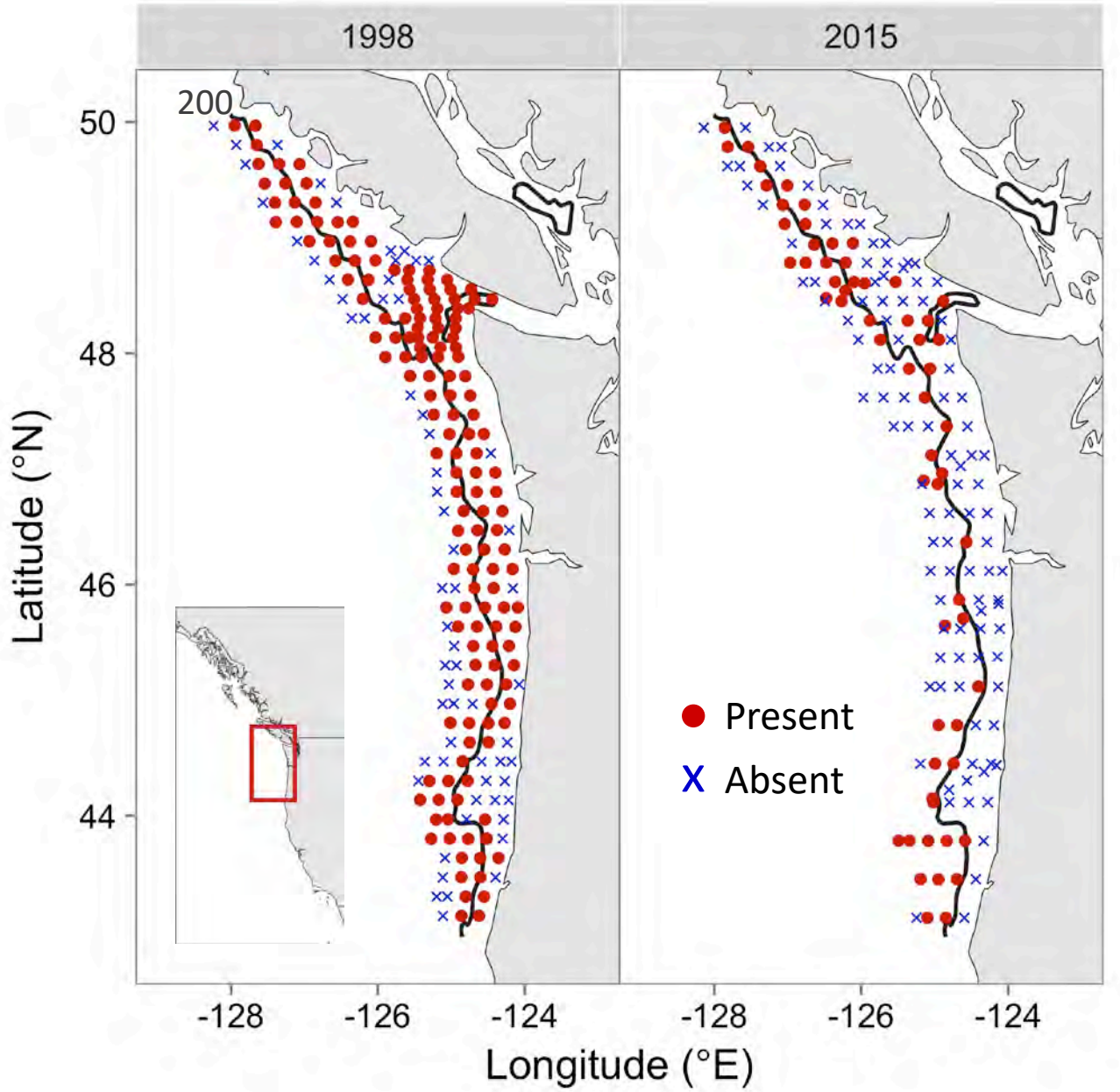
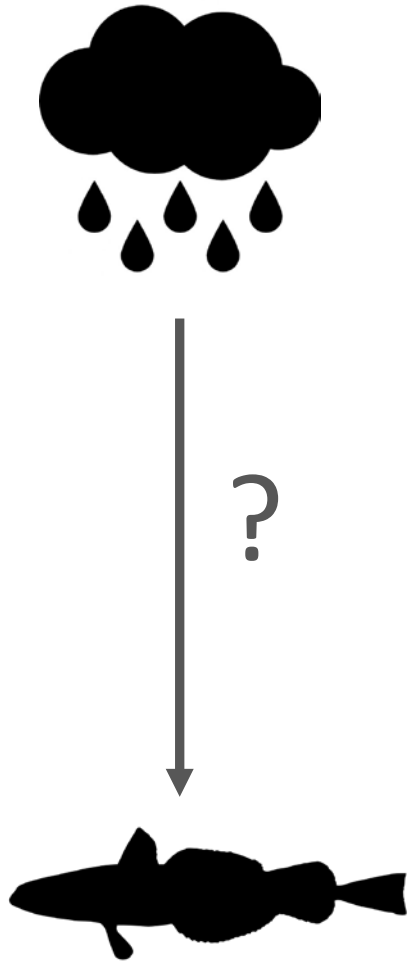
# Seasonal forecasting of Pacific hake distribution in the California Current

**Michael J. Malick**[1,2], Mary Hunsicker[1], Melissa Haltuch[1], Sandy Parker-Stetter[1], Isaac Kaplan[1], Aaron Berger[1], Kristin Marshall[1], Richard Brodeur[1], Samantha Siedlecki[3], Nicholas Bond[3], Albert Hermann[3], Emily Norton[3], and Jan Newton[3]

