

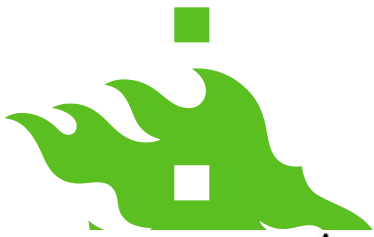
By-catch of grey seal in Baltic fisheries - A Bayesian analysis of interview survey

HELCOM, Seal Expert Group
22.10.2014, Turku

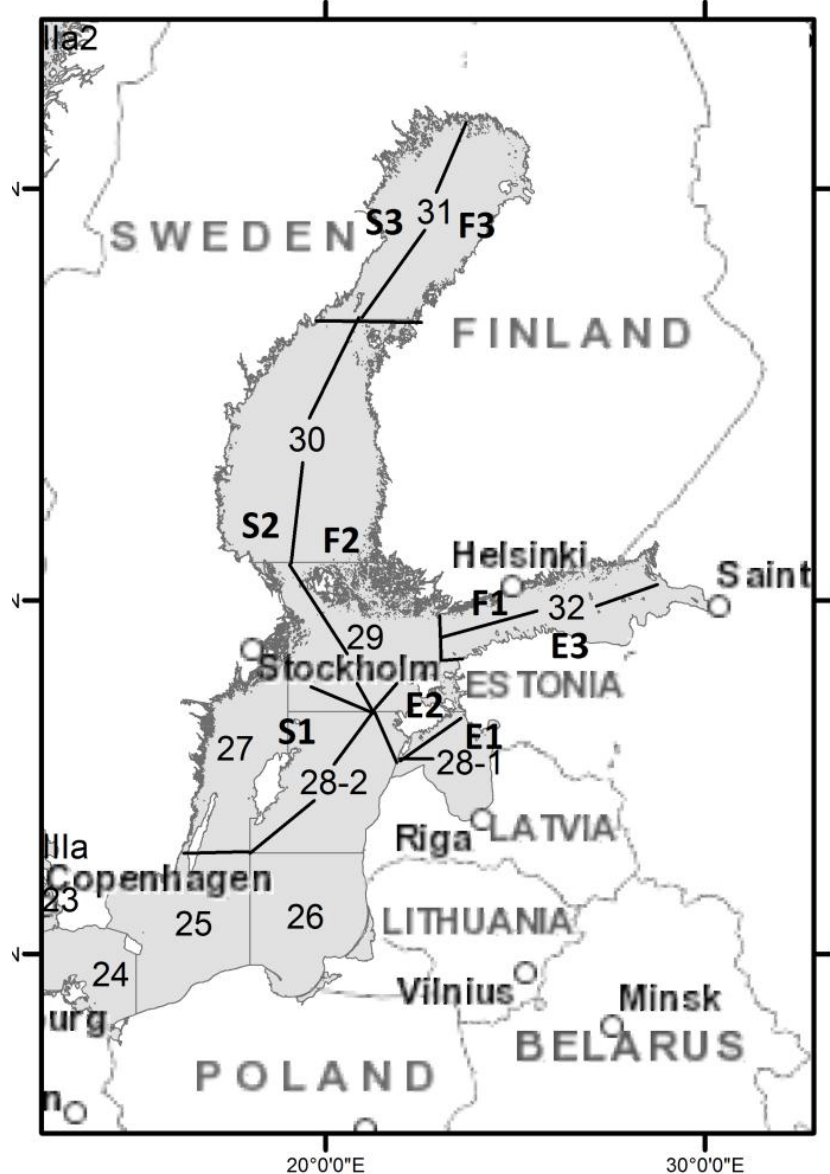
Jarno Vanhatalo (jarno.vanhatalo@helsinki.fi)
Department of Environmental Sciences
University of Helsinki

Joint with:

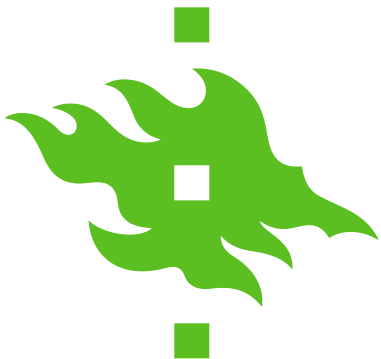
Markus Vetemaa (University of Tartu)
Annika Herrero (*Finnish Game and Fisheries Research Institute, FGFRI*),
Teija Aho (Swedish University of Agricultural Sciences),
Raisa Tiilikainen (*Metsähallitus, Natural heritage services Finland*)



