Ecosystem model of Icelandic waters using the Atlantis modelling framework

Erla Sturludottir, Christopher Desjardins, Bjarki Elvarsson
Kai Logemann, Gudrun Marteinsdottir
and Gunnar Stefansson

Advances in Ecosystem-based Fisheries Management
14th December 2017
Brussels, Belgium

MareFrame

MINOUW

MARINE & FRESHWATER RESEARCH INSTITUTE

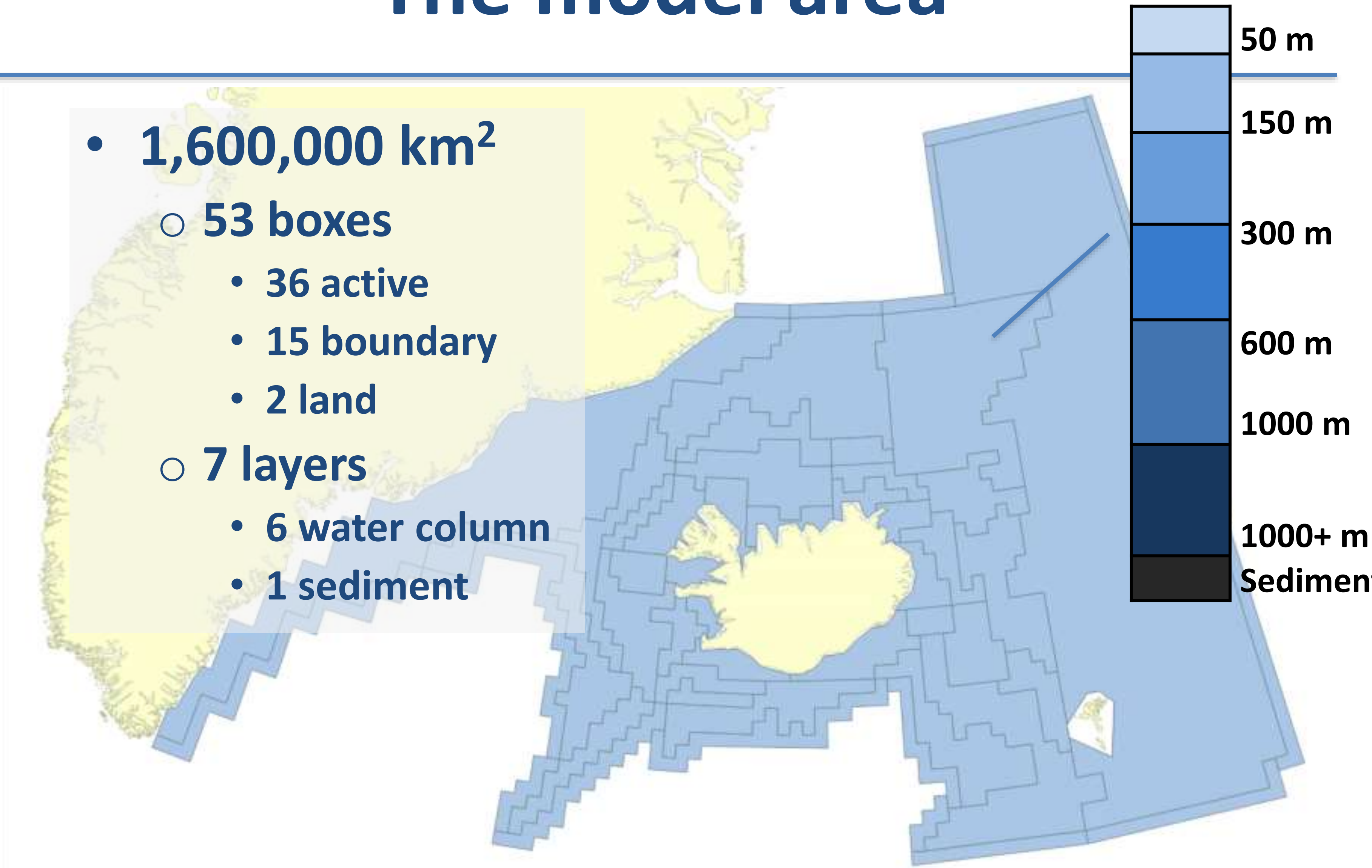
SIGILLUM UNIVERSITATIS ISLANDIAE

Atlantis

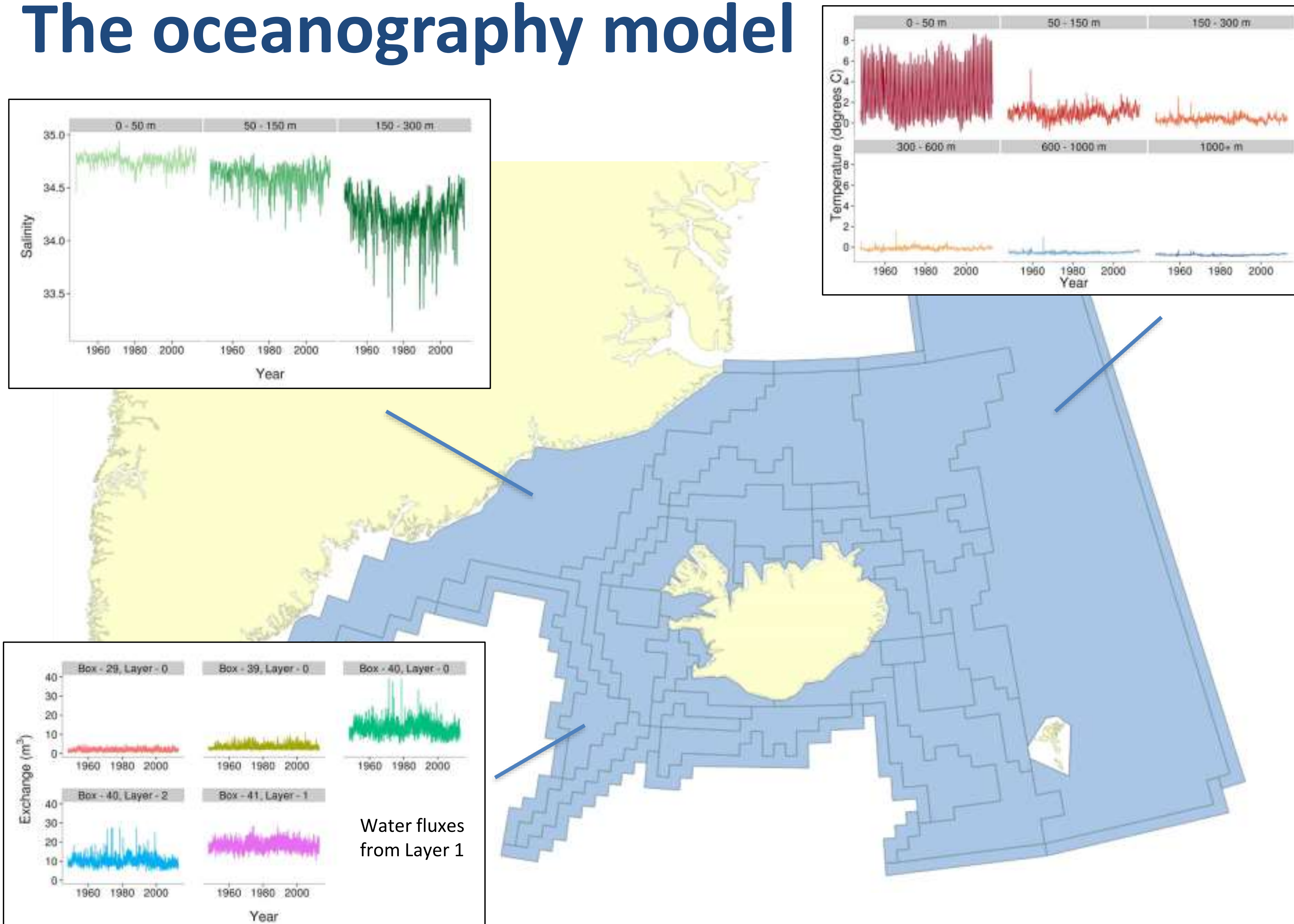
- Simulates the entire ecosystem.
- Ecosystem model
- Fisheries model
- Sampling and assessment model
- Management model
- Socio-economic model

