Physics & Hydrodynamics
Biogeochemistry
Primary Production
Parameter files

Isaac Kaplan, isaac.kaplan@noaa.gov.

Atlantis Summit, Tuesday 0900

Physics & Hydrodynamics, Biogeochemistry
Primary Production

- Illustrate the range of approaches to hydrodynamics
- Discuss options for handling biogeochemistry, both nutrient-driven and CO2 driven
- Evaluate range of parameterizations for primary production

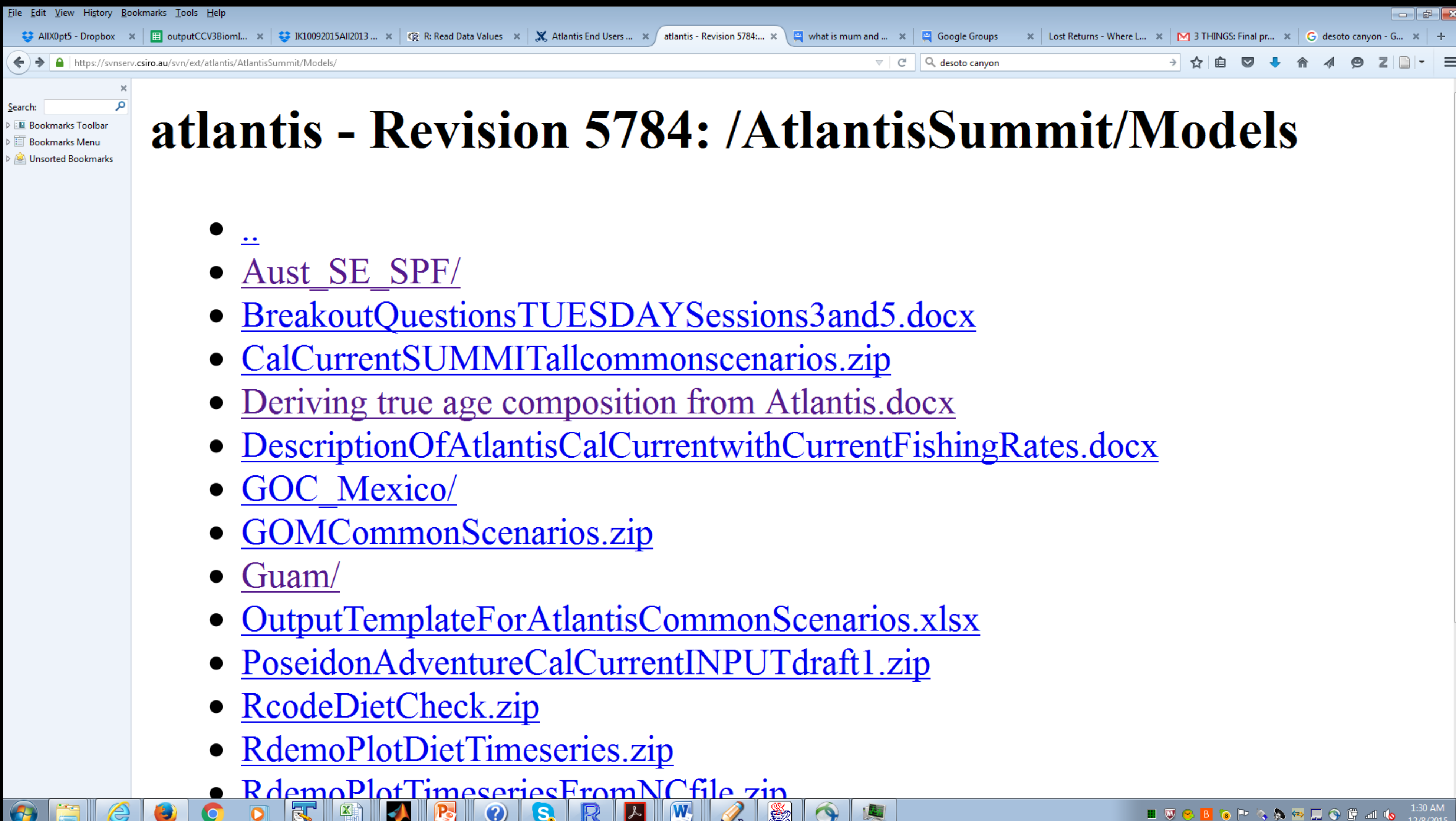
Why?

- Illustrate the range of approaches to hydrodynamics (New users; review paper)
- Discuss options for handling biogeochemistry, both nutrient-driven and CO2 driven (coastal models, coral models and others with pH; Common scenarios)
- Evaluate range of parameterizations for primary production (ecologists and reviewers, priors for new models, input error checking)

Format for this session

- QUESTIONS appear here and in handout on SVN.
- Questions will be addressed in breakout groups
- Please keep discussion broad and focused on processes not parameter names.
- Report back after 45 minutes. Rapporteur notes to Sarah.
- Goal is Best Practices guidelines for parameterizing Physics & Hydrodynamics, Biogeochemistry, and Primary Production

BreakoutQuestionsTUESDAYSessions3and5.docx



Physics & Hydrodynamics

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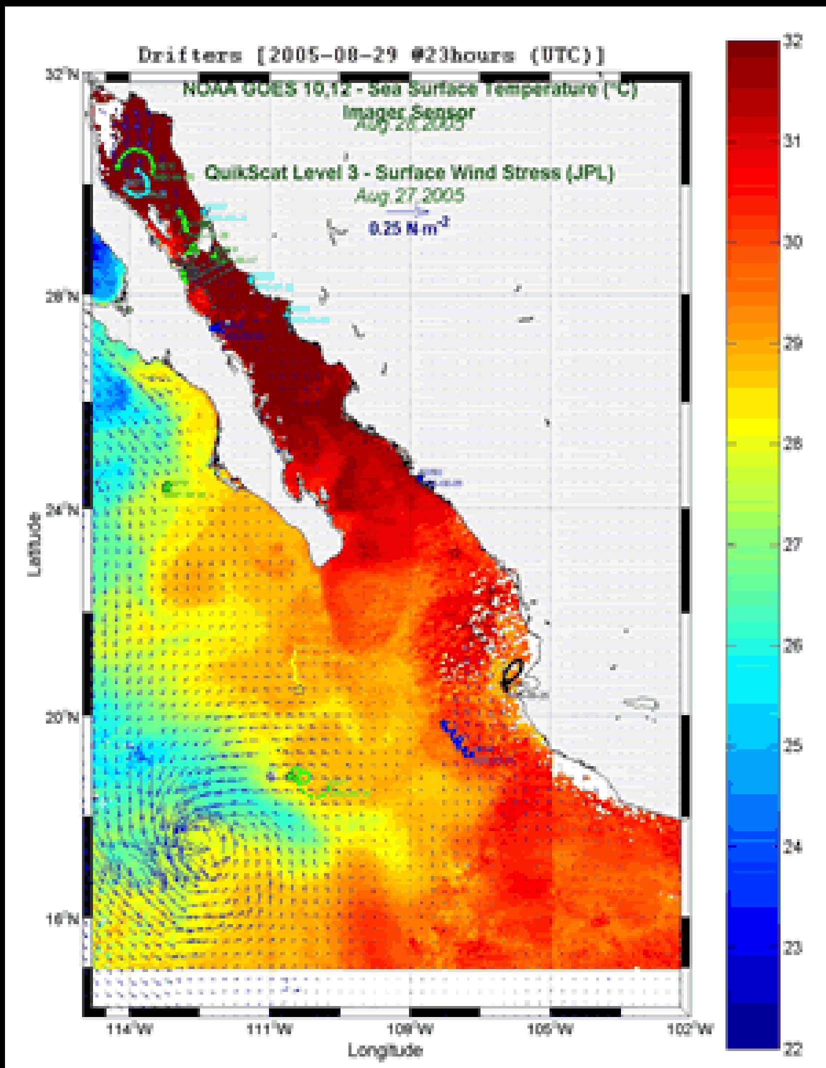
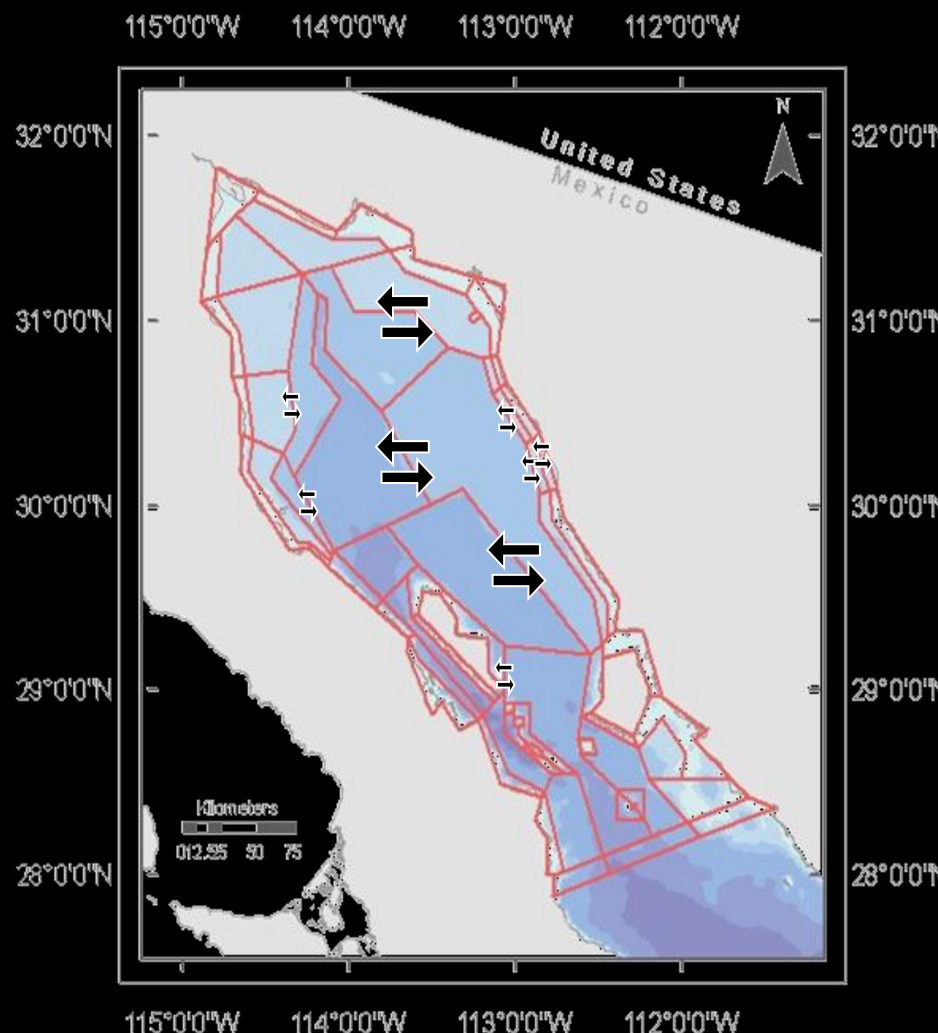
Questions: hydrodynamics

- What is the range of approaches to hydrodynamics taken by your modeling group?
- Have you tested shortcuts besides full hydrodynamic models, or do you have code to facilitate inclusion of hydrodynamic model output?
- Are there other hydrodynamic questions you have tackled – larval diffusion, etc?

Model input: Oceanography
(ROMS model courtesy A. Pares Sierra)



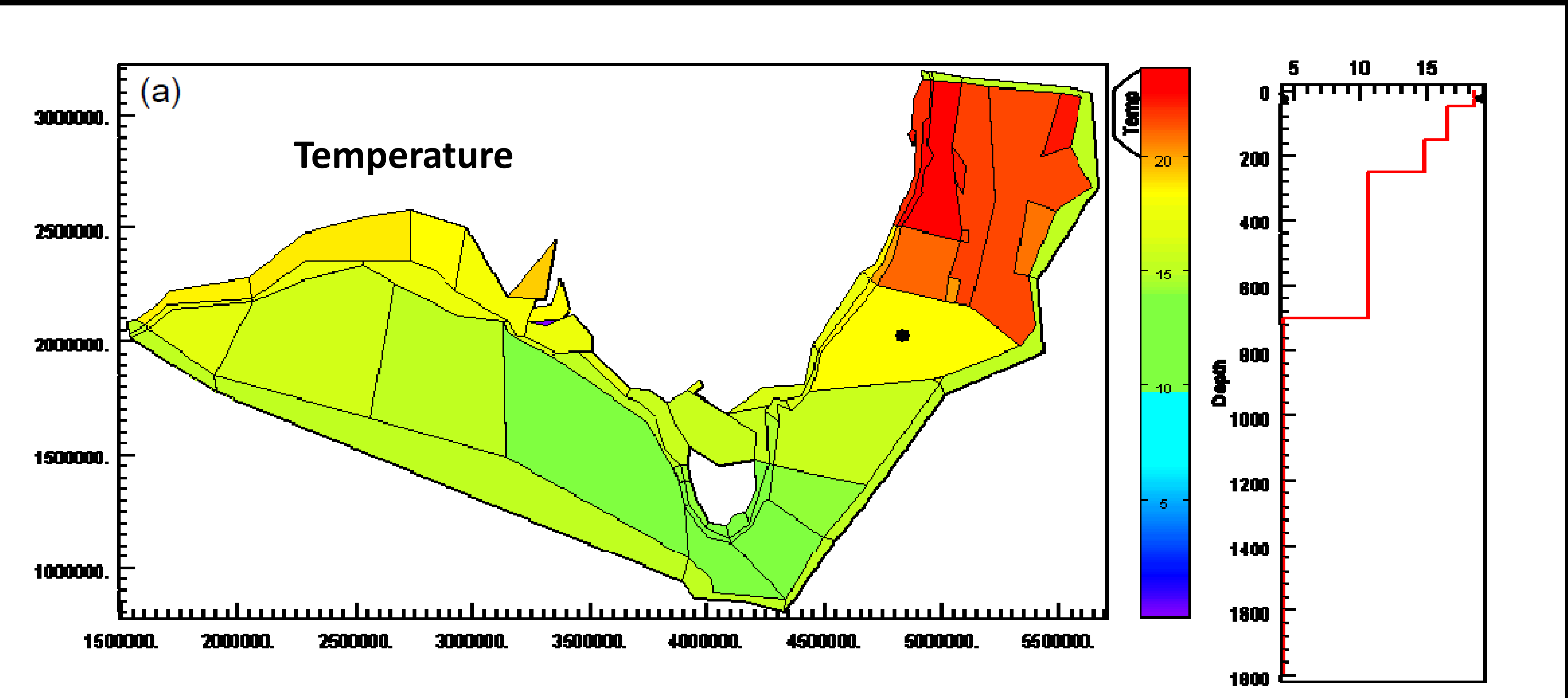
Heat, salt, water movement (3D)



Exchange between polygons

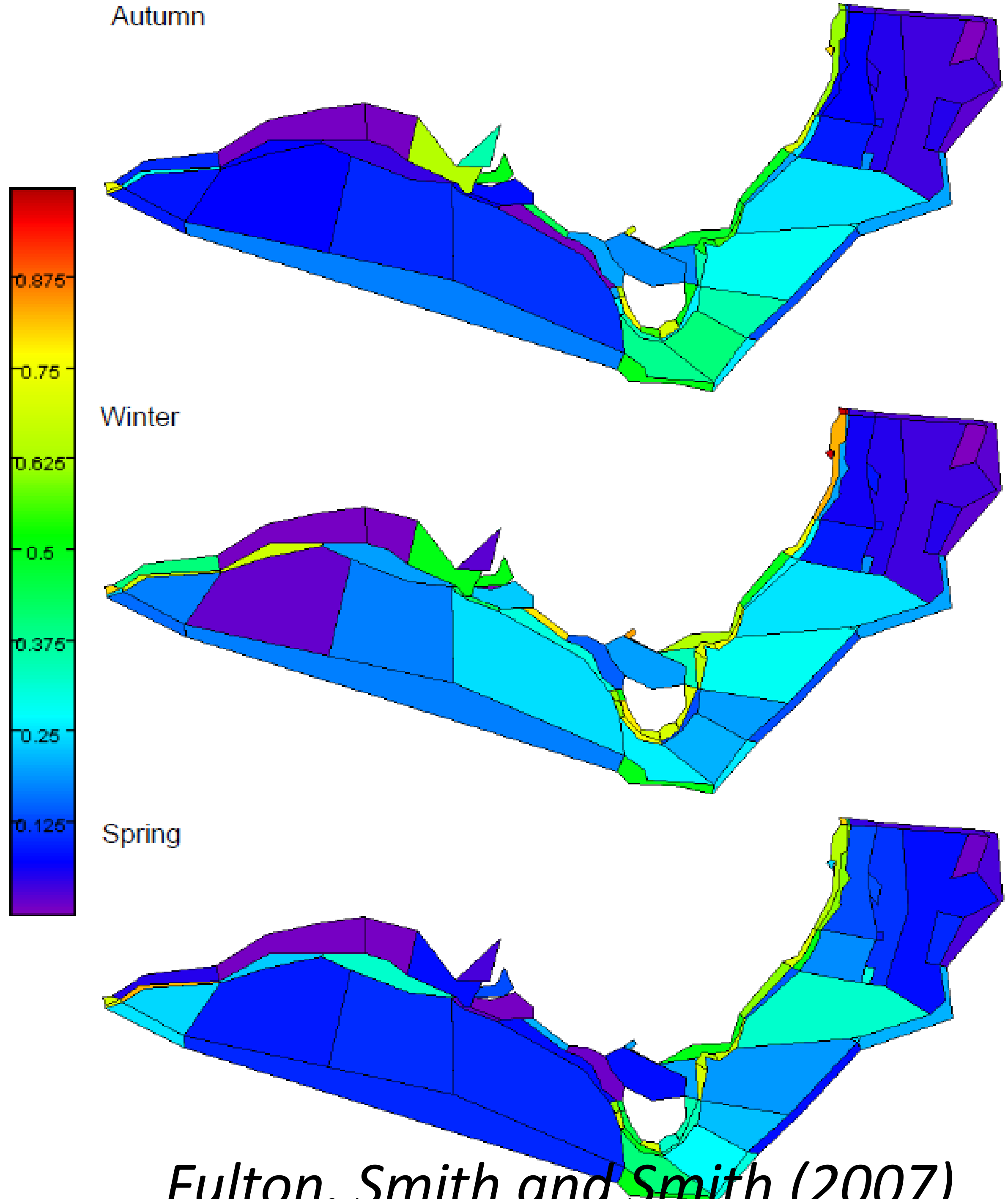
Slide stolen from Hem and Cam

Bluelink (Fulton, Smith and Smith 2007)



Eddy strength from Bluelink to Atlantis –

who else has tried this?



Fulton, Smith and Smith (2007)

Figure 2-7: Quarterly energy fields (scaled 0-1) used to represent eddy strength in the southeast Atlantis model.

What are simpler approaches if you don’t have a ROMS or HYCOM modeler nearby?

ROMS Slicer/Dicer code

- There was an effort by NOAA NCOS to develop generic code to ‘slice’ ROMS or HYCOM output into Atlantis input .
- Used for Chesapeake and Gulf of Mexico models, could be fruitful for someone with serious computer science background.

