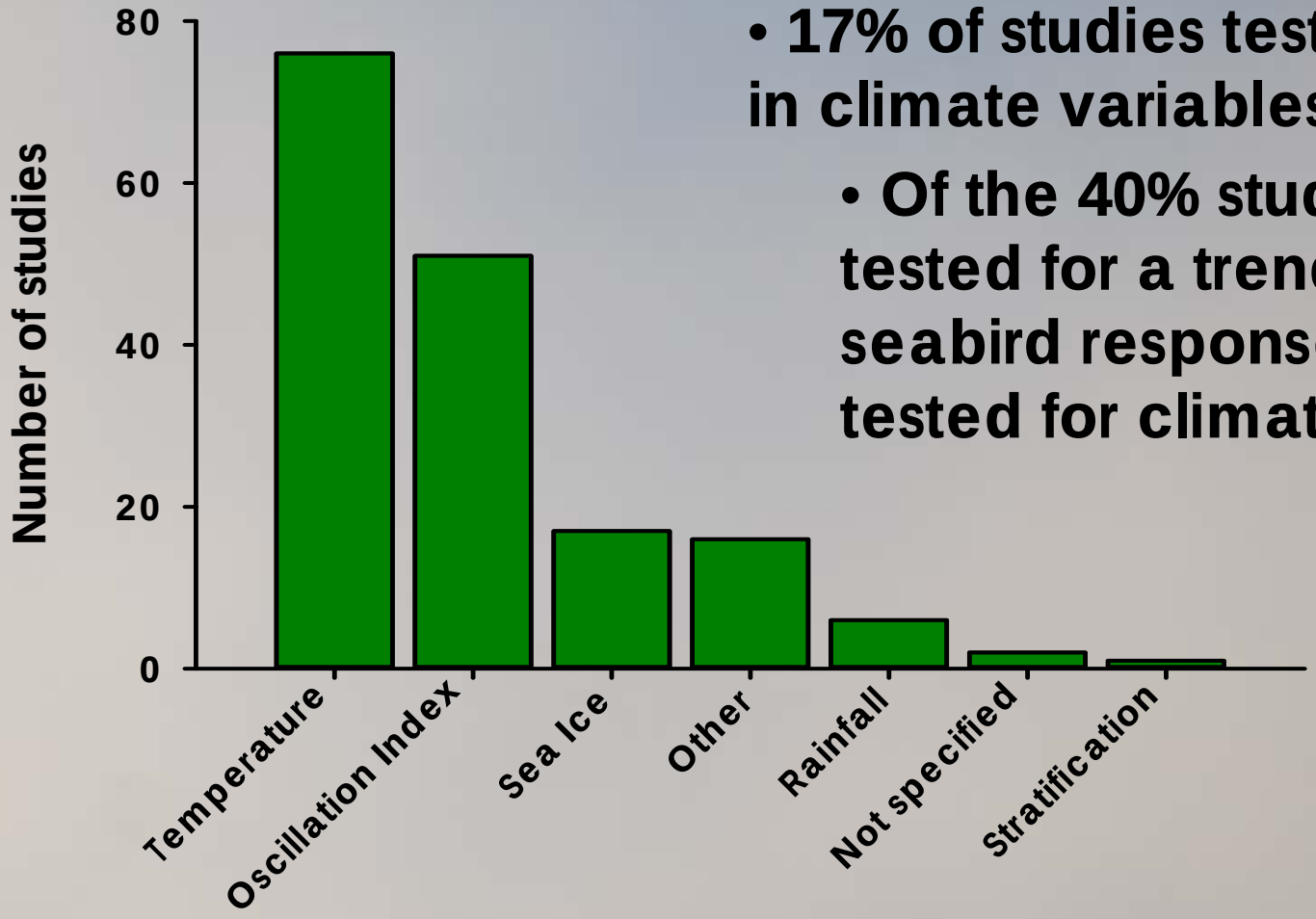


Seabird Responses (4 primary variables)



- 40% of responses (n=2597) were tested for temporal trends (almost none adjusted for autocorrelation)

