Forecasting Changes in Habitat Use by Bowhead Whales in Response to Arctic Climate Change

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Acknowledgements

- NASA Biodiversity and Ecological Forecasting
  – BIOCLIM
- NASA Ocean Biology & Biogeochemistry, and Cryosphere programs
- ASAMM program

Western Arctic Bowhead Whales

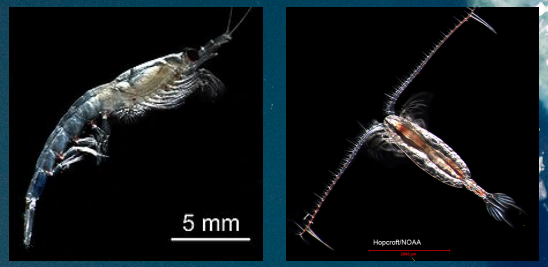


Photo: NOAA/AFSC/NMML

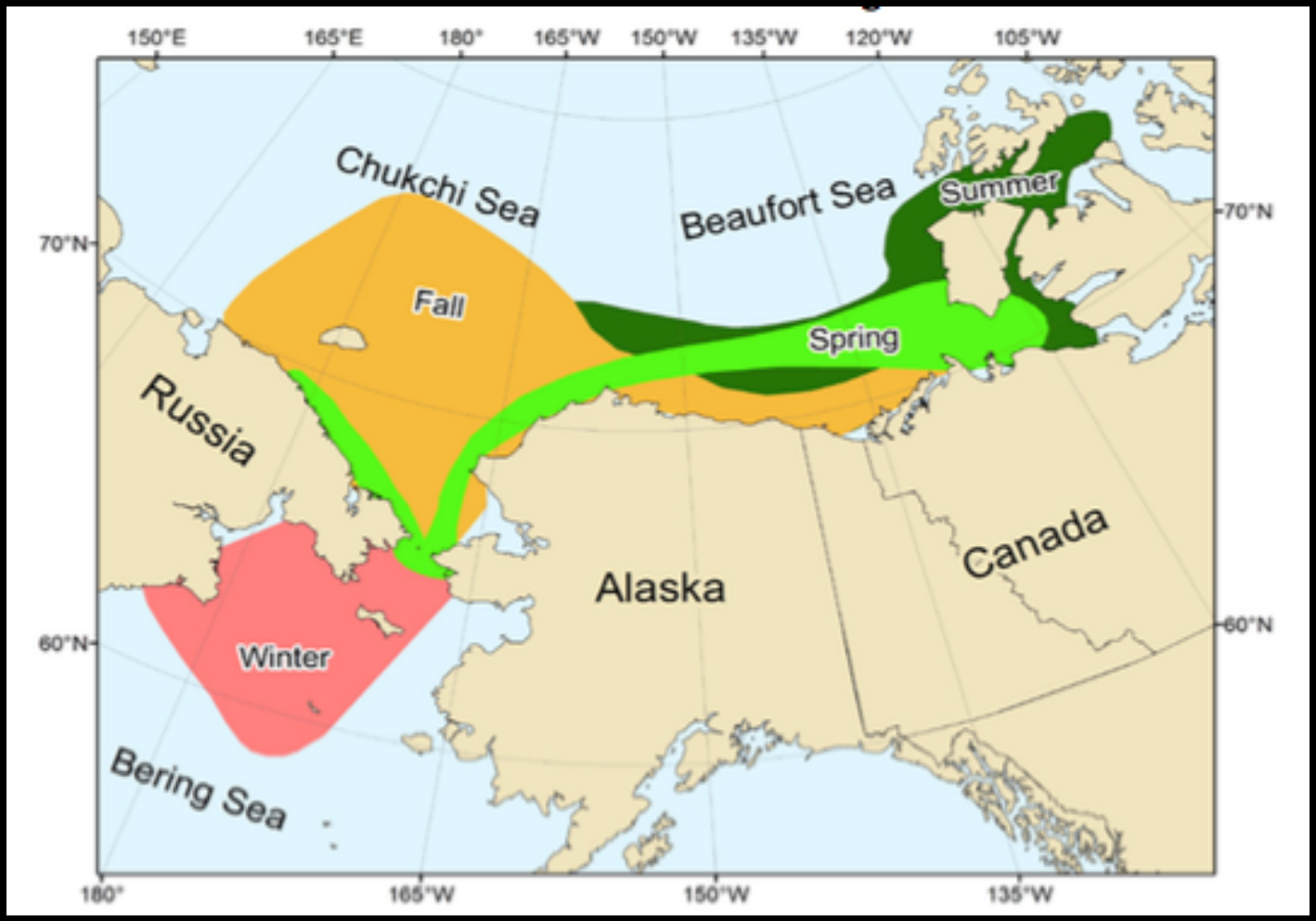
Photo: Hopcroft

Research Objectives

- Map bowhead whale potential habitat suitability throughout their summer range
  - 25 years aerial survey data
  - Satellite derived SST, ice, & bathymetry
  - Arctic ocean biophysical model
  - Species distribution models
    - Maxent and BRT
- Phase 1: Hindcasts from 1988 – 2012
- Phase 2: Forecast from 2015-2050 using forecasted ocean conditions

