Implementing a whole of system ecosystem model for the Icelandic waters

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MareFrame

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What is a whole-of-system ecosystem model?

- Attempt to capture all major processes within a system
- **Physical**
- **Biological**
- **Human impact**
- Many parameters are estimated; high model complexity; and high parameter uncertainty
- Strategic not tactical use

Whole-Of-System Marine Ecosystem Models

- Ecopath with Ecosim
- **Atlantis**
- OSMOSE
- InVitro
- Many more ...

What is Atlantis?

- Developed by Beth Fulton at CSIRO.
- Deterministic biodemographic and biogeochemical box model
- Tracks nitrogen through the biological and detritus groups
- Models invertebrates as biomass pools (mg N/m^2 or mg N/m^3); vertebrates age-structured models
- All major processes modeled

Atlantis requirements

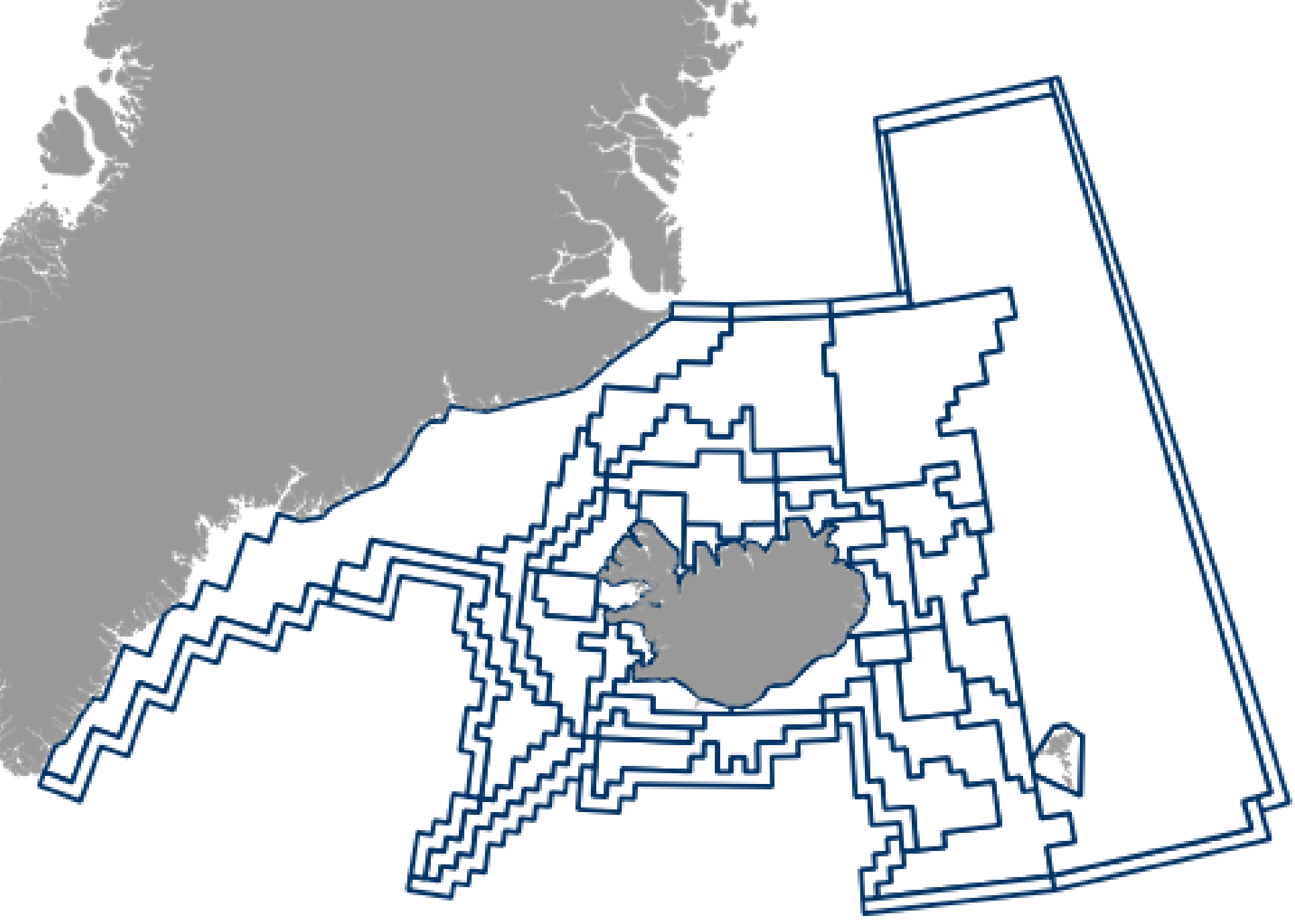
DATA DATA DATA

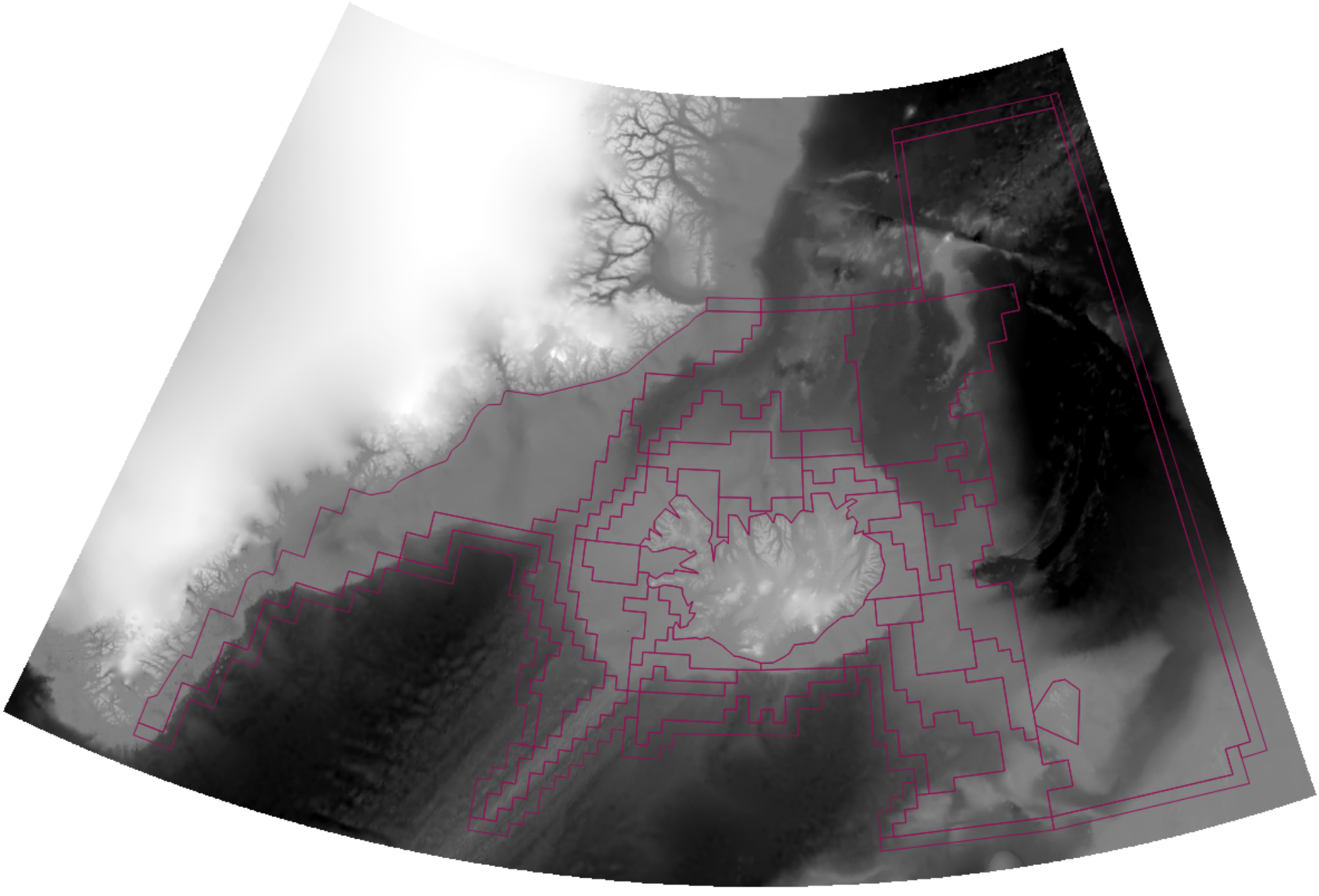
Knowledge

Ecology, particular to your ecosystem

Fisheries and plankton models

Programming





The Icelandic Atlantis model

- 53 spatial boxes
- 7 vertical layers
- 52 functional groups
  - Cod, haddock, saithe, Greenland halibut, capelin, herring, and minke whale treated separately
  - 13 other functionally-equivalent fish groups; 4 mammal and 1 seabird group; 3 zooplankton and 5 phytoplankton/plant groups; and the remaining groups: benthic invertebrates, dinoflagellates, bacteria, and carrion.
- Data necessary to initialize and parameterize the model come from the Marine Research Institute, the CODE model, NOAA, FishBase, and published literature.

