MINOUW

Atlantis

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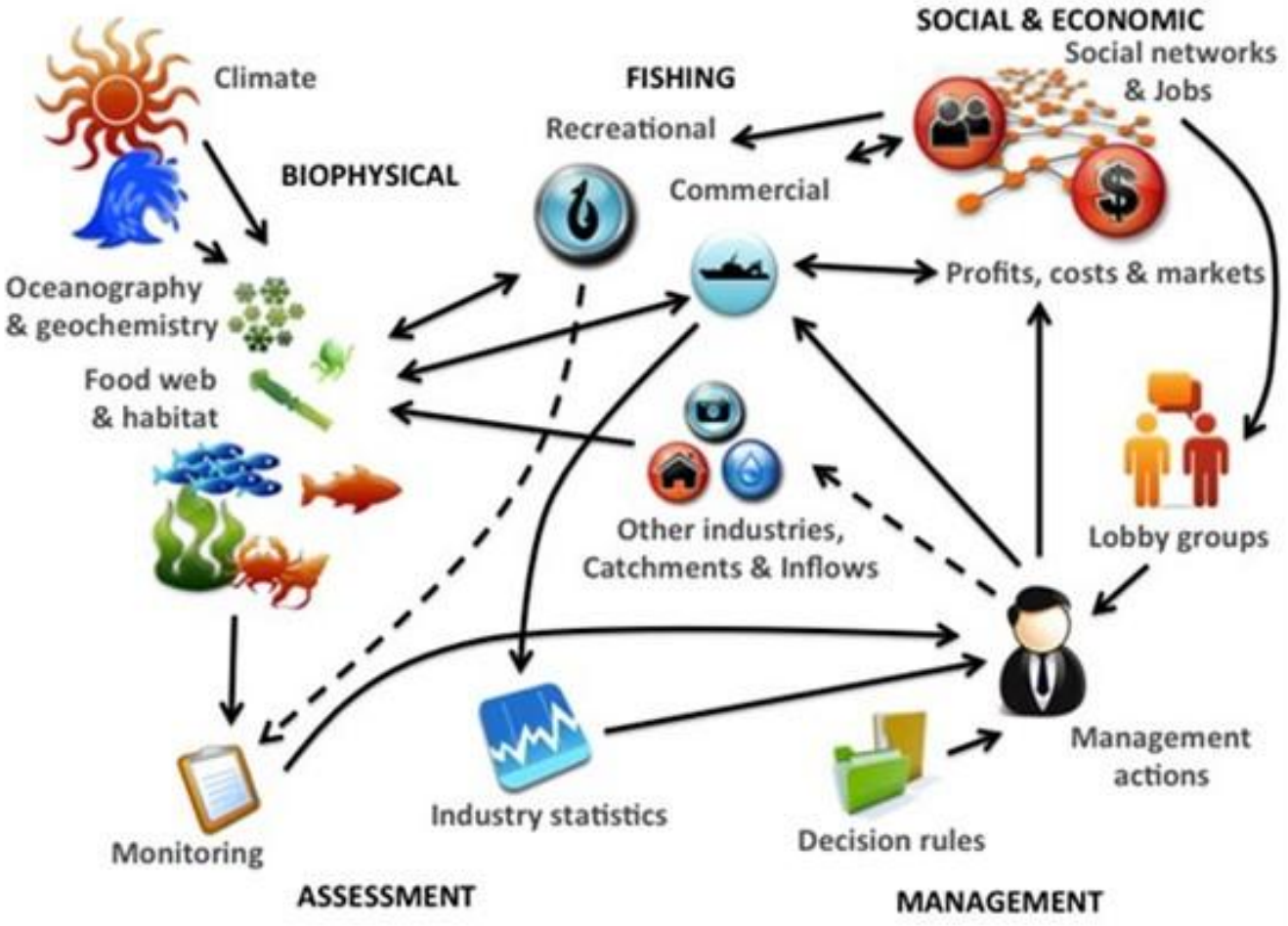
Managing discards in fisheries
9-13 April 2018
Zaragosa

Atlantis

- Simulates the entire ecosystem
- Oceanographic model
- Biology model
- Fisheries model
- Sampling and assessment model
- Management model
- Socio-economic model

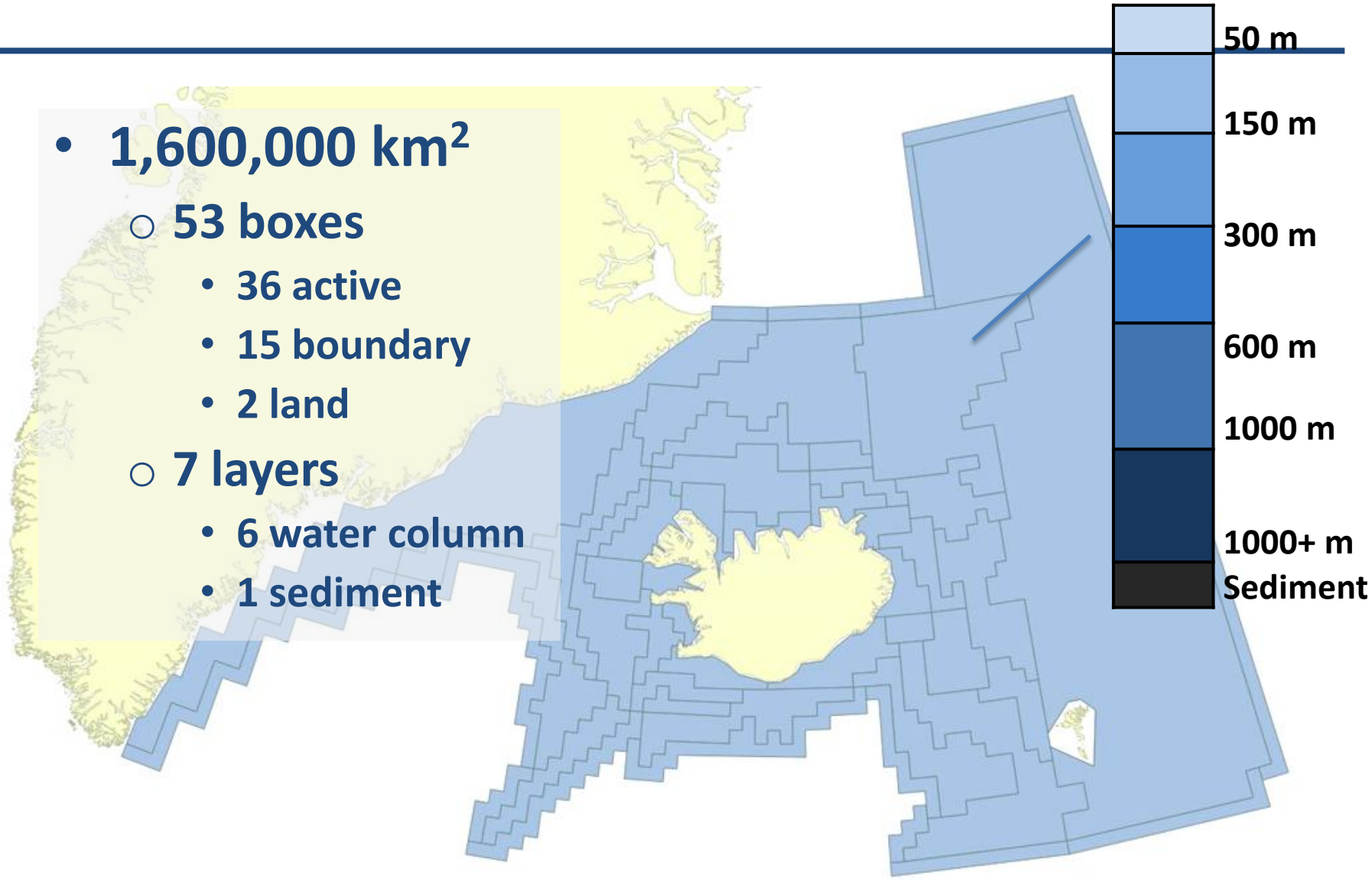
Atlantis



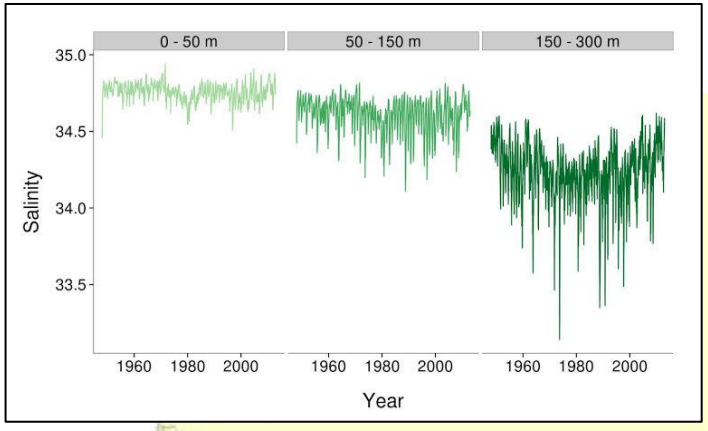
From Beth Fulton, CSIRO, Australia

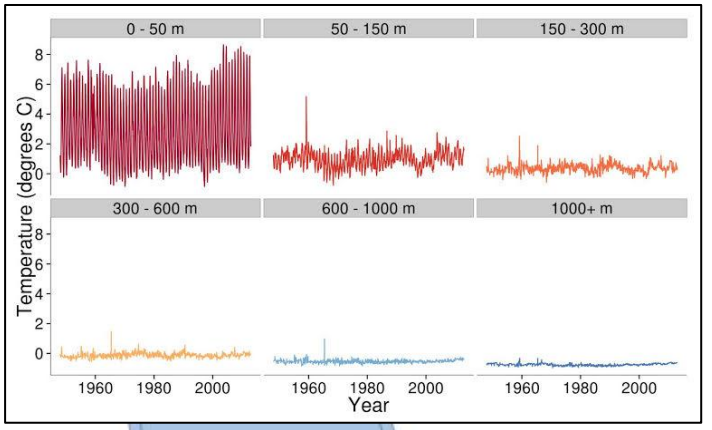
The Icelandic Atlantis model

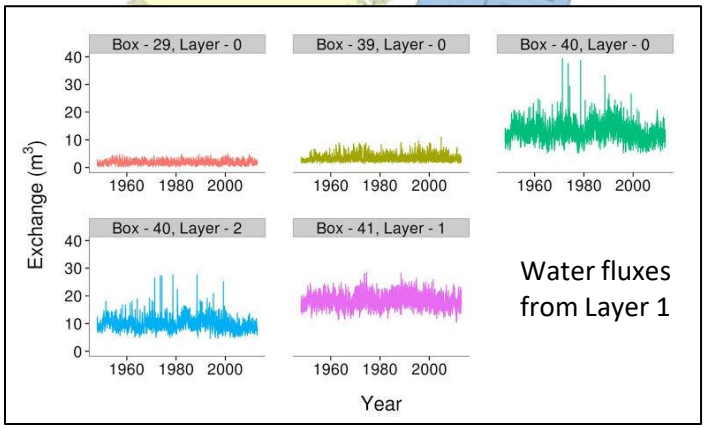
- 1,600,000 km^2
  - 53 boxes
    - 36 active
    - 15 boundary
    - 2 land
  - 7 layers
    - 6 water column
    - 1 sediment



