

Methodology to determine overfished and overfishing reference points for skates

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Procedure

- Skate indices (number) were generated for spawners (knife-edge at L_{50}) and recruits with ~full vulnerability
- Beverton-Holt models fit in ADMB

$$R = aS/(1+S/K)$$

a is slope at origin

- \hat{a} calculated from a:

$$\hat{a} = a * (\text{virgin spawners per recruit})$$

\hat{a} is maximum lifetime reproduction (Myers et al. 1997, 1999)

Procedure (cont.)

- Reference points calculated from \hat{a}

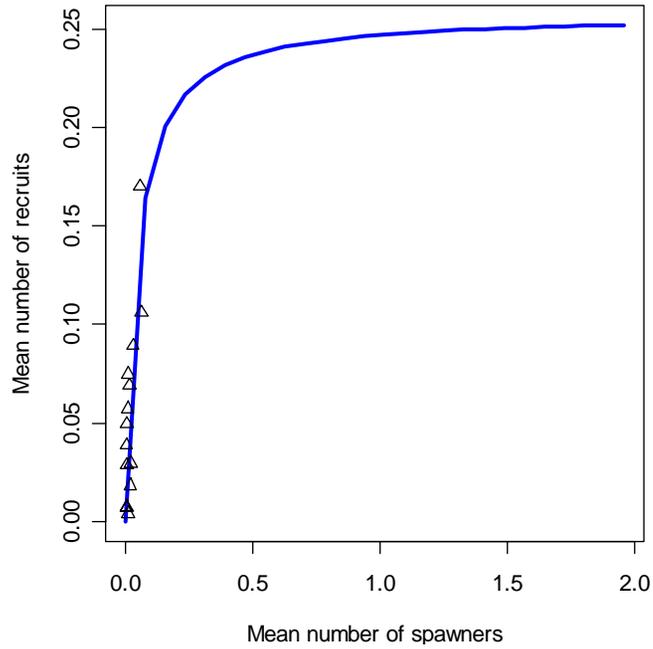
$$- \text{SPR}_{\text{MER}} = 1/\text{sqrt}(\hat{a})$$

$$- B_{\text{MER}}/B_0 = [\text{sqrt}(\hat{a}) - 1] / [\hat{a} - 1]$$

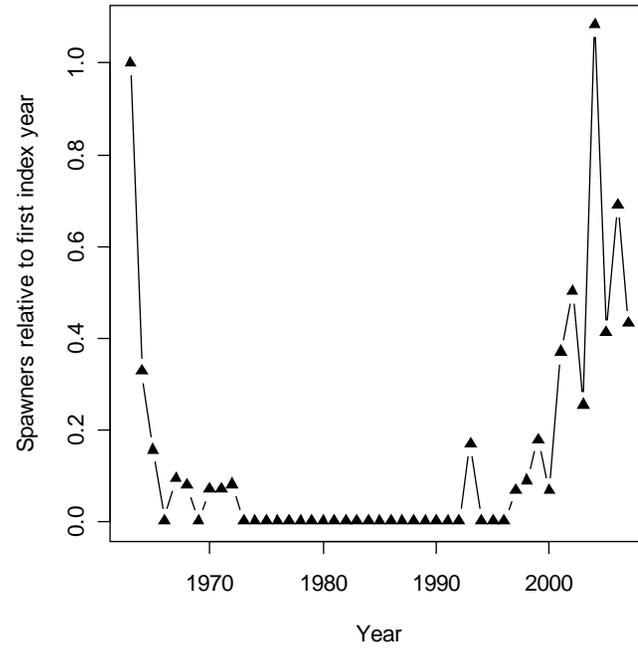
Skates modeled

- Barndoor (recr. age 2, spawners age 6.5)
- Thorny (recr. age 4, spawners age 11)
- Winter (recr. age 4, spawners age 11)
- Clearnose (recr. age 4, spawners age 6)

