Incorporating BSFRF side-by-side catchability studies in the Tanner crab assessment

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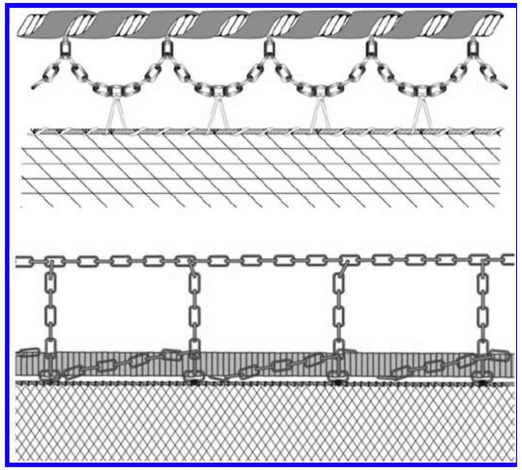
Introduction

- BSFRF and NMFS conducted joint catchability studies focused on Tanner crab
  - 2013-2018
  - side-by-side (SBS) tows
    - simultaneous start
    - 0.5 nmi separation
    - same tow direction
- BSFRF
  - modified Nephrops trawl assumed* to capture ALL crab in gear path
  - 5-minute tow
  - net equipped with mensuration gear to determine area swept
- NMFS
  - standard EBS 83-112 bottom trawl gear
  - standard 30-minute tow
  - standard net mensuration gear to determine area swept

footropes

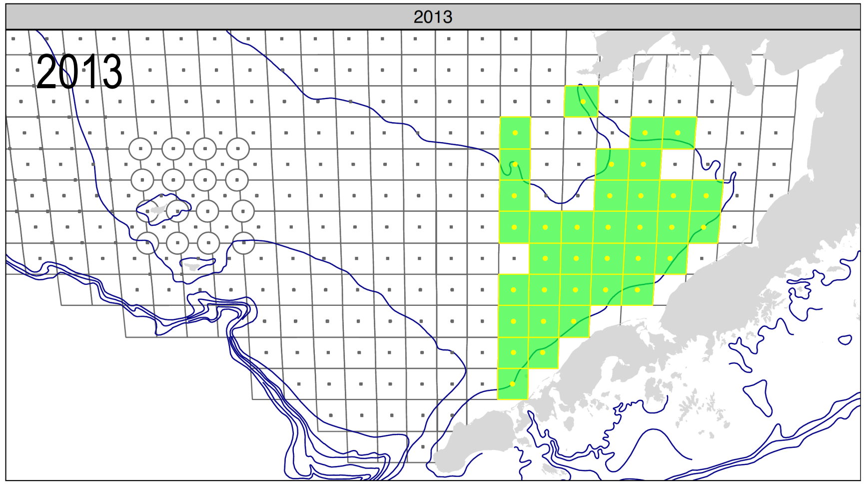
83-112

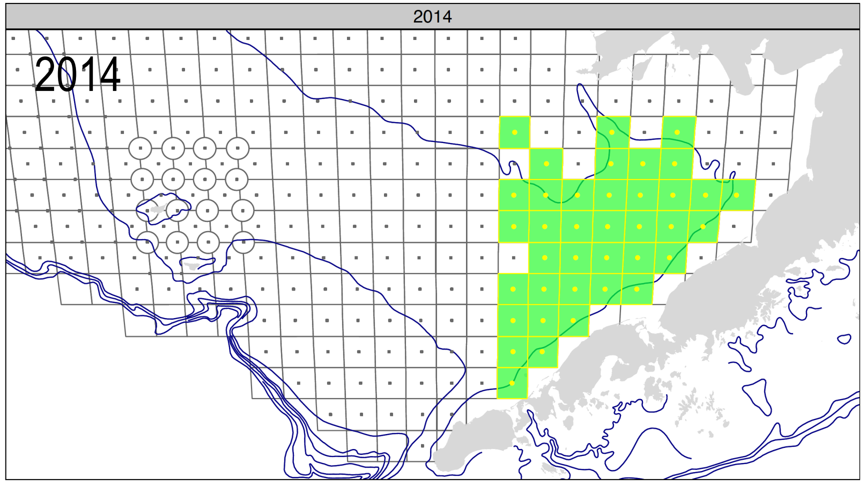


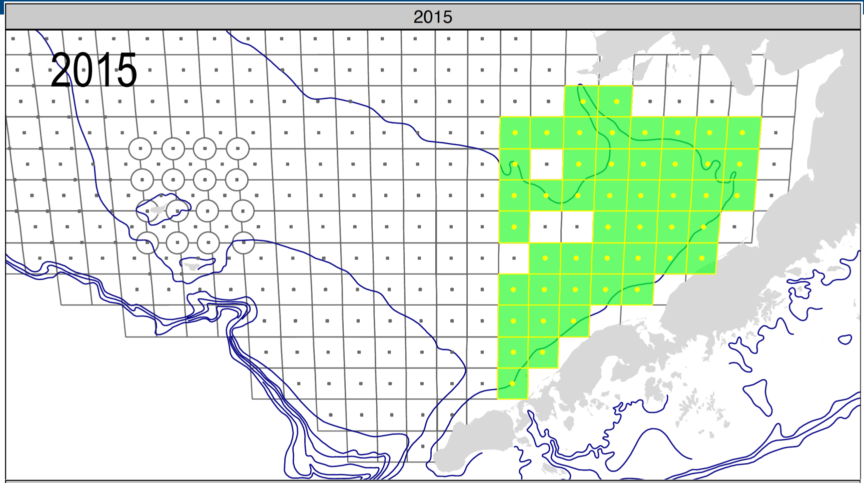
nephrops

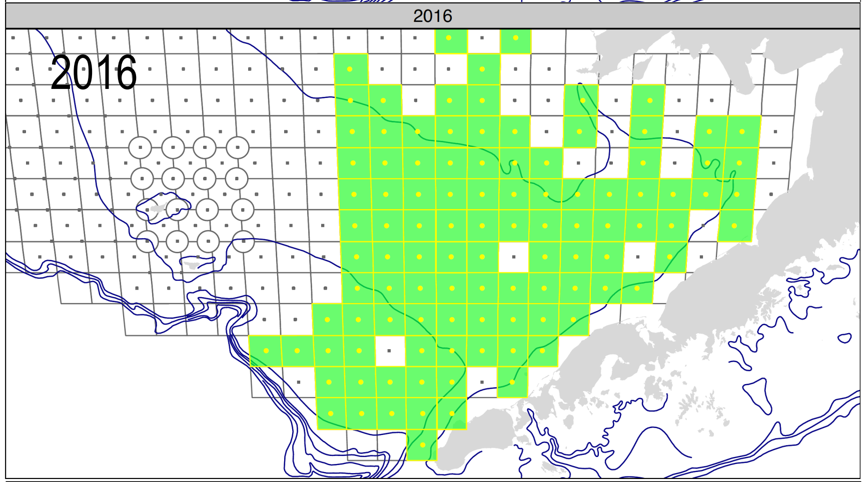
*-Kotwicki et al (2017) present evidence this is not true for snow crab at large sizes