Photo: B. Rone, NOAA/AFSC/NMML

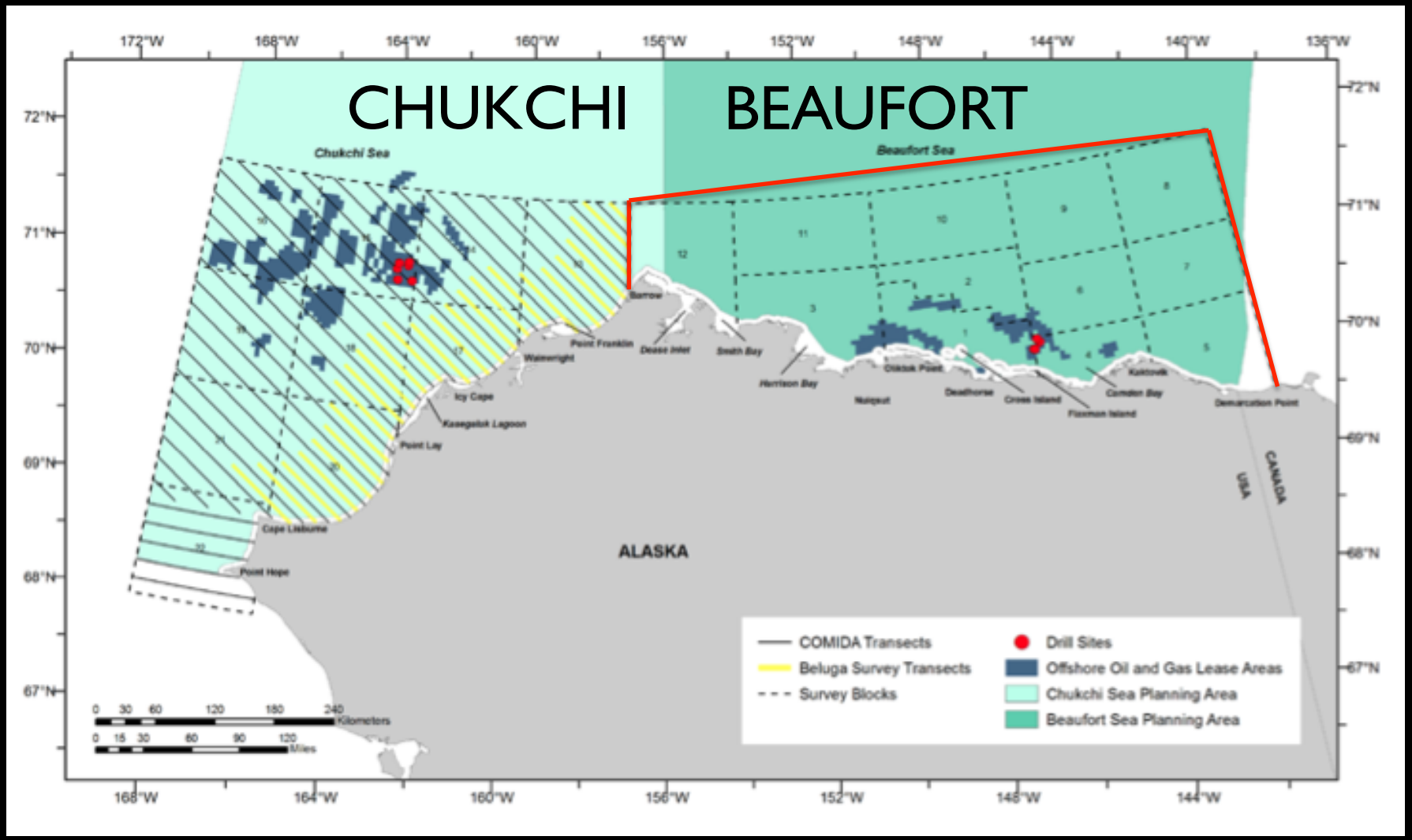
General Bowhead Distribution



Quakenbush et al. 2012

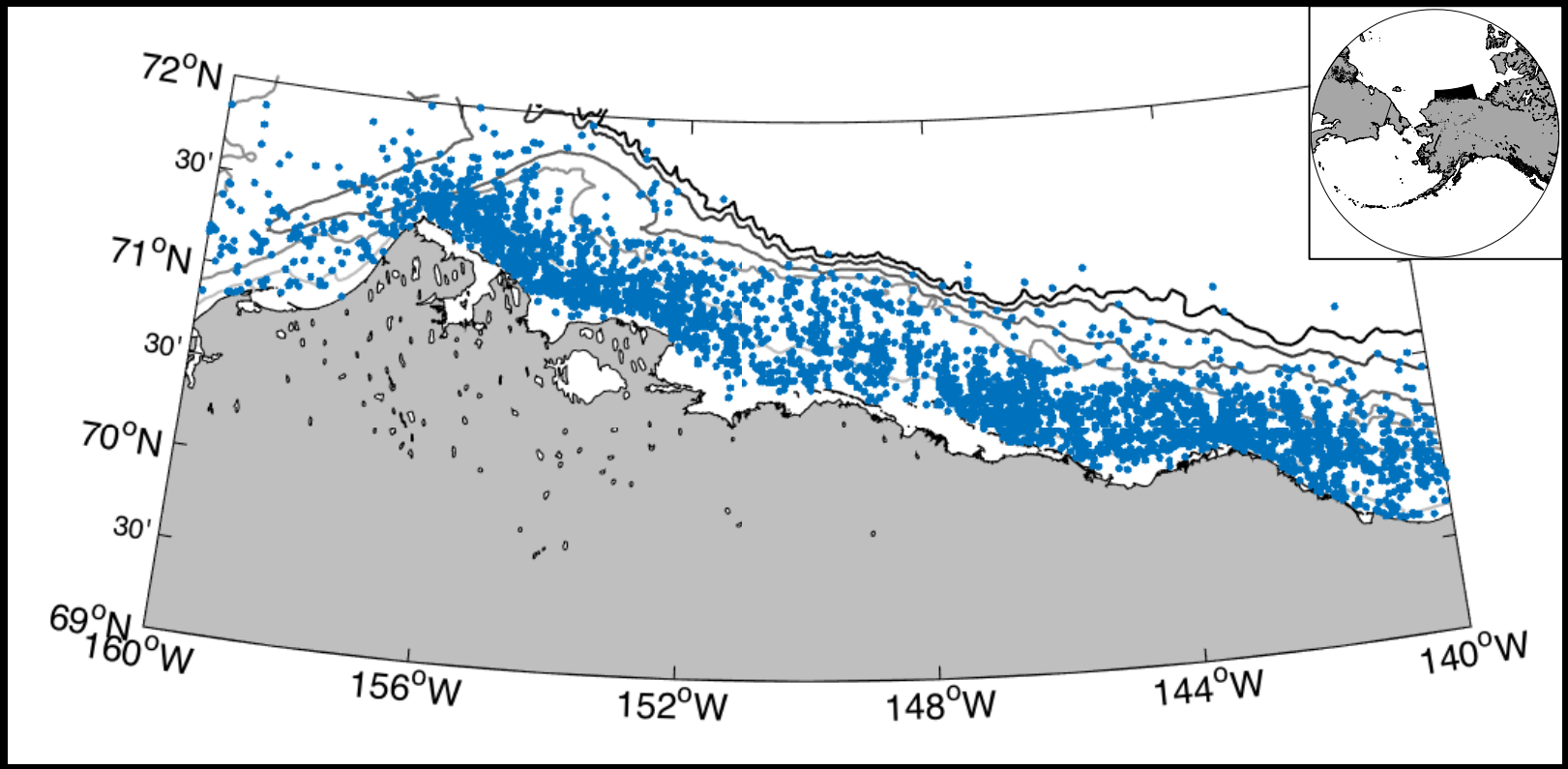
Study Area
BEAUFORT SEA
CHUKCHI SEA
RUSSIA
ALASKA, USA
CANADA
BERING SEA

