Biomass fluctuations of Eastern Bering Sea jellyfish: recent trends and environmental drivers

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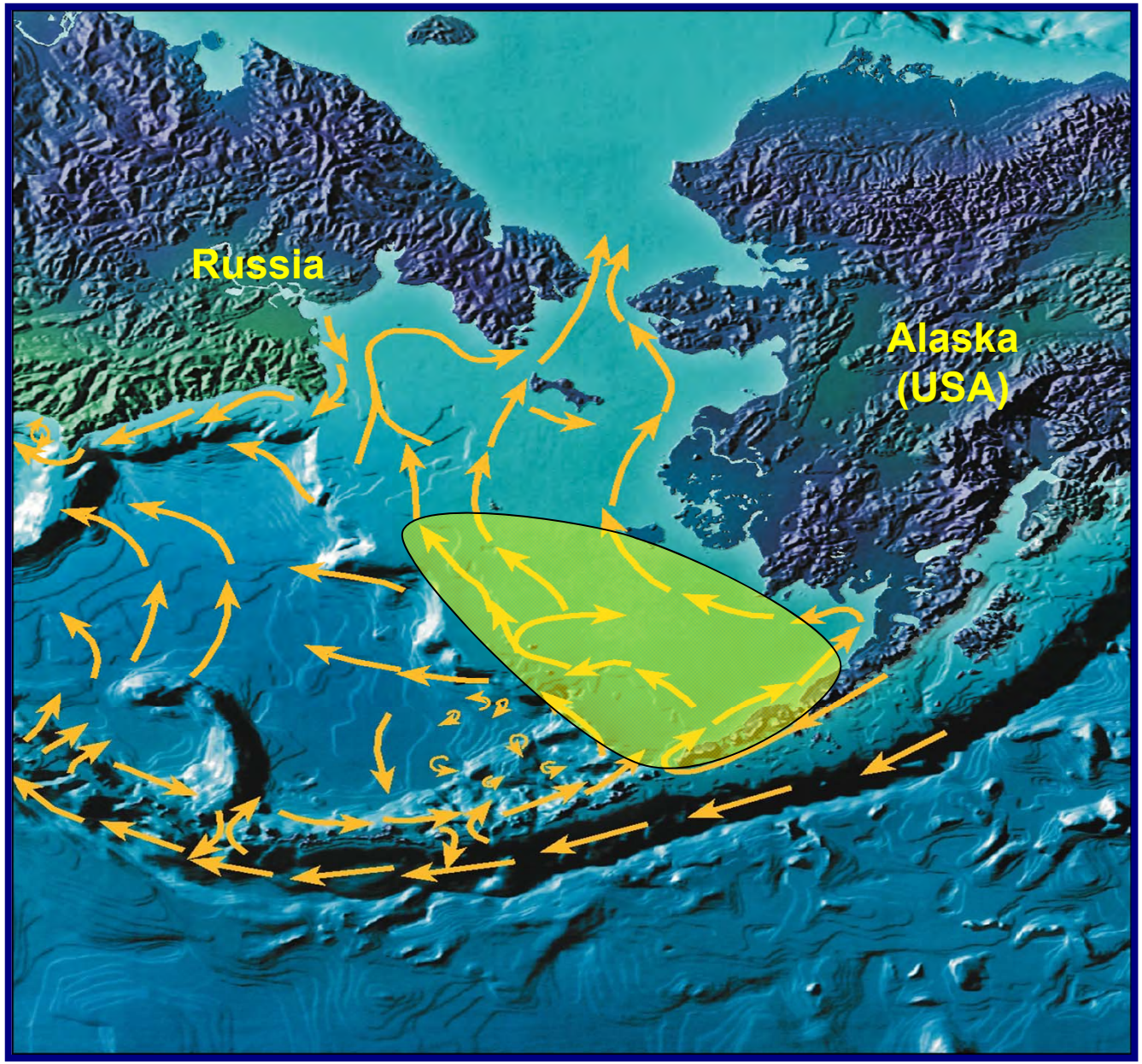
Study Area: Eastern Bering Sea Shelf