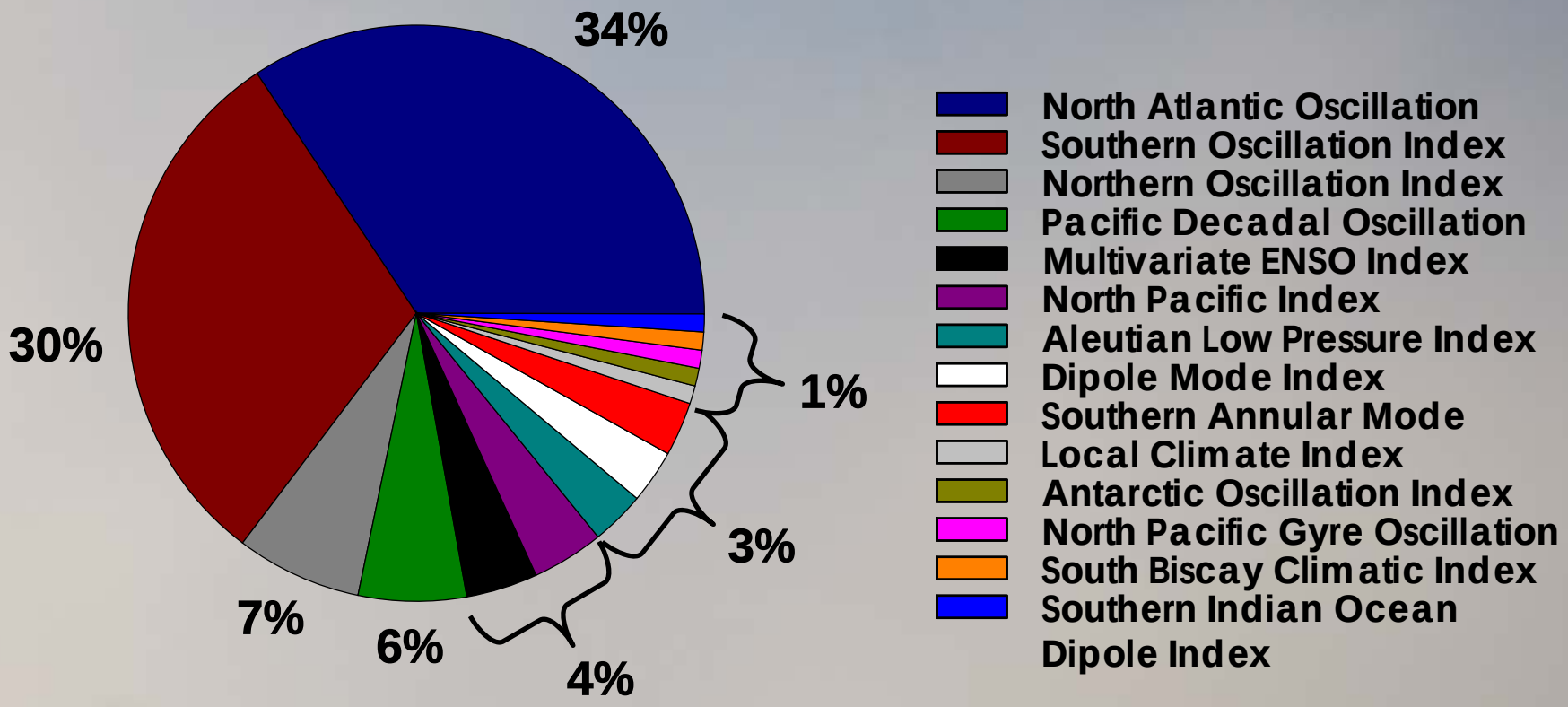
Climate Drivers



- 59 different “climate” variables
- 17% of studies tested for trends in climate variables
  - Of the 40% studies that tested for a trend in the seabird response, 31% also tested for climate trends

Climate Oscillation Indices (mixture of atmospheric and oceanographic indices)

- NAO and SOI constitute ~2/3 of the tests



Meta-analysis

- **Meta-analysis is an analysis of previous analyses**
  - In CC ecology – conducted to illustrate "fingerprints of CC"

  (Parmesan and Yohe 2003 Nature; Root et al. 2003 Nature; Rosensweig et al. 2008 Nature; Parmesan 2009 GCB)

- **Seabird-climate relationships**
  - Air temperature
  - Sea temperature (includes SST, T @ depth, salinity, stratification)
  - Sea ice (extent, concentration, etc., not timing of retreat)
  - Atmospheric indictors
  - (SOI, NAO, most wNAO)

