Estimating a mortality threshold for the Belt Sea population of harbour porpoises

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Naturhistoriska riksmuseet

Photo by Håkan Aronsson

Introduction

- Mortality limits are needed for management of species/populations under D1C1 of the Marine Strategy Framework Directive
- Implemented through HELCOM and OSPAR
- For many species thresholds are missing
- Task 2.1 of the HELCOM BLUES project aims to improve indicator assessments for bycatch for many species, including harbour porpoises
- NRM lead the calculations for the Belt Sea population for HOLAS III.

How to calculate mortality limits?

- **Removals Limit Algorithm (RLA)**- requires a time series of bycatch data which is unavailable for the Belt Sea population.
- **Potential Biological Removal (PBR)**- but it is tuned to the US MMPA conservation objective which states that a population at:
  1) Maximum net productivity level (MNPL) is able to remain there for 20 years, and
  2) 30% carrying capacity (K) is able to reached MNPL in 100 years (Wade 1998)
- **Set percentage of the population size**. However, this approach does not:
  1) Take population dynamics and demographic differences between species and populations into account
  2) Factor in potential sources of biases into the calculation
  3) Work towards any given conservation objective

Modified PBR (mPBR) method

- ASCOBANS resolutions (3.3 and 5.5)
- Conservation objective for harbour porpoises states: “populations should be kept at or restored to 80% of their carrying capacity” (No time frame or level of certainty is specified).
- Bycatch of harbour porpoises should be reduced to < 1% of the best available population estimate as an “intermediate precautionary objective”, and that bycatch > 1.7% of the population is an “unacceptable interaction”.
- “Meeting the objective in a shorter time will require that annual bycatch be reduced to an even lower fraction of the abundance.”
- “Additional sources of uncertainty and potential biases will also require more conservative management to ensure a high probability of meeting the objective."

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  - “Meeting the objective in a shorter time will require that annual bycatch be reduced to an even lower fraction of the abundance.”
  - “Additional sources of uncertainty and potential biases will also require more conservative management to ensure a high probability of meeting the objective."
- HELCOM “Number of drowned mammals and waterbirds in fishing gear” has been set to < 1% of the population size.
  - Still a need for modelling that takes demography and sources of bias into account
- Genu et al. 2021- modified PBR (mPBR) method tuned to the ASCOBANS conservation objective, with the assumption that it needs to be achieved with 80% certainty within 100 years.

Aims

- Calculate the mPBR mortality limit for the Belt Sea population of harbour porpoises
- Propose a new threshold value for use in HELCOM HOLAS III

Methods

Step 1 – population dynamics model

- Model used is a generalized logistic (Pella-Tomlinson), density-dependent, and age-disaggregated model
- Allows population-specific demographic parameters to be utilised to simulate population growth towards carrying capacity (assumed to be 50,000 animals – based on SCANS estimate)
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Step 2- Simulate bycatch impact prior to management

- Randomised removals (between 0.1% and 5% of K) completed every year as a result of unregulated bycatch that depletes the population to likely current day levels for 60 years (i.e. since 1960)

Methods cont.

Step 3- Select simulations

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<u>Step 4- Robustness trials</u>

- Function “pbr_nouveau” (Genu et al. 2021) was used to complete 10 scenarios to determine impact of bias in data on population recovery in relation to base case scenario (where no bias is assumed)

- Assumed an Rmax of 4% (used for cetaceans in MMPA and world wide):
  - Morro Bay population has the highest growth rate (9.6%) for the species. Also 5.8% and 6.1% in two other populations with greatly reduced bycatch.
  - However, Belt Sea population distributional range is in one of the most PCB concentrated areas in the world (limits reproduction)
  - Lack of a positive population growth trend (as observed in Morro bay) suggests any higher than 4% is unrealistic.

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Step 5- Selection of recovery factor

- Look at results to determine which recovery factor (Fr) value is required for the population to meet the conservation objective, and determine associated mortality level using the PBR equation

Methods cont.

- PBR is calculated as:

$$PBR = N_{min} \times 0.5R_{max} \times F_r$$

Where Nmin equals:

$$N_{min} = \frac{17{,}301}{exp\left(0.842\sqrt{l_n(1+0.2^2)}\right)}$$

- Using the best available abundance estimate from MiniSCANS II: 17,301 (95% CI = 11,695-25,688; CV = 0.20) (Unger et al. 2021), and an Rmax of 4%,

N_{min} = 14,644 animals for the Belt Sea population.