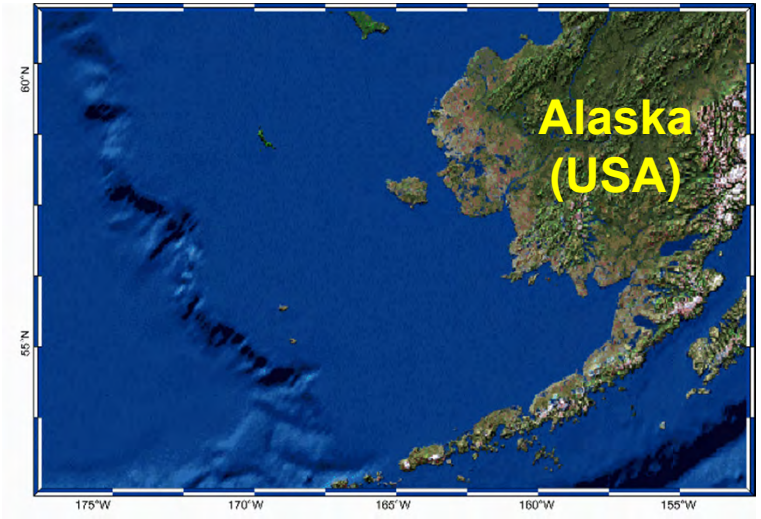


P. Stabeno (PMEL, NOAA)

A Highly Productive Ecosystem

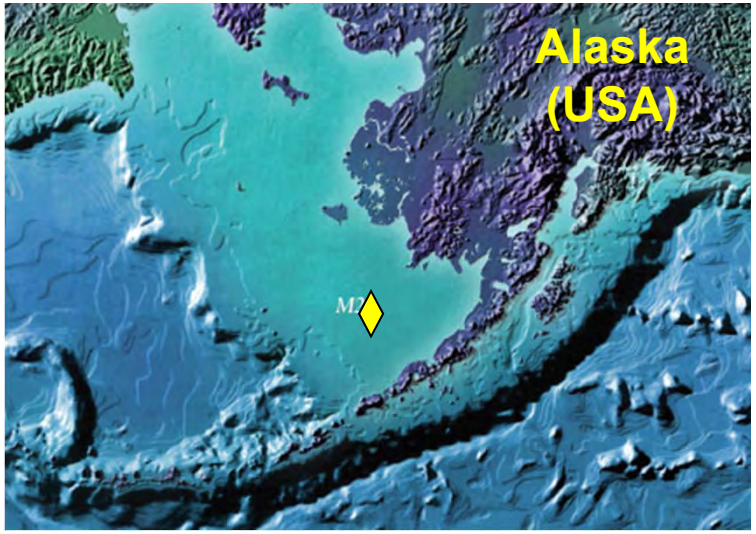
Photo: Mike Brittain

Evidence of Changes in the Eastern Bering Sea

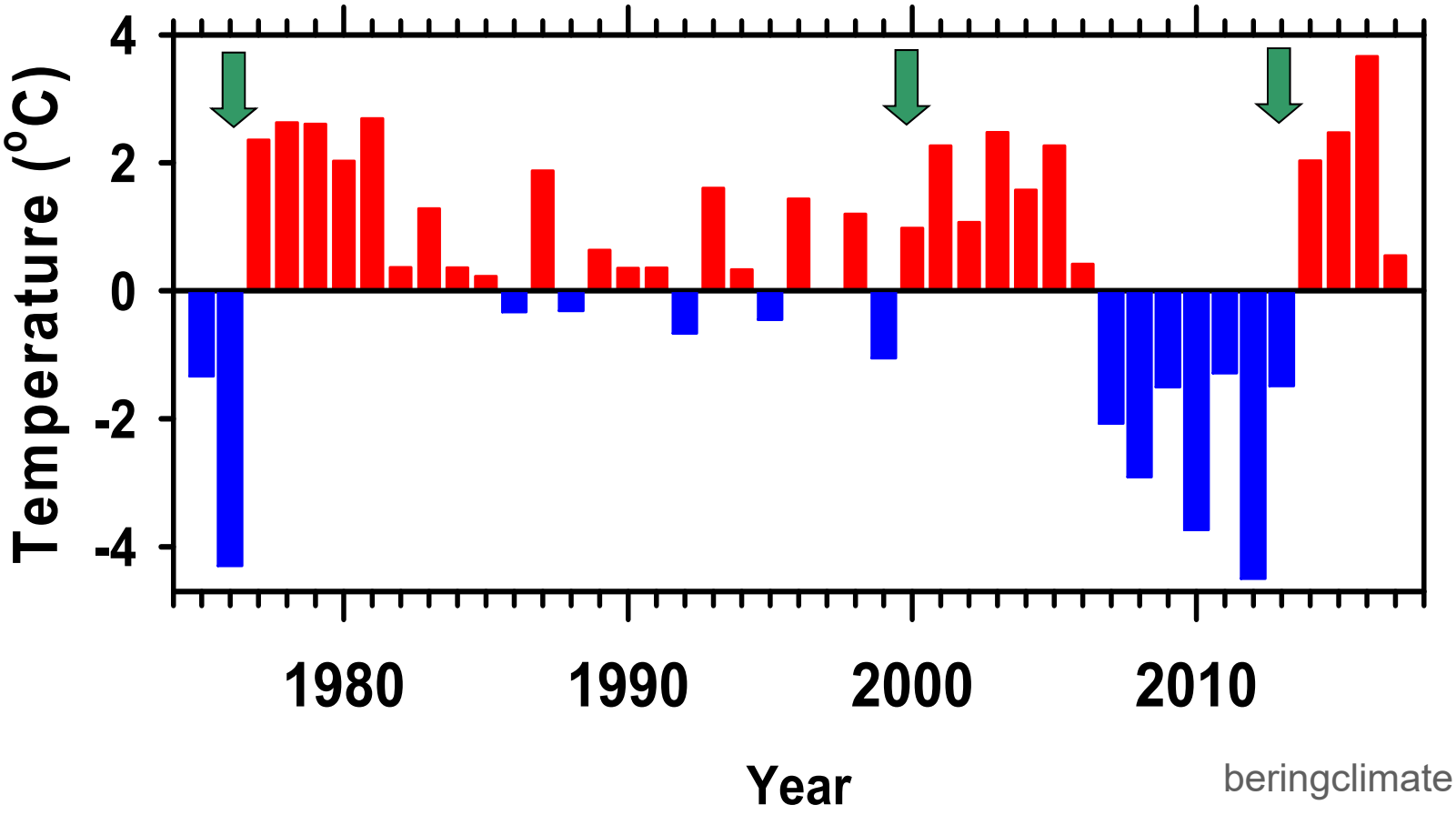


- Changing Sea Water Temperatures
- Changing Seasonal Sea Ice Cover
- Changing Timing of Spring Primary Production
- Occurrence of Unusual Phytoplankton Blooms
- Fluctuating Summer Zooplankton Biomass
- Decreasing Seabird and Pinniped Populations
- Fluctuations in Jellyfish Biomass