Study area



Clarke, J.T. et al. (2013) OCS Study BOEM 2013-00117. NMML

Bowhead whale sightings 1988 – 2012
N = 4163

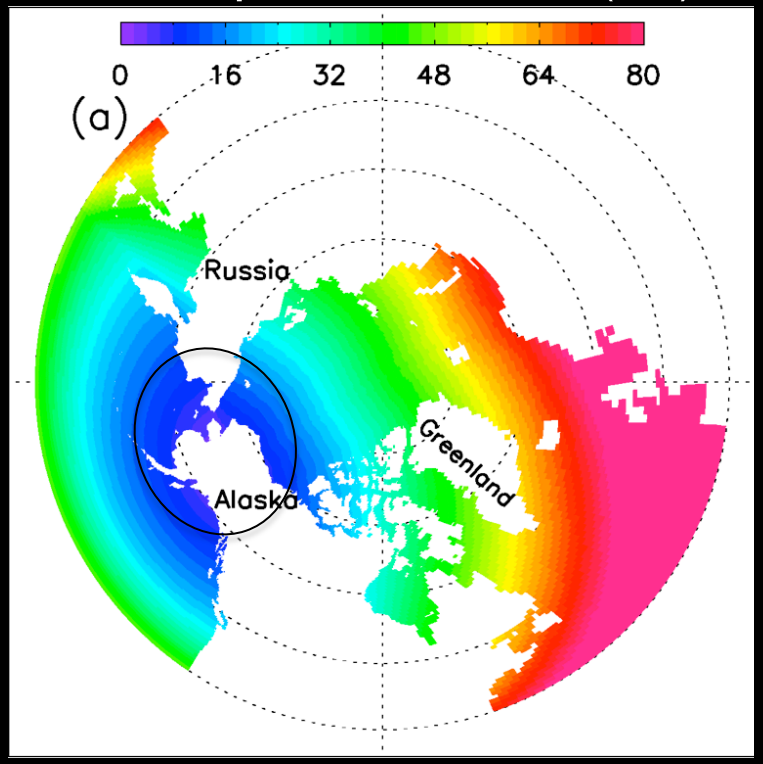


BIOMAS Arctic Ocean Model

(leveraging products from another NASA funded project)