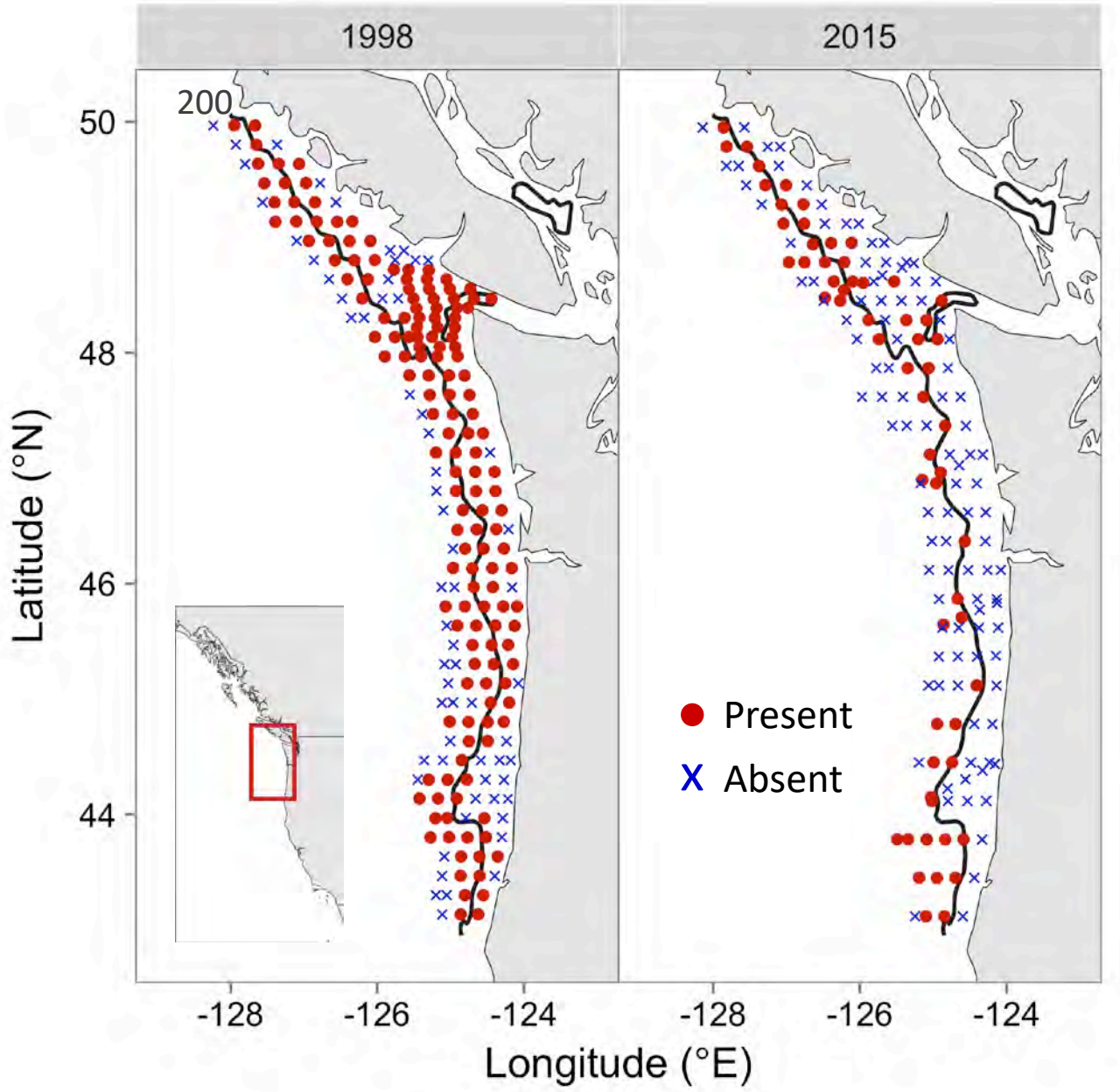
1 2 3

# Variability in summer spatial distribution



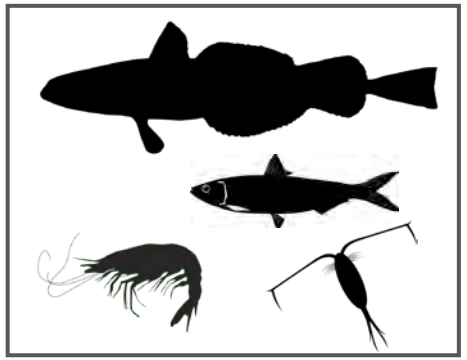



# Variability in summer spatial distribution



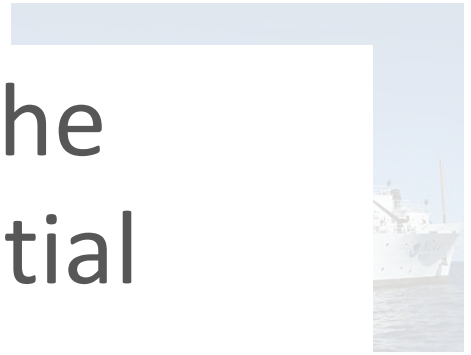


MSE



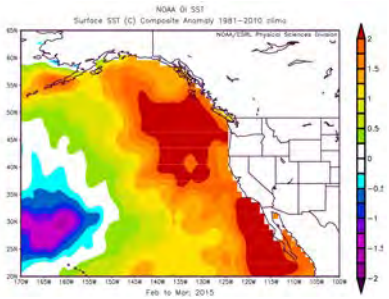
# Variability in summer spatial distribution

1. Test hypotheses regarding the drivers of hake summer spatial distribution
2. Develop 1–6 month lead-time forecasts of Pacific hake summer distribution