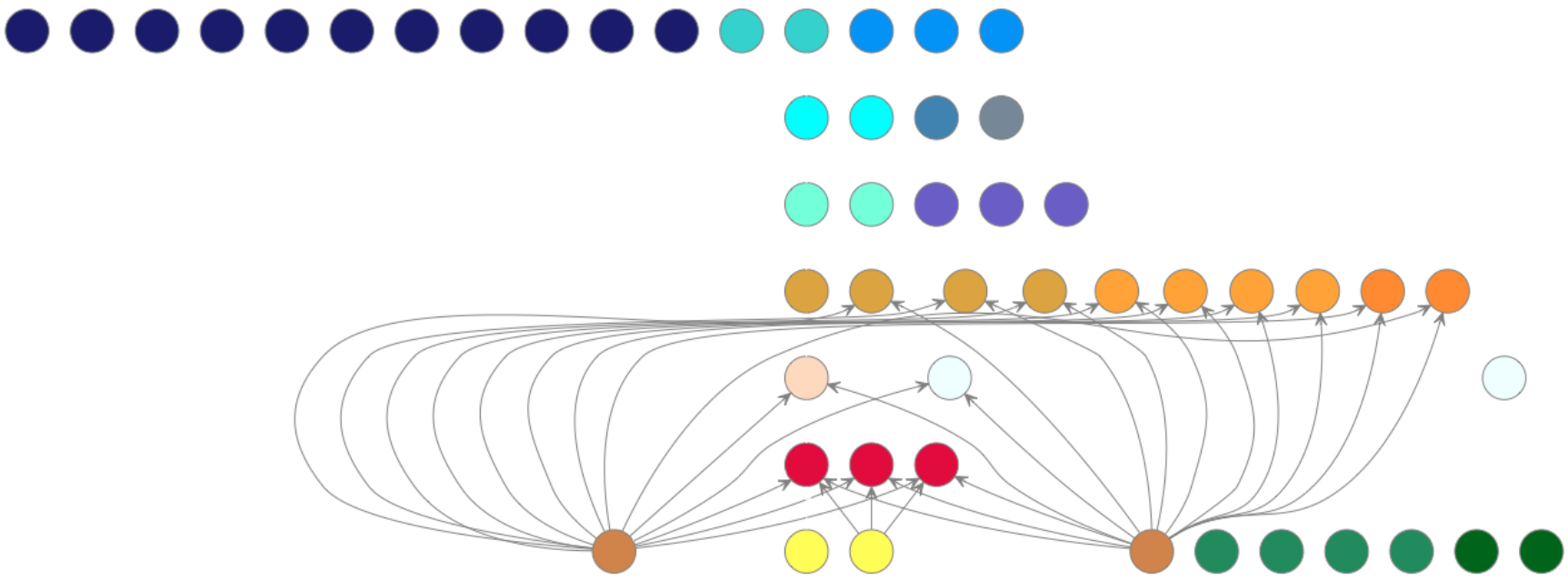
Modelling decisions

- Functional groups
- Consumption formulation
- Recruitment
- Distributions
- Environmental changes
- Track fine-scale diet
- Habitat dependency

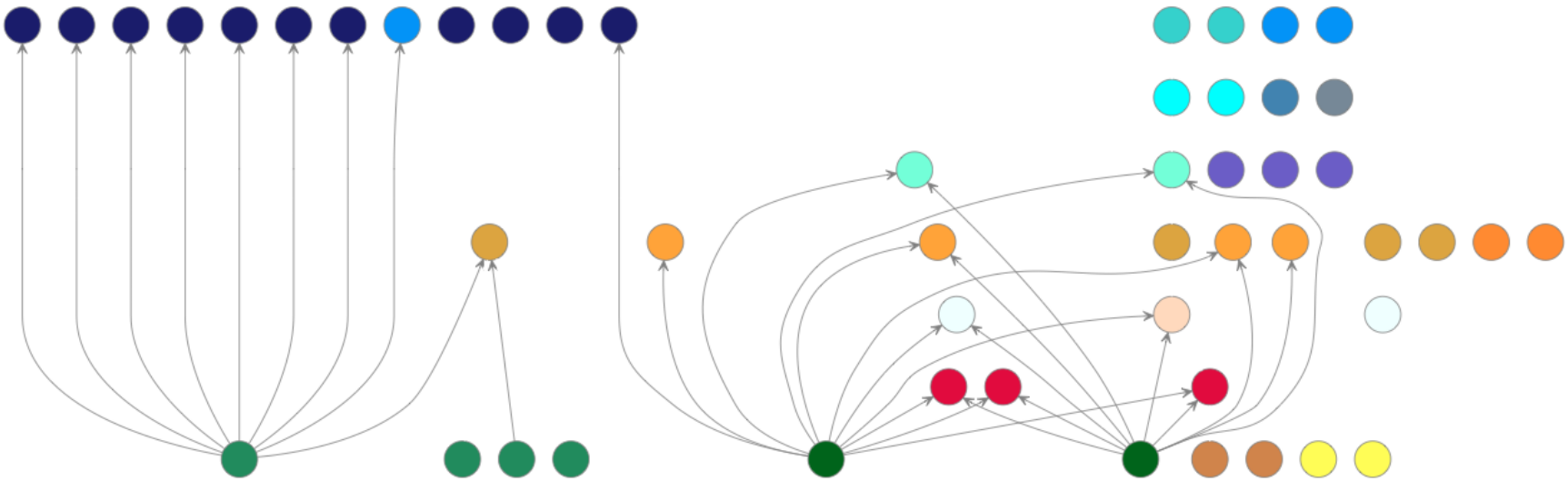
Tuning parameters

- Many parameters can be estimated but could require tuning in order to stabilize growth
  - Structural and reserve nitrogen for vertebrates should be within 0.8 - 1.2 of starting values
  - Biomass pools must not explode or go extinct
- Consumption (maximum daily growth, consumption per day), recruitment, prey availability, unexplained mortality (density dependent and independent)
- No fish is an island, so can't start with a simple model
- Model runs can be quite long