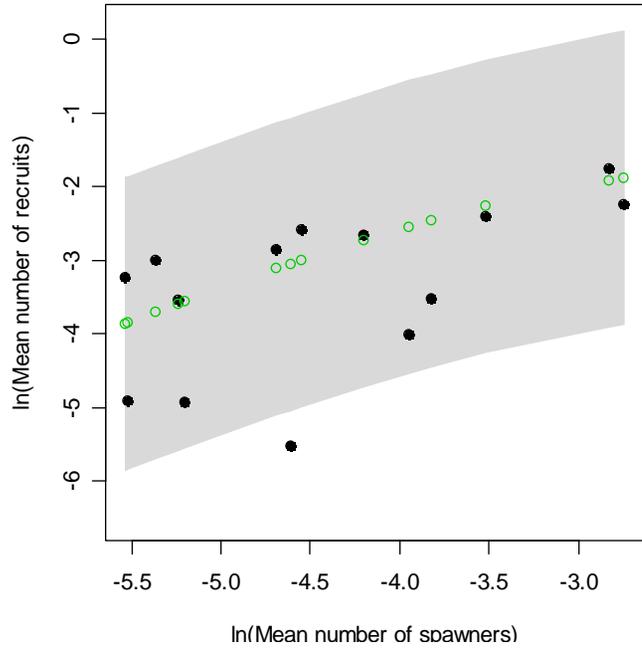
barndoor recruits vs spawners



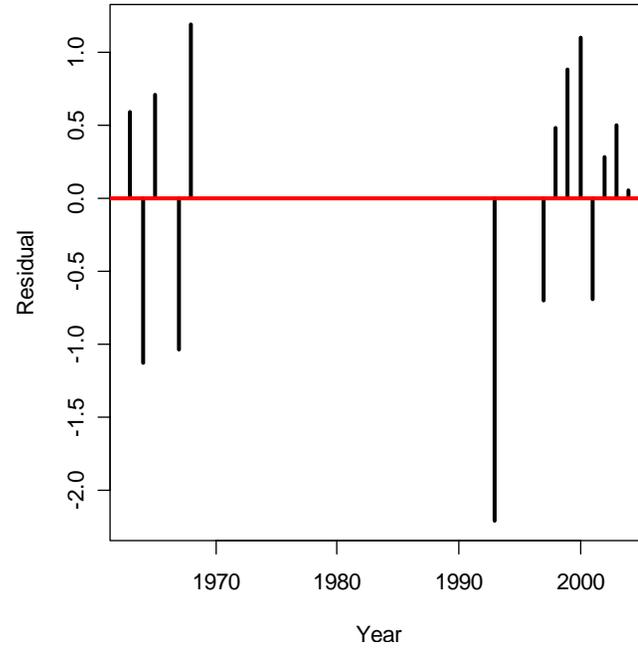
Relative trend in barndoor spawners



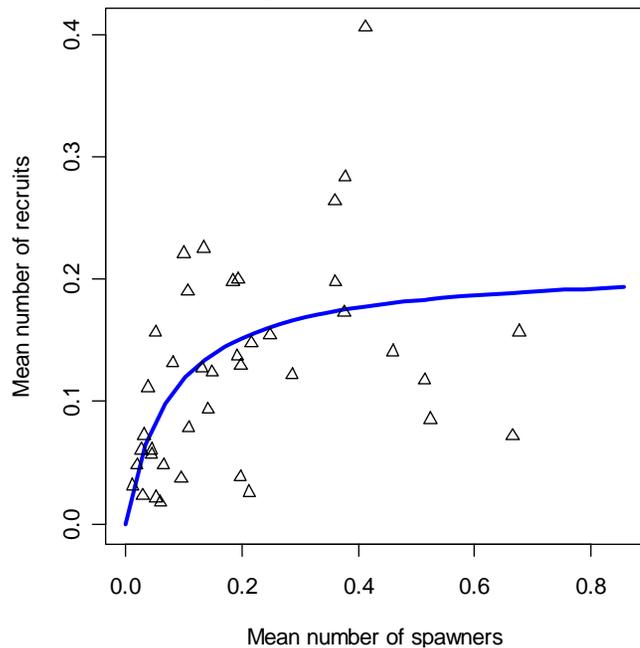
log-scale barndoor recruits vs spawners



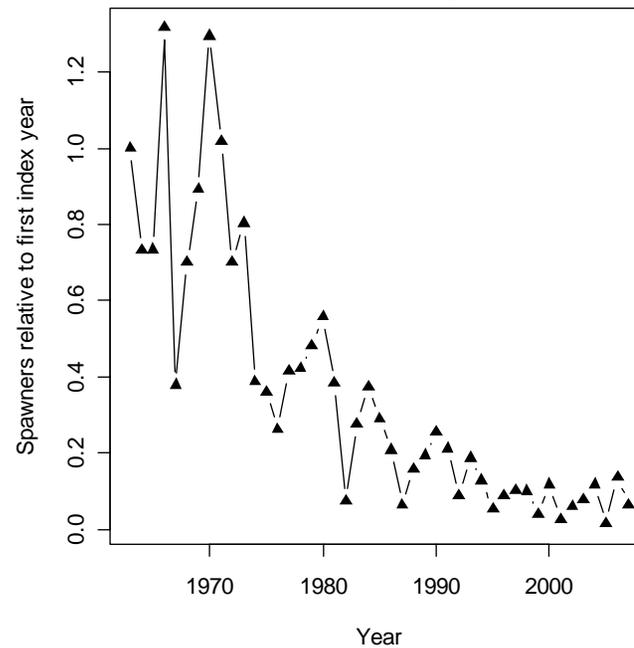
log-scale std.residuals for barndoor



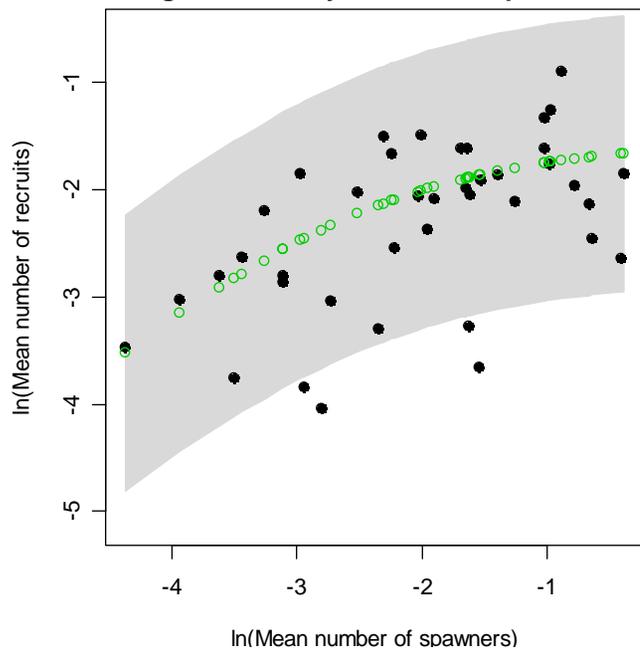
thorny recruits vs spawners