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Standard PBR based on Nmin

Fr	PBR
0.1	29
0.2	58
0.3	87
0.4	117
0.5	146
0.6	175
0.7	205
0.8	234
0.9	263
1	292

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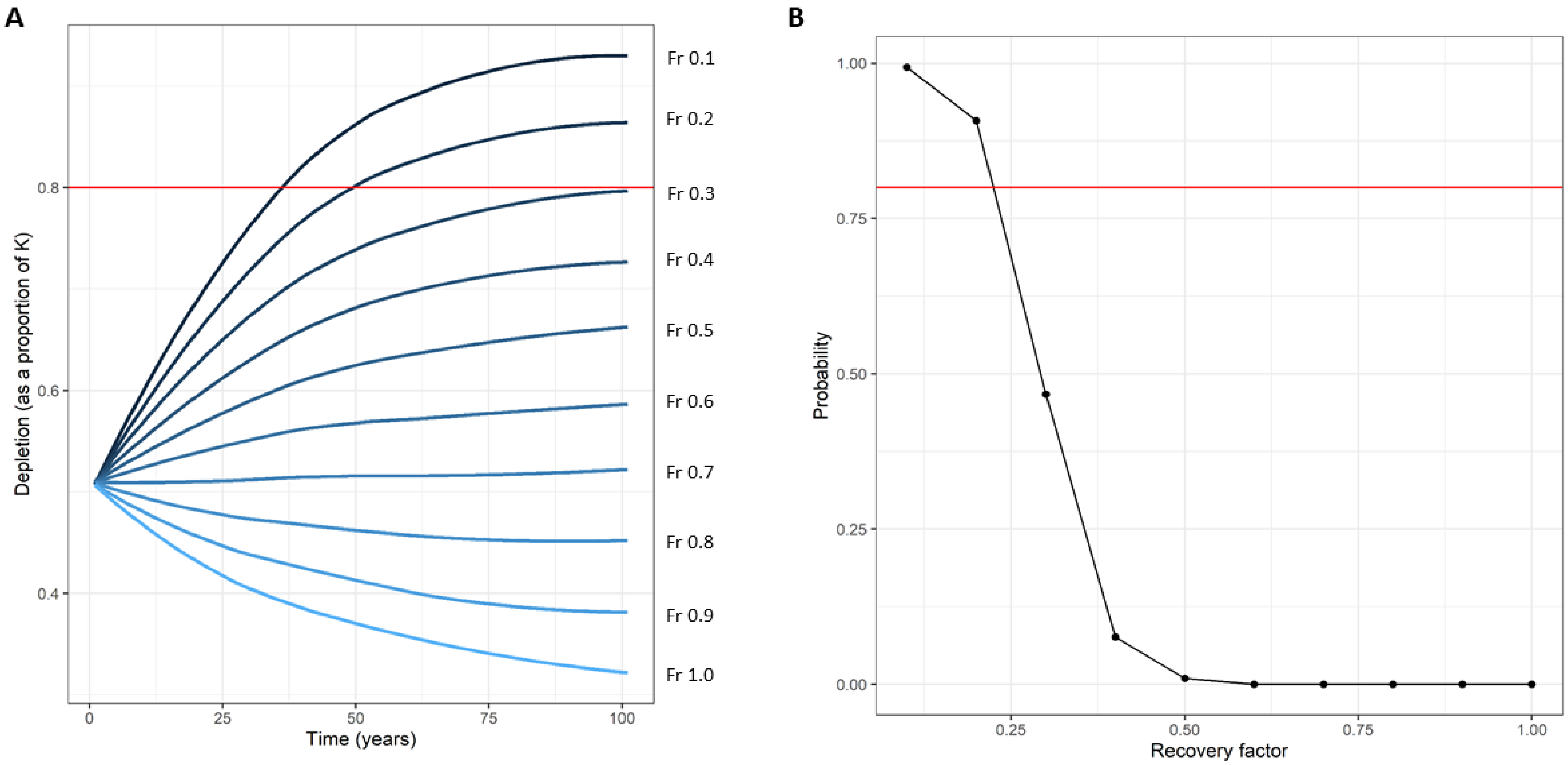
- Assessment units that are depleted, threatened or have an unknown status it is generally recommended that Fr is set to a maximum of 0.5
- Fr of 1.0 should only be used if the population is increasing
- Which of these allow the population to reach the ASCOBANS conservation objective?