By-catch estimate for year 2012

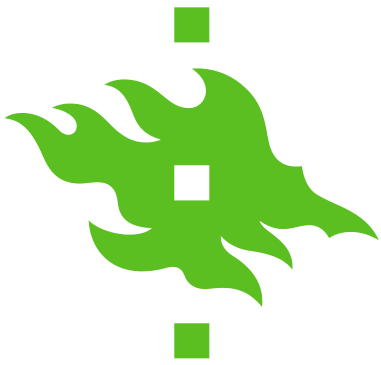


- Done within ECOSEAL project
- Objective
 - To estimate the total by-catch in coastal fisheries in Finland, Sweden and Estonia
- Data
 - Interview survey
 - How many by-caught seals in 2012
 - With which gear
 - Fishing effort per sub-area
 - Gill nets
 - Trap nets



Data

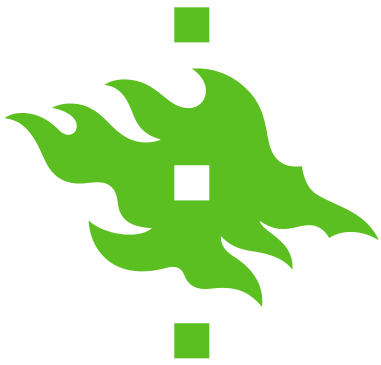
sub-area	Trap nets			Gill nets			number of interviews	proportion of seals		
	by-catch in sample	effort in sample (gear-days)	total effort (gear-days)	by-catch in sample	effort in sample (km-days)	total effort (km-days)		expected (%)	spring (%)	fall (%)
E1	104	2458	11772				34	6.25	7.5	5
E2	59	1542	8722				25	6.25	7.5	5
E3	10	1096	3135				13	1.75	0.5	3
F1	45	23533	36636				25	1.75	0.5	3
F2	5	3823	58863				10	30	35	25
F3	0	0	5057				0	2	0	4
S1	0	0	8515	20	1402	7904	13	22.5	25	20
S2	61	2450	2563	35	1540	1611	41	16.5	15	18
S3	0	0	4806				0	2	0	4
total	284	34902	140069	55	2942	9515	161	89	91	87



Analysis



- The probability of a seal to be caught by a fishing gear depends on
 - Gear
 - How it is used
 - Effort (gear days, km-days)
→ mortality rate (catchability) per effort
- Total by-catch depends on
 - Number of seals & probability to be by-caught
 - Division to sub-areas corresponding to
 - different kind of gears and use of those gears
 - Approximately similar average seal abundance across each of the sub-area
→ Area specific catchability
→ Area specific average seal abundance



Analysis

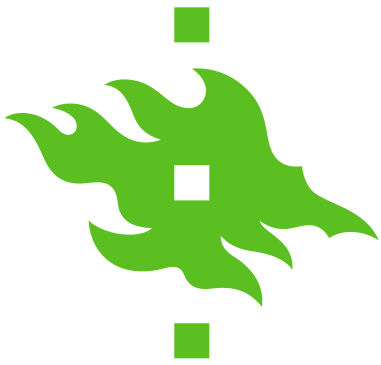
- The probability for a seal to die via by-catch in gill-net in sub-area a

$$p_{\text{gill},a} = \frac{E_{g,a} C_{g,a}}{E_{g,a} C_{g,a} + E_{t,a} C_{t,a}} (1 - e^{-E_{g,a} C_{g,a} - E_{t,a} C_{t,a}})$$

- $E_{g,a} / E_{t,a}$: fishing effort with gill net / trap net
- $C_{g,a} / C_{t,a}$: the catchability of gill net / trap net

Compare to Baranov equation

$$\text{Catch} = \left(\frac{F}{F + M} e^{-F-M} \right) N$$



Analysis



- Number of by-caught seals in sub-area a

$$y_{\text{gill},a} \sim \text{Binom}(N_a, p_{\text{gill},a})$$

- N_a : average number of seals in the sub-area (that have survived other mortality sources)