Sea Surface Temperatures on Middle Shelf from March - May, 1975-2017



Climatic Regime Shifts



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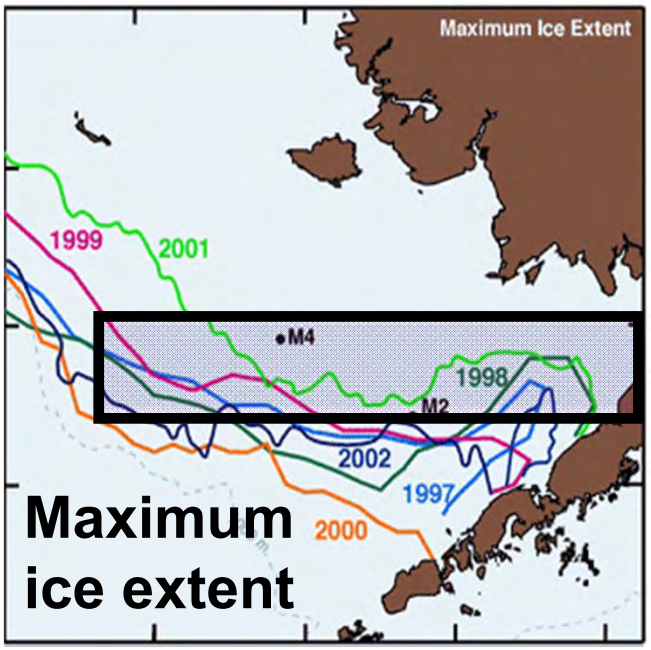
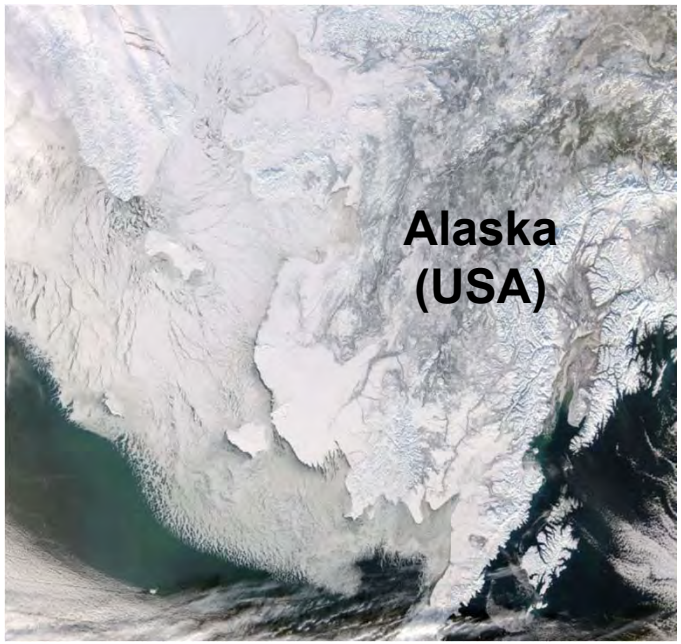
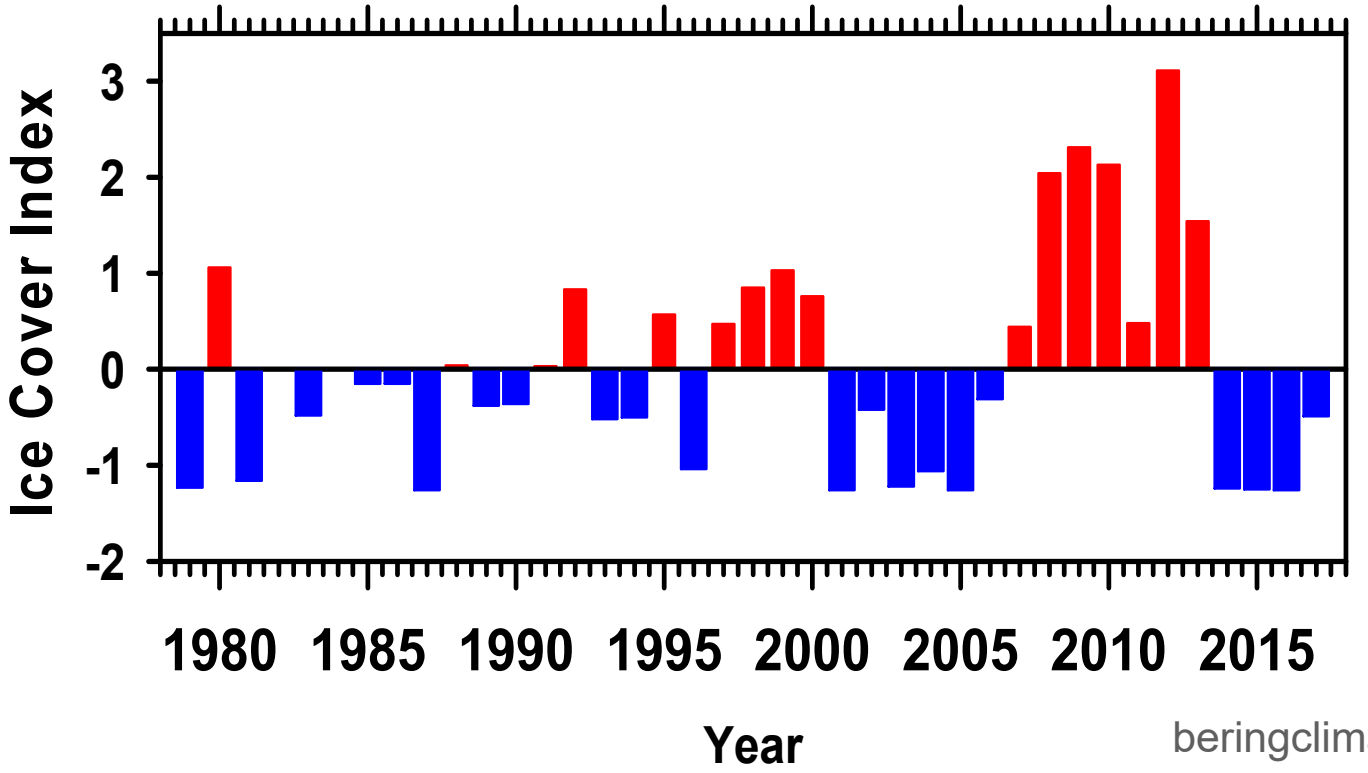


Sea Ice Cover Jan-May, 1979-2017





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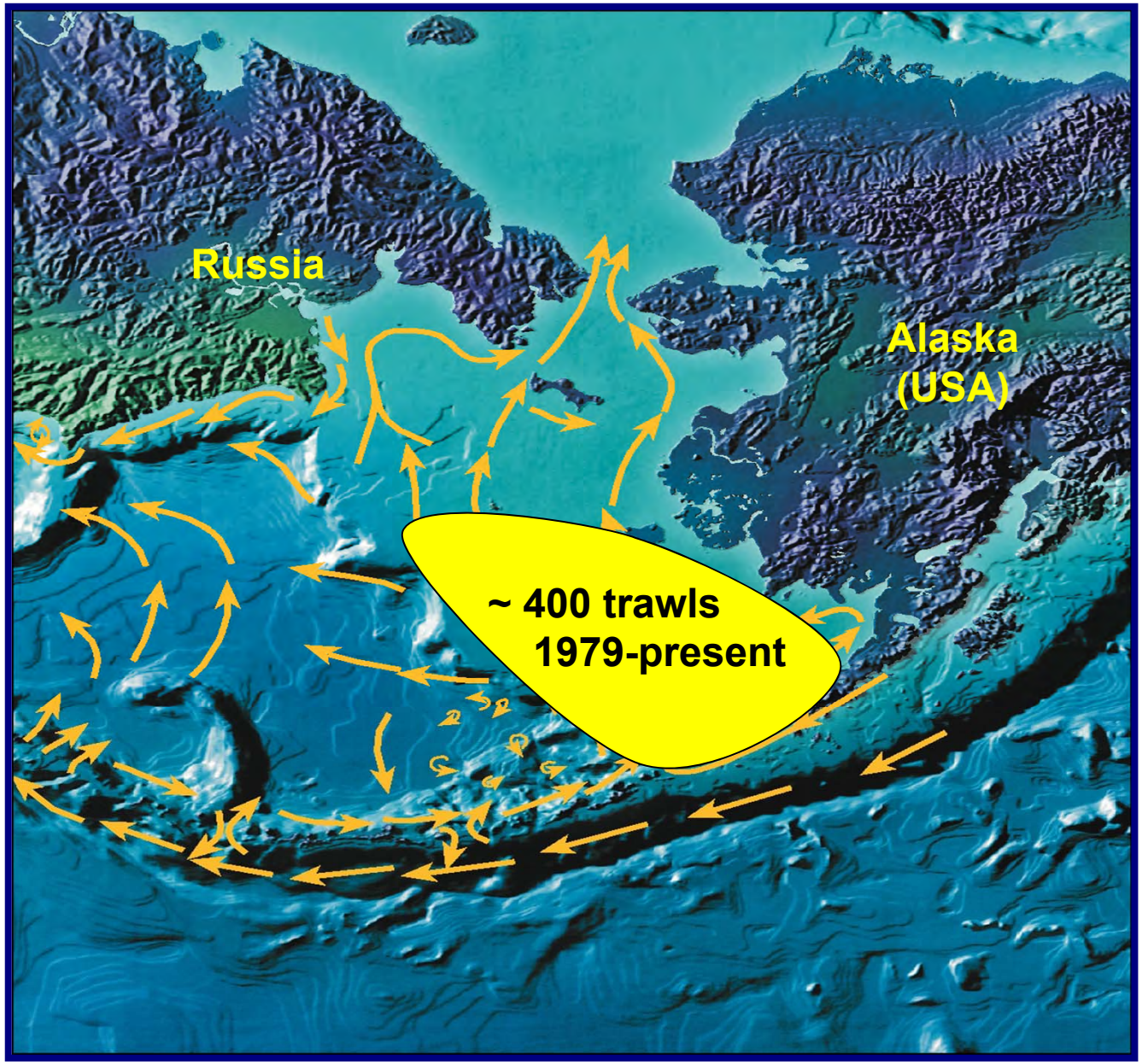
Eastern Bering Sea Shelf Groundfish Bottom Trawl Survey

NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ALASKA FISHERIES SCIENCE CENTER

Jellyfish weighed, standardized (kg hectare^{-1})

Relative annual biomass since 1982

Study Area: Eastern Bering Sea



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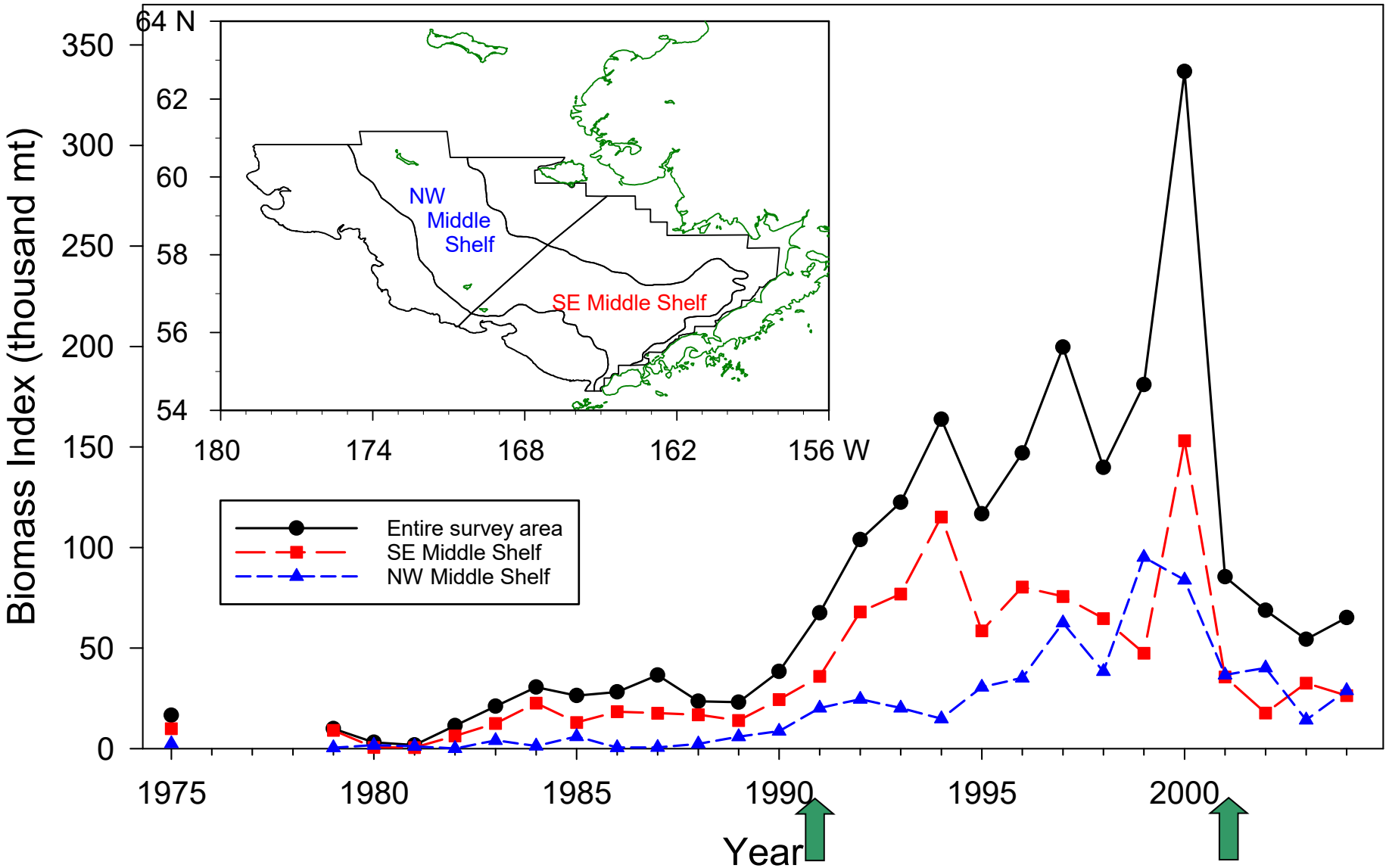
Jellyfish Biomass in the Eastern Bering Sea, 1975-2004



Climatic Regime Shifts

Brodeur *et al.* (2008) PiO

Previous Analyses

Methods:

- Examined interannual trends in jellyfish biomass, 1982-2004, separately for 2 regions
- Examined abiotic and biotic correlates of jellyfish biomass
- Constructed GAM models for best fitting variables

Brodeur *et al.* (2008) PiO

Generalized Additive Modeling (GAM)

1) GAMs: non-linear regressions; nonparametric smooth functions are determined from the data

2) Constructed separate models for SE and NW using *log (CPUE)* as dependent variable

3) Forward stepwise selection strategy, limiting degrees of freedom to 4

4) Minimize Generalized Cross Validation (GCV)

