Critique of Small Pelagic Stock Assessment

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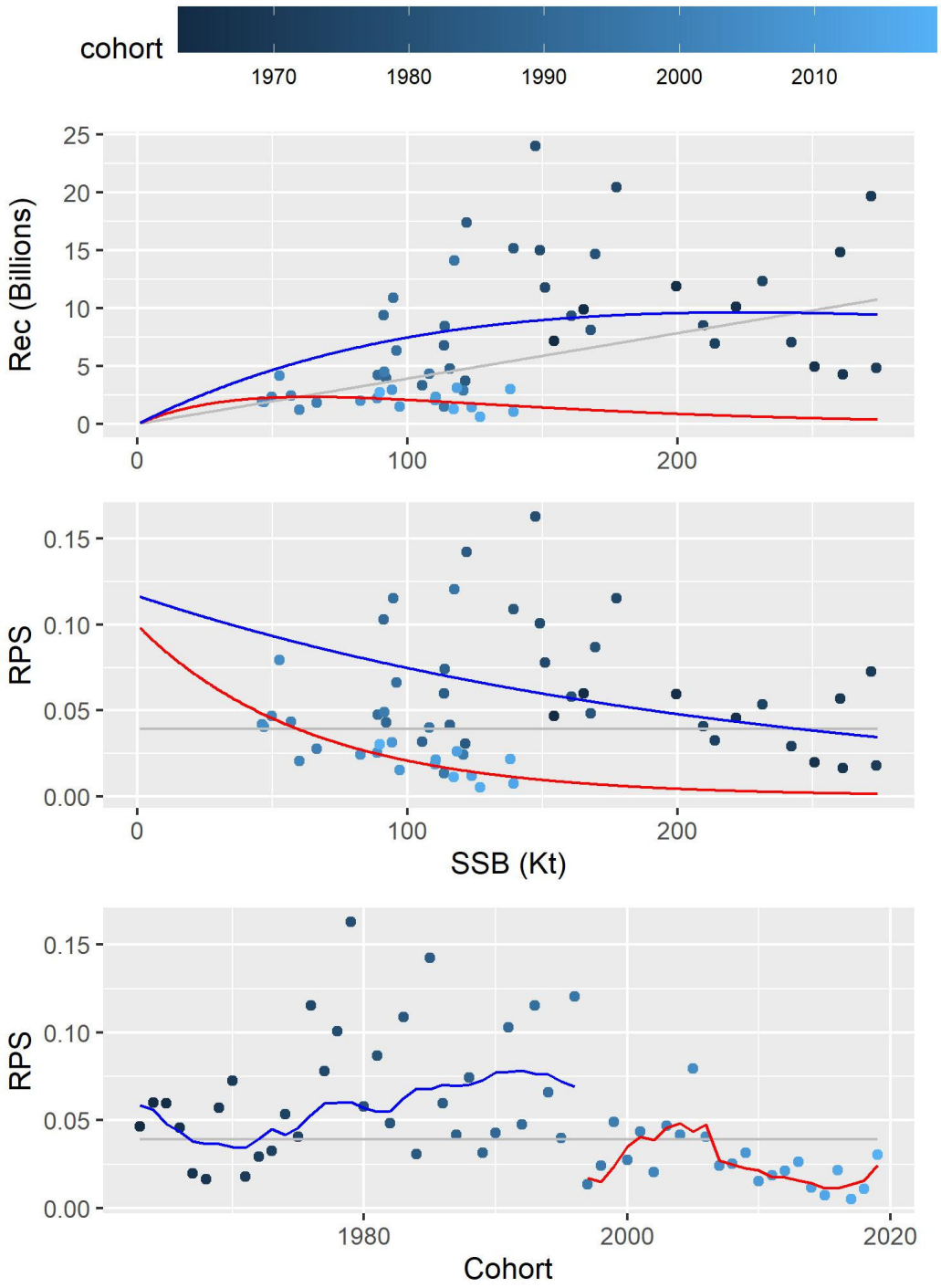
First main focus area: challenges in existing stock assessments/management strategy evaluations (MSEs) for small pelagics (i.e., a lack of a stock recruitment relationship) and potential solutions

- Poor recruitment can occur at high SSB because of poor early life-stage survival
- Flemming survey in NL
- The problem is when there is really good recruitment at low SSB
- Why does that happen?

Stock recruitment regimes?



Tang, X., Zheng, N., Rideout, R.M., Wang, S. and Zhang, F., 2021.

Identification of recruitment regime shifts with a hidden Markov stock-recruitment model.

ICES Journal of Marine Science, *78*(7), pp.2591-2602.