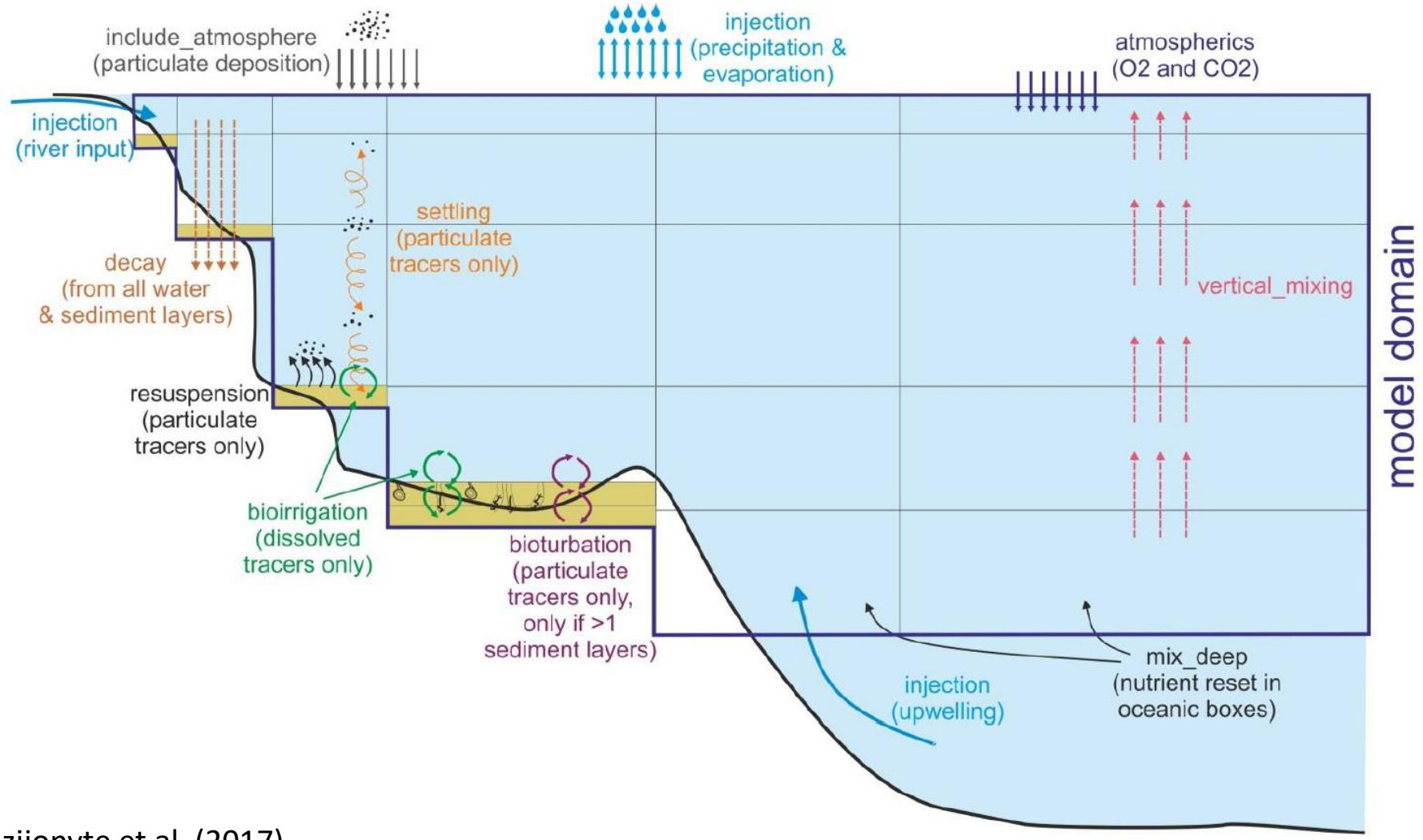
The oceanography model







The physics model



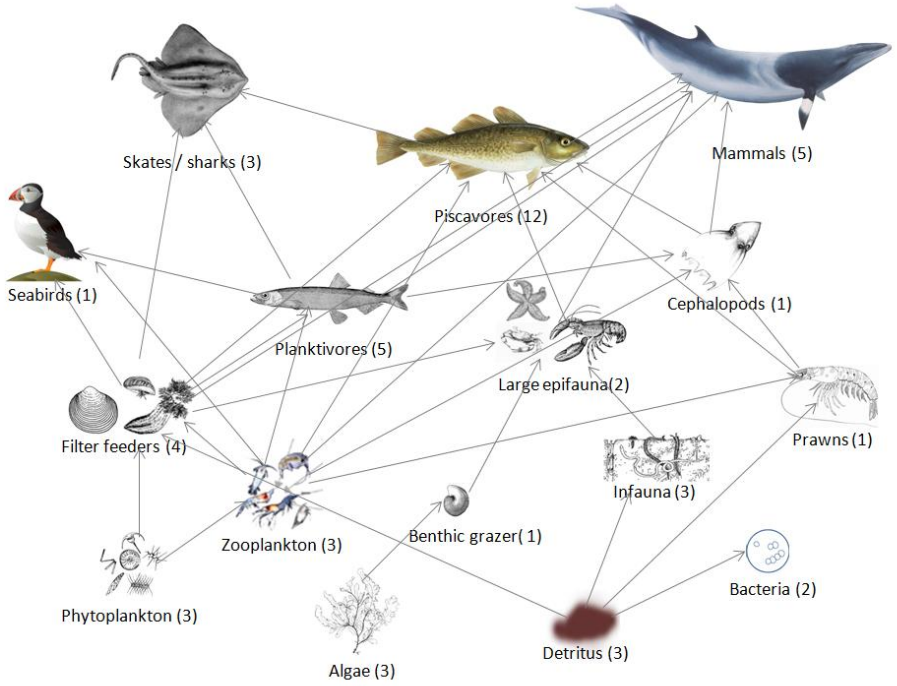
Audzijonyte et al. (2017)
Atlantis User's Guide Part I

The biology model

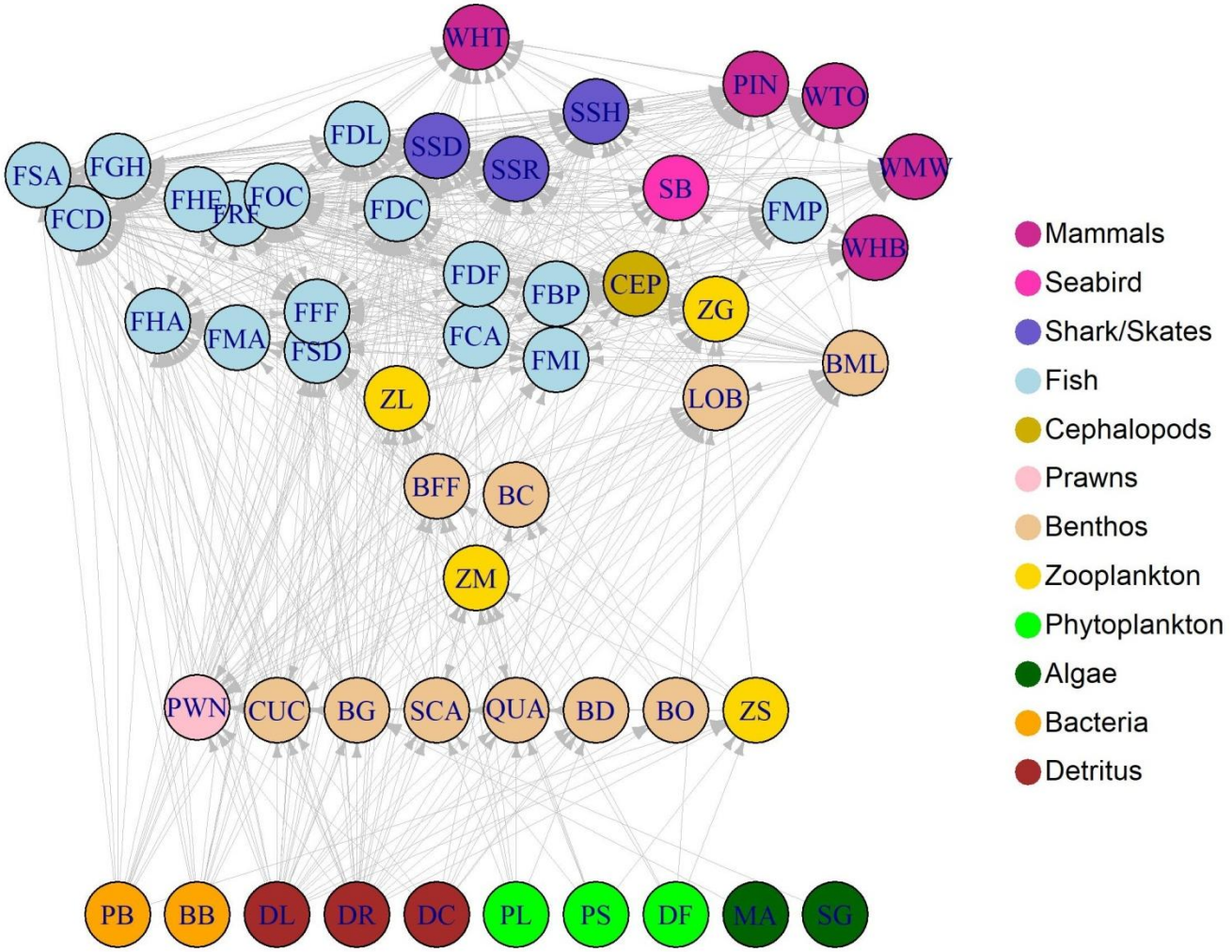
- Functional groups
- Consumption
- Predation
- Growth
- Reproduction
- Mortality
- Waste production
- Movement
- Migration

