Exploring the determinants of ecological predictability

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Ecologists, managers, & stakeholders often ask:

How many individuals?

Why are they there?

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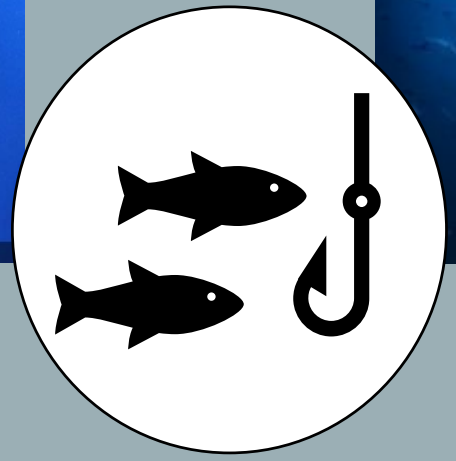

Why are they there?

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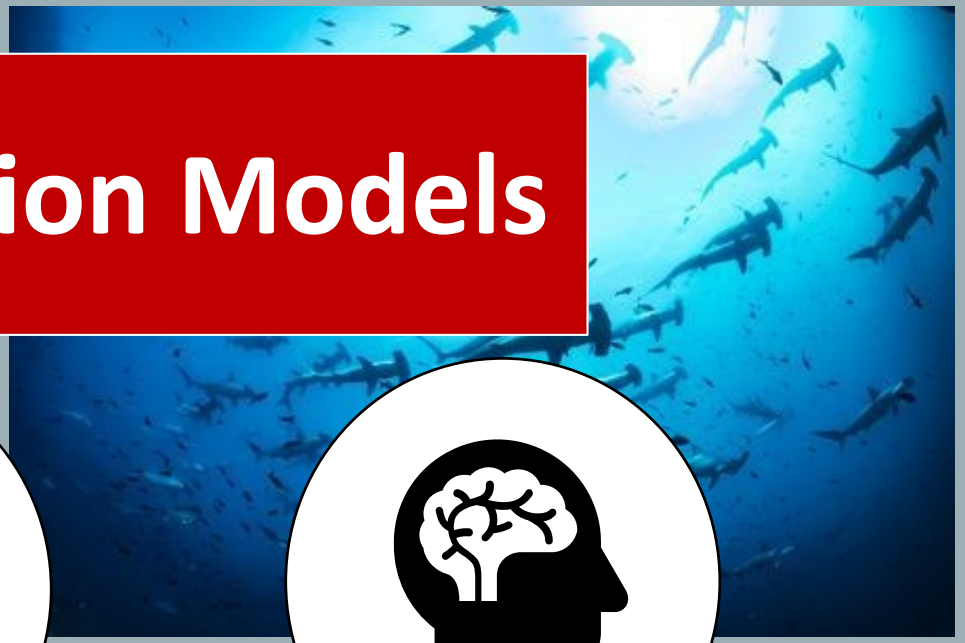
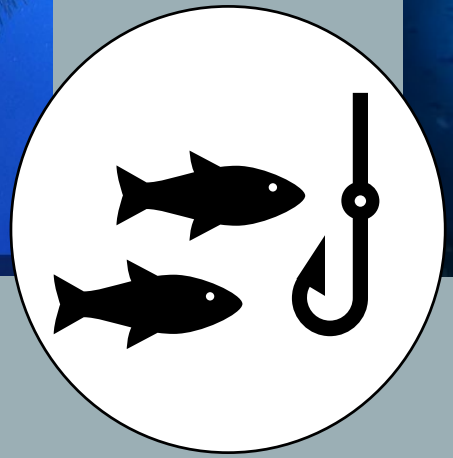
How many individuals?

Why are they there?

Species Distribution Models

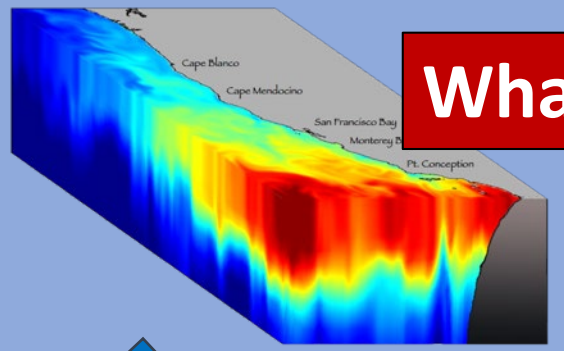




Species Distribution Model

Species data

Covariates



What covariates?

What model is best?

Statistical or mechanistic model

Predictions

Model Comparison

3x3 factorial design

3 Models
Boosted Regression Tree (BRT)
Generalised Additive Model (GAM)
Vector Autoregressive Spatiotemporal model (VAST)