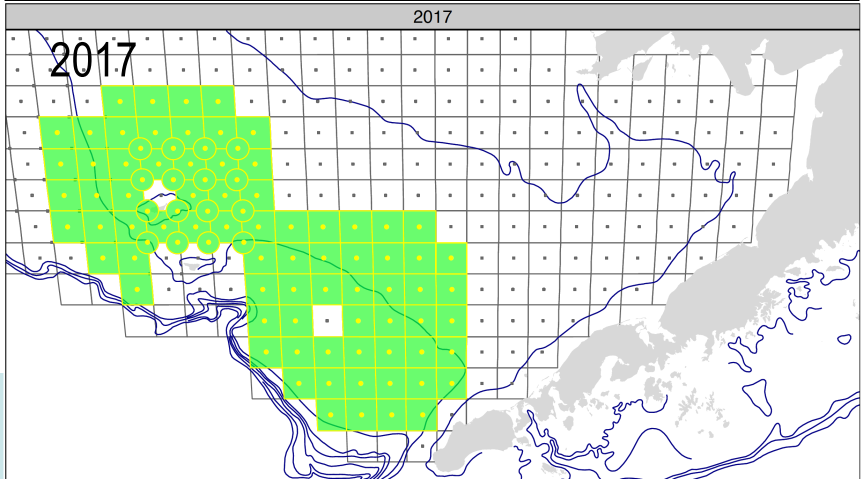
SBS Study Areas



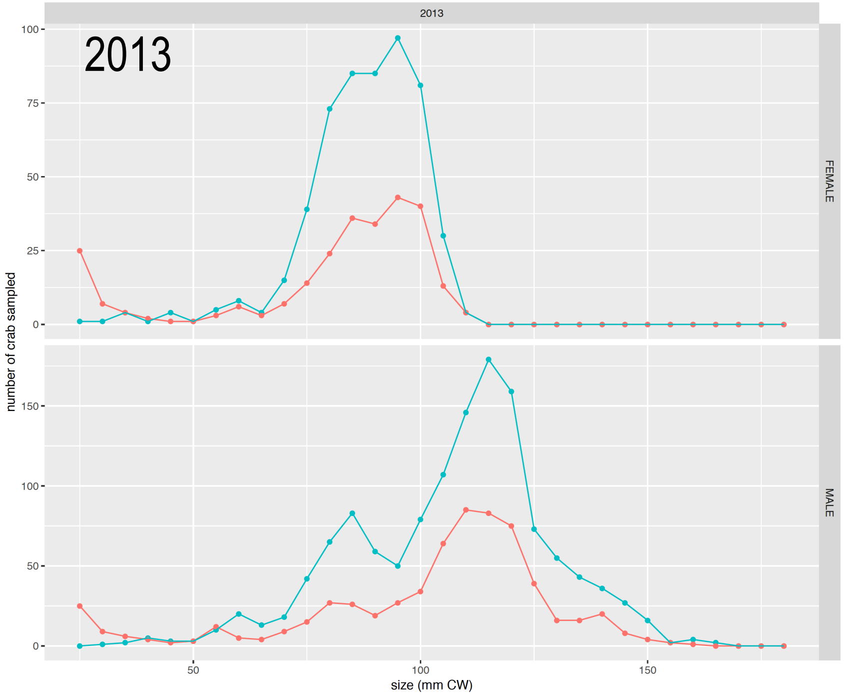


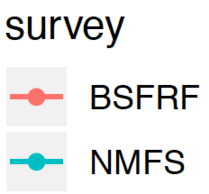


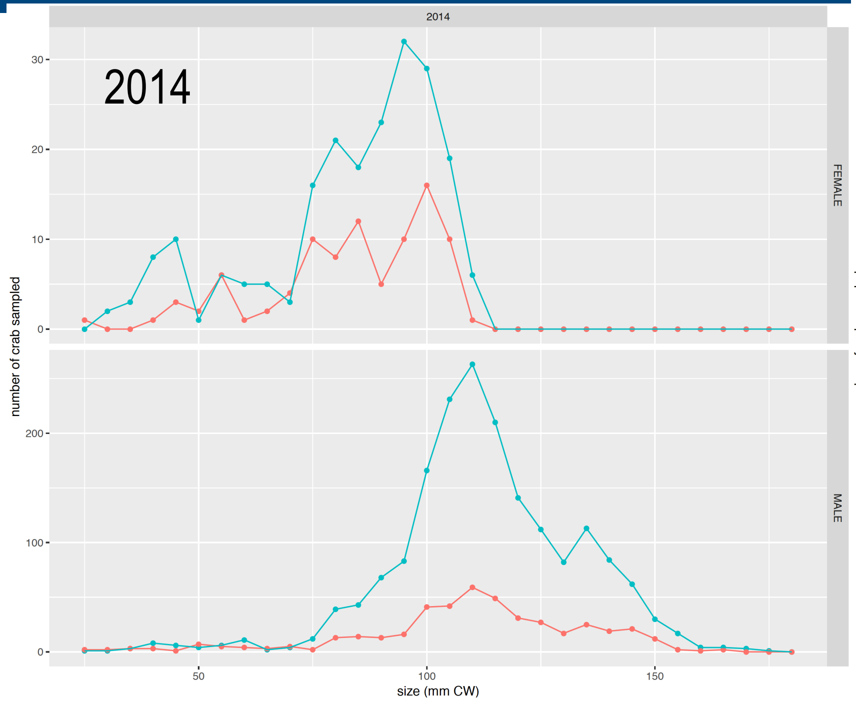


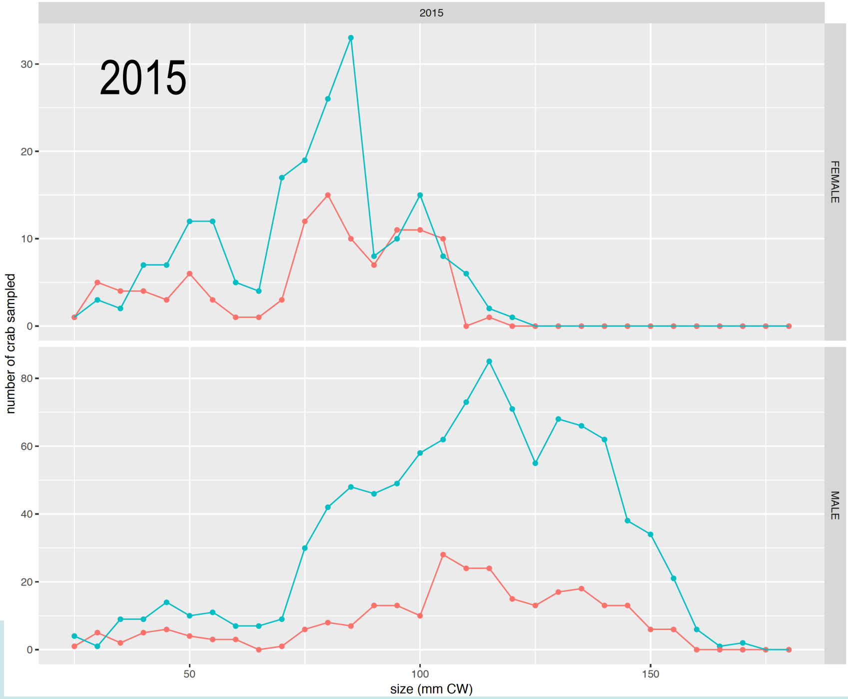


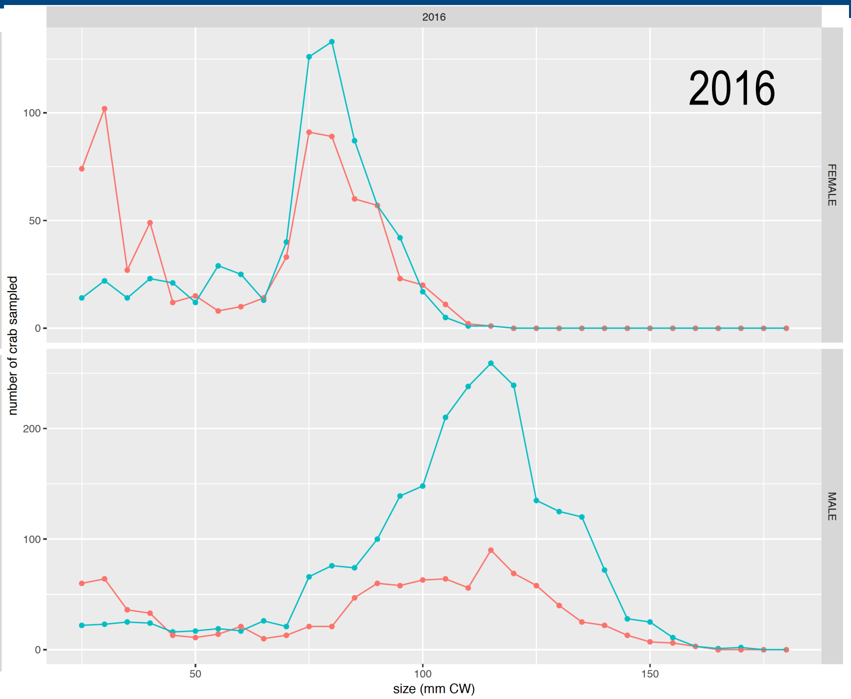
SBS catchability studies: number of crab caught