5) Variables could be dropped if addition of subsequent variables decreased significance

Brodeur *et al.* (2008)

Dependent	**sebiom, nwbiom**	Jellyfish biomass, CPUE (catch per unit effort)

Variable names

	sesprtemp	March-May SST in southeast region
	nwsprtemp	March-May SST in northwest region
	sesumtemp	June-August SST in southeast region
	nwsumtemp	June-August SST in northwest region
	wstressna	Wind stress, November-April
	wstressmj	Wind stress, May-June
Physical	**wmixmay**	Wind mixing index, May
	wmixjj	Wind mixing index, June-July
	current	Distance OSCURS model drifters traveled
	icecover	Sea ice cover index
	iceretreat	Days with ice cover after March 15
	mszoop	Middle Shelf zooplankton biomass
	oszoop	Outer Shelf zooplankton biomass
Biological	**pollock**	Juvenile walleye pollock CPUE
	forage	Herring, eulachon and capelin CPUE

Brodeur *et al.* (2008) PiO

Generalized Additive Modeling (GAM)
1982-2004

Best SE Model

$$log\ (CPUE) = \beta_o + s(sebiomlag) + s(sesprtemp) + s(wmixmay) + s(sepollock) + s(icecover)$$

$R^2\ (\%) = 89.6$ $GCV = 0.356$

Biological

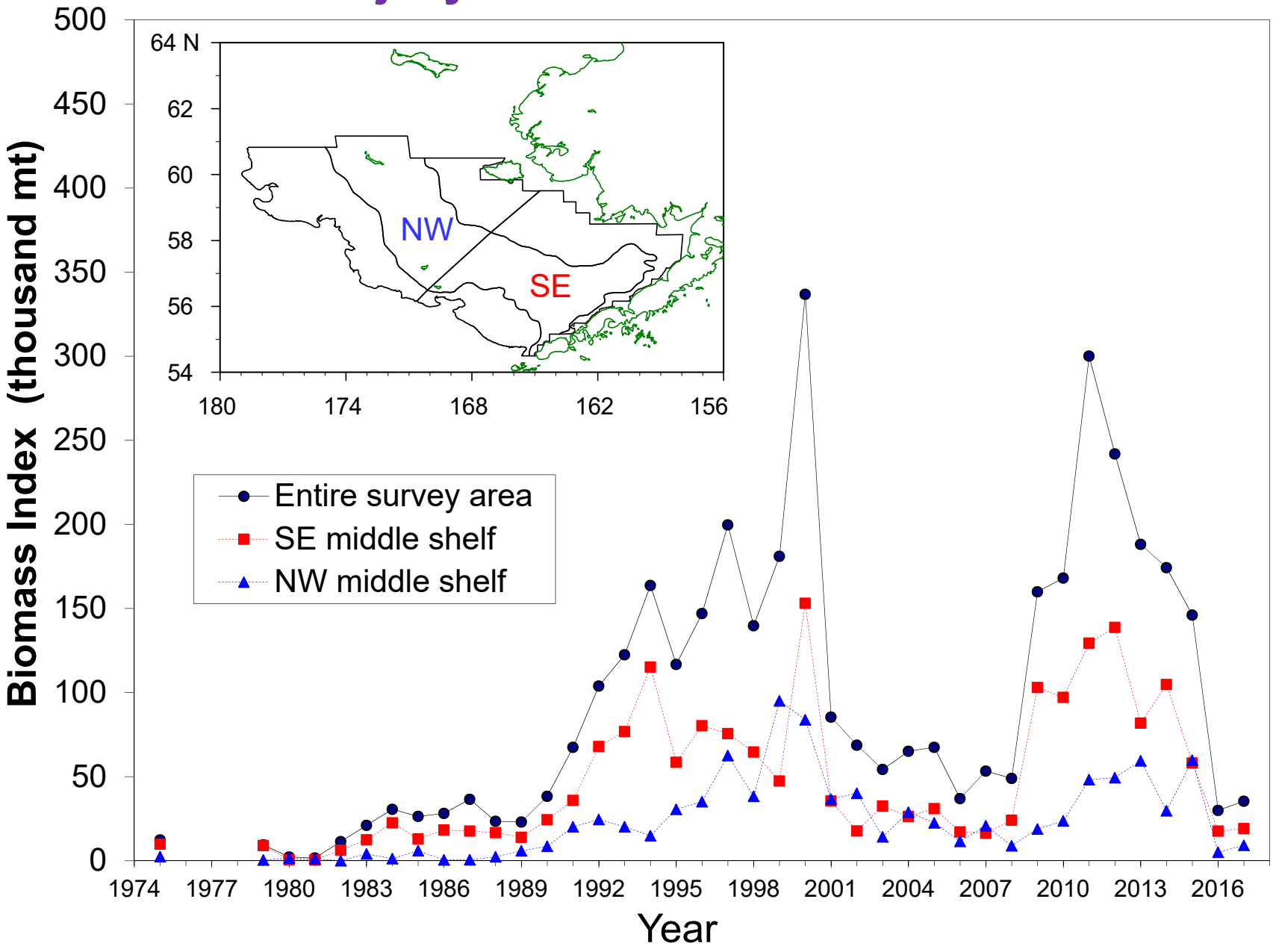
Best NW Model

$$log\ (CPUE) = \beta_o + s(sebiomlag) + s(nwsumtemp) + s(iceretreat) + s(mszoop) + s(currentlag)$$

$R^2\ (\%) = 93.8$ $GCV = 0.463$

Brodeur *et al.* (2008)

Can we use our previous GAM models to 'hindcast' the observed jellyfish biomass for 2005-2017?



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Generalized Additive Modeling (GAM) 1982-2017

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$$log\ (CPUE) = \beta_o + s(sebiomlag) + s(sesprtemp) + s(wstressna) + s(wstressmj) + s(wmixmay) + s(wmixjj) + s(iceretreat) + s(current)$$