3 Covariate configurations
Spatiotemporal
Environmental
Spatiotemporal & Environmental

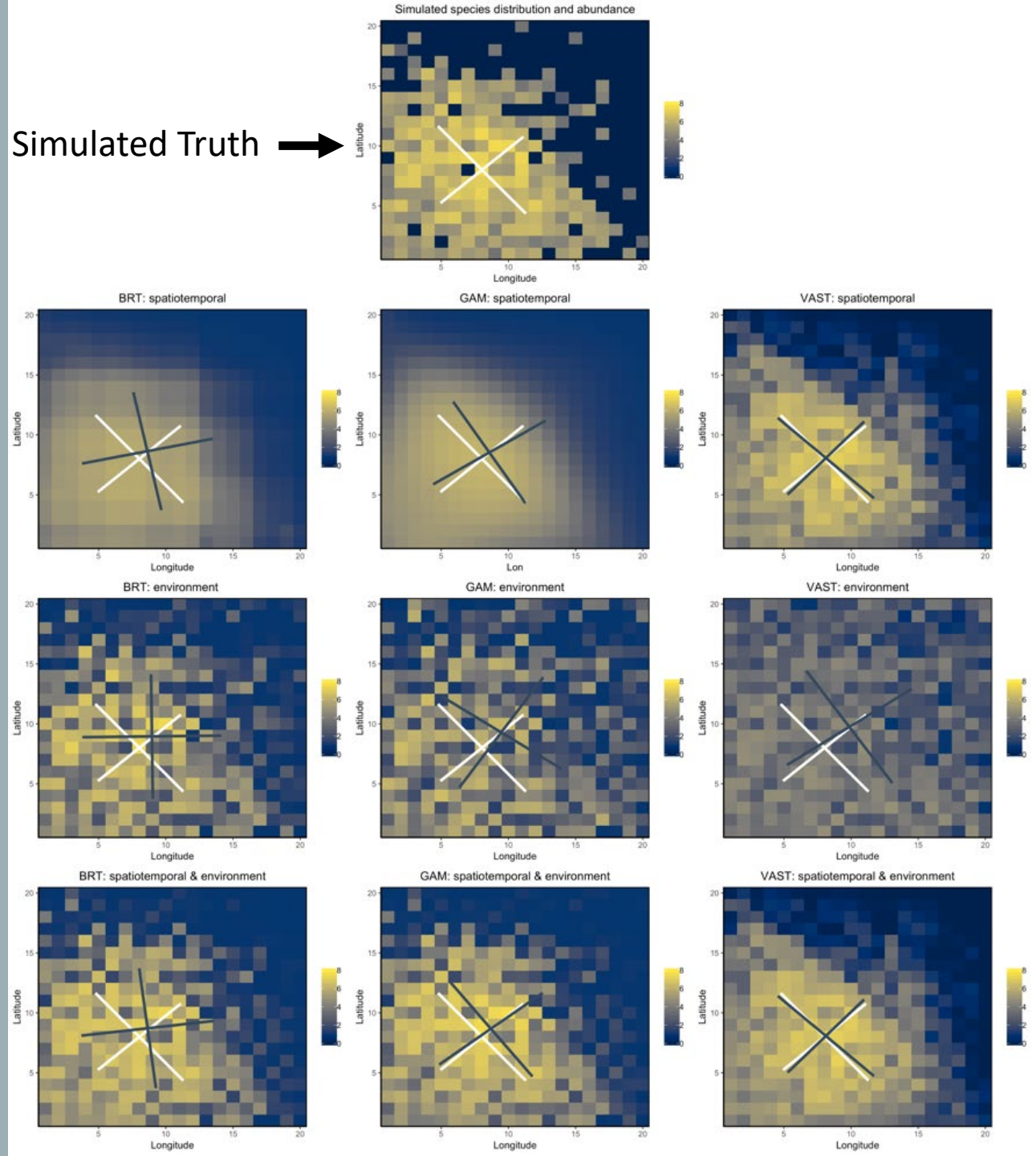
Results: Spatial Predictions

Simulated Truth →

Environment is missing →

Space & time is missing →

All covariates included →



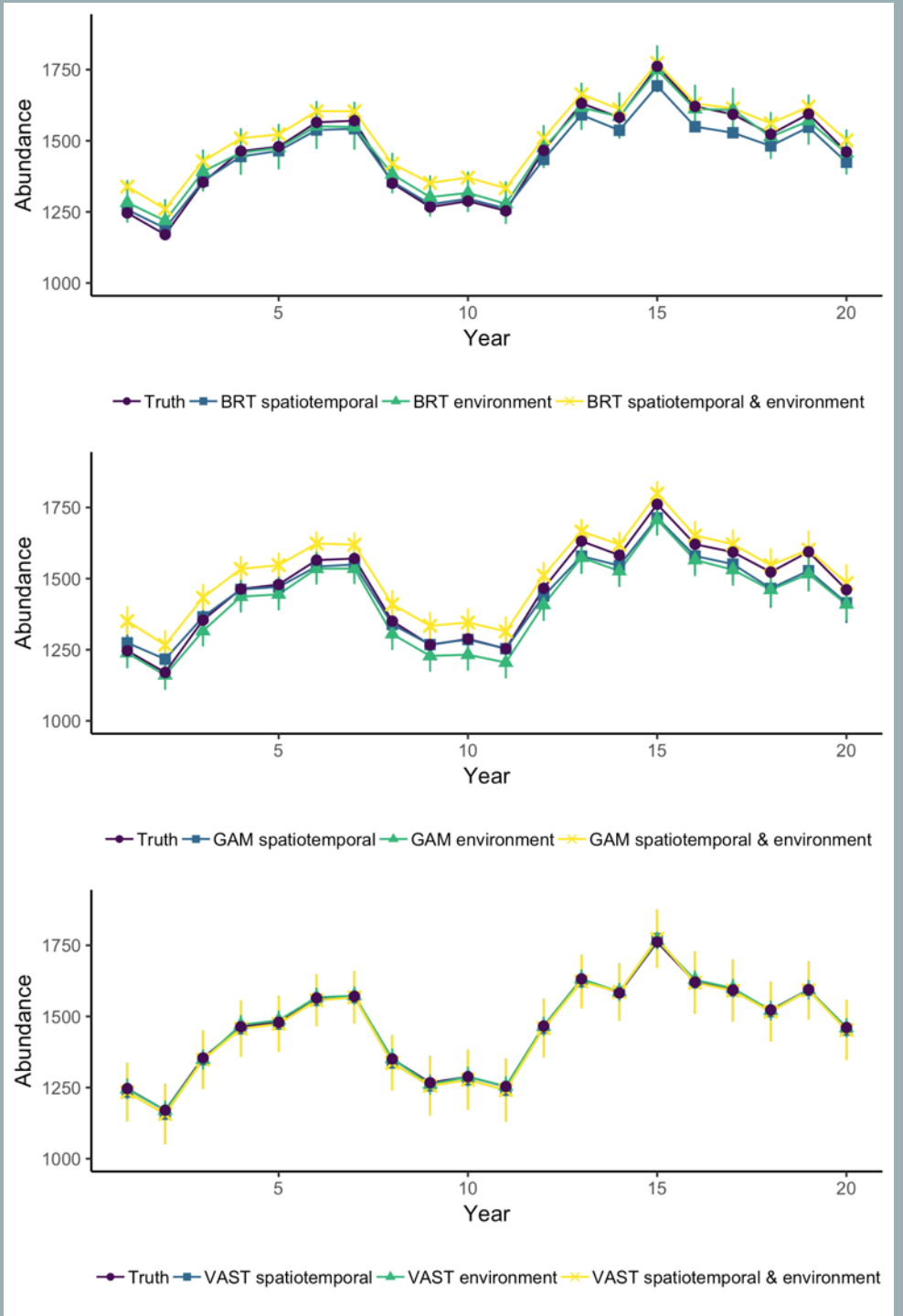
Brodie et al., 2019 Ecography

Results:
Time-series of abundance

BRT models →

GAM models →

All models do well but VAST is best →



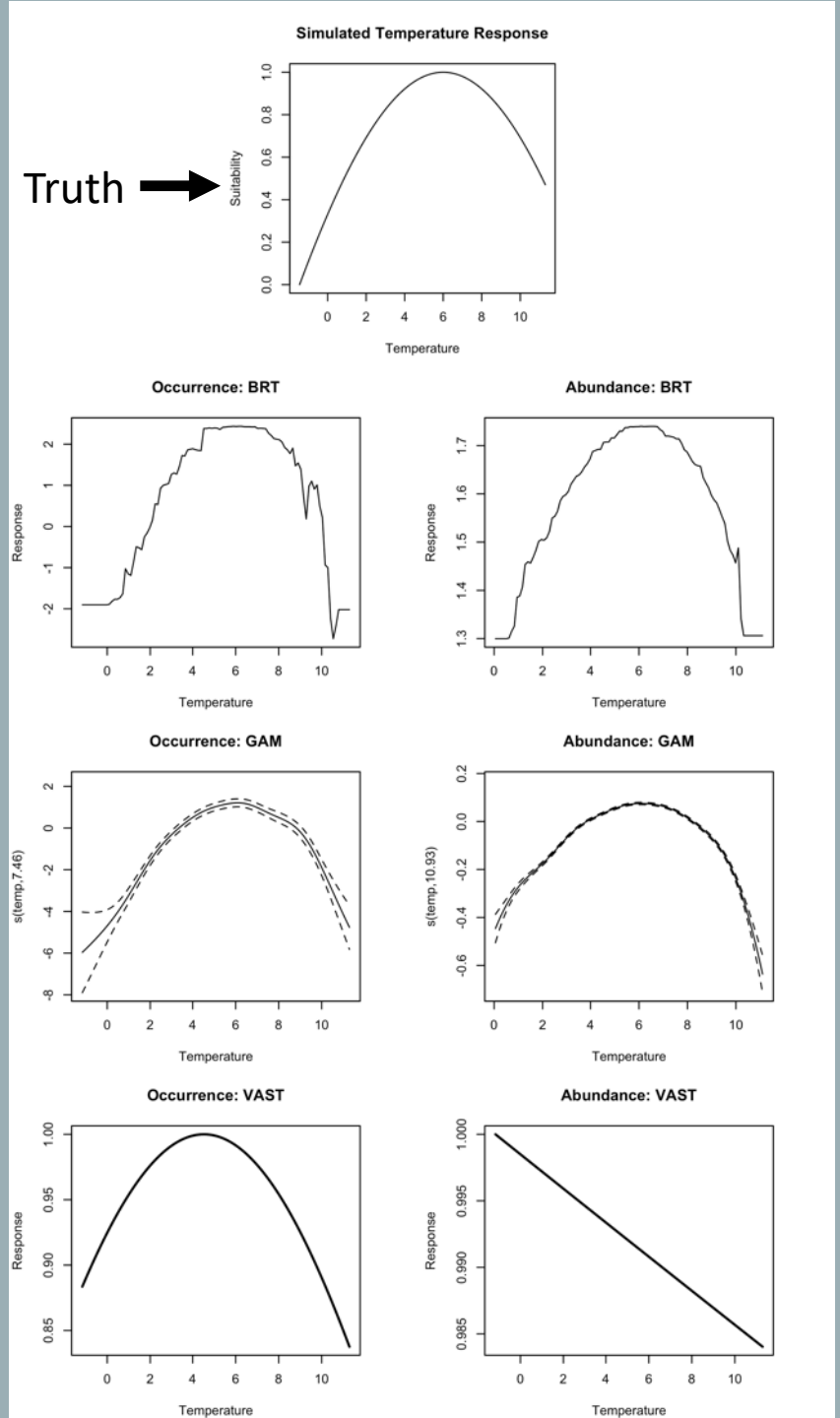
Brodie et al., 2019 Ecography

Results:
Model response curves

BRT models:
regression tree splits

GAM models:
spline smoother

VAST models:
quadratic functions



Brodie et al., 2019 Ecography

Simulation Summary

- VAST was best for estimating abundance
- Non-linear models can accurately represent environmental relationships