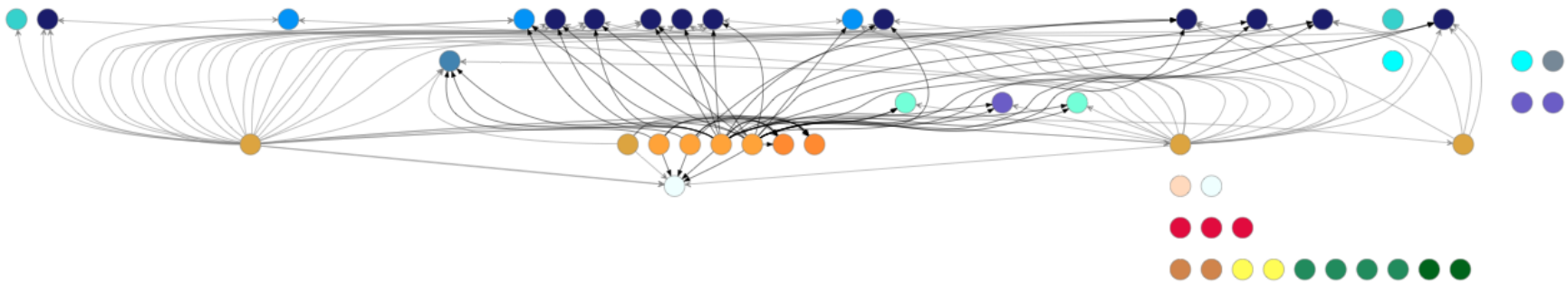
Detritus and Bacteria



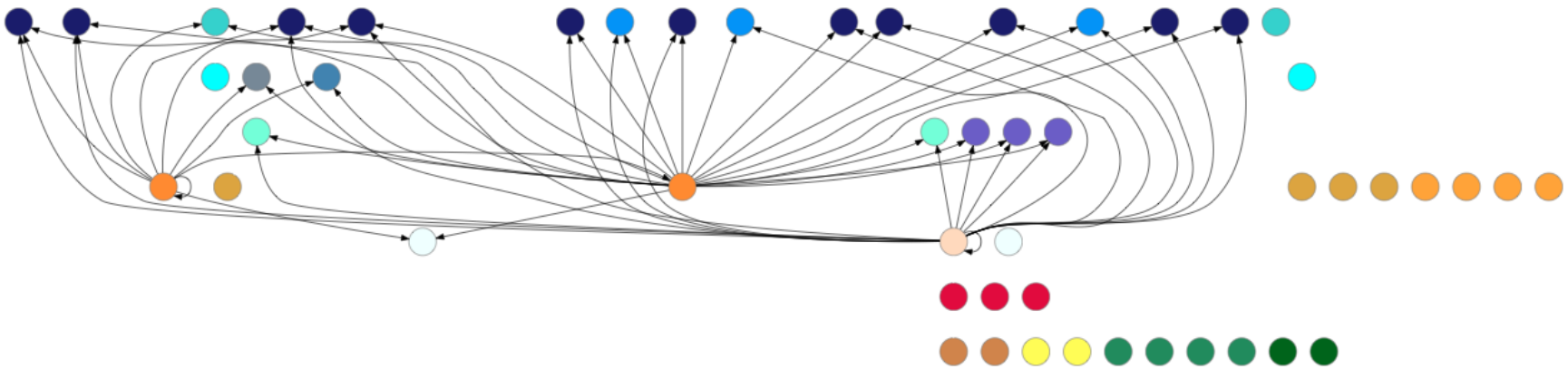
Plants



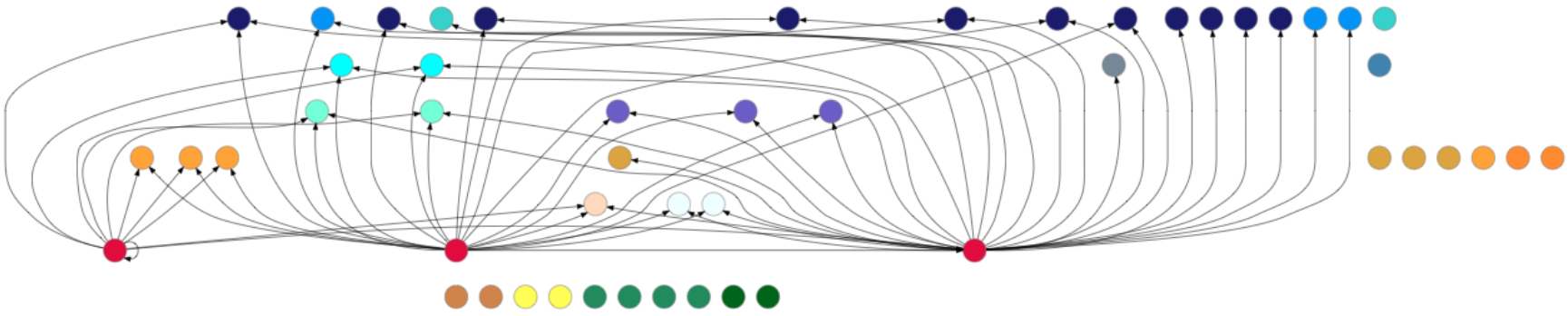
Benthic Inverts and Filter Feeders