The model area

- $1,600,000\ km^2$
  - 53 boxes
    - 36 active
    - 15 boundary
    - 2 land
  - 7 layers
    - 6 water column
    - 1 sediment



The oceanography model

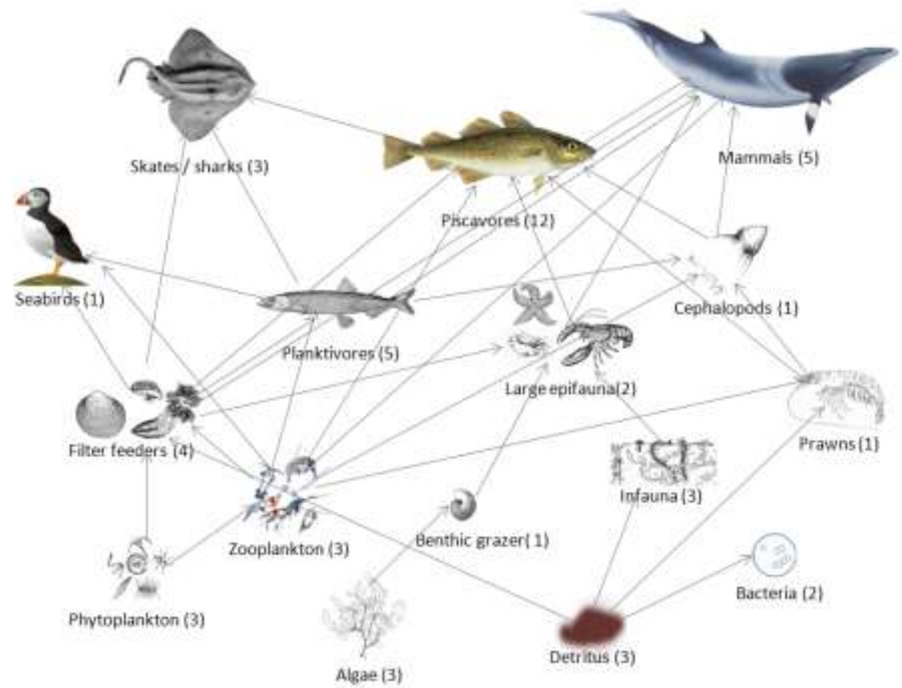


The biology model

- Functional groups
- Consumption
- Predation
- Growth
- Reproduction
- Movement
- Migration

The functional groups

- 51 functional group
  - 25 vertebrates
    - 16 fish
    - 3 shark/skates
    - 5 mammal
    - 1 seabird
  - 16 invertebrate groups
  - 5 primary producers
  - 2 bacteria
  - 3 detritus



The biology model

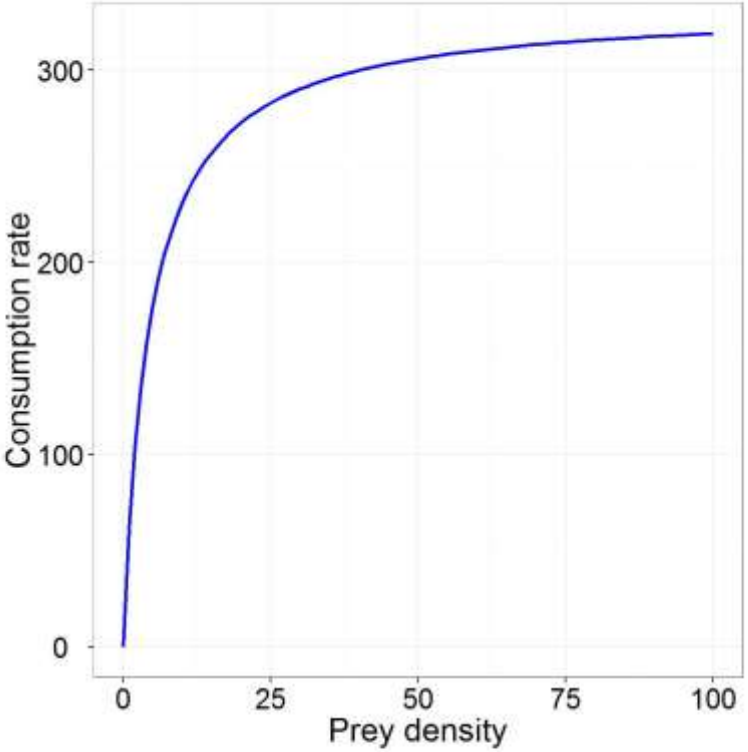
- Vertebrates
  - 10 age classes
    - Numbers per age within ageclass
  - Weight in mg N
    - Reserved weight
    - Structural weight