The functional groups

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



Food web from the Atlantis model



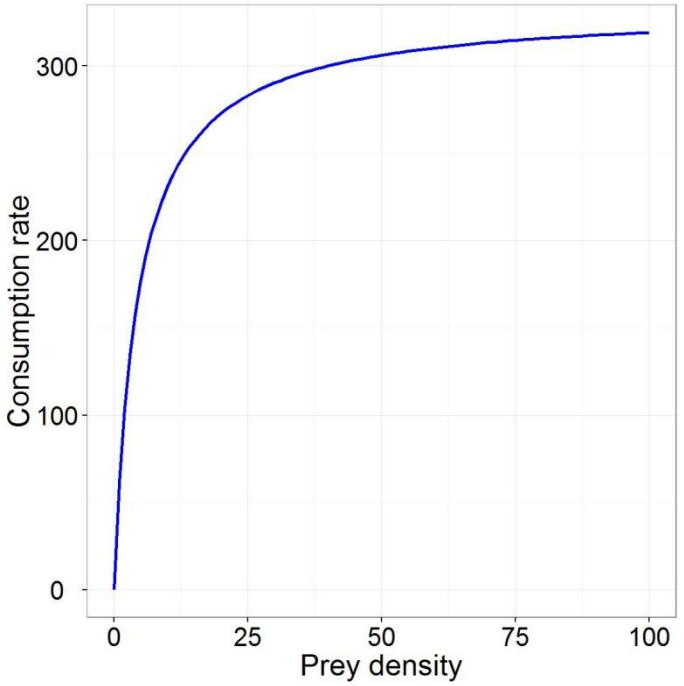
The biology model

- Vertebrates
  - 10 age classes
    - Numbers per age within ageclass
  - Weight in mg N per individual
    - Reserved weight
    - Structural weight
- Invertebrates
  - 2 ageclasses
  - Biomass pools mg N m^{-3}

Consumption

- Holling type II
- Gape limitation
- Spatial overlap
- Prey availability

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



Growth - Vertebrates

- **Division of growth into reserved and structual weight for invertebrates**

$$G_{RN} = (A - Rs) \cdot (1 - \lambda)$$

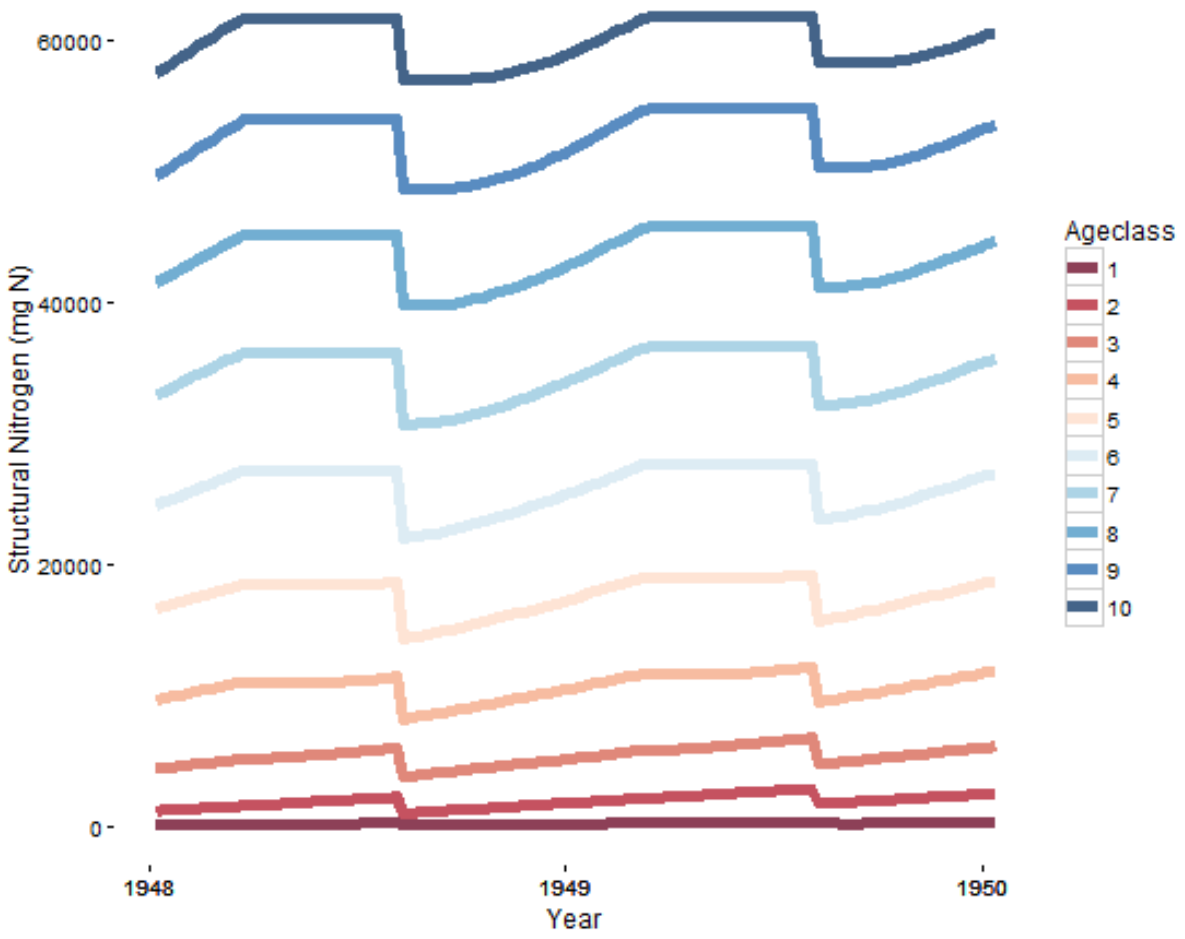
$$G_{SN} = (A - Rs) \cdot \lambda$$

- **A = Consumed * assimilation**
- **Rs = Respiration**
- **λ = division between RN and SN**

Growth - Vertebrates

$$G_{RN} = (A - Rs) \cdot (1 - \lambda)$$

$$G_{SN} = (A - Rs) \cdot \lambda$$



Growth – Primary producers

- **Limited by:**
  - **Nutrients**
  - **Light**
  - **Space**
  - **Eddies (optional)**
  - **pH (optional)**

$$G_{pp} = mum \cdot B_{PP} \cdot \delta_{light} \cdot \delta_{nutrient} \cdot \delta_{space} \cdot \delta_{eddy} \cdot pHscalar$$

mum = maximum growth rate

B = biomass

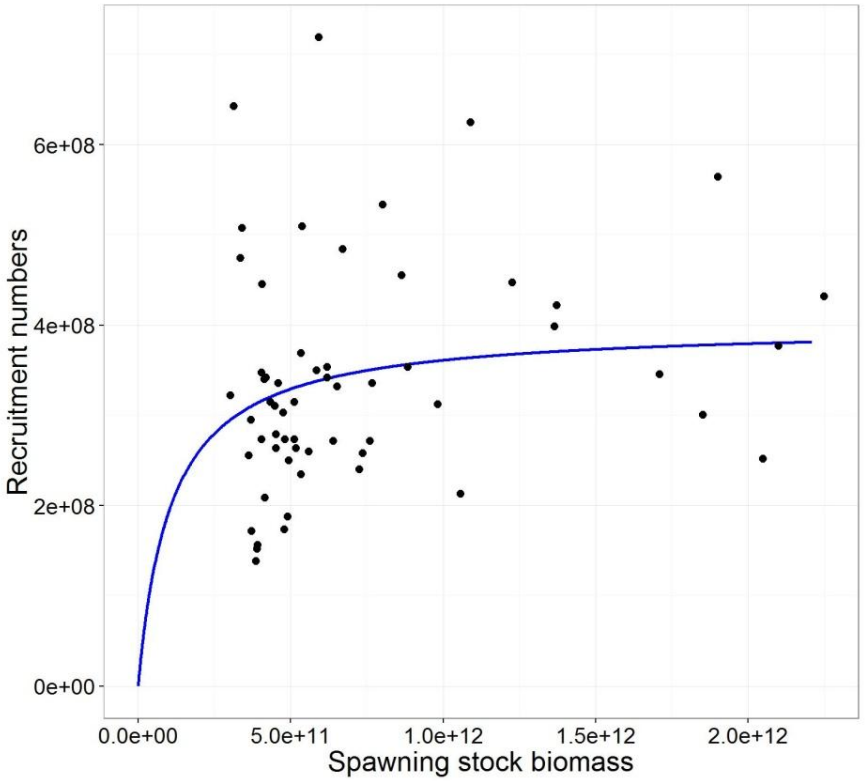
Growth affecting parameters

- **Consumption**
  - Temperature
  - Salinity
- **Assimilation**
  - Time-series of scales
  - Temperature
  - Salinity
  - pH
- **Respiration**
  - Threshold

Reproduction

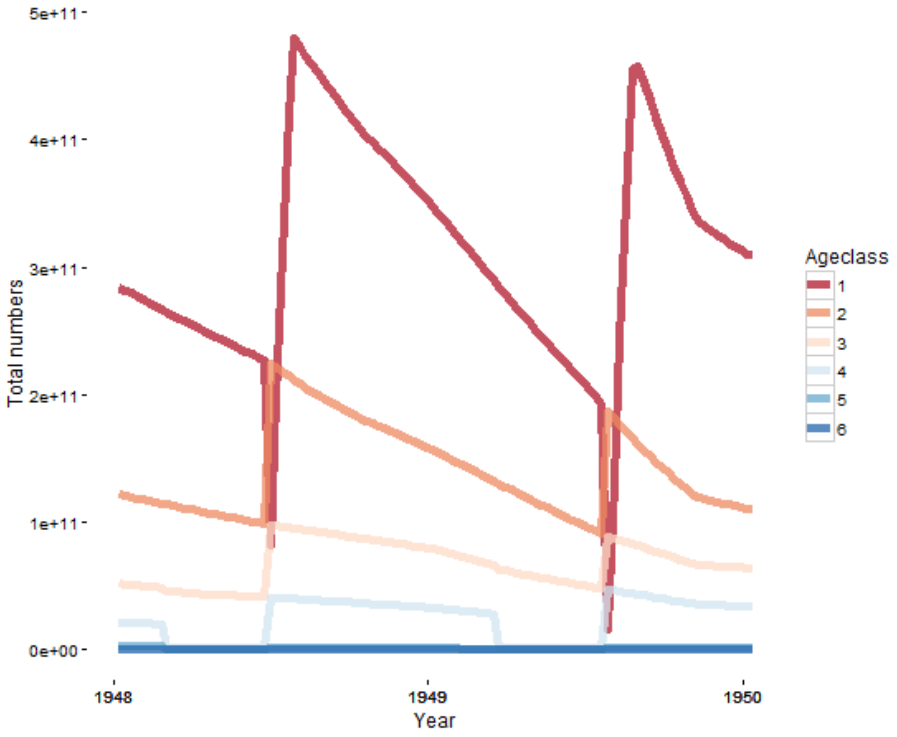
- **Fixed number per adult**
- **Beverton – Holt**

