

# Do eggs collected in surveys accurately reflect adult fecundities?

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# Measurements of fecundity

- Spawning stock biomass (SSB)
- Population fecundity
- Stock reproductive potential (SRP)



# Population fecundity

- Potential: Number of maturing oocytes
- Realized: Number of eggs in the Sea

**How well do they match?**

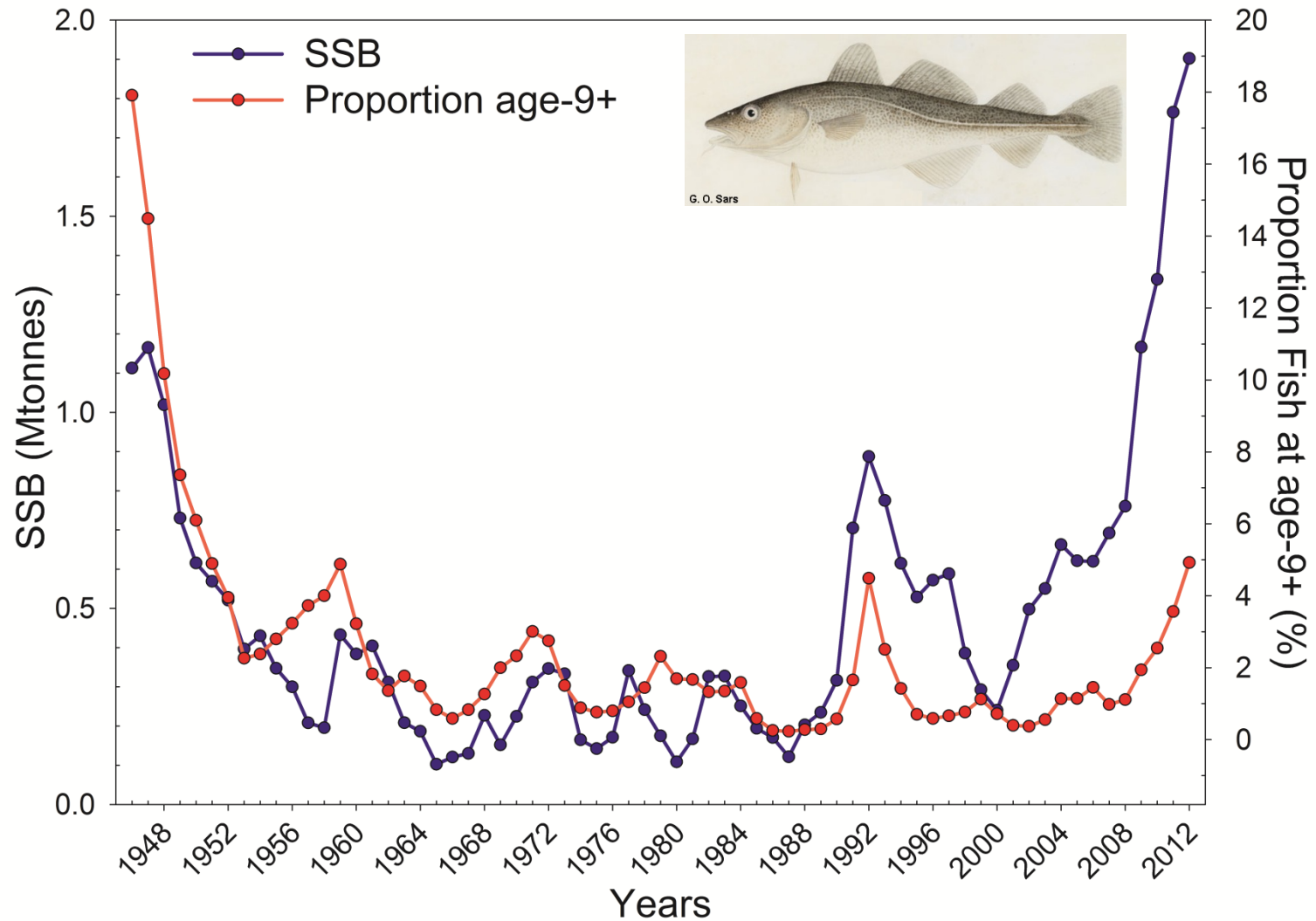


# Sources of Error

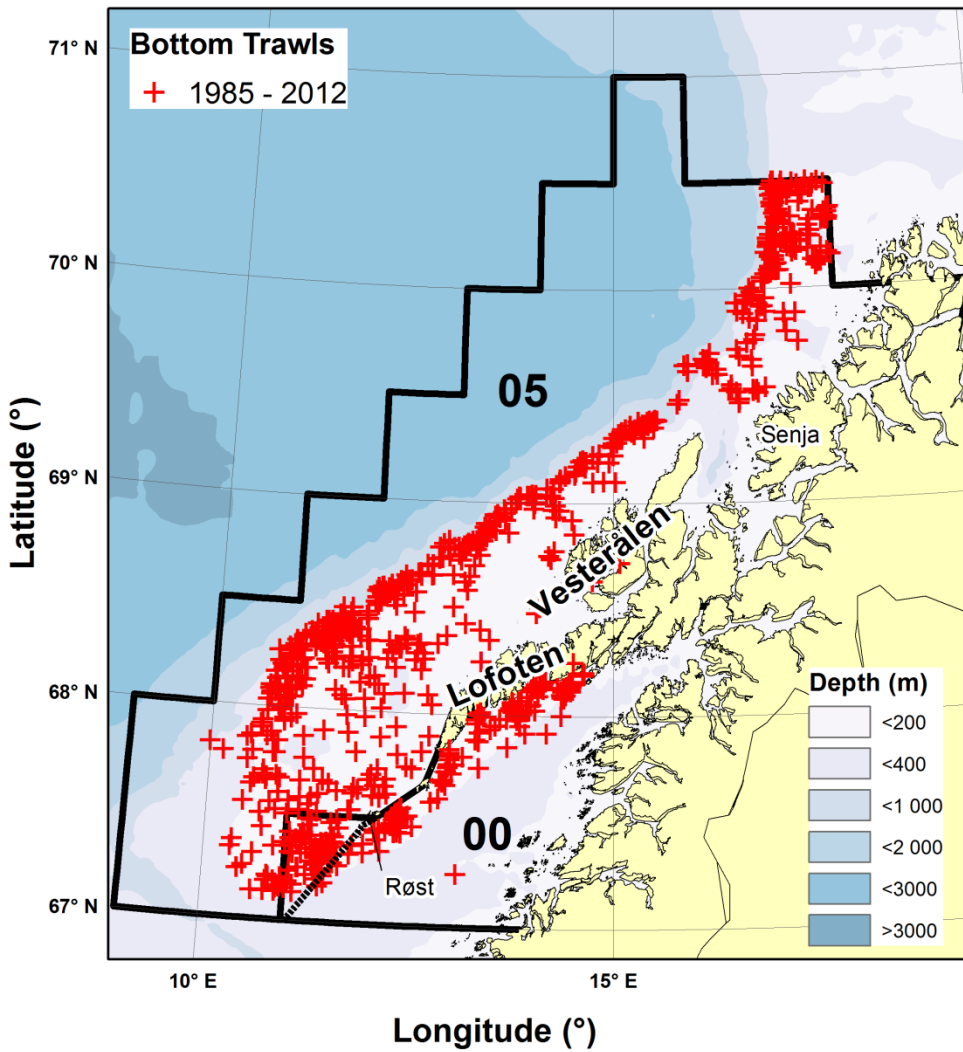
- Sampling error
- Size and age structure
- Atresia
- Egg mortality
- Movement between different batches



# North East Arctic cod



# Spawning migration survey



Mar. – Apr., since 1985

Acoustics

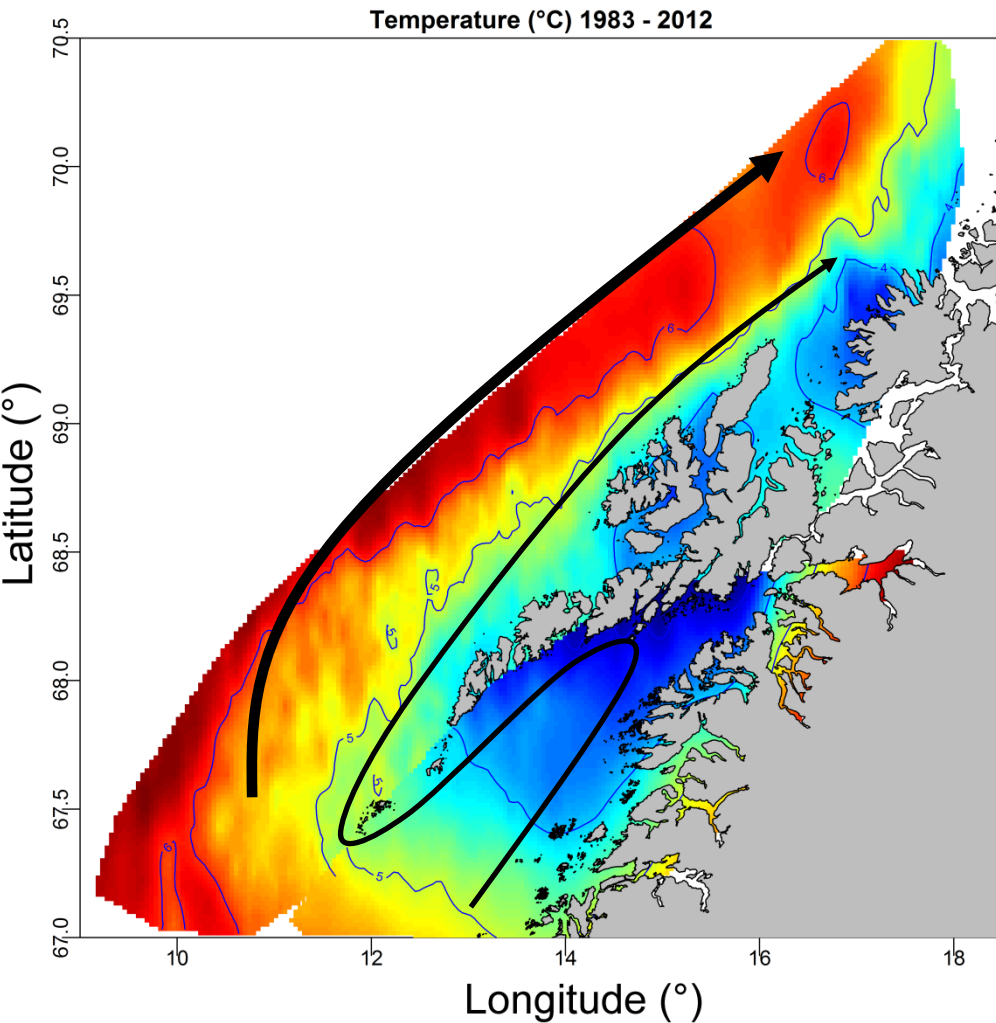
CTD

Bottom Trawls (N=902)