Summary of Statistical* Tests On Seabird Parameter – Climate Relationships

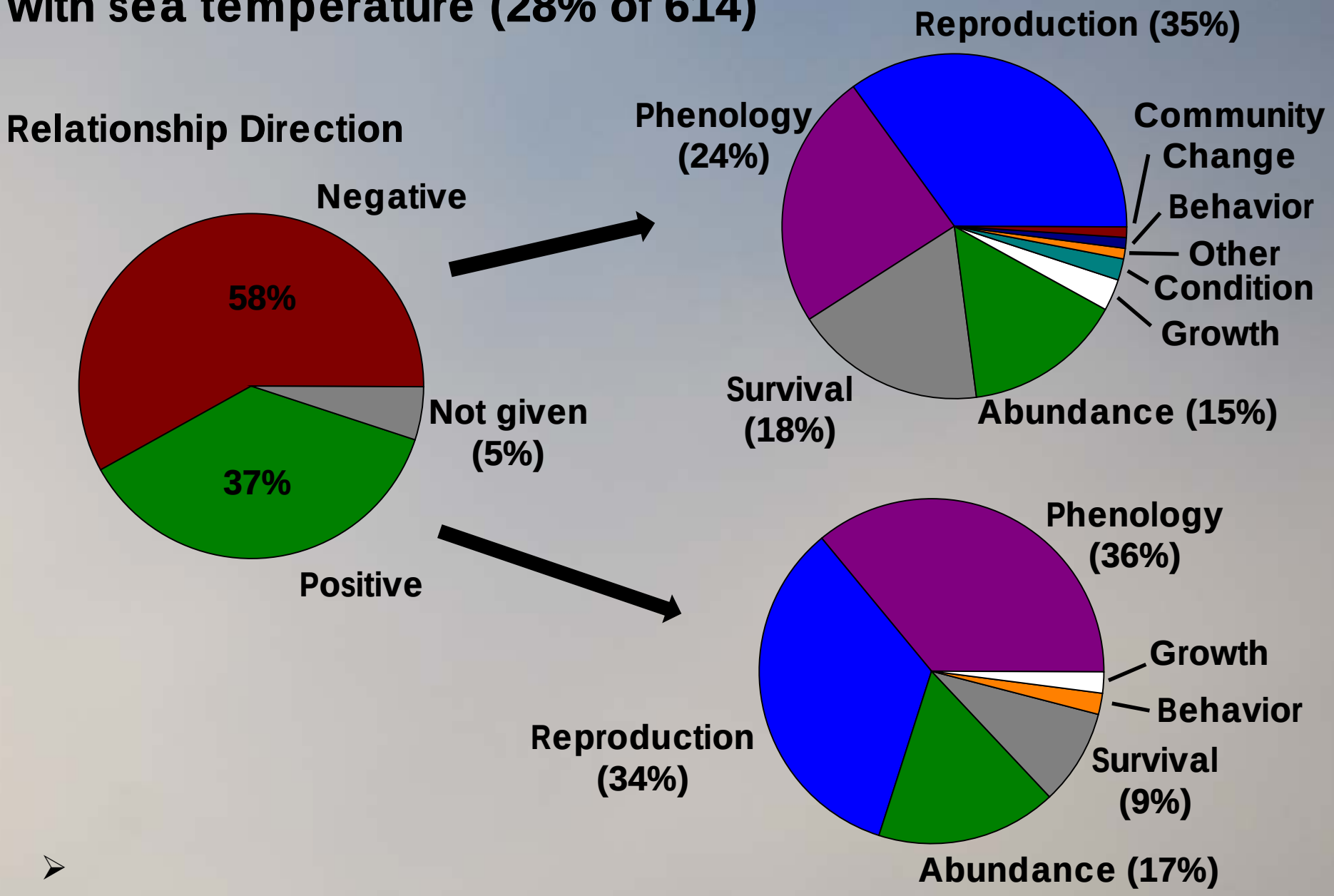
Climate Parameter	No. Records	% Significant
Sea Temperature	614	28%
Air Temperature	226	20%
Sea Ice	404	18%
SOI	184	14%
NAO	443	20%