Lack of a stock recruitment relationship

- What if density-dependent recruitment effects are “local” rather than “global”
- so that if all the SSB is in a small area then we can expect less recruitment than if the SSB is spread over multiple spawning sites.
- i.e., density-dependence depends on density and not total abundance or SSB
- Hedge-betting.
- A reduction in spawning sites reduces expected aggregate recruitment, even for the same level of SSB

Lack of a stock recruitment relationship

- Let the density of recruits and *SSB* in the area occupied be denoted as μ_R and μ_{SSB}.
- Assume that μ_R is a Beverton-Holt function of parental μ_{SSB},

$$\mu_R(\mu_{SSB}) = \frac{\alpha\mu_{SSB}}{\beta+\mu_{SSB}}.$$

- The total recruitment and SSB is $R = \mu_R A$ and $SSB = \mu_{SSB} A$
- the total stock-recruit (SR) model is

$$R(SSB, A) = \frac{\alpha\mu_{SSB}A}{\beta + \mu_{SSB}} = \frac{\alpha SSB}{\beta + SSB/A}$$

Illustration

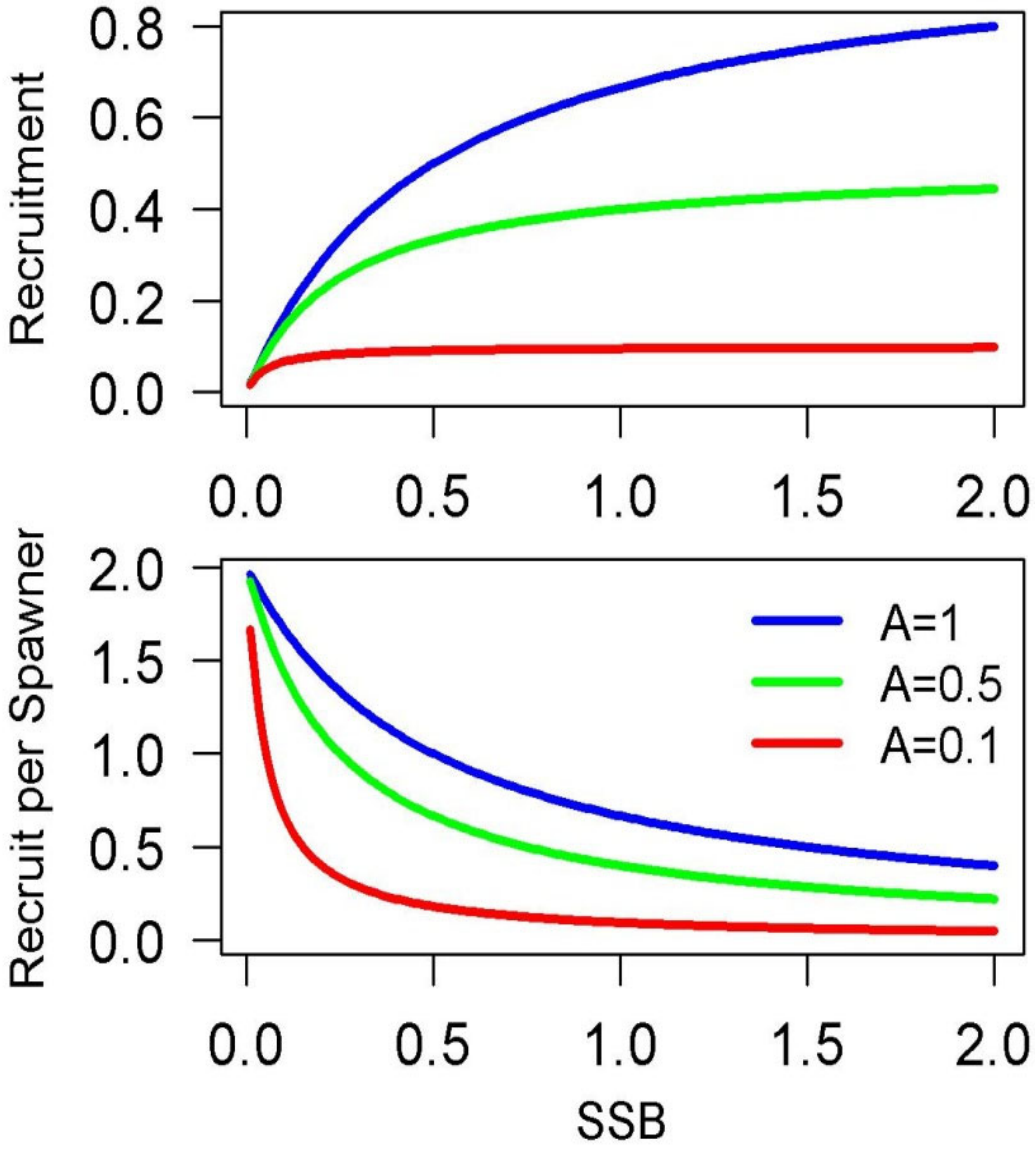
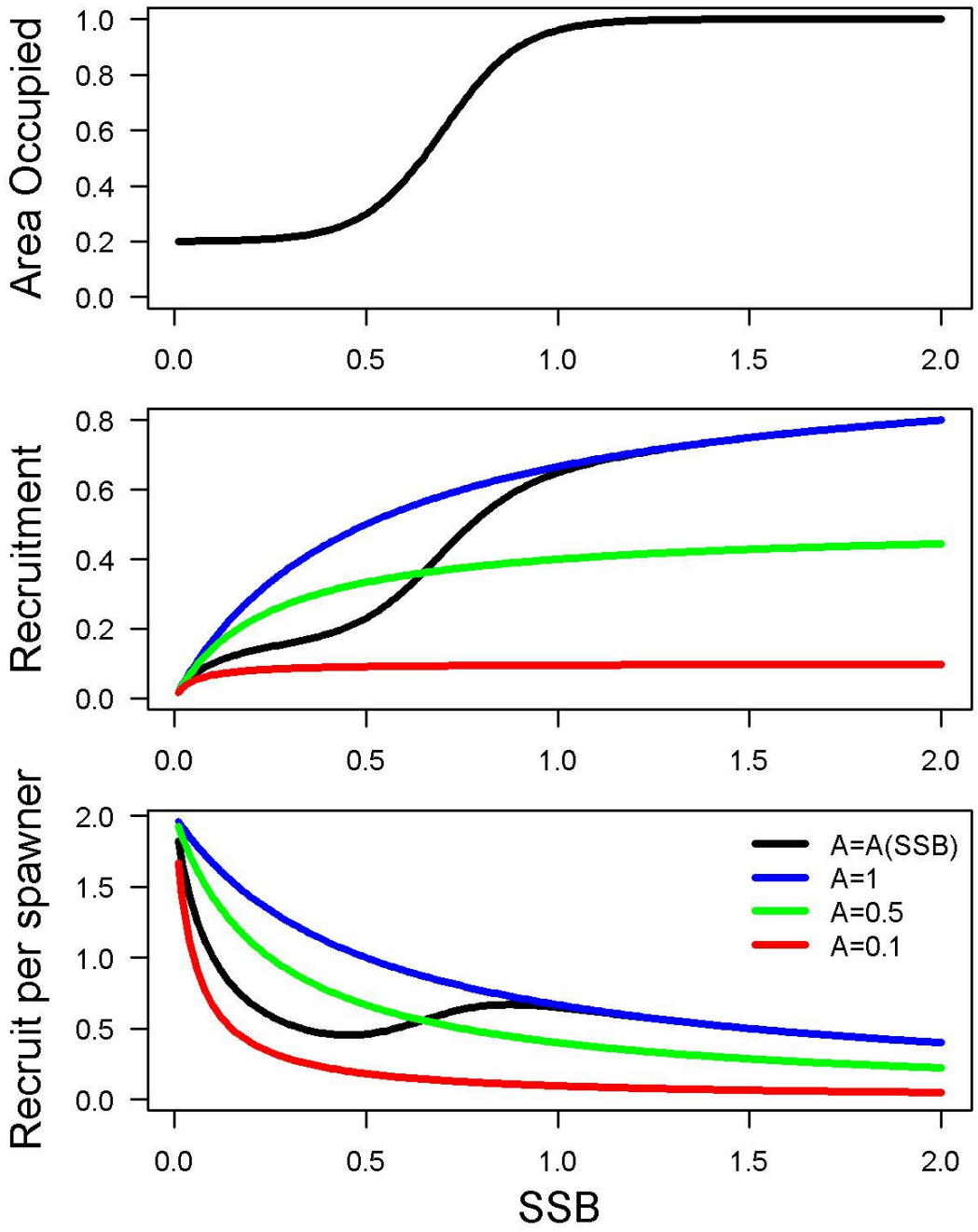


