Predicting herring distributions during winter

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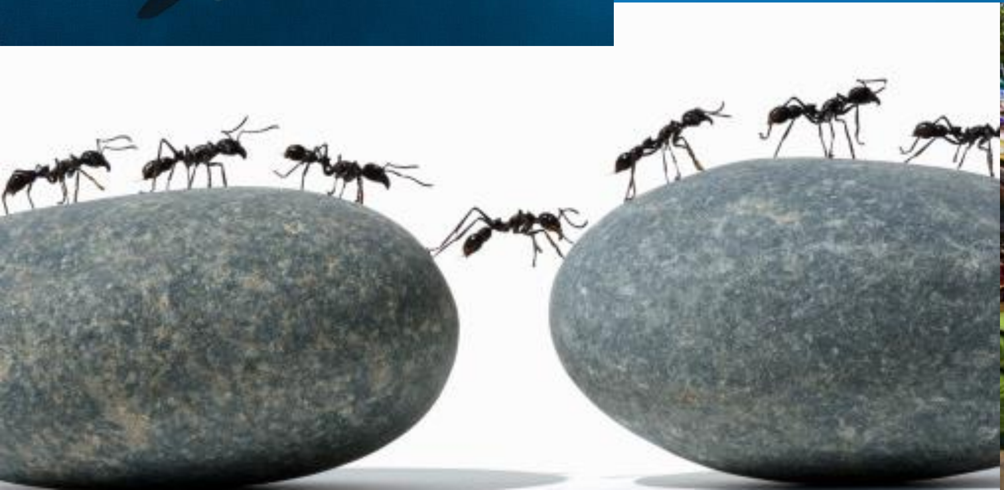
Rannsóknasjóðs síldarútvegsins

Collective learning and sociality

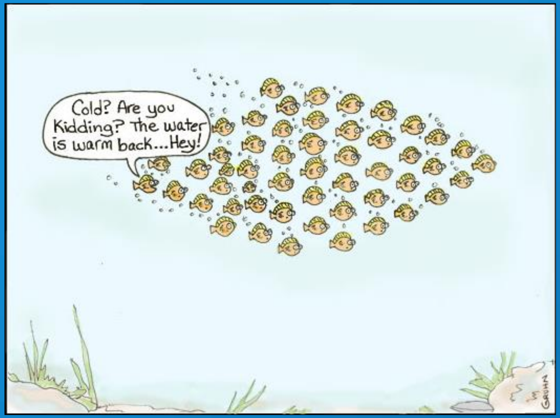


Atlantic herring (*Clupea harengus*)


Atlantic herring (Clupea harengus)
Conservatism (Jakobsson 1969; Corten 1993, 2002)

Conservatism defined…

Habits



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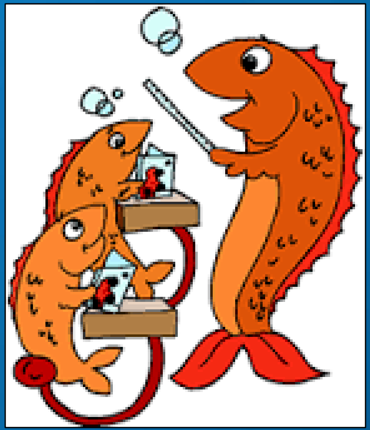
Traditions