*linear correlation or regression, typically without adjustment for serial autocorrelation; generally “significance” was assumed if $P<0.05$

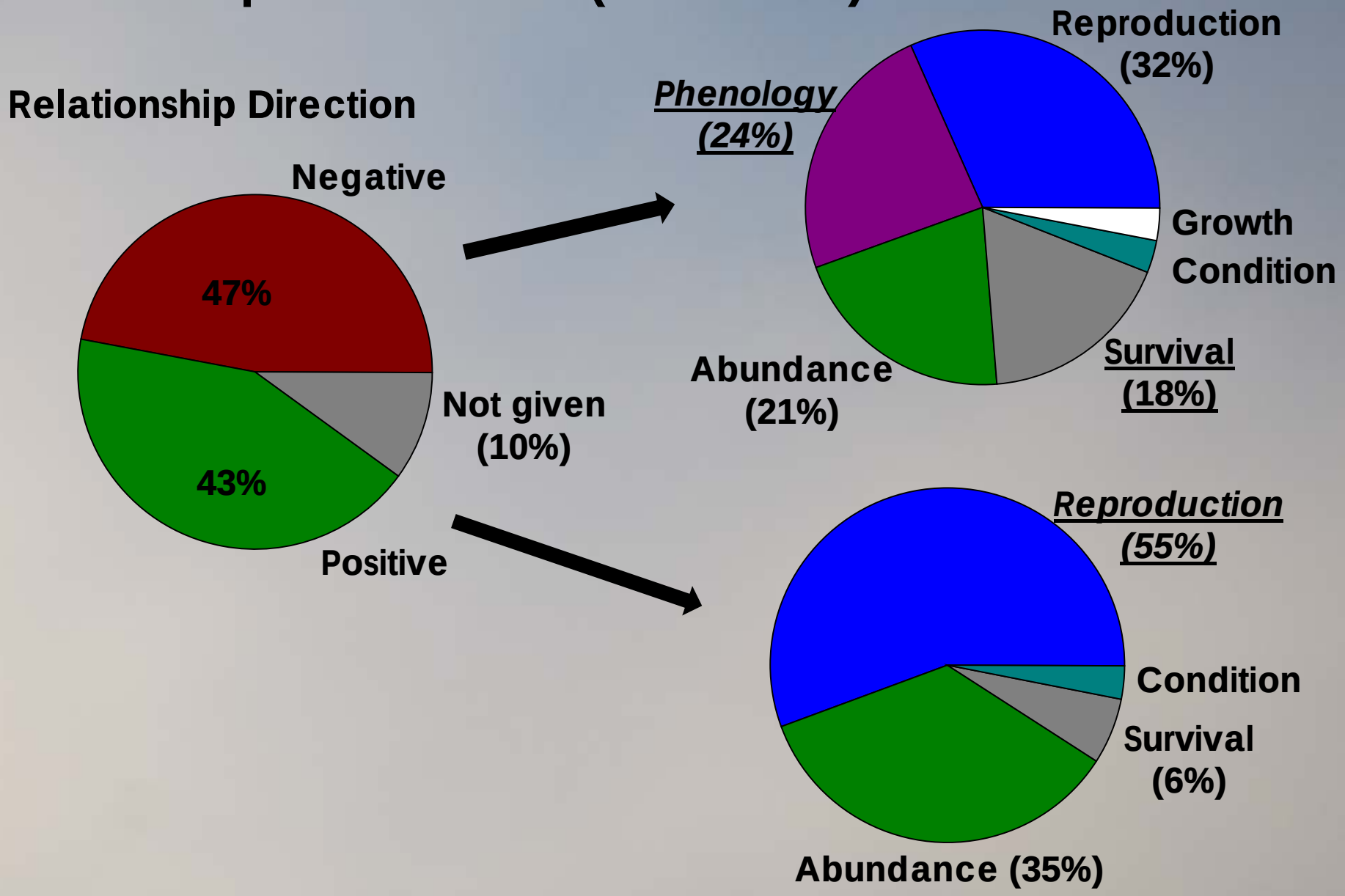
The Question

For significant seabird-climate relationships, which seabird parameters were most associated with each climate variable?