Physics & Hydrodynamics
Biogeochemistry
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Physics & Hydrodynamics

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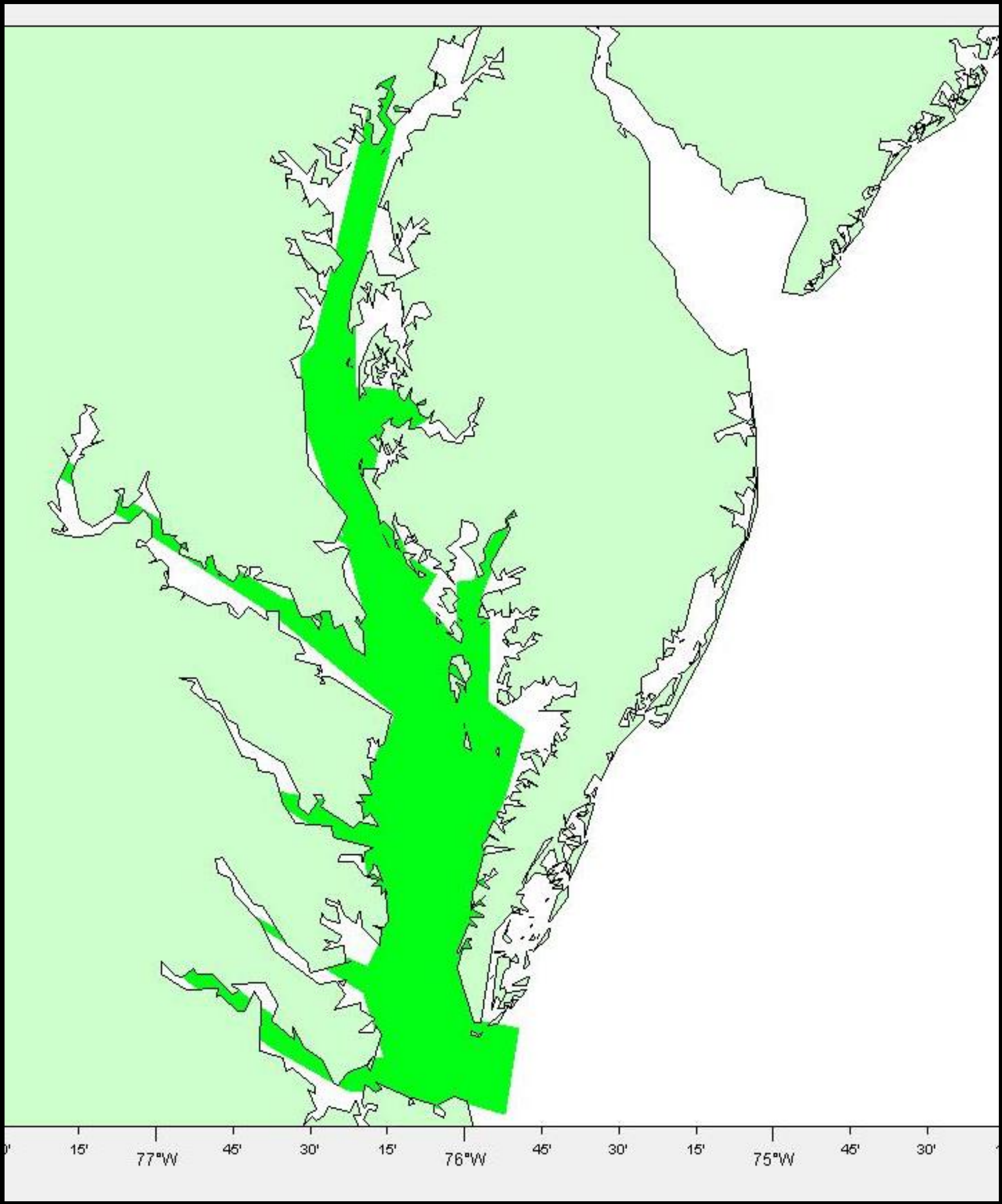
Questions

- What is the range of approaches you have taken, advantages, and drawbacks related to

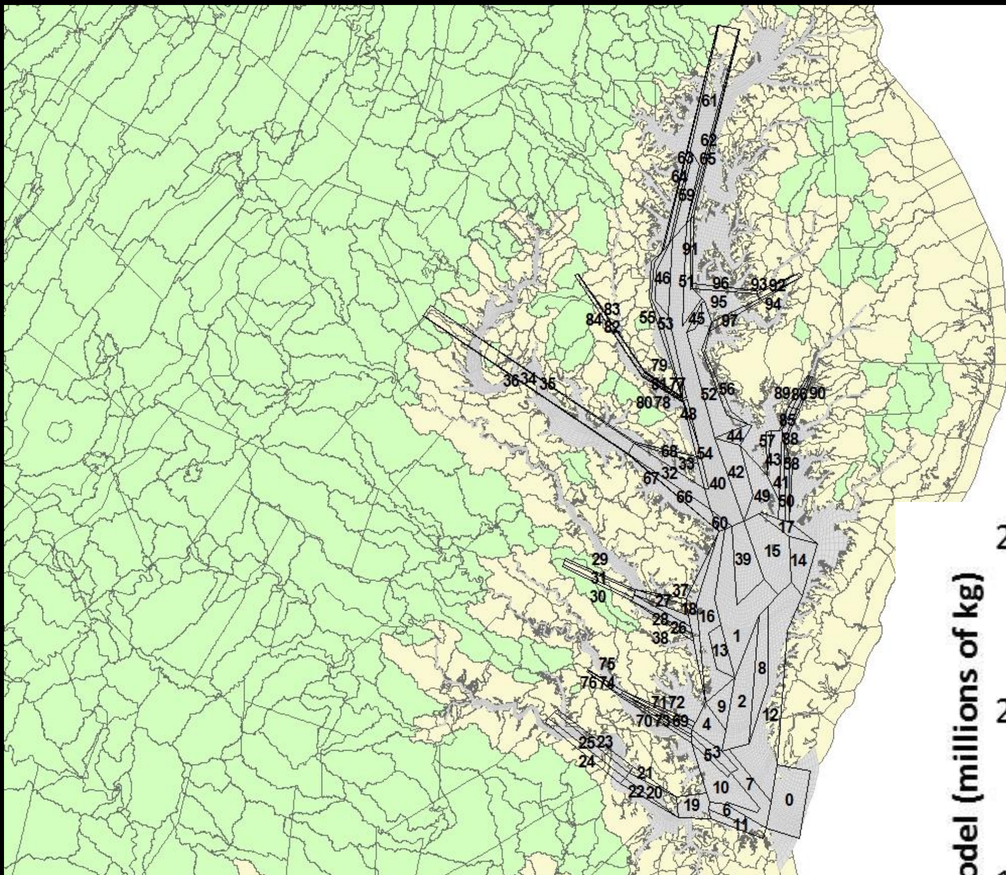
1. Nutrient loading
2. Predicting Ocean acidification (pH)
3. Predicting impacts of acidification on biology

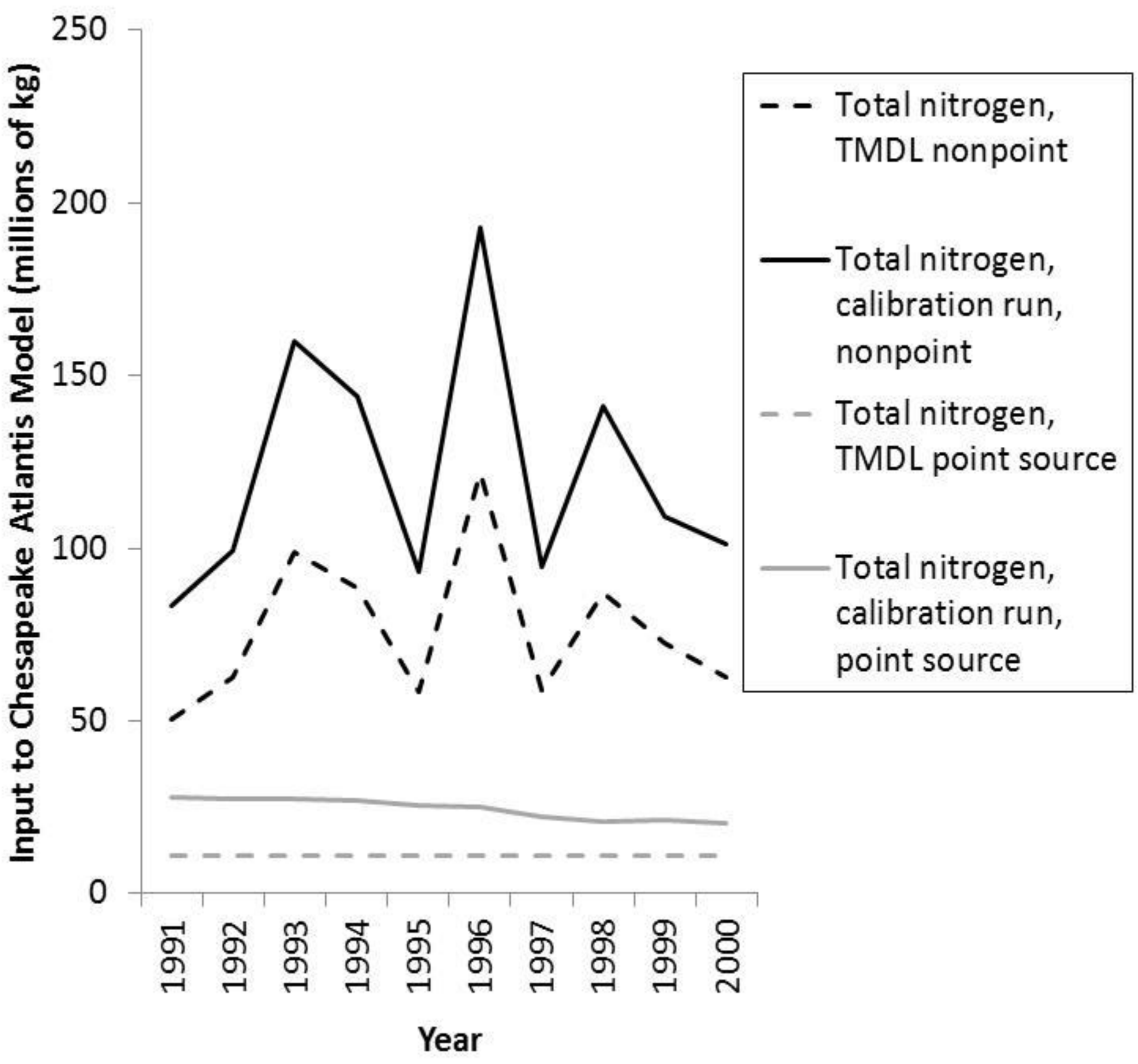
- Are there other biogeochemical questions you have tackled?

Biogeochemistry: Nutrient Addition, Chesapeake Bay, USA (stolen from Tom and Howard)



Detailed modeling of point and non-point nutrient pollution

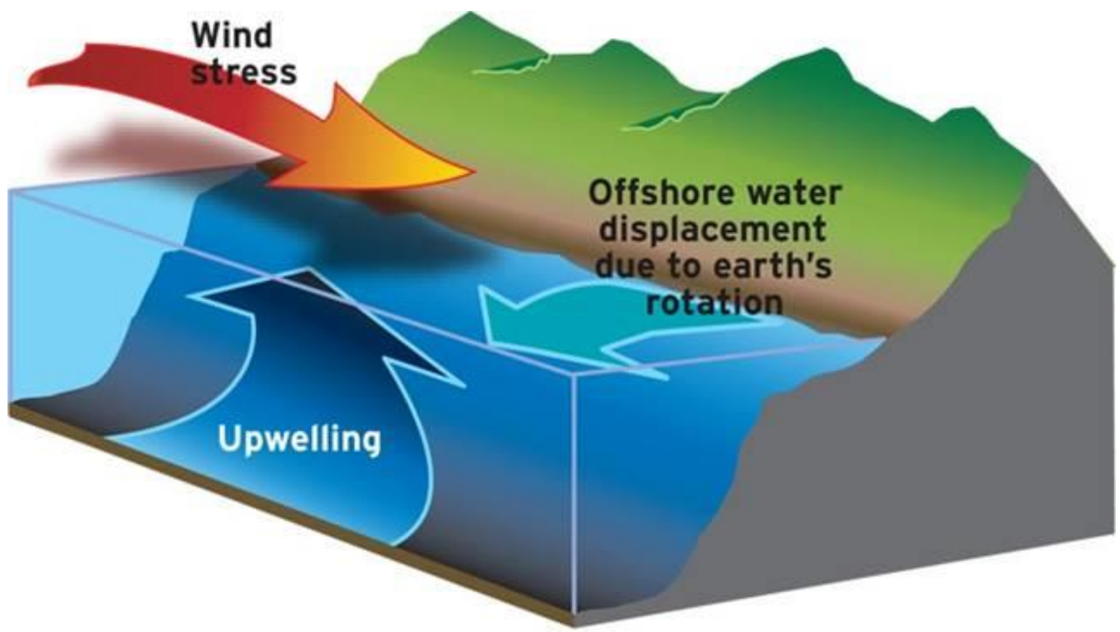




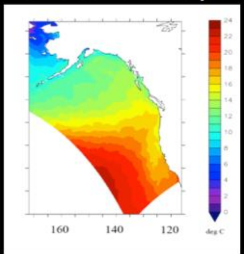
Nutrient.ts file: California Curent nutrient “pipes” for upwelling

Box5.ts

```
# This is a dummy nutrient forcing data file,
# For EMOCC 9/26/06
# Nutriet flux is based on multiplying bakun upwelling index from PFEG 3 degree latitude bins (in units of m^3/s/100 m of coastli
# by NO3 and Si concentrations at 20m depth reported in World Ocean Atlas.
# see UpwellingAndNuts.xls
#
# ALL VALUES OTHER THAN NO3 AND SI ARE CURRENTLY A GUESS !!!!!
#
## COLUMNS 6
##
## COLUMN1.name Time
## COLUMN1.long_name Time
## COLUMN1.units days since 1930-01-01 0:00:00 +10
## COLUMN1.missing_value -999
##
## COLUMN2.name NH3
## COLUMN2.long_name NH3
## COLUMN2.units mg s-1
## COLUMN2.missing_value -999
#
## COLUMN3.name NO3
## COLUMN3.long_name NO3
## COLUMN3.units mg s-1
## COLUMN3.missing_value -999
##
## COLUMN4.name Lab_Det_N
## COLUMN4.long_name Lab_Sed_N
## COLUMN4.units mg s-1
## COLUMN4.missing_value -999
##
## COLUMN5.name Si
## COLUMN5.long_name Silica
## COLUMN5.units mg s-1
## COLUMN5.missing_value -999
##
## COLUMN6.name Det_Si
## COLUMN6.long_name Detrital Silica
## COLUMN6.units mg s-1
## COLUMN6.missing_value -999
##
1       840000.00       16800000.00     0.00
2       0.00    0.00    0.00    0.00    0.00
3       0.00    0.00    0.00    0.00    0.00
```



Oceanographic Model
Predicts 2060s pH

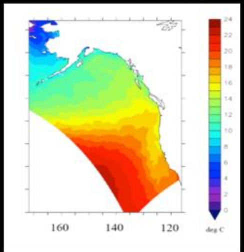


Biogeochemistry
1. Ocean acidification, California Current

Collaborator: Albert Hermann

- Regional Ocean Modeling System (ROMS) forced by GFDL ESM2M
- Carbonate dynamics
- **RCP 8.5** (IPCC 'High-emissions')
- Future = **2060**s

Oceanographic Model
Predicts 2060s pH



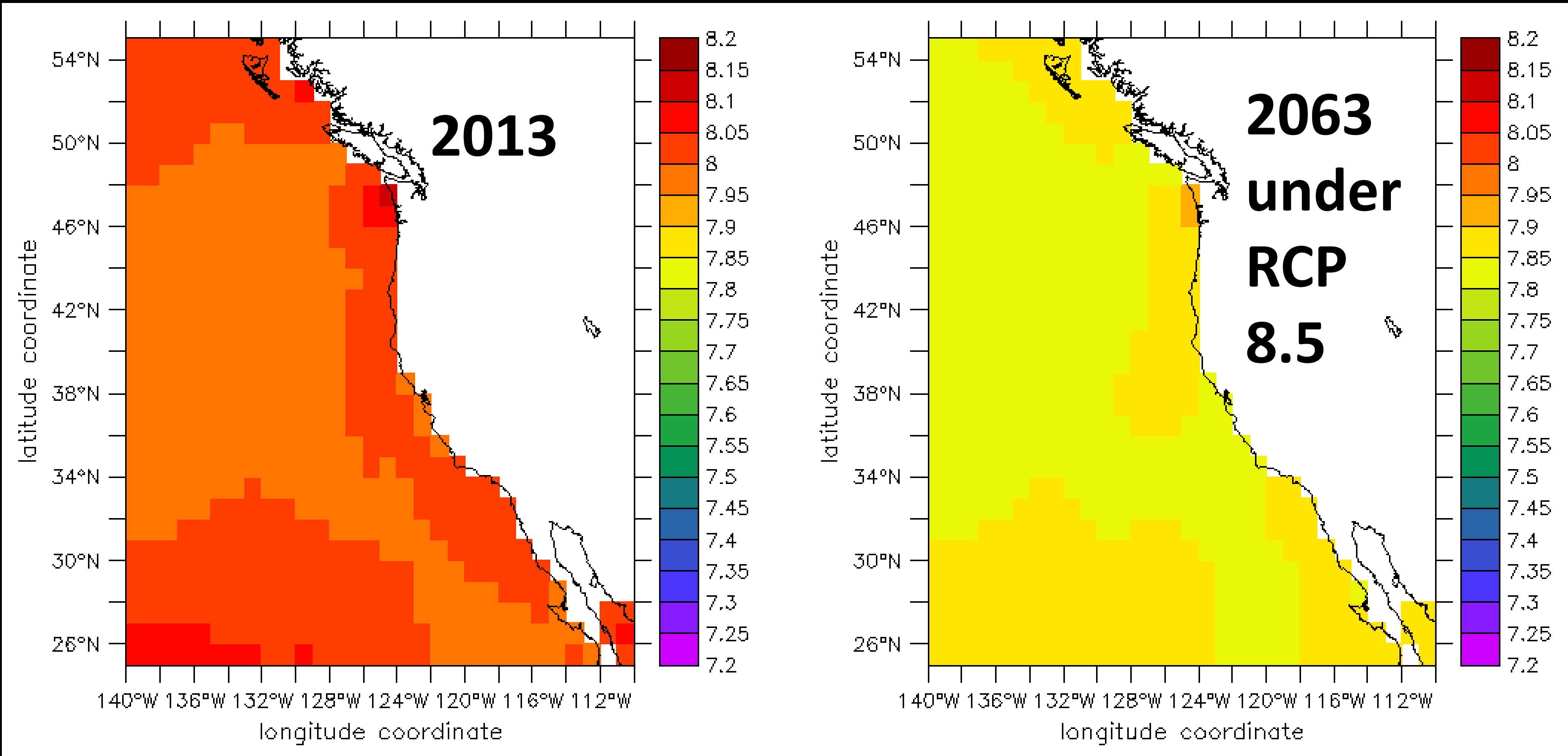
Biogeochemistry
1. Ocean acidification, California Current