- Models including both environmental and spatiotemporal covariates are best

Limitation: Ecological Forecasting

Brodie et al., 2019 Ecography

Why predict the future?

Understand the world

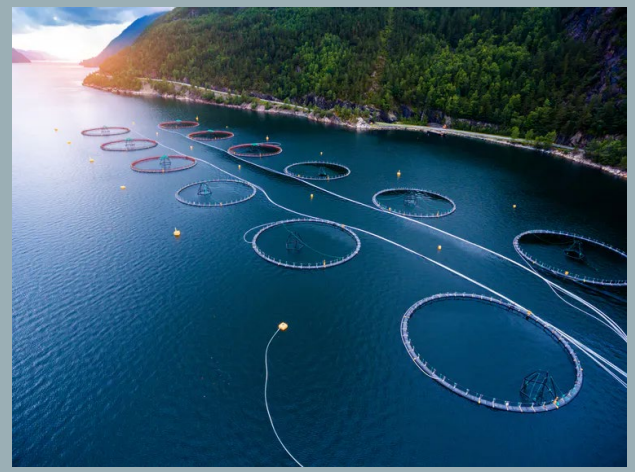
Inform decision making

Decisions change across time-scales

Decision Lead Time

0-10 days

Weeks to Months



Decades to Centuries

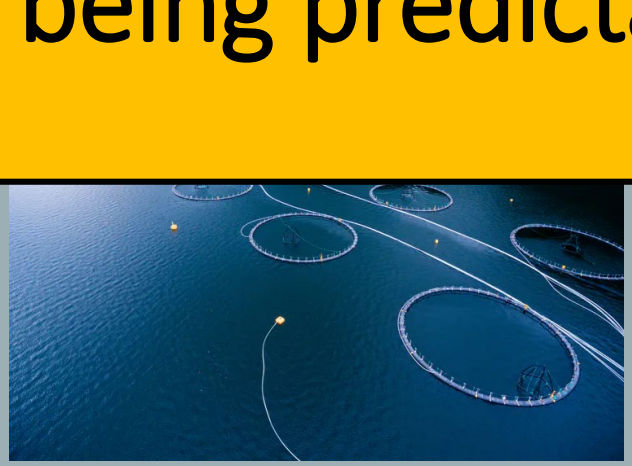
Hobday et al., 2016 FOG

Decisions change across time-scales

Decision Lead Time

0-

Forecasting ecology relies on ecology being predictable



Hobday et al., 2016 FOG

Where can ecological predictability come from?

- Advection

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- Phenology

WhaleWatch; Hazen et al., 2016

Where can ecological predictability come from?