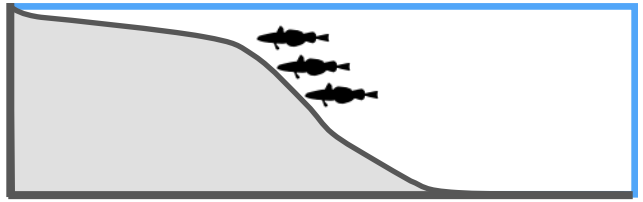


# Hypothesized drivers

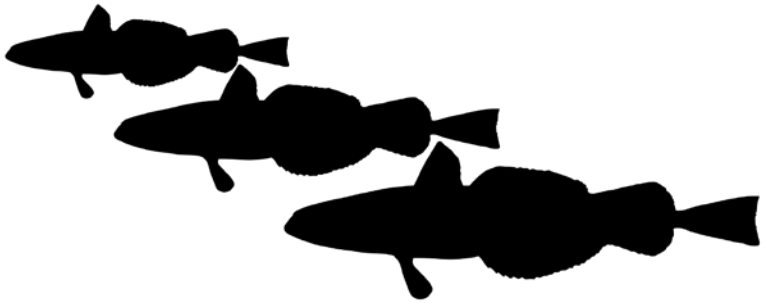
1. Temperature hypothesis

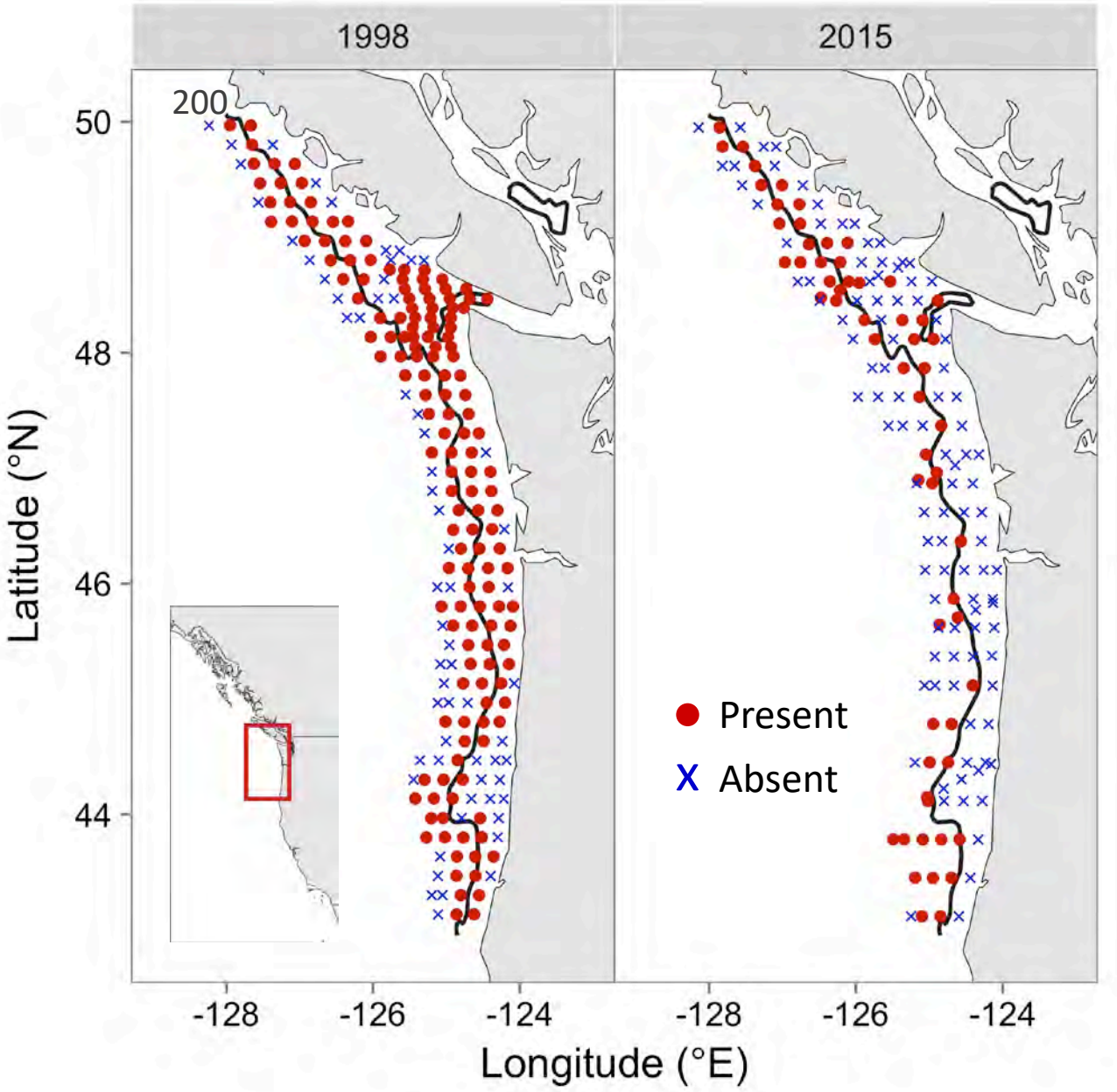


2. Shelf break hypothesis

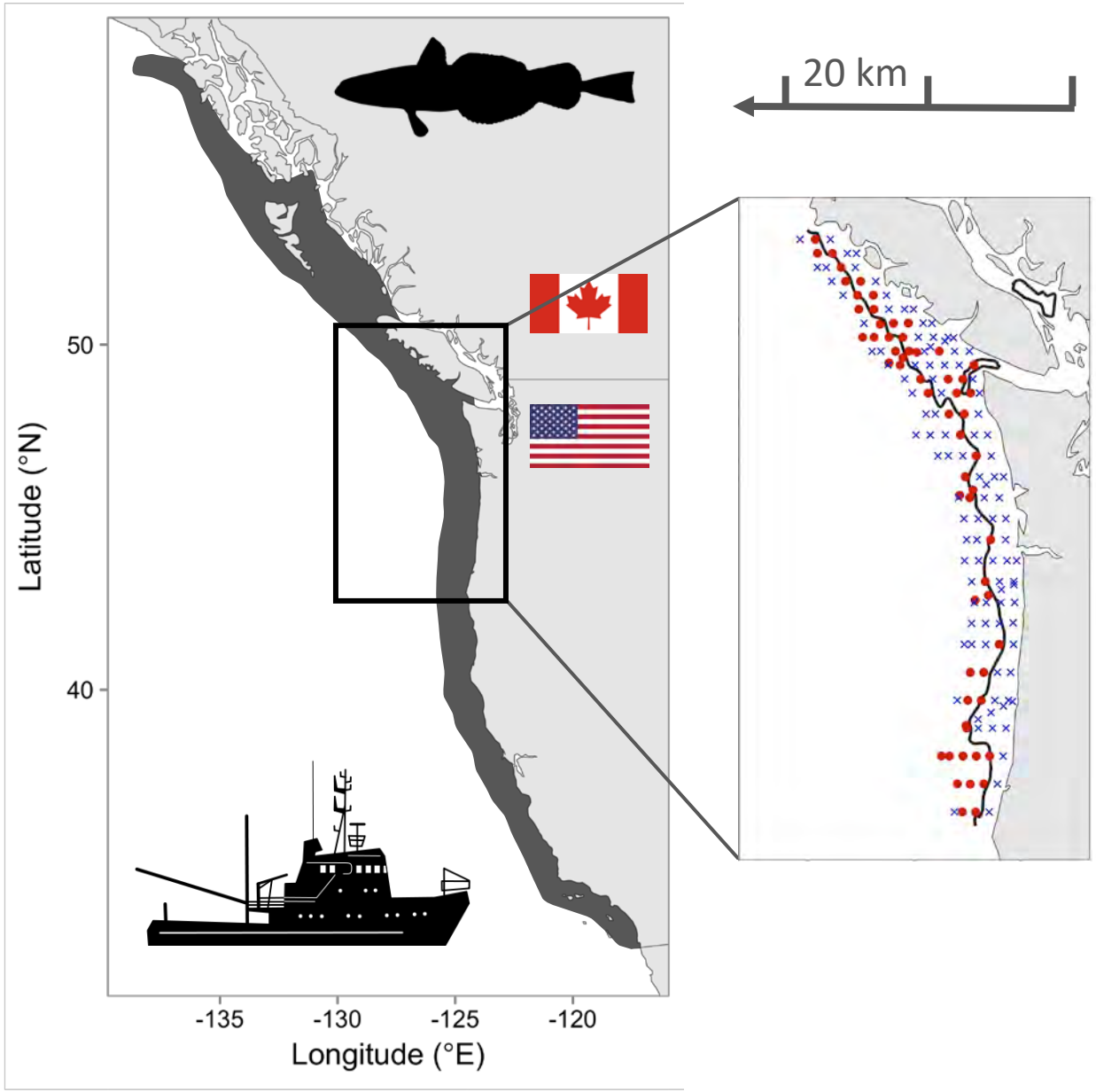