Collaborator: Albert Hermann

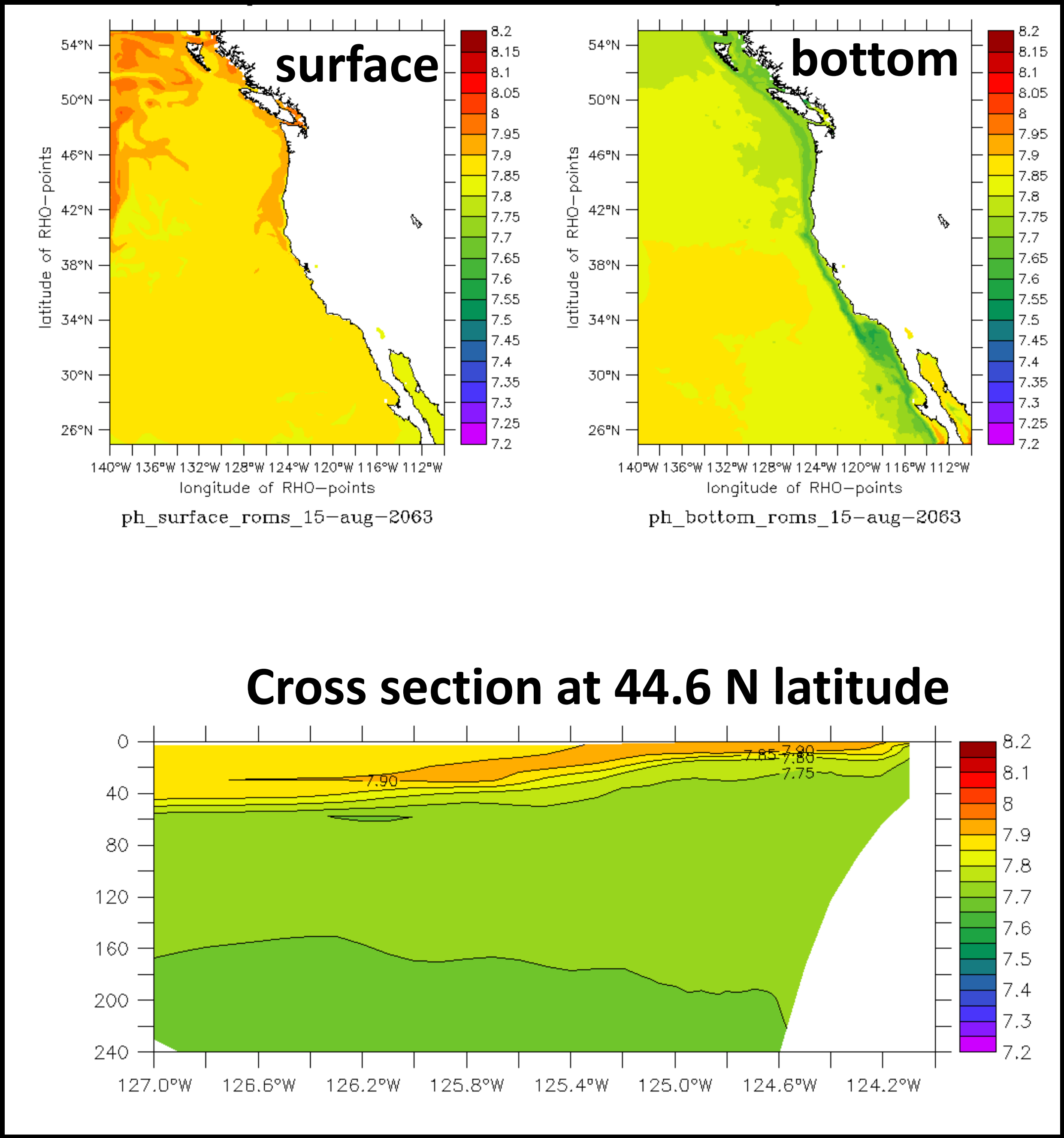
- Regional Ocean Modeling System (ROMS) forced by GFDL ESM2M
- Carbonate dynamics
- **RCP 8.5** (IPCC ‘High-emissions’)
- Future = **2060**s

Result: pH declines from 8.0 to ~7.8 by 2060

August surface pH, GFDL ESM2M 2013 vs. 2063 under RCP 8.5 ‘business as usual’ emissions



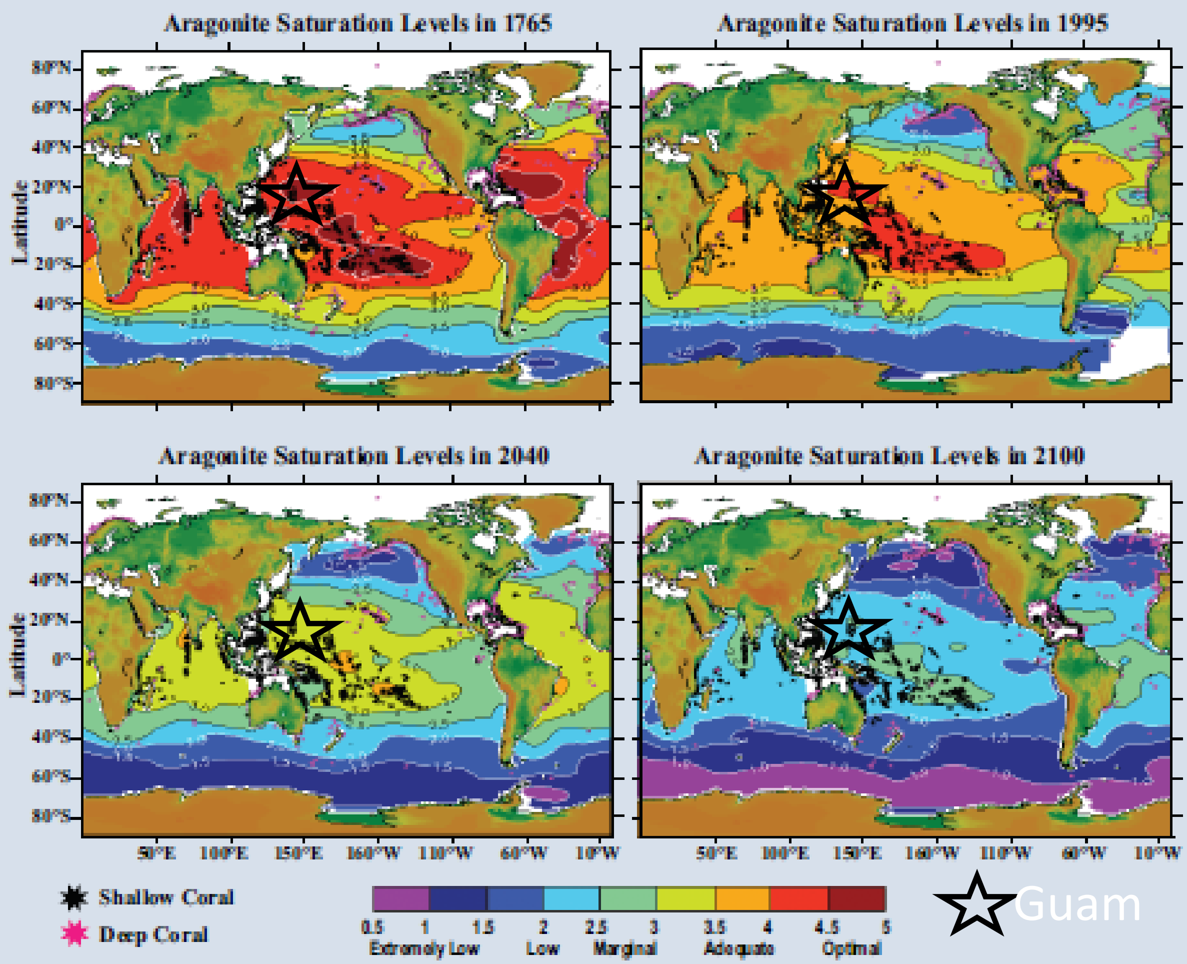
August 2063 pH, ROMS, RCP 8.5



Biogeochemistry
2. Ocean acidification, Atmospheric approach for Guam

Ocean Acidification

coral growth rate = base coral growth rate * (net calcification rate / base calcification rate)



Estimated aragonite saturation states of the surface ocean for the years 1765, 1995, 2040, and 2100 (Feely *et al.*, submitted), based on the modeling results of Orr *et al.* (2005) and a Business-As-Usual CO_2 emissions scenario. The distributions of deep-sea coral banks are from Guinotte *et al.* (2006).

Kleypas et al 2006

pH

Aragonite saturation

Calcification rate

Coral growth

Silverman et al 2009, Anthony et al 2011, Kleypas et al 2006, Cohen and Holcomb 2009

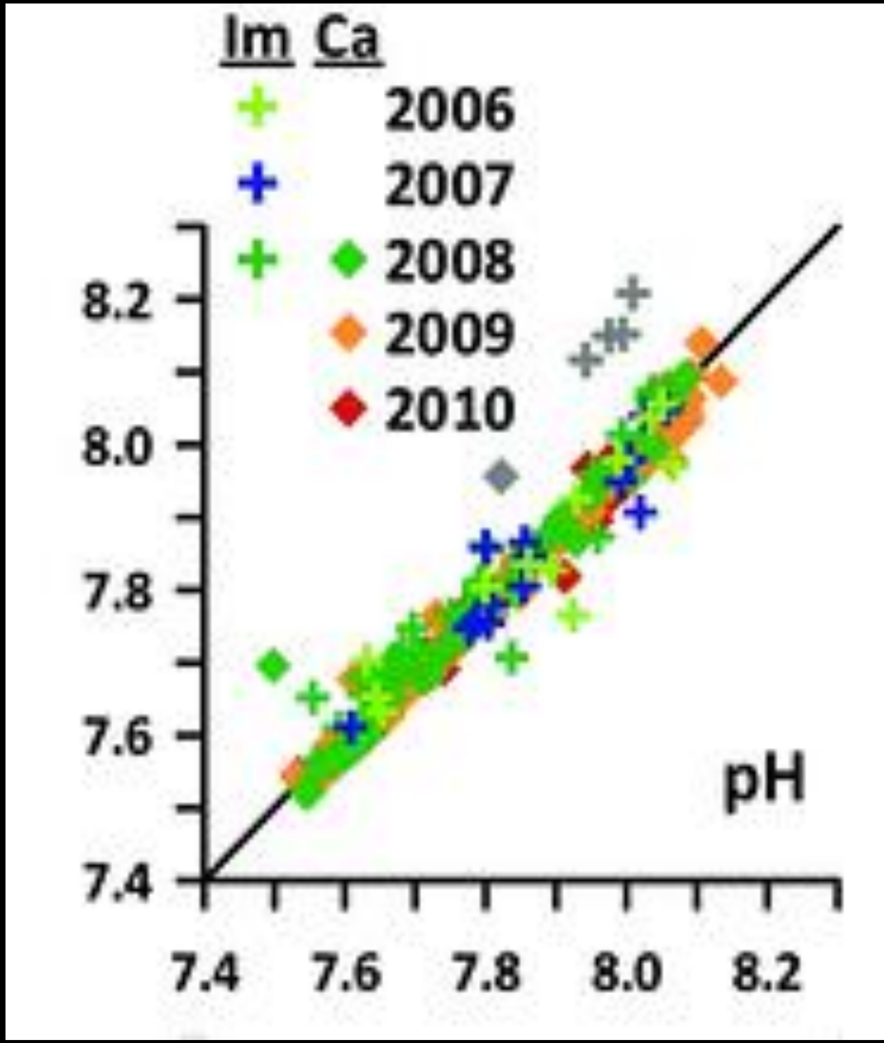
Biogeochemistry

3. Ocean acidification, empirical relationships

Robust empirical relationships for estimating the carbonate system in the southern California Current System and application to CalCOFI hydrographic cruise data (2005–2011)

Predictors of pH:

Temperature
Oxygen
Salinity
depth



SR Alin et al. (2012) Journal of Geophysical Research: Oceans

Physics & Hydrodynamics

Biogeochemistry

Primary Production

Parameter files

Questions

- How has your modeling group parameterized
  - biomass of primary producers? (initial conditions)
  - Growth rates of primary producers?
  - Mixotrophic dinoflagellates

Methods for biomass estimates for primary producers

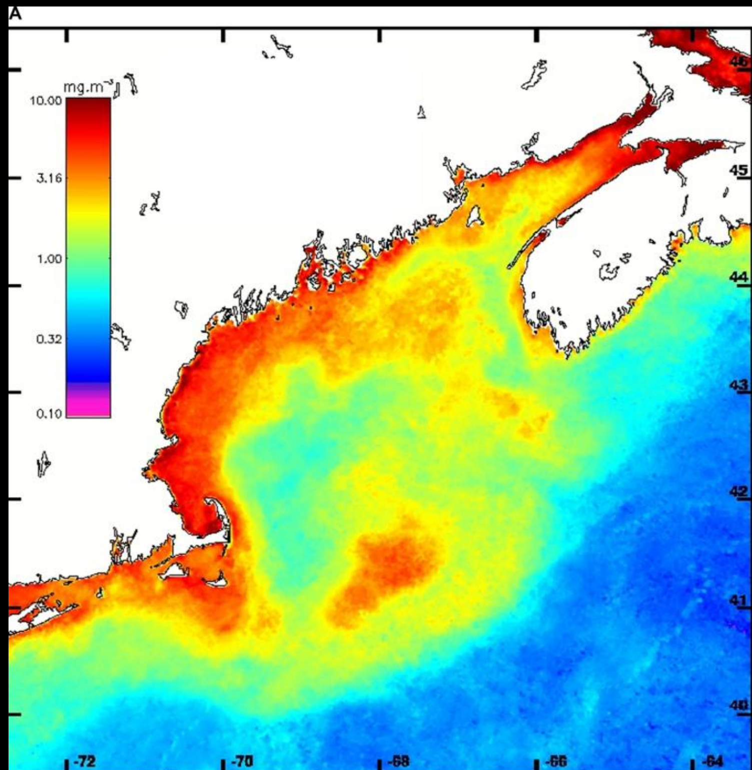
- Satellite Chlorophyll a
- In-situ rosette (bottle) samples
- Assigning chlorophyll a to different phytoplankton groups
- Converting chlorophyll a to mg N

Primary producers

- **One choice is whether to include mixotrophic dinoflagellates**

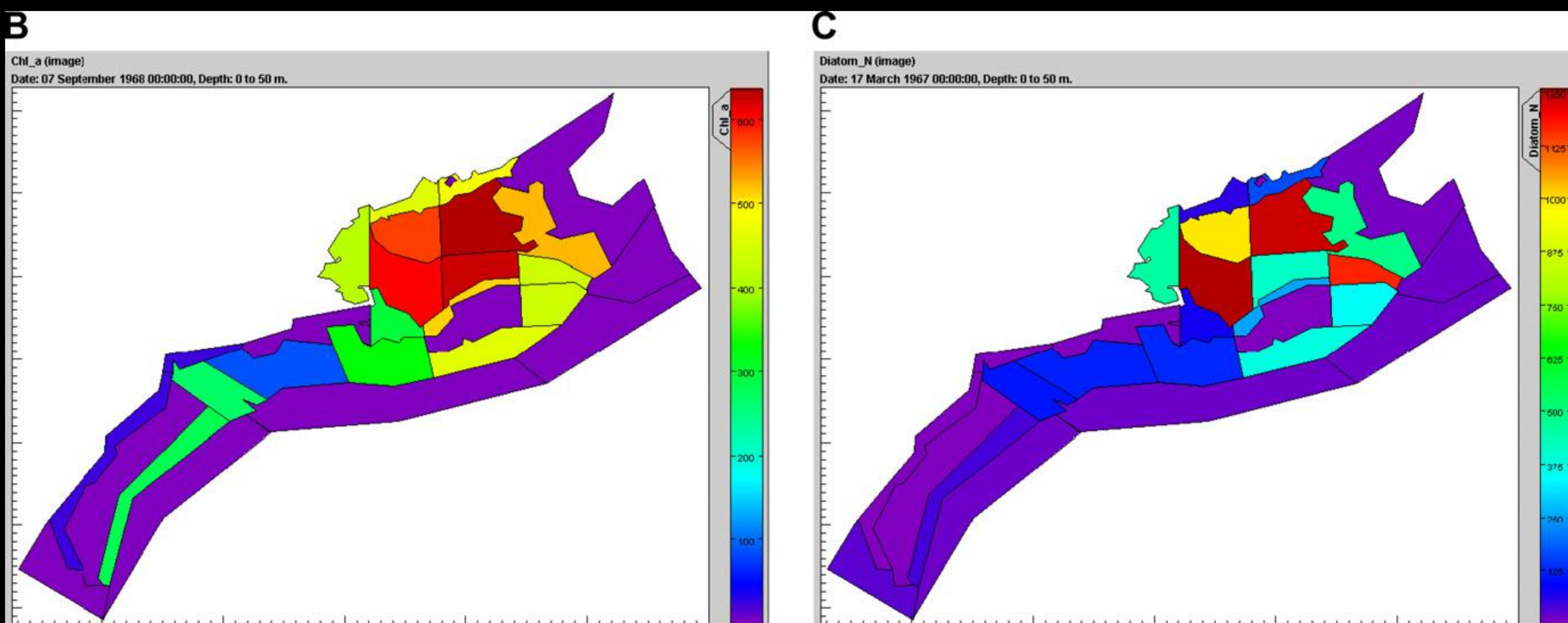
Questions

- How has your modeling group tested model behavior or skill for primary producer
  - Spatial distribution
  - Seasonality
  - Time series trends