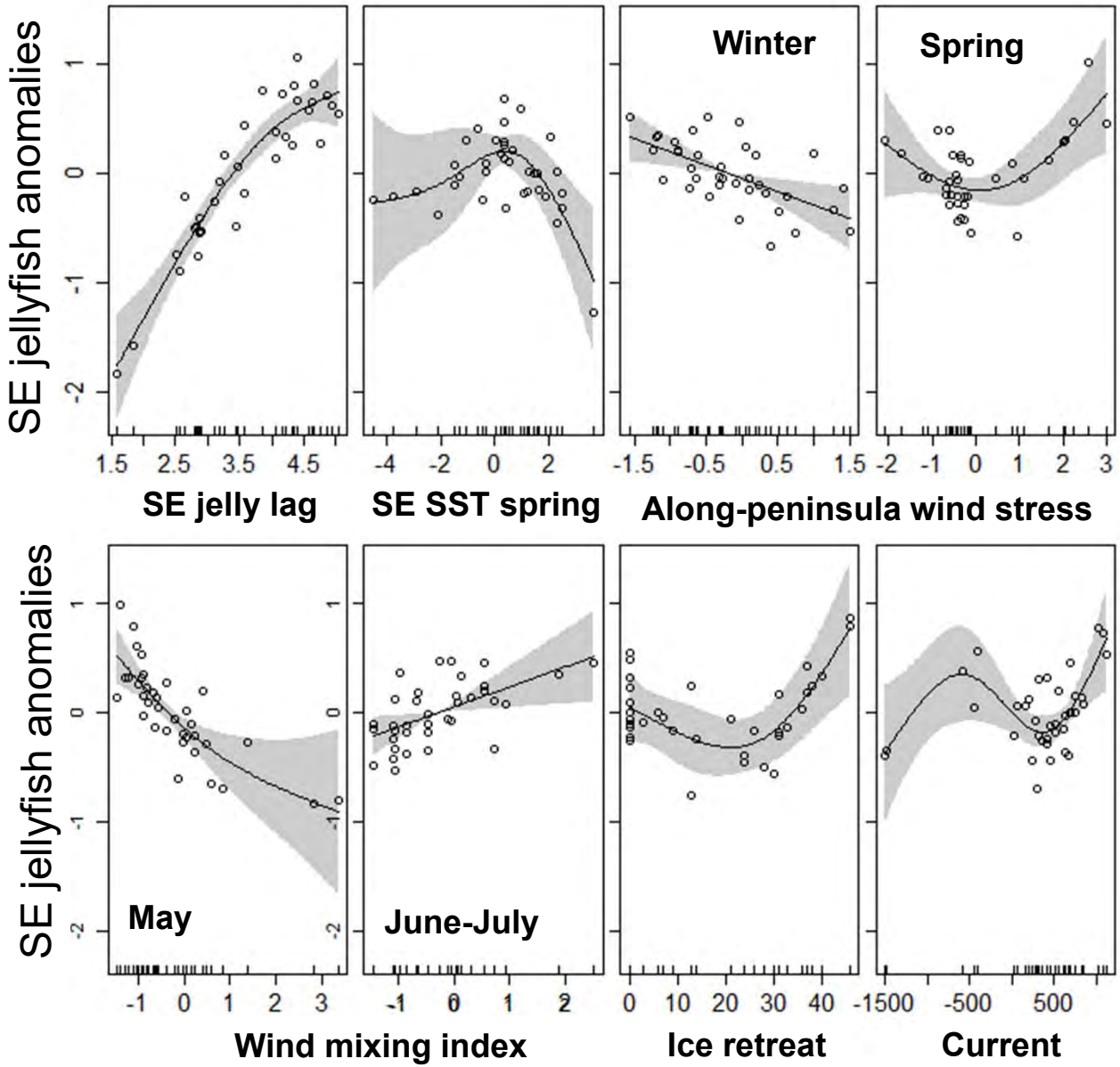
$R^2\ (\%) = 92.3$ $GCV = 0.18$

Best NW Model

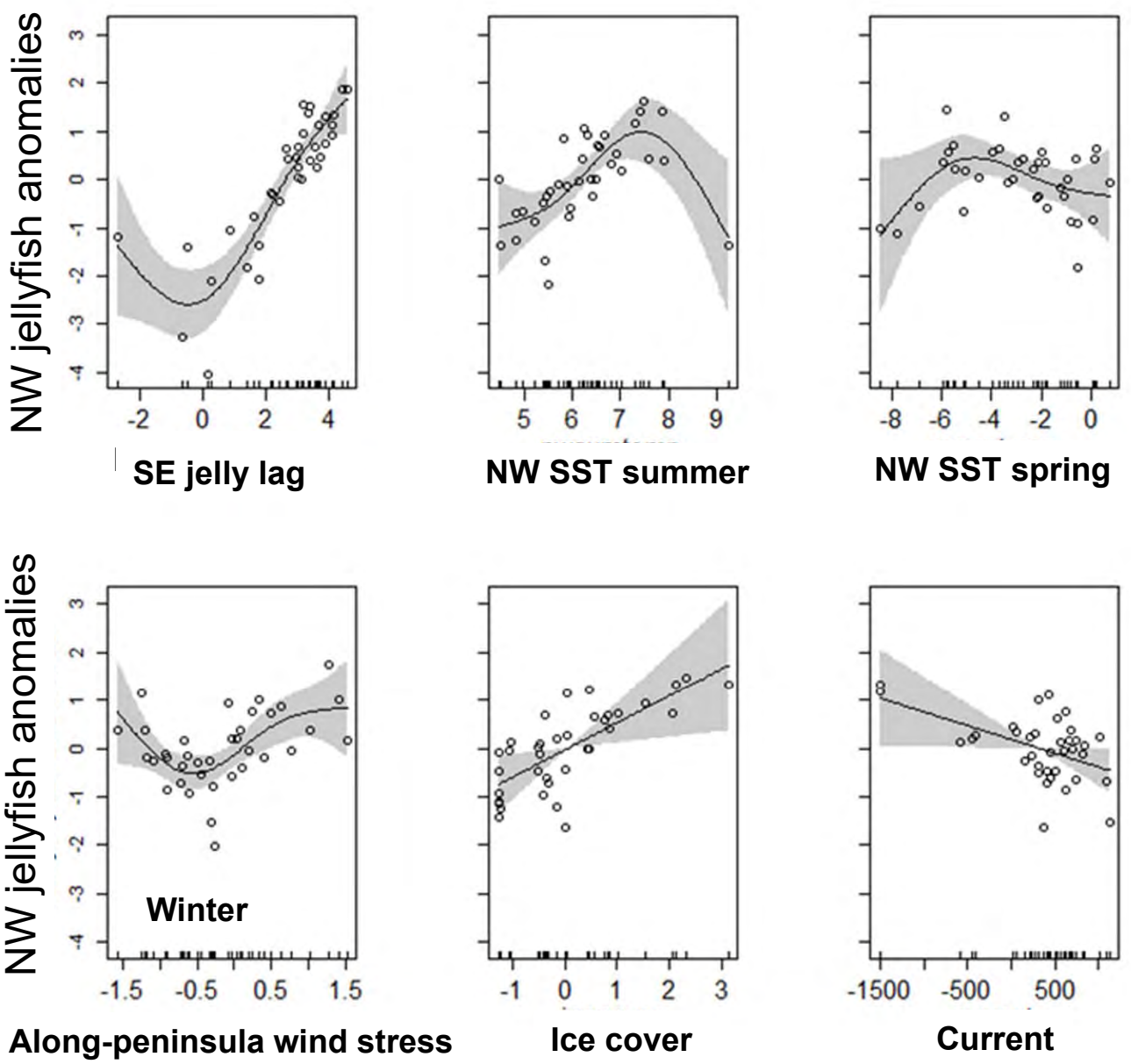
$$log\ (CPUE) = \beta_o + s(sebiomlag) + s(nwsumtemp) + s(nwsprtemp) + s(wstressna) + s(icecover) + (currentlag)$$