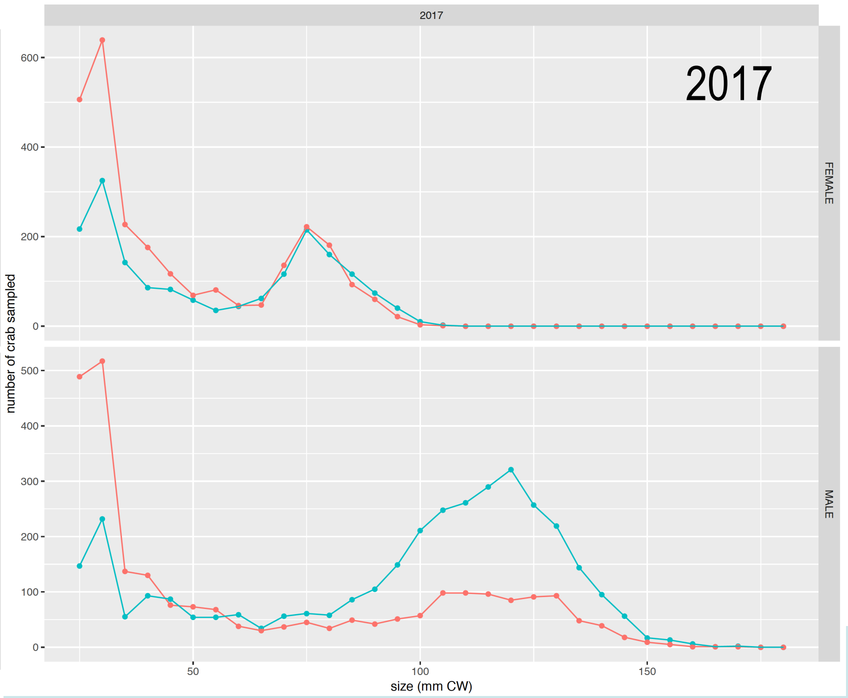












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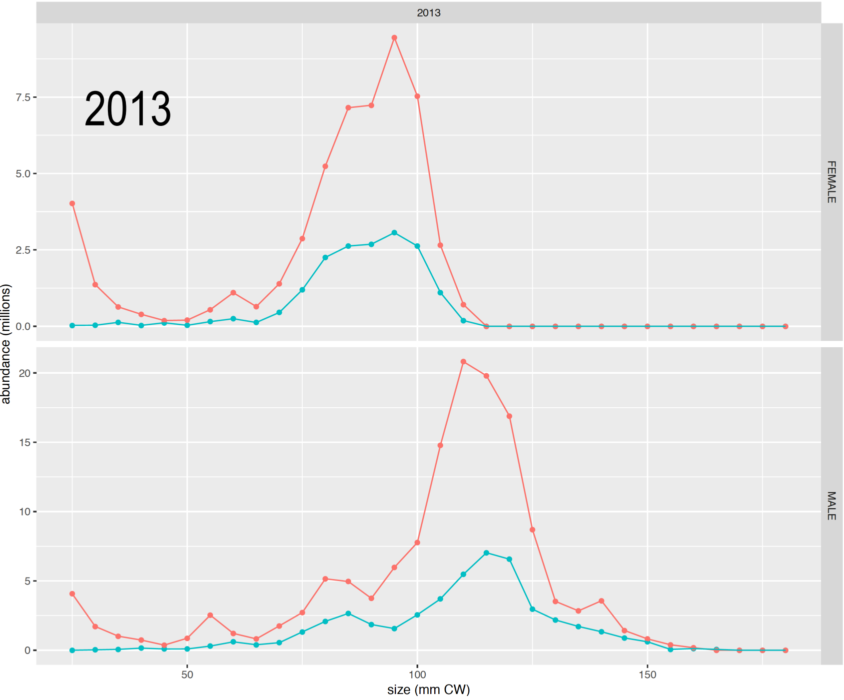
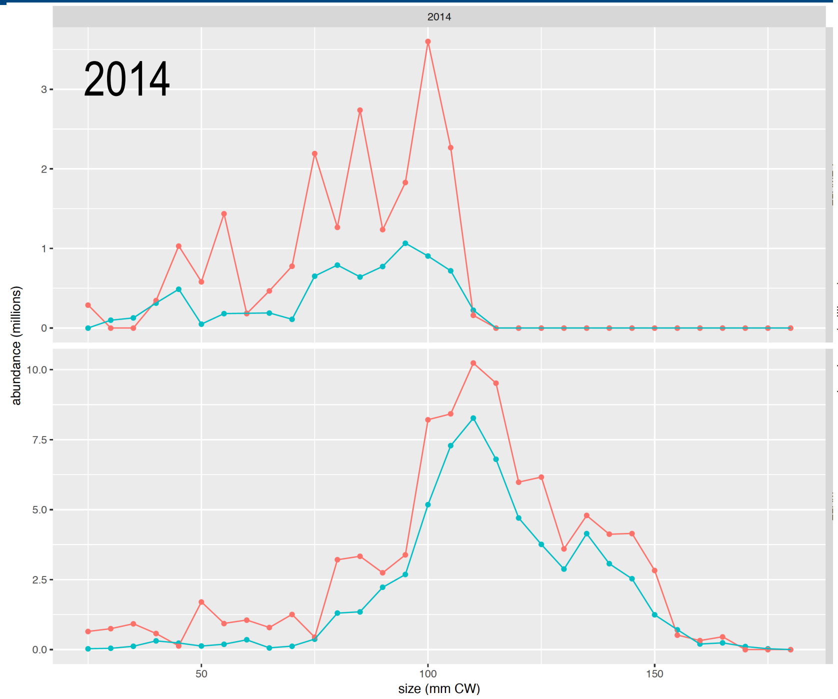
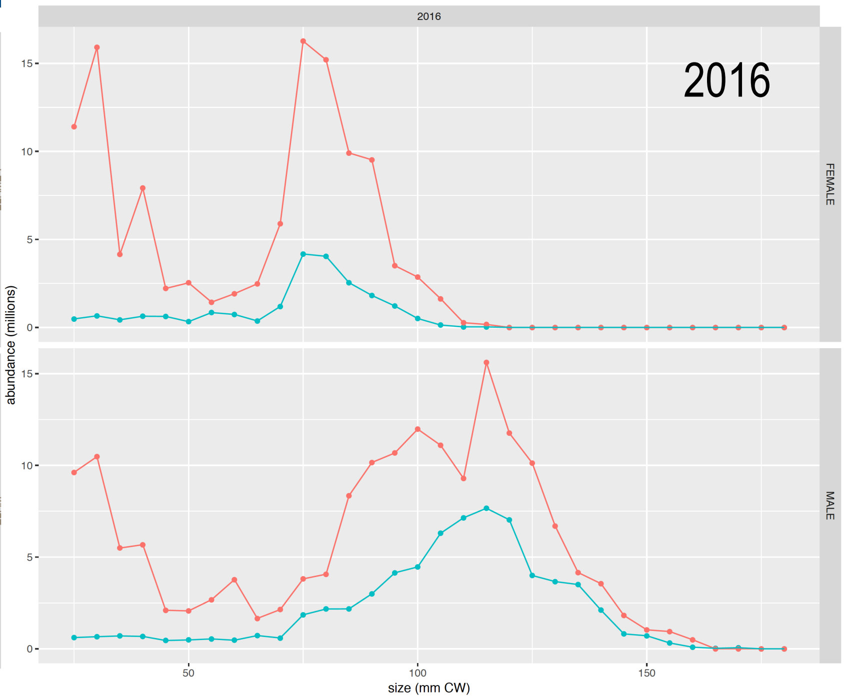
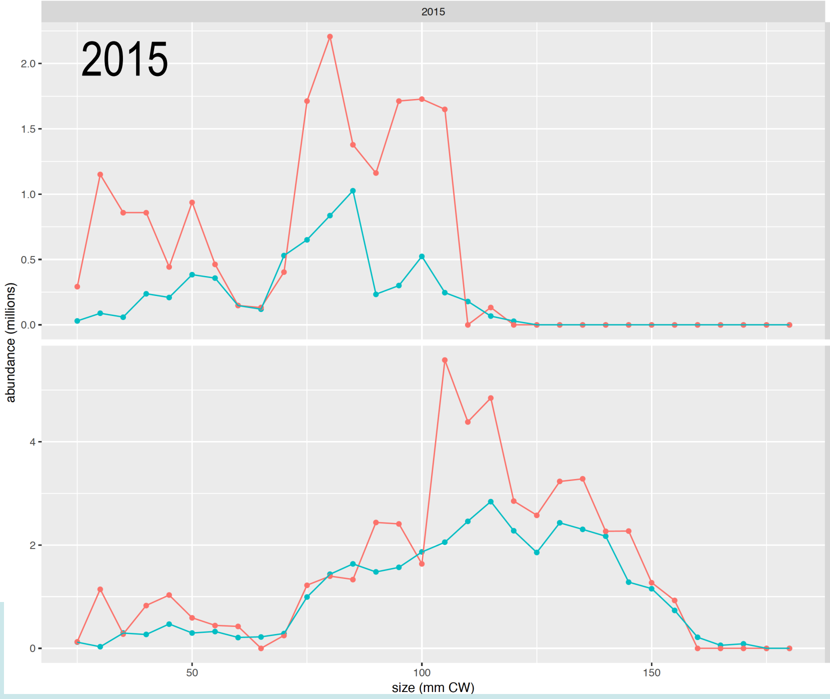
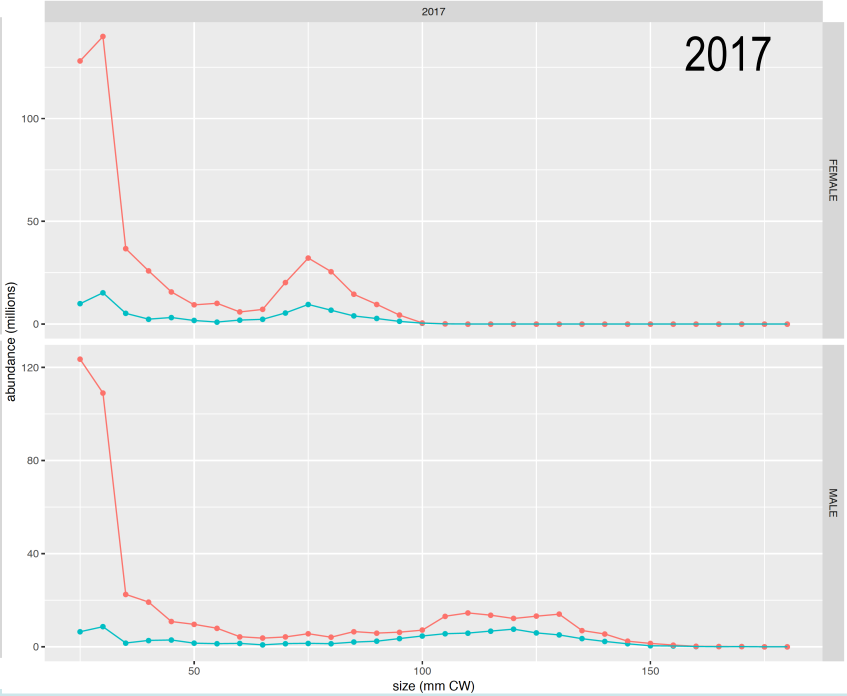
SBS catchability studies: area-swept abundance