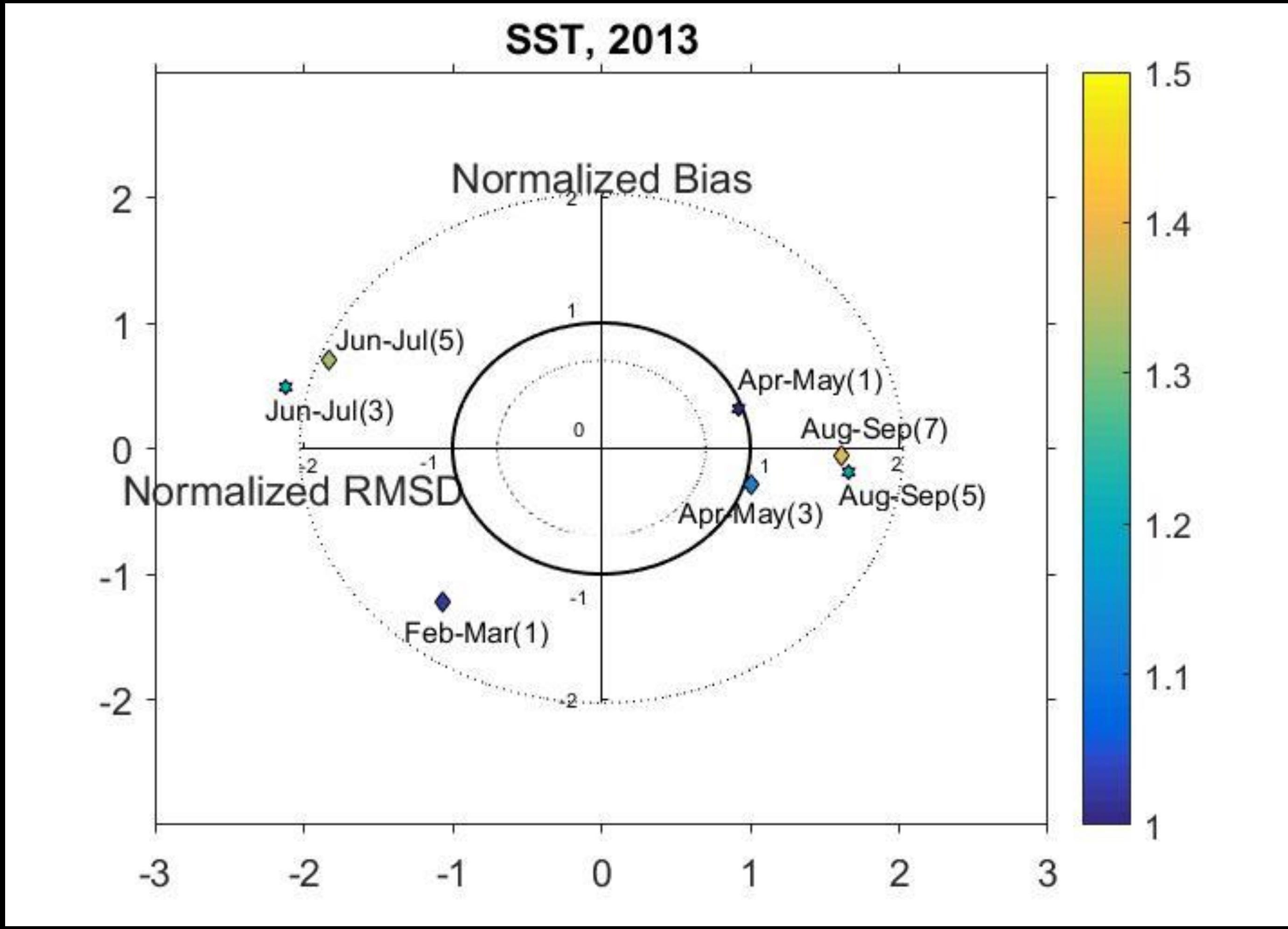
Checking spatial distribution of Chl a

Link et al. 2010 Progress in Oceanography

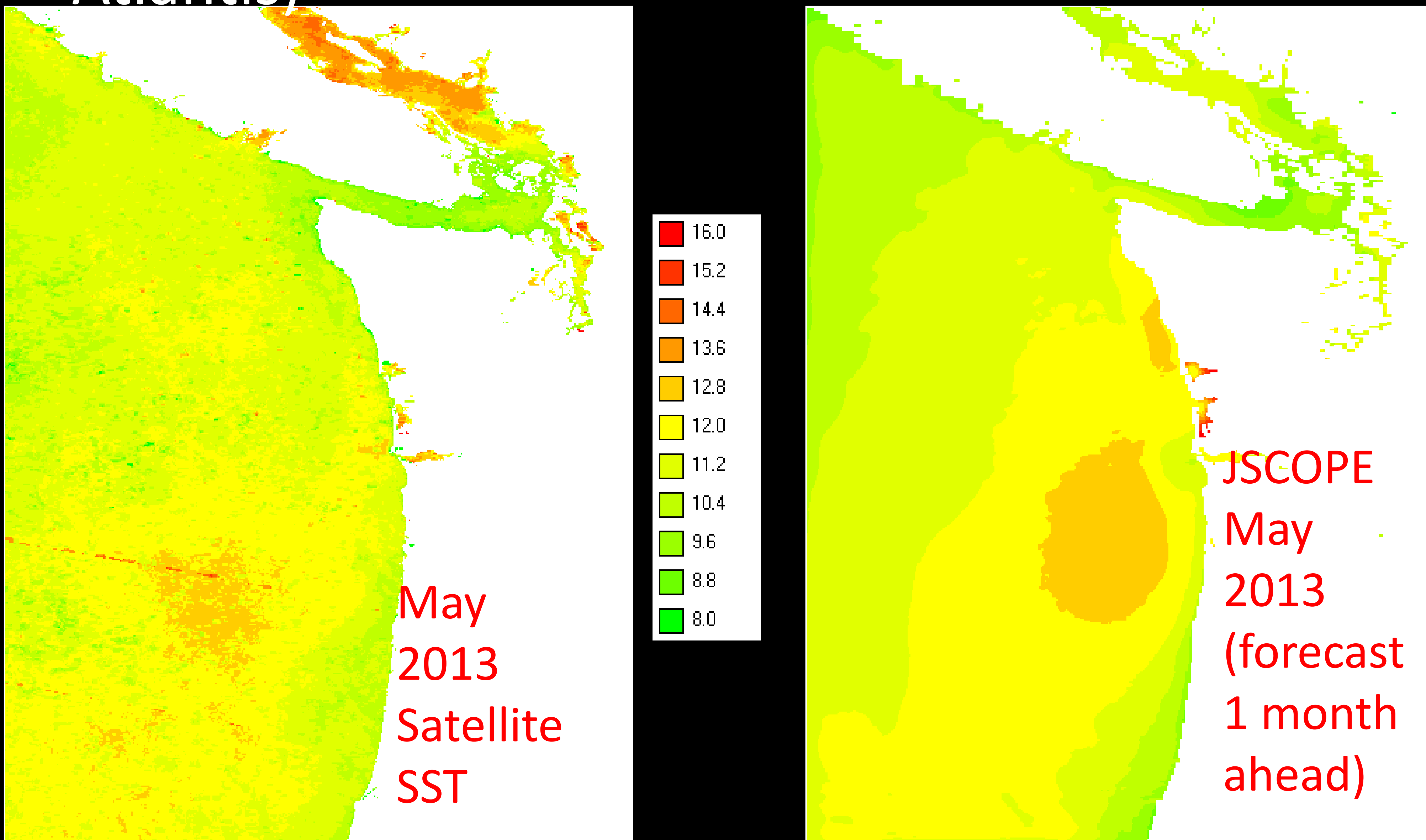


One method for spatial comparison–

Taylor/Target diagram (not from Atlantis)



One method for spatial comparison (not from Atlantis)–



Fuzzy kappa statistic =0.953, after 1.97 C bias correction.
See Map Comparison Kit. http://mck.riks.nl/

Physics & Hydrodynamics

Biogeochemistry

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Questions

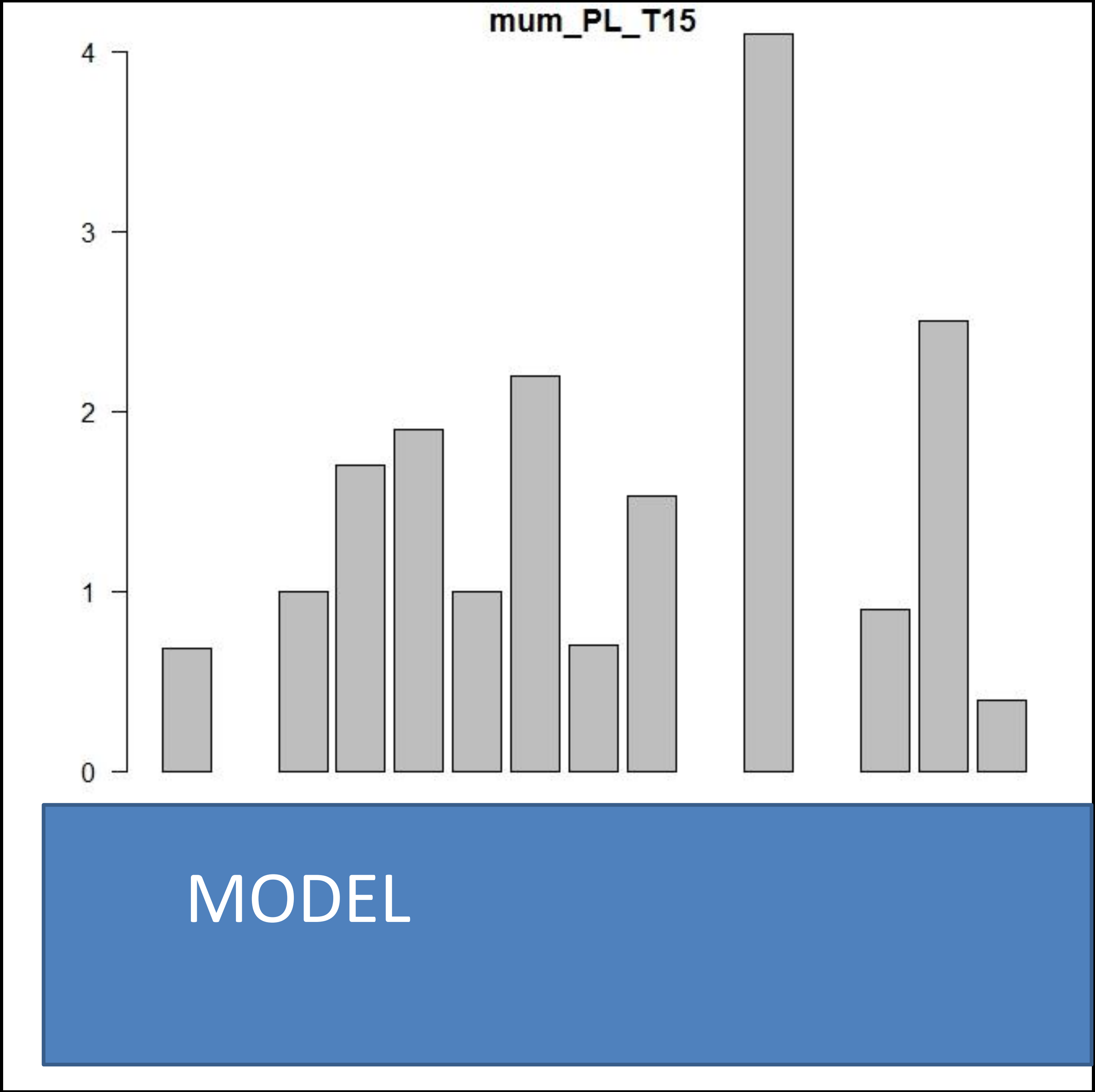
- How can we use distributions of model inputs (growth rates, biomasses) for
  - Construction of new models
  - Model calibration
  - Input error checking
  - Other uses?

15 Brave volunteers

Just searching for standard group codes (therefore some groups omitted in some models, for now)