Base Case Scenario (assuming no bias)



Assuming CV = 0.2

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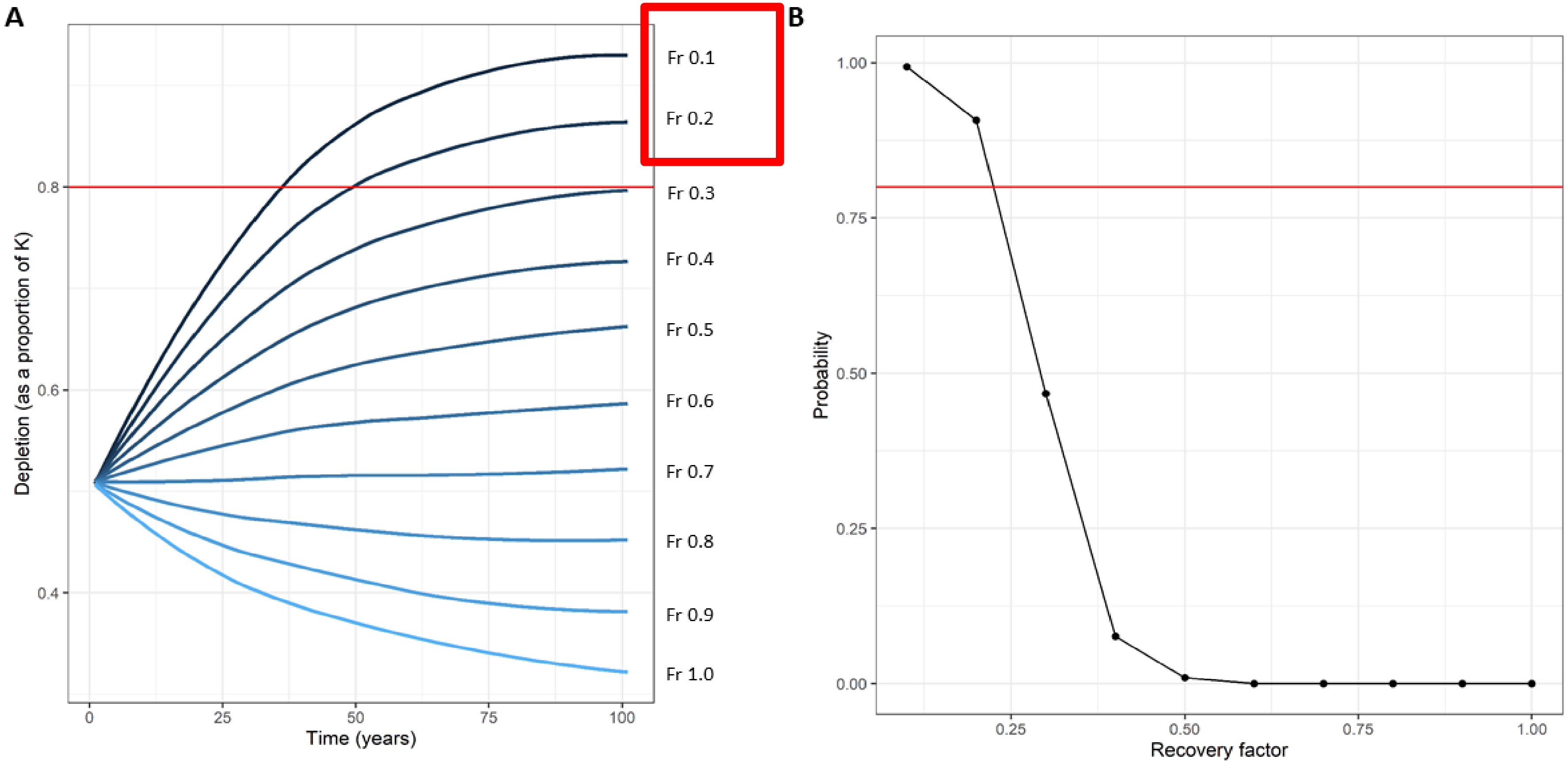