- Advection
- Phenology
- Life-history

Anderson et al. 2014

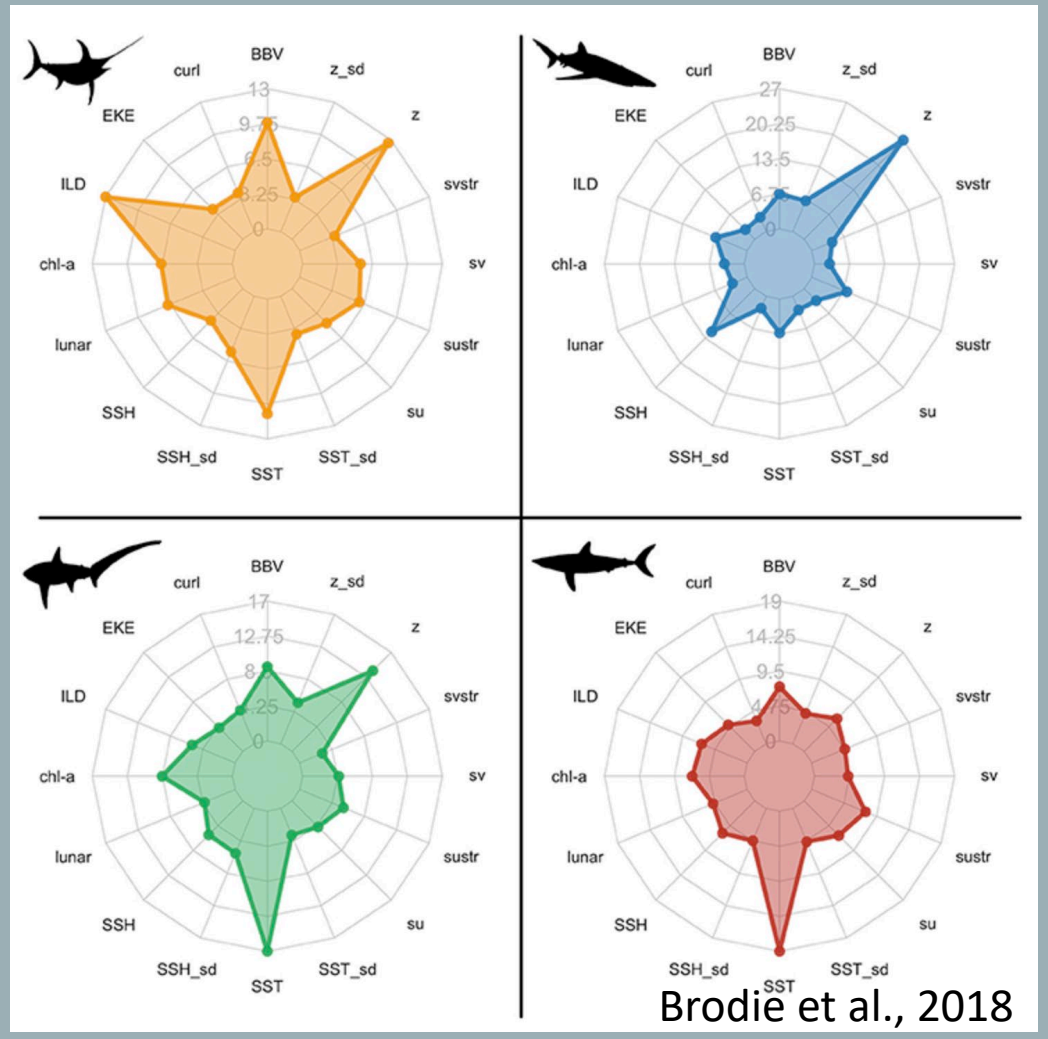
Where can ecological predictability come from?

- Advection
- Phenology
- Life-history
- Persistence

Hazen et al., 2018; Welch et al., 2018

Where can ecological predictability come from?

- Advection
- Phenology
- Life-history
- Persistence
- Response to the environment



Brodie et al., 2018

Where can ecological predictability come from?

- Advection
- Phenology
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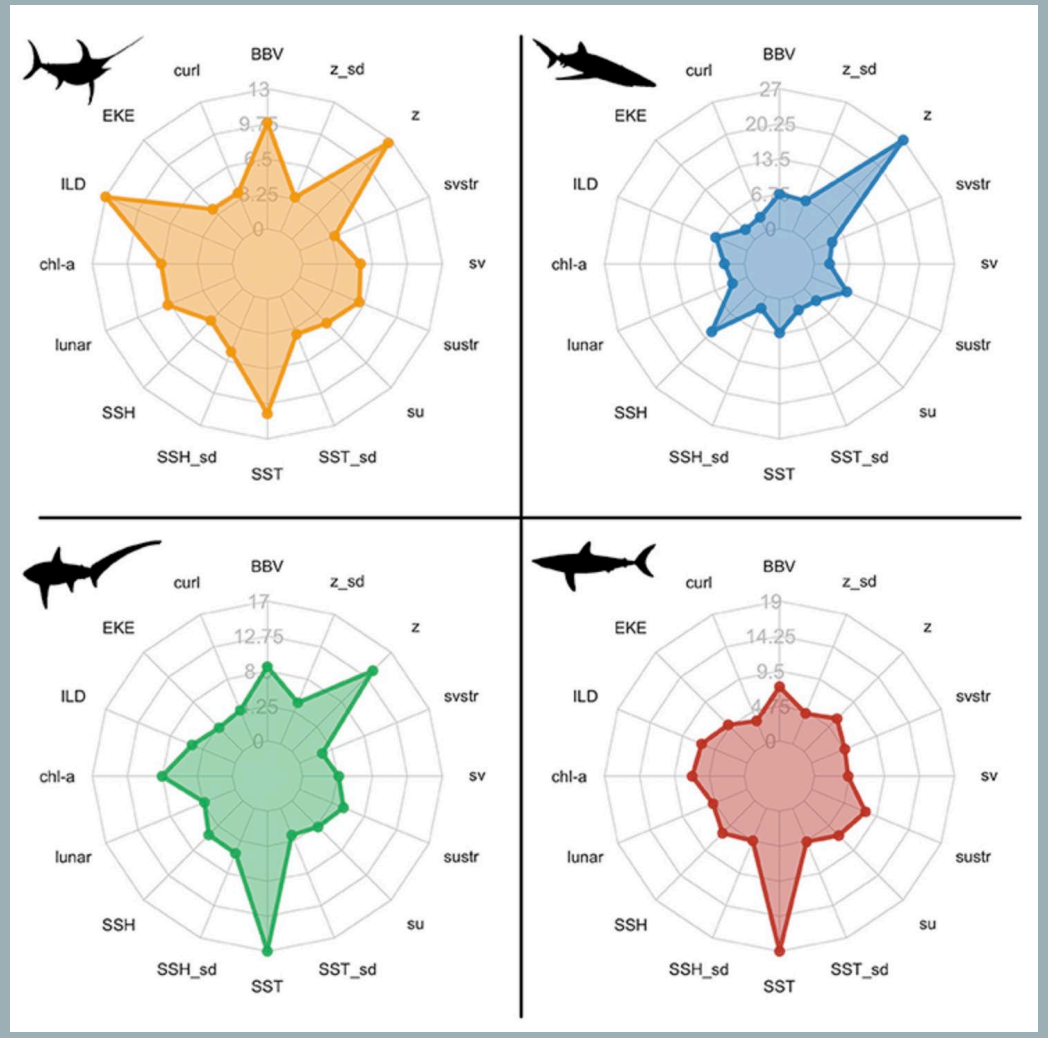
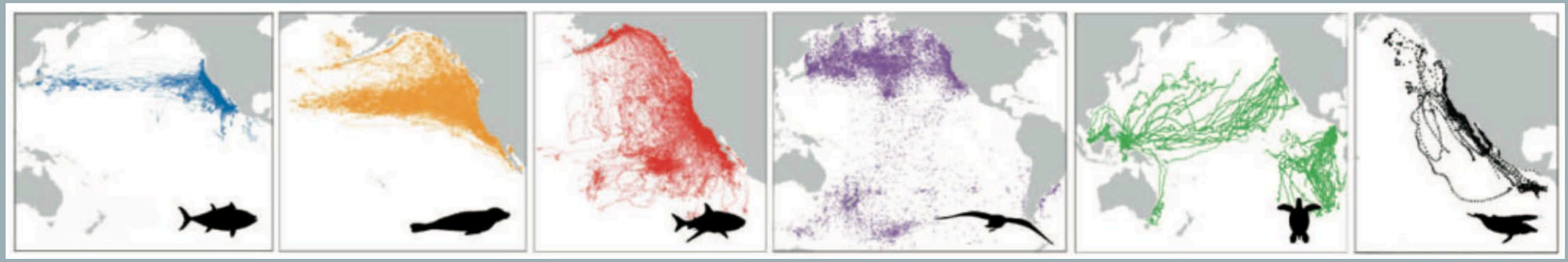
- Persistence
- Response to the environment



Brodie et al., 2018

What about highly migratory species?