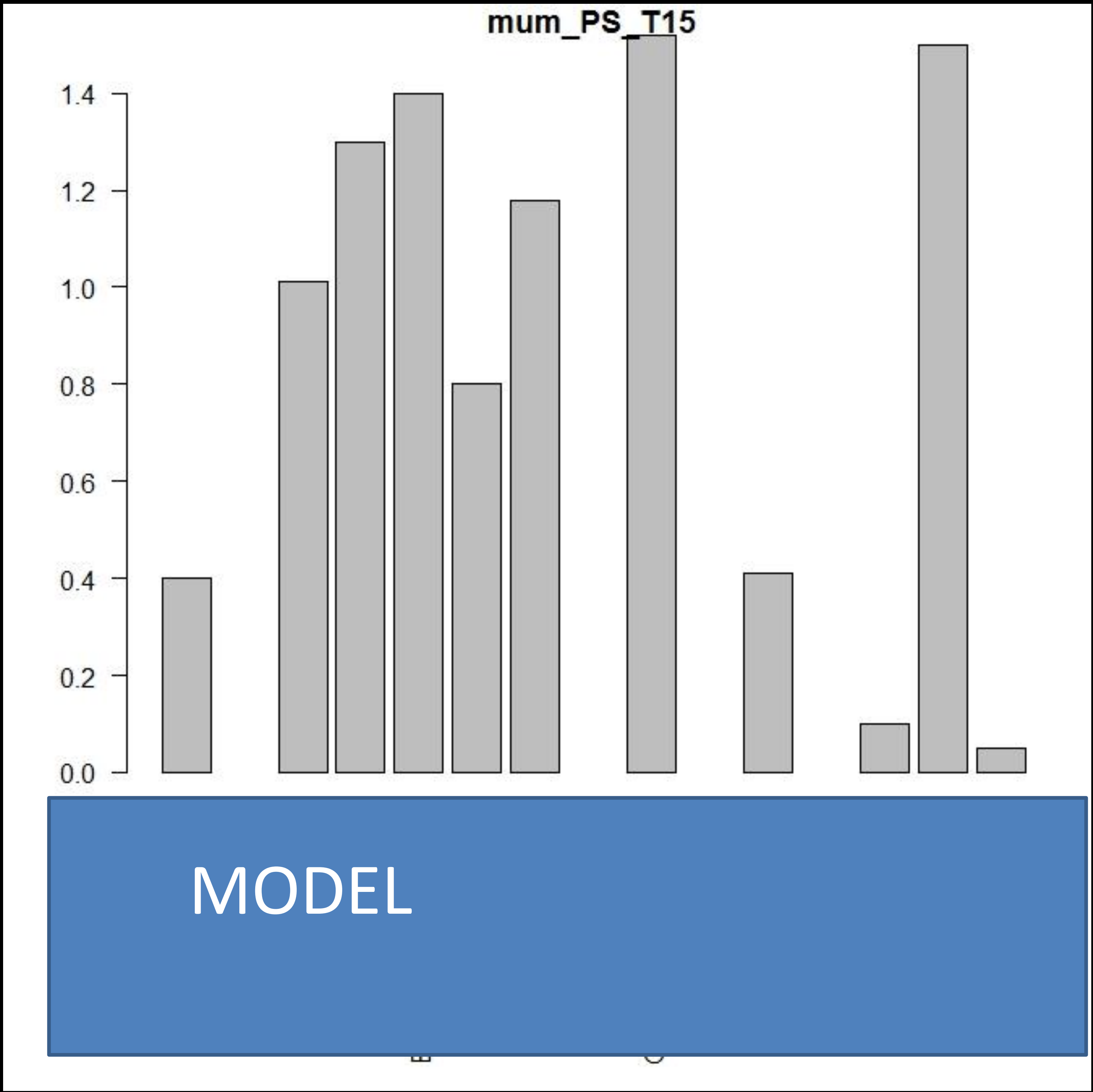
Large Phytoplankton (PL) growth rates,

mg N/m3/day



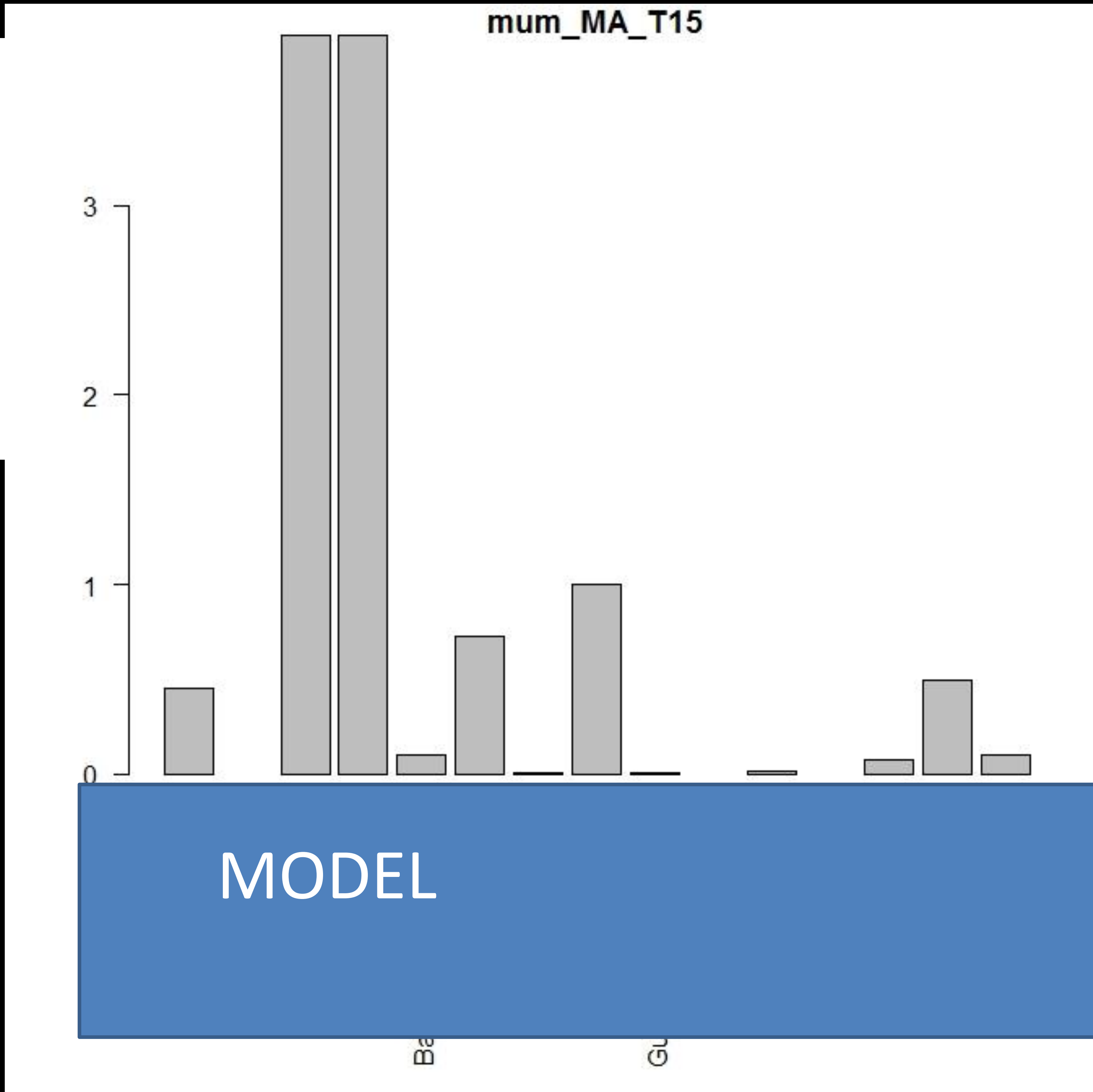
Small Phytoplankton (PS) growth rates,

mg N/m3/day



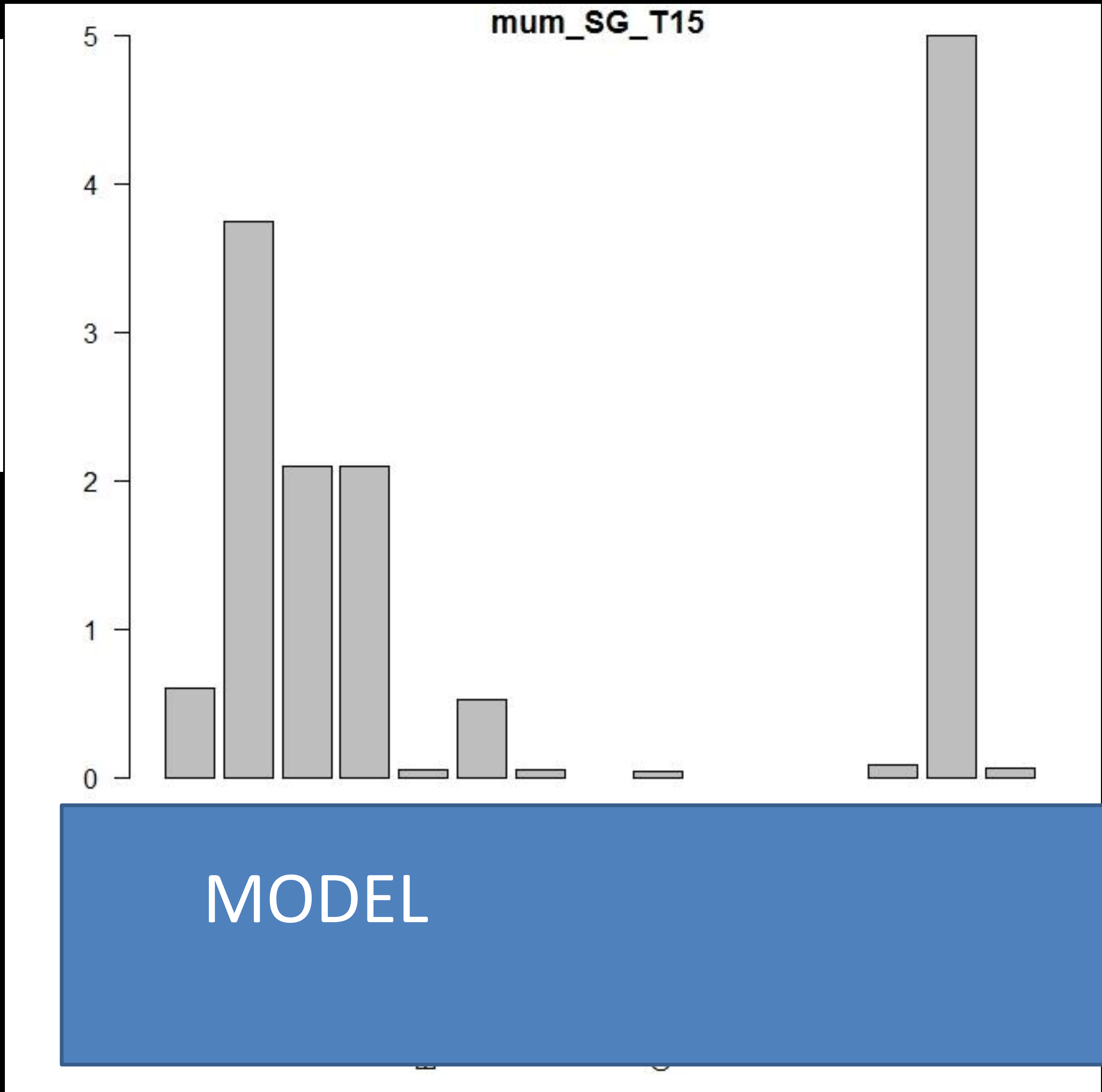
Macroalgae (MA) growth rates,

mg N/m3/day



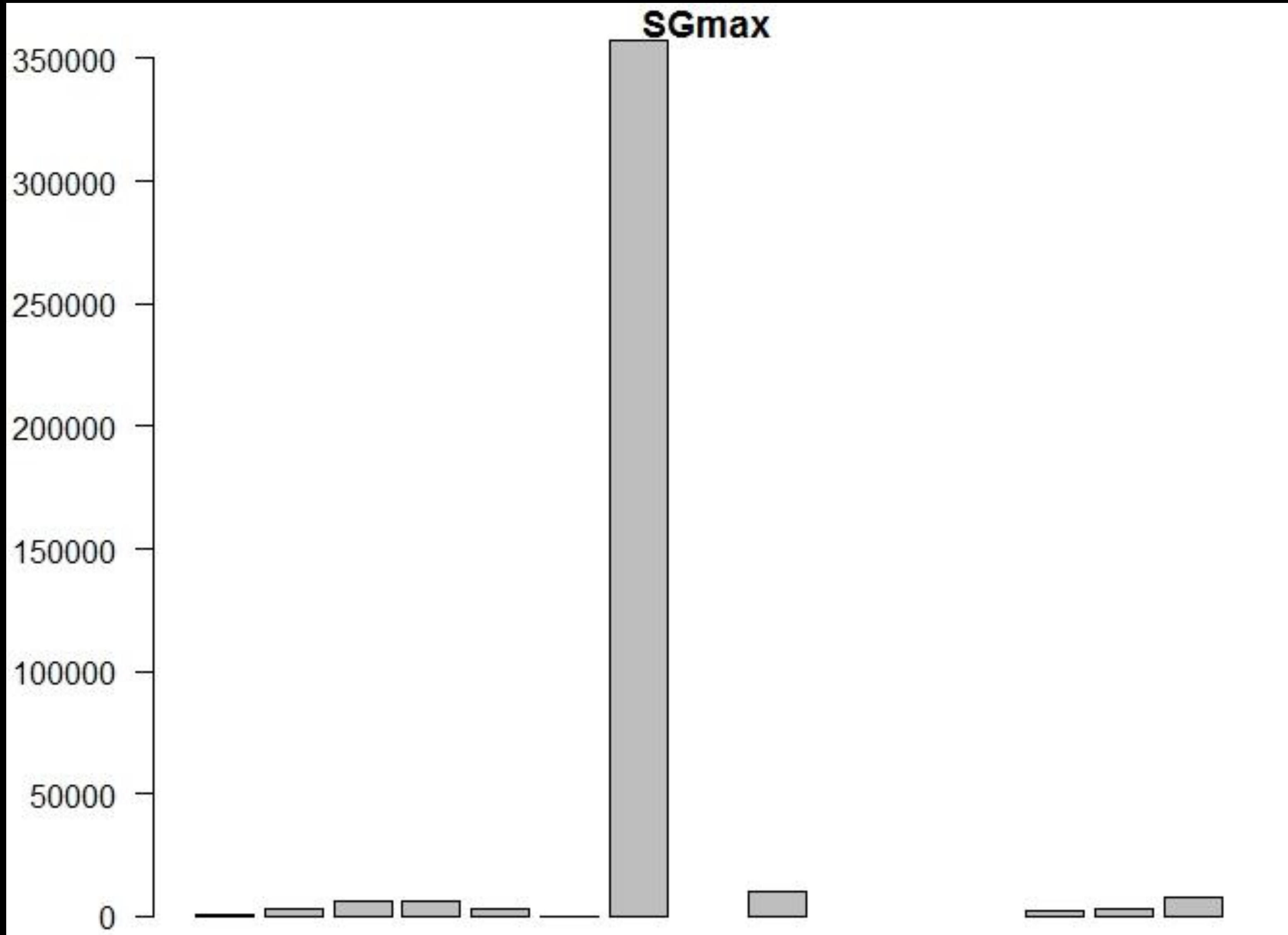
Seagrass (SG) growth rates,

mg N/m3/day



Seagrass (SG)max densities,

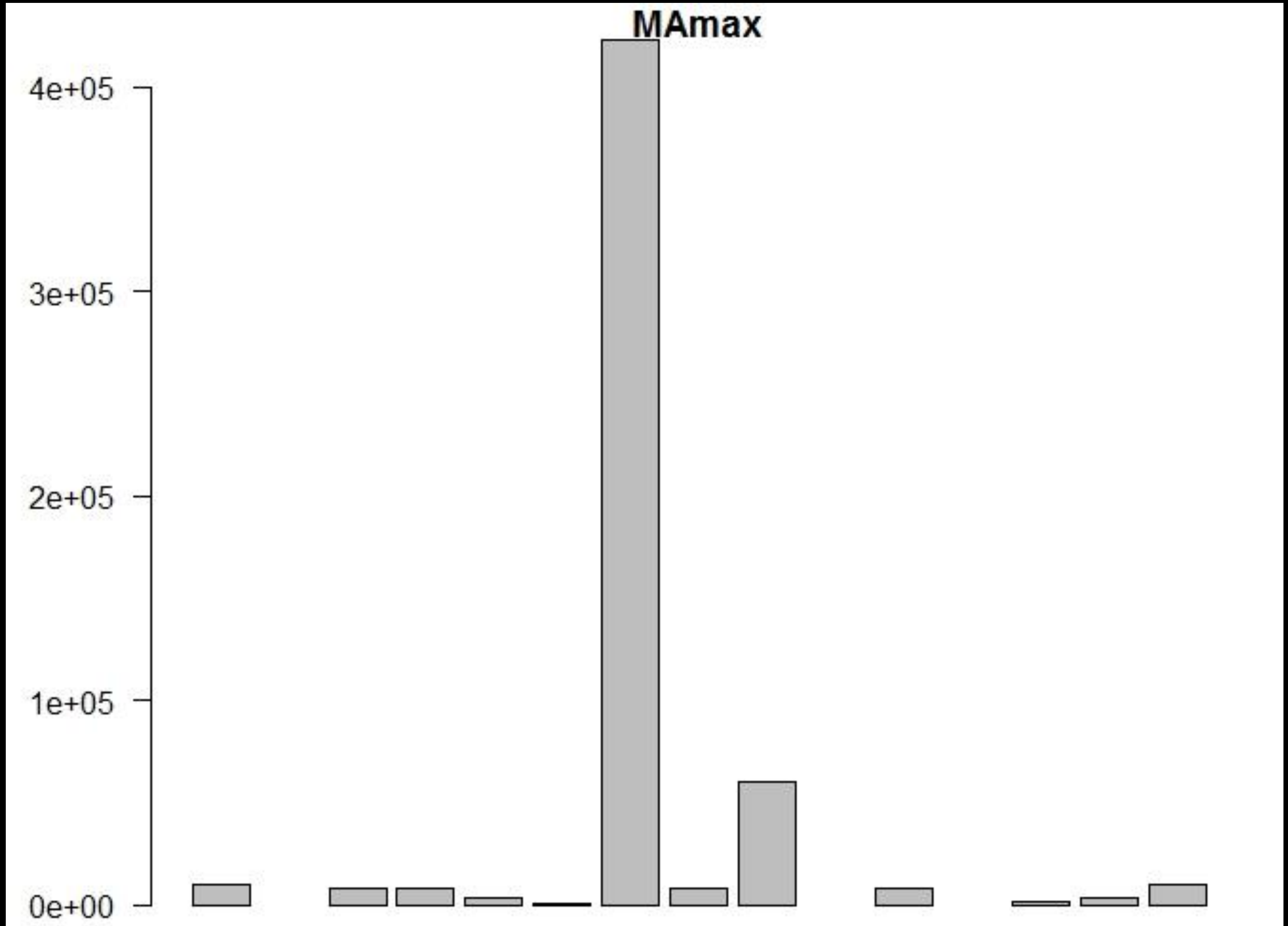
mg N/m2



MODEL

Macroalgae (MA)max densities,

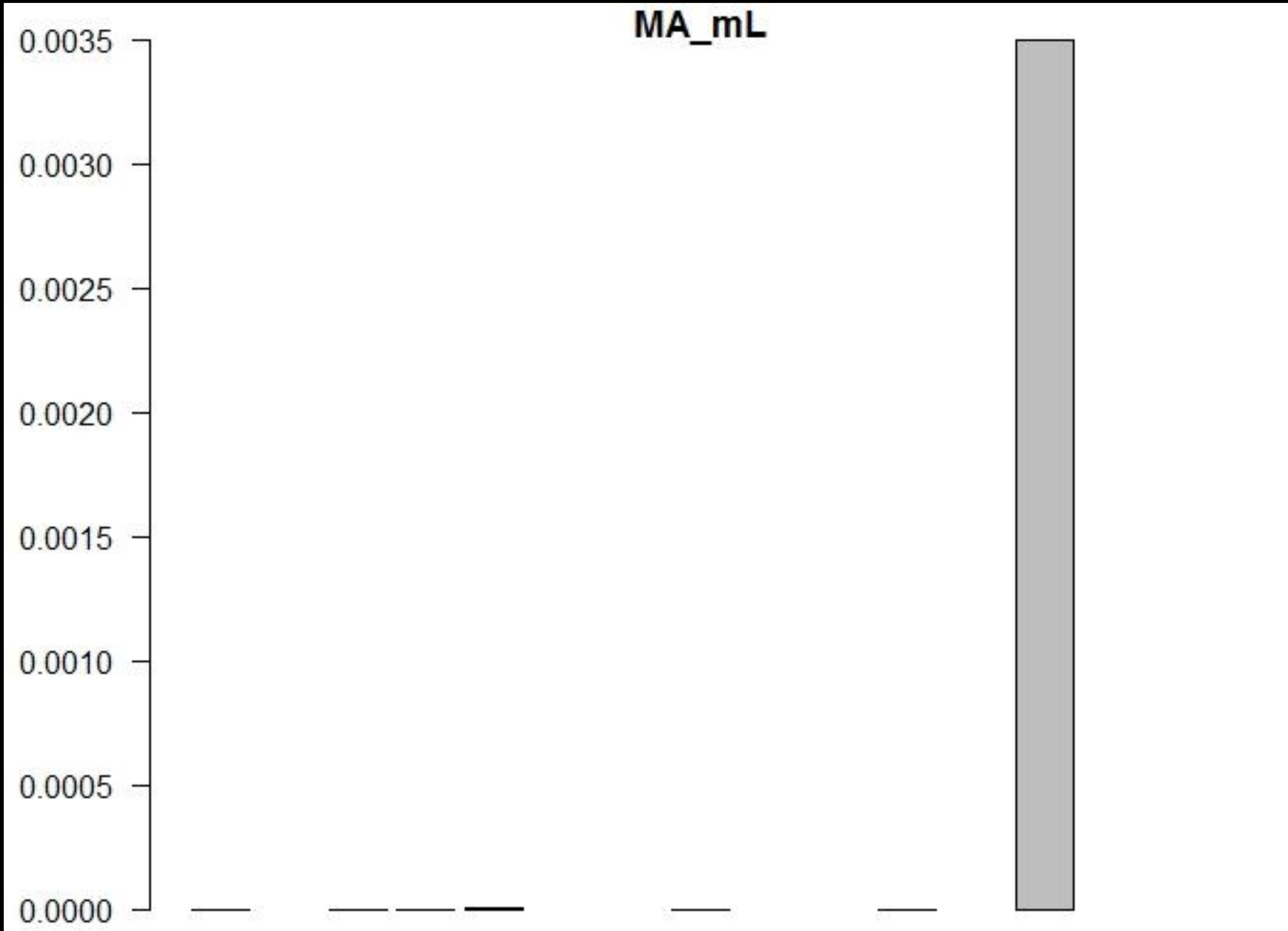
mg N/m2



MODEL

Macroalgae (MA) linear mortality

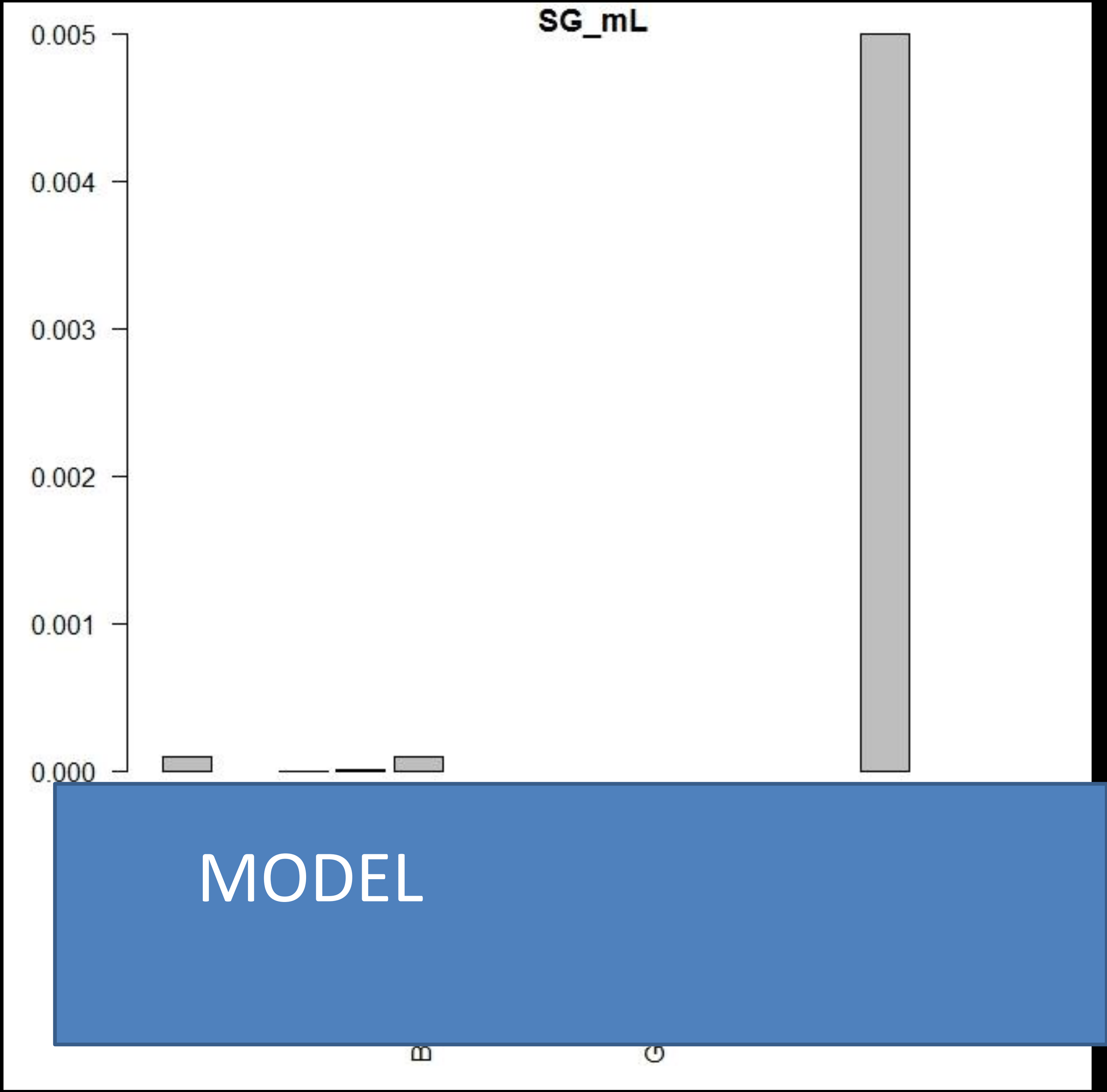
Per day



MODEL

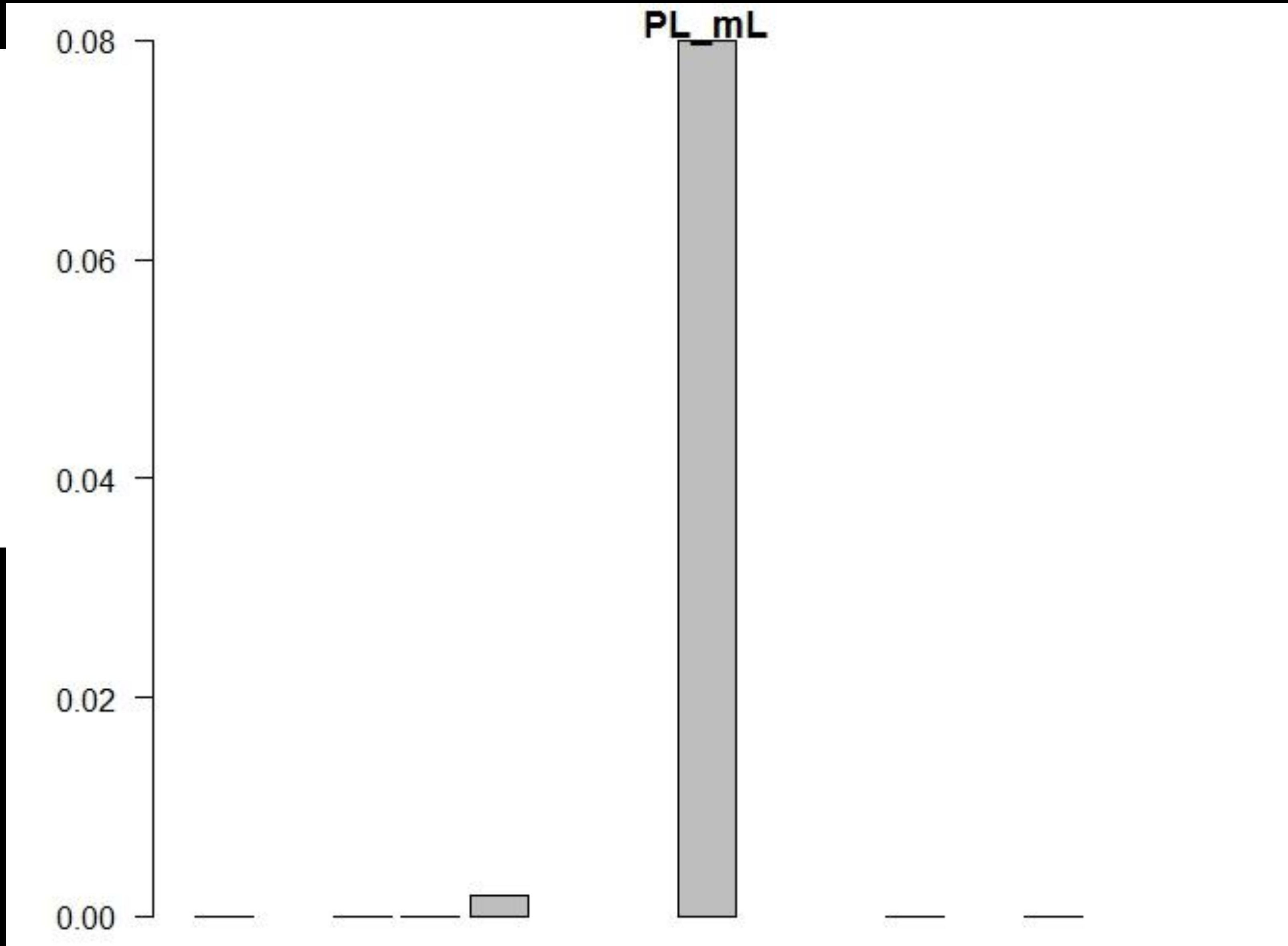
Seagrass (SG) linear mortality

Per day



Lg
Phytoplankton
(PL) linear
mortality

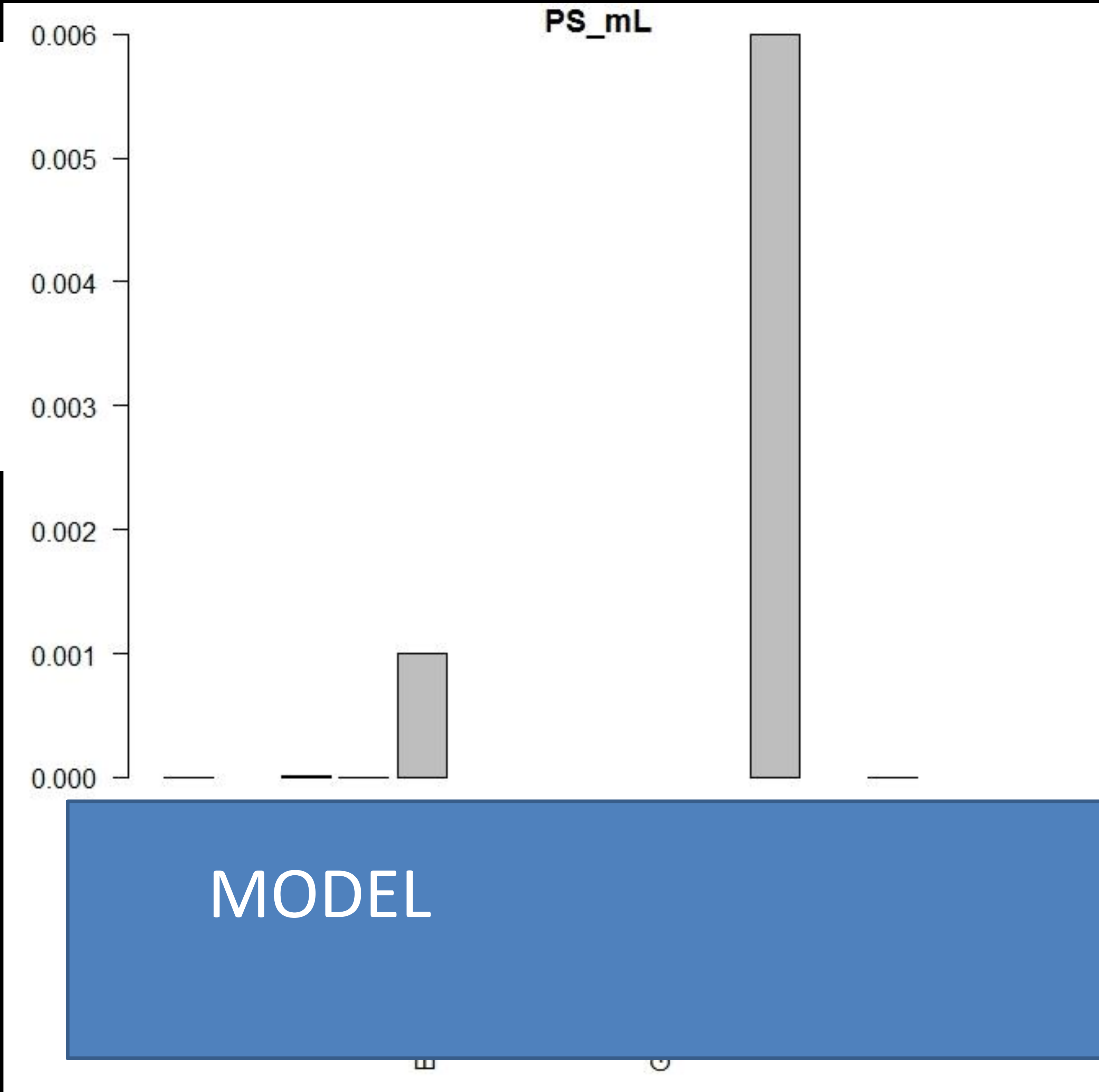
Per day



MODEL

Small Phytoplankton (PS) linear mortality

Per day



Tuesday 1pm-4pm

Parameters, data, and comparison:

Lower trophic levels
Inverts
Verts

Isaac Kaplan, isaac.kaplan@noaa.gov.

Atlantis Summit, Tuesday 1300

Parameters, Data and Comparison

- Lower trophic levels
- Inverts
- Verts

Format for this session

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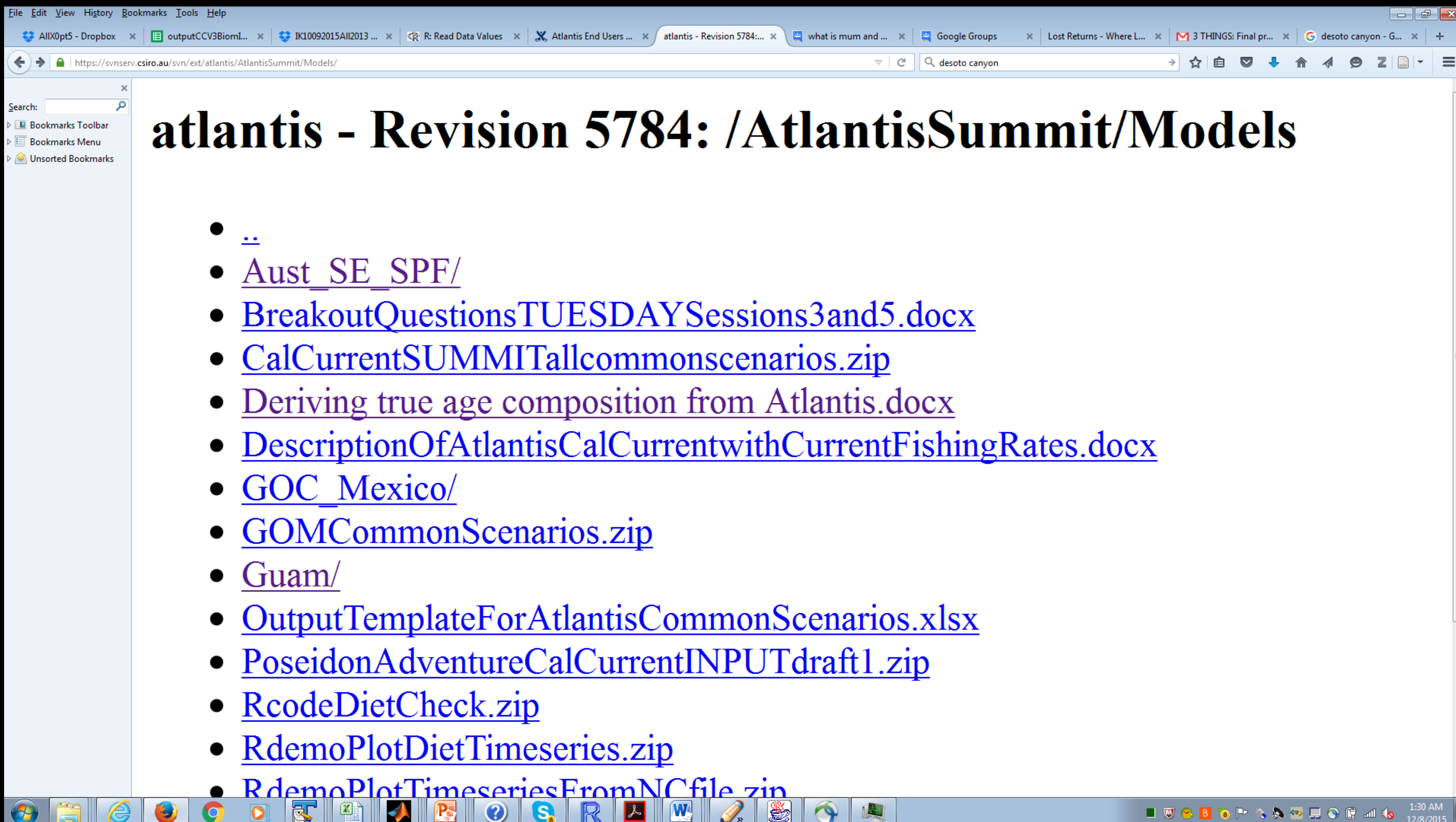
- Questions will be addressed in breakout groups
- Please keep discussion broad and focused on processes not parameter names.
- Report back after 45 minutes. Rapporteur notes to Sarah.
- Goal is Best Practices guidelines for parameterizing lower trophic levels, invertebrates, and vertebrates

BreakoutQuestionsTUESDAYSessions3and5.docx



Questions: Invertebrates

- How has your modeling group parameterized abundance and rate parameters for plankton and benthic invertebrates?