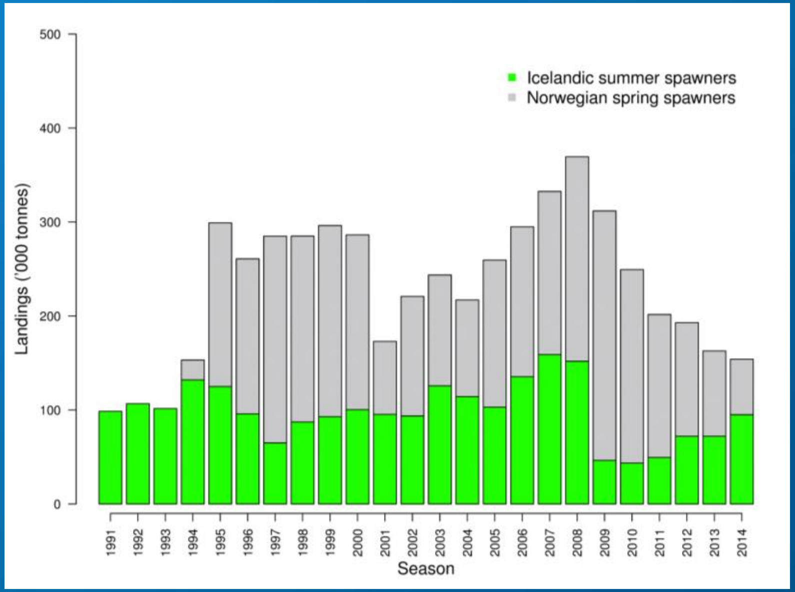
- ❖ Younger fish learn traditional migration routes from older ones and these are remembered.
- ❖ Disruption of learning opportunities can trigger a distribution shift.

Why and *when* but…

Photo: George McCallum

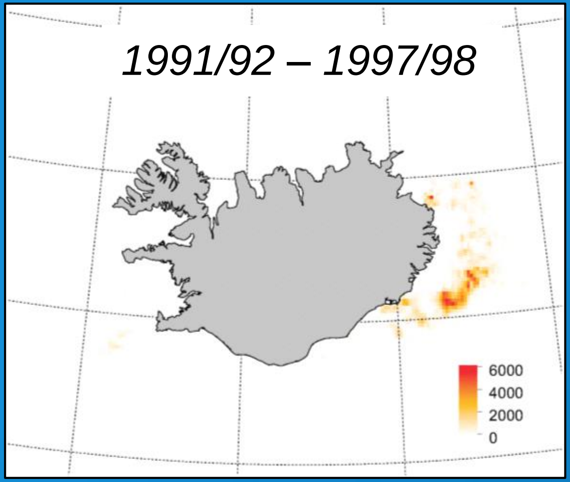
Icelandic summer spawners (ISS)

- Major fishery in Icelandic waters.
- Age 3+ adults targeted from October to January each year.

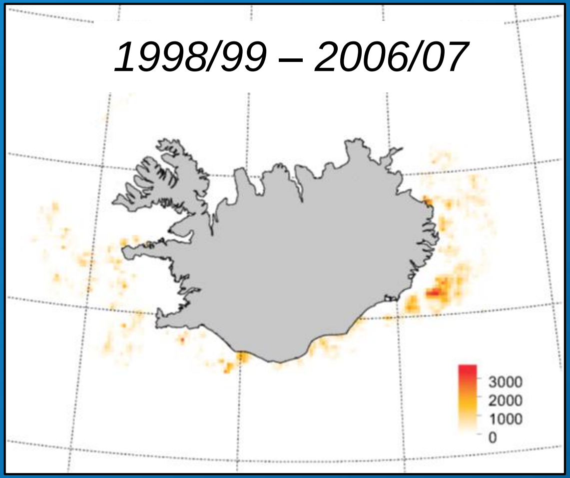


- Purse-seine, pelagic trawl.
- Fishing season follows the summer NSS / mackerel fishery.

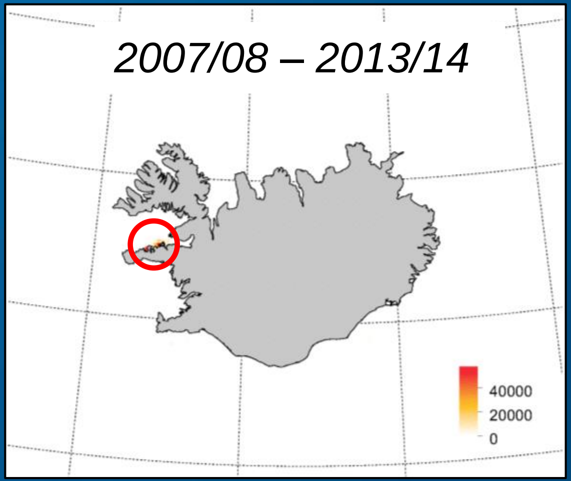
Shifting winter distribution (Óskarsson et al. 2009)