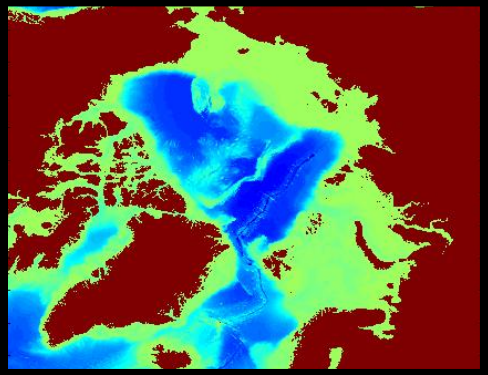
- Biology/Ice/Ocean Modeling Assimilation System
- 3D, Pan-Arctic
- Highest resolution 4-10 km
- Estimates zooplankton concentrations
- Good representation of ice, chl and temperature
- Next level – do zoop outputs match predators

Model spatial resolution (km)

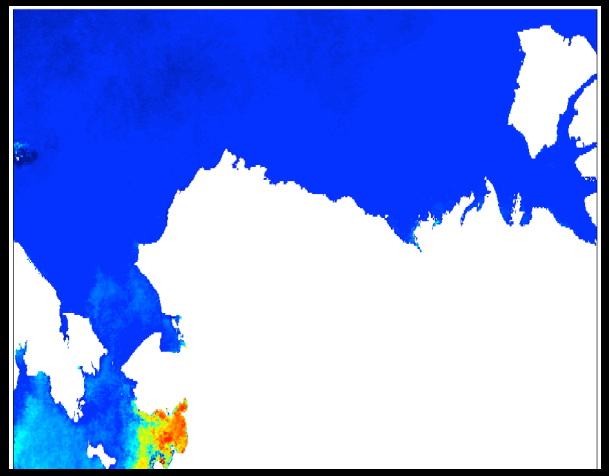


Zhang et al., 2010, JGRV 115, C10015

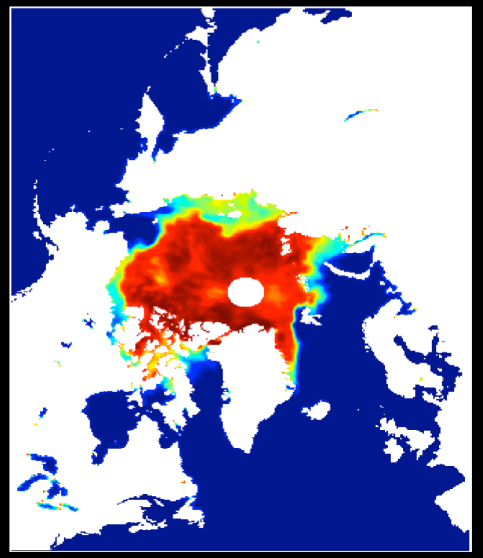
8-day averages, 100m mean