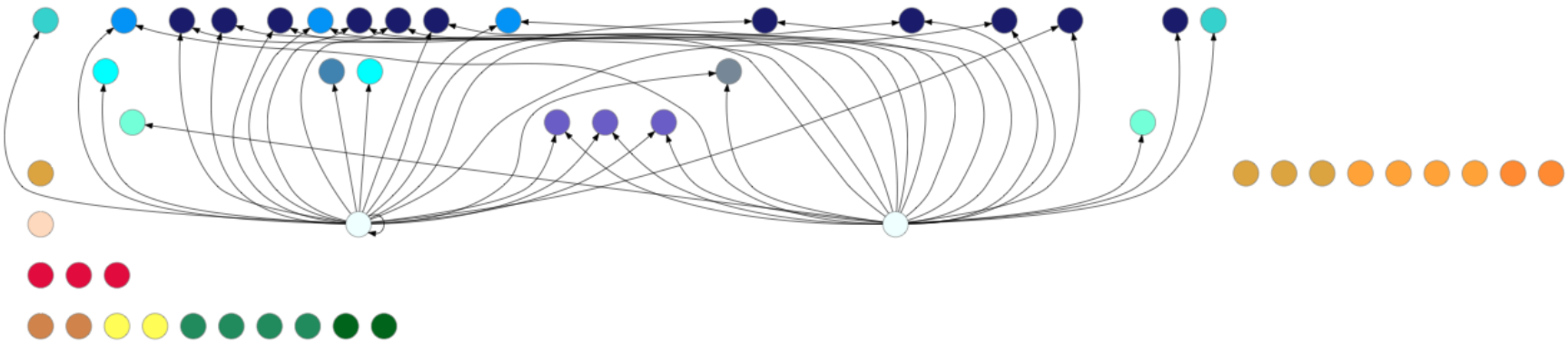
Macroinverts and Jellies



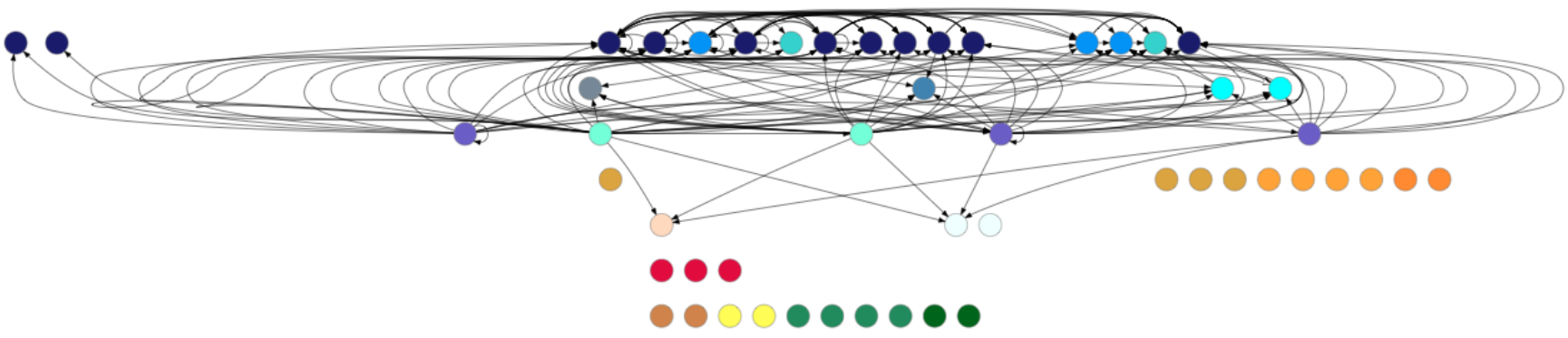
Zooplankton



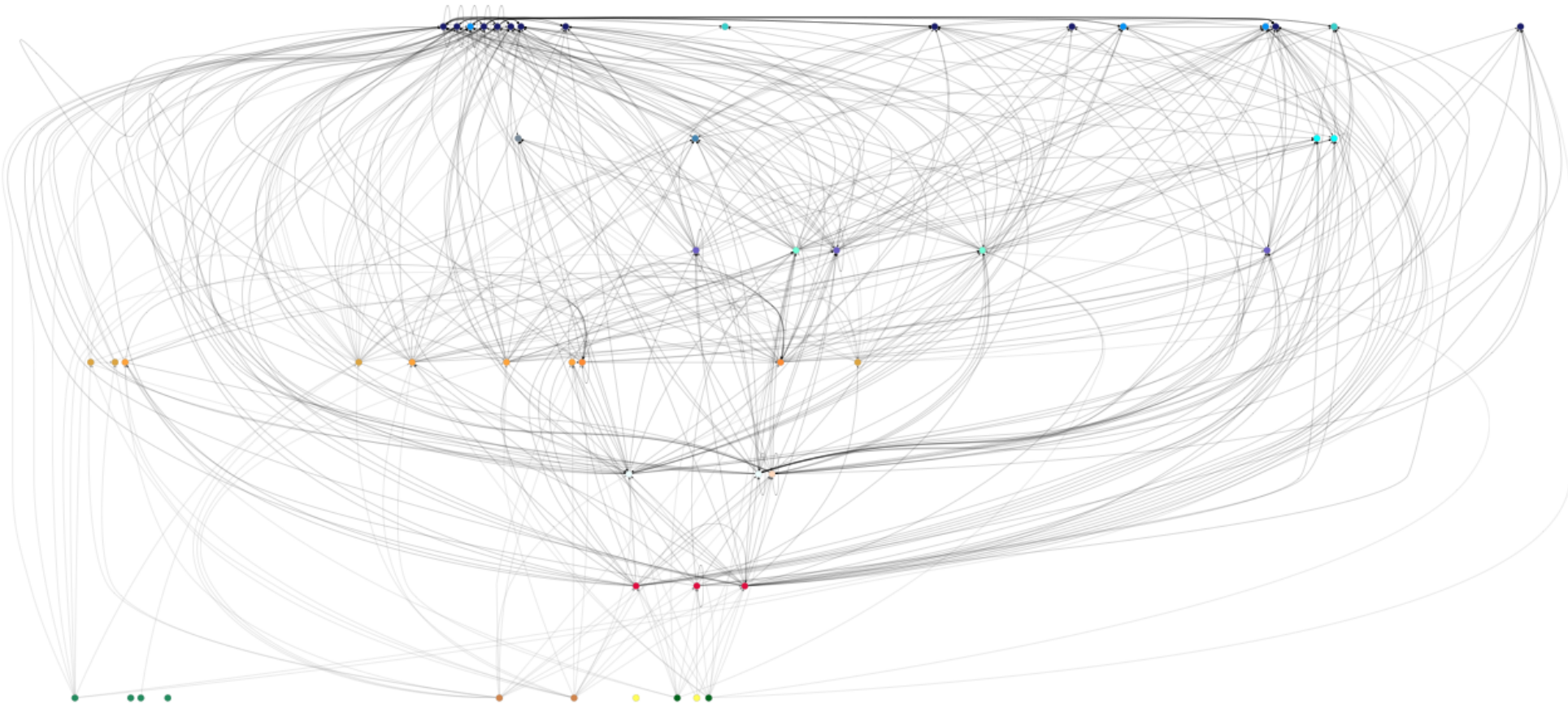
Prawn and Cephlapods



Everything else ...