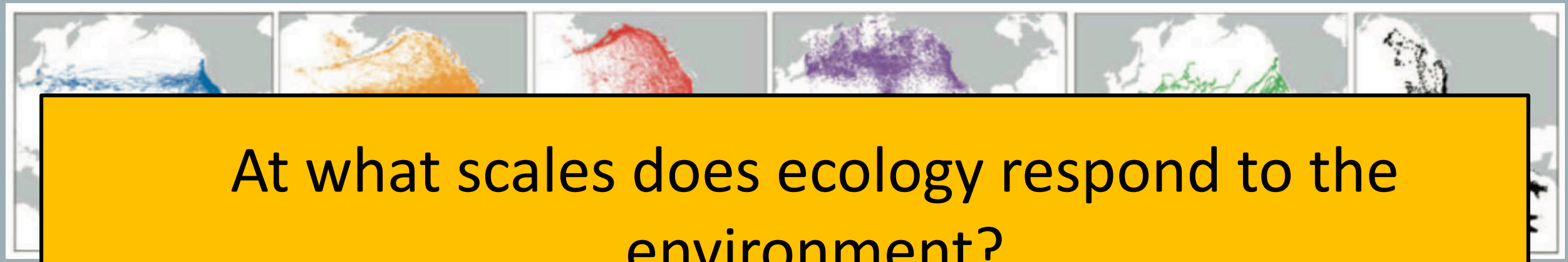
Basin-scale migrations

Memory? Age?

Regional-scale movements

Environment? Prey availability?

What about highly migratory species?

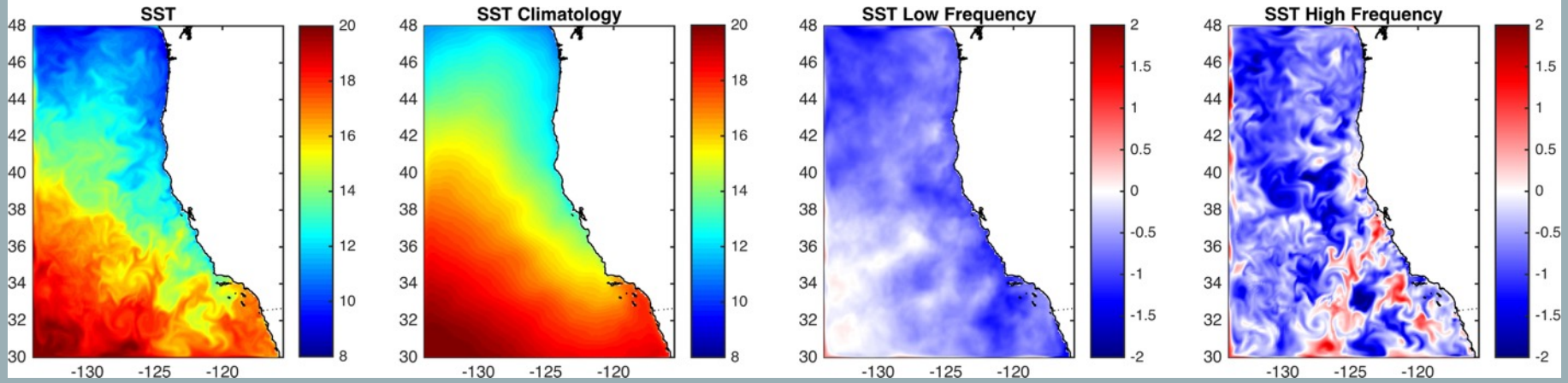


At what scales does ecology respond to the environment?