survey

BSFRF

NMFS

Availability and catchability relationships

$$N_z^{survey} = A_z^{survey} \cdot C_z^{survey} \cdot N_z^{population} \qquad C_z^{survey} = q^{survey} \cdot S_z^{survey}$$

NMFS EBS ($A_z^{NMFS\ EBS} \equiv 1$): $N_z^{NMFS\ EBS} = 1 \cdot C_z^{NMFS\ EBS} \cdot N_z^{EBS}$

BSFRF SBS ($C_z^{BSFRF\ SBS} \equiv 1$): $N_z^{BSFRF\ SBS} = A_z^{SBS} \cdot 1 \cdot N_z^{EBS}$

NMFS SBS: $N_z^{NMFS\ SBS} = A_z^{SBS} \cdot C_z^{NMFS\ EBS} \cdot N_z^{EBS}$

Availability and selectivity in the assessment model

Availability

$$A_{x,z} = \frac{1}{1+\exp\left(-p_{x,z}\right)}$$

+ smoothness penalty $\mathcal{L}_S = \lambda \cdot \left[\nabla(\nabla p_{x,z})\right]^2$

Catchability

$$C_{x,z} = \frac{q_x}{1 + \exp\left(-\ln(19)\frac{(z - z_{50})}{\Delta_{95-50}}\right)}$$

Fits to

- NMFS EBS survey biomass and size compositions
- NMFS SBS survey biomass and size compositions
- BSFRF SBS survey biomass and size compositions

Empirical estimation outside assessment model

Availability

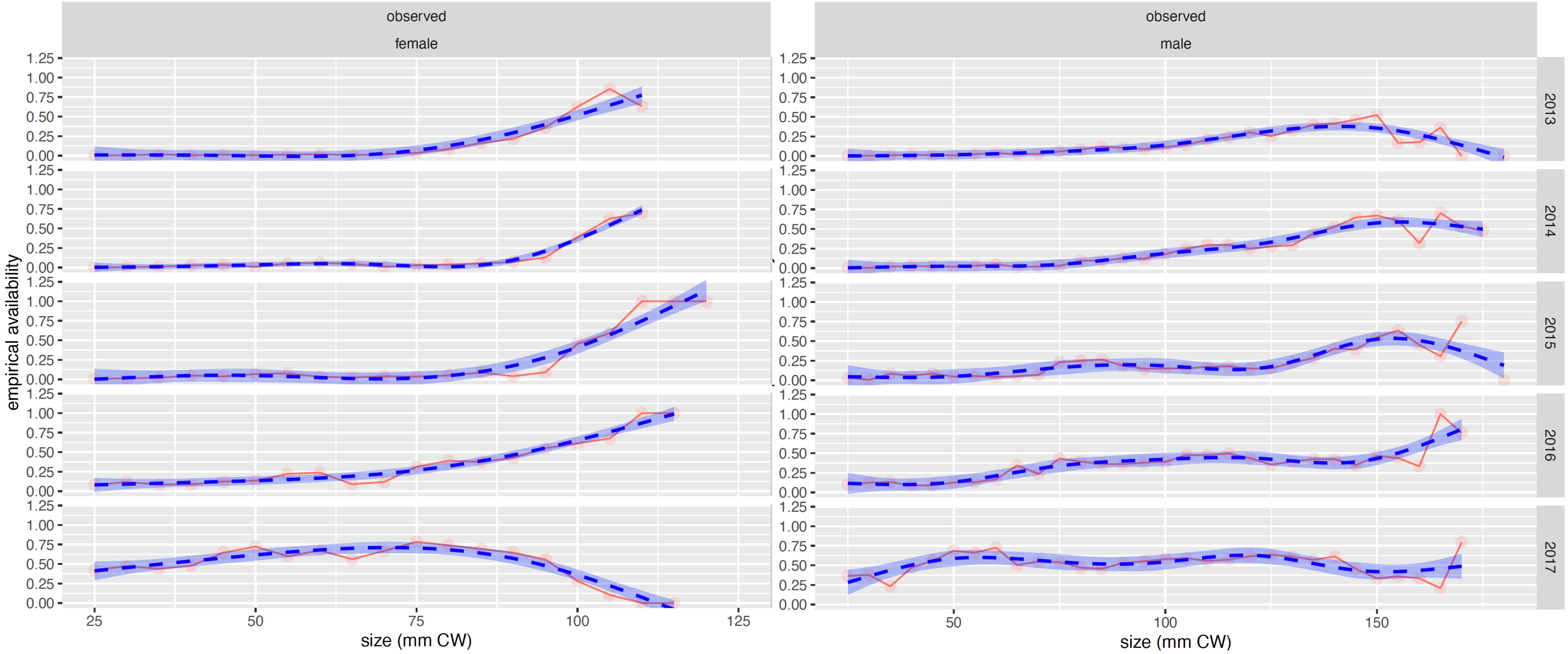
$$A_z^{SBS} = \frac{N_z^{NMFS\ SBS}}{N_z^{NMFS\ EBS}} \cdot e^{\varepsilon_z}$$

Catchability

$$C_z^{NMFS\ EBS} = \frac{N_z^{NMFS\ SBS}}{N_z^{BSFRF\ SBS}} \cdot e^{\epsilon_z}$$