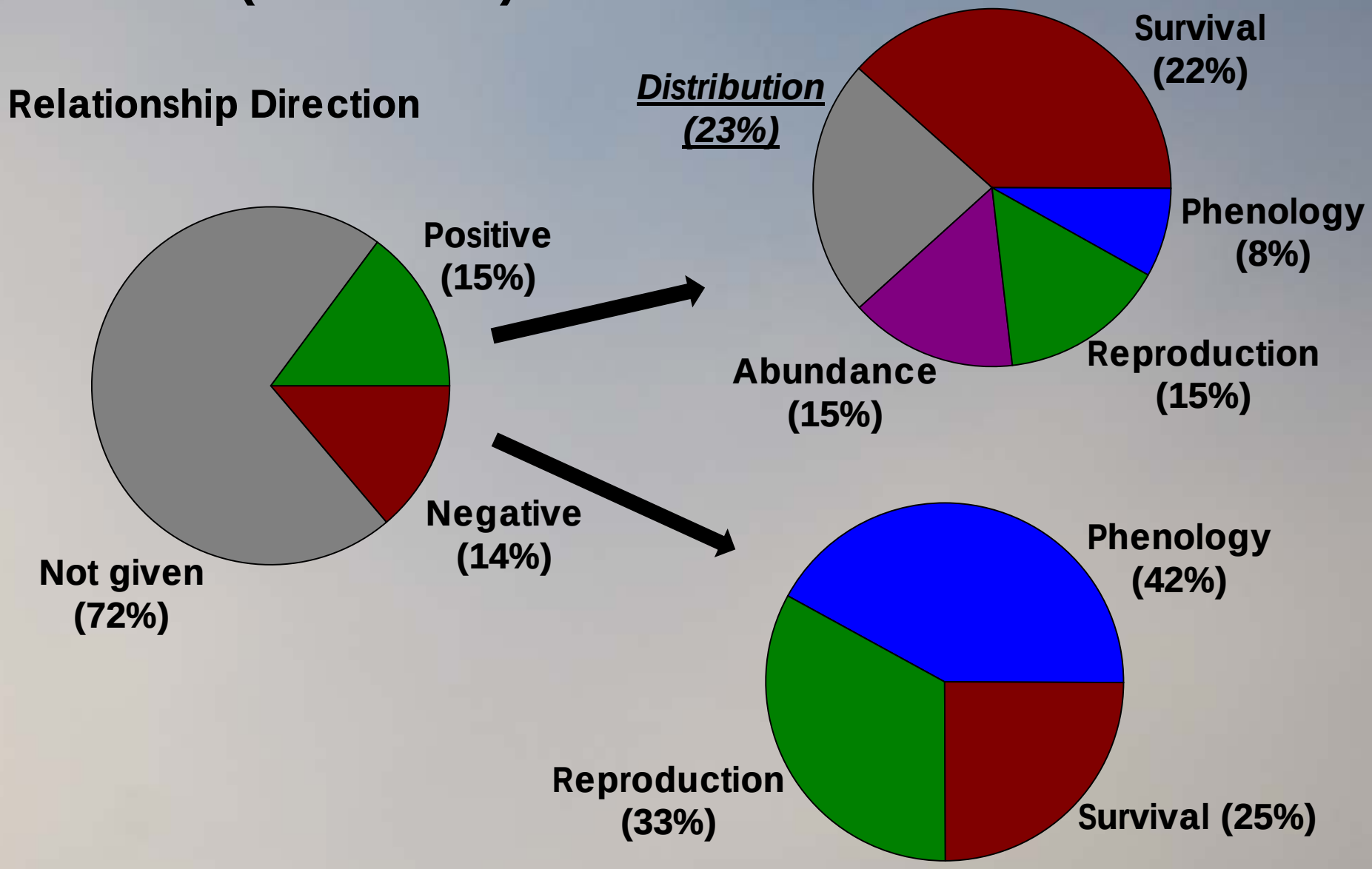
Significant biological relationships with sea temperature (28% of 614)