Offshore off east coast



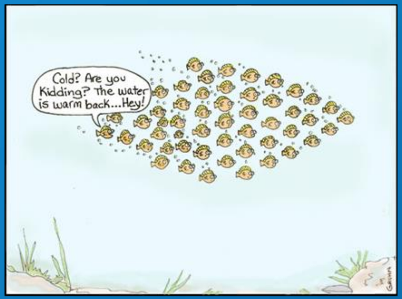
Offshore off east and west coasts

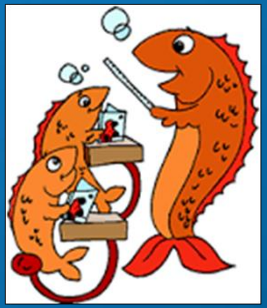


Inshore in small fjords on the north coast of Snæfellnes Peninsula

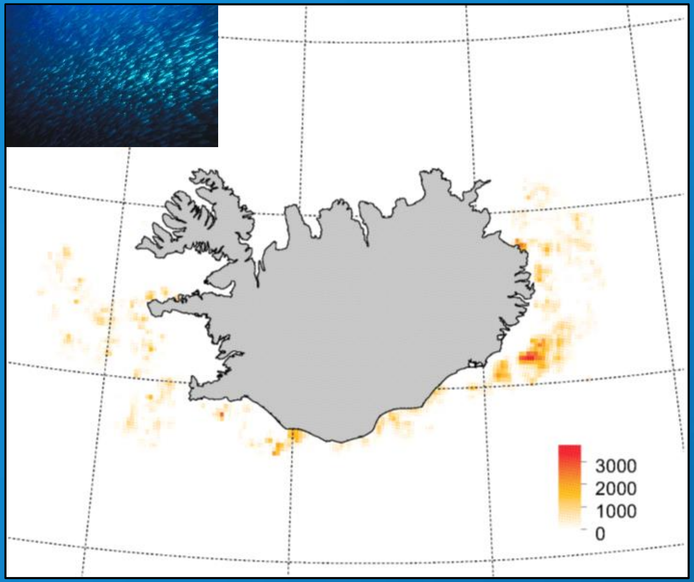