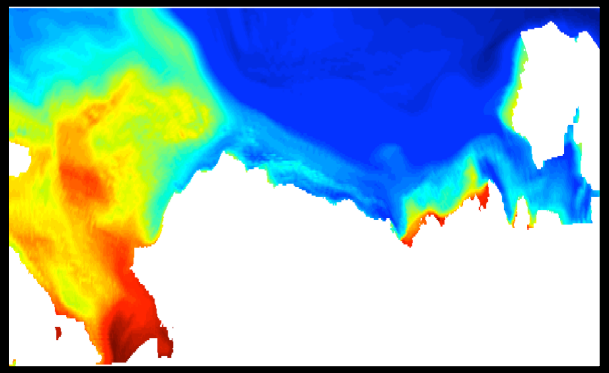
IBCAO v3 elevation/bathymetry



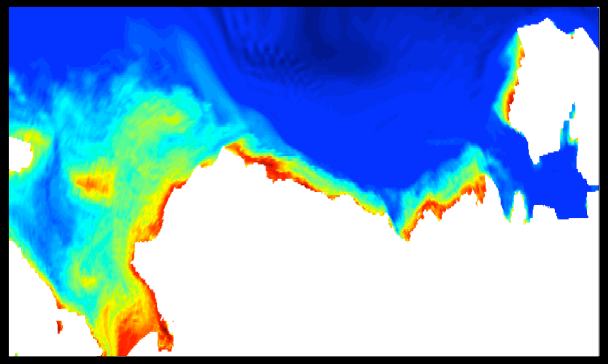
Pathfinder v5.2 SST



Sea ice concentration:
NSIDC-0051
Nimbus-7 SMMR and
DMSP SSM/I-SSMIS



BIOMAS krill



BIOMAS copepods

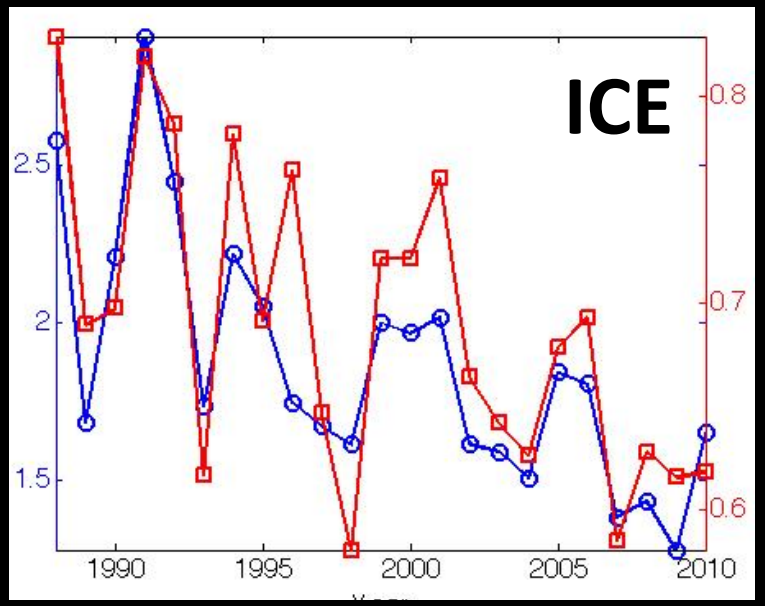
BIOMAS 100m mean

- *Micro-zooplankton*
- *Phytoplankton*
- *Sea ice*
- *Temperature*

+ 25 YEARS OF BOWHEAD WHALE SURVEY DATA

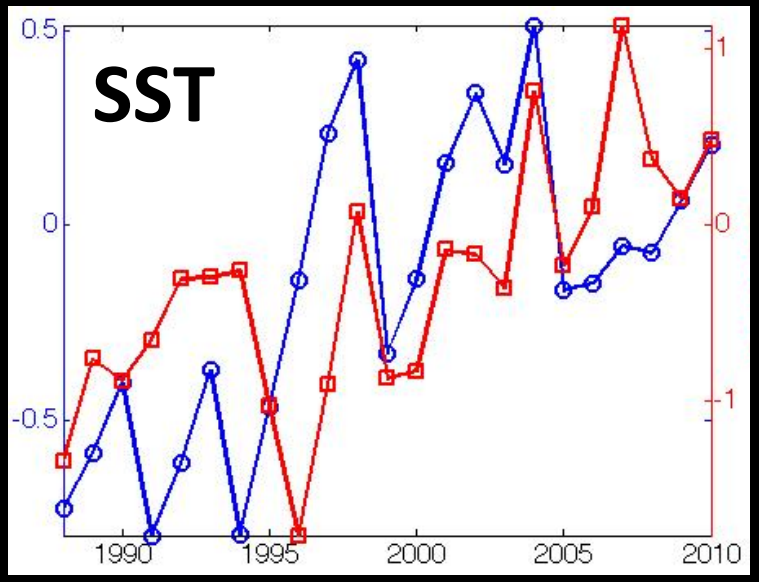