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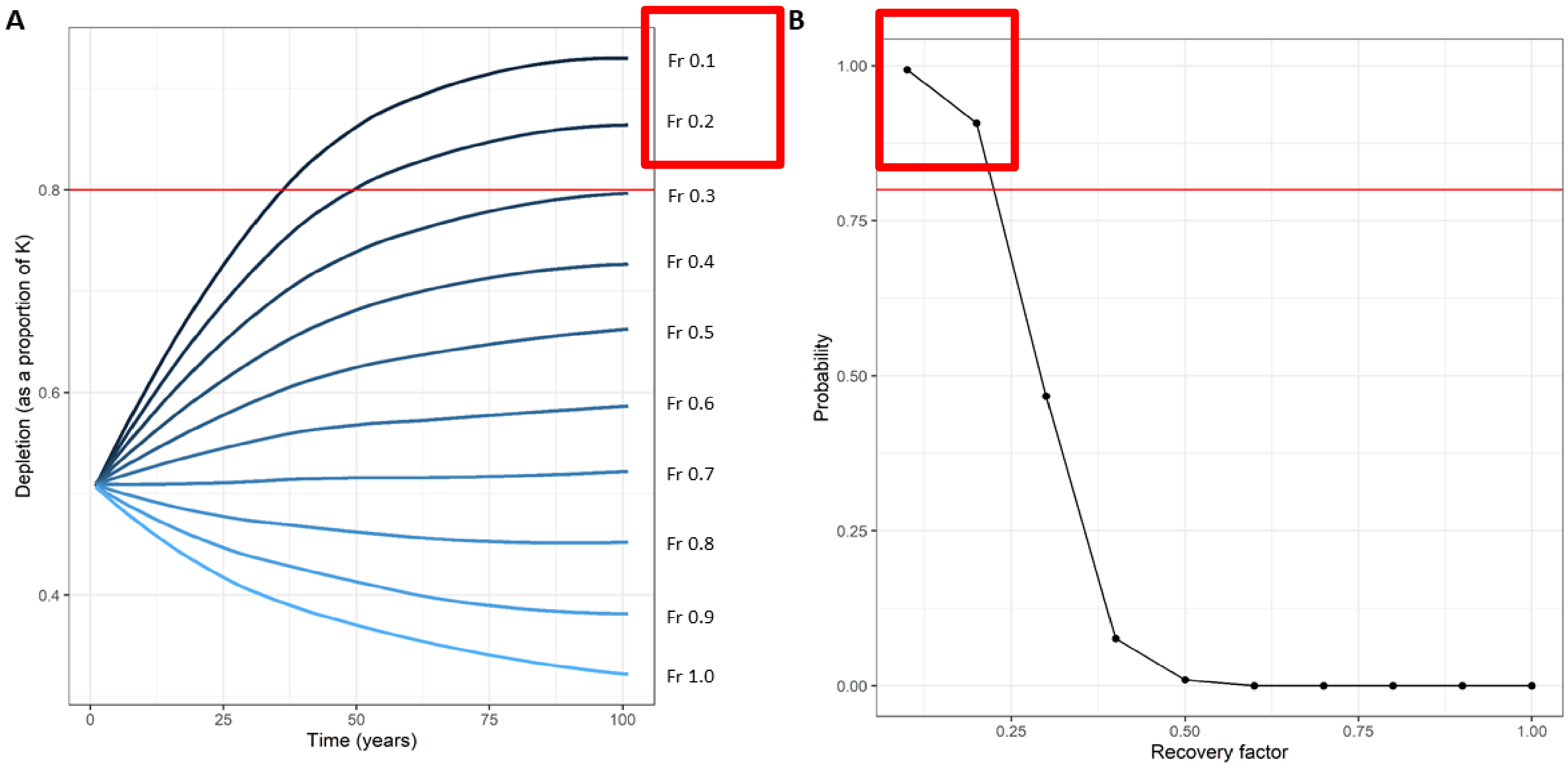