A model for wintering herring

Habits & *Traditions*





Winter distribution



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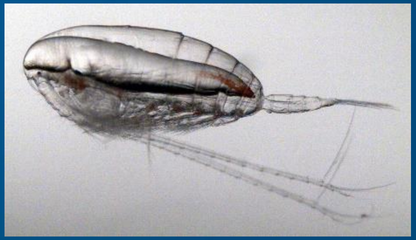
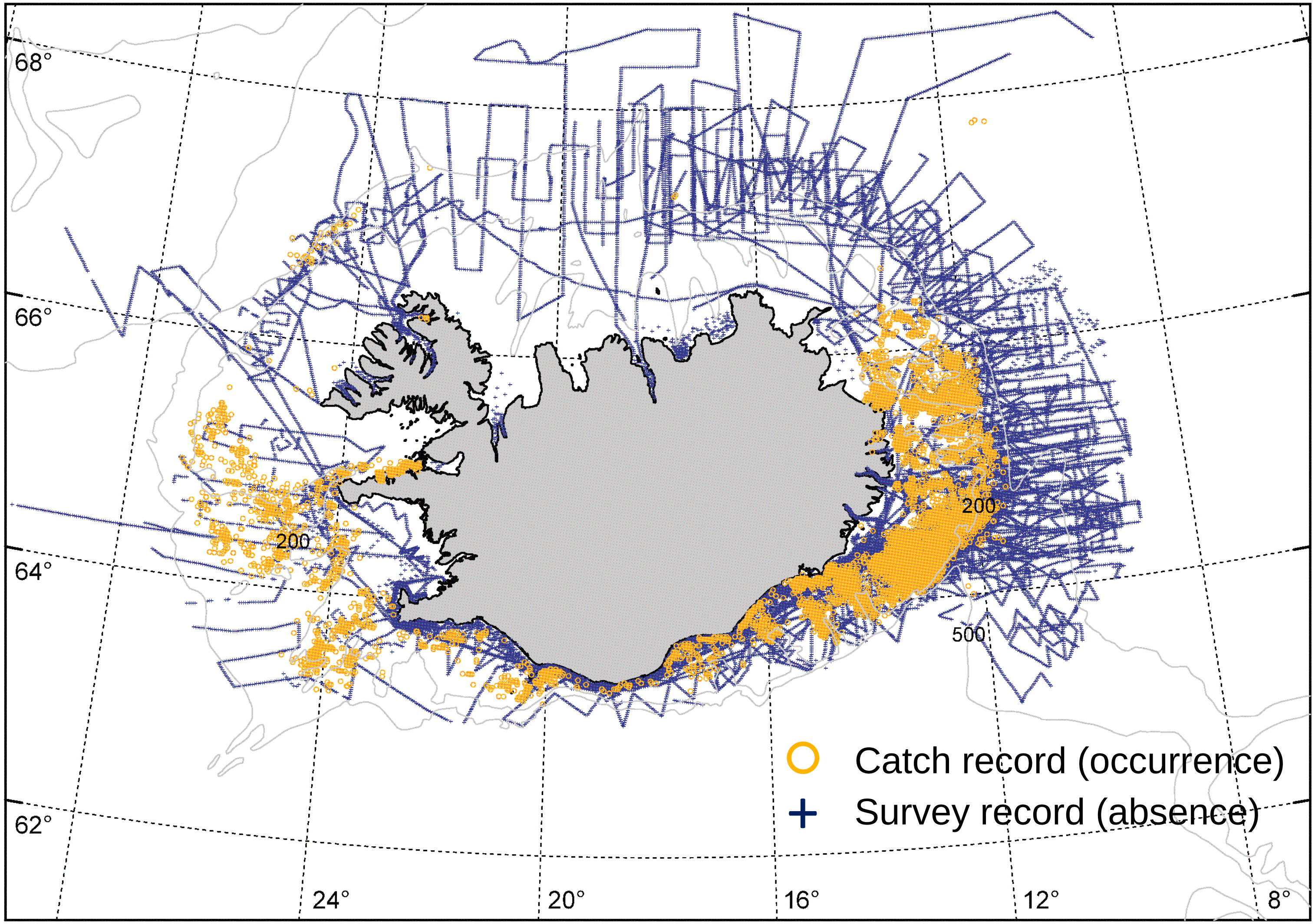
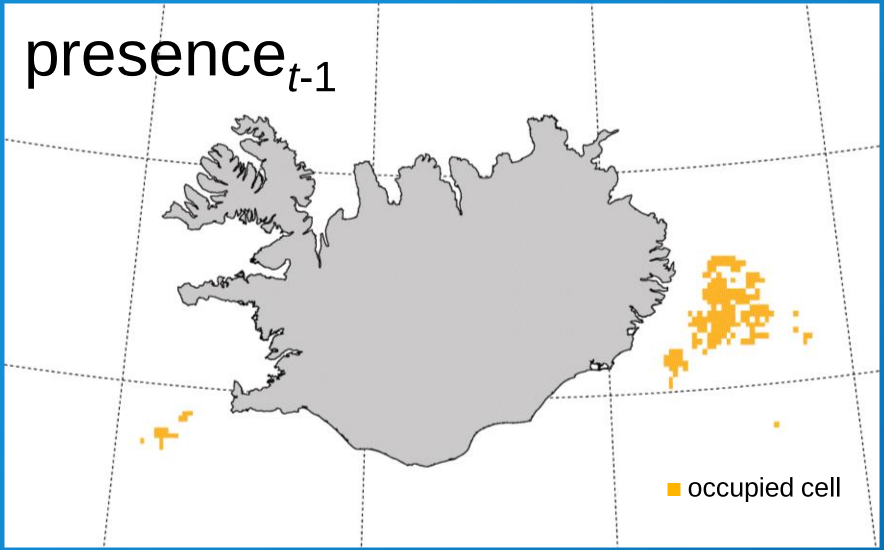