Ichthyoplankton (N=2114)



# Temperature at 30 m



- Offshore: Warm Atlantic water
- Inshore: Cool runoff influenced water
- Cooling in Vestfjorden



# Models of Stage I egg distribution

Generalized additive mixed models (GAMMs)

$$y_i = X_i\beta + f_1(x_{1i}) + f_2(x_{2i}) + \dots + f_n(x_{ni}) + Z_ib + \varepsilon_i$$

Separate for areas 00 (Vestfjorden) and 05 (Yttersida)

Models for presence/absence and non-zero abundance

## Fixed Factors

- Local temperature at 30 m
- Bottom Depth
- Proportion of old fish (age-9+)
- Regional temperature index (Kola transect)

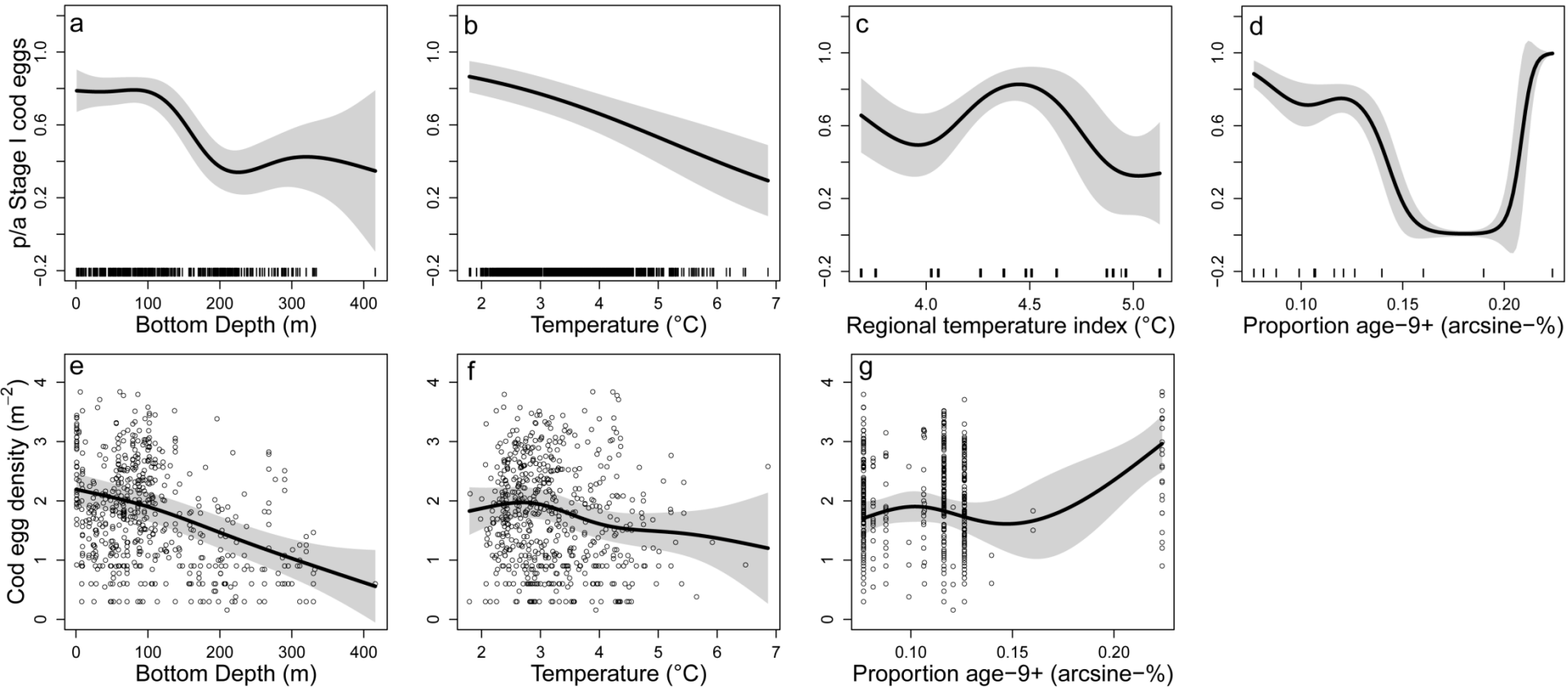
## Random Factors

- Autocovariate
- Median Year Day



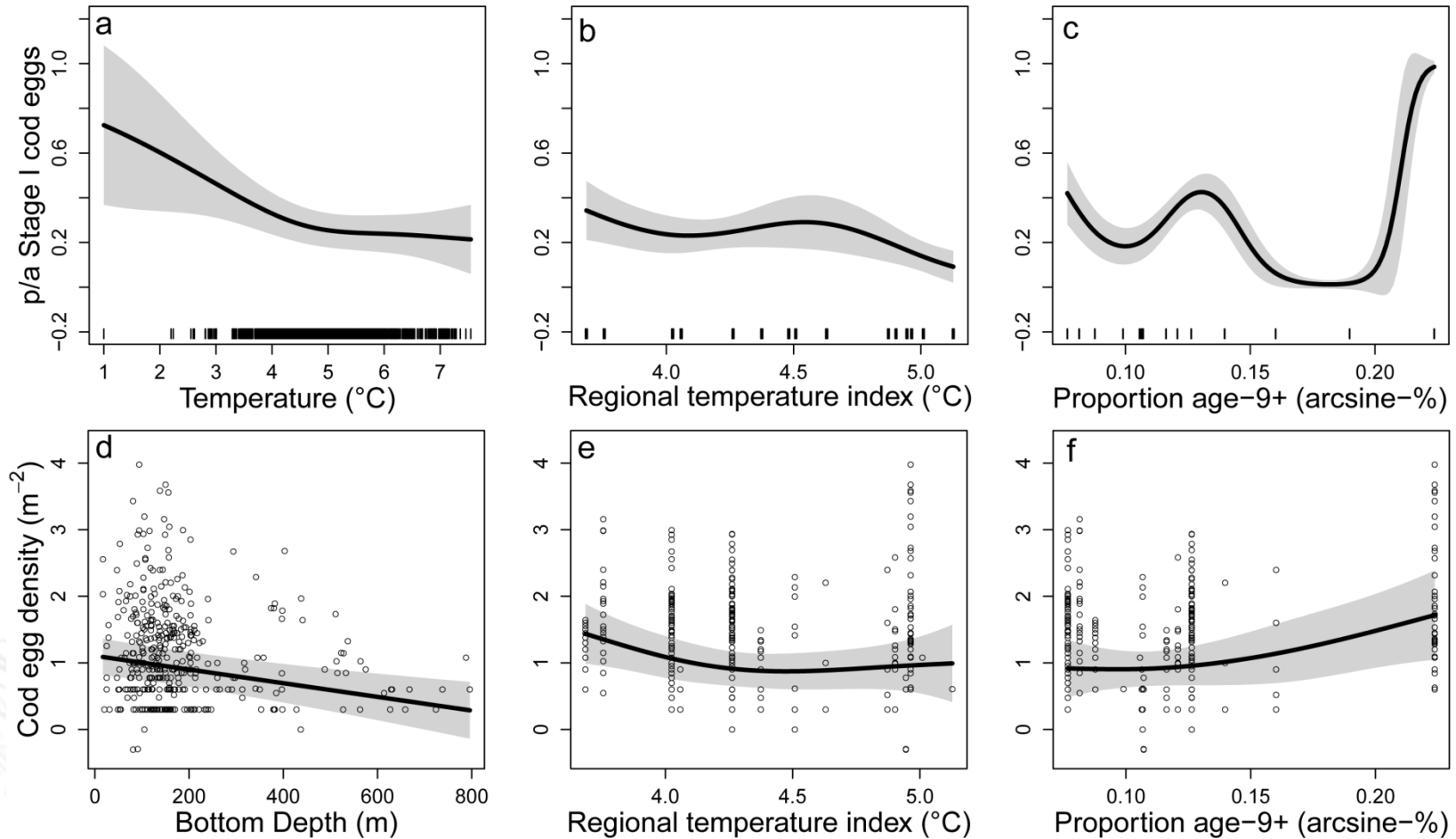


# Models of Stage I egg distribution – 00 Vestfjorden



Höfle et al. 2014

# Models of Stage I egg distribution – 05 Yttersida



Höfle et al. 2014

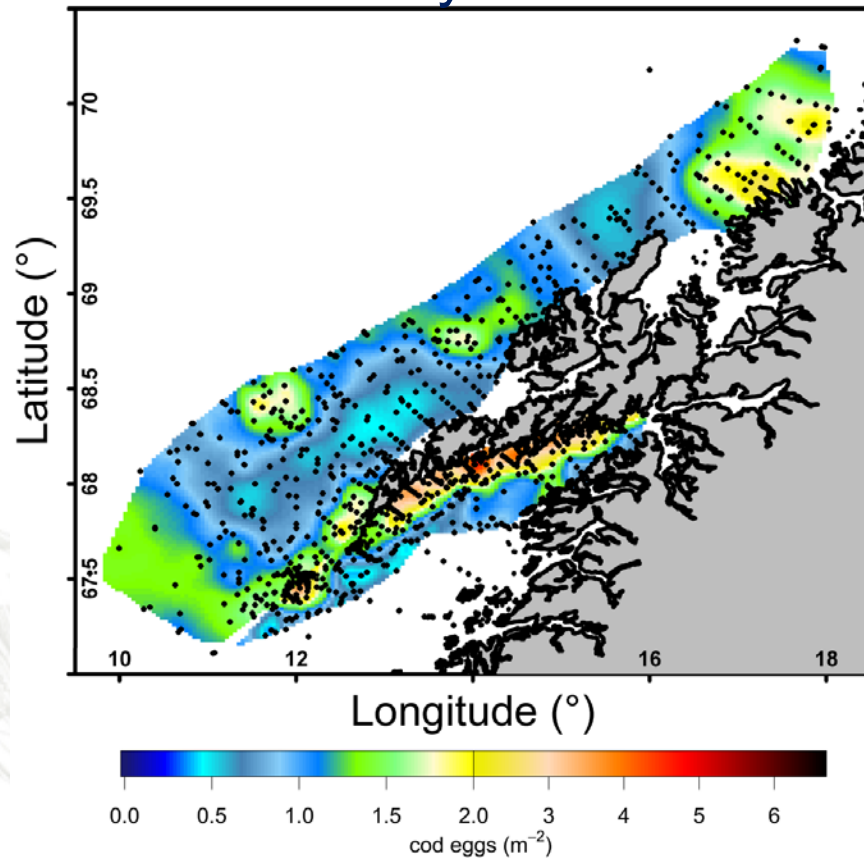


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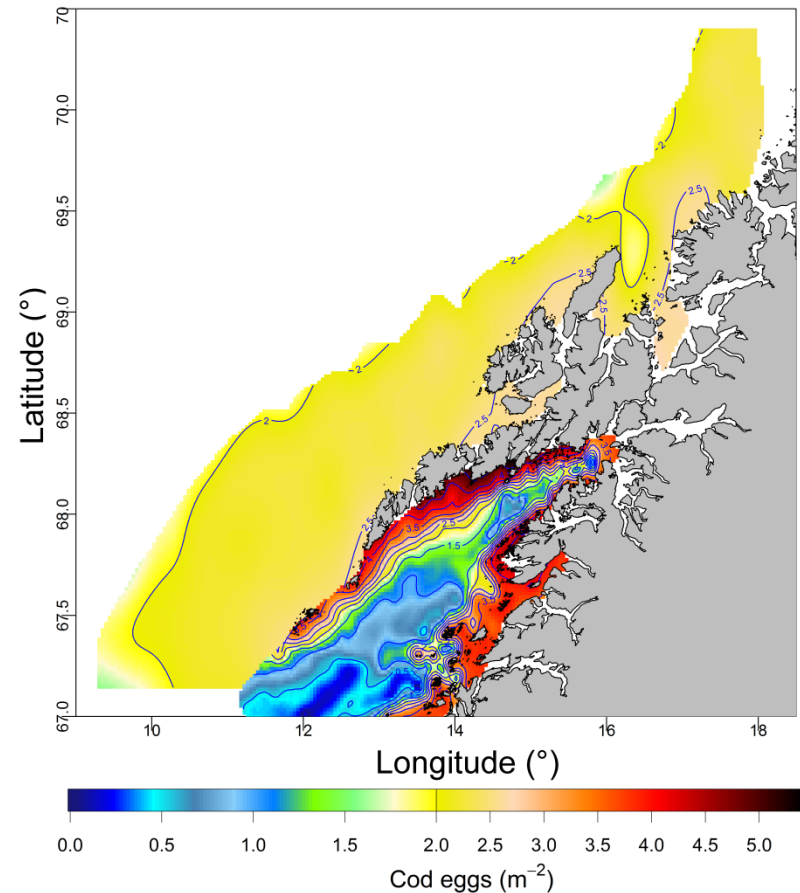
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# Real and modeled egg distribution