3. Hake age hypothesis



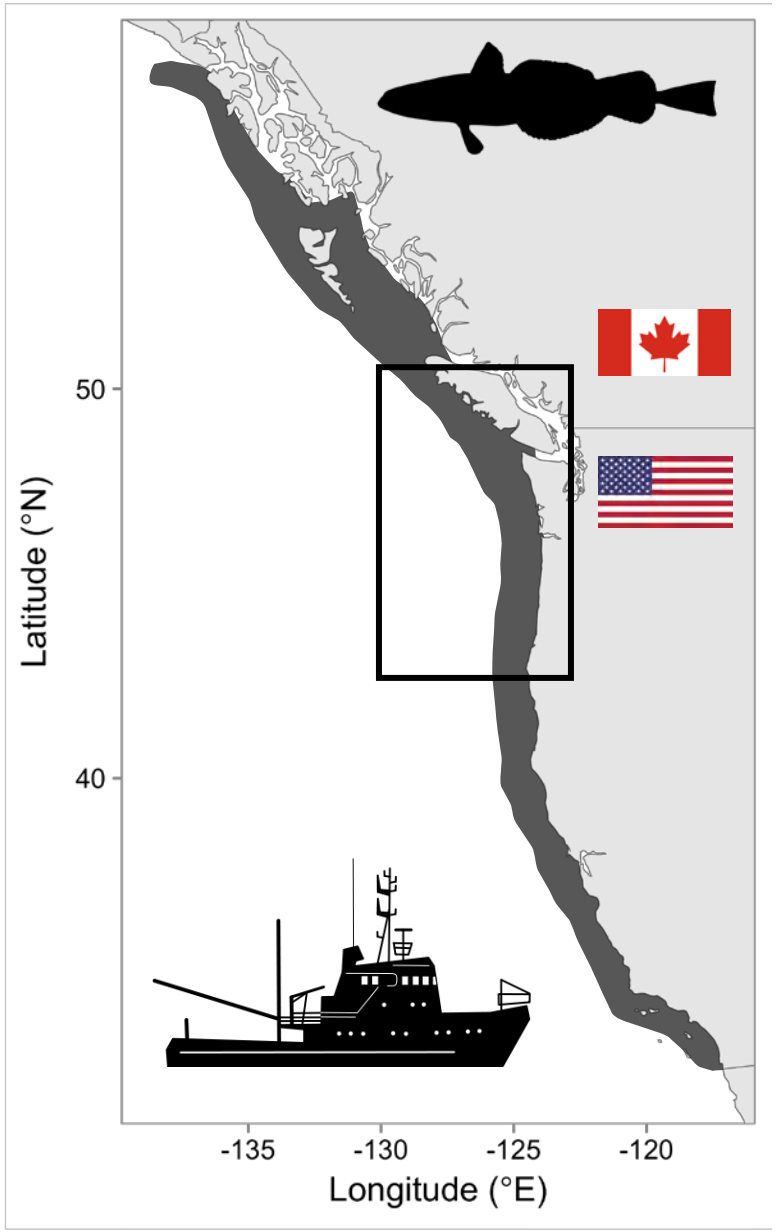


# Acoustic survey

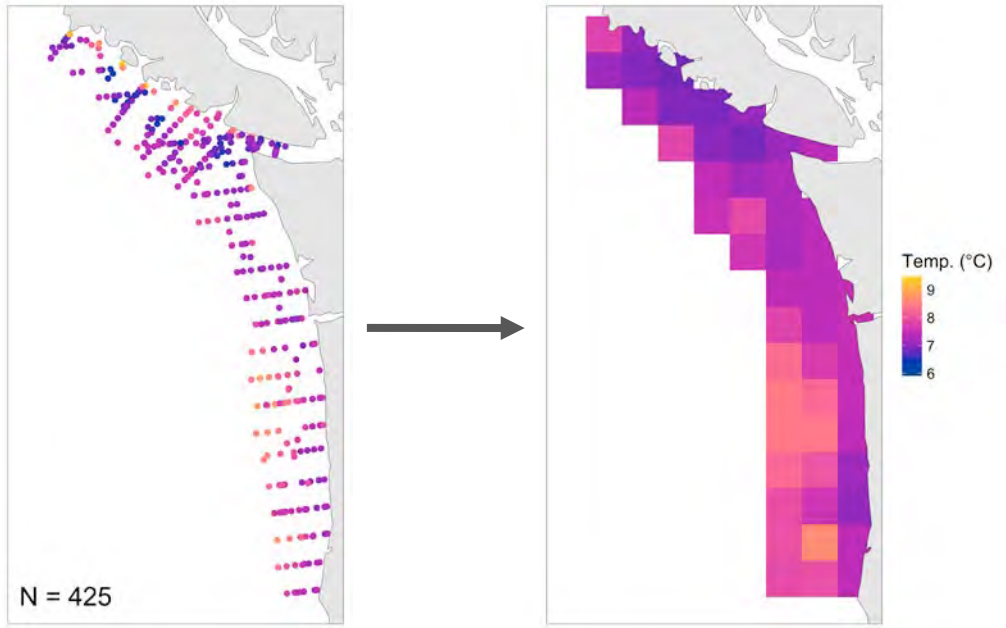



# Acoustic survey

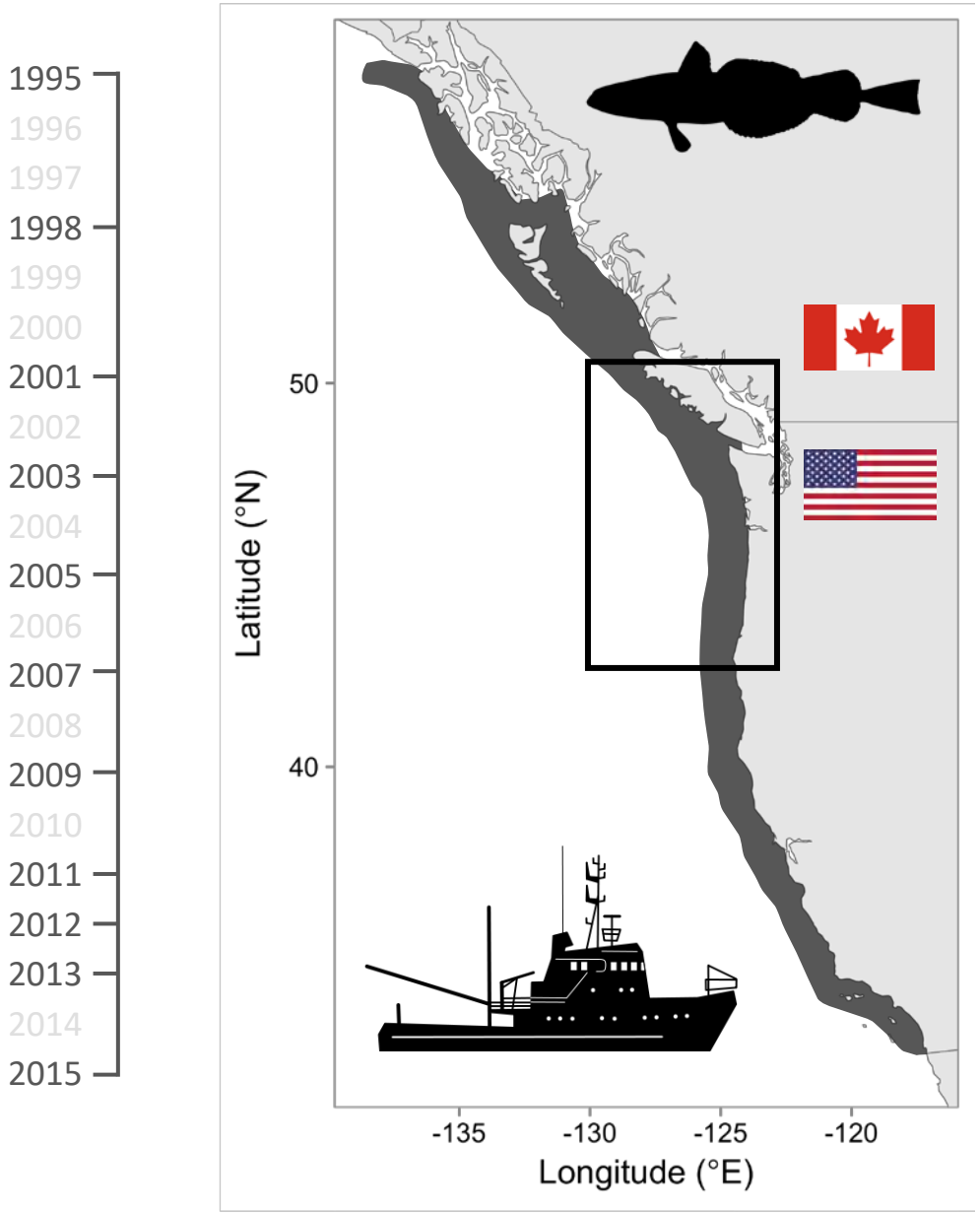
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