- Invertebrates
  - 2 ageclasses
  - Biomass pools mg N m^{-3}

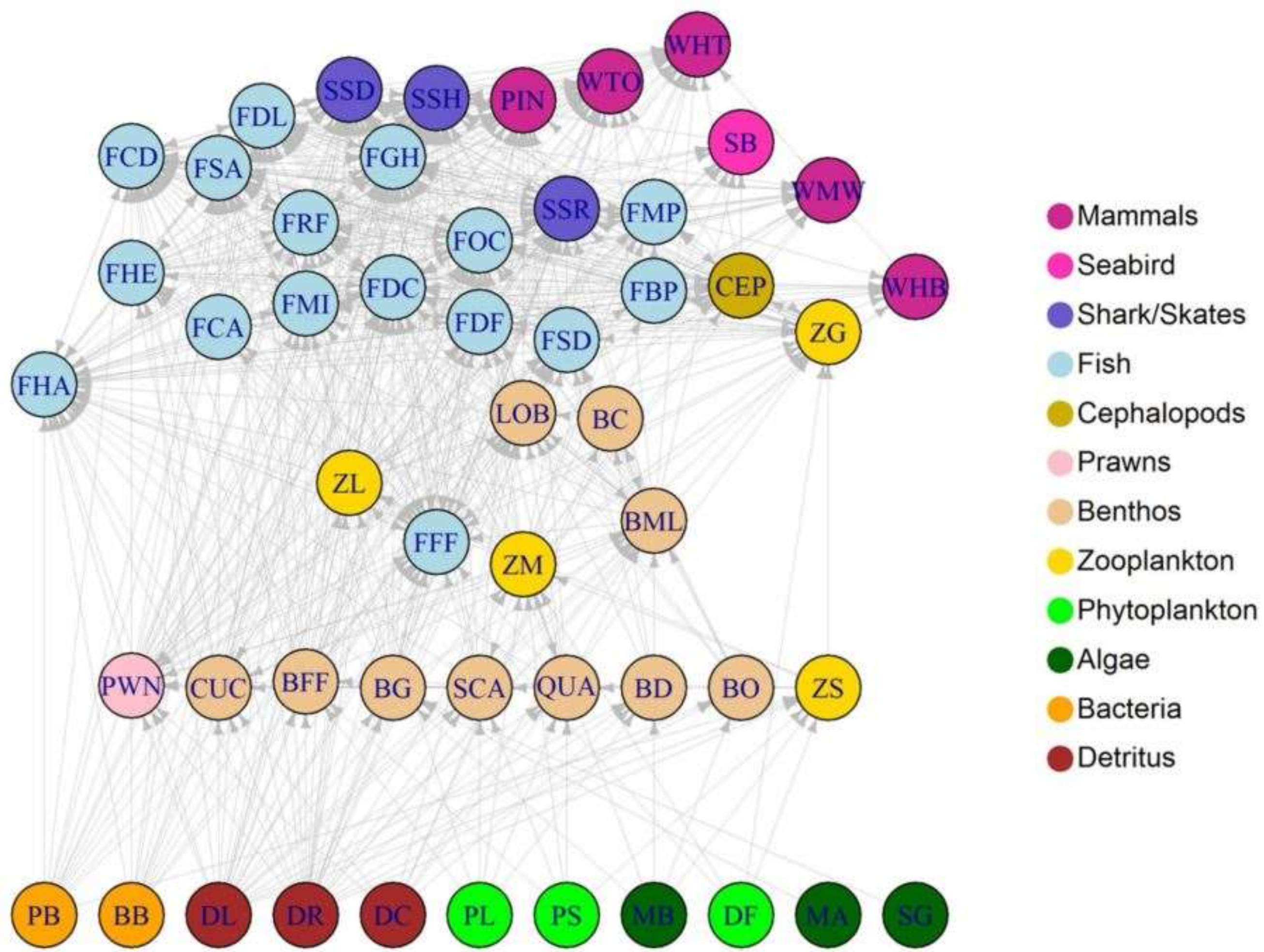
Consumption

- Holling type II
- Gape limitation
- Prey availability

$$Q_{ij} = \frac{a_{ij} \cdot Prey_i \cdot C_j}{1 + \frac{C_j}{\mu_j} \sum_k Prey_k \cdot \epsilon_{ij} \cdot a_{ij}}$$



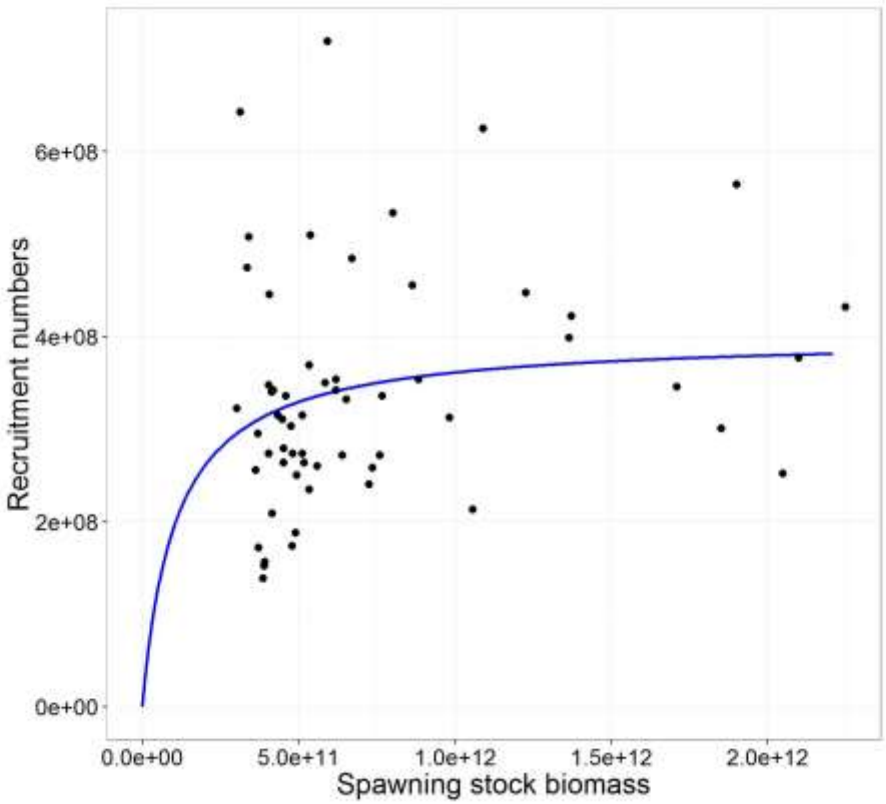
The food web


WHT
WTO
PIN
SSH
SSD
FDL
FCD
FSA
FGH
SB
WMW
SSR
FMP
FRF
FOC
FHE
FDC
FMI
FBP
CEP
WHB
FCA
FDF
FSD
ZG
FHA
LOB
BC
ZL
BML
FFF
ZM
PWN
CUC
BFF
BG
SCA
QUA
BD
BO
ZS
PB
BB
DL
DR
DC
PL
PS
MB
DF
MA
SG
Mammals
Seabird
Shark/Skates
Fish
Cephalopods
Prawns
Benthos
Zooplankton
Phytoplankton
Algae
Bacteria
Detritus