Ground truthing BIOMAS in Beaufort Sea

BIOMAS ICE



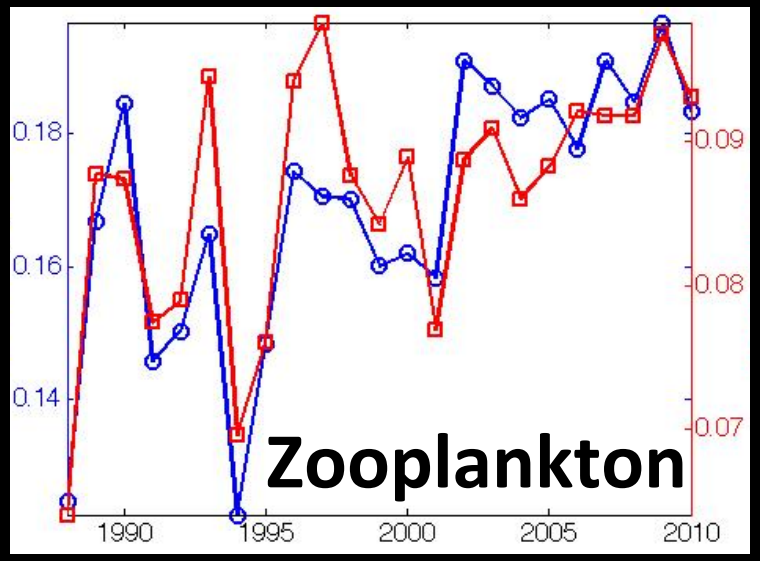
NSIDC satellite sea ice

BIOMAS 100 m

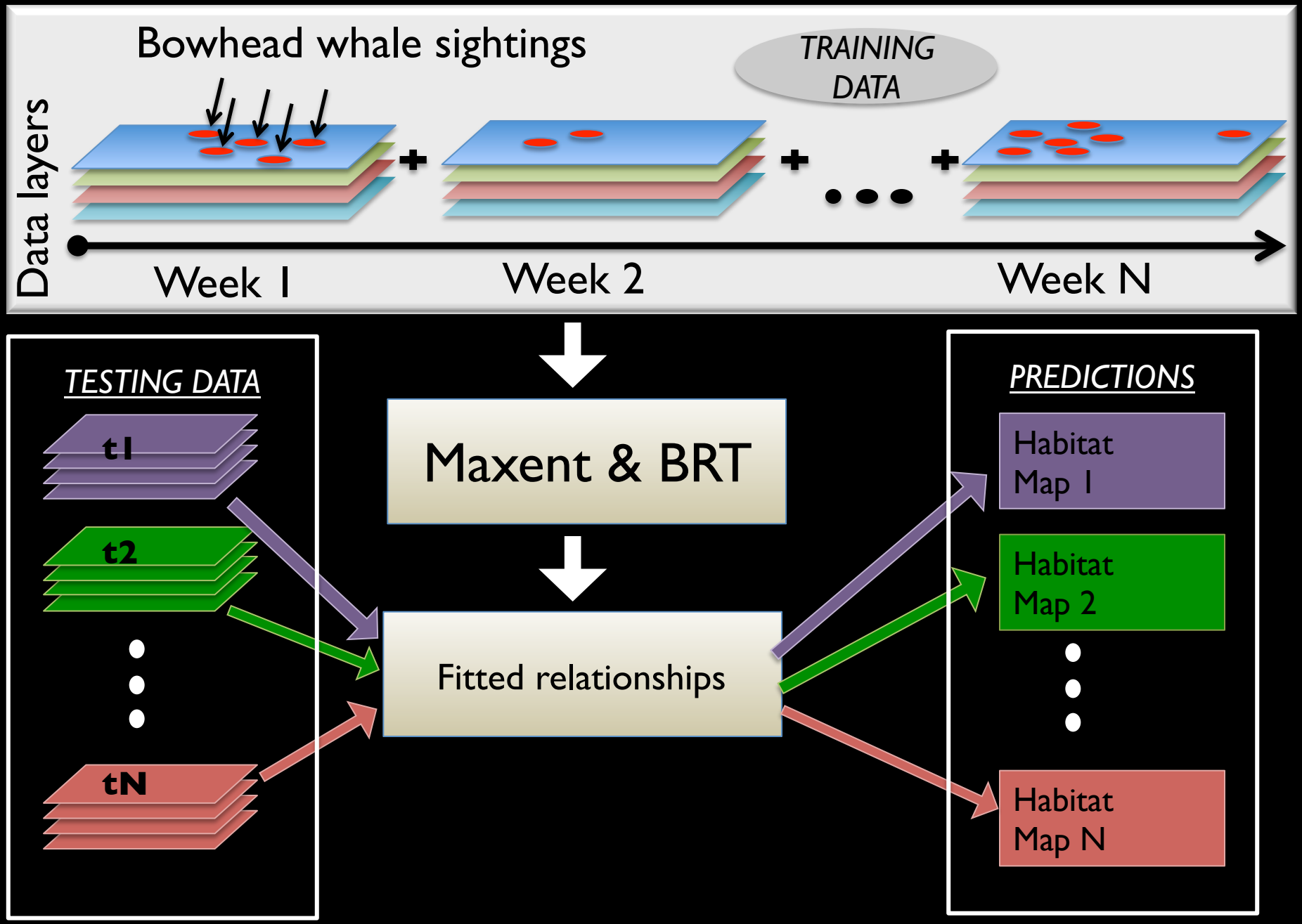


Pathfinder v5.2 SST

BIOMAS COPEPODS



BIOMAS KRILL

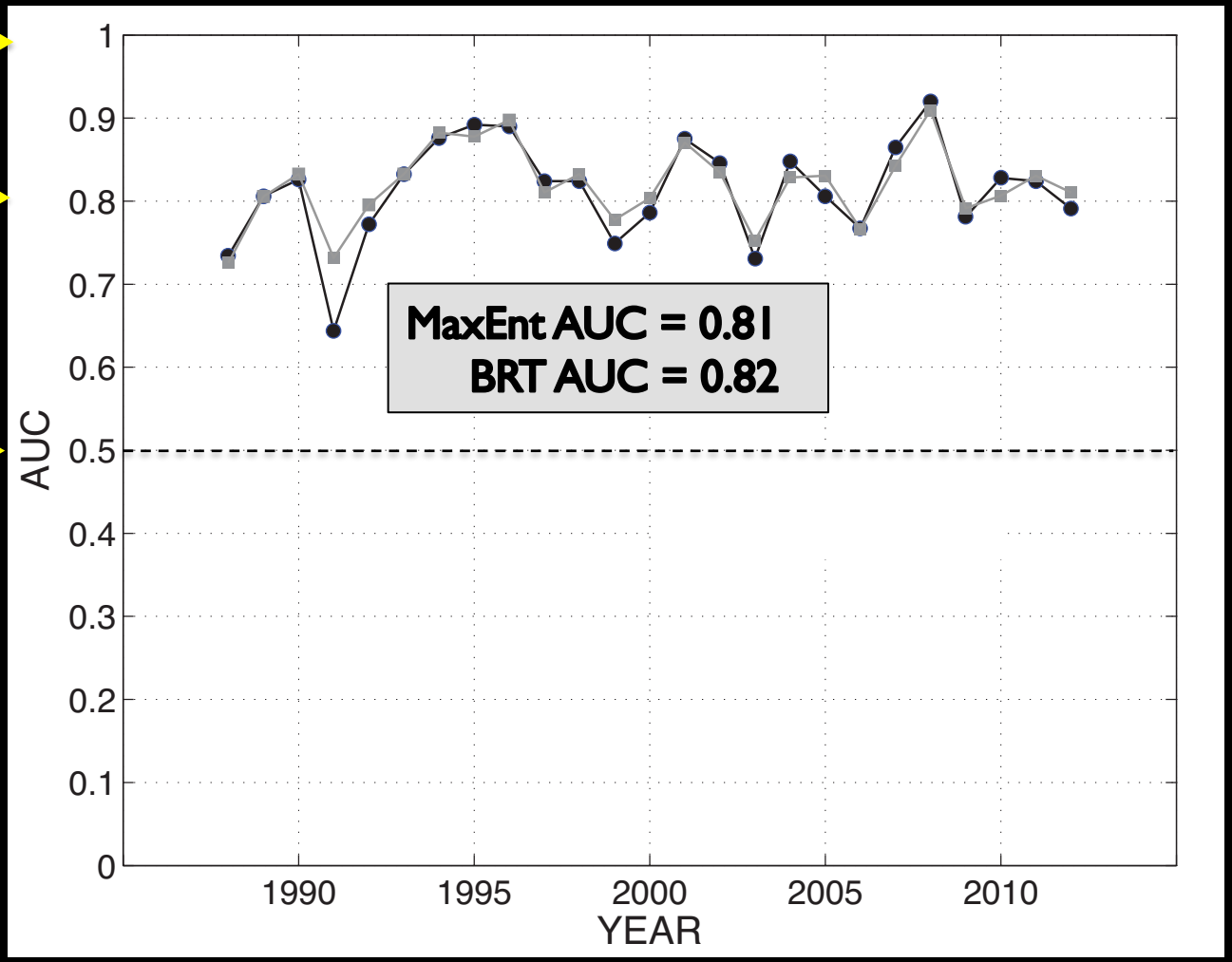

Bowhead whale sightings
TRAINING DATA
Data layers
Week 1
Week 2
Week N
TESTING DATA
t1
t2
tN
Maxent & BRT
Fitted relationships
PREDICTIONS
Habitat Map 1
Habitat Map 2
Habitat Map N