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

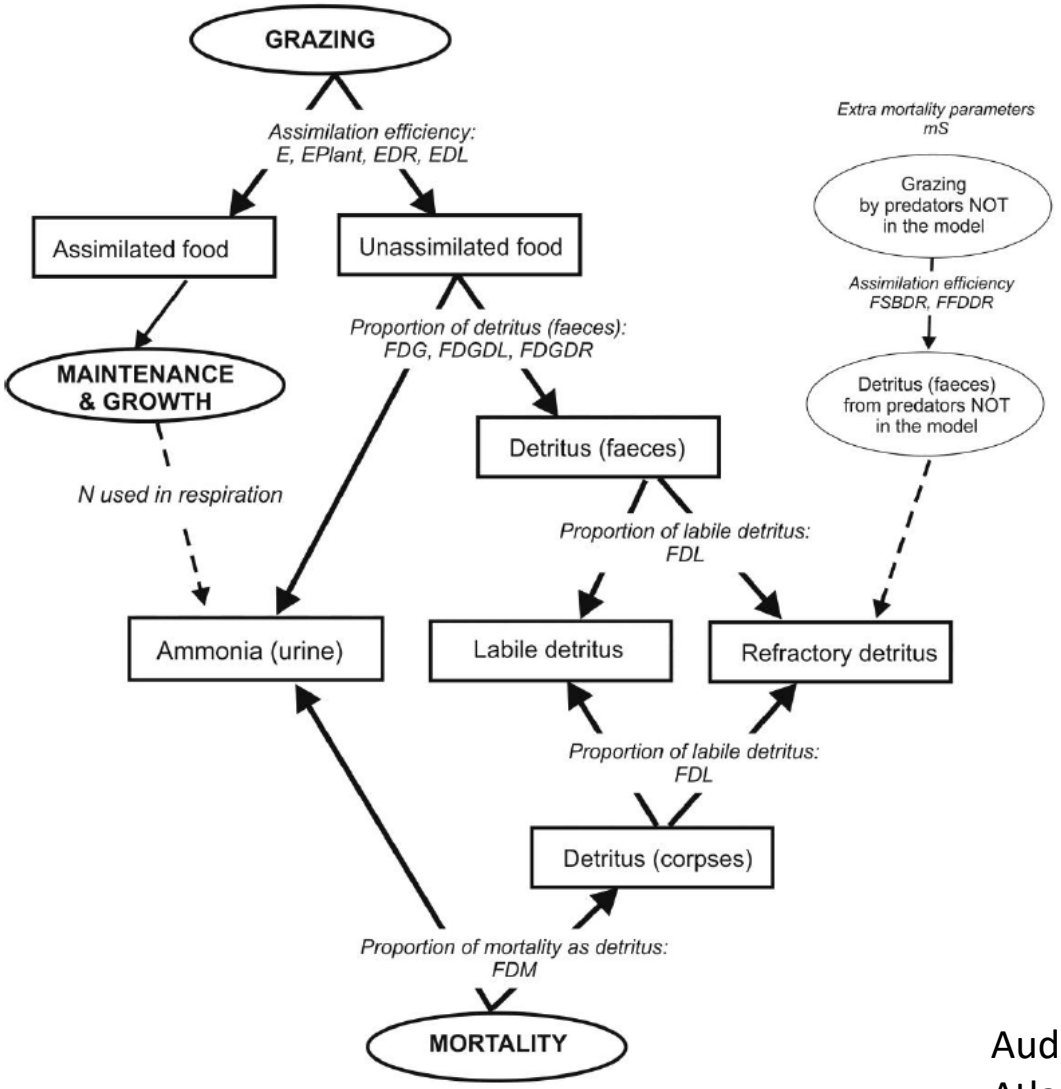


Mortality

- Linear mortality
- Quadratic mortality
- Lysis
- Starvation mortality
- Affected by:
  - Temperature
  - Salinity
  - pH
  - Oxygen



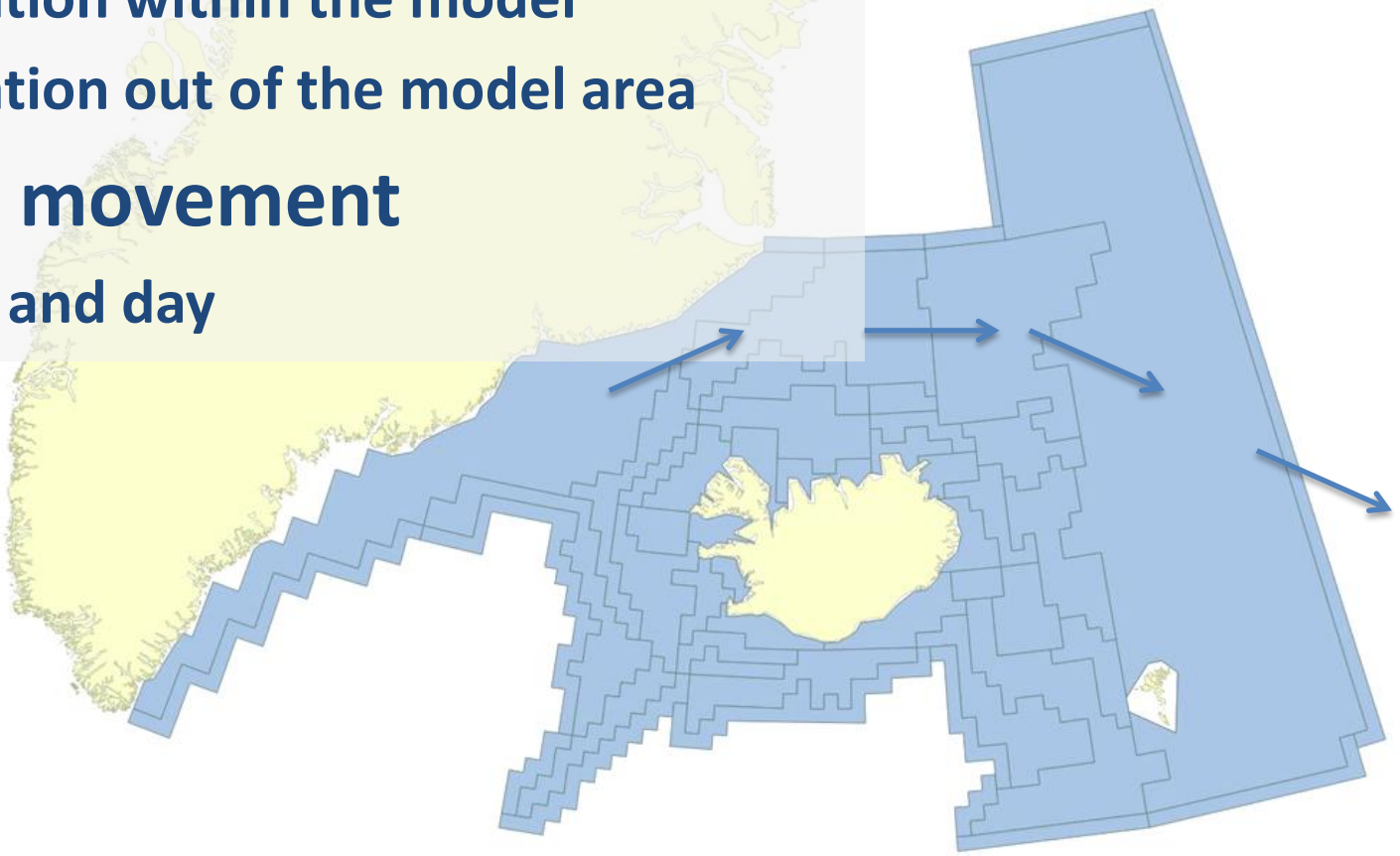
Waste



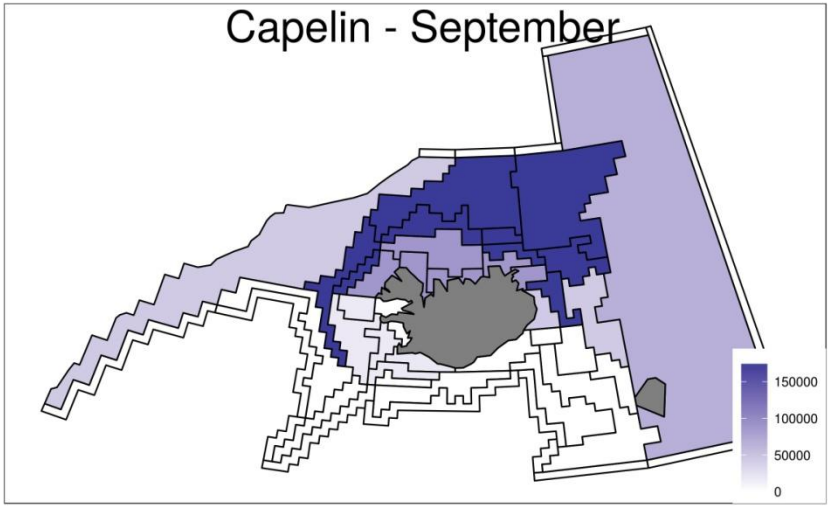
Audzijonyte et al. (2017)
Atlantis User's Guide Part I

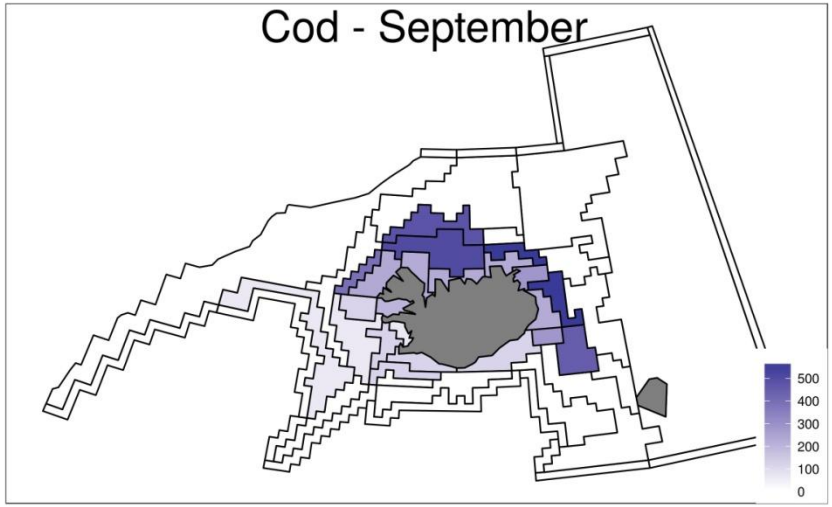
Migration and movement

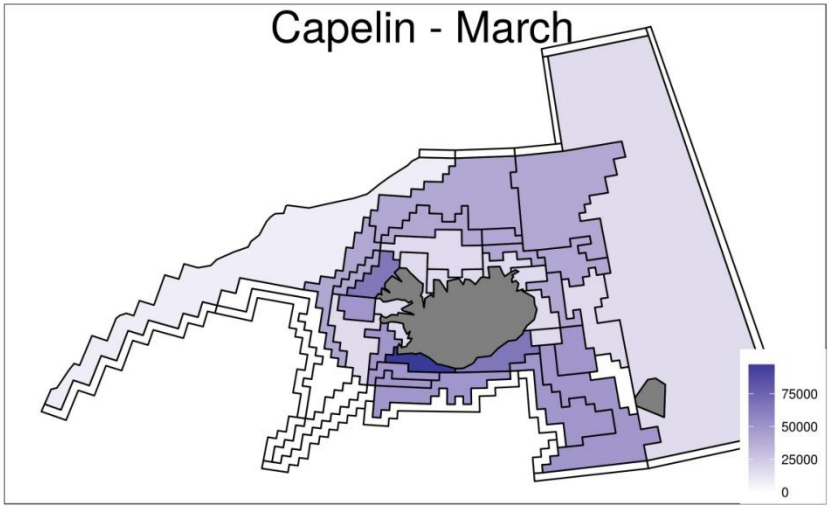
- Horizontal movement
  - Migration within the model
  - Migration out of the model area
- Vertical movement
  - Night and day