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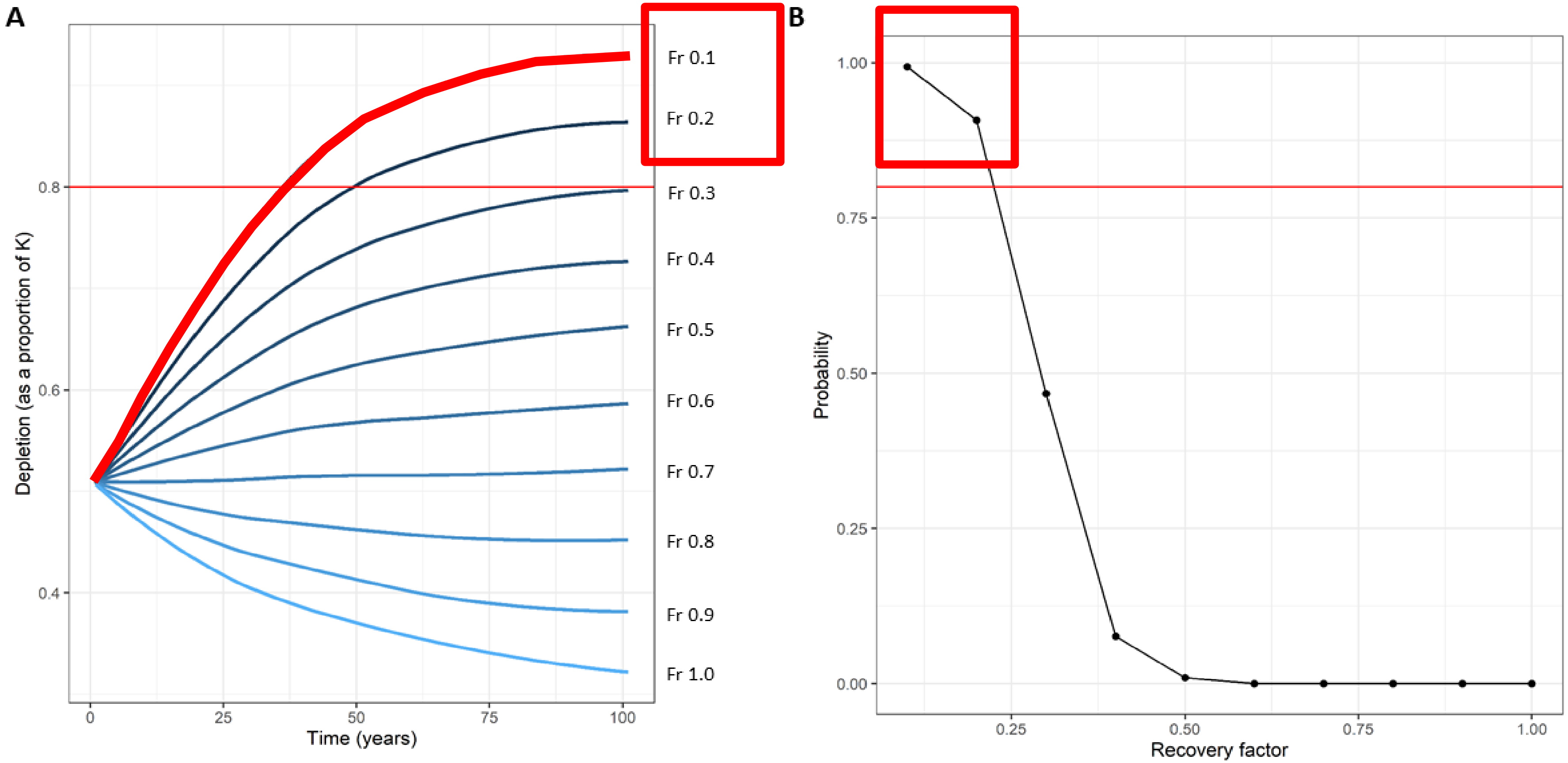