- Have you converted from C : N using Redfield ratio, or other means?

Inverts, California Current Example

- Maximum growth rate (“mum”)= Ecopath Productivity: Biomass ratio, converted to daily rate

- Clearance (“C_”)= Ecopath Consumption : Biomass ratio * 1.2, converted to daily rate

- Then heavily calibrated

Vertebrates

Vertebrates, key modeling decisions

- Including starvation
- Linear and quadratic mortality rates (mL, mQ)
- Consumption and growth rates (MUM, C_)
- Diets
- Movement
- Recruitment

Vertebrates, key modeling decisions

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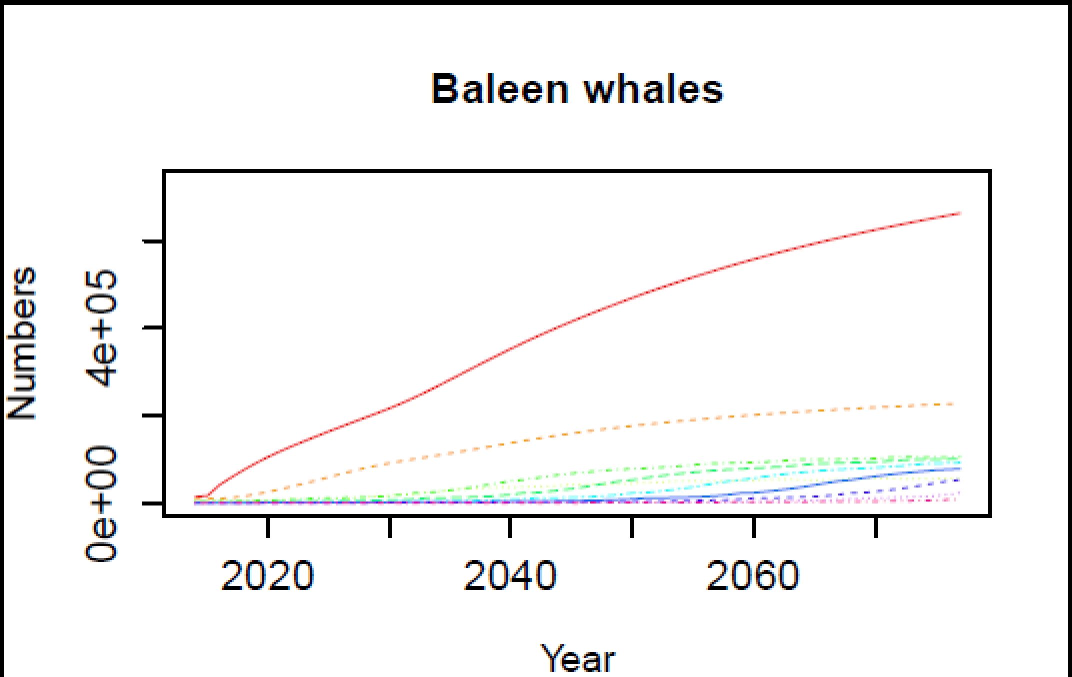
Vertebrates, key modeling decisions

- Including starvation (*mstarve* in Biol.prm)

  California current example is *mstarve* = 0.001 day/day, if weight-at-age falls below 50%.

- Linear and quadratic mortality rates (mL, mQ)

California Current example: set to 0, then titrated in (usually for apex predators) to get more realistic age structures.



Vertebrates, key modeling decisions

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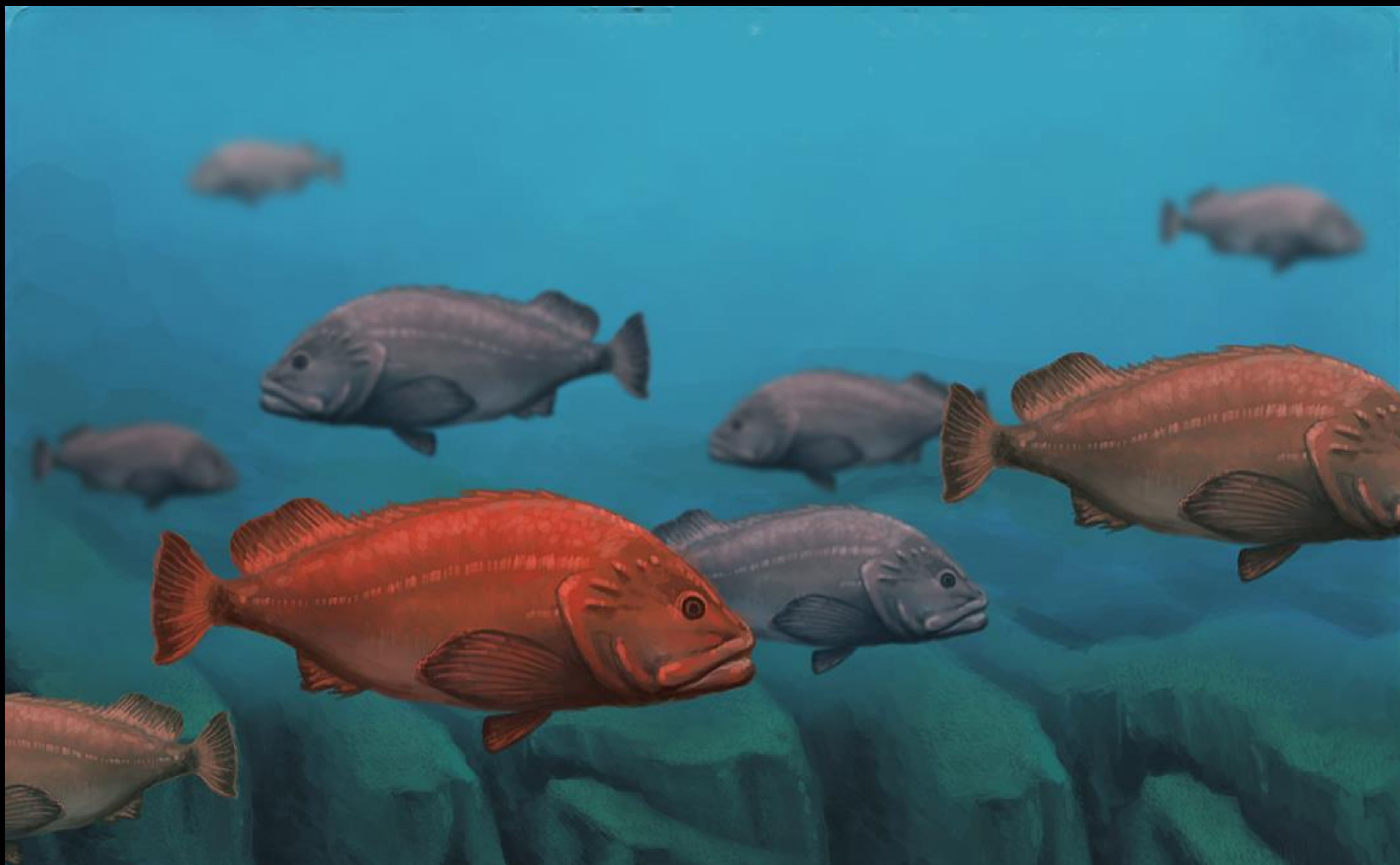
Fish consumption and growth rates, California Current example



Fish consumption and growth rates, California Current example

Wisconsin bioenergetics approach has
*Realized Consumption = 0.3 *(W)^0.7*

For Atlantis we use:

*Realized consumption = 0.3 * (rN + sN)^0.7*
*Max consumption = 3.3 * Realized consumption*

*Max growth = Assim efficiency of 0.8 * Max consumption*

Fish consumption and growth rates, California Current example

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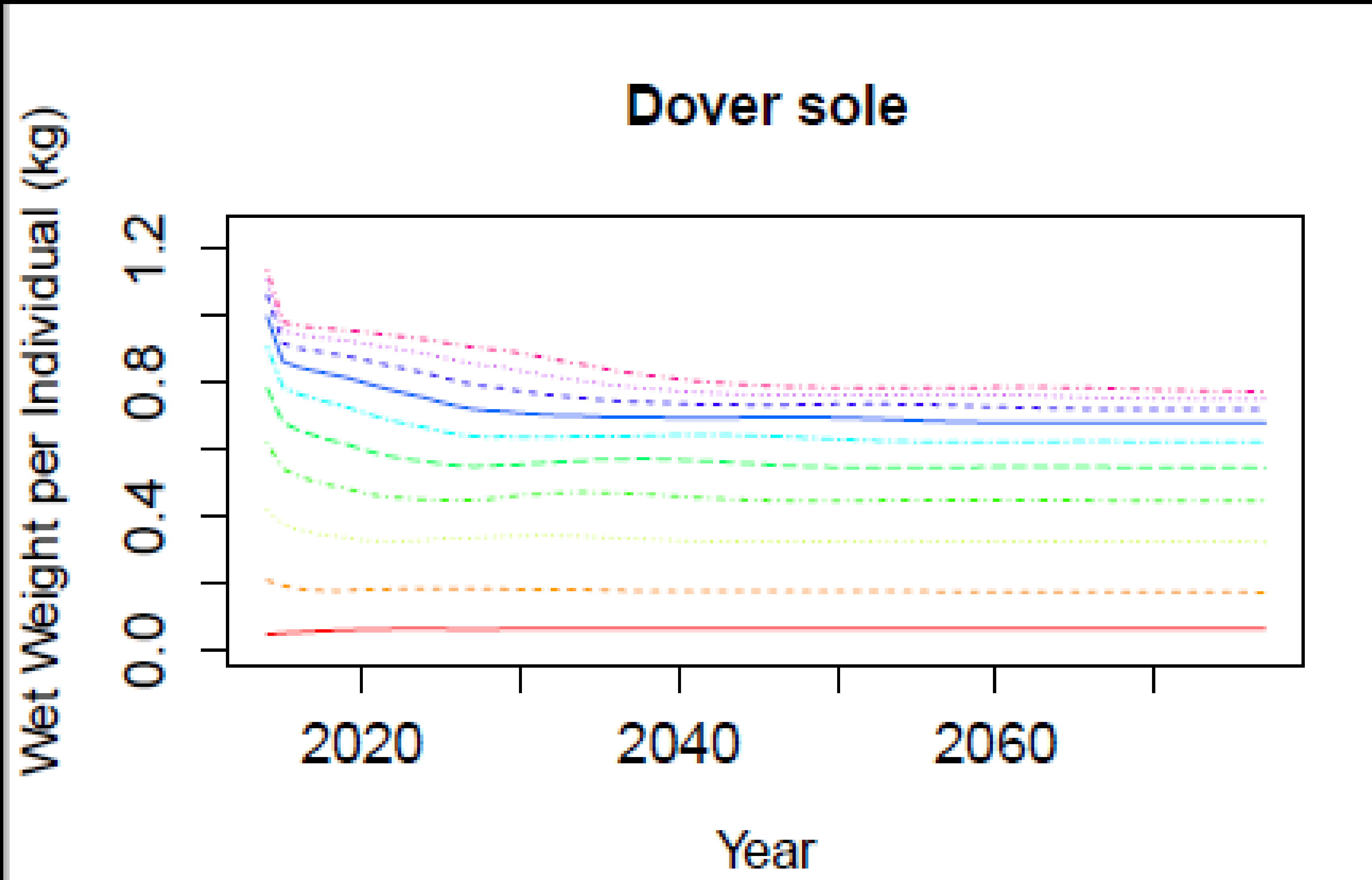
*Realized consumption = 0.3 * (rN + sN)^0.7*
*Max consumption = 3.3 * Realized consumption*