Reproduction

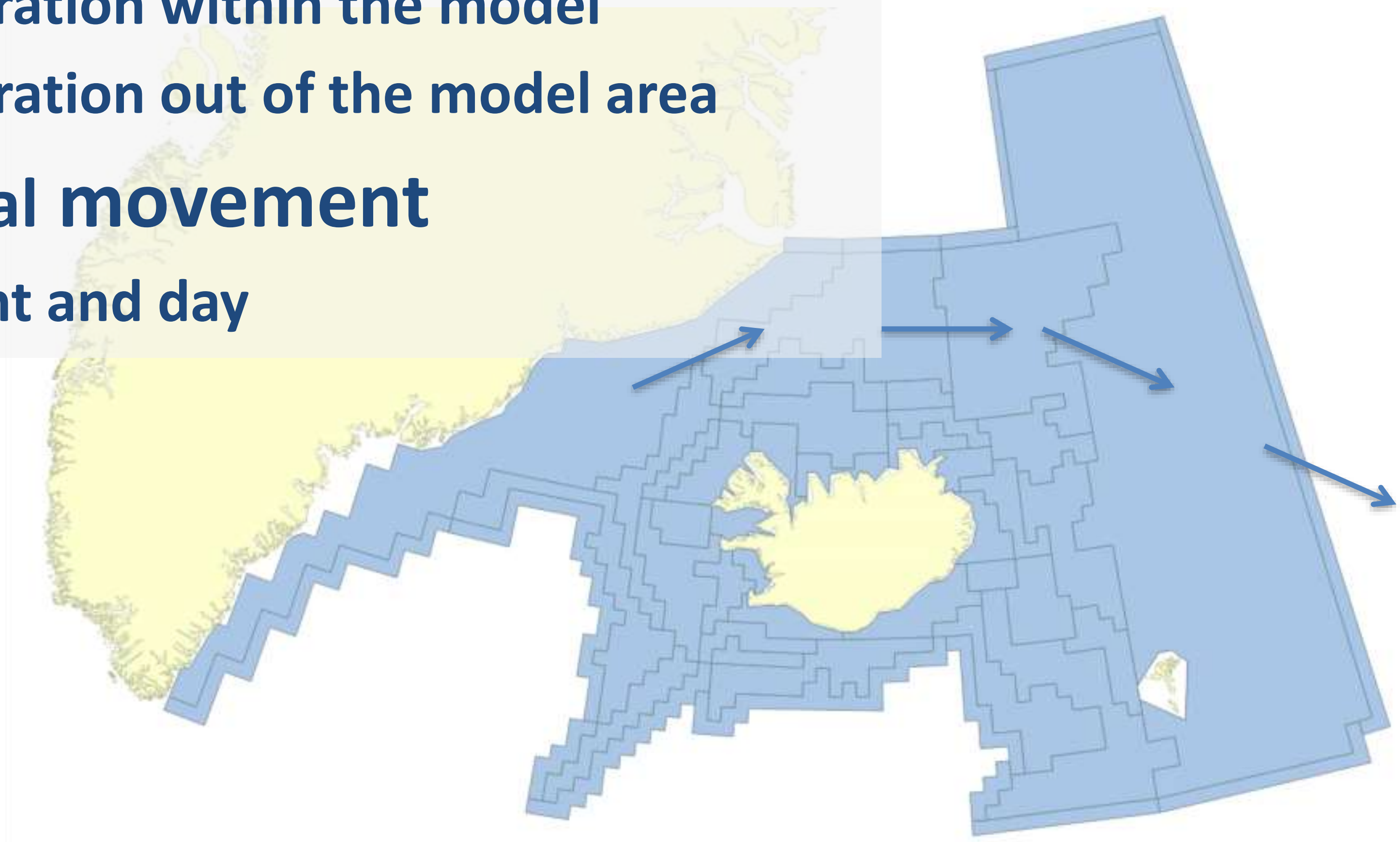
- **Beverton – Holt**
- **Fixed number per adult**

$$N_{\text{Rec}} = \frac{SSB \cdot \alpha}{\beta + SSB}$$

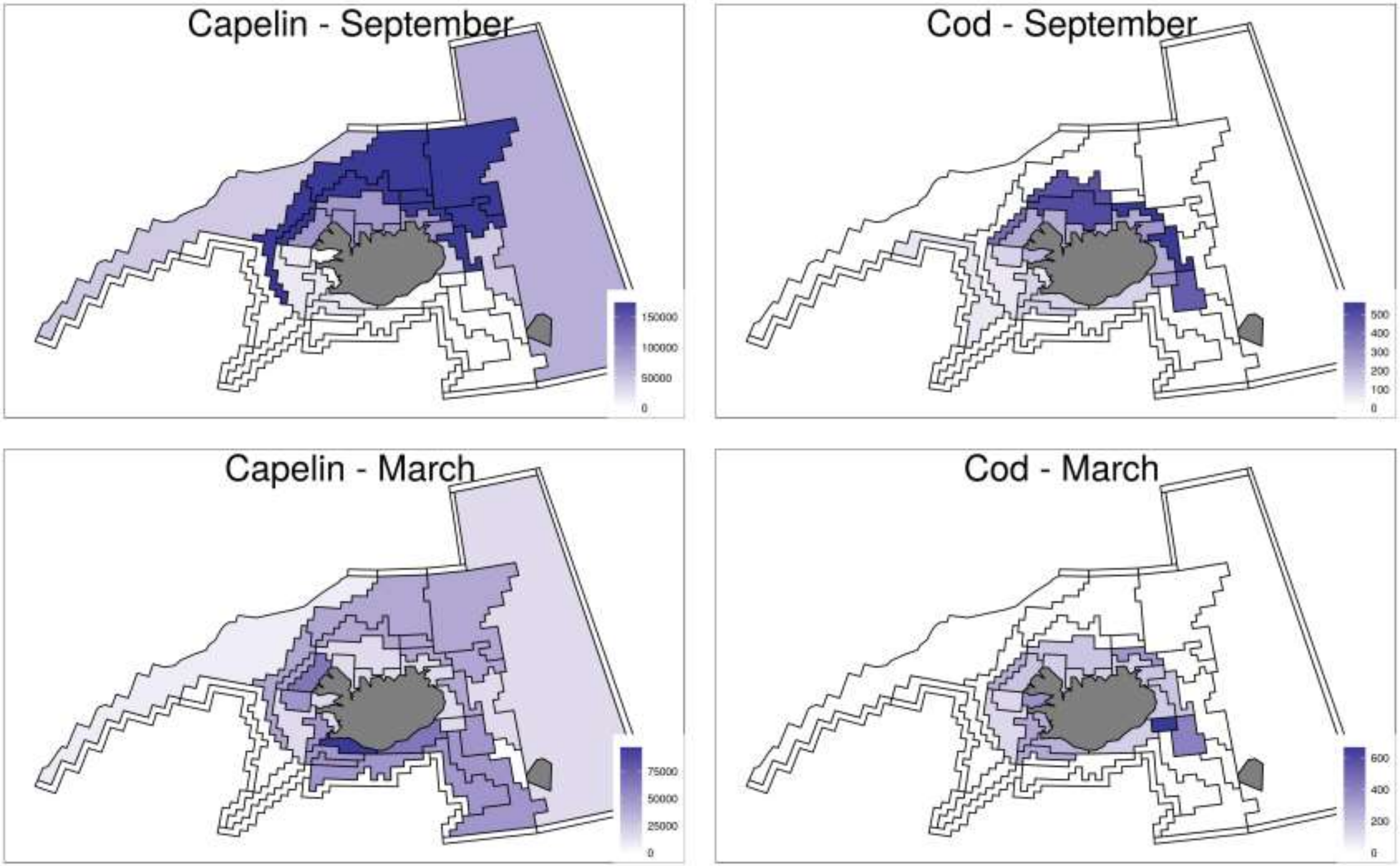


Migration and movement

- Horizontal movement
  - Migration within the model
  - Migration out of the model area
- Vertical movement
  - Night and day