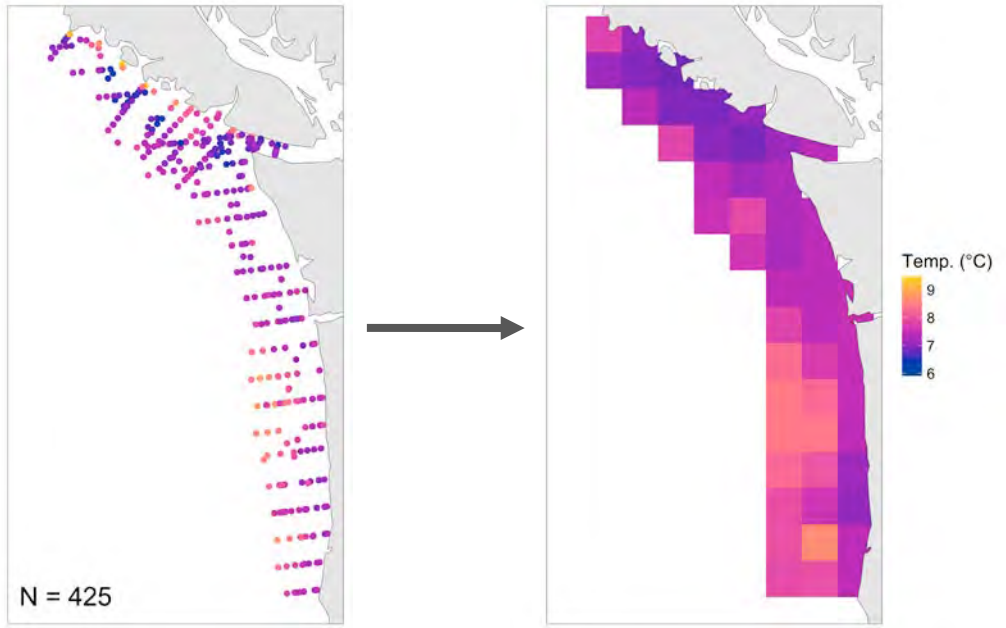

# Temperature at 100 m

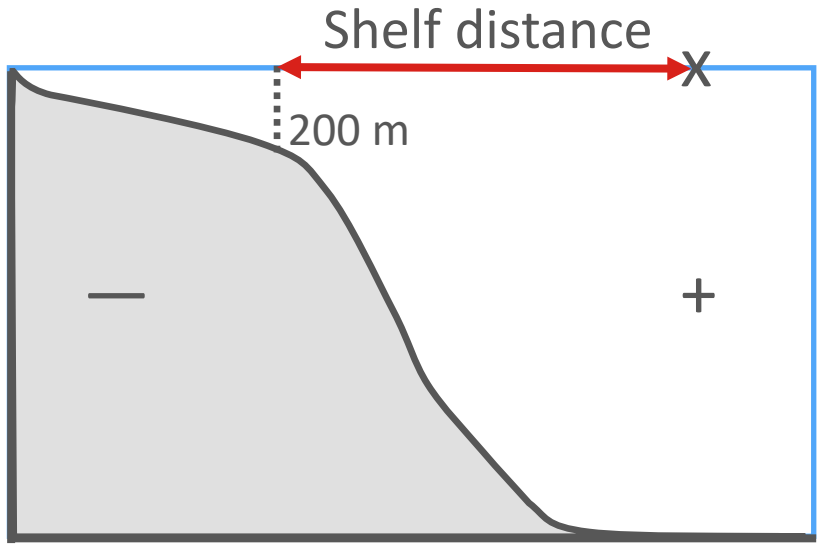


# Acoustic survey



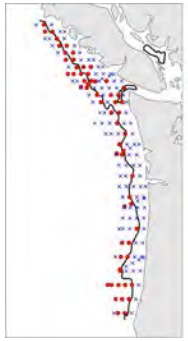

# Temperature at 100 m

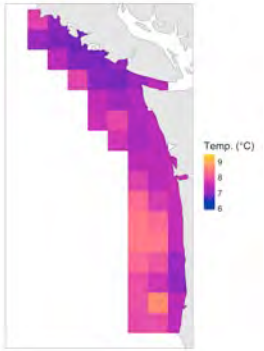


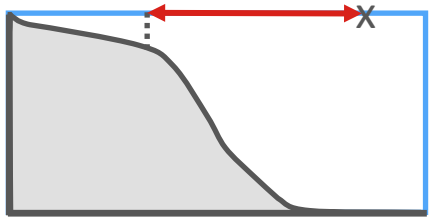



# GAM present/absent model

$$\Pr(B) = \text{Year} + f_1(\text{Temp 100 m}) + f_2(\text{Shelf distance}) + f_3(\text{Lon,Lat})$$