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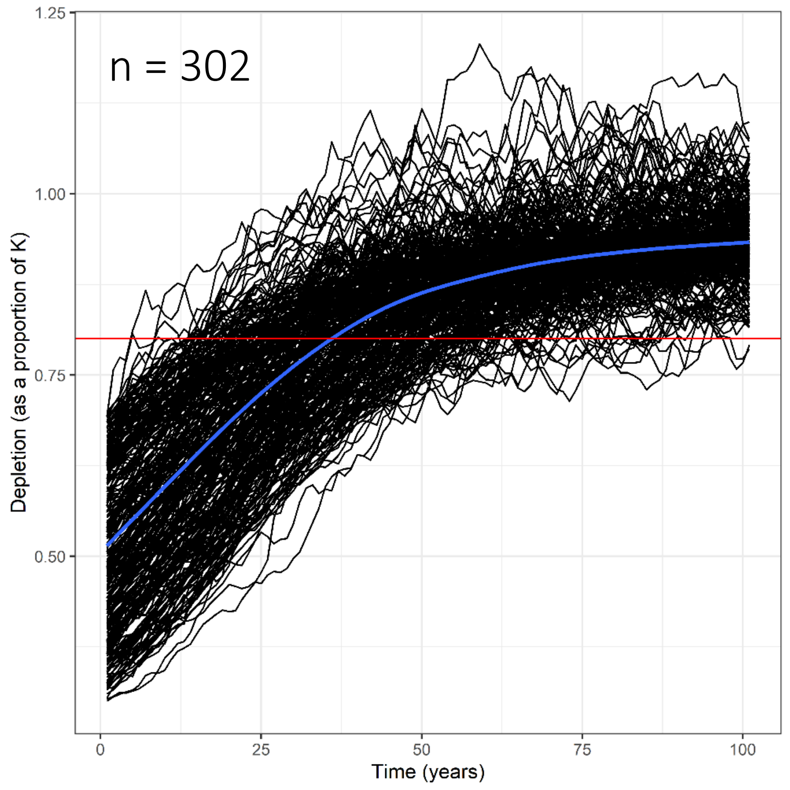

Robustness trials (impact of bias)

Robustness trial	Scenario	n	q	MNPL	K_{trend}	Frequency	R_{max}	CV	b.byc	b.abund	$b.R_{max}$	byc.CV	cata.	F_r
Base case scenario	0A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	0	0.2
	0B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	0	0.3
Bycatch underestimation	1A	302	0.2	0.5	1	6	0.04	0.2	**2**	1	1	0.3	0	0.1
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Maximum Productivity rate underestimation	3A	302	0.2	0.5	1	6	0.04	0.2	1	1	**0.5**	0.3	0	0.4
	3B	298	0.2	0.5	1	6	0.04	0.4	1	1	**0.5**	0.3	0	0.6
Higher bycatch coefficient of variation	5A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	**1.2**	0	0.2
	5B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	**1.2**	0	0.2
Lower survey frequency	6A	302	0.2	0.5	1	**10**	0.04	0.2	1	1	1	0.3	0	0.2
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Lower MNPL	7A	289	0.2	**0.45**	1	6	0.04	0.2	1	1	1	0.3	0	NA
	7B	311	0.2	**0.45**	1	6	0.04	0.4	1	1	1	0.3	0	0.1
Higher MNPL + bycatch underestimation	8A	298	0.2	**0.7**	1	6	0.04	0.2	**2**	1	1	0.3	0	0.4
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	0B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	0	0.3
Bycatch underestimation	1A	302	0.2	0.5	1	6	0.04	0.2	**2**	1	1	0.3	0	0.1
	1B	298	0.2	0.5	1	6	0.04	0.4	**2**	1	1	0.3	0	0.1
Abundance overestimation	2A	302	0.2	0.5	1	6	0.04	0.2	1	**2**	1	0.3	0	0.1
	2B	298	0.2	0.5	1	6	0.04	0.4	1	**2**	1	0.3	0	0.1
Maximum Productivity rate underestimation	3A	302	0.2	0.5	1	6	0.04	0.2	1	1	**0.5**	0.3	0	0.4
	3B	298	0.2	0.5	1	6	0.04	0.4	1	1	**0.5**	0.3	0	0.6
Higher bycatch coefficient of variation	5A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	**1.2**	0	0.2
	5B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	**1.2**	0	0.2
Lower survey frequency	6A	302	0.2	0.5	1	**10**	0.04	0.2	1	1	1	0.3	0	0.2
	6B	298	0.2	0.5	1	**10**	0.04	0.4	1	1	1	0.3	0	0.2
Lower MNPL	7A	289	0.2	**0.45**	1	6	0.04	0.2	1	1	1	0.3	0	NA
	7B	311	0.2	**0.45**	1	6	0.04	0.4	1	1	1	0.3	0	0.1
Higher MNPL + bycatch underestimation	8A	298	0.2	**0.7**	1	6	0.04	0.2	**2**	1	1	0.3	0	0.4
	8B	302	0.2	**0.7**	1	6	0.04	0.4	**2**	1	1	0.3	0	0.4
Catastrophic events happening	9A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	**0.1**	0.2
	9B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	**0.1**	0.2
Carrying capacity degradation	10A	302	0.2	0.5	**0.5**	6	0.04	0.2	1	1	1	0.3	0	0.4
	10B	298	0.2	0.5	**0.5**	6	0.04	0.4	1	1	1	0.3	0	0.5