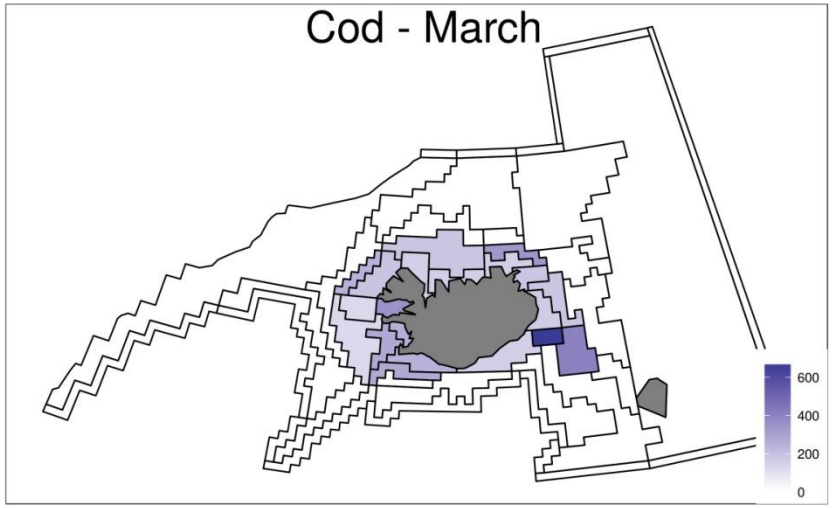


Spatial distribution

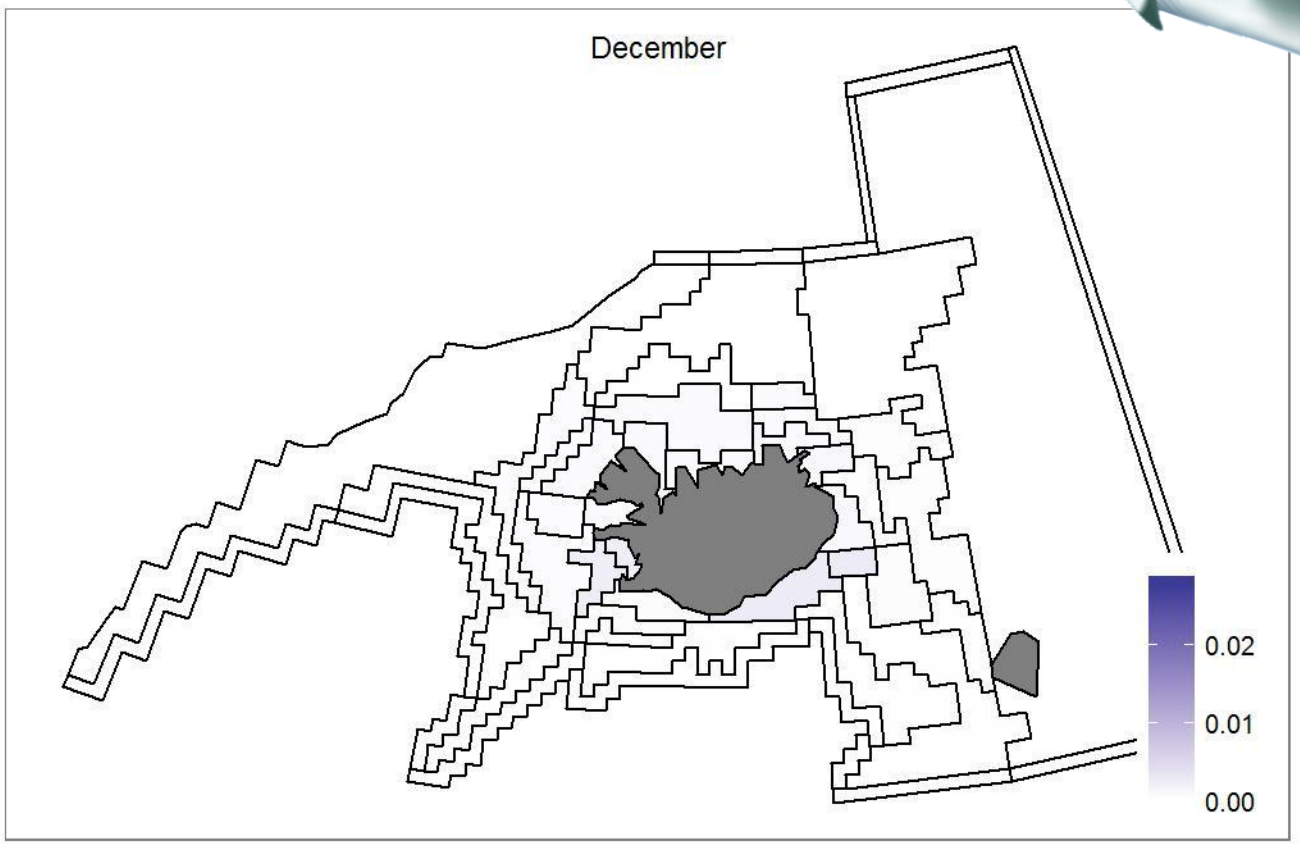








Migration of Minke Whale



The fisheries model

- **Fisheries**
  - **Multiple fleets**
    - **Gear**
    - **Target**
    - **Selectivity**


Photo: Sigurður Bergþórsson


Photo: Magnús Jónsson

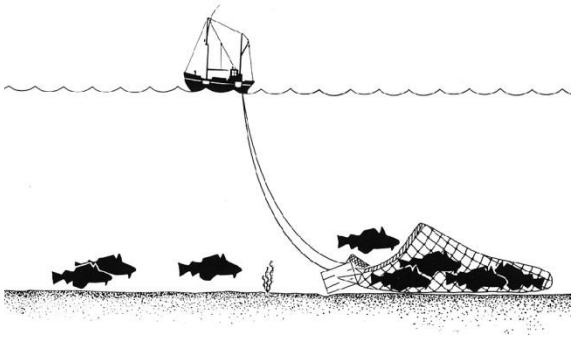

Photo Vinnslustöðin

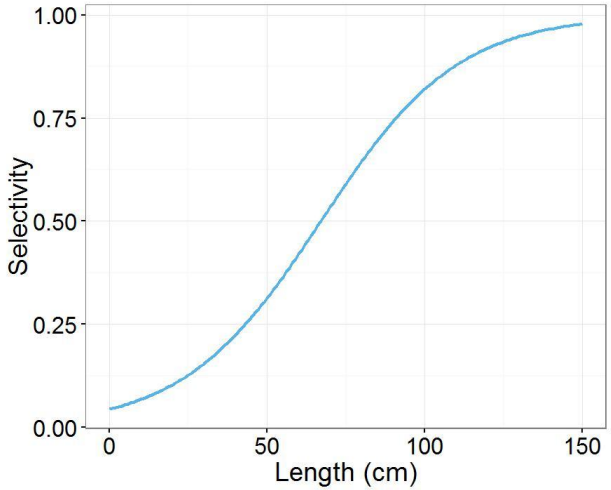
Fishing fleets

- Longline
- Gillnet
- Handline
- Purse seine
- Danish seine
- Midwater trawl
- Bottom trawl
- Shrimp trawl
- Lobster traps
- Dredge
- Whaling

Fishing

Fishing gear → Selectivity → Harvest rate → Catch biomass



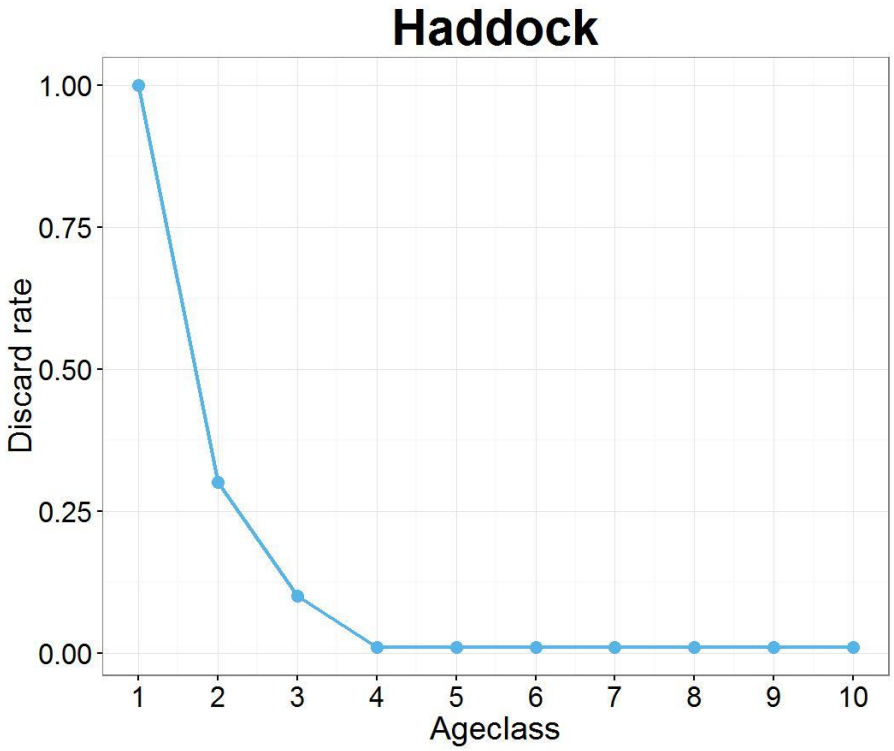


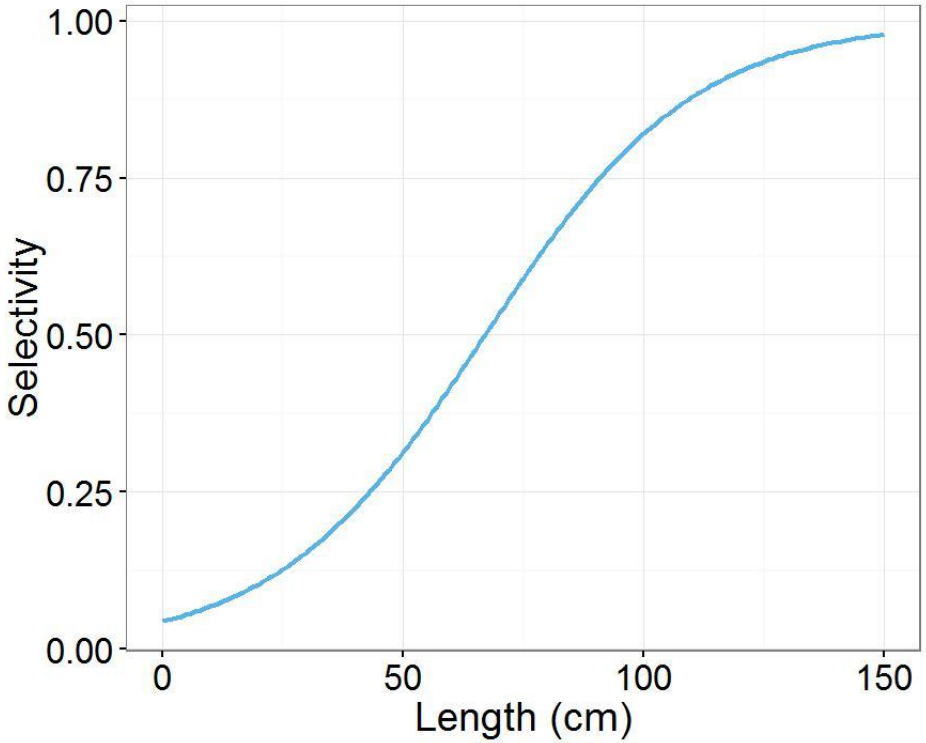
Discards

- Constant
- Constant per age class
- Size based
- Discard survival
- Discarded waste