Logit function — Year intercepts — Covariates

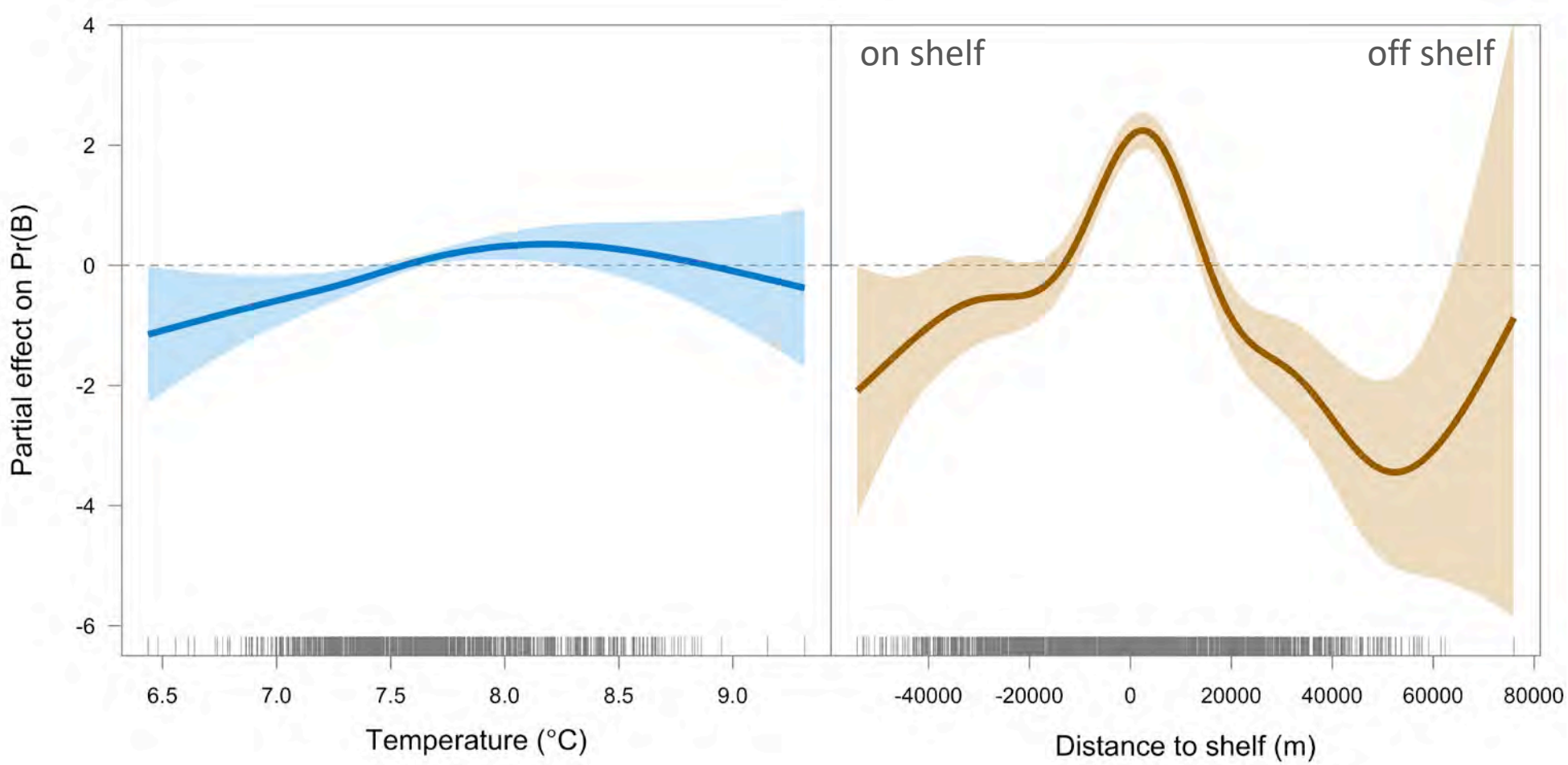
$$g(E(Y)) = \mathbf{A} + f_1(x_1) + f_2(x_2) + f_3(x_3, x_4)$$