Analysis



- Given the by-catch and effort by the interviewed fishermen we calculate the posterior distribution of the catchability and area specific abundance
- Bayes theorem

$$p(C, N|E, y) \propto p(y|E, C, N) p(N) p(C)$$

Prior distributions

Likelihood:

$$\text{Binom}(y_1|N_1, p_{\text{gill},1}) \times \dots \times \text{Binom}(y_9|N_9, p_{\text{trap},1})$$



Analysis

Posterior distribution

$$\text{Binom}(\tilde{y}_a | N, p_{\text{gill},1})$$

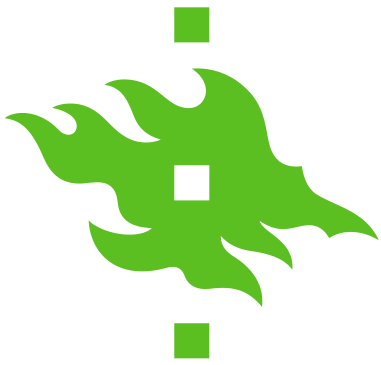
- Given the posterior we can predict the by-catch by rest of the fishermen

$$p(\tilde{y}_a | \tilde{E}_a, E, y) \propto \int p(\tilde{y}_a | \tilde{E}_a, C, N) p(C, N | E, y) dC dN$$