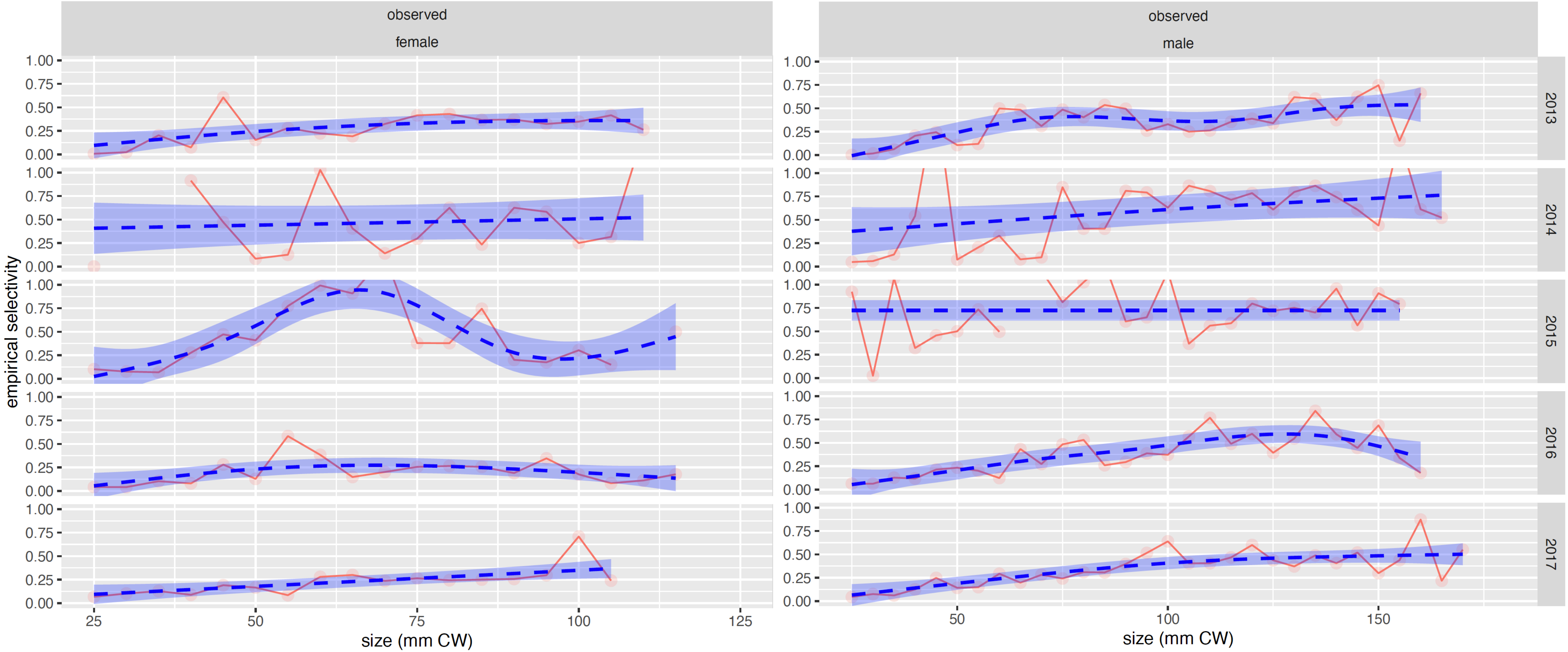
Empirical availability

$$A_{y,x,z}^{SBS} = \frac{N_{y,x,z}^{NMFS\ SBS}}{N_{y,x,z}^{NMFS\ EBS}}$$



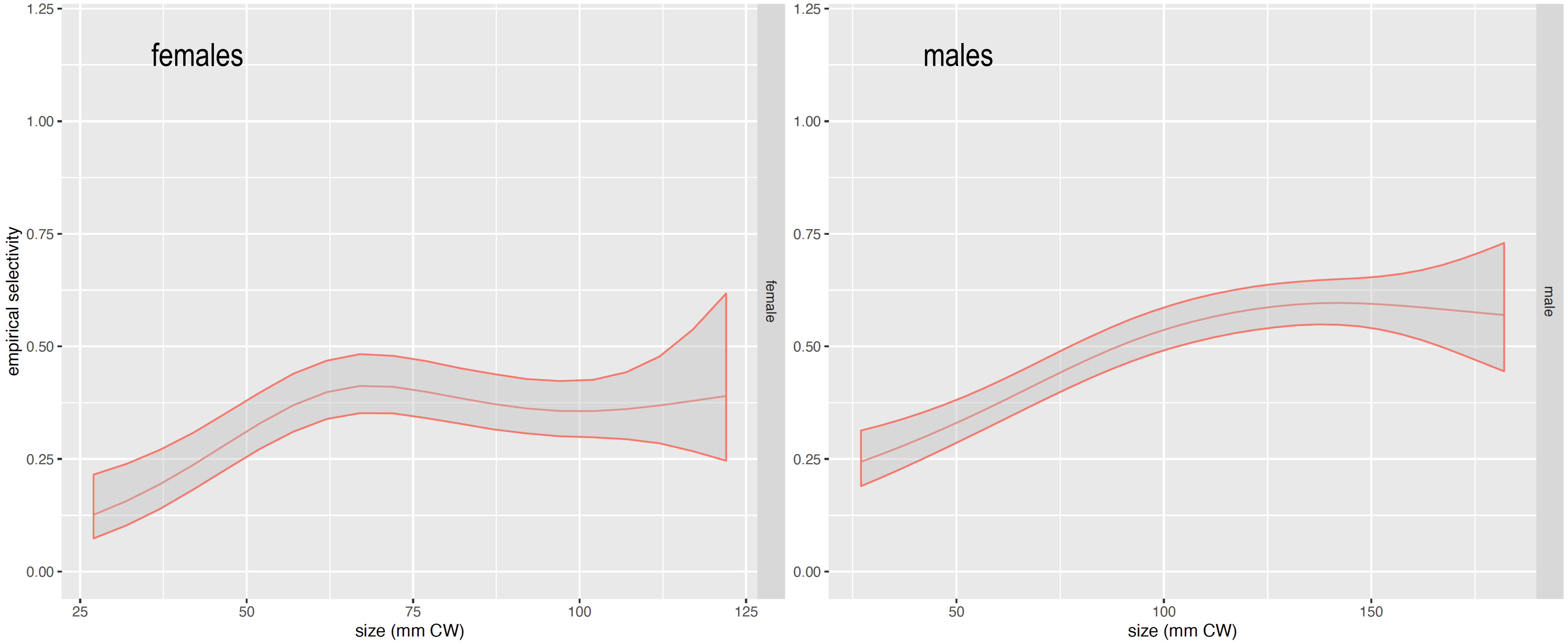
Empirical catchability

$$C_{y,x,z}^{NMFS\ EBS} = \frac{N_{y,x,z}^{NMFS\ SBS}}{N_{y,x,z}^{BSFRF\ SBS}}$$



"smooth " estimates are cubic splines

Catchability estimated from empirical catchability



smooth function of size

$$\ln\left(C_{y,x,z}\right) \sim s_x(z) + \epsilon_{y,x,z}$$

estimated using "gam" function in R package mgcv

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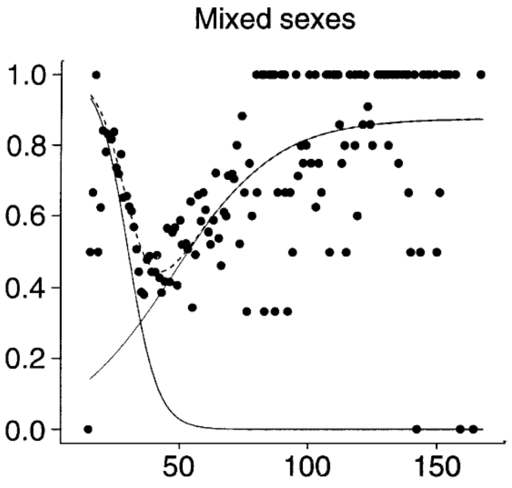
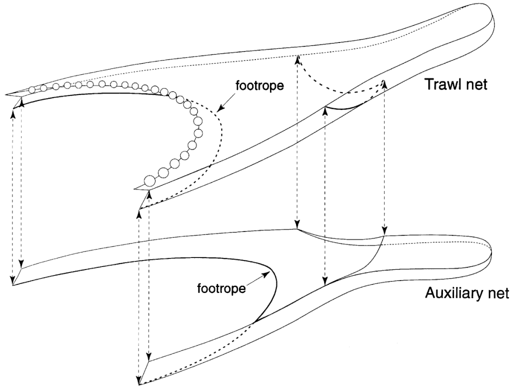
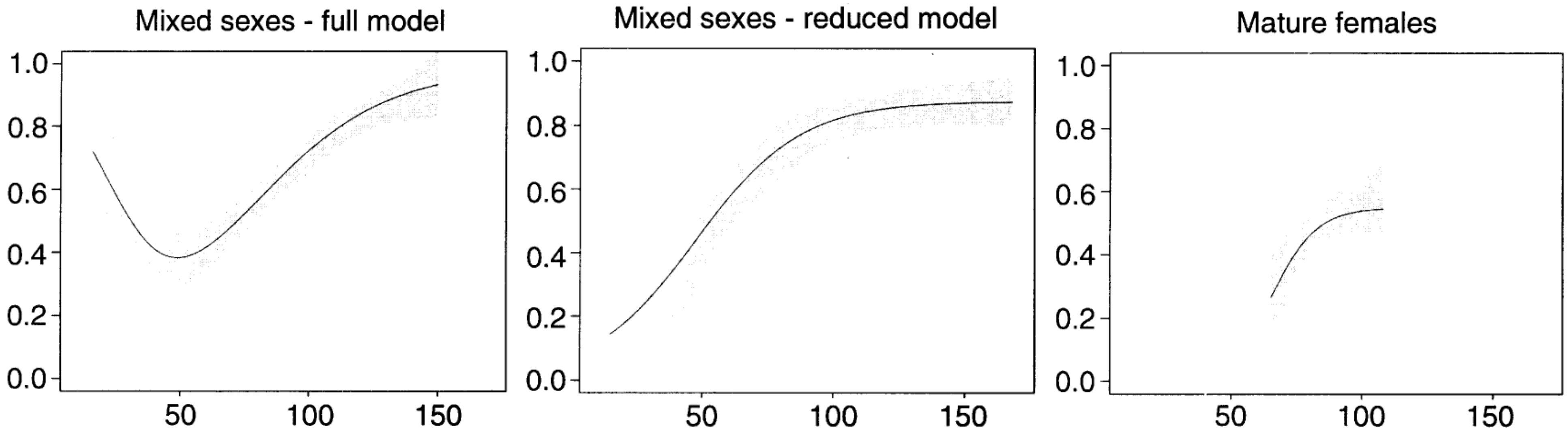
Other approaches: Somerton and Otto (1999) Underbag Experiment