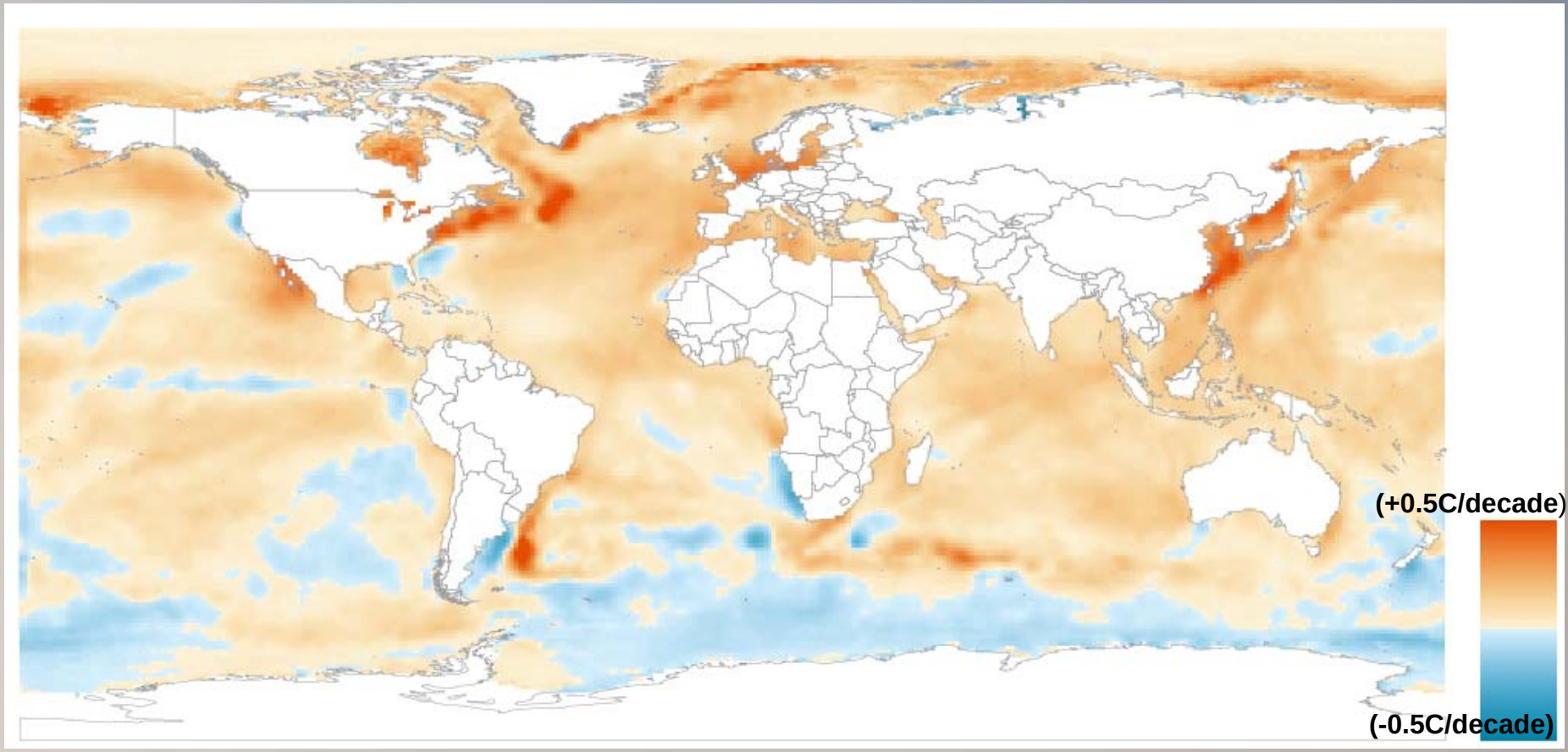
Significant biological relationships with sea ice (18% of 404)



Significant biological relationships with NAO (20% of 443)



Warming and Cooling in the Ocean: Trends in 1º x 1º Hadley SST1, 1960-2009



M. Burrows/ NCEAS WG in prep.

Summary/Conclusion I

- 91 peer-reviewed seabird-climate papers entered into database, ~2600 records on 95 species, on 4 primary parameters
- Most studies tested seabird parameter-climate relationships, but statistical treatments need improvement
- Only ~22% of tests found significant results with ST being most compelling
- Contrary to literature, local "ocean climate" drivers performed somewhat better than large-scale climate indices
- "Devil in the Details" – variable responses; …local mechanisms drive responses, resulting in positive and negative relationships; <u>universal expectations under climate change and effects on seabirds (and other taxa?) seemingly not possible</u>.