- Total by-catch

$$y_a^{\text{Total}} = \tilde{y}_a + y_a$$

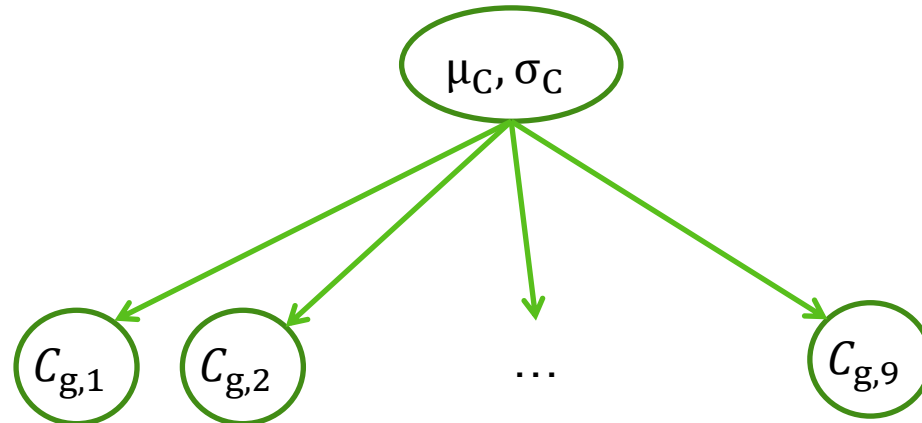




Priors



- Hierarchical prior for catchabilities

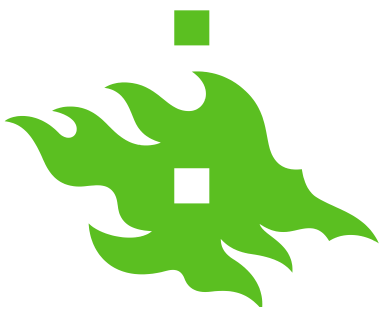


- Prior for N

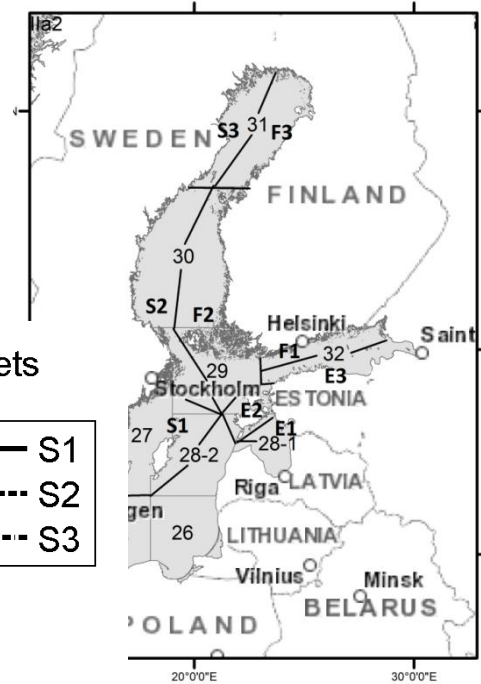
- Total number of seals

$$\sim N(\mu = \text{counted}/0.85, \sigma = 2 \times 10^3)$$

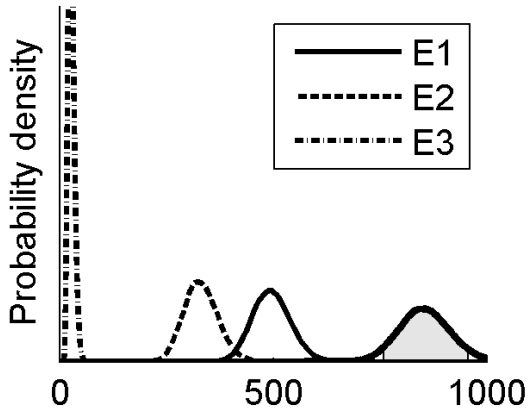
- Division between sub-areas Dirichlet with expectation (approximately) from counts