Probability some hake — Thin plate splines

# GAM present/absent model

$$Pr(B) = Year + f_1(Temp\ 100\ m) + f_2(Shelf\ distance) + f_3(Lon,Lat)$$

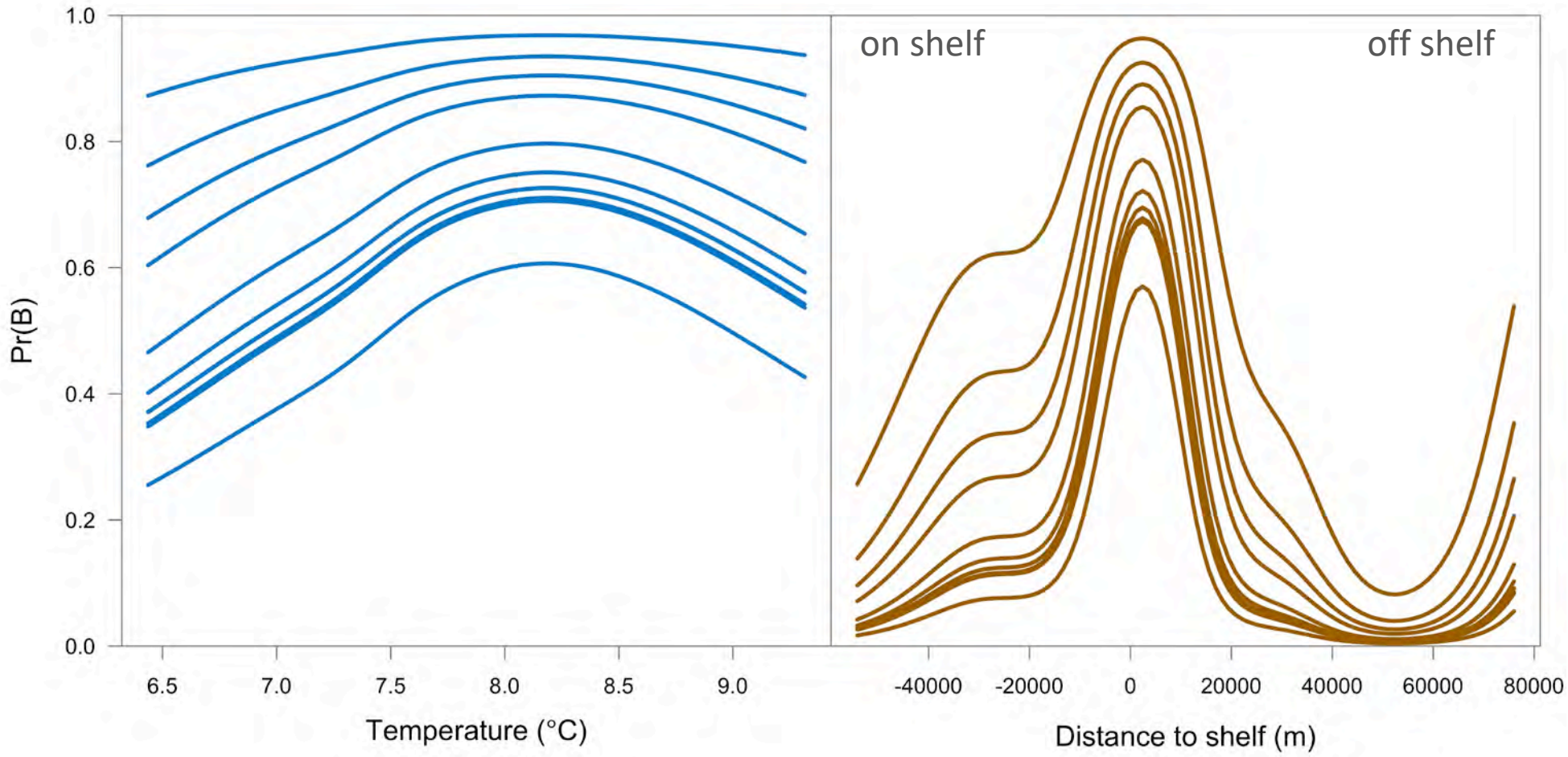
Deviance explained = 35%  AUC = 0.87



# GAM present/absent model

$$Pr(B) = Year + f_1(Temp\ 100\ m) + f_2(Shelf\ distance) + f_3(Lon,Lat)$$

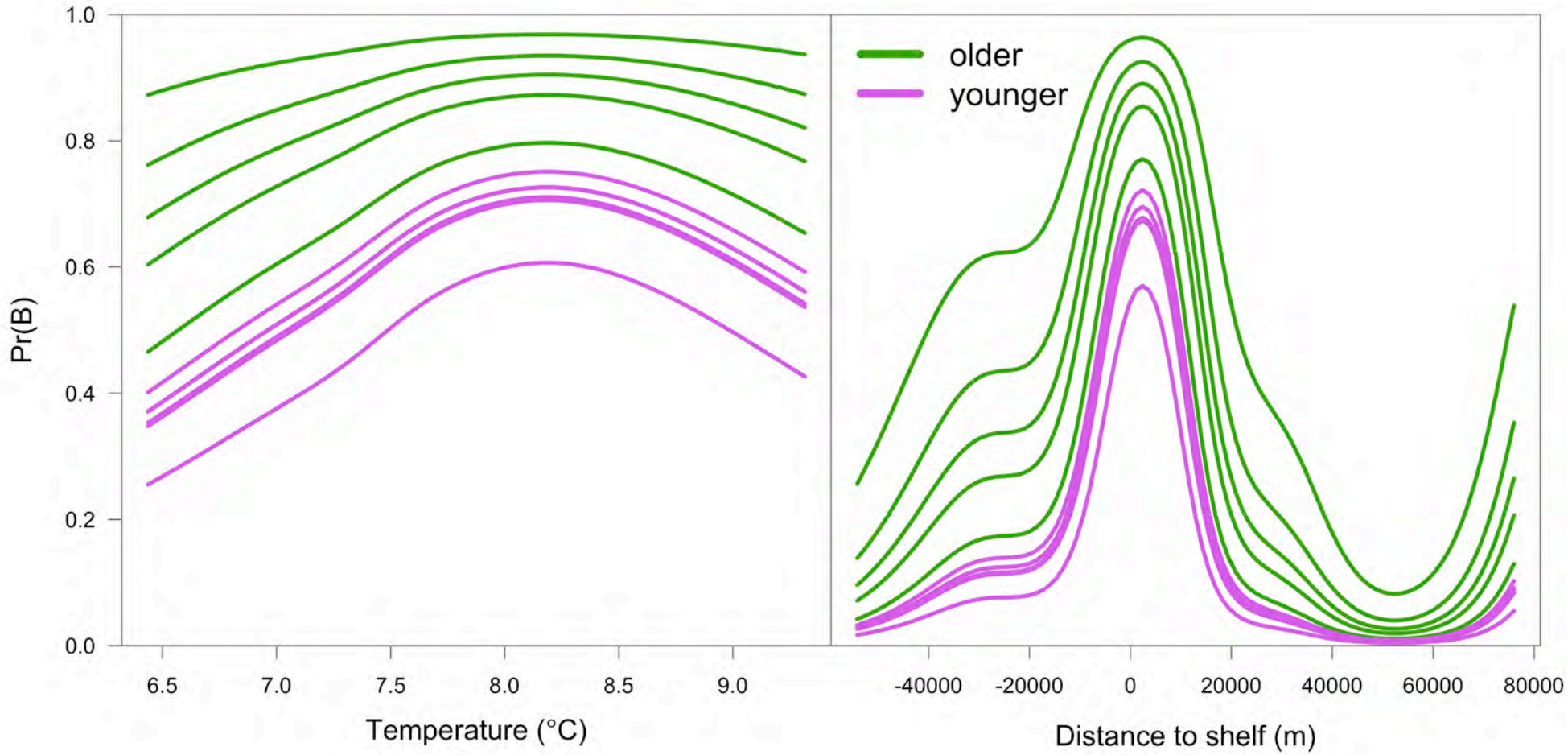
Deviance explained = 35%  AUC = 0.87



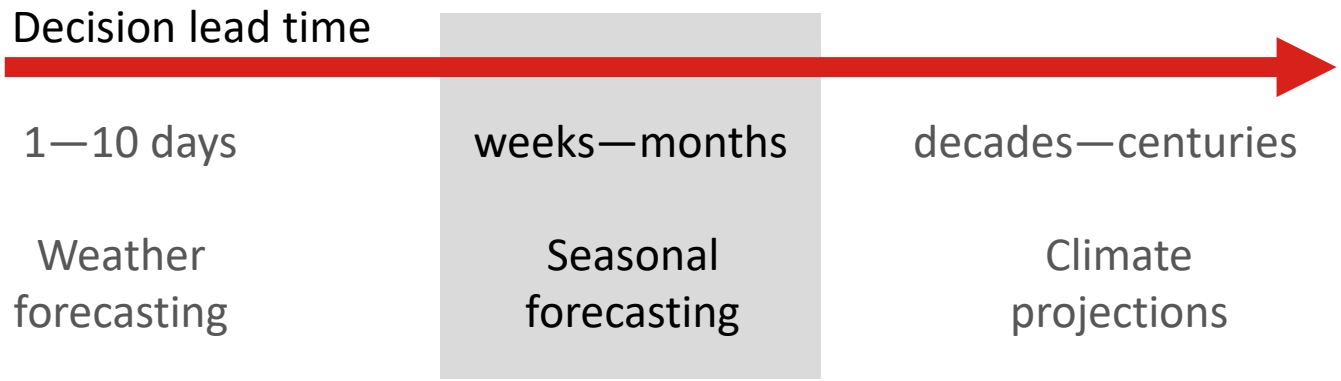
# GAM present/absent model

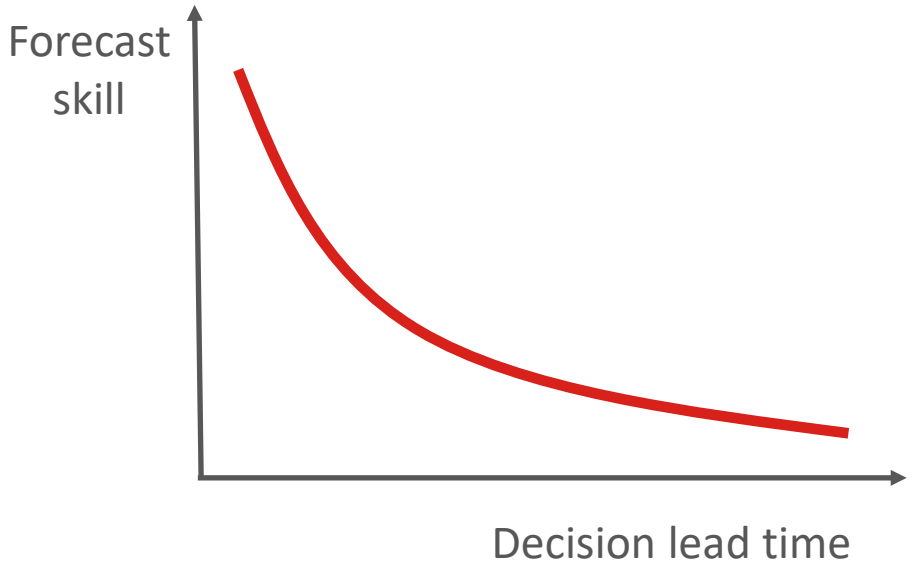
$$Pr(B) = \underline{Year} + f_1(\text{Temp 100 m}) + f_2(\text{Shelf distance}) + f_3(\text{Lon,Lat})$$