Spatial distribution



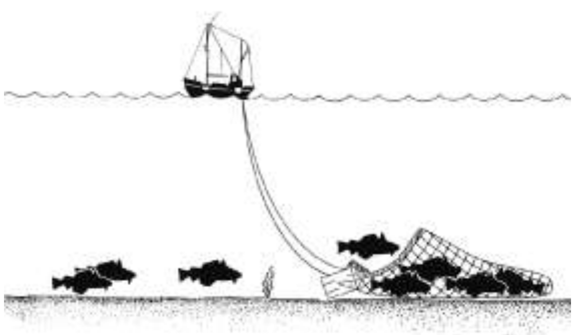
The fisheries model

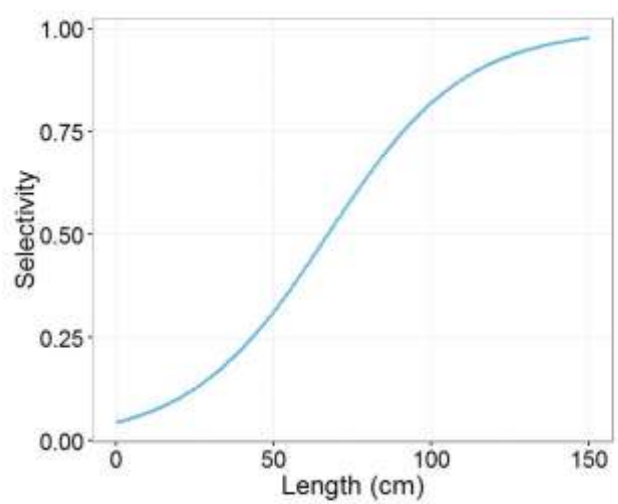
- Fisheries
  - Multiple fleets
    - Gear
    - Target
    - Selectivity

Fishing in Atlantis

Discard

Fishing gear → Selectivity → Harvest rate → Biomass → Catch biomass





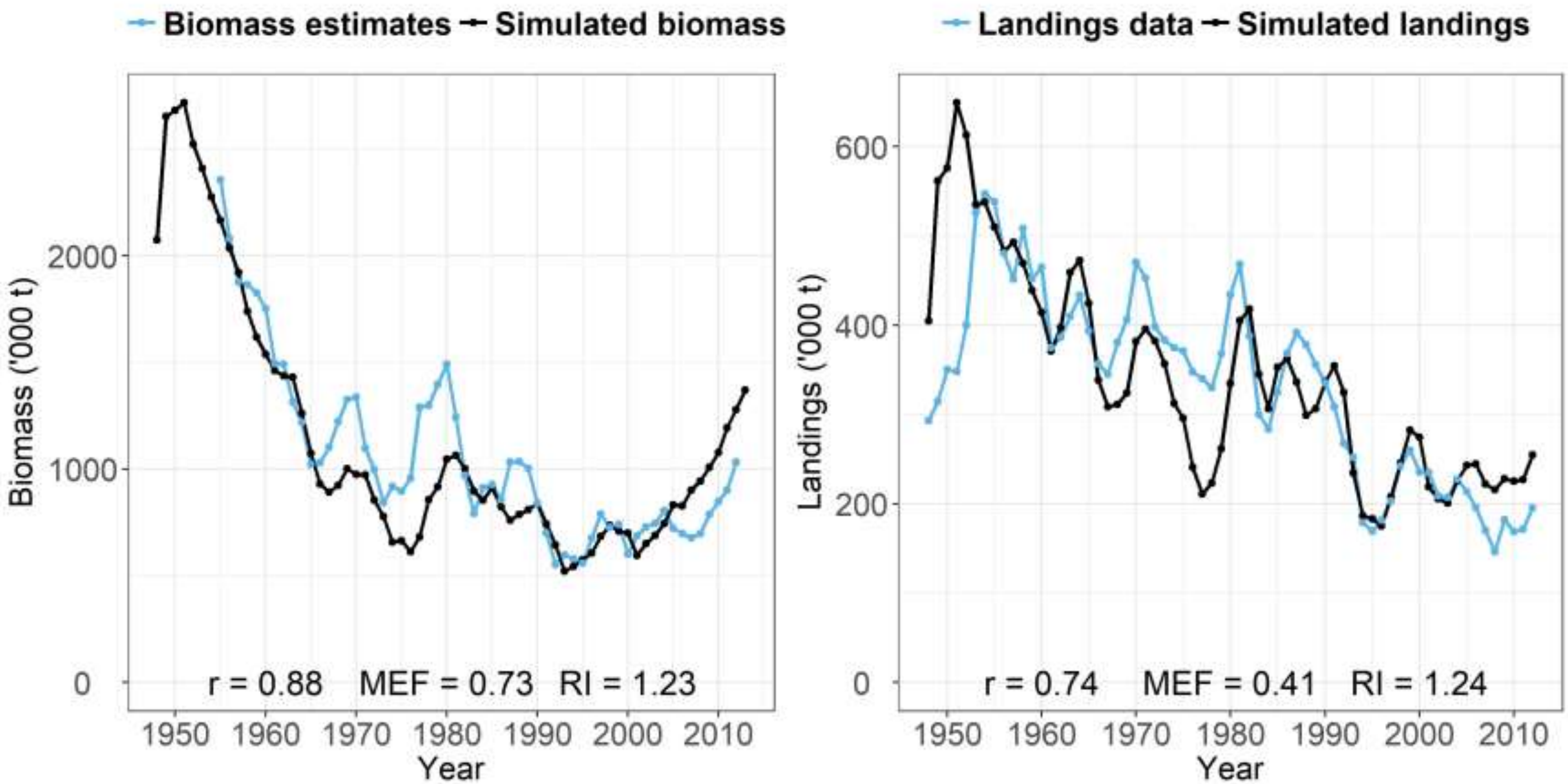
Skill assessment

$$r = \frac{\sum_{i=1}^{n}(O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \bar{O})^2 \sum_{i=1}^{n}(P_i - \bar{P})^2}}$$