Discards

- **Constant per age-class**

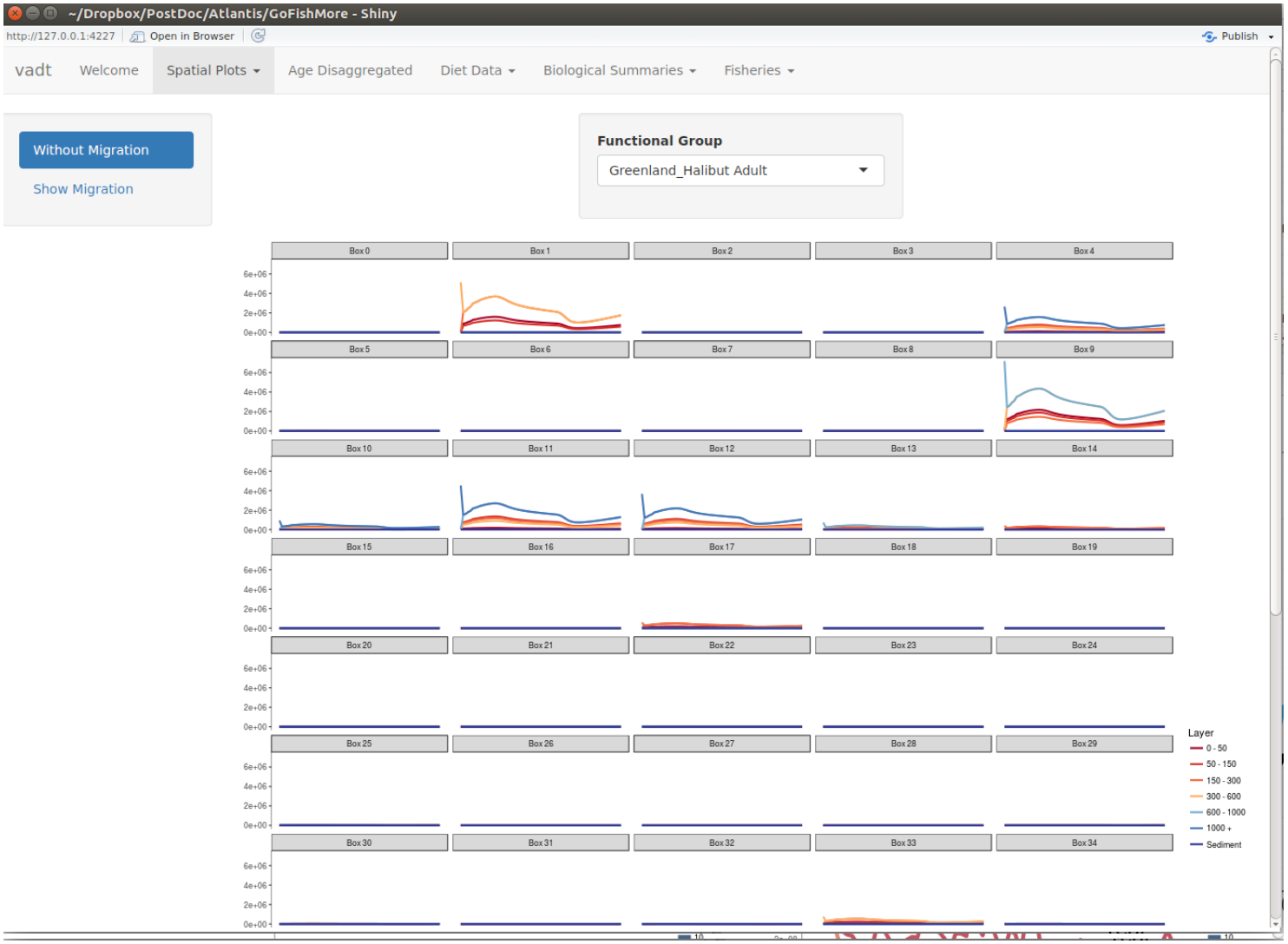




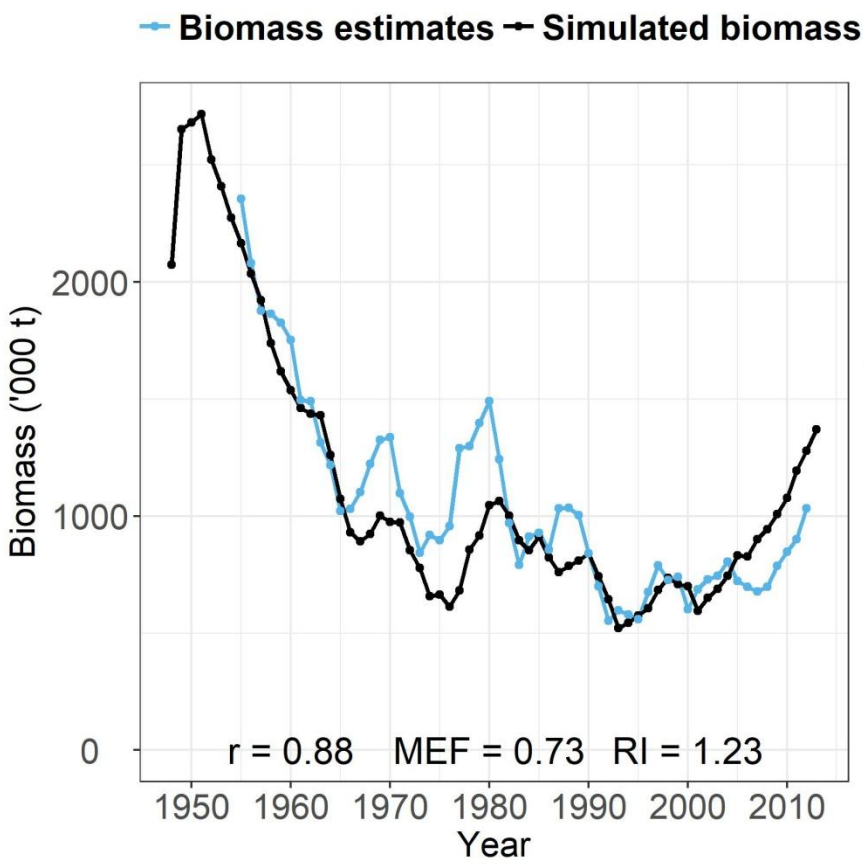
Building the model

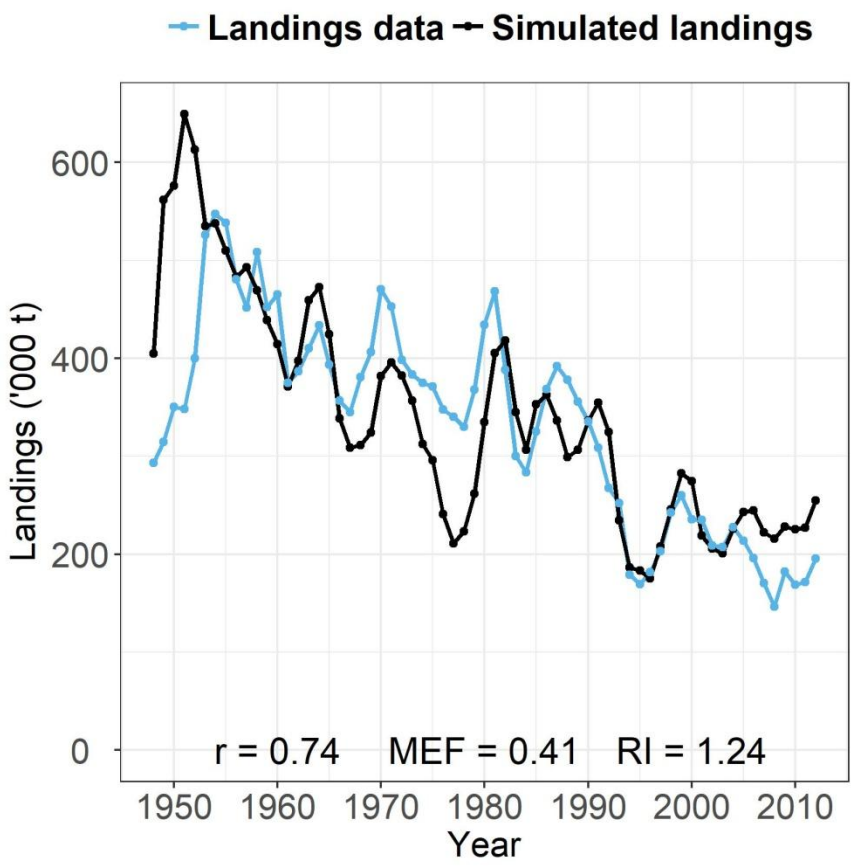
- **Survey data from MRI used**
  - Only available for the commercial species
  - Biomass estimates from single stock assessments
  - Stomach content data
- **Logbooks**
  - Information about each tow
- **Parameters estimted outside of the model**
  - Recruitment curve
  - Growth curve
  - Length-weight relationship
  - Selectivity
- **A lot of tuning and debugging (2-4+ years)!**