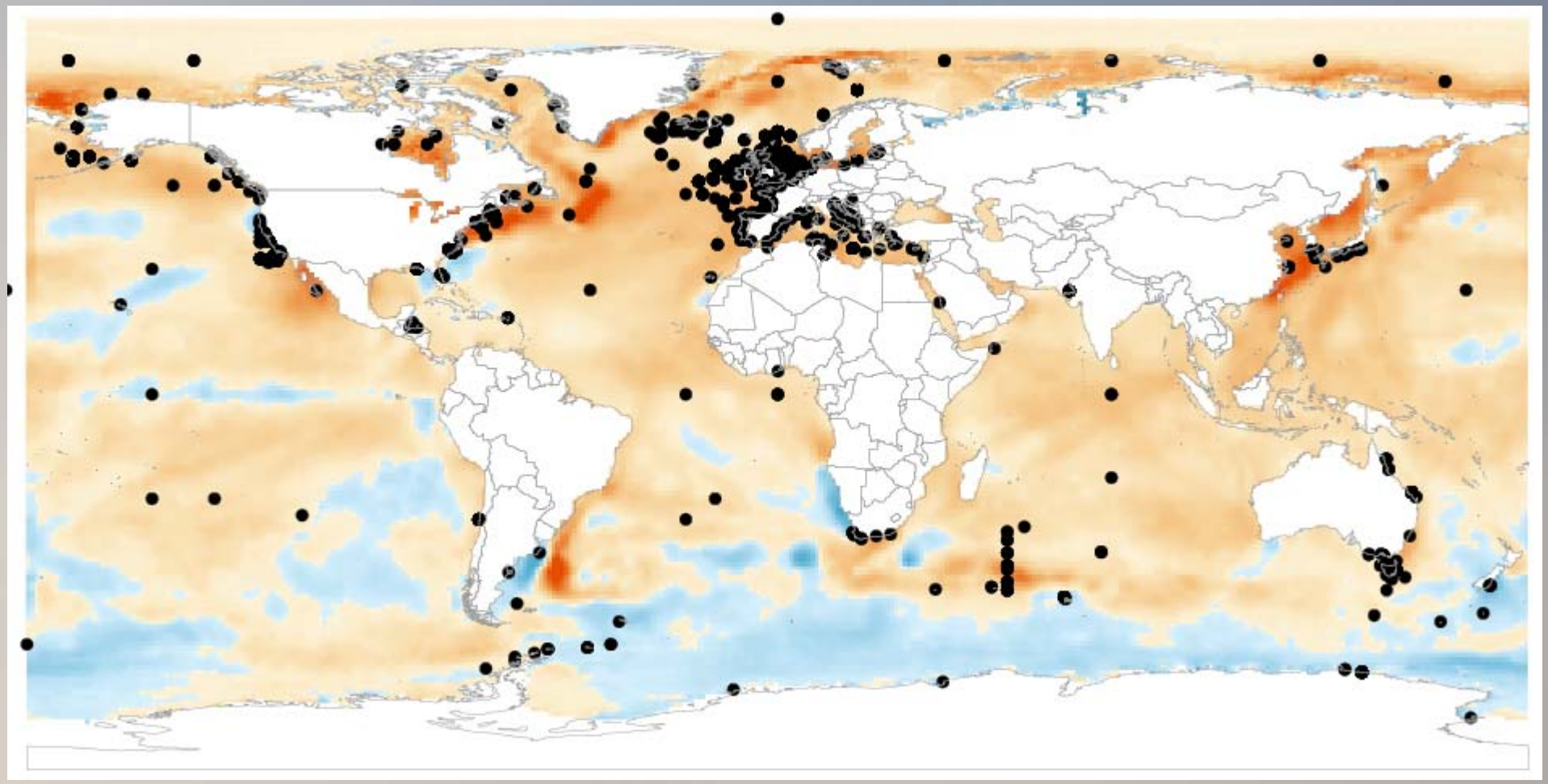
Summary/Conclusion II

- **<u>Seabirds as Ecological Indicators</u>:**

seabirds are well-studied globally, but complexity in drivers (e.g., warming and cooling) and responses, as well as indirect (food web) mechanisms and non-linear relationships, provides a challenge to using seabirds as indicators of climate-ecosystem change.