## Survey Data



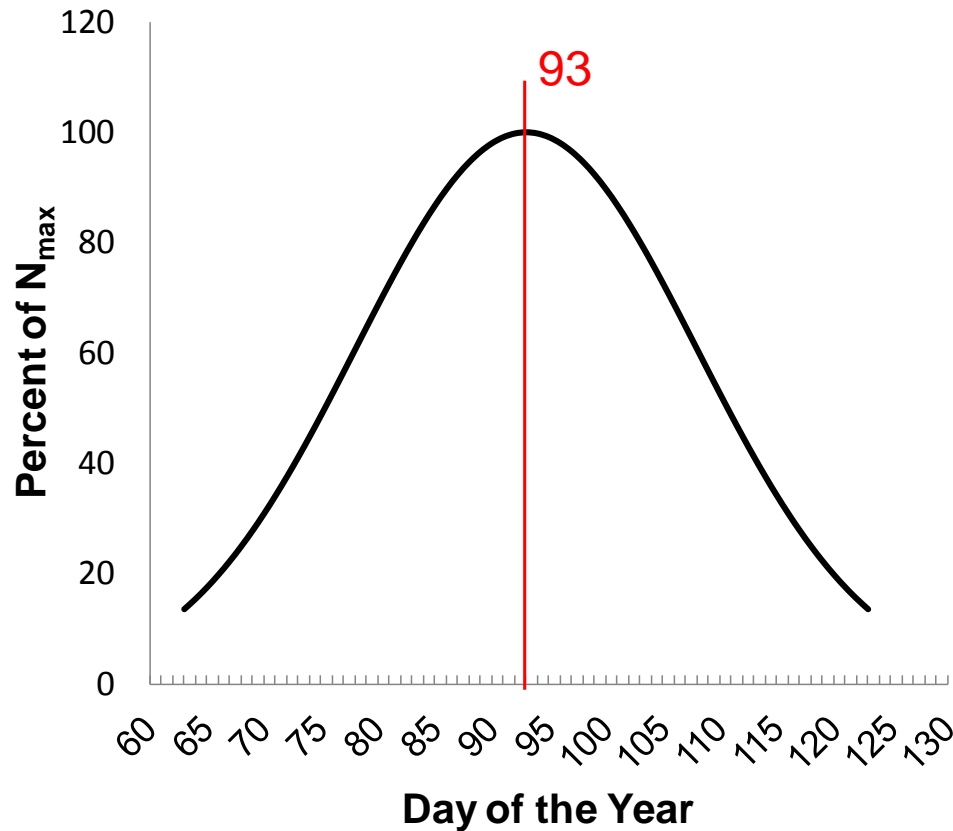
## Model



Höfle et al. 2014



# Scaling to annual egg production



$$N_{(t)} = N_{max} e^{\frac{-1}{2\sigma^2}(t-t_{max})^2}$$

$\sigma$  .... Standard Deviation

$t$  .... Day of the Year

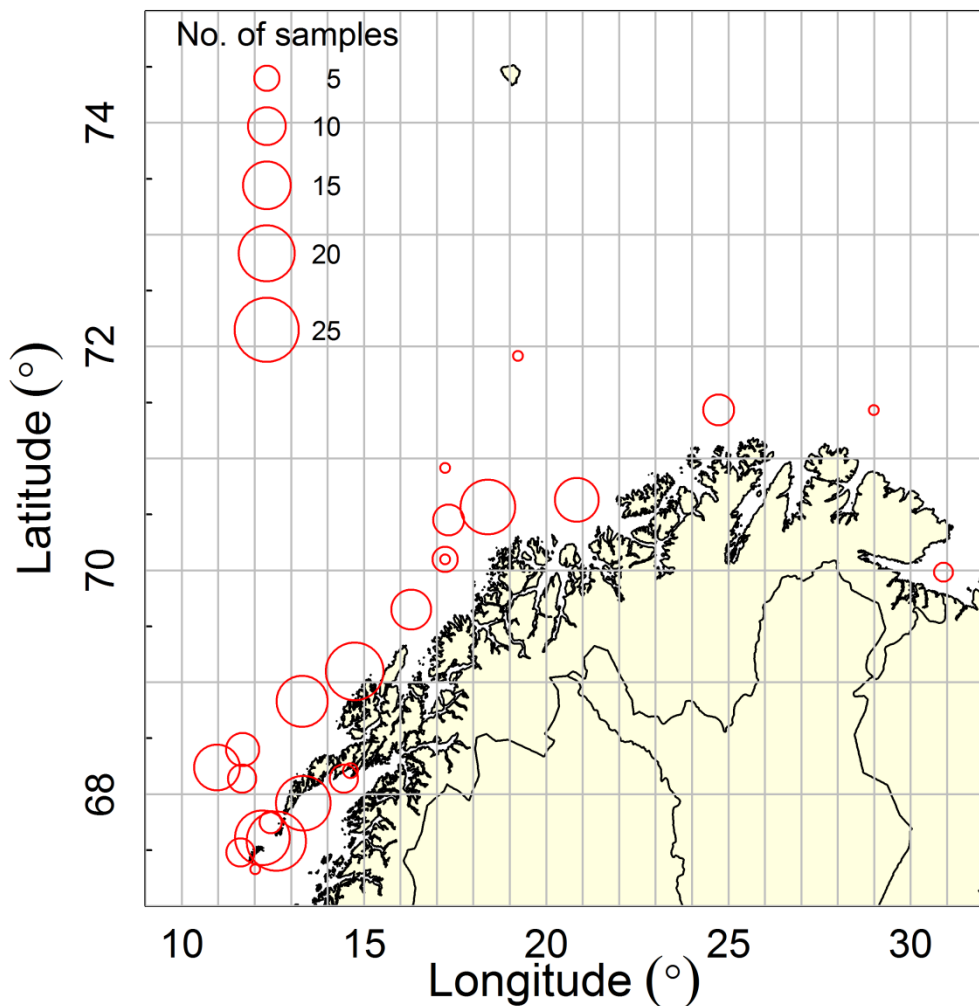
$N_{(t)}$  .... No. eggs at day  $t$

Peak spawning: Days 93 and 98 (>69°N)

