Modeling habitat restoration using the Atlantis ecosystem model

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Florida Restore Act Centers of Excellence Program

FLRACEP Investment in Ecosystem science

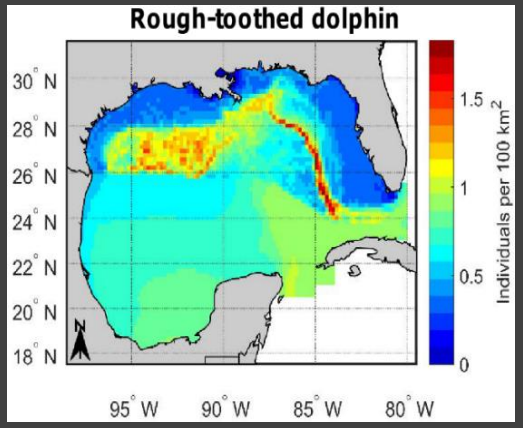
- RFP II (2016) Babcock, Ainsworth
  - Ecosystem modeling database (GRIIDC)
- RFP III (2019) Ainsworth, Putman, Hu
  - Seagrass-manatee dynamics
- RFP IV (2023) Ainsworth, Stallings
  - Modeling FL TIG restoration

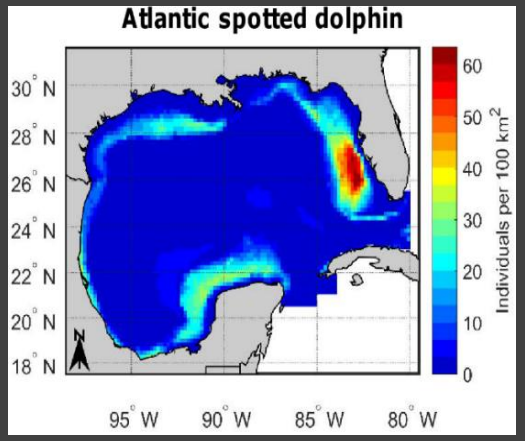
Elizabeth Babcock UM
Arnaud Gruss, NWA

RFP II

Created ecosystem modeling database

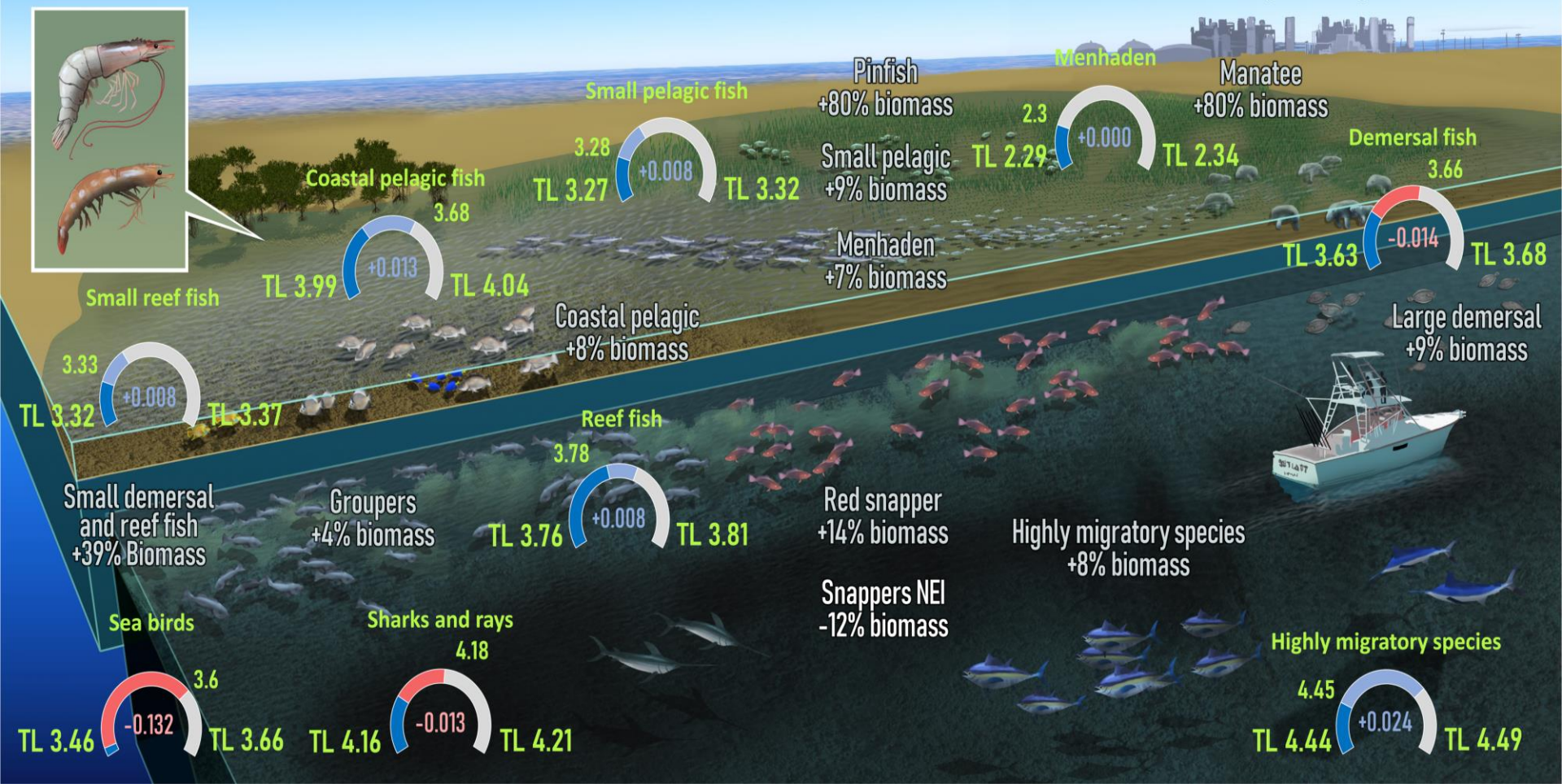
- FLRACEP Project no. 2015-01-UM-522
- Data workshop
  - Jan 15, 2016 Miami
  - Sutton (NOVA), Switzer (FWC), DeVries , Fitzhugh, Gardner, Raley (SEFSC-Panama City), Ingram, Pollack, Briggers, Campbell, Gledhill (SEFSC-Pascagoula), Nero (SEFSC-Stennis), Minello, Brown, Schott-Denton (SEFSC Galveston)





Seagrass restoration

- Availability of small inshore fish increases
- Most predators feed at higher trophic levels