Robustness trials (impact of bias)

Robustness trial	Scenario	n	q	MNPL	K_{trend}	Frequency	R_{max}	CV	b.byc	b.abund	b.R_{max}	byc.CV	cata.	F_r
Base case scenario	0A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	0	0.2
	0B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	0	0.3
Bycatch underestimation	1A	302	0.2	0.5	1	6	0.04	0.2	**2**	1	1	0.3	0	0.1
	1B	298	0.2	0.5	1	6	0.04	0.4	**2**	1	1	0.3	0	0.1
Abundance overestimation	2A	302	0.2	0.5	1	6	0.04	0.2	1	**2**	1	0.3	0	0.1
	2B	298	0.2	0.5	1	6	0.04	0.4	1	**2**	1	0.3	0	0.1
Maximum Productivity rate underestimation	3A	302	0.2	0.5	1	6	0.04	0.2	1	1	**0.5**	0.3	0	0.4
	3B	298	0.2	0.5	1	6	0.04	0.4	1	1	**0.5**	0.3	0	0.6
Higher bycatch coefficient of variation	5A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	**1.2**	0	0.2
	5B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	**1.2**	0	0.2
Lower survey frequency	6A	302	0.2	0.5	1	**10**	0.04	0.2	1	1	1	0.3	0	0.2
	6B	298	0.2	0.5	1	**10**	0.04	0.4	1	1	1	0.3	0	0.2
Lower MNPL	7A	289	0.2	**0.45**	1	6	0.04	0.2	1	1	1	0.3	0	NA
	7B	311	0.2	**0.45**	1	6	0.04	0.4	1	1	1	0.3	0	0.1
Higher MNPL + bycatch underestimation	8A	298	0.2	**0.7**	1	6	0.04	0.2	**2**	1	1	0.3	0	0.4
	8B	302	0.2	**0.7**	1	6	0.04	0.4	**2**	1	1	0.3	0	0.4
Catastrophic events happening	9A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	**0.1**	0.2
	9B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	**0.1**	0.2
Carrying capacity degradation	10A	302	0.2	0.5	**0.5**	6	0.04	0.2	1	1	1	0.3	0	0.4
	10B	298	0.2	0.5	**0.5**	6	0.04	0.4	1	1	1	0.3	0	0.5

Robustness trials (impact of bias)

Robustness trial	Scenario	n	q	MNPL	K_{trend}	Frequency	R_{max}	CV	b.byc	b.abund	b.R_{max}	byc.CV	cata.	F_r
Base case scenario	0A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	0	0.2
	0B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	0	0.3
Bycatch underestimation	1A	302	0.2	0.5	1	6	0.04	0.2	**2**	1	1	0.3	0	0.1
	1B	298	0.2	0.5	1	6	0.04	0.4	**2**	1	1	0.3	0	0.1
Abundance overestimation	2A	302	0.2	0.5	1	6	0.04	0.2	1	**2**	1	0.3	0	0.1
	2B	298	0.2	0.5	1	6	0.04	0.4	1	**2**	1	0.3	0	0.1
Maximum Productivity rate underestimation	3A	302	0.2	0.5	1	6	0.04	0.2	1	1	**0.5**	0.3	0	0.4
	3B	298	0.2	0.5	1	6	0.04	0.4	1	1	**0.5**	0.3	0	0.6
Higher bycatch coefficient of variation	5A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	**1.2**	0	0.2
	5B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	**1.2**	0	0.2
Lower survey frequency	6A	302	0.2	0.5	1	**10**	0.04	0.2	1	1	1	0.3	0	0.2
	6B	298	0.2	0.5	1	**10**	0.04	0.4	1	1	1	0.3	0	0.2
Lower MNPL	7A	289	0.2	**0.45**	1	6	0.04	0.2	1	1	1	0.3	0	NA
	7B	311	0.2	**0.45**	1	6	0.04	0.4	1	1	1	0.3	0	0.1
Higher MNPL + bycatch underestimation	8A	298	0.2	**0.7**	1	6	0.04	0.2	**2**	1	1	0.3	0	0.4
	8B	302	0.2	**0.7**	1	6	0.04	0.4	**2**	1	1	0.3	0	0.4
Catastrophic events happening	9A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	**0.1**	0.2
	9B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	**0.1**	0.2
Carrying capacity degradation	10A	302	0.2	0.5	**0.5**	6	0.04	0.2	1	1	1	0.3	0	0.4
	10B	298	0.2	0.5	**0.5**	6	0.04	0.4	1	1	1	0.3	0	0.5