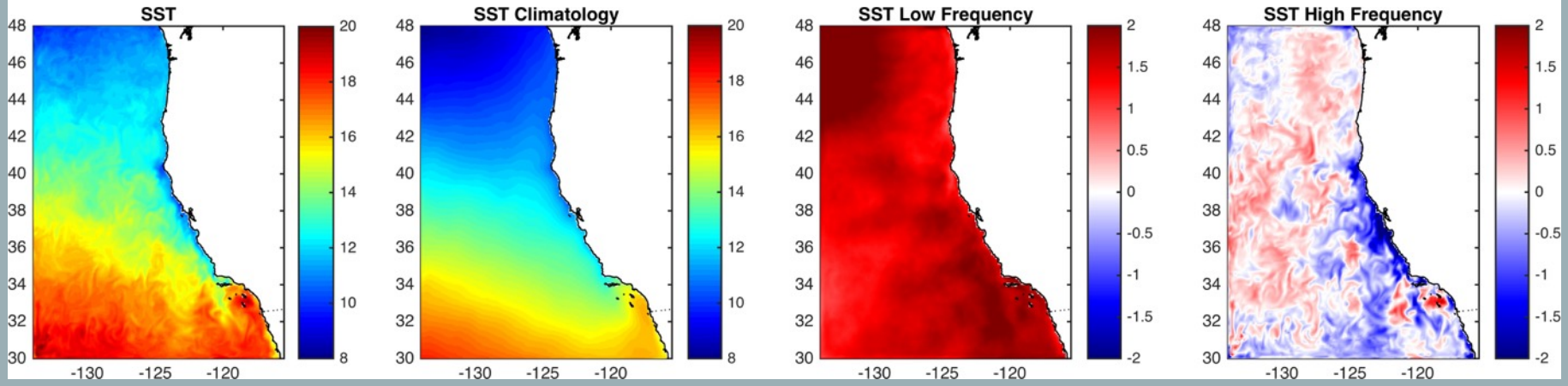
Test using temporal decomposition

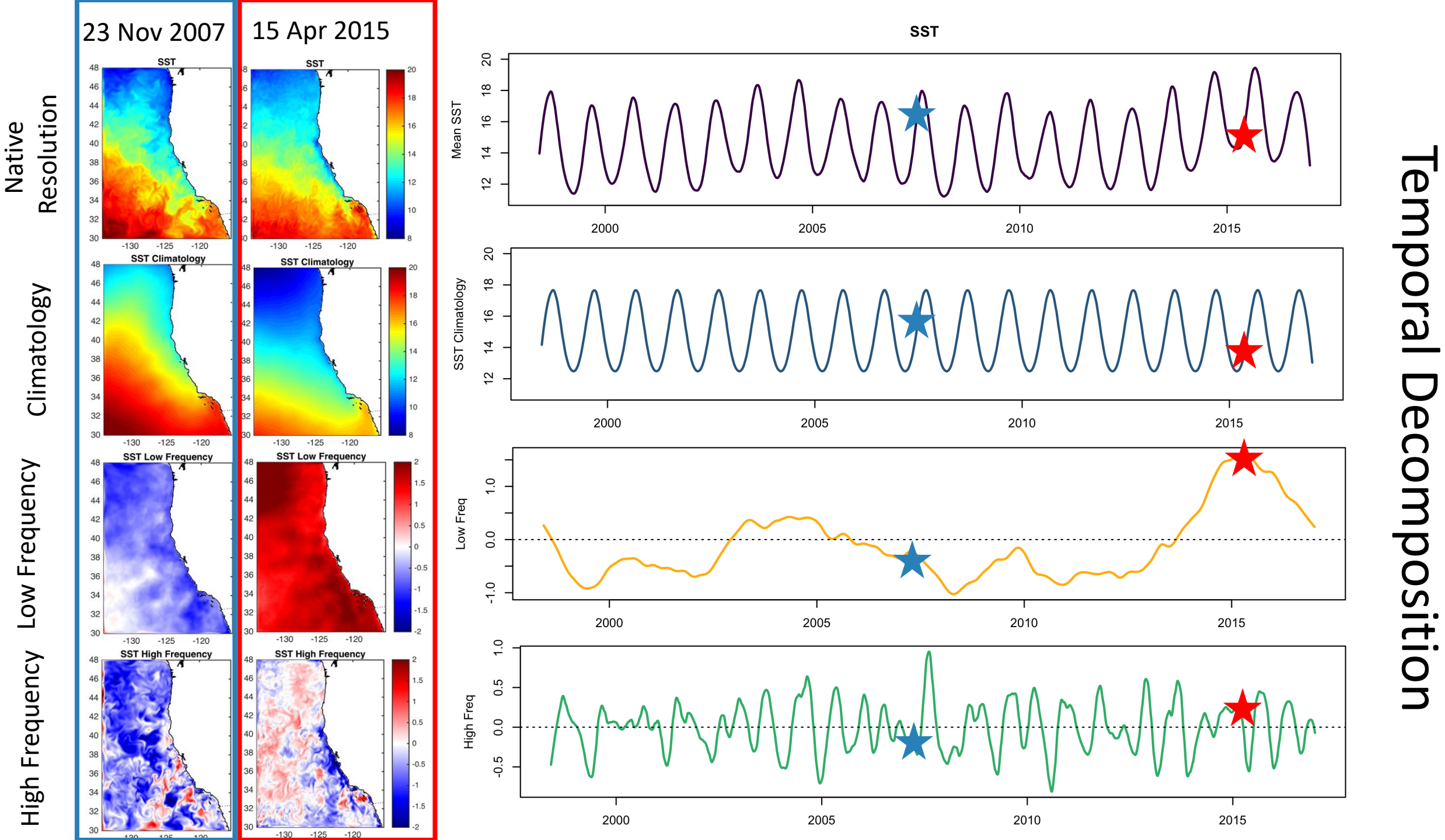
Temporal Decomposition of SST

23 November 2007

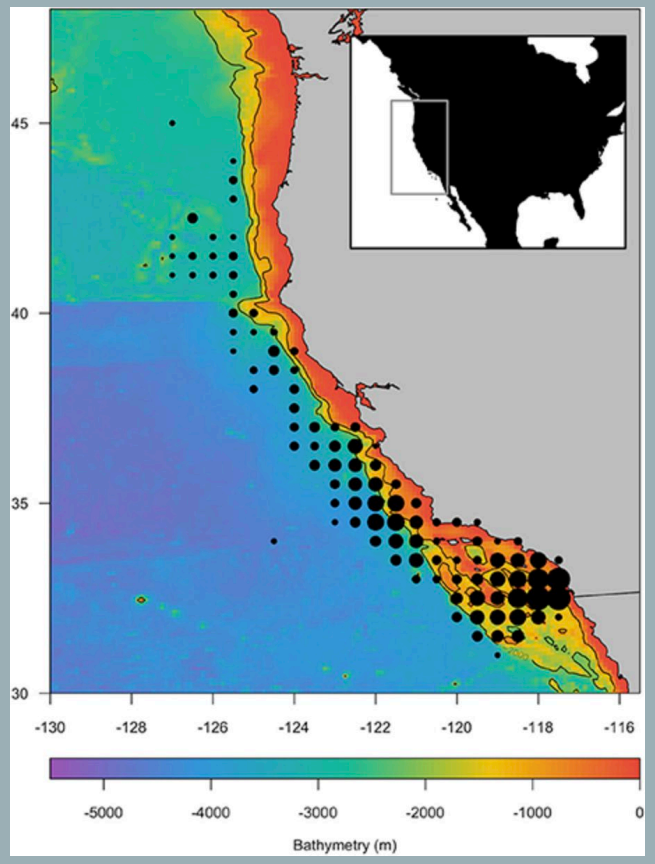


15 April 2015

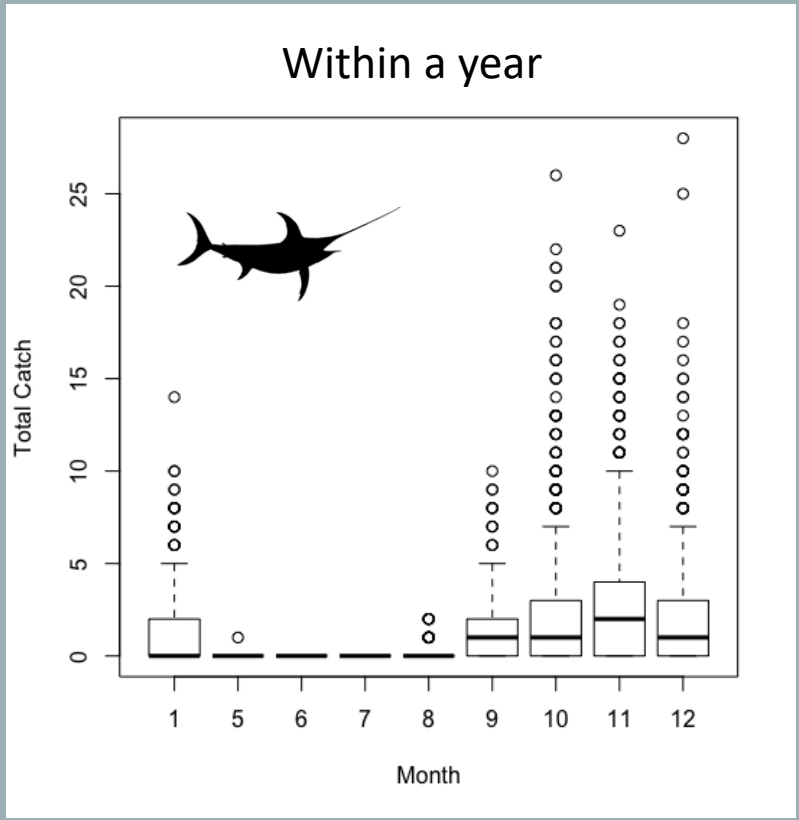


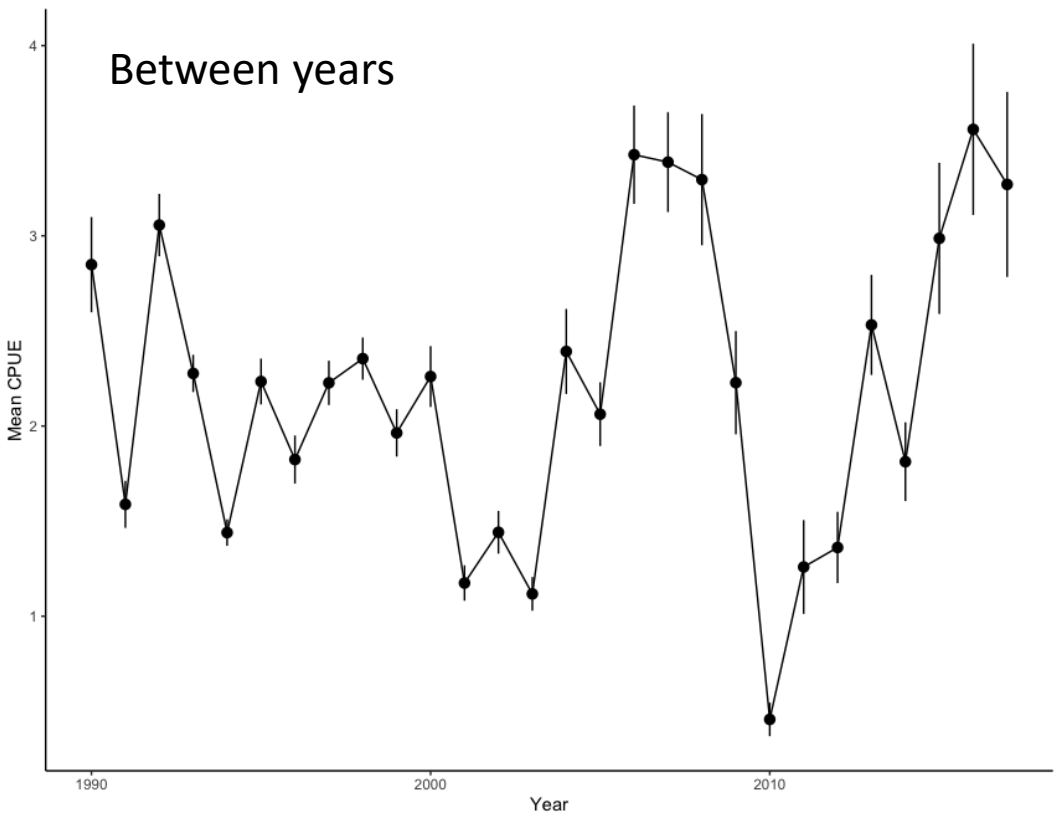

23 Nov 2007
15 Apr 2015
Native Resolution
Climatology
Low Frequency
High Frequency
SST
SST Climatology
SST Low Frequency
SST High Frequency
Mean SST
Low Freq
High Freq
2000
2005
2010
2015
Temporal Decomposition

Case Study: Swordfish in the California Current



At what temporal scales are swordfish responding to?