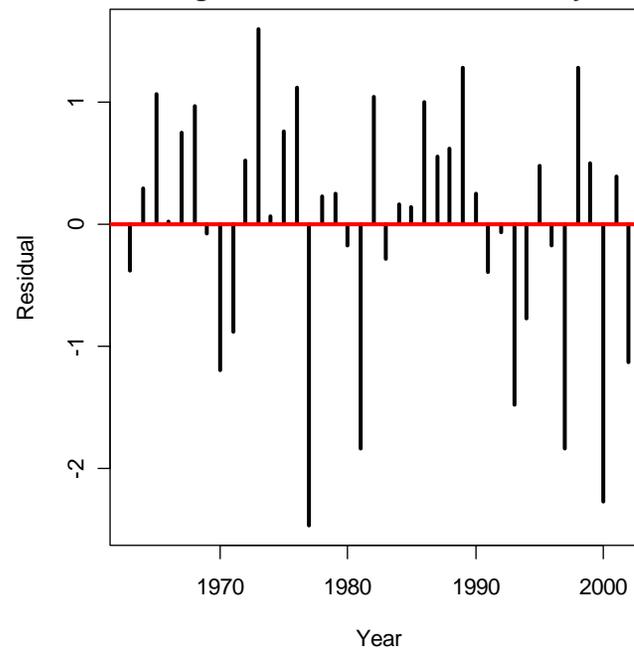
Relative trend in thorny spawners



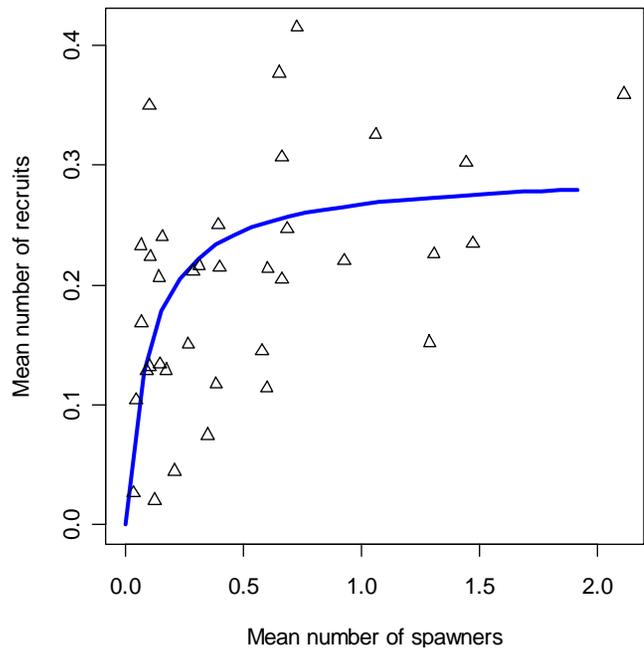
log-scale thorny recruits vs spawners



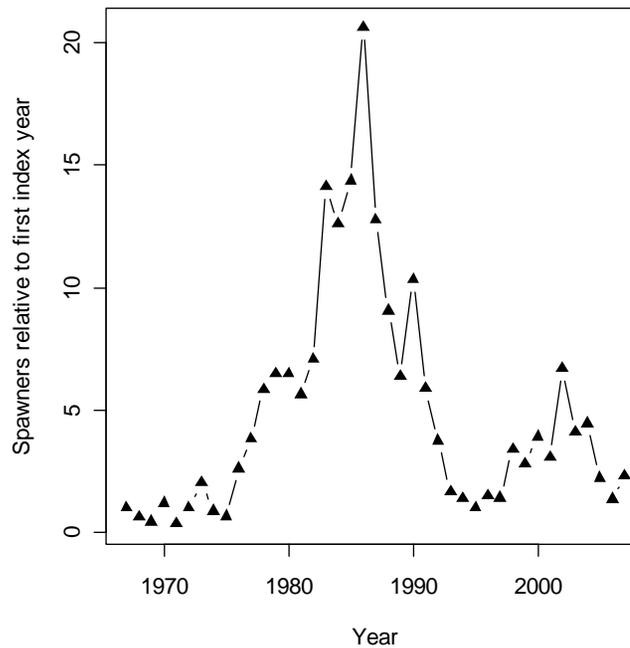
log-scale std.residuals for thorny



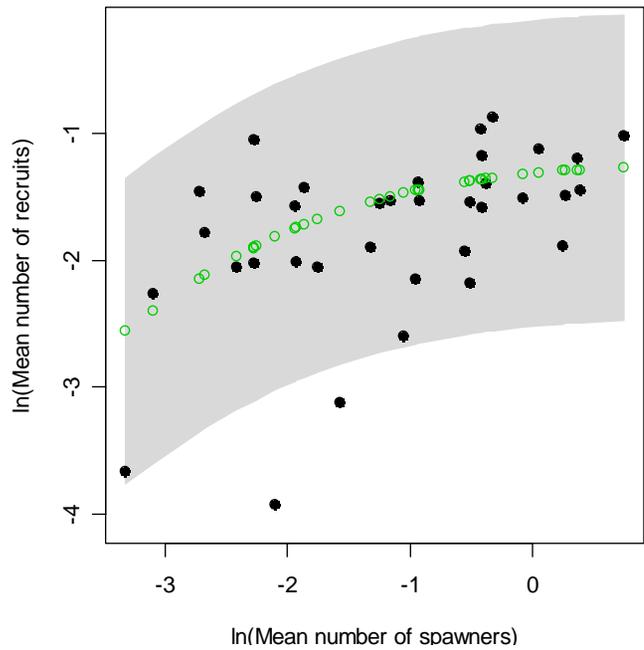
winter recruits vs spawners



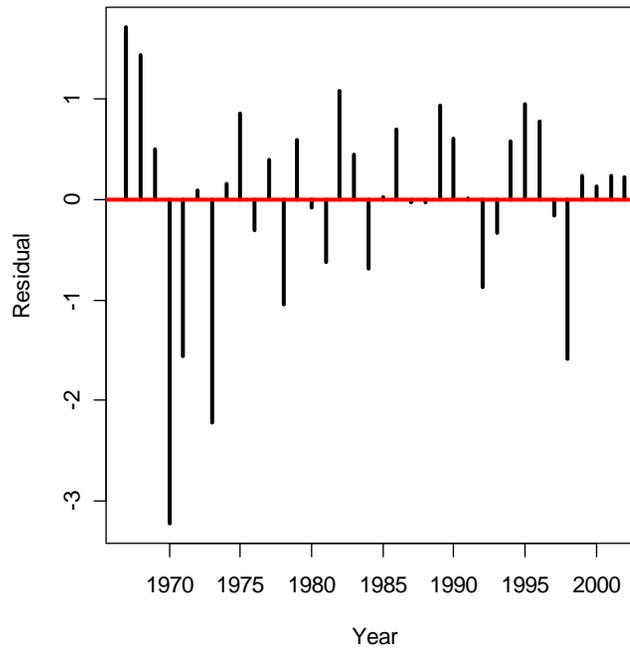