Robustness trials (impact of bias)

Robustness trial	Scenario	n	q	MNPL	K_{trend}	Frequency	R_{max}	CV	b.byc	b.abund	$b.R_{max}$	byc.CV	cata.	F_r
Base case scenario	0A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	0	0.2
	0B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	0	0.3
Bycatch underestimation	1A	302	0.2	0.5	1	6	0.04	0.2	**2**	1	1	0.3	0	0.1
	1B	298	0.2	0.5	1	6	0.04	0.4	**2**	1	1	0.3	0	0.1
Abundance overestimation	2A	302	0.2	0.5	1	6	0.04	0.2	1	**2**	1	0.3	0	0.1
	2B	298	0.2	0.5	1	6	0.04	0.4	1	**2**	1	0.3	0	0.1
Maximum Productivity rate underestimation	3A	302	0.2	0.5	1	6	0.04	0.2	1	1	**0.5**	0.3	0	0.4
	3B	298	0.2	0.5	1	6	0.04	0.4	1	1	**0.5**	0.3	0	0.6
Higher bycatch coefficient of variation	5A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	**1.2**	0	0.2
	5B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	**1.2**	0	0.2
Lower survey frequency	6A	302	0.2	0.5	1	**10**	0.04	0.2	1	1	1	0.3	0	0.2
	6B	298	0.2	0.5	1	**10**	0.04	0.4	1	1	1	0.3	0	0.2
Lower MNPL	7A	289	0.2	**0.45**	1	6	0.04	0.2	1	1	1	0.3	0	NA
	7B	311	0.2	**0.45**	1	6	0.04	0.4	1	1	1	0.3	0	0.1
Higher MNPL + bycatch underestimation	8A	298	0.2	**0.7**	1	6	0.04	0.2	**2**	1	1	0.3	0	0.4
	8B	302	0.2	**0.7**	1	6	0.04	0.4	**2**	1	1	0.3	0	0.4
Catastrophic events happening	9A	302	0.2	0.5	1	6	0.04	0.2	1	1	1	0.3	**0.1**	0.2
	9B	298	0.2	0.5	1	6	0.04	0.4	1	1	1	0.3	**0.1**	0.2
Carrying capacity degradation	10A	302	0.2	0.5	**0.5**	6	0.04	0.2	1	1	1	0.3	0	0.4
	10B	298	0.2	0.5	**0.5**	6	0.04	0.4	1	1	1	0.3	0	0.5

Conclusion

Fr	PBR
0.1	**29**
0.2	58
0.3	87
0.4	117
0.5	146
0.6	175
0.7	205
0.8	234
0.9	263
1	292

- Fr of 0.1 should be used to allow population to reach ASCOBANS conservation objective
- This equates to a <u>mortality limit of 29 individuals</u>
- We propose this should be used as a threshold by HELCOM in HOLAS III for the Belt Sea population
- Need accurate information on total bycatch levels (bycatch rate and fishing effort) in order to accurately assess
- More accurate time series of bycatch data would allow:
- Less need to account for uncertainty (higher Fr can be used)
- Use of RLA method
- *More robust*
- *Results in a larger mortality threshod.*