$R^2\ (\%) = 86.4$ $GCV = 0.86$

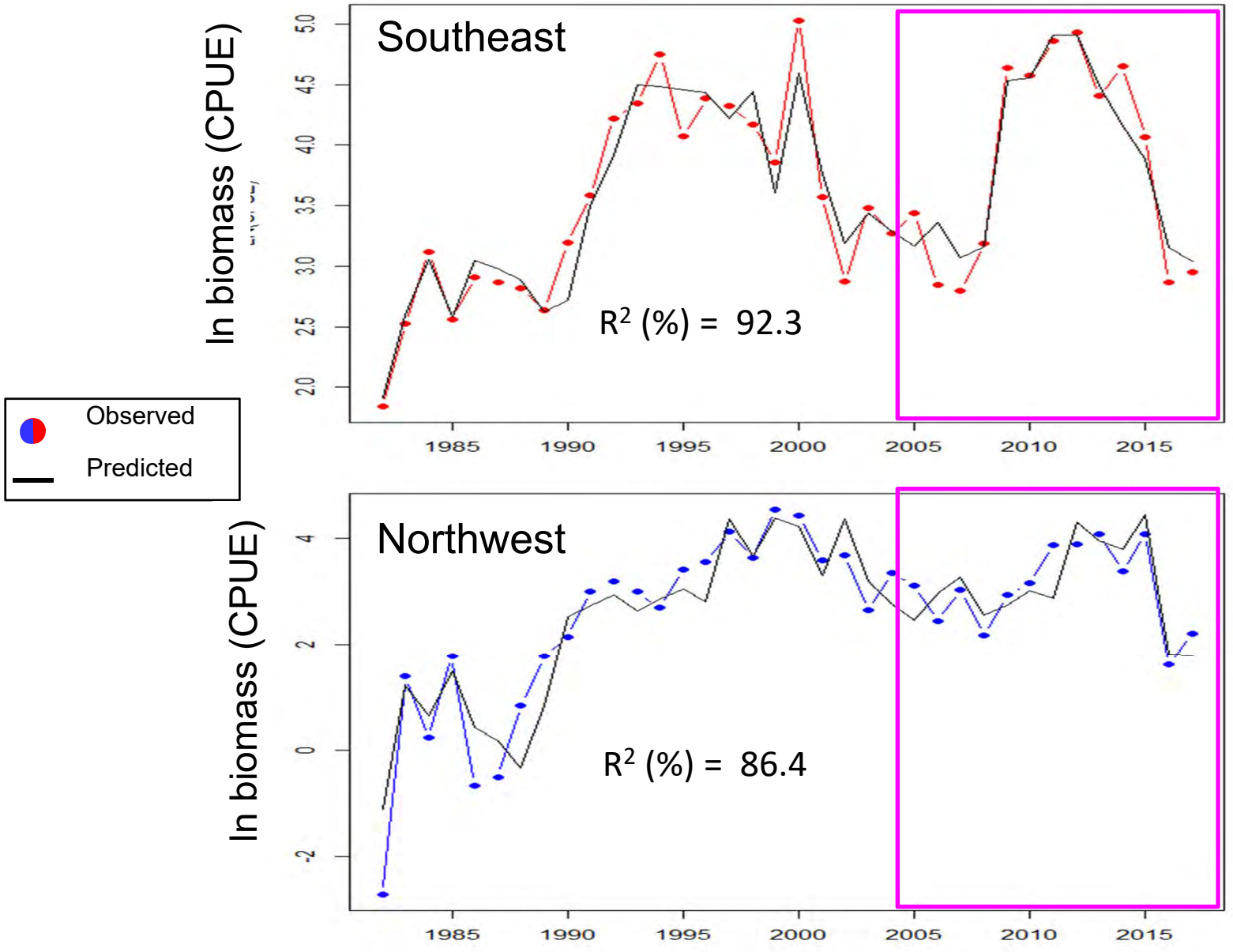
Additive effects of significant covariates in the SE jellyfish biomass model