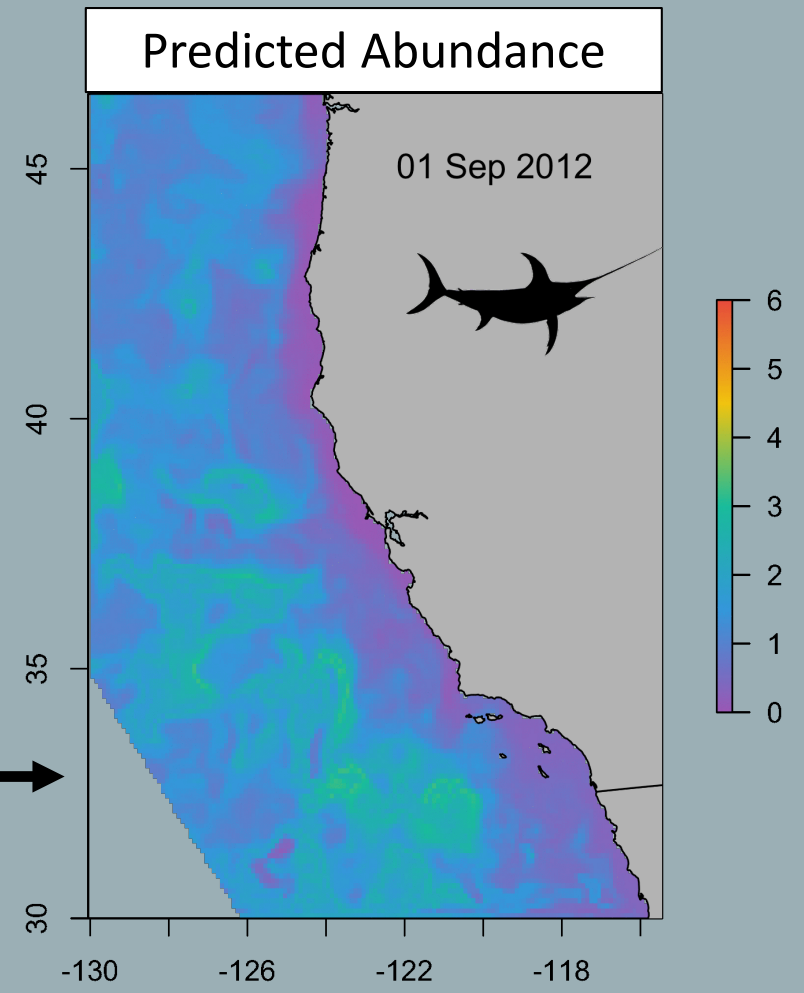


Species Distribution Model

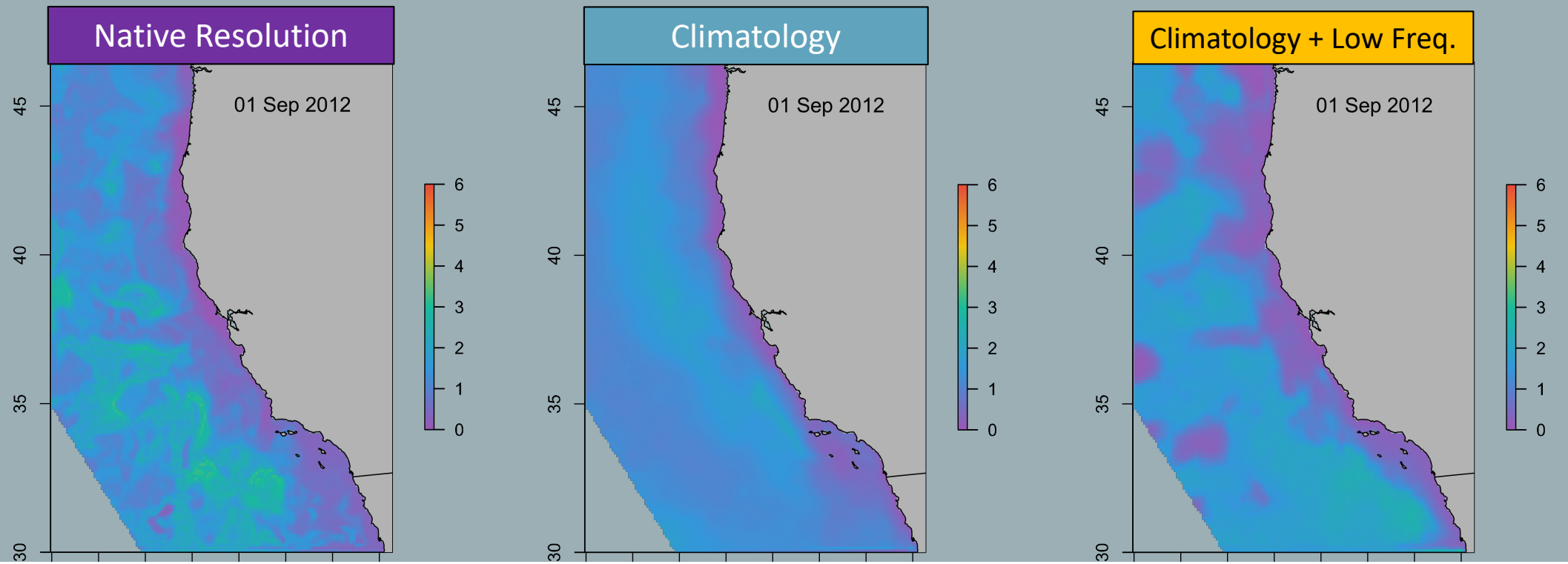
GAM Covariates

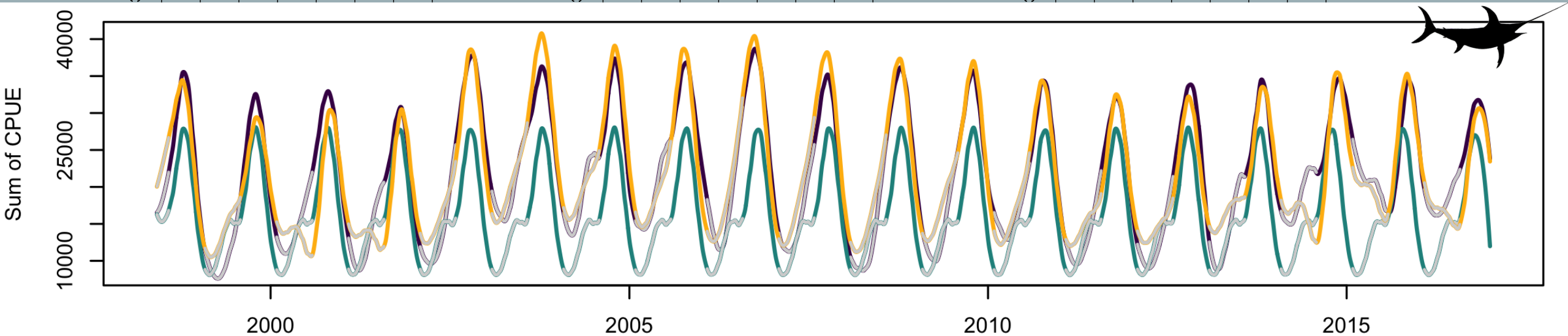
MLD
SST
Chl-a
Gear soak time
Trip number (random)
Lunar illumination

Note the fine-scale features
Forecasts can't resolve this

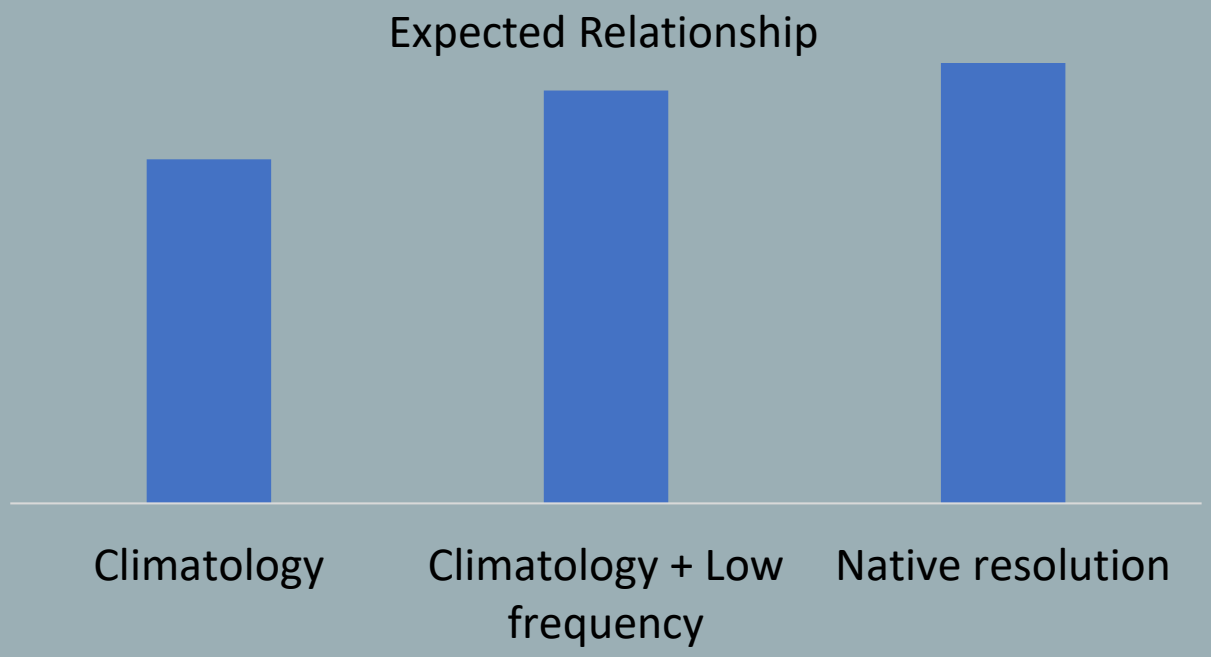


Climatology + Low frequency is the dominant signal





What about predictive performance?



- True for model fit
- BUT no consistent relationship for predictive performance
- Predictability comes from the climatology

What this means

- Swordfish distribution and abundance most strongly associated with the climatology
- Don’t expect predictability of swordfish based on climatology AND skillful forecasts of environment
- Gives us a better understanding of the sources of skill for ecological forecasting

Next Steps

- Test concepts on more species & tracking data
  - Tracking data is more sensitive to ephemeral and mesoscale features
- Retrospective seasonal forecast

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