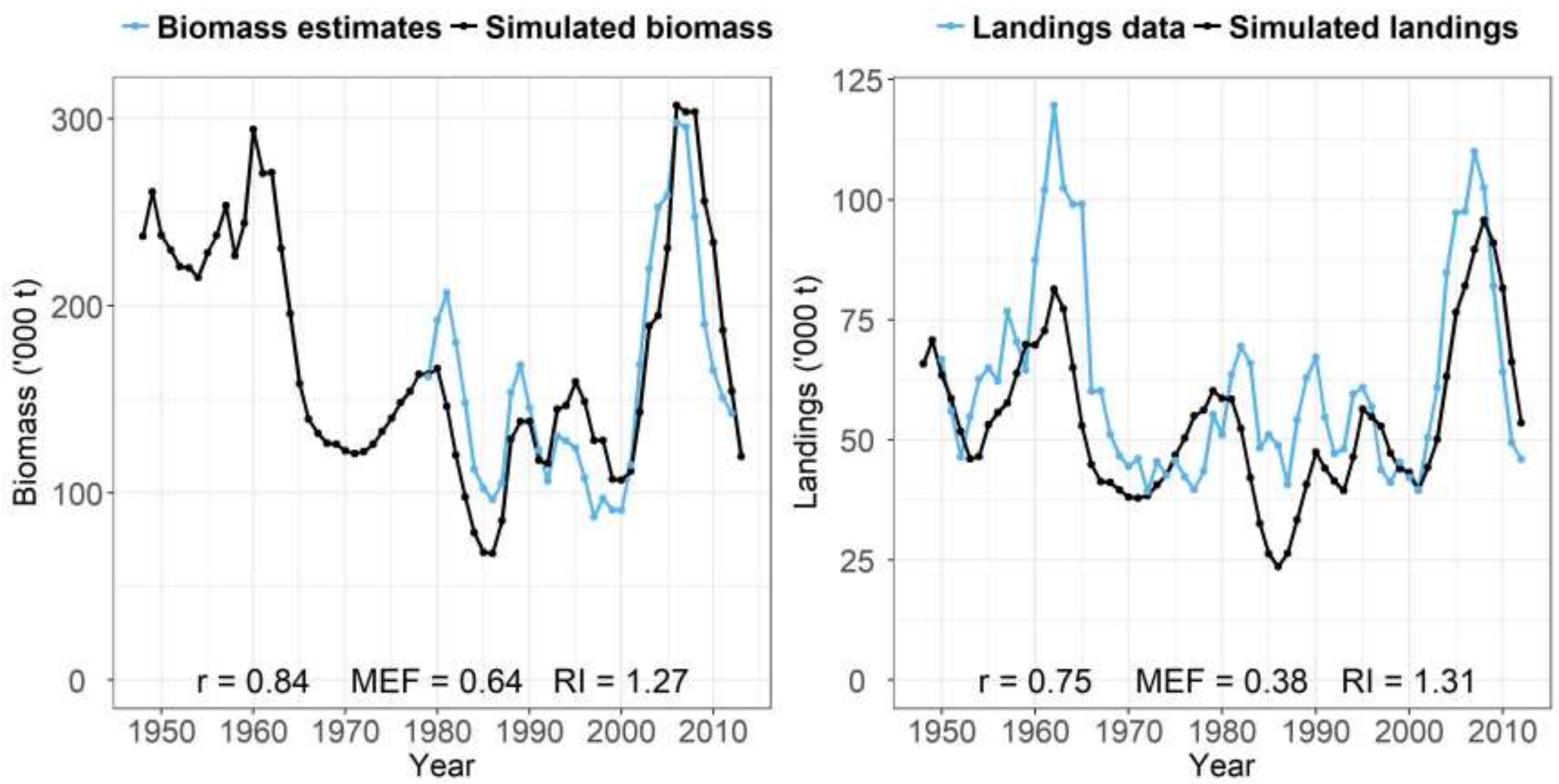
$$RI = exp\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\log\frac{O_i}{P_i}\right)^2}$$

$$MEF = \frac{\sum_{i=1}^{n}(O_i - \bar{O})^2 - \sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(O_i - \bar{O})^2}$$

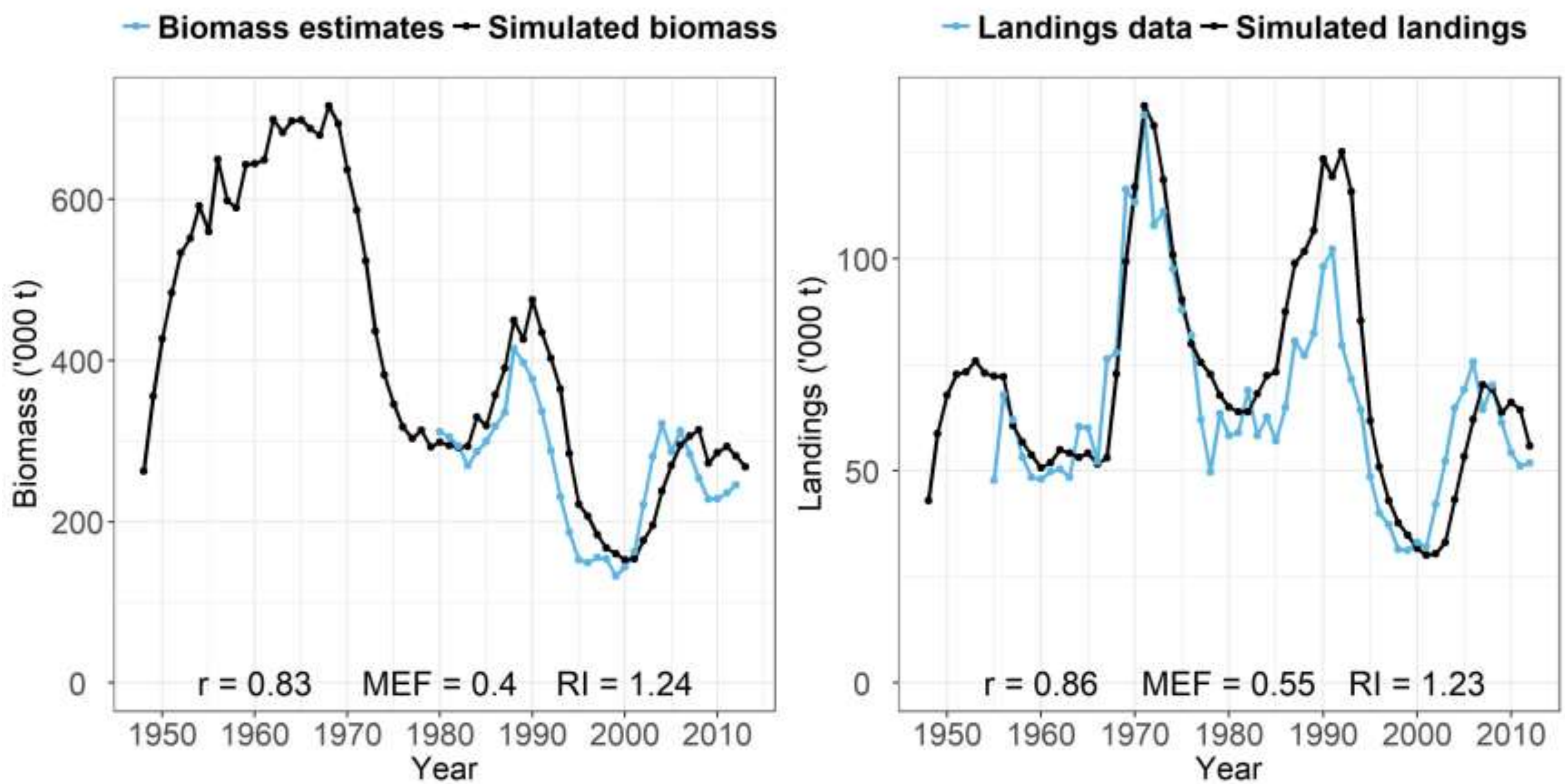
Cod


Biomass estimates
Simulated biomass
Biomass ('000 t)
2000
1000
0
r = 0.88 MEF = 0.73 RI = 1.23
1950 1960 1970 1980 1990 2000 2010
Year
Landings data
Simulated landings
Landings ('000 t)
600
400
200
0
r = 0.74 MEF = 0.41 RI = 1.24
1950 1960 1970 1980 1990 2000 2010
Year