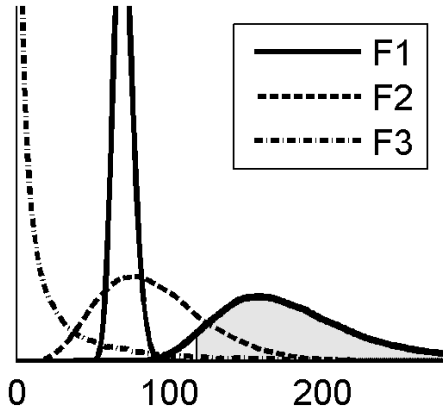
Results, by-catch



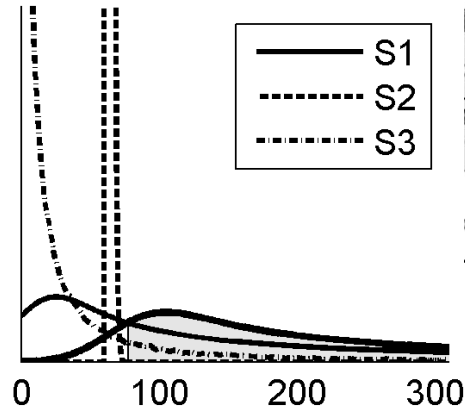
Estonia



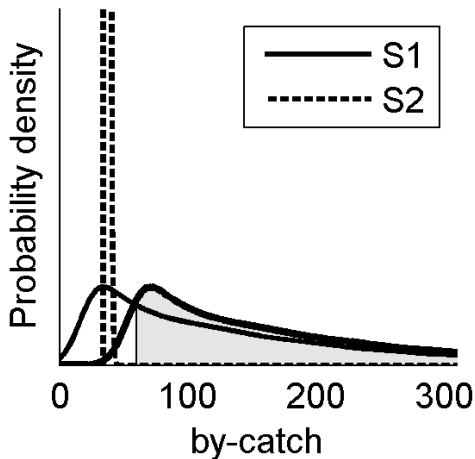
Finland



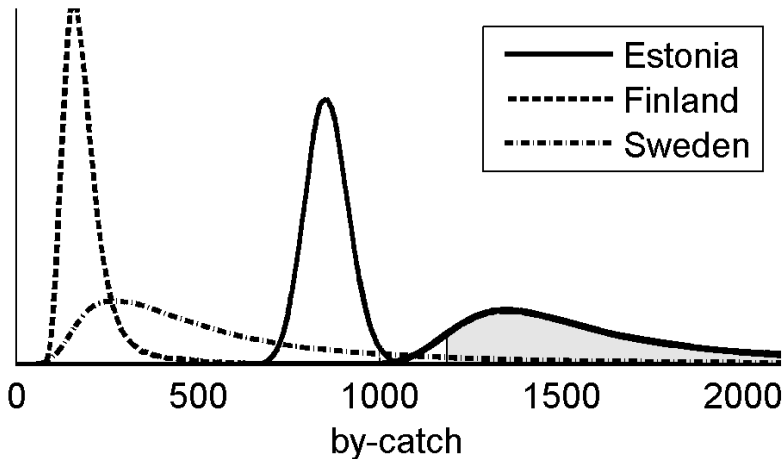
Sweden, trap nets

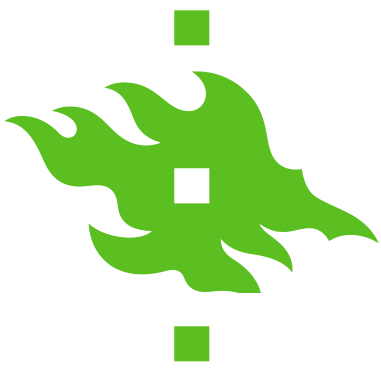


Sweden, gill nets

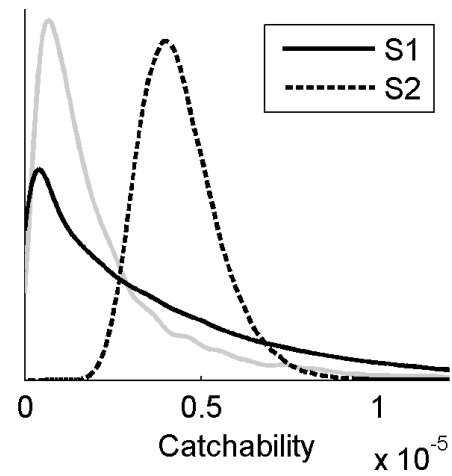
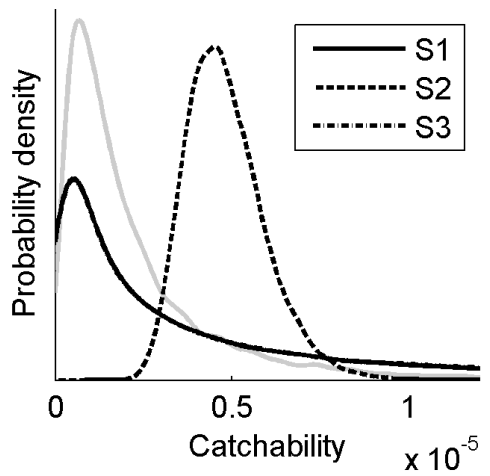
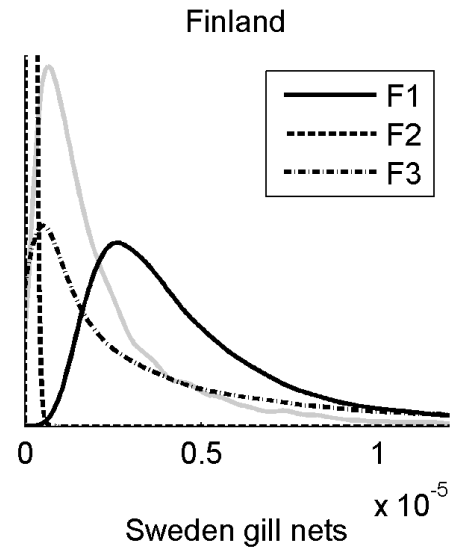
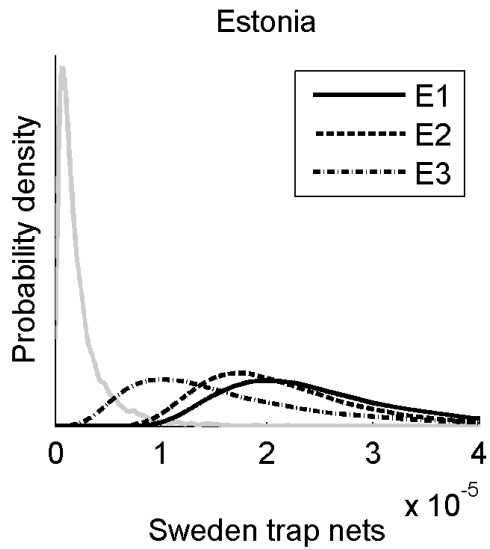