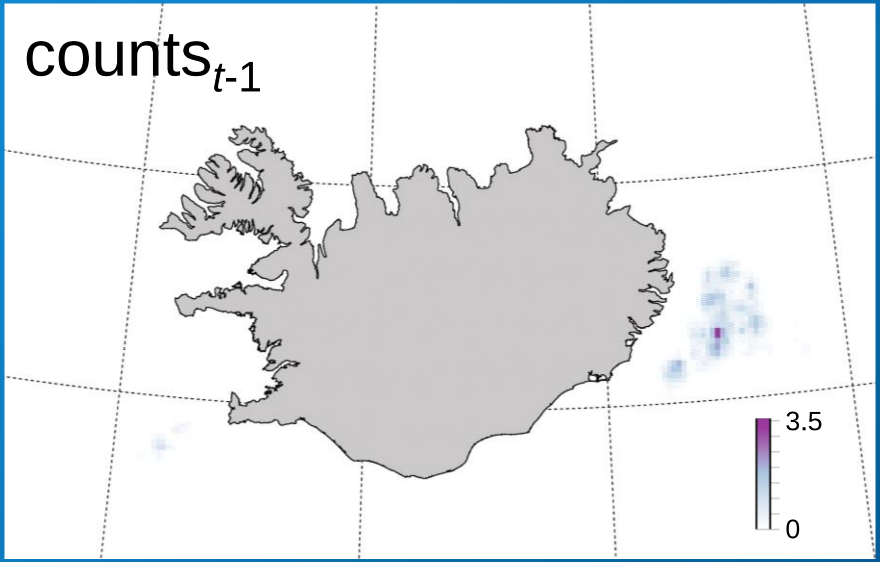
Fishery and survey records – 23 years



Habits and traditions



- Describes the occurrence pattern of the stock the previous season (*t*-1).



- Describes the number of occurrence records in *t*-1.

Environment, predators and prey

Dynamic | **Static**

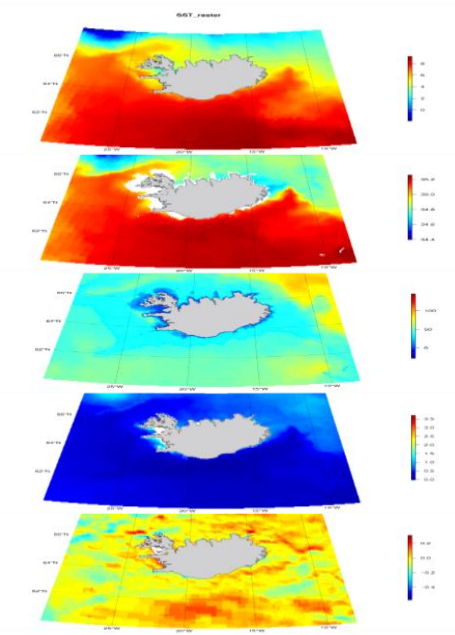
Temperature

Salinity

Stratification

Temperature gradient

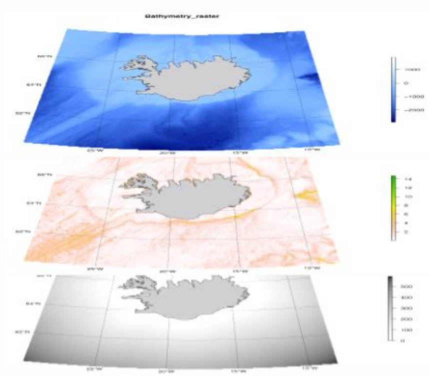
Current velocity



Bottom depth

Bottom slope

Distance to shore



Sources

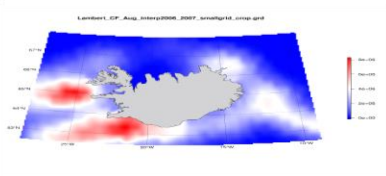
- CODE
- GEBCO
- Fishery logbooks
- Hjøllo et al. 2012