*Max growth = Assim efficiency of 0.8 * Max consumption*

MUM = Max growth
*C_ = 0.1 * MUM*

Checking growth resulting from consumption

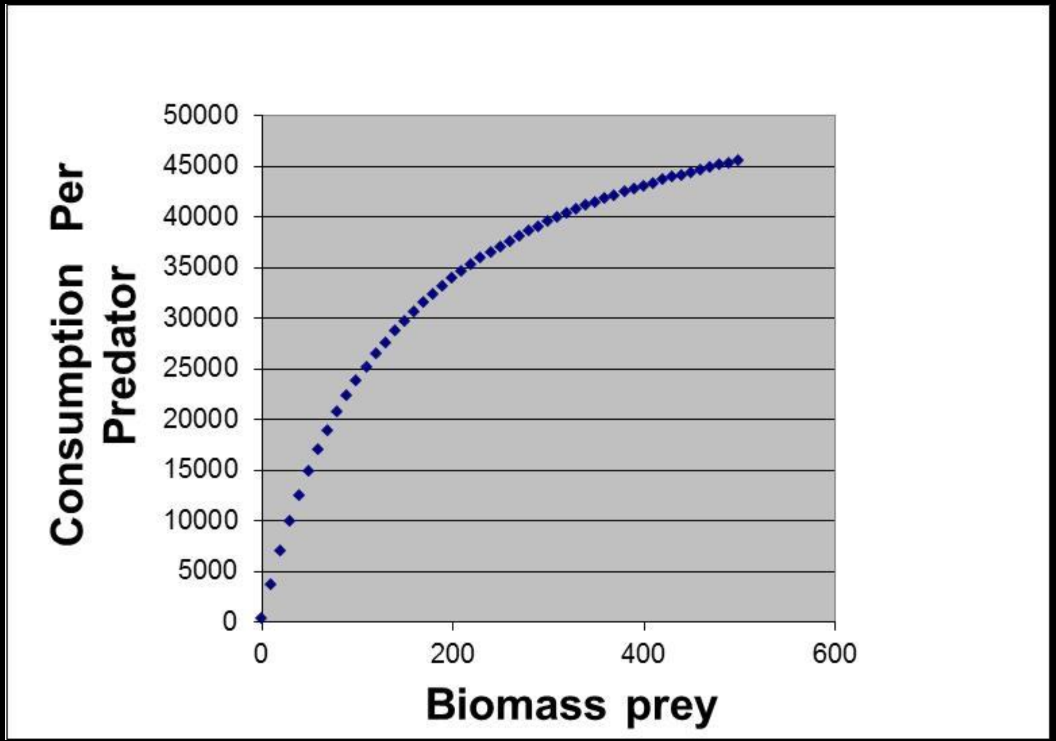


Vertebrates, key modeling decisions

- Including starvation
- Linear and quadratic mortality rates (mL, mQ)
- Consumption and growth rates (MUM, C_)
- Diets
- Movement
- Recruitment

Vertebrates, key modeling decisions

- Diets: a key challenge is that we observe diet compositions in the field, but we parameterize "*a*" interaction parameters in functional response.



Vertebrates, key modeling decisions

- Diets: California Current example

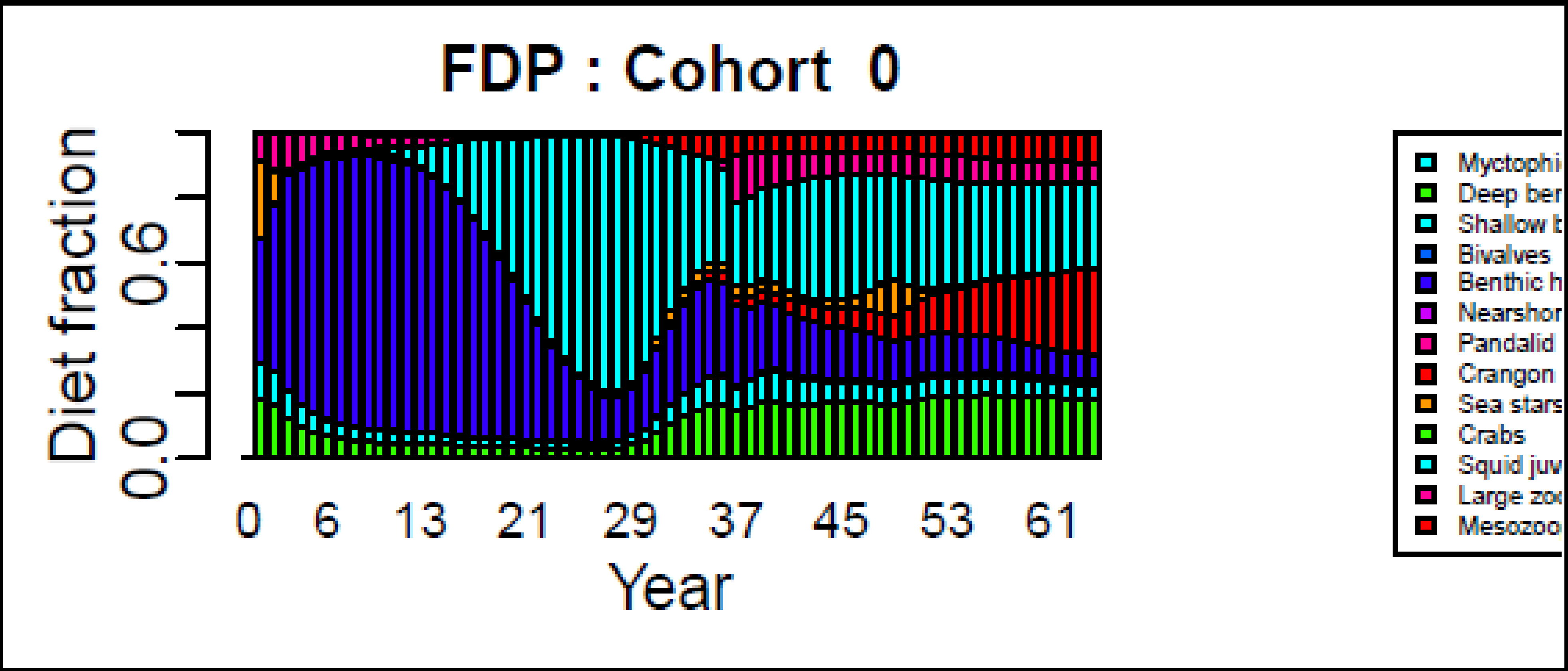
Chose Holling type II functional response

Looked at distribution of interaction parameters (*a*) in an old calibrated model

Rule of thumb was diet fraction x 0.1 = interaction parameter (a, or *pPREY* in Biol.prm)

Vertebrates, key modeling decisions

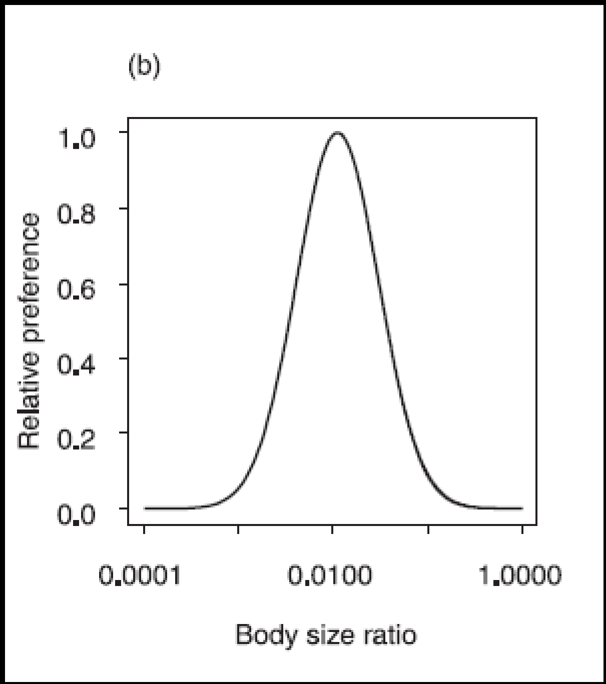
- Diets: Realized diet outputs



Vertebrates, key modeling decisions

- Diets: LeMANS style length-based diets

Preference



Ratio of prey to predator body weight, for that age class

Hall et al. (2006) CJFAS

Vertebrates, key modeling decisions

- Including starvation
- Linear and quadratic mortality rates (mL, mQ)
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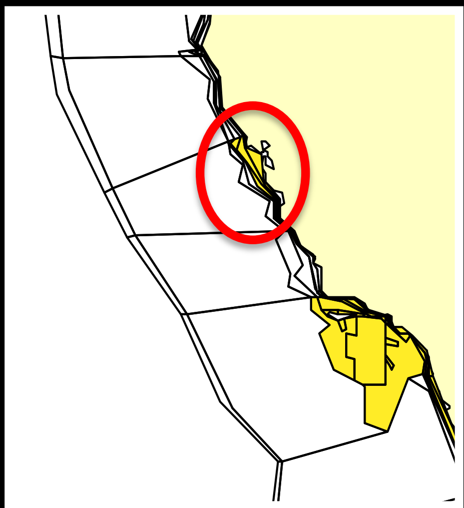
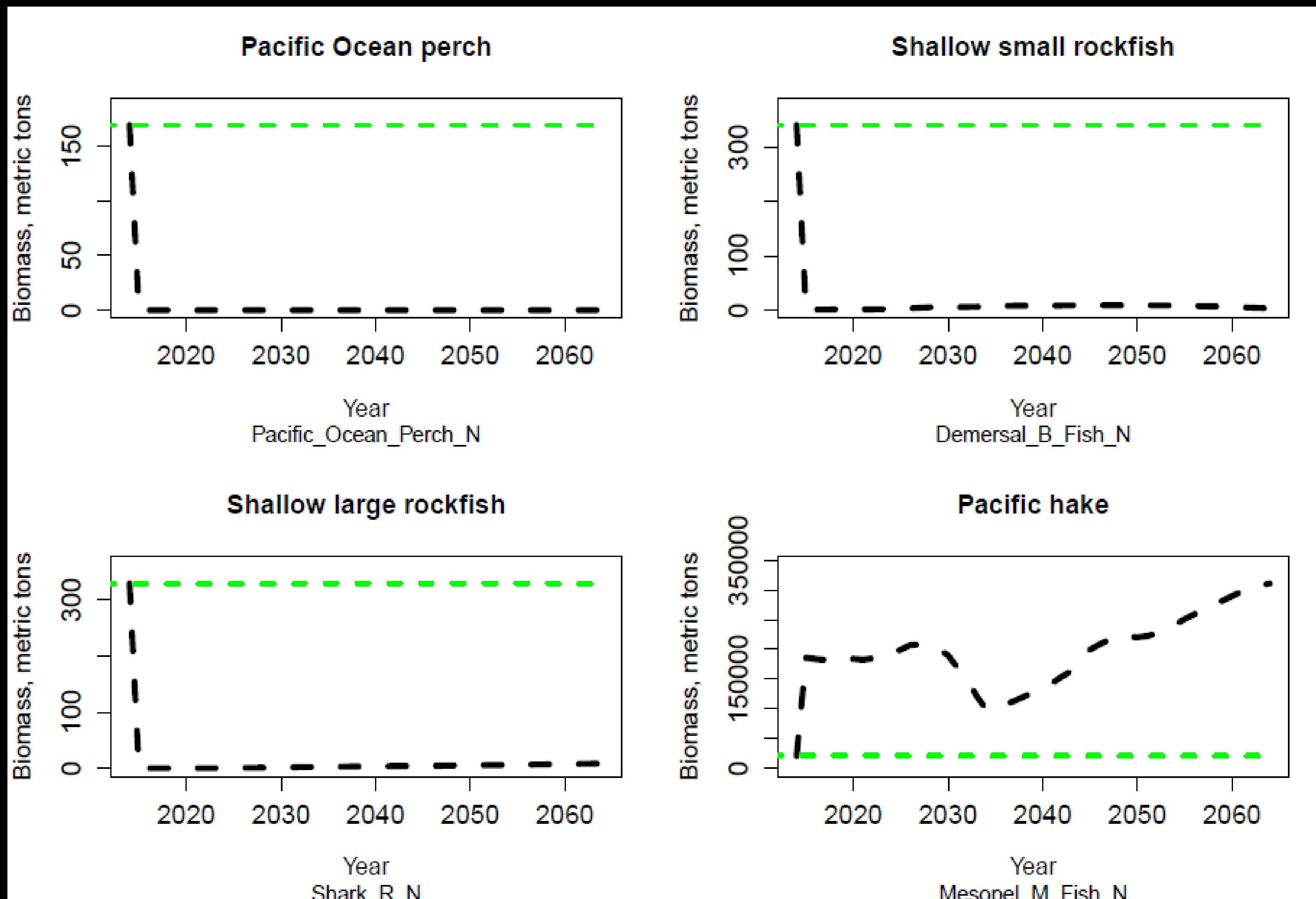
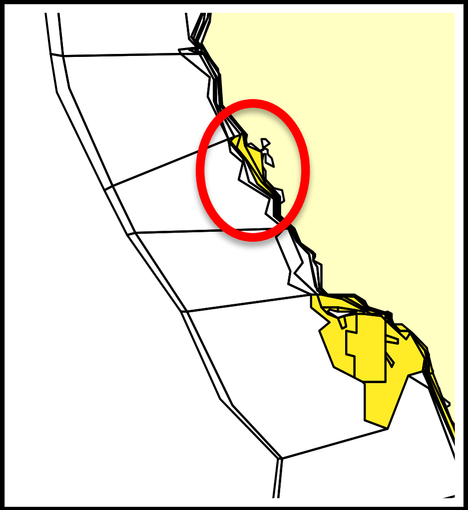
A run with mobile groundfish– which leave to go chase euphausiids.
ddepend_move = 2



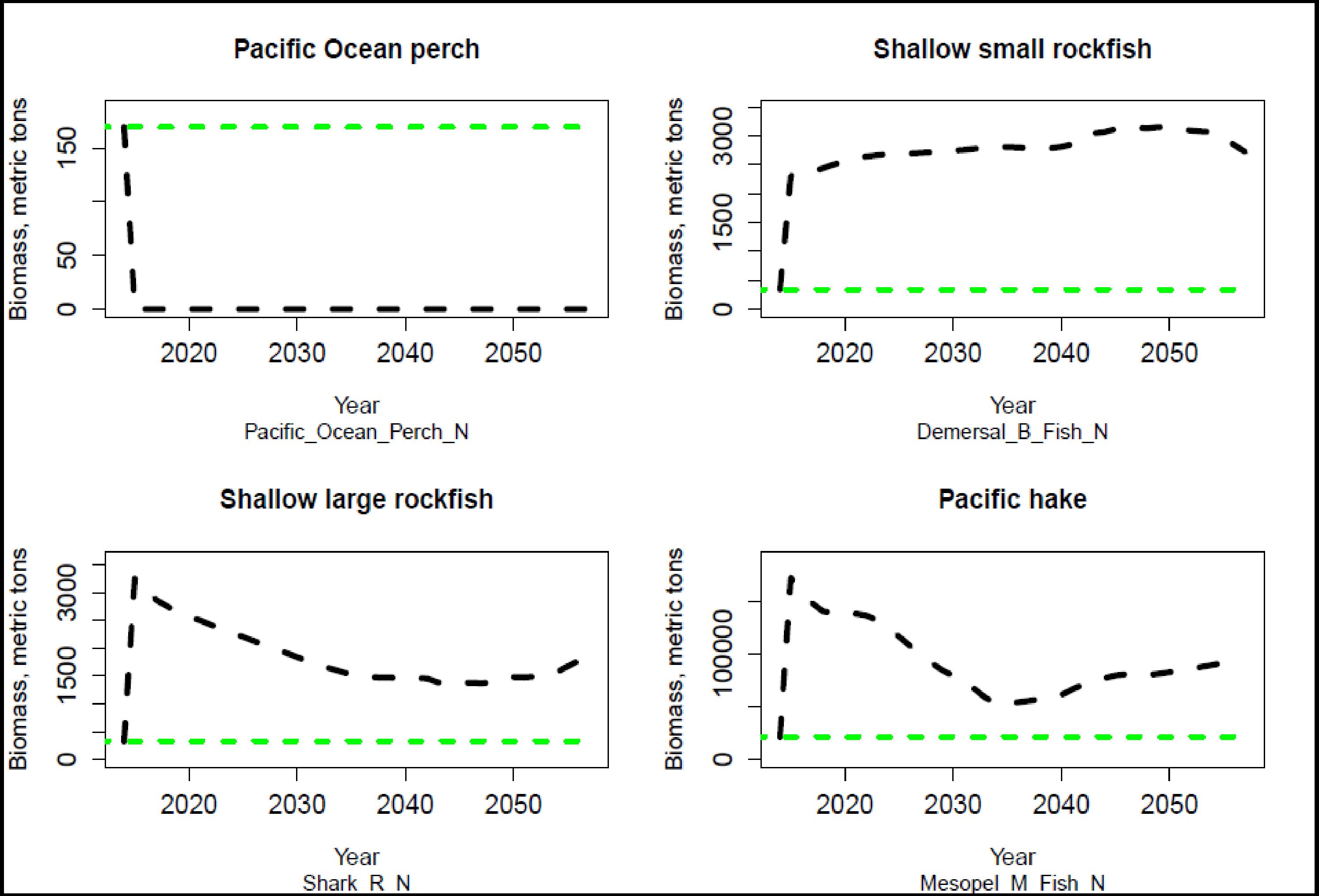
Central California Shelf



Scenario with sedentary groundfish, can not leave (but still linked via recruitment). *ddepend_move* = 1



Central California Shelf



Movement really matters, and drives the consumption rates and subsequent size-at-age of predators!

Vertebrates, key modeling decisions

- Including starvation
- Linear and quadratic mortality rates (mL, mQ)
- Consumption and growth rates (MUM, C_)
- Diets
- Movement
- Recruitment

Recruitment options

- Fixed offspring per adult (mammals, birds, sharks)
- Beverton Holt
- Ricker
- Lot of other options!