- estimated “net efficiency” for Tanner (and snow) crab
- fit ascending, descending logistic curves
    - crab captured entering net through mouth
    - crab captured entering through mesh underneath







Somerton et al (2013): NMFS/BSFRF SBS Study

- snow crab targeted
- estimated ”relative net efficiency” of NMFS gear to BSFRF gear

$$\frac{C_a}{C_a + C_b} = \phi = \frac{r_a}{r_a + R_A R_P}$$

$$logit(\phi) = \log(r_a) - \log(R_A R_P)$$

$$logit\left(\frac{C_{a,z}}{C_{a,z} + C_{b,z}}\right) \sim \Omega_1(z) + \Omega_2(D,S)$$

at each SBS station

$$r_{a,z} = \exp[\Omega_1(z) + \Omega_2(D,S) + \log(R_A R_P)]$$

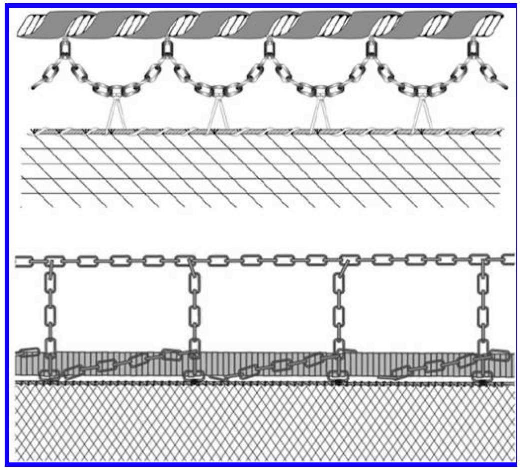
average for all EBS

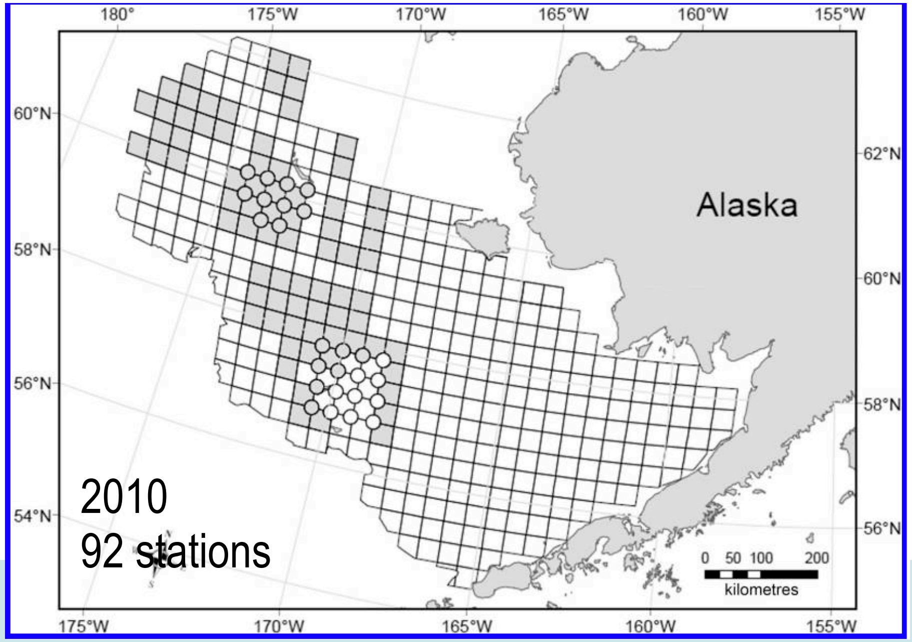
$$\hat{r}_{a,z} = \frac{\sum_s (n_s \cdot r_{a,s})}{\sum_s n_s}$$