Predators 

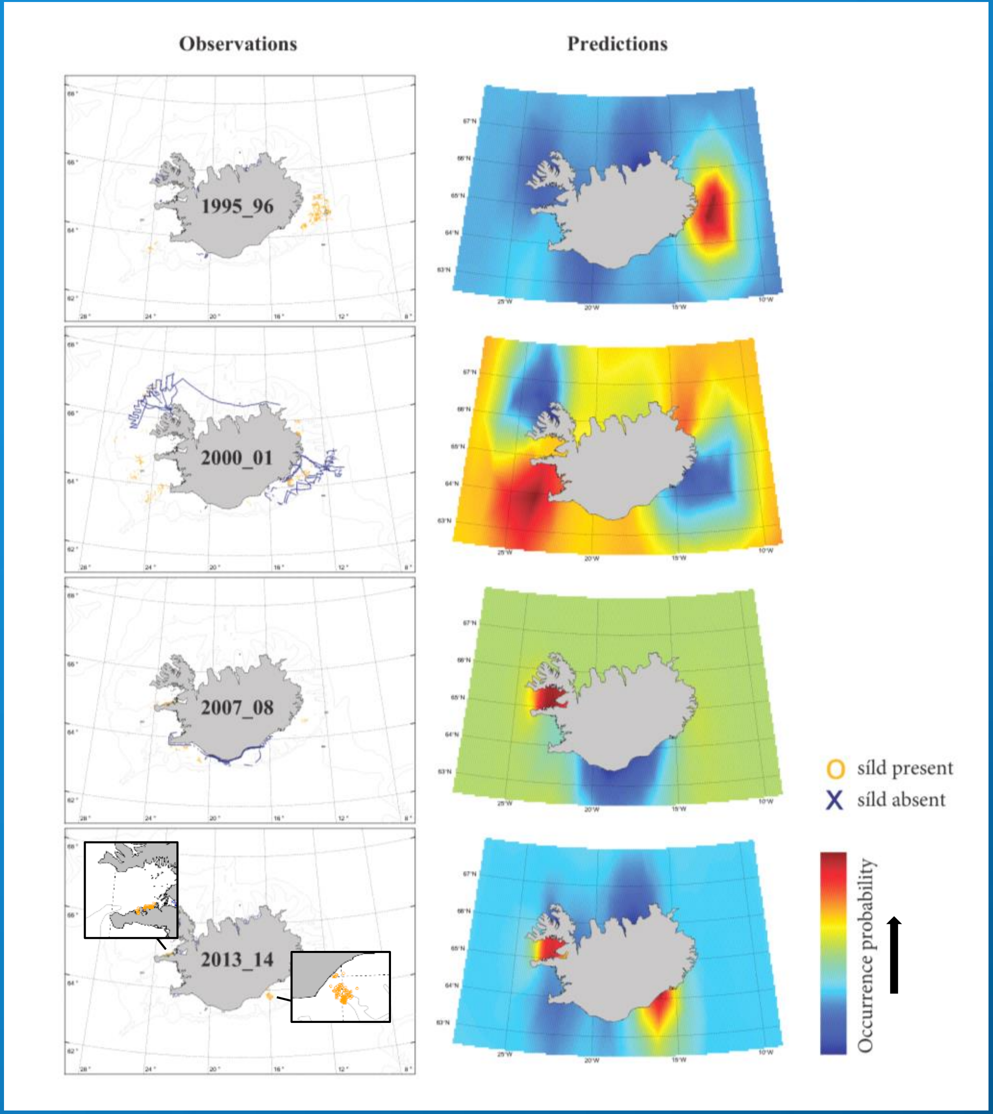
Fishing intensity in prev. week

Prey 

Zooplankton biomass in prev. August



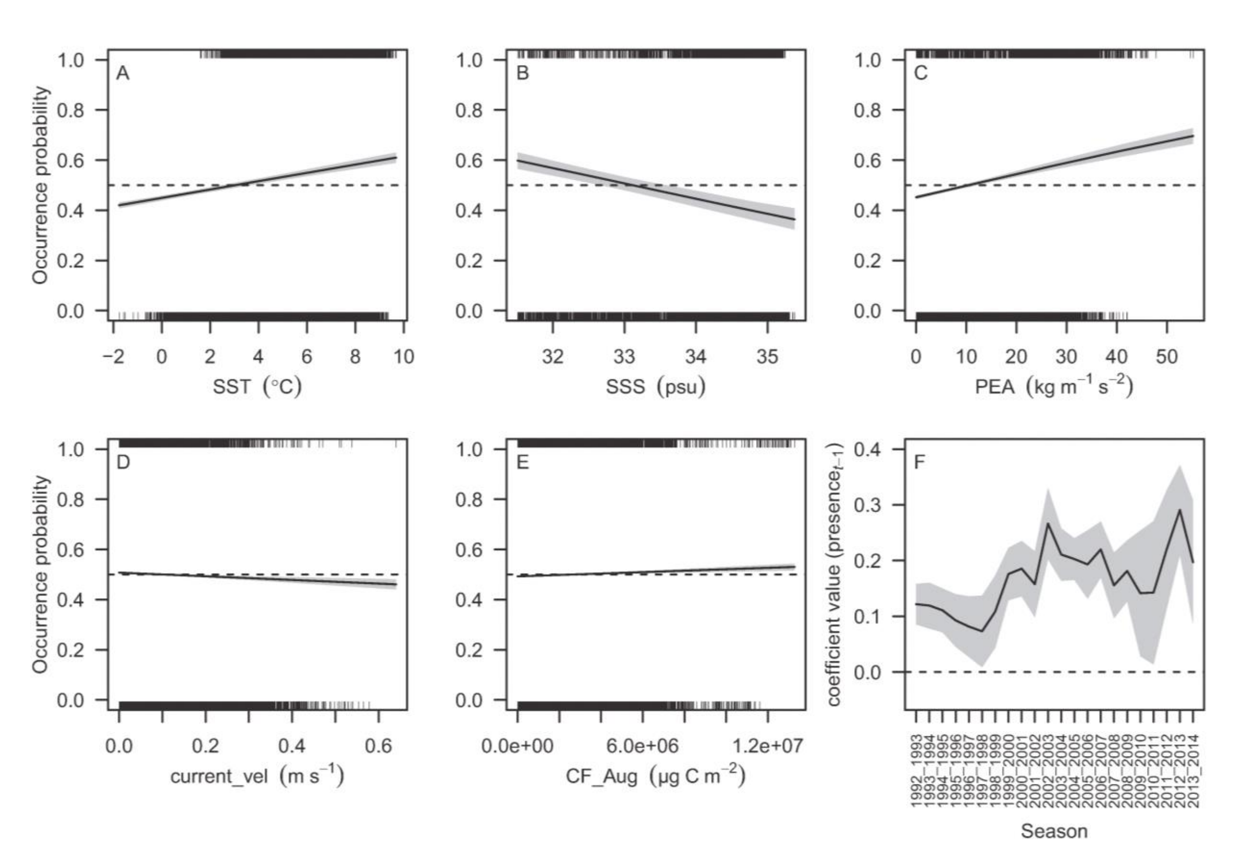
Results – spatial predictions



- Models accurately predicted the observations for each year of the time series...
- Both in years when the wintering area stayed the same.
- And, when the distribution shifted to a new location.