Haddock

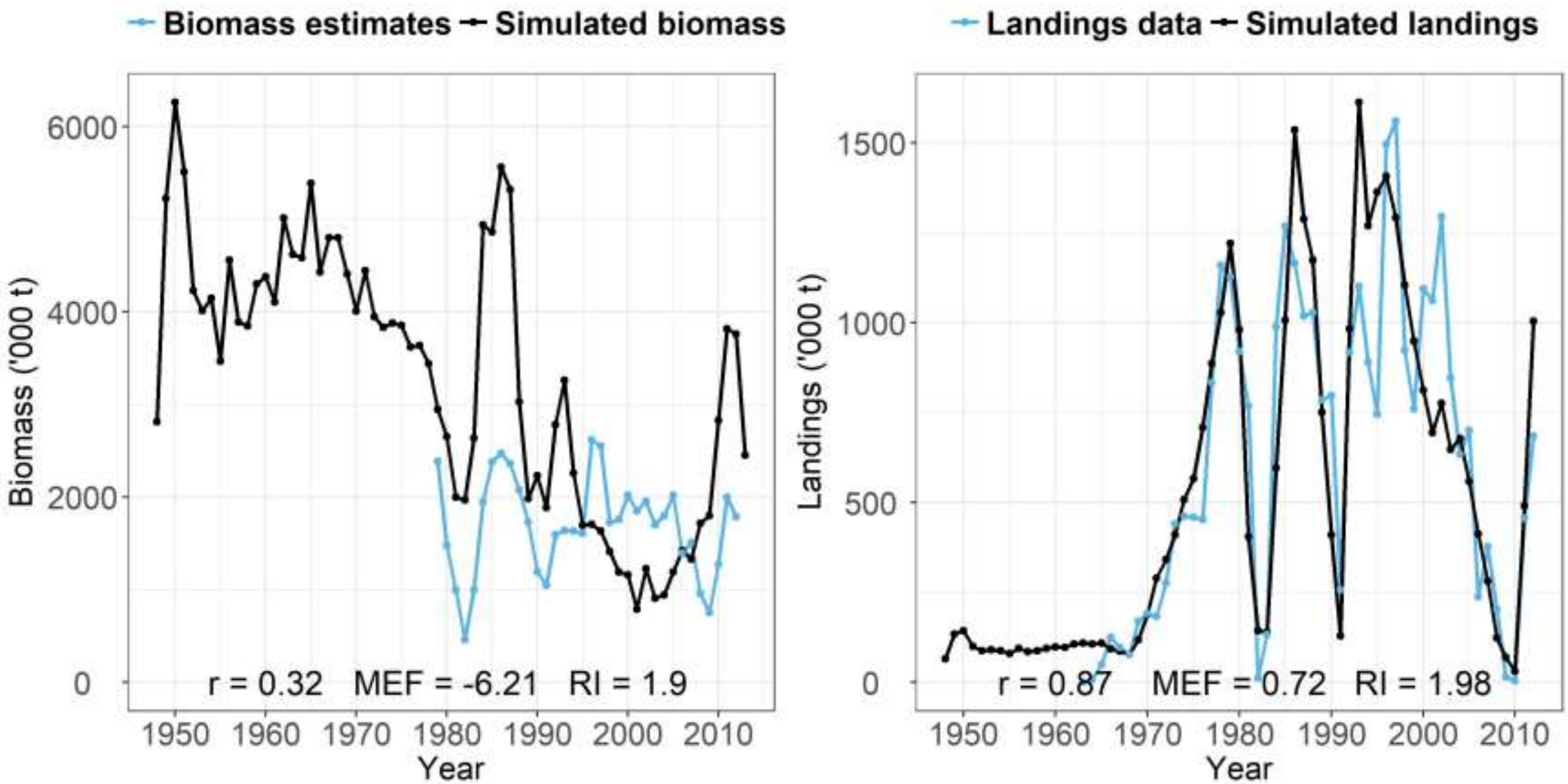

Biomass estimates
Simulated biomass
Biomass ('000 t)
300
200
100
0
r = 0.84 MEF = 0.64 RI = 1.27
1950 1960 1970 1980 1990 2000 2010
Year
Landings data
Simulated landings
Landings ('000 t)
125
100
75
50
25
0
r = 0.75 MEF = 0.38 RI = 1.31
1950 1960 1970 1980 1990 2000 2010
Year

Saithe



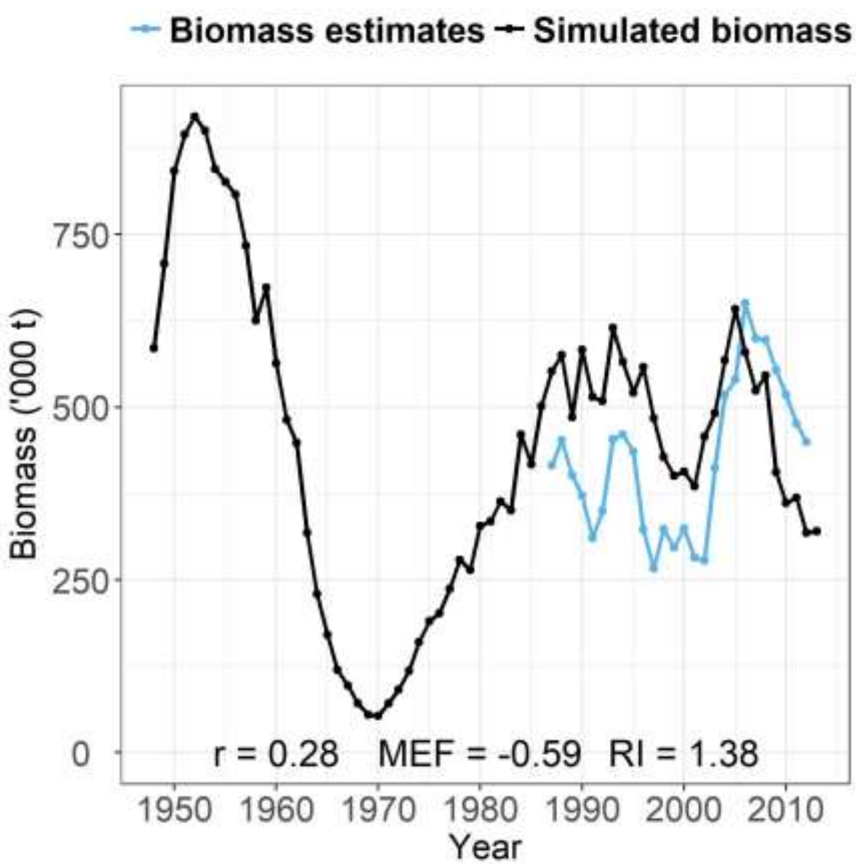
Biomass estimates
Simulated biomass
Biomass ('000 t)
600
400
200
0
r = 0.83
MEF = 0.4
RI = 1.24
1950
1960
1970
1980
1990
2000
2010
Year
Landings data
Simulated landings
Landings ('000 t)
100
50
0
r = 0.86
MEF = 0.55
RI = 1.23
1950
1960
1970
1980
1990
2000
2010
Year