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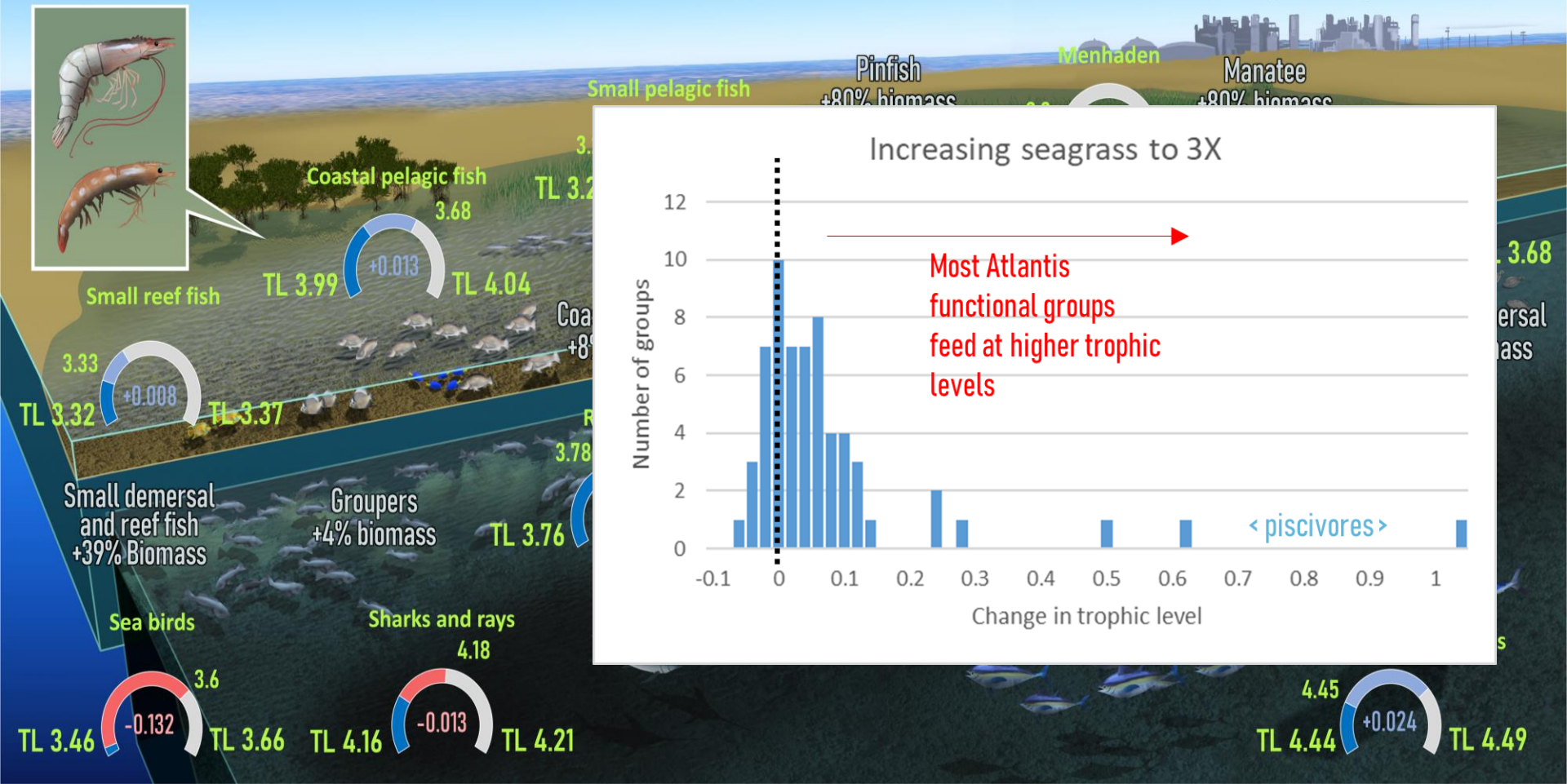