Maxent and BRT model performance

EXCELLENT

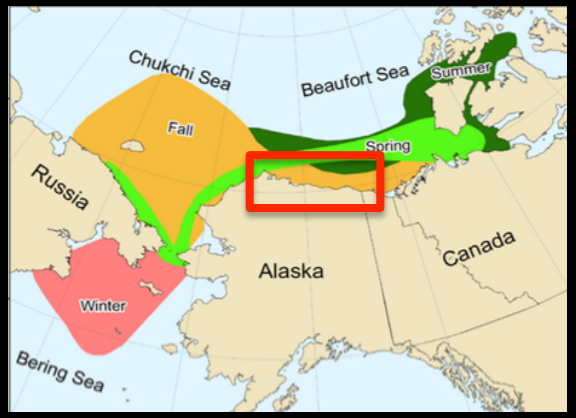
GOOD

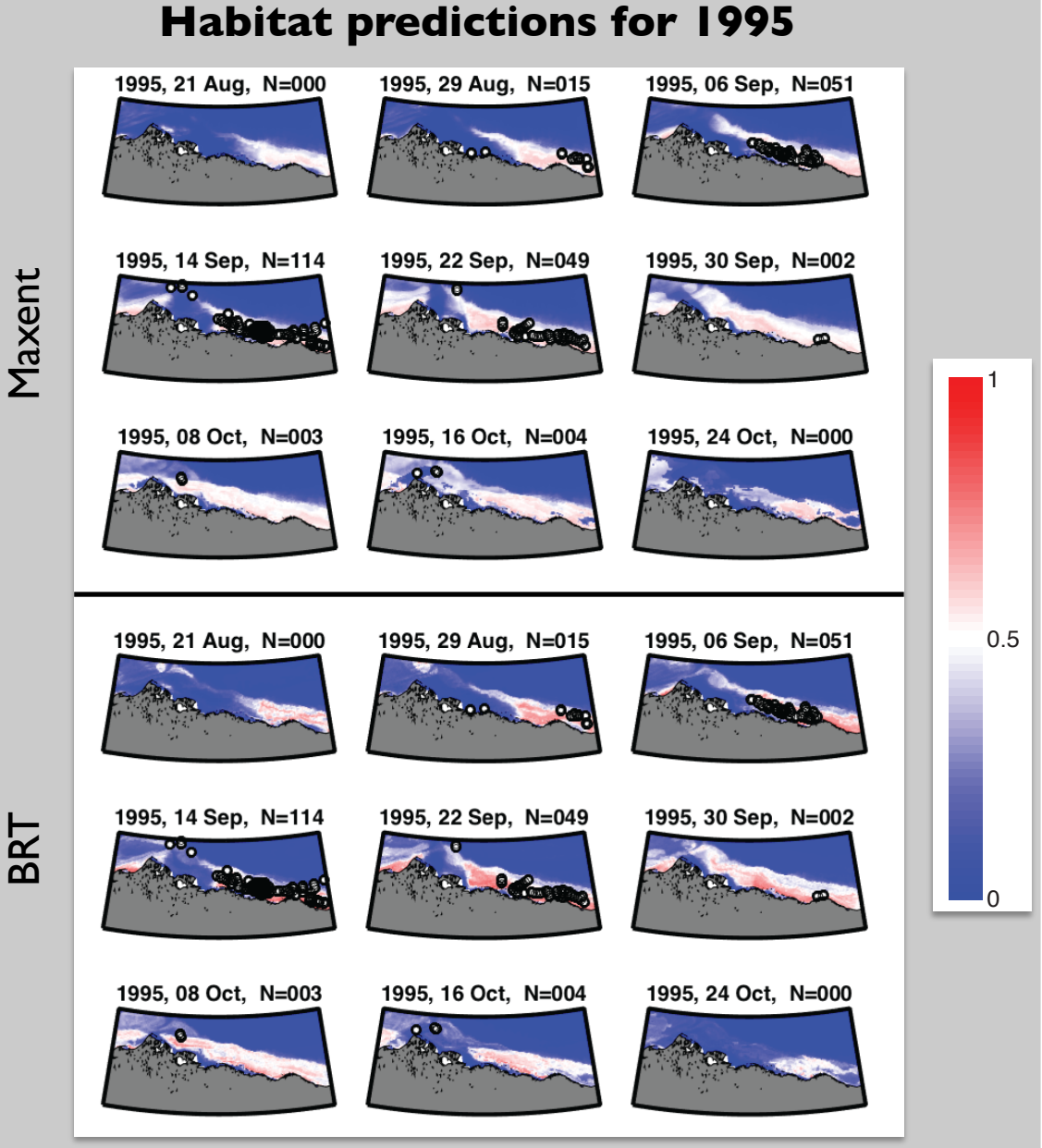
RANDOM



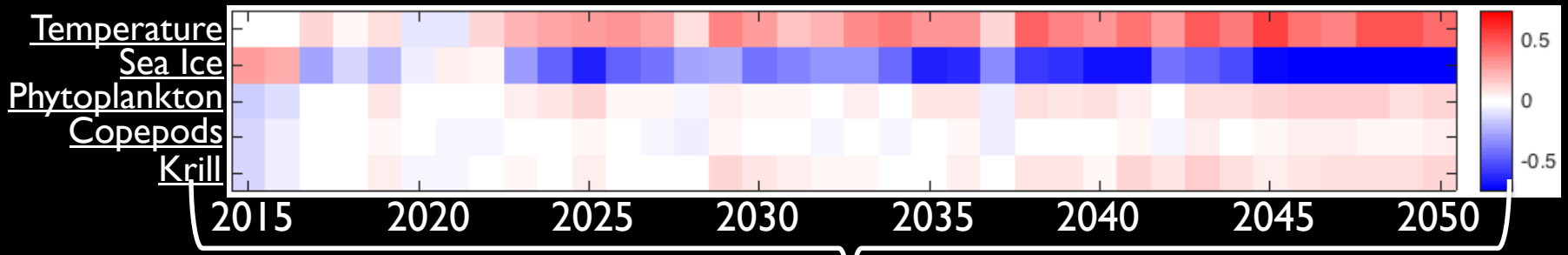
Hindcast predictions

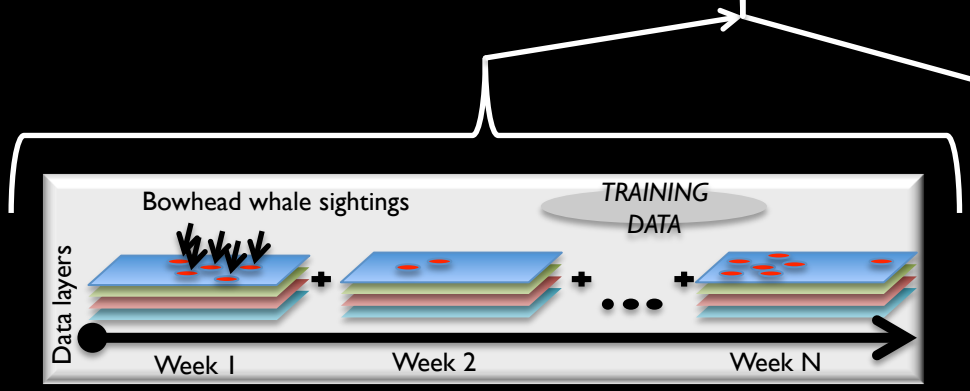
- Good matchup: red = whales
- Maxent and BRT are similar
- Coastal areas most suitable





BIOMAS Futurecast:
Anomalies relative to 1988-2012 mean





Forecasts

2015-2050 12-month Forecast

Forecast anomaly
Sept 30 – Oct 6, 2041

Forecasted Habitat Suitability Index Anomalies in the Beaufort Sea

Conclusions

Carl Buell Art