Standard Deviation: 15



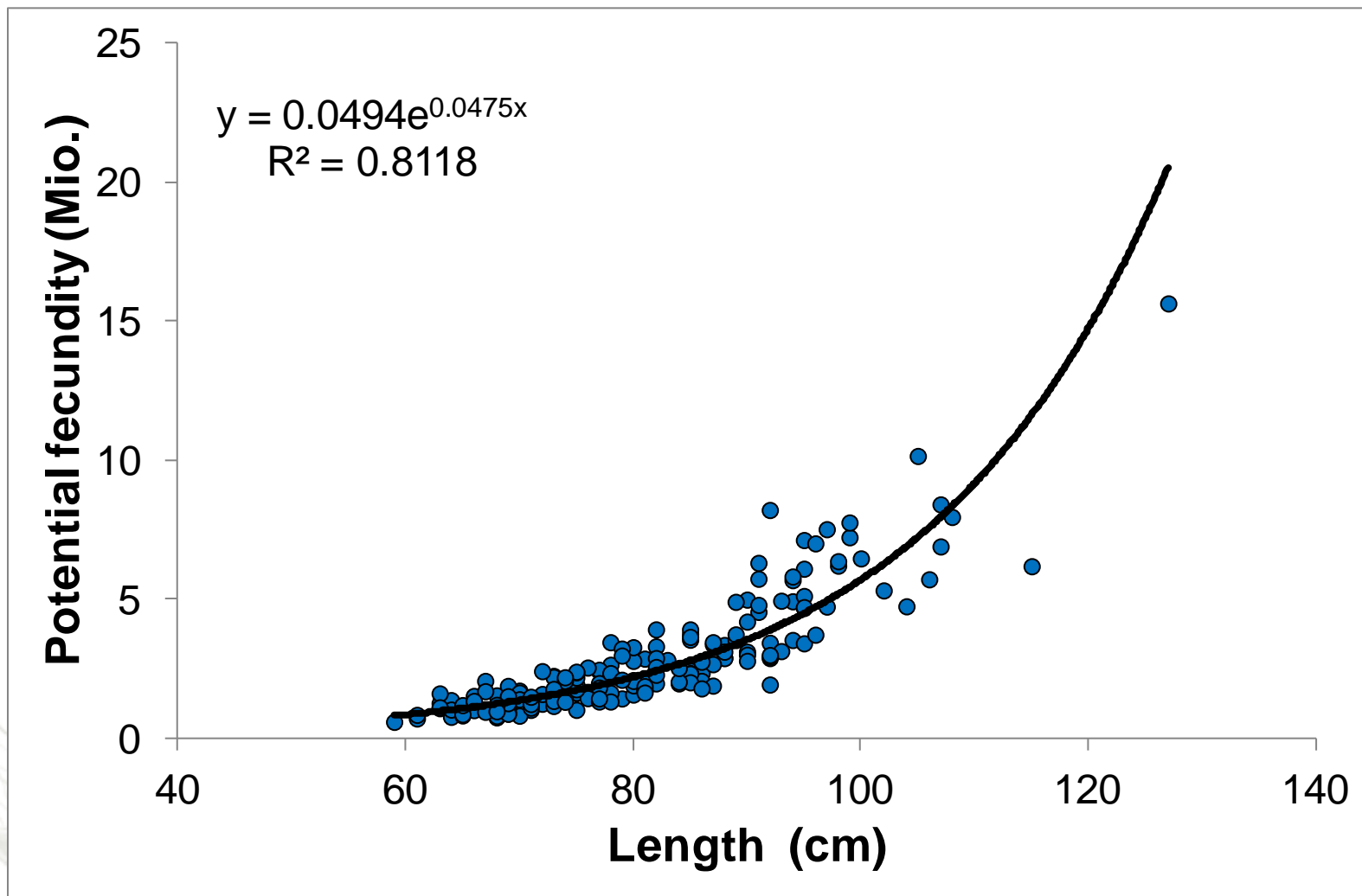
# Potential fecundity – NEA cod



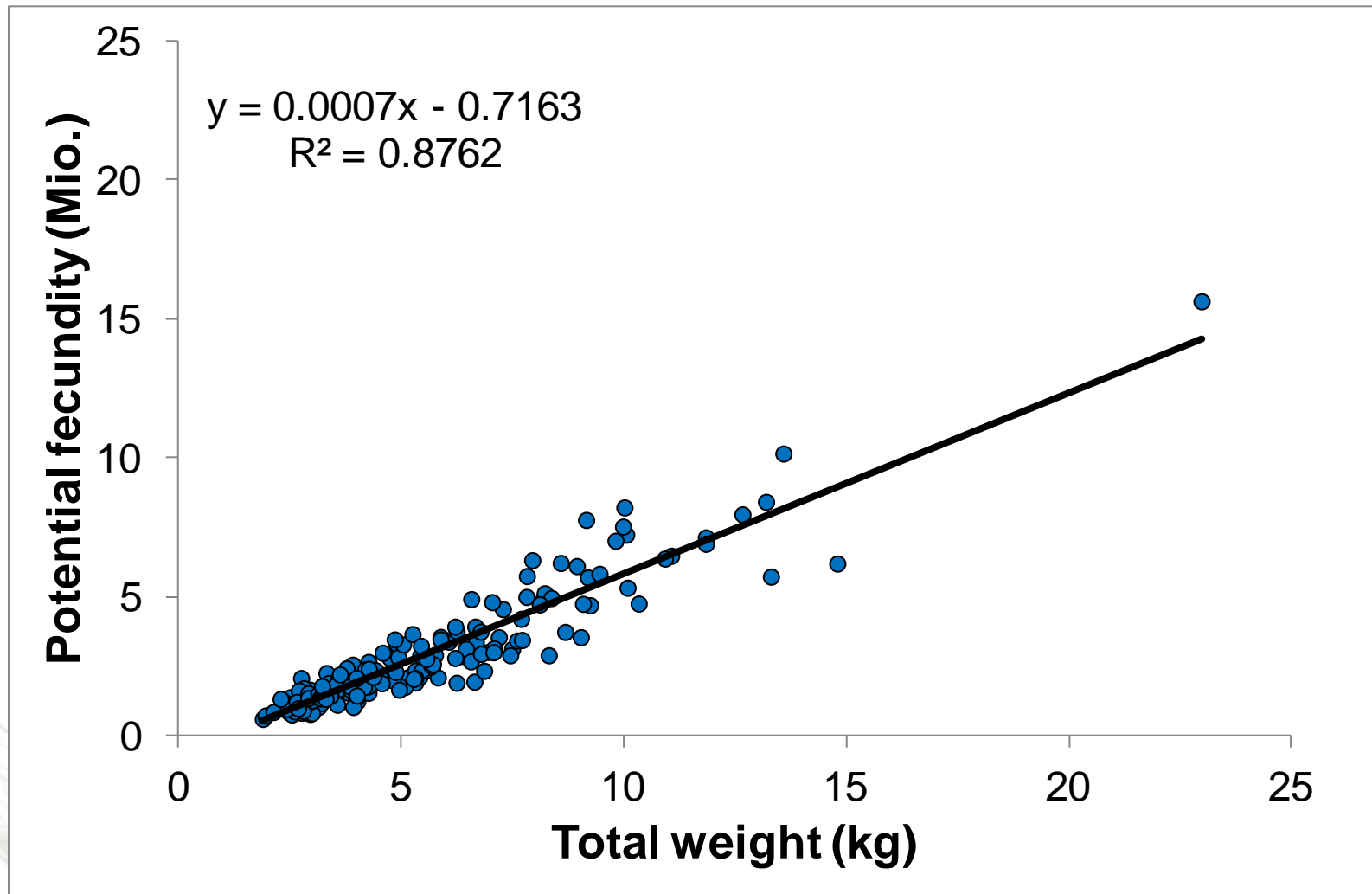
- Gonad samples
- Winter and Lofoten cruise
- 191 fish
- Number and size of oocytes
- Image analysis (auto-diametric)