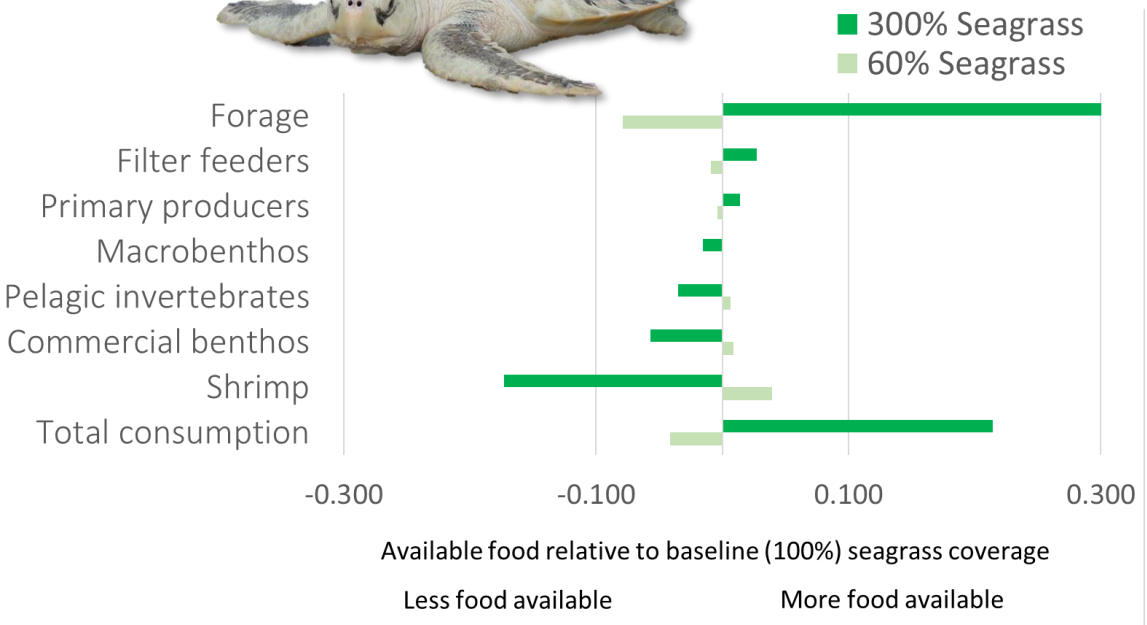
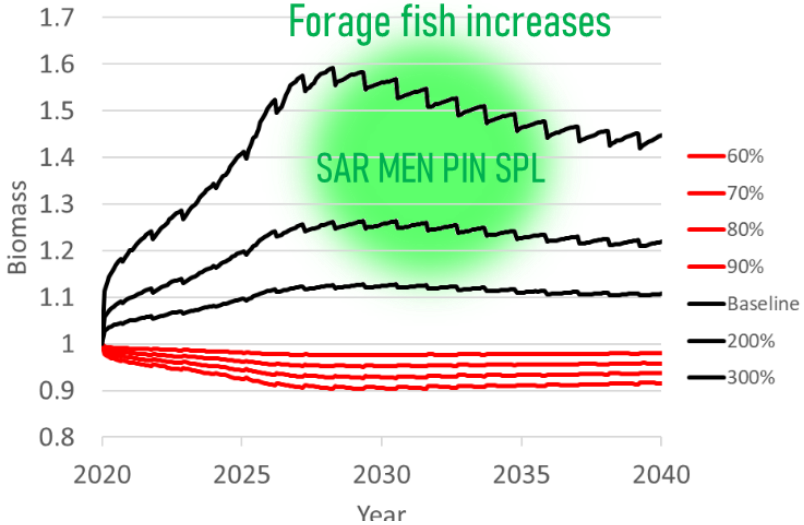