Figure 1. Beverton-Holt curves for $\alpha=1$, $\beta=0.5$ and three values of A.

Illustration 2



Area occupied may affect recruitment variability

SR Drivers

- Recruitment drivers are often ephemeral
- Drivers may be difficult to predict in the future
- Should not be modelling model output
- Should be estimated within SA models to control for various estimation errors
- WHAM is good for this, and includes uncertainty about the drivers, ….

Brooks, E.N. and Deroba, J.J., 2015. When “data” are not data: the pitfalls of post hoc analyses that use stock assessment model output. *CJFAS*, *72*(4), pp.634-641.

Stock, B.C. and Miller, T.J., 2021. The Woods Hole Assessment Model (WHAM): a general state-space assessment framework that incorporates time-and age-varying processes via random effects and links to environmental covariates. *Fisheries Research*, *240*, p.105967.

Quasi-Recommendations

1. There are problems with defining recruitment regimes based on just absolute recruitment or RPS
2. simple (maybe too simple) density-dependence theory suggests R and RPS should be functions of SSB
3. I am keen on hidden-Markov models for time-varying productivity => can produce more sensible forecasts
4. Space matters!
5. loss of spawning components may have important and complicated effects that are difficult to account for in sub-component-aggregated models
6. Aspiration: Assess the spawning components!

Albertsen, C. M., Nielsen, A. and Thygesen, U. H. (2018) Connecting single-stock assessment models through correlated survival. *ICES Journal of Marine Science*, 75(1), 235-244. doi: 10.1093/icesjms/fsx114