Relative trend in winter spawners



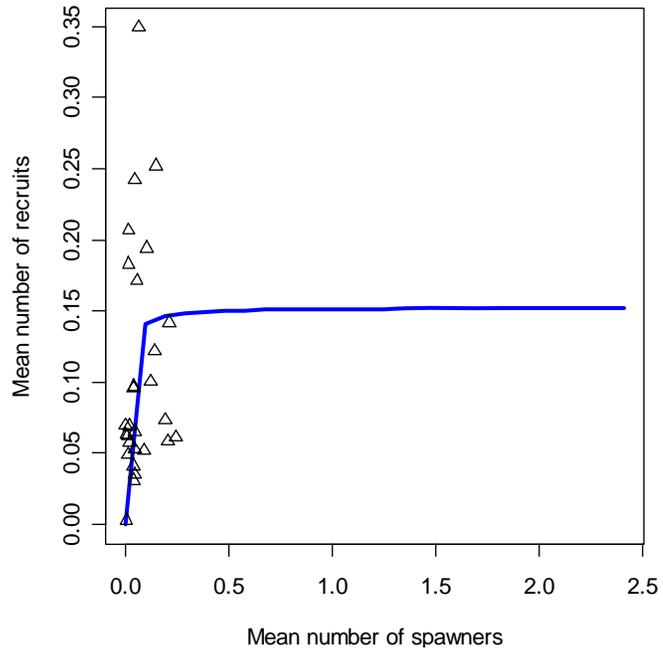
log-scale winter recruits vs spawners



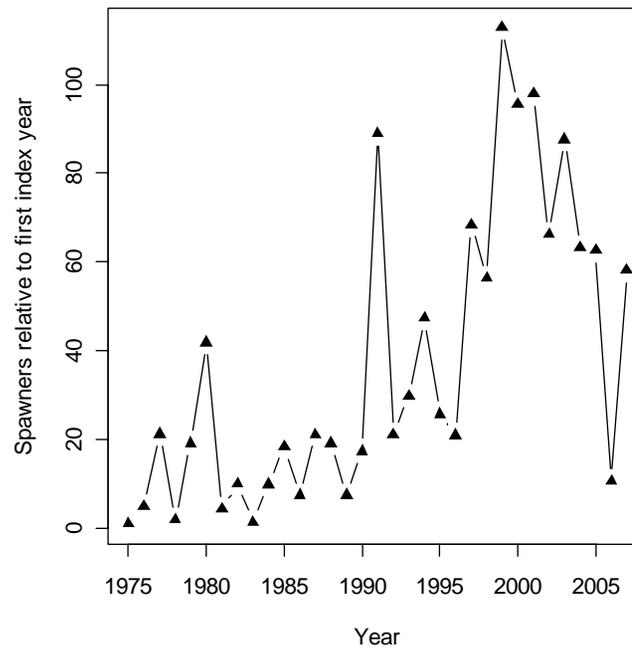
log-scale std.residuals for winter



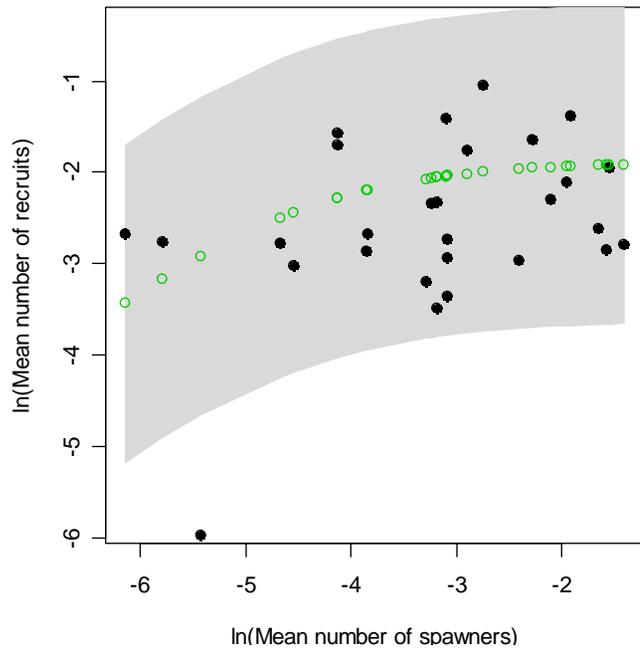
clearnose recruits vs spawners



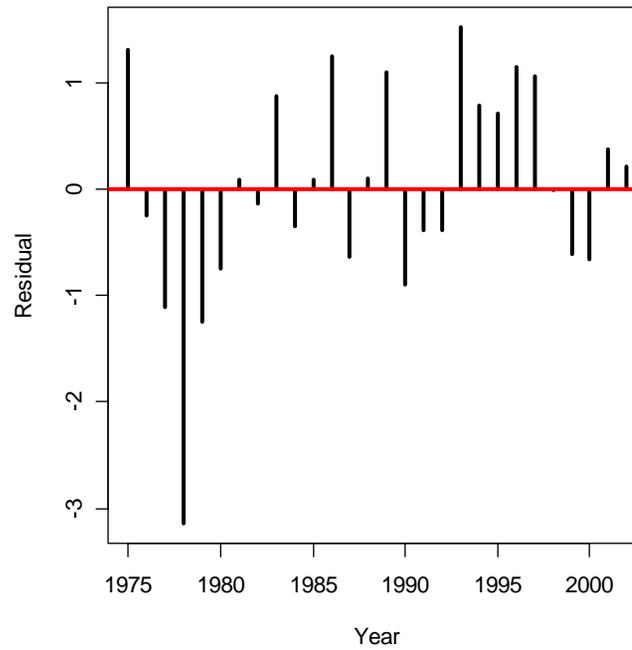
Relative trend in clearnose spawners



log-scale clearnose recruits vs spawners



log-scale std.residuals for clearnose



Results – estimates (CV)

Parameter	Barndoor	Thorny	Winter	Clearnose
a (slope at origin)	5.78 (0.50)	2.71 (0.31)	2.94 (0.39)	19.01 (0.65)
K	0.01 (1.65)	0.08 (0.48)	0.10 (0.52)	0.01 (0.80)
E (Total No. of eggs/female)	80	41	48	40
$S_{egg} S_0 \dots S_{r-1}$	0.07	0.03	0.04	0.24
$(S_{egg} S_0 \dots S_{r-1})^{1/r}$	0.27	0.51	0.50	0.83