footropes

83-112

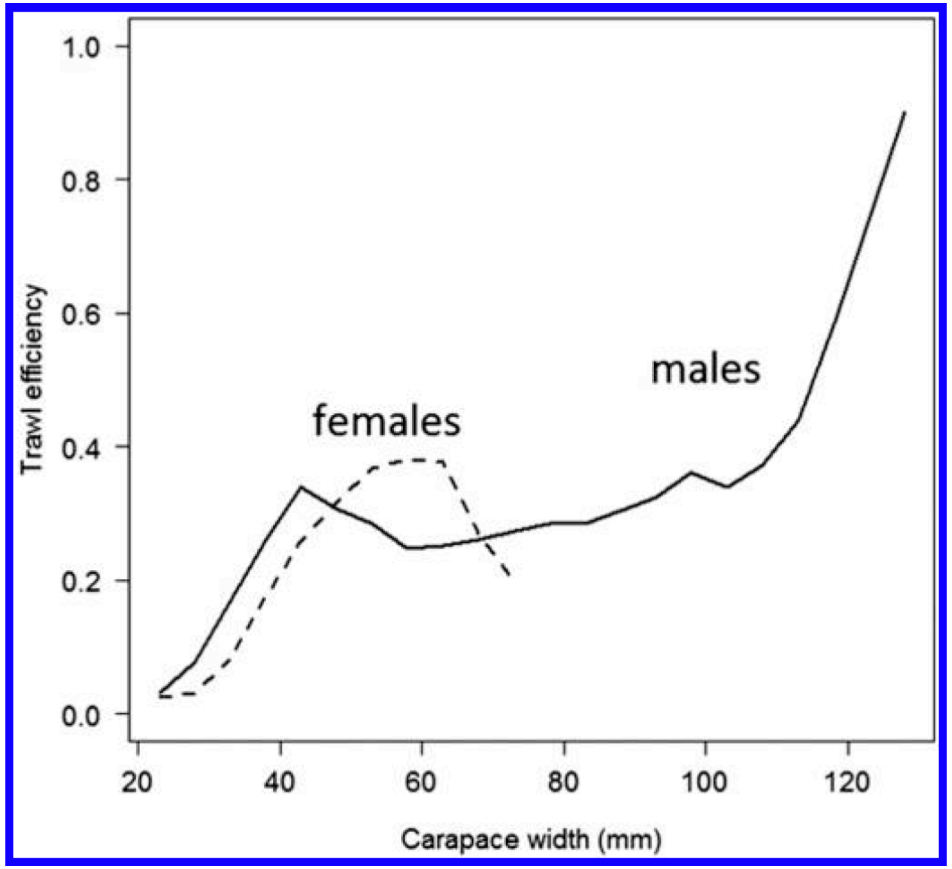
nephrops



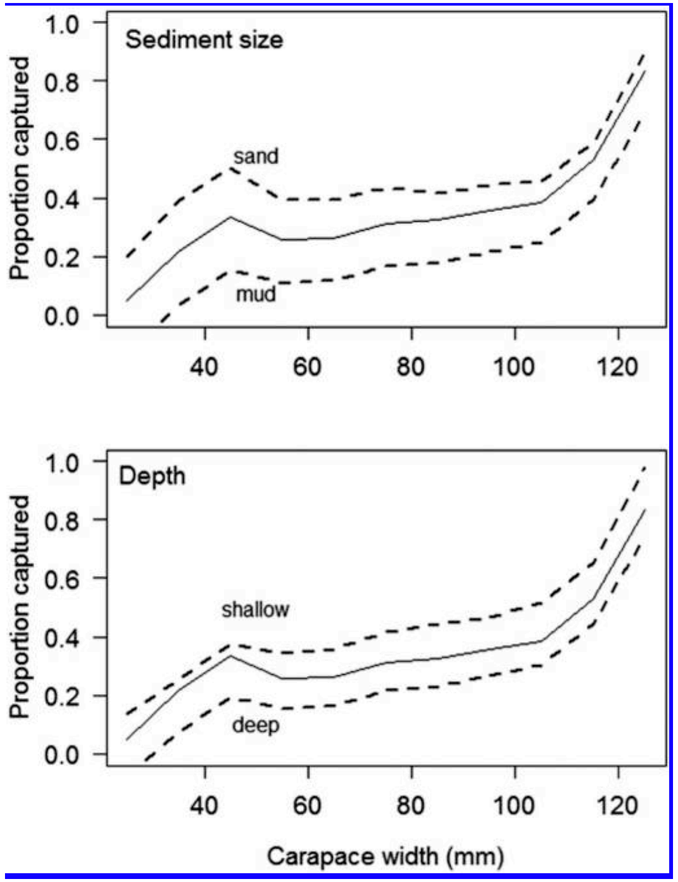


Somerton et al., 2013 for snow crab (cont.)

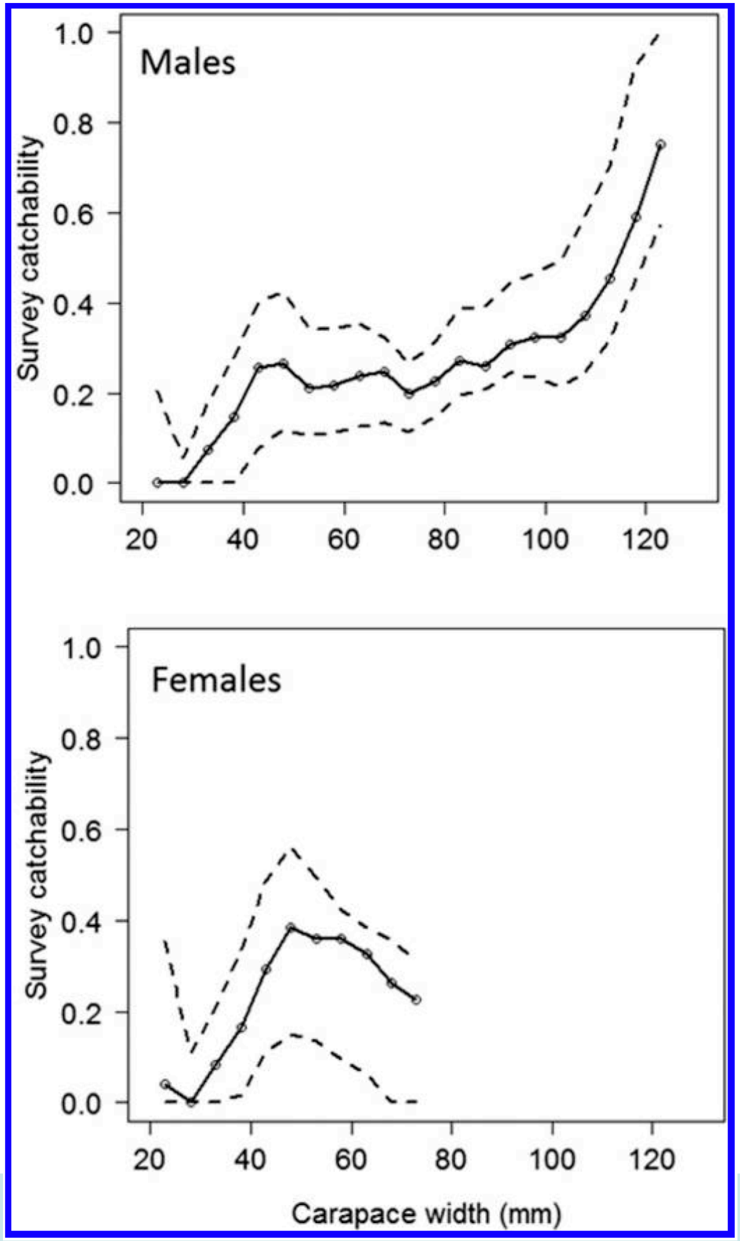
unweighted average r_a over SBS stations



environmental covariates



weighted r_a expanded to EBS stations



Kotwicki et al. (2017): Return to NMFS/BSFRF SBS Study

- used 2010 SBS data for snow crab
- estimated ”selectivity ratio” of BSFRF gear to NMFS gear

$$\mathrm{CPUE}_{L,i} = s_{L,i} N_L$$

$$\frac{\mathrm{CPUE}_{j,L,2}}{\mathrm{CPUE}_{j,L,1}} = \frac{s_{j,L,2}}{s_{j,L,1}} = S_{j,L,2,1}$$

selectivity ratio

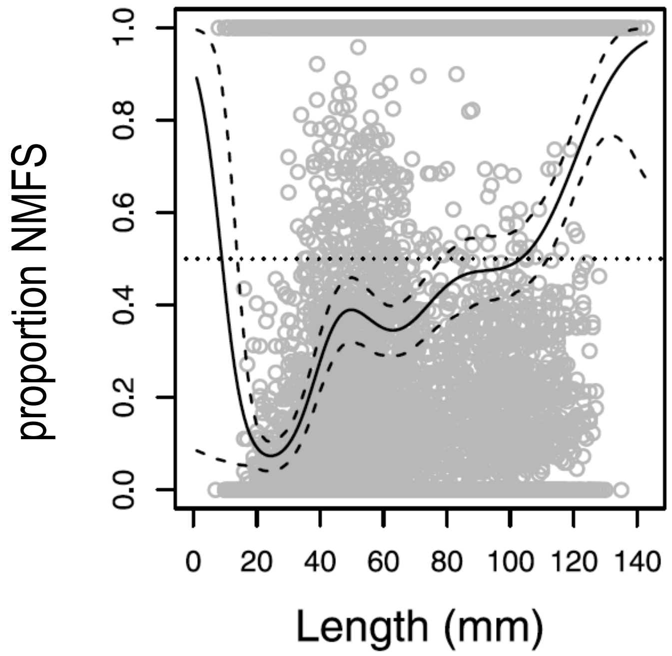
$$p_{j,L,1,2} = \frac{\mathrm{CPUE}_{j,L,1}}{\mathrm{CPUE}_{j,L,1} + \mathrm{CPUE}_{j,L,2}}$$