Visualizing the output with Shiny app in R

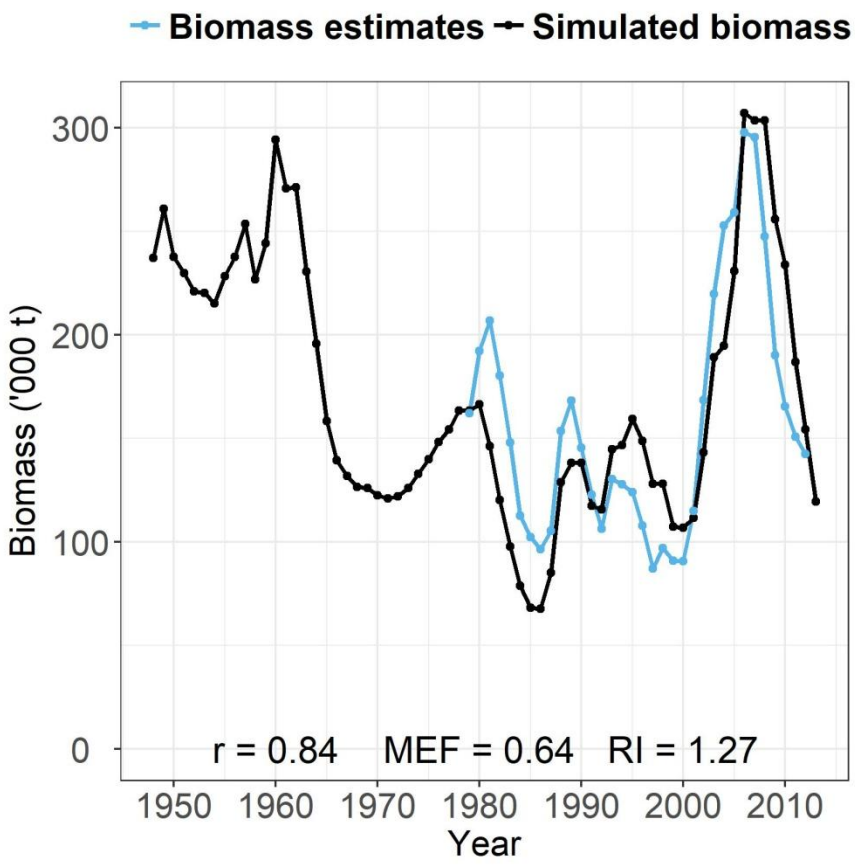


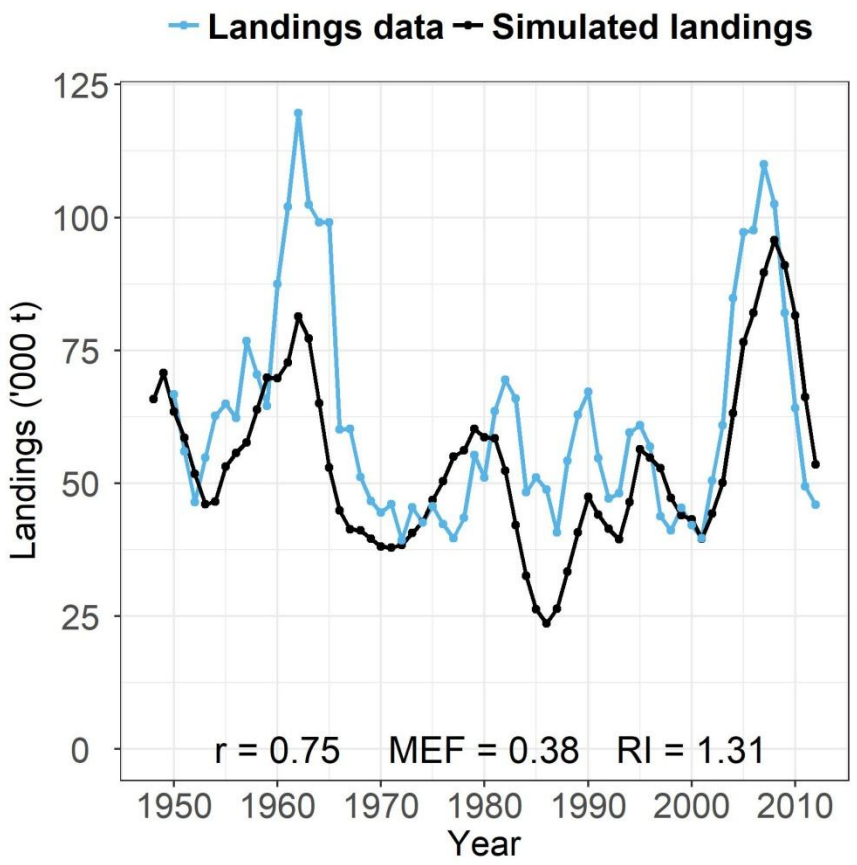
Cod


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

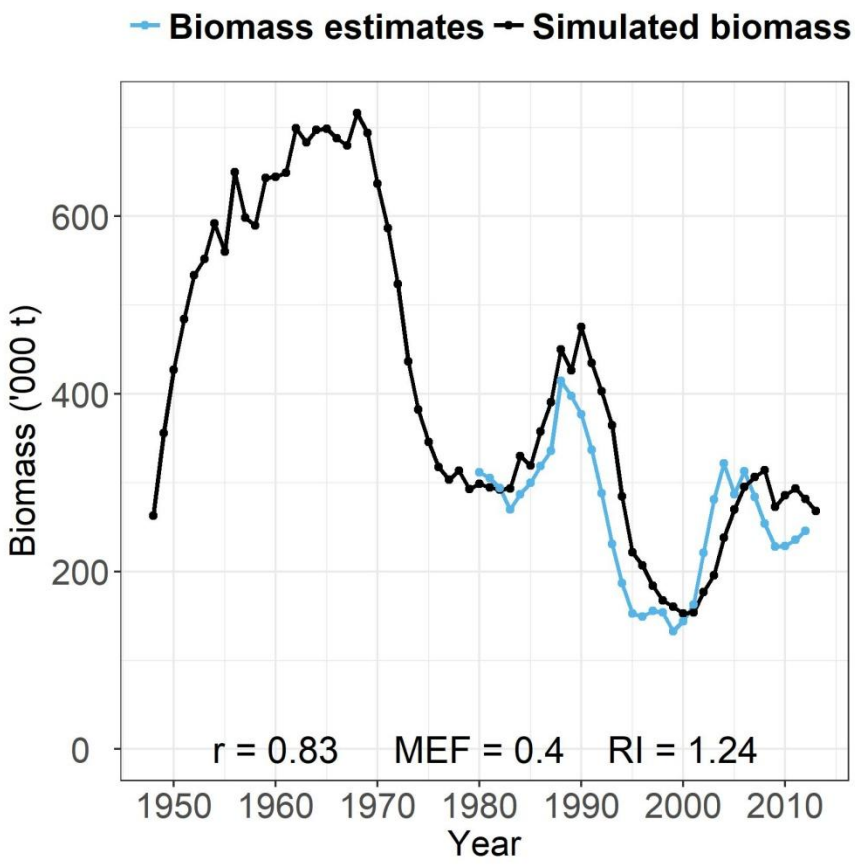

Landings data
Simulated landings
Landings ('000 t)
600
400
200
0
r = 0.74 MEF = 0.41 RI = 1.24
1950 1960 1970 1980 1990 2000 2010
Year

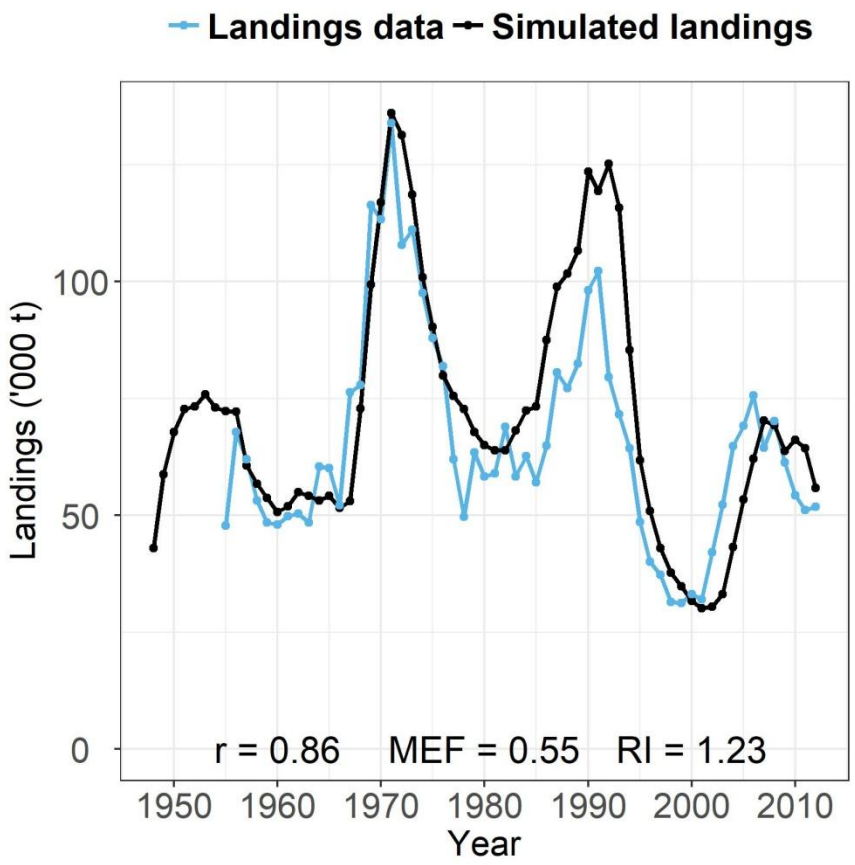
Haddock


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

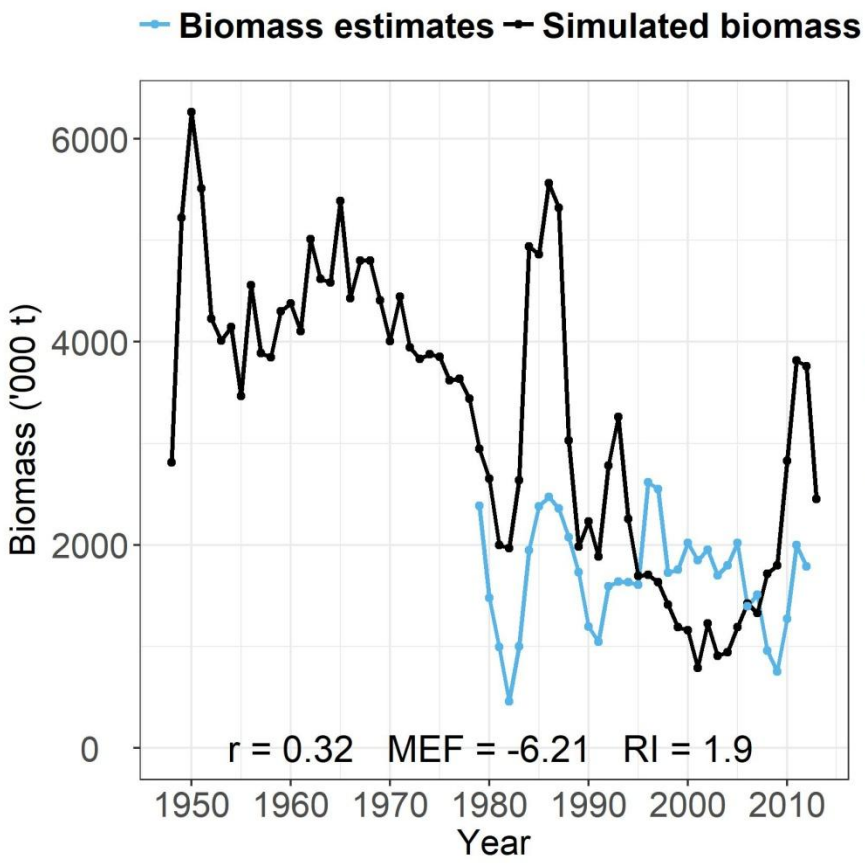

Landings data
Simulated landings
Landings ('000 t)
125
100
75
50
25
0
r = 0.75 MEF = 0.38 RI = 1.31
1950 1960 1970 1980 1990 2000 2010
Year