Table 3

Results – estimates (CV)

Parameter	Barndoor	Thorny	Winter	Clearnose
M (natural mortality)	0.18	0.18	0.15	0.15
\hat{a}	15.61 (0.50)	4.67 (0.31)	7.39 (0.39)	101.10 (0.33)
steepness	0.80	0.54	0.65	0.96
SPR_{MER}	0.25 (0.25)	0.46 (0.16)	0.37 (0.19)	N/A
S_{MER}/S_0	0.20 (0.20)	0.32 (0.11)	0.27 (0.14)	N/A

Table 4

Sensitivities

- Assumed value of M on SPR_{MER} , $F_{\%SPR}$, S_{MER}/S_0 , and $spr(F=0)$
 - minor (Tables 5-8)

Sensitivities

- Assumed value of M on SPR_{MER} , $F_{\%SPR}$, S_{MER}/S_0 , and $spr(F=0)$
- Age of recruitment on S-R curve and reference points

Sensitivity to Age of recruitment

Parameter	Barndoor	Thorny	Winter	Clearnose
Recr age	1 (2)	3 (4)	3 (4)	3 (4)
a (slope at origin)	3.69 (5.78)	3.79 (2.71)	2.18 (2.94)	37.79 (19.01)
Λ a	8.32 (15.61)	5.44 (4.67)	4.71 (7.39)	173.01 (101.10)
steepness	0.68 (0.80)	0.58 (0.54)	0.54 (0.65)	0.98 (0.96)
SPR_{MER}	0.35 (0.25)	0.43 (0.46)	0.46 (0.37)	N/A
S_{MER}/S_0	0.26 (0.20)	0.30 (0.32)	0.32 (0.27)	N/A

Sensitivities

- Assumed value of M on SPR_{MER} , $F_{\%SPR}$, S_{MER}/S_0 , and $spr(F=0)$
- Age of recruitment on S-R curve and reference points
 - Generally reduced $\hat{a} \rightarrow$ less resilient, so need larger SPR_{MER}
 - Logical, since fishing on younger age