The whole shebang



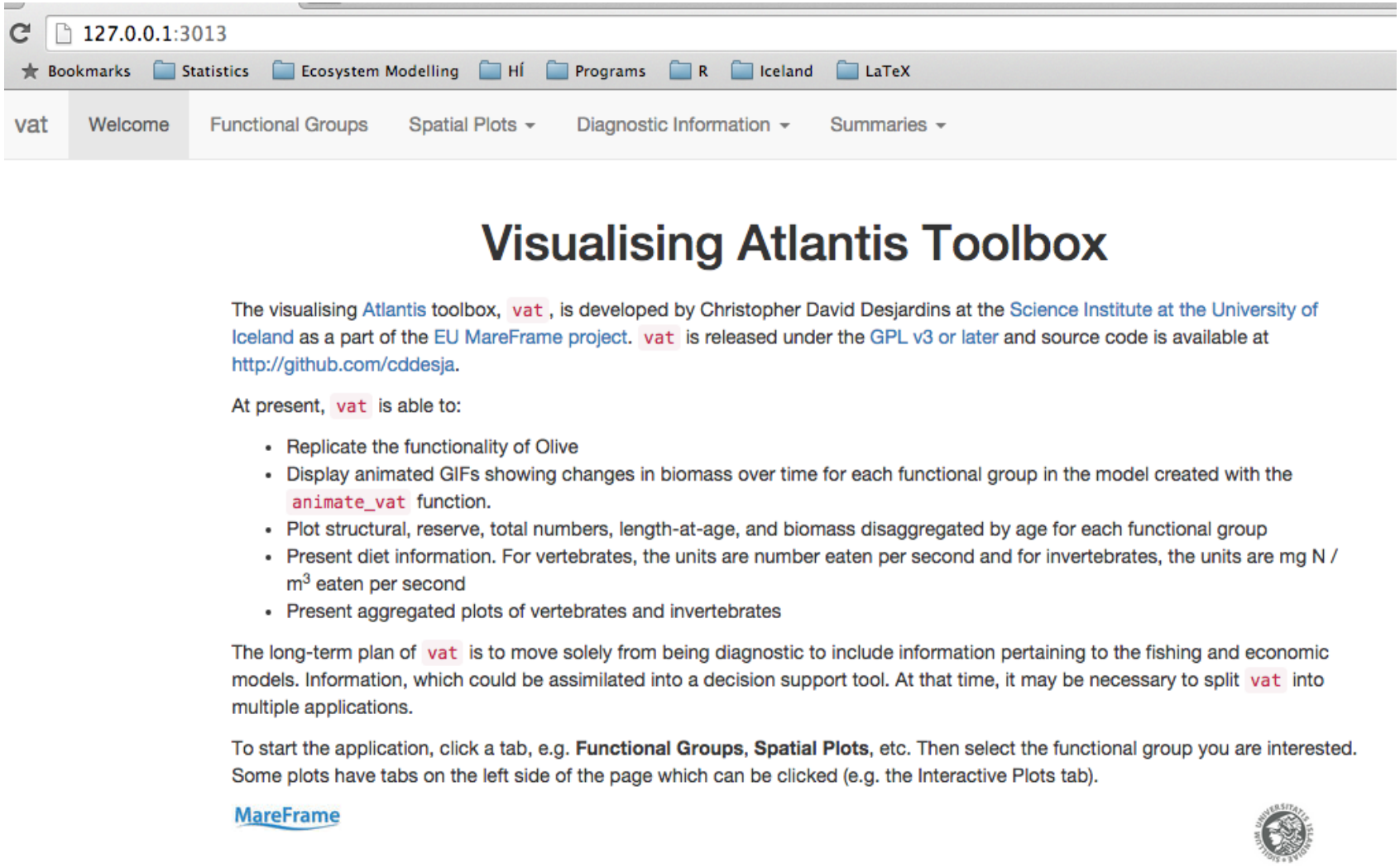
How to tune?

- Subjectively
  - Principal
  - Use of visual aids and log file
- Objectively
  - RSS, likelihood
  - But which parameters?
    - A vertebrate functional group has at least 100 parameters
    - Model run takes at least 4 hours
    - Algorithms need to be generic
    - Parallel processing not possible
  - **Trying to do this**

visualising Atlantis toolbox

Source Code: https://github.com/cddesja/vat

Demonstration: 130.208.71.121:3838/iceland_vat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Bookmarks
Statistics
Ecosystem Modelling
HÍ
Programs
R
Iceland
LaTeX
vat
Welcome
Functional Groups
Spatial Plots
Diagnostic Information
Summaries
Visualising Atlantis Toolbox
The visualising Atlantis toolbox, vat, is developed by Christopher David Desjardins at the Science Institute at the University of Iceland as a part of the EU MareFrame project. vat is released under the GPL v3 or later and source code is available at http://github.com/cddesja.
At present, vat is able to:
Replicate the functionality of Olive
Display animated GIFs showing changes in biomass over time for each functional group in the model created with the animate_vat function.
Plot structural, reserve, total numbers, length-at-age, and biomass disaggregated by age for each functional group
Present diet information. For vertebrates, the units are number eaten per second and for invertebrates, the units are mg N / m3 eaten per second
Present aggregated plots of vertebrates and invertebrates
The long-term plan of vat is to move solely from being diagnostic to include information pertaining to the fishing and economic models. Information, which could be assimilated into a decision support tool. At that time, it may be necessary to split vat into multiple applications.
To start the application, click a tab, e.g. Functional Groups, Spatial Plots, etc. Then select the functional group you are interested. Some plots have tabs on the left side of the page which can be clicked (e.g. the Interactive Plots tab).
MareFrame

vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

Show 10 entries

Search:

	Code	Index	IsTurnedOn	Name	LongName	NumCohorts	NumGeneTypes	NumStages	NumSpawns	NumAgeClassSize
1	FCD	0	1	Cod	Gadus morhua	10	1	2	1	2
2	FHA	1	1	Haddock	Melanogrammus aeglefinus	10	1	2	1	2
3	FSA	2	1	Saithe	Pollachius virens	10	1	2	1	2
4	FRF	3	1	Redfish	Redfish	10	1	2	1	5
5	FGH	4	1	Greenland_Halibut	Reinhardtius hippoglossoides	10	1	2	1	2
6	FFF	5	1	Flatfish	Flatfish	10	1	2	1	2
7	FHE	6	1	Herring	Clupea harengus	10	1	2	1	2
8	FCA	7	1	Capelin	Mallotus villosus	6	1	2	1	1
9	FMI	8	1	Migratory_Pelagic	Migratory pelagics	10	1	2	1	1
10	FOC	9	1	Other_Codfish	Other Codfish	10	1	2	1	2

Showing 1 to 10 of 42 entries

Previous 1 2 3 4 5 Next

vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

Vertebrates

Invertebrates

Tracers

Cod1_Nums

Choose a layer to display

1 7

1 2 3 4 5 6 7

Choose a time to display

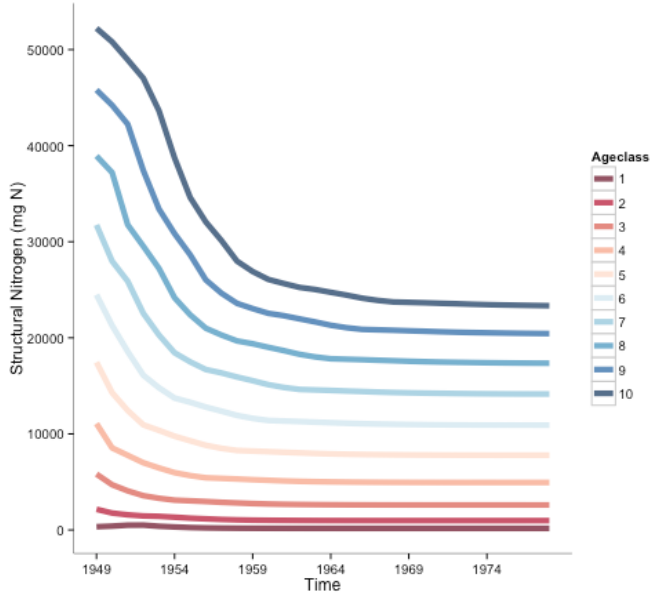
1 30

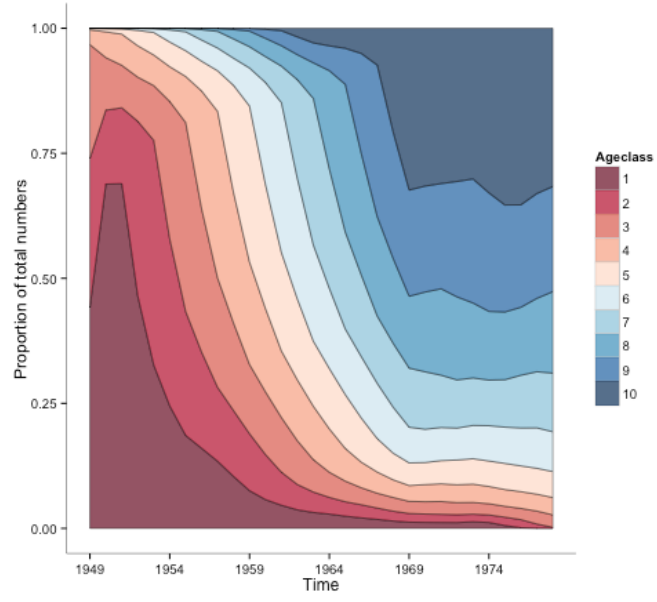
1 4 7 10 13 16 19 22 25 28 30

vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

Functional Group

Cod





vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

Predator: All

Prey: All

Show 10 entries

Search:

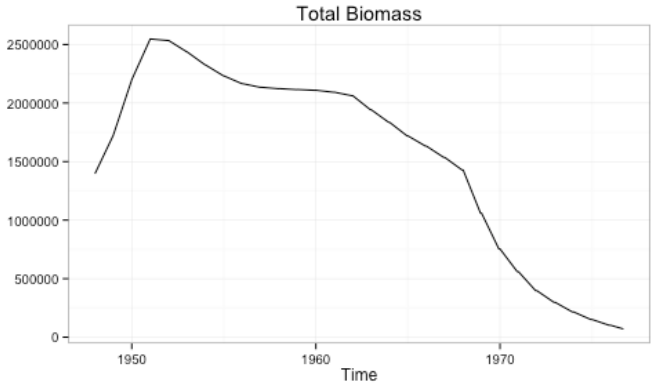
	Predator	Prey	Eaten
1237	ZG	PL	0.852703222758621
930	SSD	CEP	0.781124734827586
865	SB	FRF	0.660287915275862
76	DF	PL	0.609827725024138
114	FBP	PWN	0.605441611448276
1168	WTO	FFF	0.548218701034483
650	FRF	FRF	0.510786763186207
973	SSH	CEP	0.466636832241379
1375	ZS	DR	0.463208389827586
371	FFF	CEP	0.461678267841379