# Potential fecundity vs. length



# Potential fecundity vs. weight

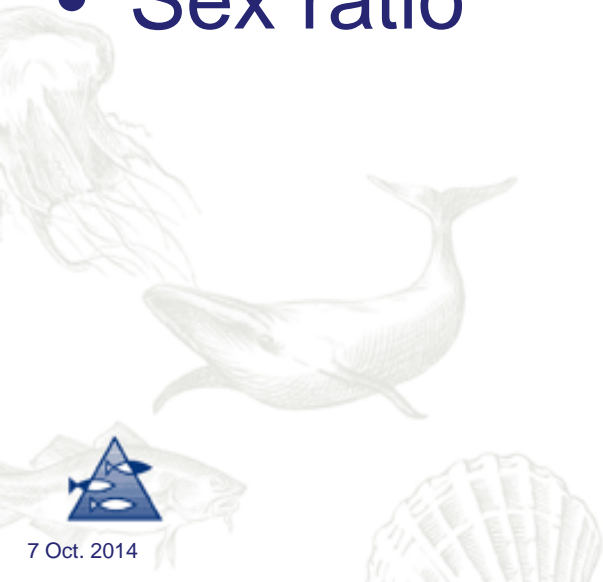


# Scaling to population fecundity

- Length and Weight based formulae

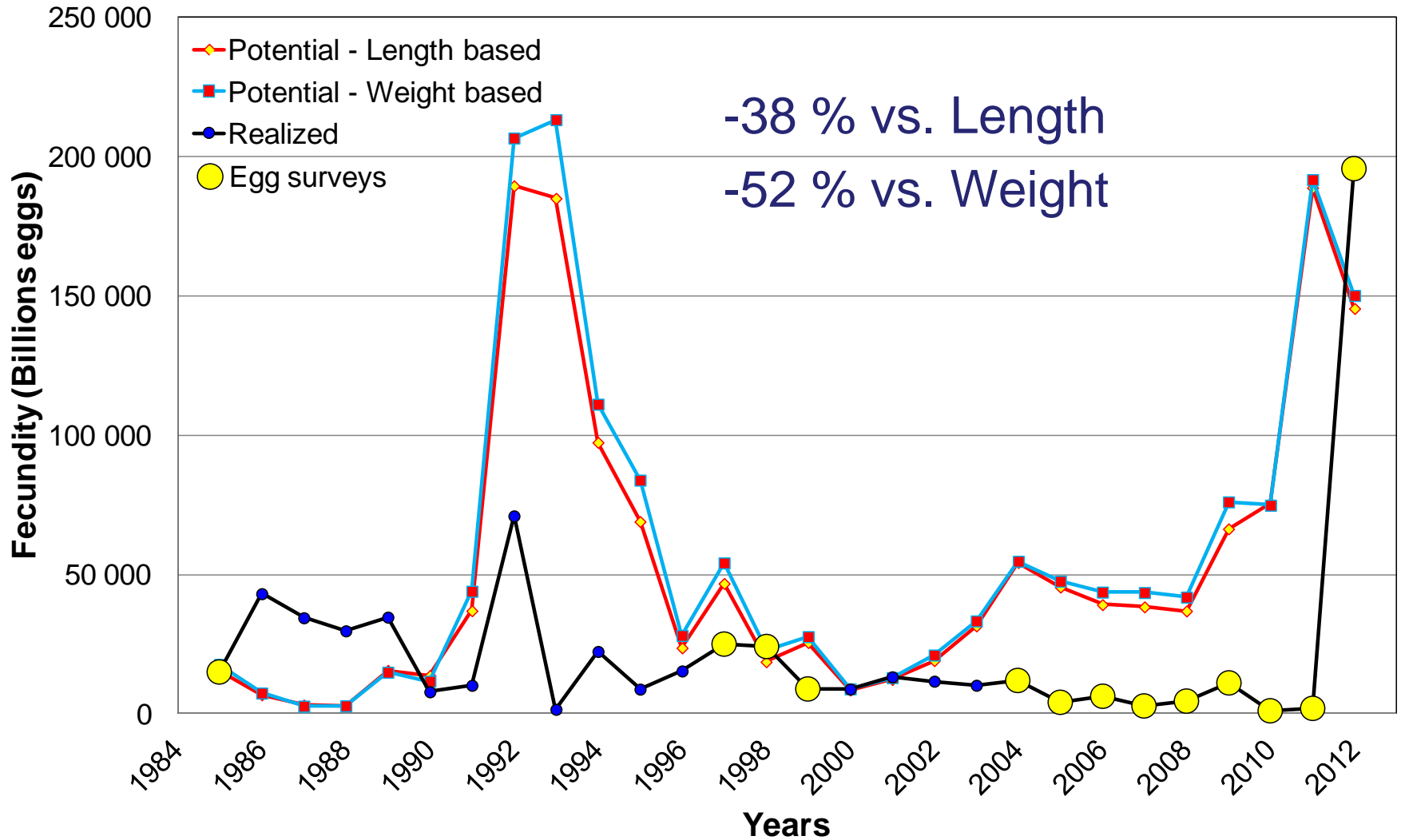
## Data from Stock assessment and survey

- Length, weight, maturity and numbers at age
- Sex ratio





# Potential and realized fecundity



# Conclusion and outlook

- Highly variable relationship of realized and potential fecundity

## What next?

- Include atresia, mortality and drift
- Resolve spatial distribution of fecundities



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