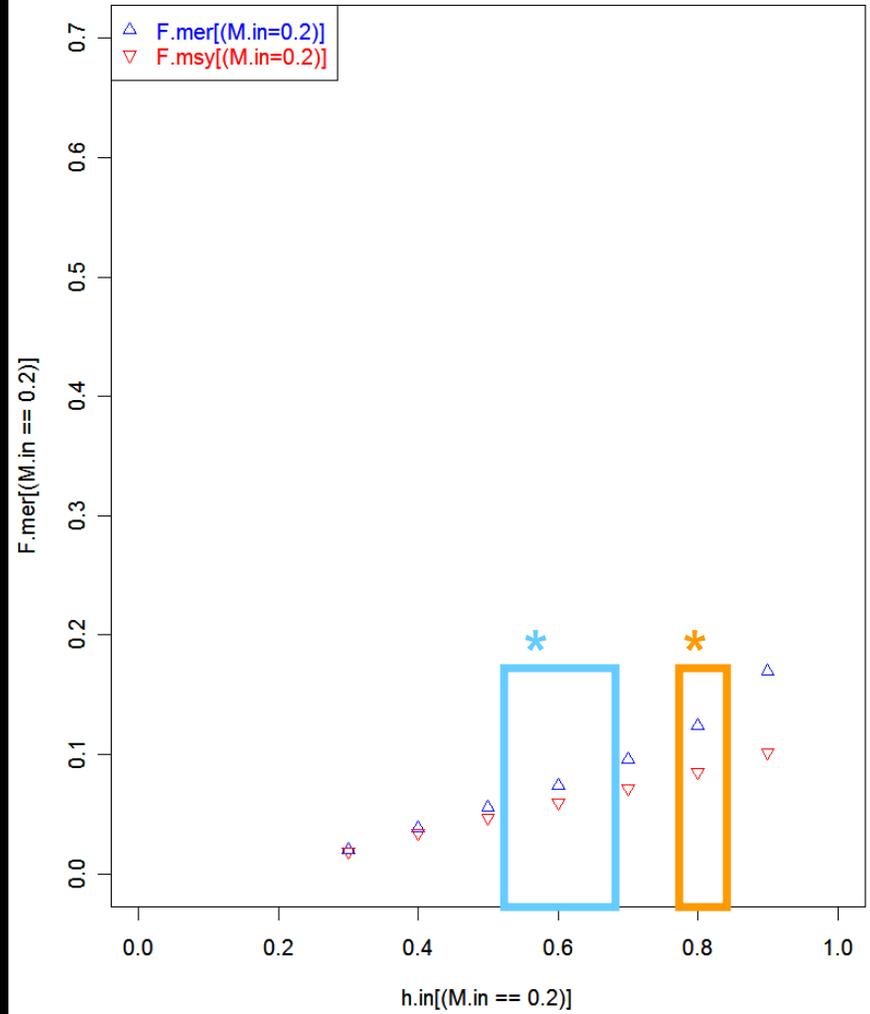
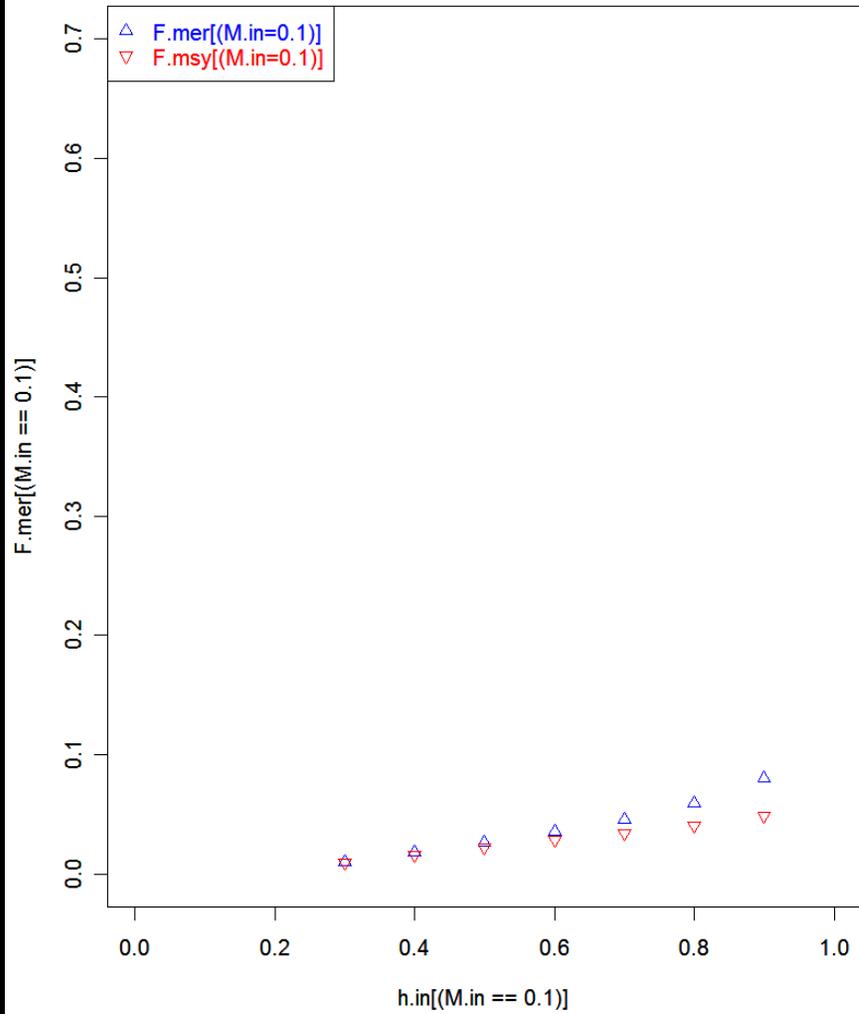
Sensitivities

- Assumed value of M on SPR_{MER} , $F_{\%SPR}$, S_{MER}/S_0 , and $spr(F=0)$
- Age of recruitment on S-R curve and reference points
- Examine MSY vs MER reference points

	Barndoor		Thorny		Winter	
	MSY	MER	MSY	MER	MSY	MER
%SPR	0.4	0.25	0.55	0.46	0.43	0.37
F	0.13	0.18	0.06	0.07	0.07	0.08
S/S0	0.38	0.19	0.42	0.32	0.38	0.27