Recruitment options, California Current examples

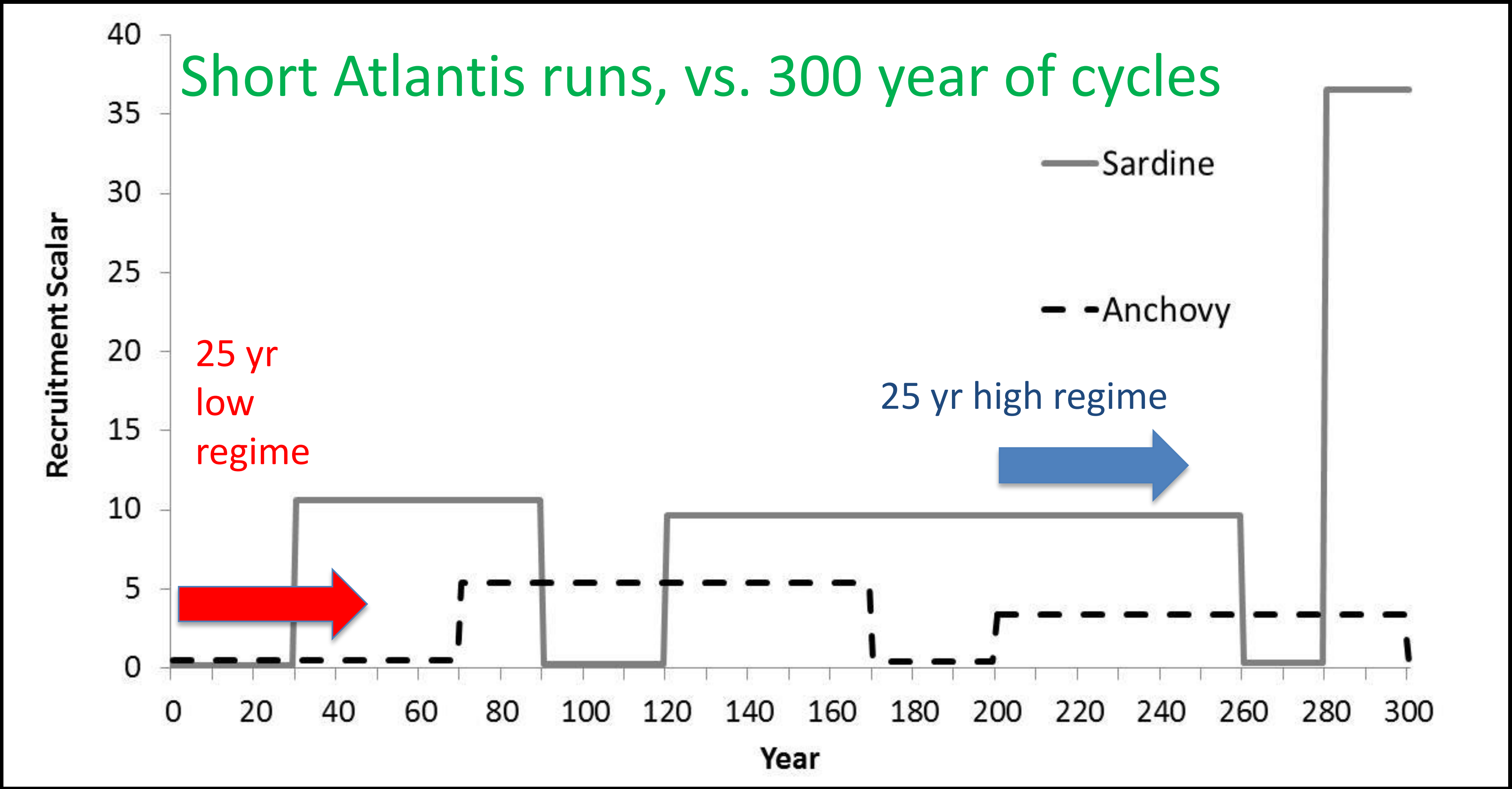
- Fixed offspring per adult (mammals, birds, sharks), *flagrecruit* =12

- Beverton Holt, *flagrecruit* =3 ; Params calculated from Unfished adult biomass, unfished # recruits, Steepness

Chesapeake name	Code	*So, metric tons wet weight (max unfished adult stock biomass, both sexes, wet weight, in metric tons)*	*So,mg WW (max unfished adult stock biomass, both sexes, wet weight, in milligrams)*	*Ro (max # of ecological recruits for whole area)*	*Steep ness*	*Proportion of Smax at which recruitment is .5*max recruitment*	alpha	beta
Tom's favorite fish	FPS	10000	1E+13	2.26E+11	0.99	**0.002518892**	2.26E+11	2.21E+08
Mejs's favorite fish	FPL	10000	1E+13	9.78E+09	0.80	**0.058823529**	9.78E+09	5.16E+09
howard's favorite fish	FVT	10000	1E+13	4.61E+04	0.20	**0.5**	4.61E+04	4.39E+10
Don't use this for non-fish	FVB	10000	1E+13	3.63E+06	0.50	**0.2**	3.63E+06	1.75E+10
	FBP	10000	1E+13	1.89E+10	0.50	**0.2**	1.89E+10	1.75E+10
	FDD	10000	1E+13	8.87E+06	0.50	**0.2**	8.87E+06	1.75E+10

- Not surprisingly, model is really sensitive to recruitment (one of the first things tuned here); also Atlantis recruits are NOT equal to stock assessment recruits

Recruitment Regimes can also be included
(https://wiki.csiro.au/display/Atlantis/Recruitment+forcing)



Questions: Vertebrates

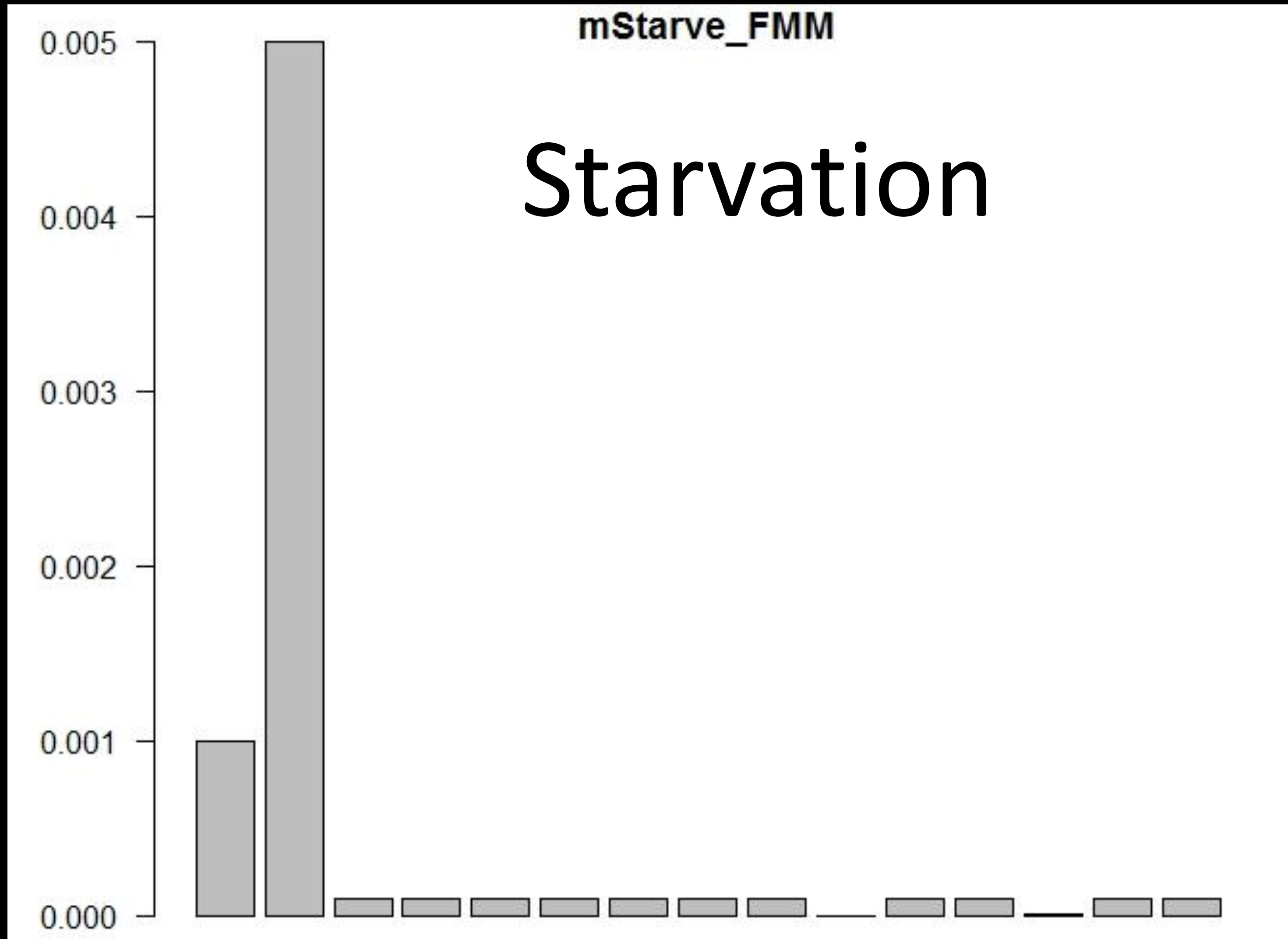
- What is your modeling group's approach to 1) <u>parameterizing</u>, then 2) <u>calibrating</u>
  - Linear and quadratic mortality rates
  - Consumption and growth rate parameters
  - Diets and functional response
  - Vertebrate movement
  - Stock recruitment
  - Including starvation

Modeling options: survey of models

Focus on one fish species from each model: Mesopelagic M Fish, COD, GAG grouper, ...

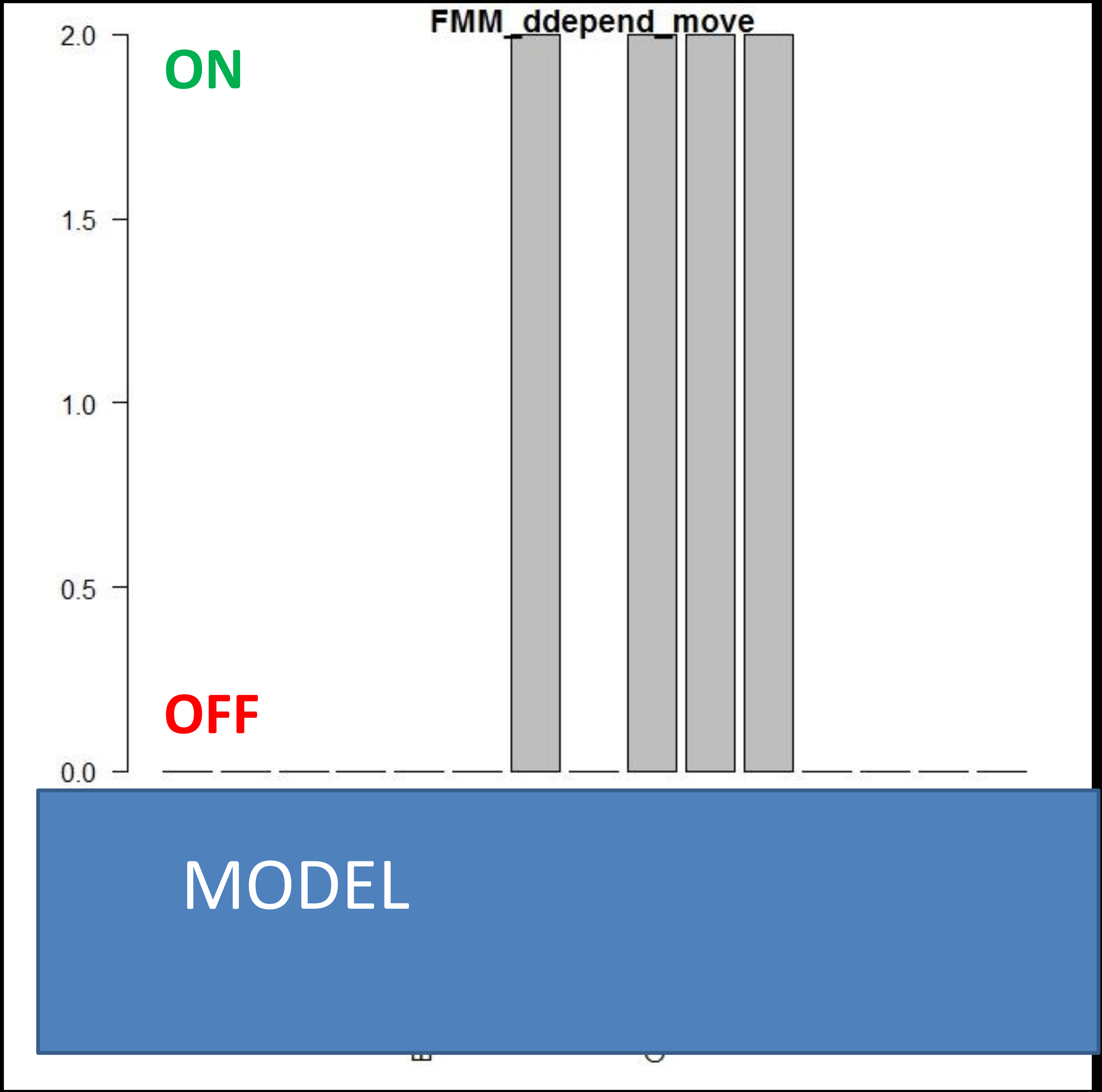
I am hoping these are representative of all fish

Daily mortality rate if below size threshold



MODEL

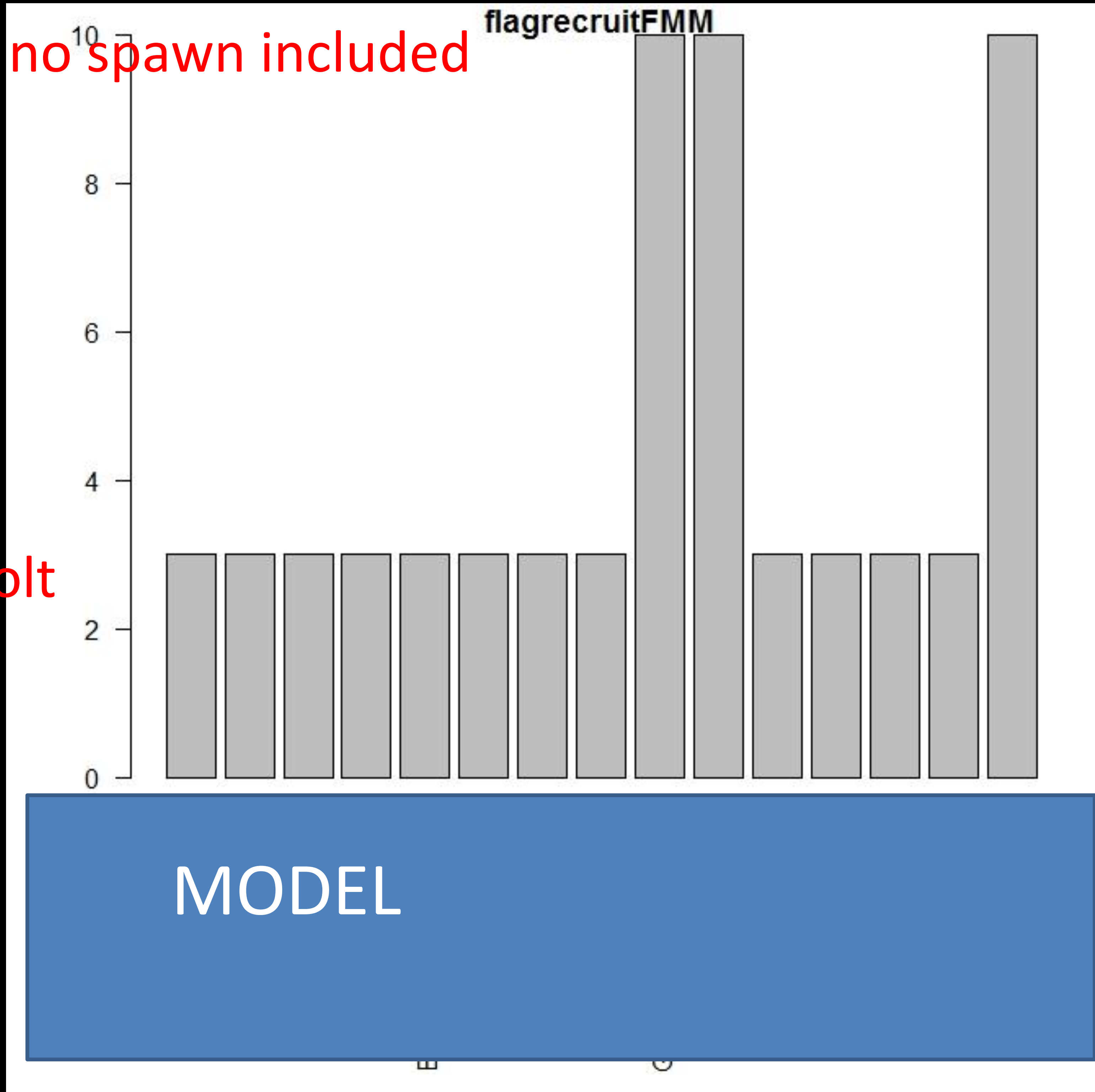
Density dependent movement off (0) or on (2)



Beverton Holt, no spawn included

Stock recruit options

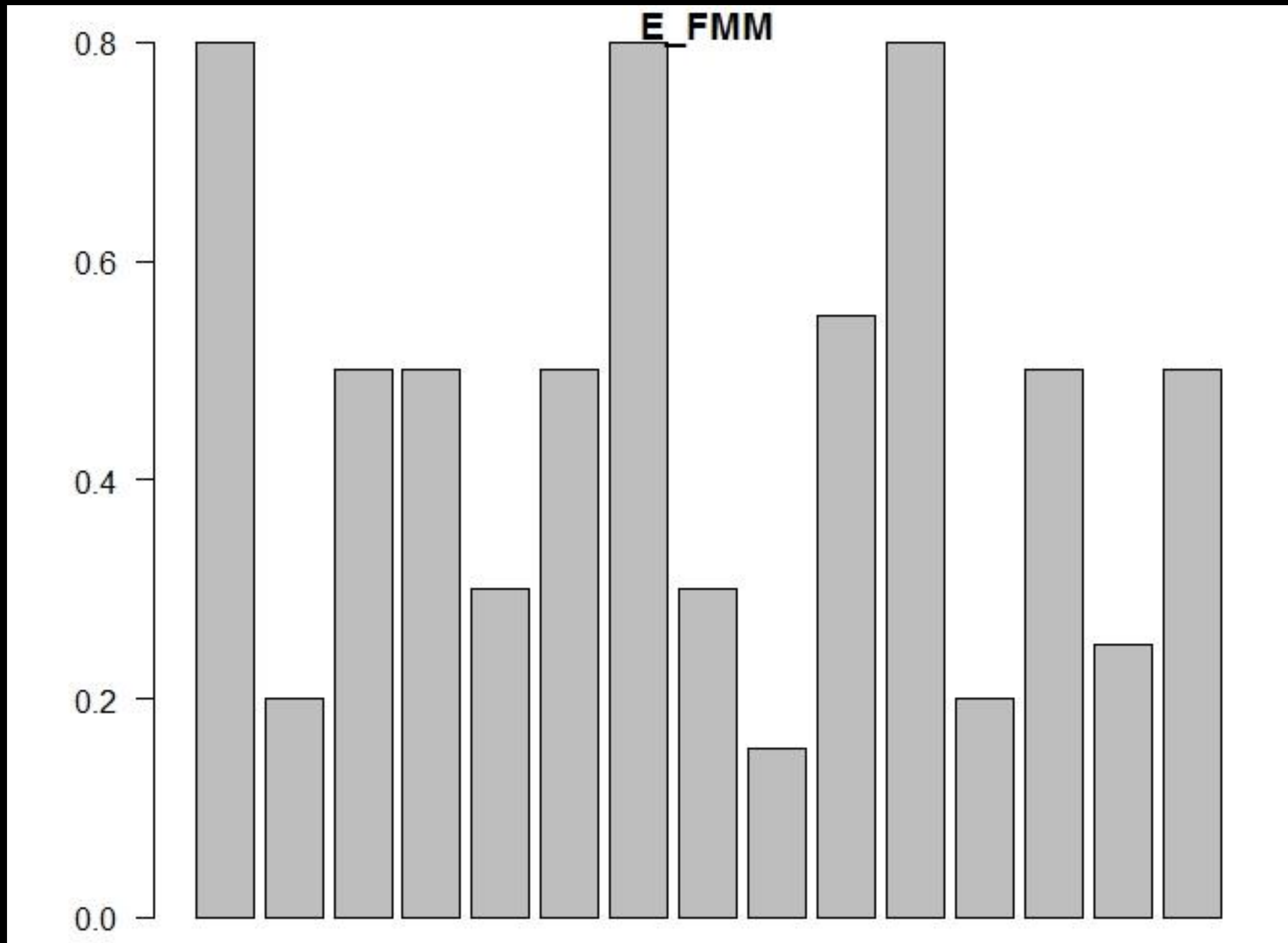
Beverton Holt



MODEL

Assimilation Efficiency

Assimilation efficiency, proportion



MODEL

All 15 models omit respiration

All 15 models use Holling type II functional response

Questions

- What is your modeling group's approach to 1) parameterizing, then 2) calibrating
  - Linear and quadratic mortality rates
  - Consumption and growth rate parameters
  - Diets and functional response
  - Vertebrate movement
  - Stock recruitment
  - Including starvation