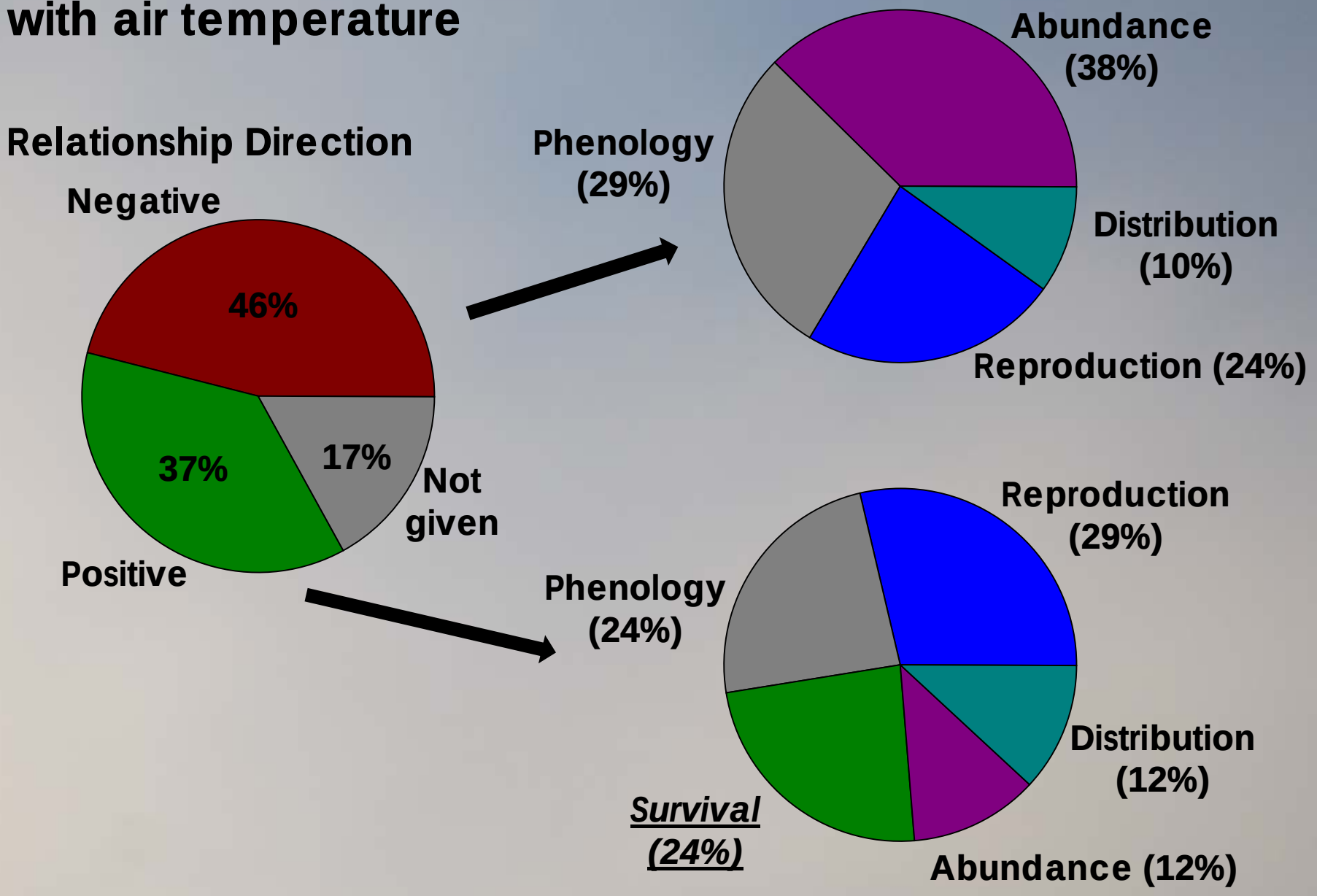
- **Future work on this database will include examining parameter-climate relationships by functional group (planktivore, piscivore; diver, surface-feeder, neritic, pelagic) and "region" (LME, Longhurst province) to clarify emergent patterns.**

Locations, All Taxa/Species, NCEAS Database



Poloczanska et al in prep.

Significant biological relationships with air temperature



Significant biological relationships with Southern Oscillation Index