RFP III

- **Seagrass restoration**
- Forage fish increase

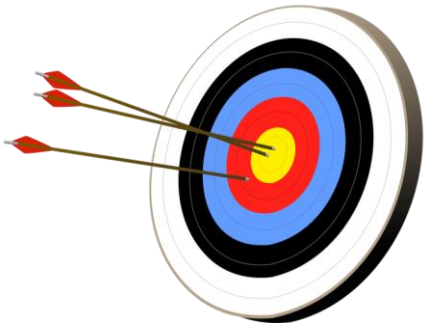




Questions that motivate our RFP IV study

1. Seagrass communities provide an express way for production to reach upper trophic levels
2. If so, is residency time this material in the upper trophic levels?
3. Is there a habitat mosaic effect? (e.g., interaction with mangroves, salt marsh)

RFP IV



What is the goal of restoration?

Is there a goal?

- Deepwater Horizon Trustees have so far approved 157 restoration activities in Florida
- Trustees (8)

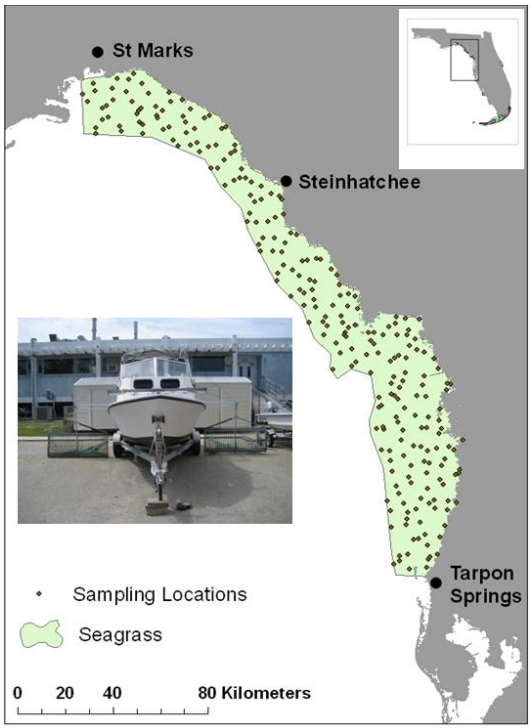
  Federal: US Fish and Wildlife Service, Bureau of Land Management, National Park Service, NOAA, EPA, Dept. of Agriculture