Results – covariate influence

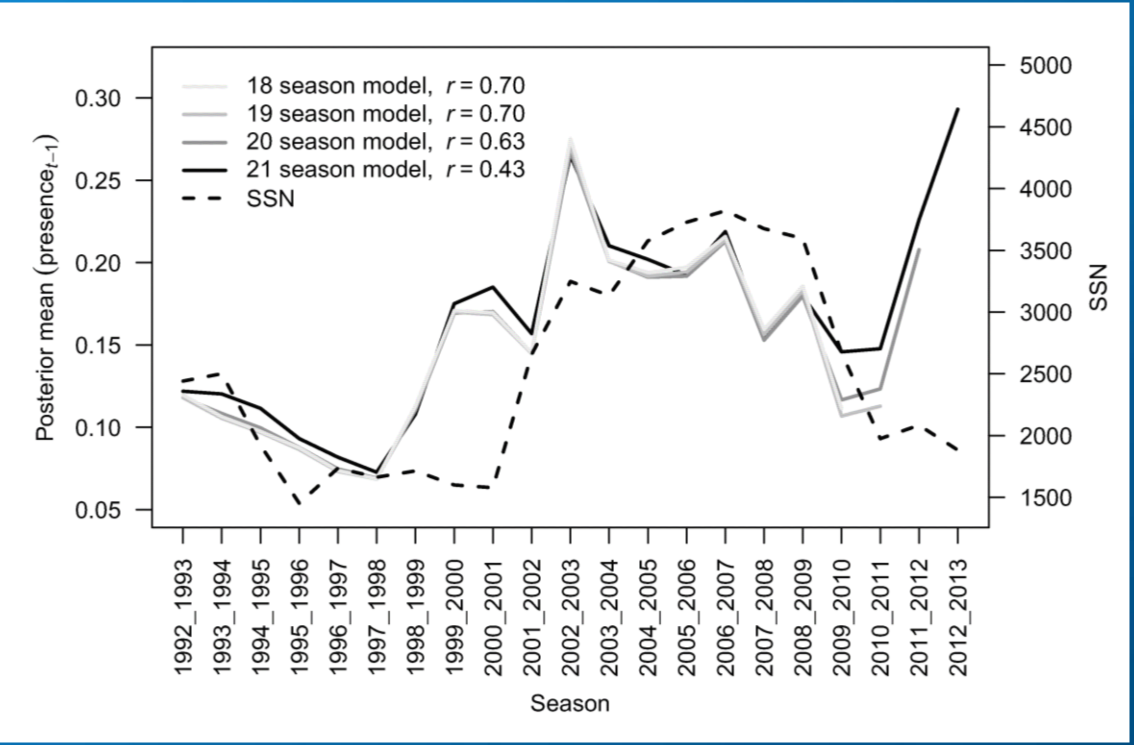
- Warmer
- Fresher
- ↑ stratified
- ↓ velocity
- ↑ zooplank.



- Recent fishing activity and static environment variables had little influence.

Results – demographic effects?

- Strong correlation between the population size and the probability of herring returning to the same wintering area.



- Suggests that prediction of the winter distribution one-year ahead is possible…

Results – prediction one-year ahead

- Prediction to last four seasons of the time series.

Season	*r*	cv AUC	cv Brier score
2010_11	0.704	0.961	0.142
2011_12	0.703	0.976	0.137
2012_13	0.631	0.976	0.129
2013_14	0.432	0.588	0.194

- Performance was good in three out of four seasons.
- Unusual mass mortality events forcing the SSN estimate down, concurrent with strong overlap in fished area b/n 2011_12 and 2012_13.

Discussion

- Our model gave highly accurate spatial predictions both within the time series, and to independent observations one-year ahead.
- The occurrence pattern of herring in one winter was the best predictor of where they were the next.
- Environmental factors (i.e. temperature, salinity, stratification, summer prey avaliability) were also influential.
- Attachment to wintering sites increased with adult population size.

Conclusions

- Collective learning often influences decision making in animal societies.
- Yet, capturing such phenomena in large-scale spatial models remains challenging.
- The models presented here attempt to incorporate these processes in an intuitive, flexible framework.
- The approach and predictions can (we hope!) benefit ecologists, fishers and fisheries managers alike.