Capelin

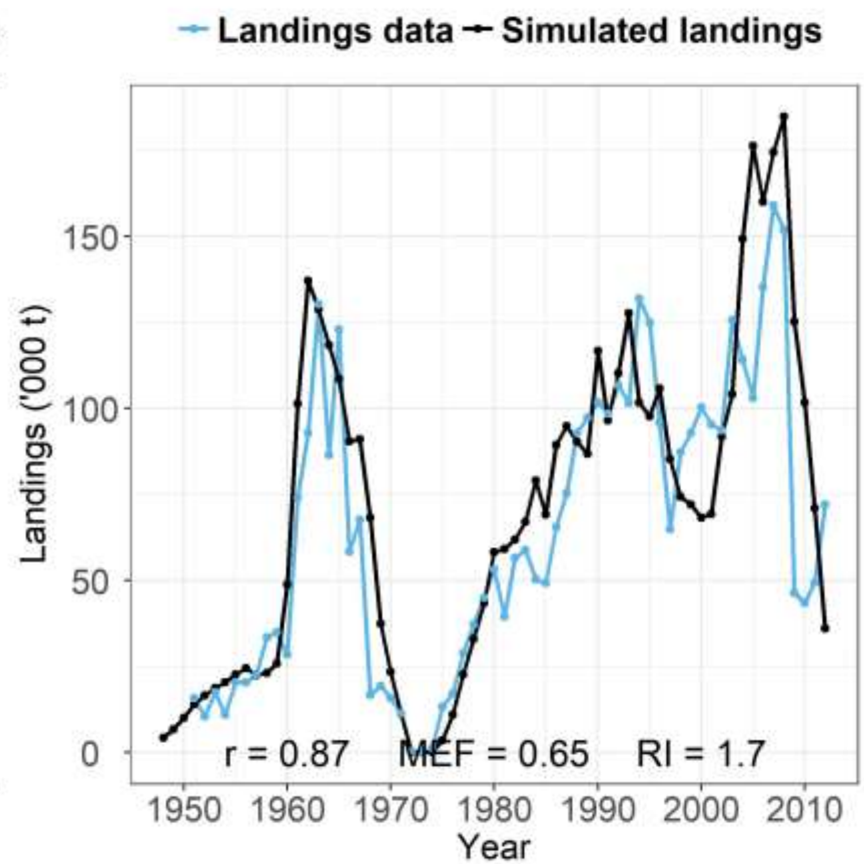


Biomass estimates
Simulated biomass
Biomass ('000 t)
6000
4000
2000
0
r = 0.32 MEF = -6.21 RI = 1.9
1950 1960 1970 1980 1990 2000 2010
Year
Landings data
Simulated landings
Landings ('000 t)
1500
1000
500
0
r = 0.87 MEF = 0.72 RI = 1.98
1950 1960 1970 1980 1990 2000 2010
Year

Herring



Biomass estimates
Simulated biomass
Biomass ('000 t)
750
500
250
0
r = 0.28 MEF = -0.59 RI = 1.38
1950 1960 1970 1980 1990 2000 2010
Year



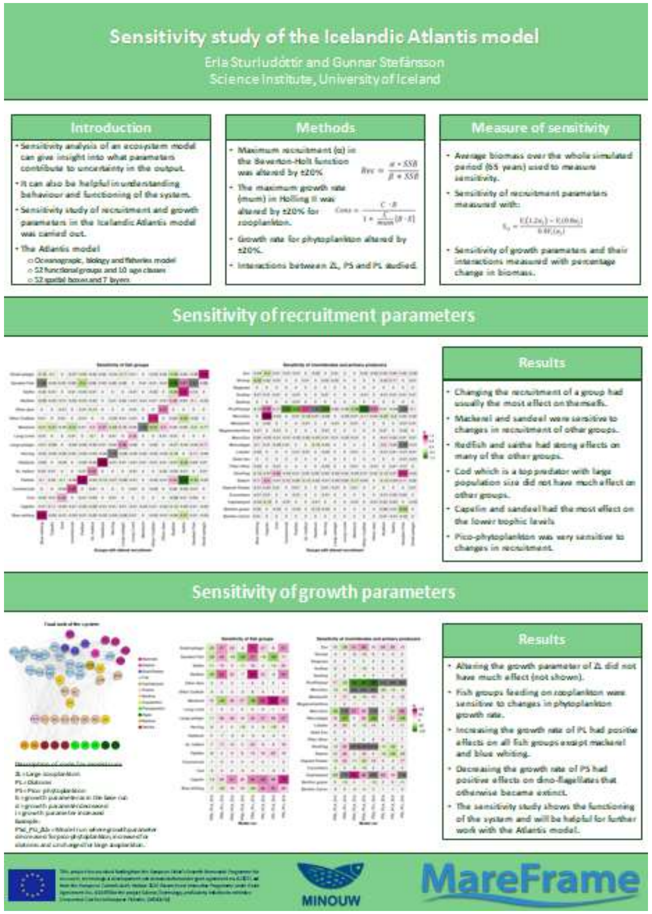
Landings data
Simulated landings
Landings ('000 t)
150
100
50
0
r = 0.87 MEF = 0.65 RI = 1.7
1950 1960 1970 1980 1990 2000 2010
Year

Use of Atlantis

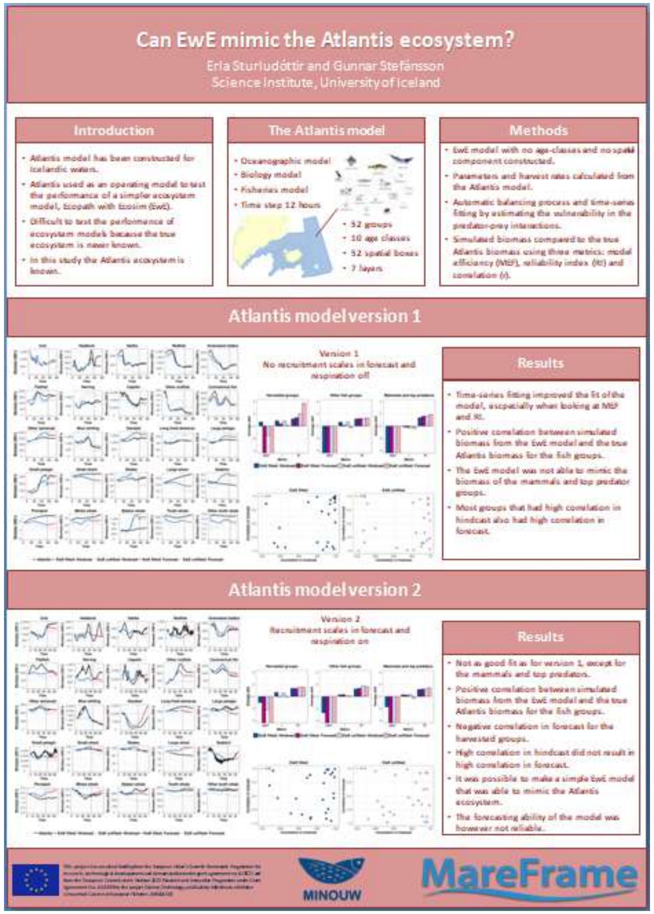
- Supporting tool for EBFM
  - Understanding
  - Scenarios
    - Fishing pressure
    - Effect of discards
  - Manangement strategy evaluation
  - Operating model

Poster Session

Sensitivity study



Can EwE mimic the Atlantis ecosystem?



Acknowledgement

This project has received funding from the European Union's Seventh Framework Programme for research, technological developement and demonstration under grant agreement no. 613571 and from the European Commission's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 634495 for the project Science, Technology, and Society Initiative to minimize Unwanted Catches in European Fisheries (MINOUW).

MareFrame

MINOUW

MARINE & FRESHWATER RESEARCH INSTITUTE

SIGILLUM UNIVERSITATIS ISLANDIAE