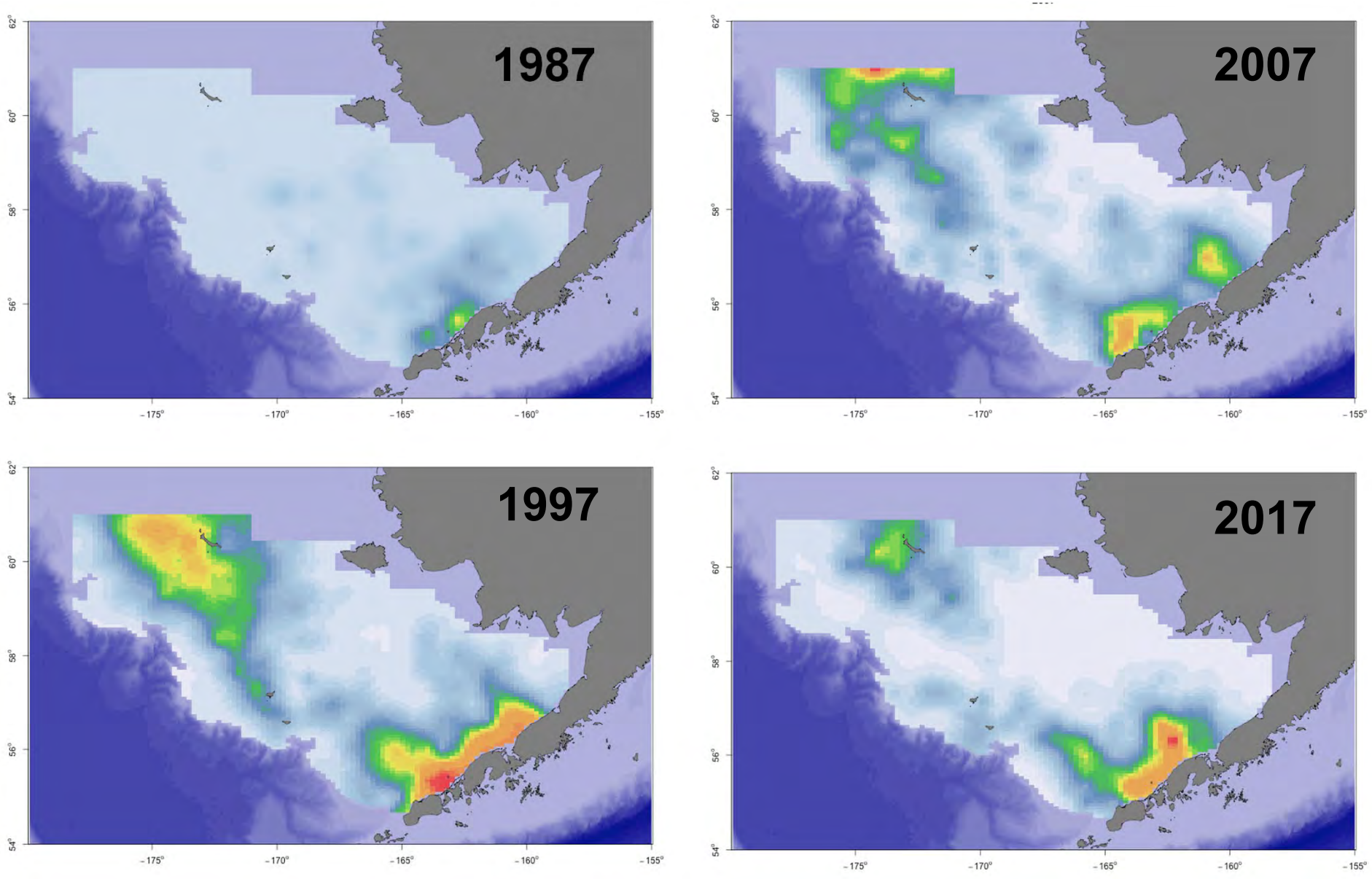
Additive effects of significant covariates in the NW jellyfish biomass model



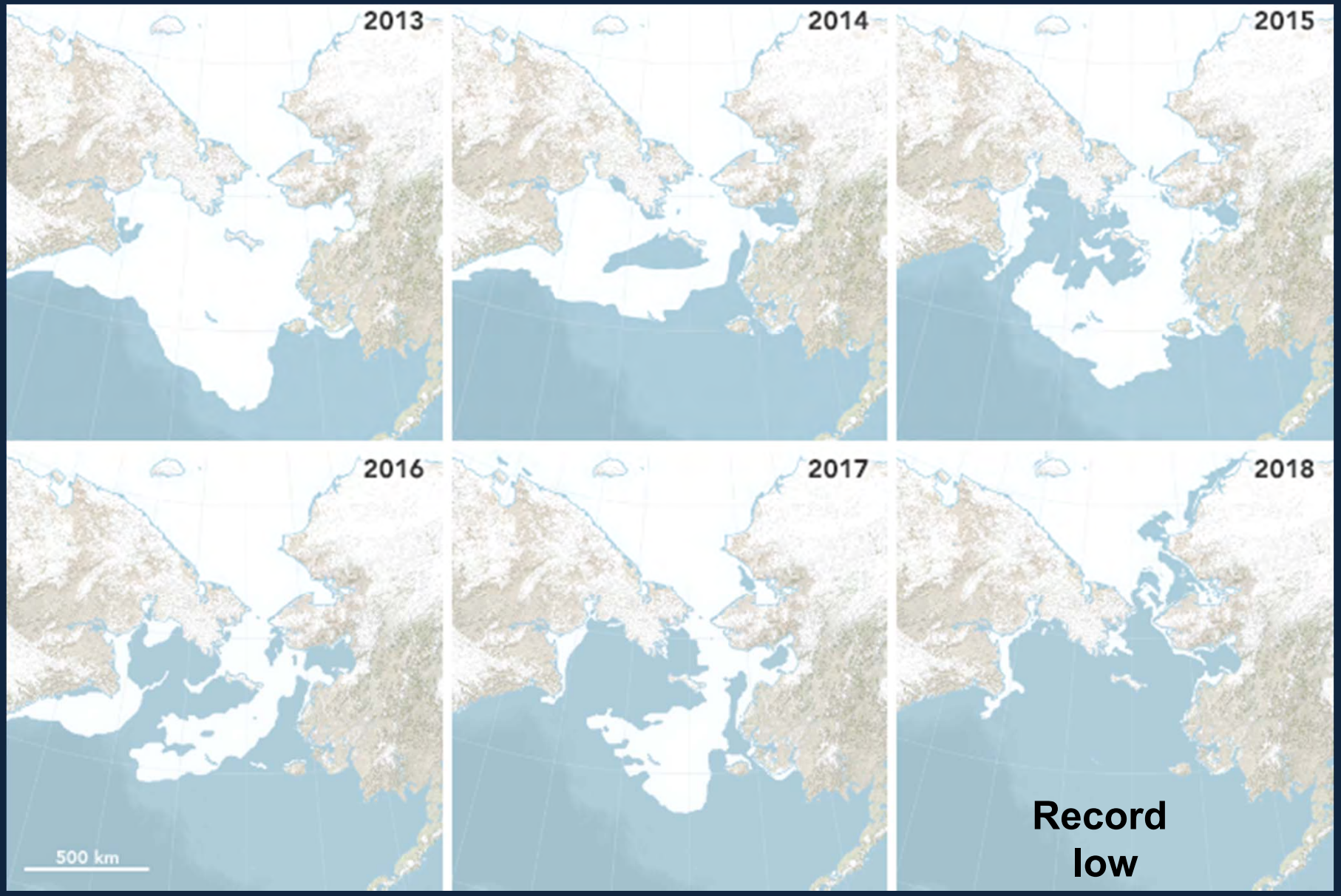
We “hindcasted” our models using new environmental data from 2005-2017



Jellyfish northward range expansion



Sea ice coverage in late April



NASA's Earth Observatory

Conclusions

- Jellyfish in SE Bering Sea continue to show fluctuations in biomass and a northward shift in distribution
- Jellyfish biomass during 1982-2004 is influenced regionally by interacting variables (e.g., sea ice cover, SST, currents, wind mixing and food availability).
- Models “hindcasted” with 2005-2017 environmental data estimate recent trends in Bering Sea jellyfish with only physical variables
- Models that predict jellyfish biomass may help understand climate-induced ecosystem changes.

Acknowledgements

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Thank you!

Photo: Raskoff/MPC