Deviance explained = 35%  AUC = 0.87



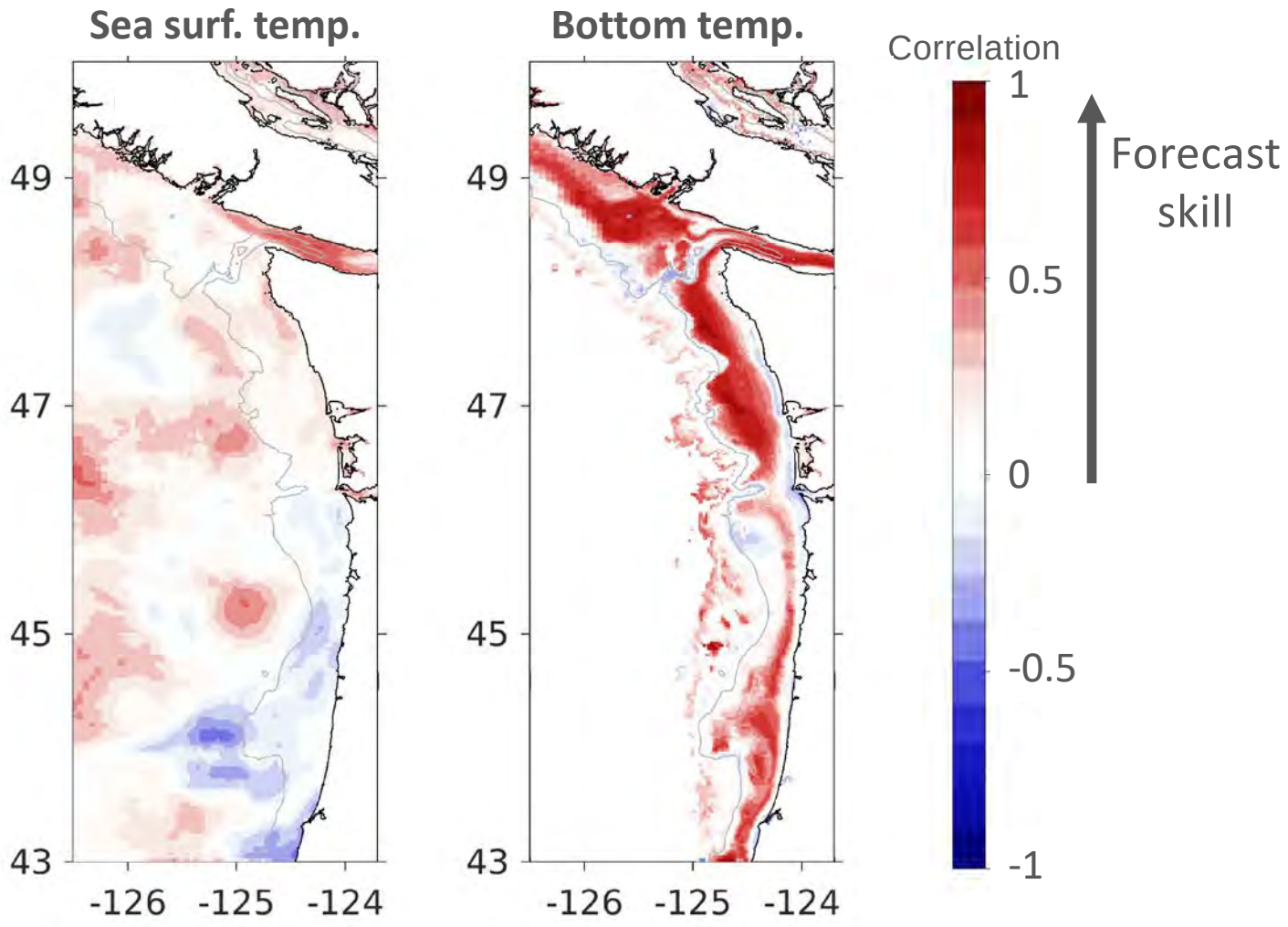
# Seasonal forecasting




Hobday et al. (2016) Fisheries Oceanography

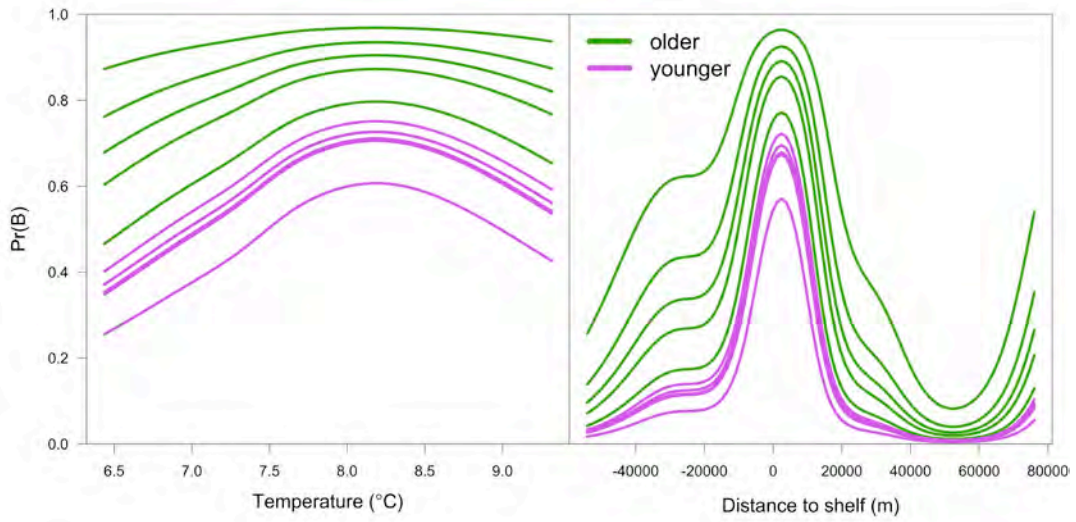
# J-SCOPE ocean forecasting system




Siedlecki et al. (2016) Scientific Reports

# Summary

## Strength of evidence & relative importance of hypotheses



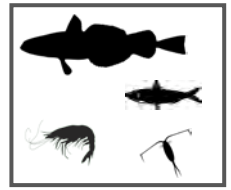

## Seasonal forecasts of spatial distribution

Decision lead time

weeks—months

Seasonal forecasting

MSE




NASA