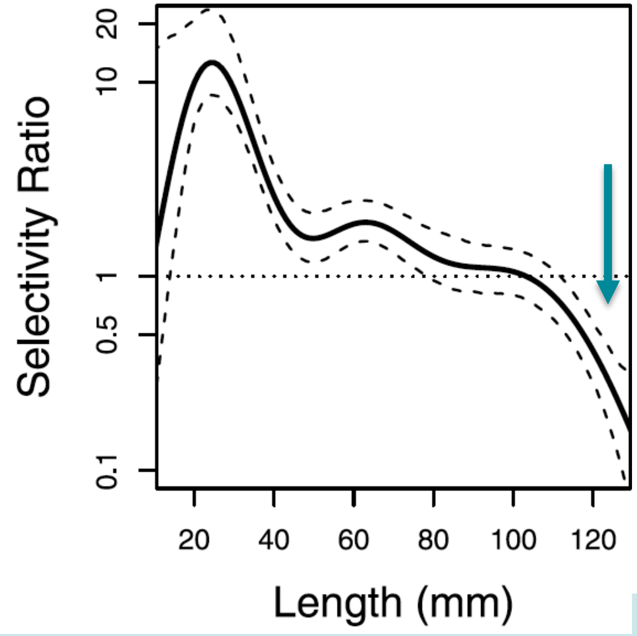
catch comparison ratio

$$logit(p_{L,1,2}) = s(L_i) + \alpha + \varepsilon_i, \quad \varepsilon \sim N(0, \sigma_1^2)$$

$$\alpha = \alpha_0 + \alpha_i, \quad \alpha_i \sim N(0, \sigma_2^2)$$

$$\frac{\mathrm{CPUE}_{j,L,2}}{\mathrm{CPUE}_{j,L,1}} = \frac{1}{p_{j,L,1,2}} - 1$$



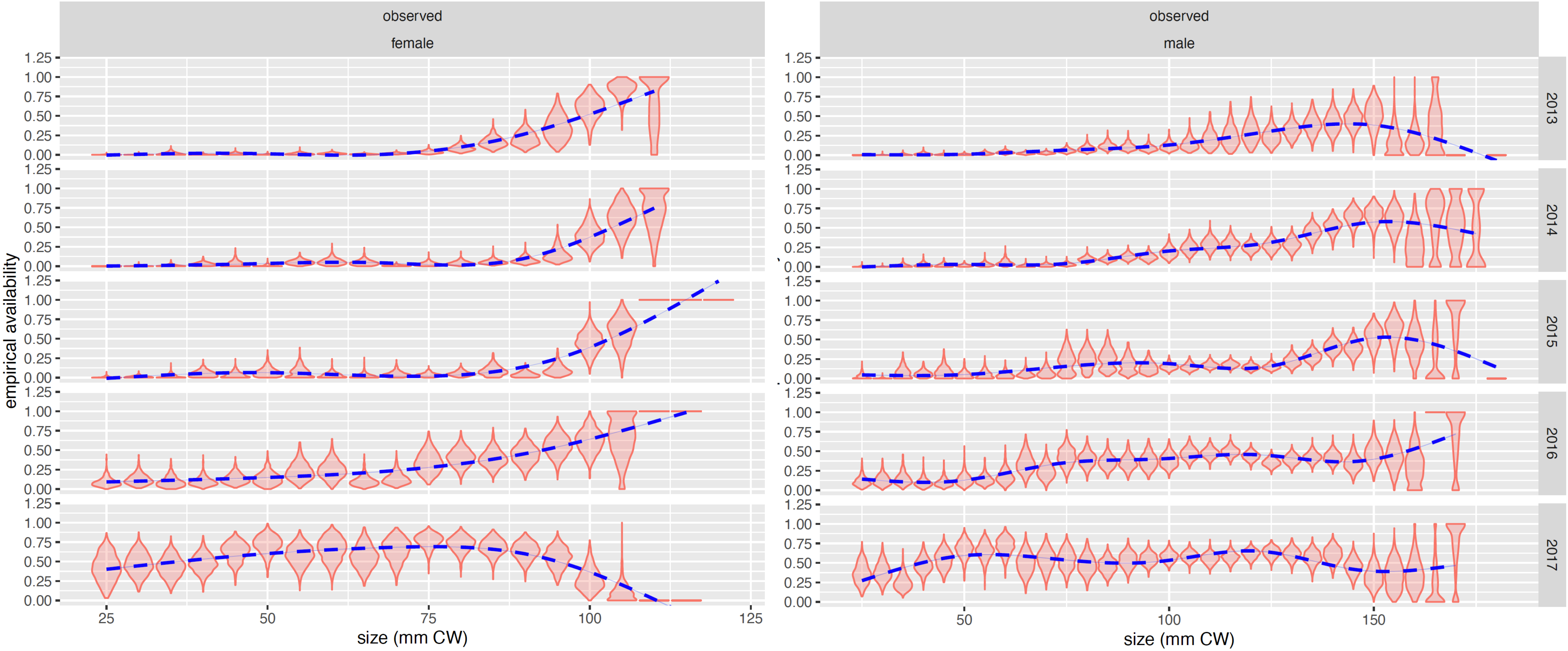


“Future” developments

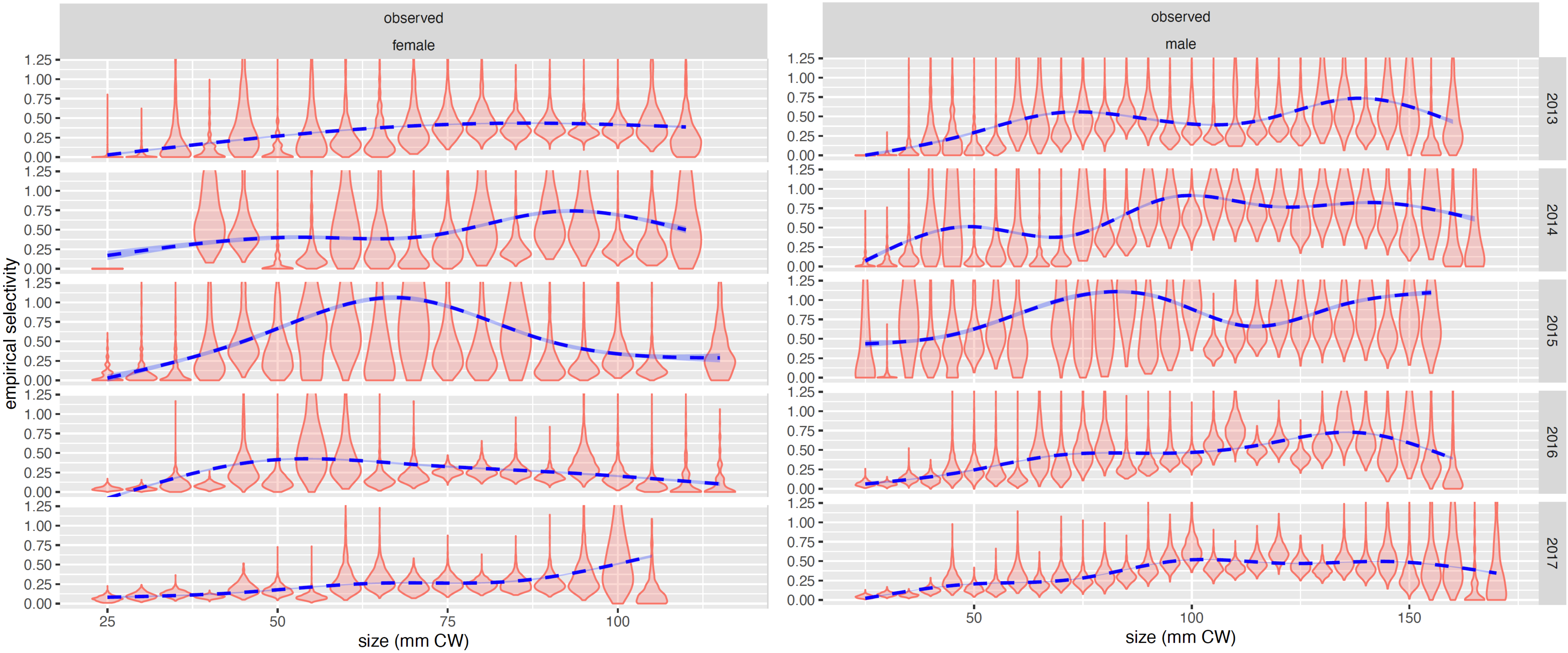
- Fit models that estimate
  - catchability and availability inside the model by fitting NMFS EBS, NMFS SBS, and BSFRF SBS data simultaneously
  - availability outside the model and estimate catchability inside the model fitting NMFS EBS and BSFRF SBS data simultaneously
  - catchability outside the model and fit only NMFS EBS data inside the model

- Fit models that
  - use availability or catchability from bootstrap analyses
  - apply priors on model-estimated availability and catchability from bootstrapping studies

Bootstrapped availability



Bootstrapped catchability to define priors



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Issues for future developments

- “best” way to do bootstrapping?
  - bootstrap data and ratios, fit models to determine “mean” behavior
  - bootstrap data, ratios, and models; determine mean model behavior
  - what are the best models to fit?

- inconsistency in “catchability” ratios
  - why so different in different years?