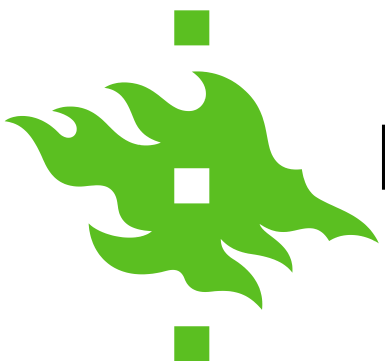
Total by-catch in the study area



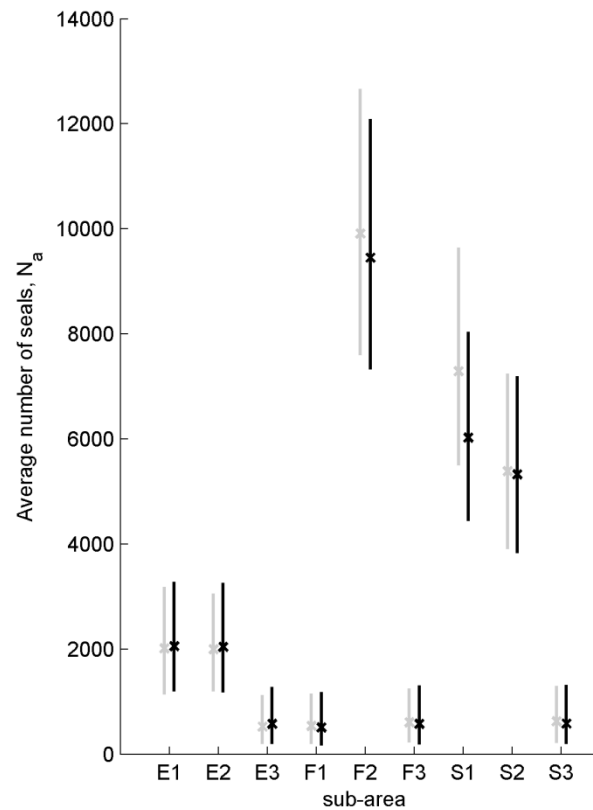
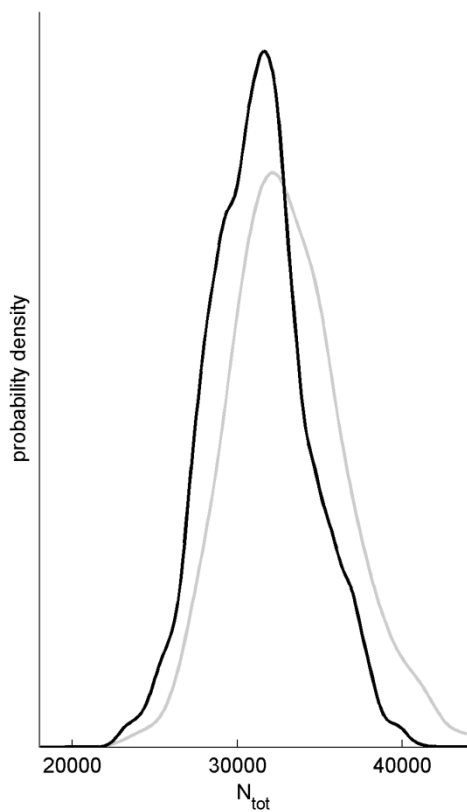


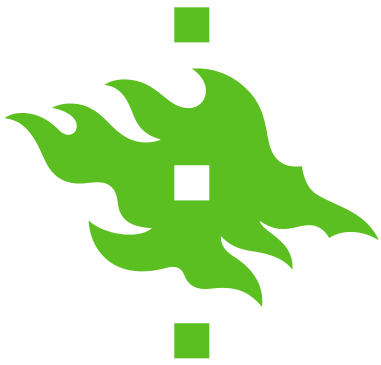
Results, catchability





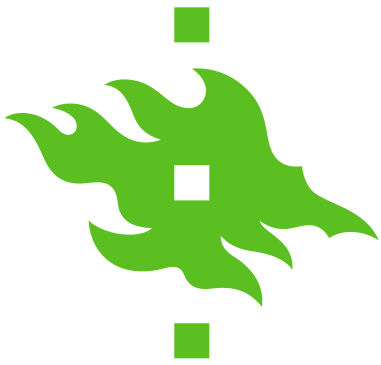
Results, seal abundance





Discussion

- Reliability of data
 - Much effort put on choosing "reliable" fishermen
 - Even if reliable, how well do you remember the last year?
 - In Estonia and Sweden the interviewed fishermen seemed trustworthy
 - In Finland (especially F2) fishermen seemed to underreport by-catch
 - Comments from interview
 - Catchability less than 1/10th of other catchabilities
 - How could we improve data reliability?
 - Fishermen's trust and volunteerines should be improved no matter how data is collected!
 - Yearly monitoring?



Discussion

- The results are not very sensitive to priors on
 - Priors affect uncertainty and right skewness of the posterior of by-catch
- Areas outside Finland, Estonia and Sweden excluded since we did not have effort data from there
 - However, the presented estimate is likely ~90% of total by-catch since majority of seals were estimated to be in this area