Sensitivities

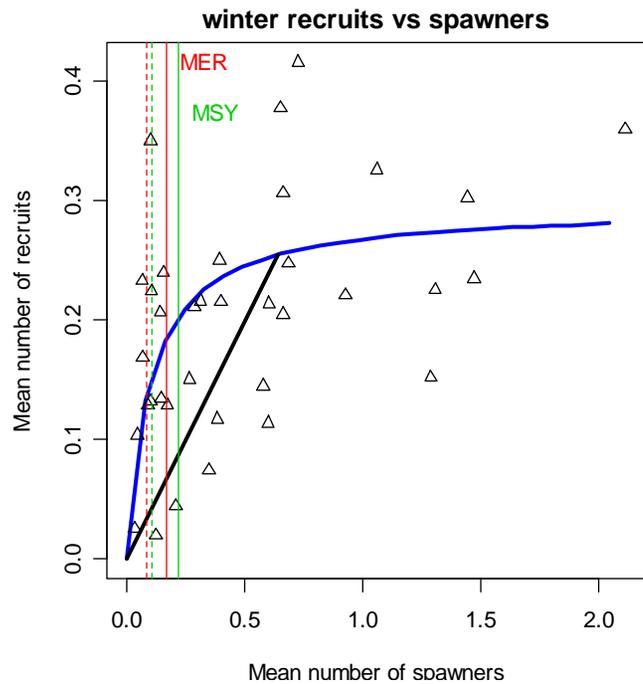
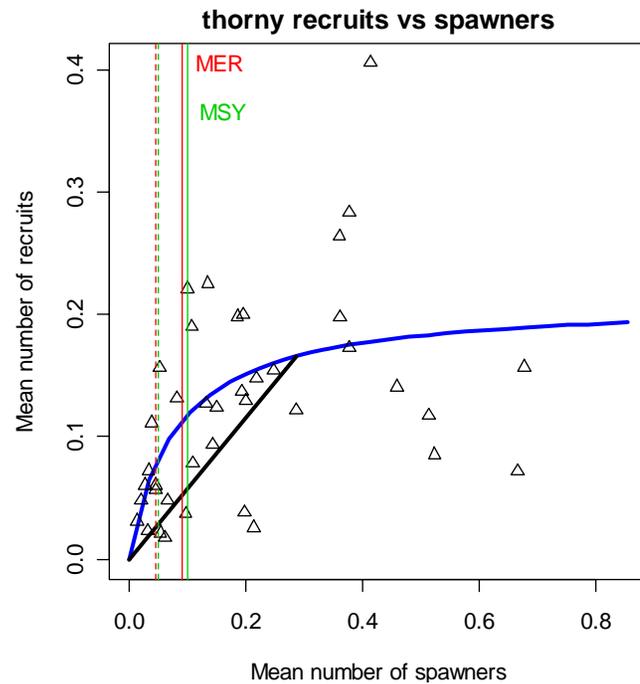
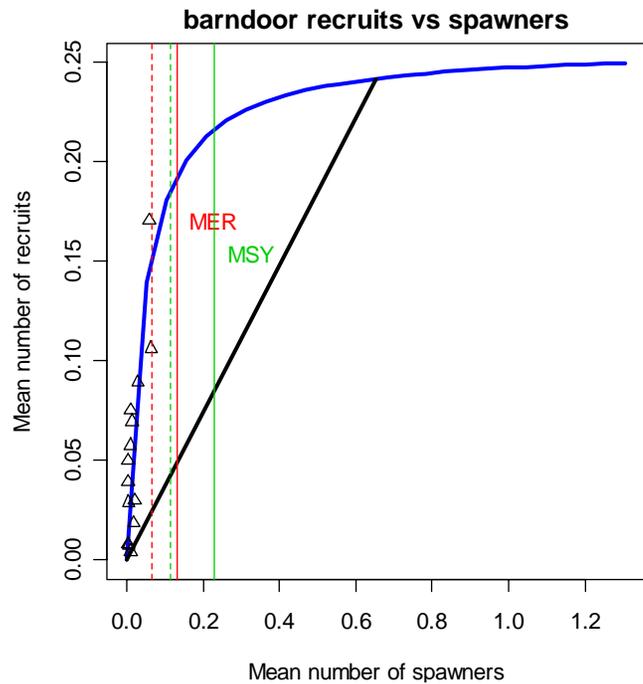
- Assumed value of M on SPR_{MER} , $F_{\%SPR}$, S_{MER}/S_0 , and $spr(F=0)$
- Age of recruitment on S-R curve and reference points
- Examine MSY vs MER reference points
 - $F_{\%SPR}$ similar (*except barndoor)
 - MSY ref. pts more conservative



* Barndoor

* Thorny, Winter

Reference Points, Replacement lines



- MER reference point for overfished
- - - 0.5*MER reference point for overfished
- MSY reference point for overfished
- - - 0.5*MSY reference point for overfished
- Replacement (no fishing)

Caveats – CVs on Indices

- Barndoor: 20 - 100%
- Thorny: 10 - 50%
- Winter: 12 - 46%
- Clearnose: 14-47%

- Recruit points not weighted, CV in spawning index ignored

Caveats and questions



Precision of \hat{a} (MCMC plots in WP, Figures 5-7)

- Barndoor: 50%
- Thorny: CV=31%
- Winter: CV=39%
- Clearnose: CV=33%



Observations of $S > S_0$



Convert to abundance from swept area?

Re: Observations of $S > S_0$



uncertainty in the index of spawners



recruits not fully selected by the survey thereby decreasing obs. R and shifting the unexploited S to the left of where they should be



M values too high → too small of an unexploited spawner value



conversion from lengths to ages is biased → incorrect ages and an inconsistency between the virtual unexploited pop. and the observed spawners

Thanks, Chris!



Stock status (overfished/overfishing)

- One could plot 2007 fall spawner estimate on predicted S-R curve
- Determine if stock is overfished if it is less than the overfished limit (MER or MSY)

Good idea, Chris!

- Overfishing could be determined by estimating current F (SEINE, length-based, SP or other model) and comparing it to the estimated $F_{\%SPR}$