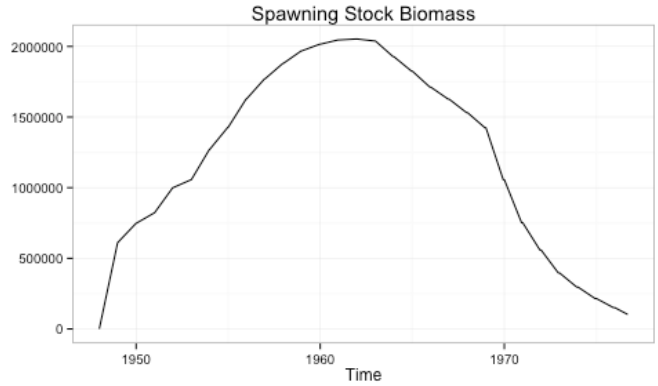
Diet Matrix: *Units are number consumed per second for vertebrates and mg N/m3 consumed per second for biomass pools.*

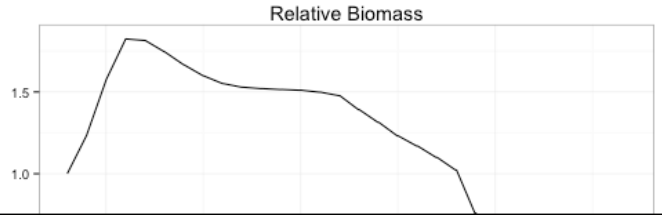
vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

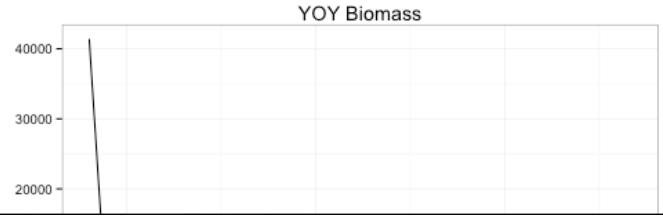
Functional Group

Cod





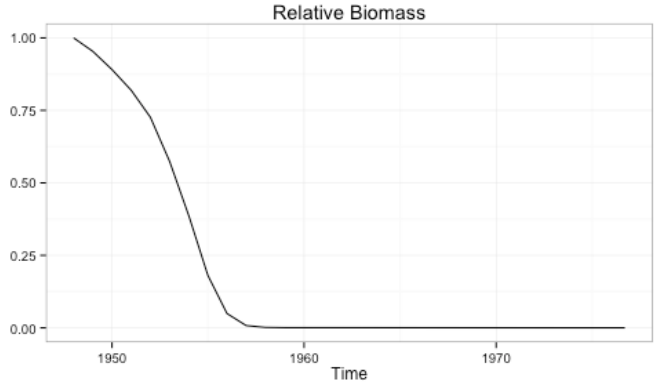


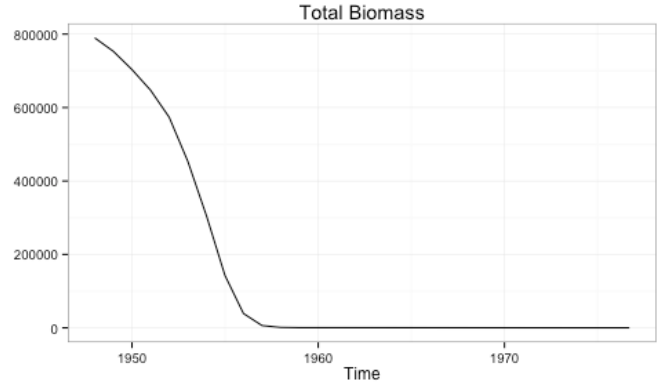


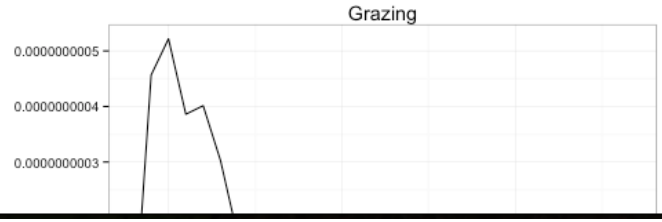
vat | Welcome | Functional Groups | Spatial Plots | Diagnostic Information | Summaries

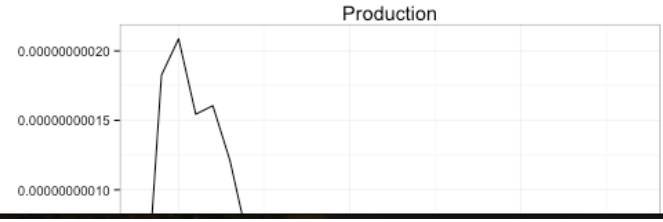
Functional Group

Cephalopod









Future uses

- Operating model
- Management strategy evaluation
- Bringing it one step closer to tactical?