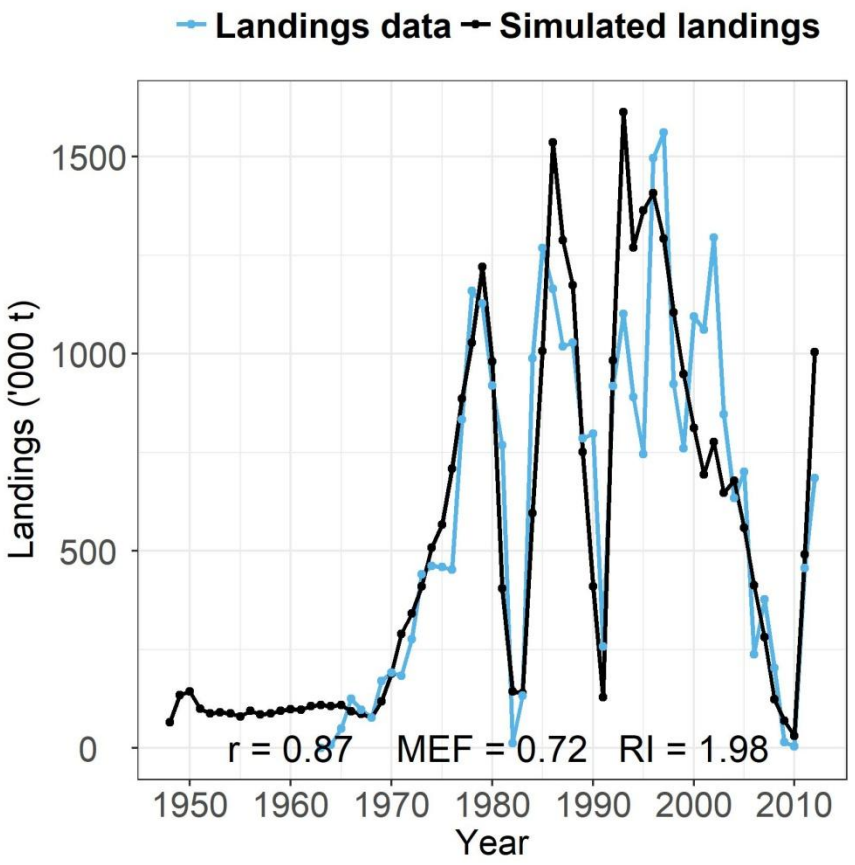
Saithe


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

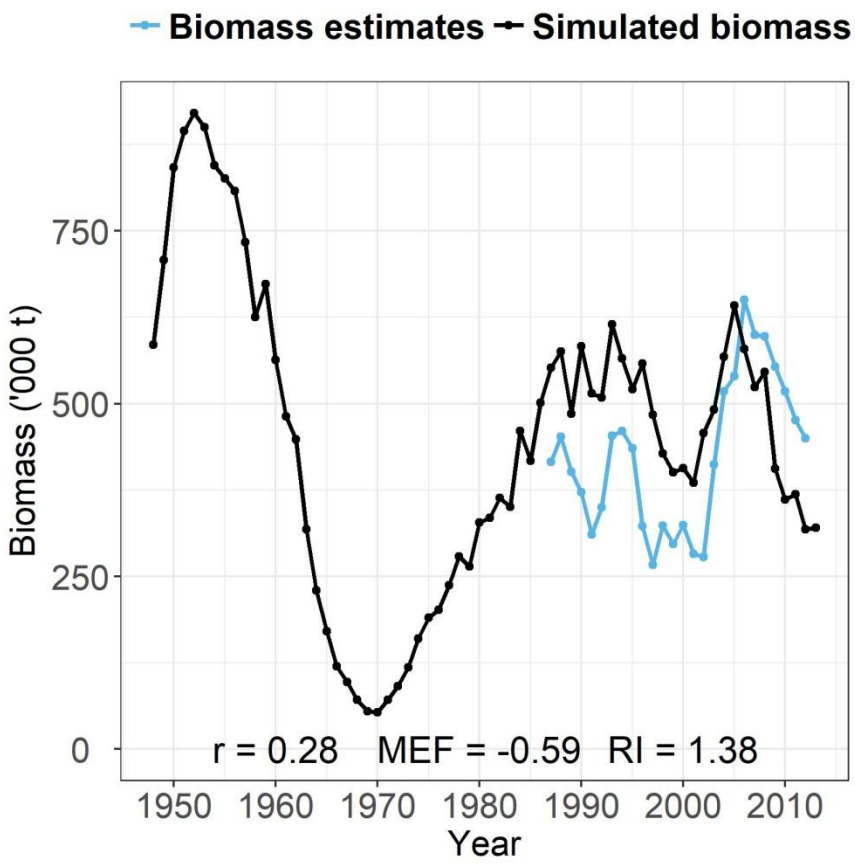

Landings data
Simulated landings
Landings ('000 t)
100
50
0
r = 0.86
MEF = 0.55
RI = 1.23
1950
1960
1970
1980
1990
2000
2010
Year

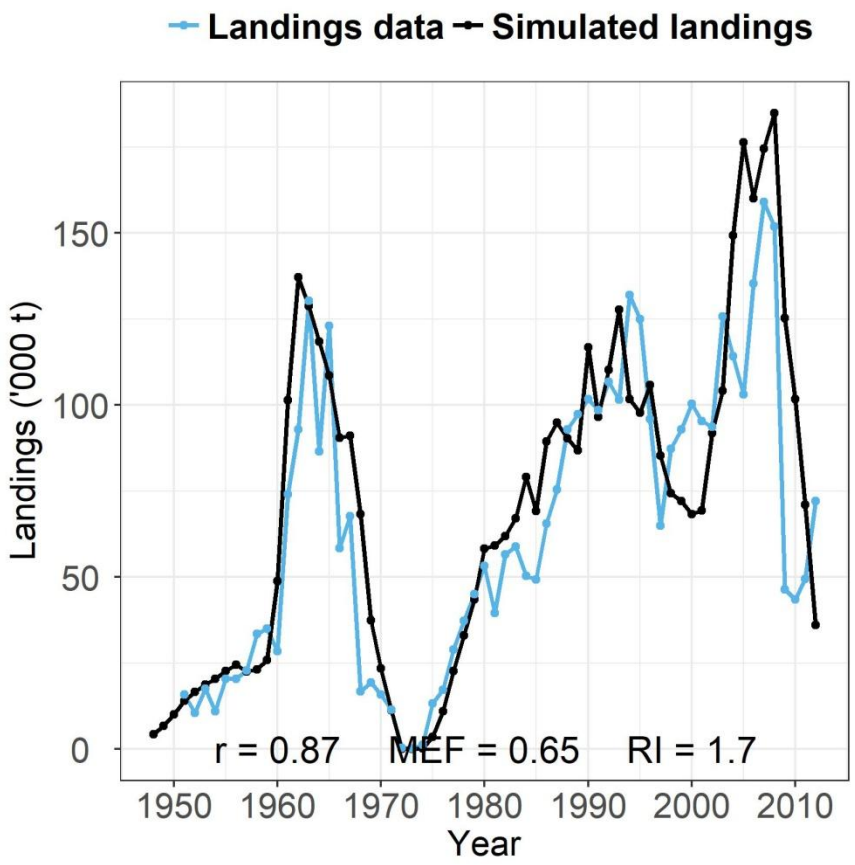
Capelin


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

- **Operating model**
- **Scenarios**
  - Fishing pressure
  - Effect of discards
- **Management strategy evaluation**

Some Atlantis Papers

- Kaplan, I. C., Holland, D. S., & Fulton, E. A., 2014. Finding the accelerator and brake in an individual quota fishery: linking ecology, economics, and fleet dynamics of US West Coast trawl fisheries. ICES Journal of Marine Science 71(2), 308-319.

- Fulton, E. A., Link, J. S., Kaplan, I. C., Savina-Rolland, M., Johnson, P., Ainsworth, C., Horne, P., Gorton, R., Gamble, R., Smith, A. D. M., Smith, D. C., 2011. Lessons in modelling and management of marine ecosystems: the Atlantis experience. Fish and Fisheries 12(2), 171-188.

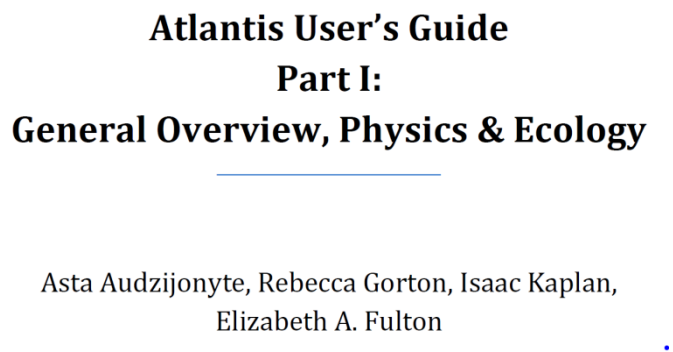
- Link, J. S., Fulton, E. A., & Gamble, R. J. (2010). The northeast US application of ATLANTIS: a full system model exploring marine ecosystem dynamics in a living marine resource management context. Progress in Oceanography, 87(1), 214-234.

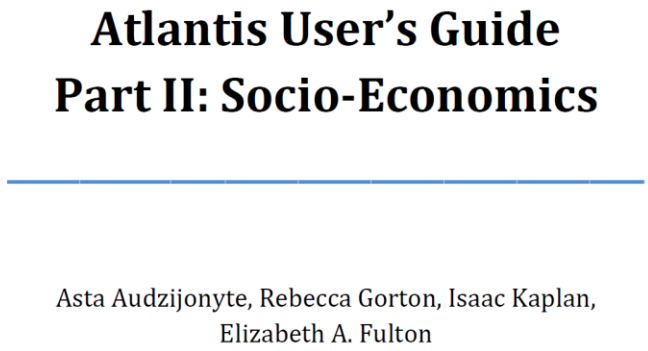
- Ortega-Cisneros, K., Cochrane, K., Fulton, E. A., 2017. An Atlantis model of the southern Benguela upwelling system: Validation, sensitivity analysis and insights into ecosystem functioning. Ecological Modelling 355, 49-63.

More info

- **Atlantis User's Guide**

  https://www.dropbox.com/sh/1yu72jkzgztfovt/AACKohScfjmsalbwEe7U1BCRa?dl=0





- **Atlantis Google Group**

  https://groups.google.com/forum/#!forum/atlantis-ecosystem-model

The official Atlantis Website

- **https://research.csiro.au/atlantis/**