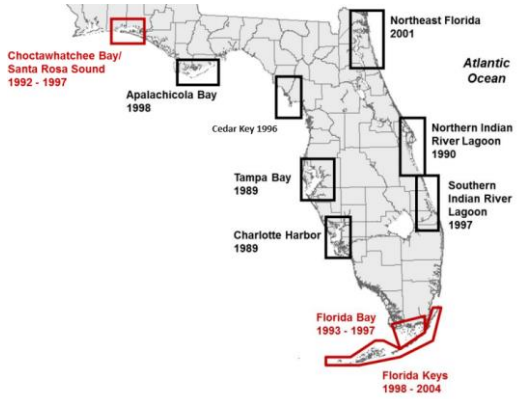
  State: Dept of Environmental Protection, Fish and Wildlife Conservation Commission

RFP IV

Statistical models

- Statistical models predict CPUE for Atlantis groups
- Seagrass occupancy (GAMs) at two different scales
  - Big Bend data (Stallings)
  - FIM data (Ainsworth)
- Helps parameterize Atlantis habitat affinities





Working with stakeholders

Solicited input

- NOAA's Restoration Center
- NOAA's Office of Habitat Conservation
- Florida Fish and Wildlife Conservation Commission

Modeling objectives that I felt we can study using statistical modeling and Atlantis...

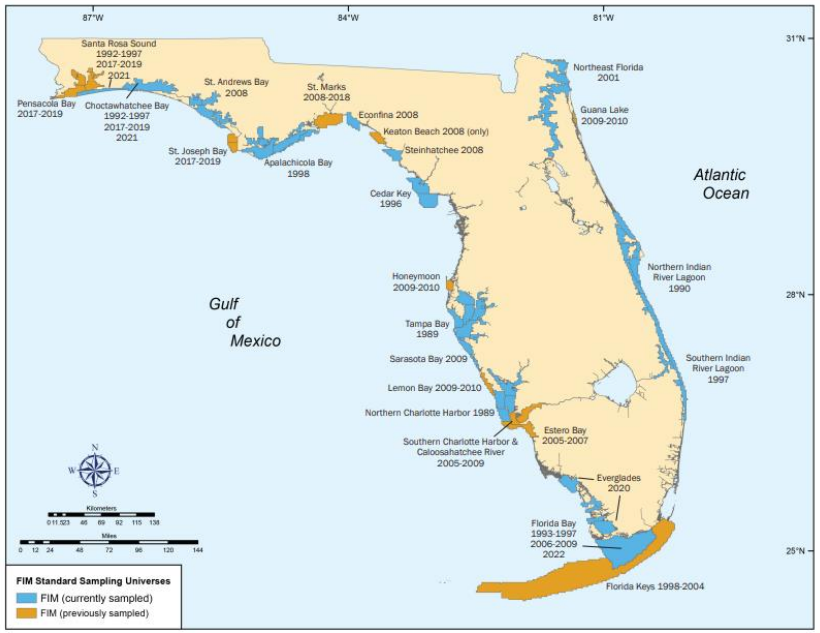
- Wave energy effect in fish community composition
- Seagrass-mangrove interaction
- Nutrient-seagrass interaction
- Provide a regional perspective on restoration
- Understand the role of forage fish in piscivore energy budget

New breakwaters
Oyster reefs
Salt marsh

Response variable

Catch per unit effort (CPUE) data

- Fisheries independent monitoring (FIM)
- 21.3 m boat & beach seines
- 6.1 m otter trawls
- Normal, neg. binomial, gamma, Weibull, exponential, log normal, skew exponential



FIM Catch per unit effort data

Environmental data

- Co-linearity analysis ensures that variables are not correlated
- QQ plots examines residuals

Aqua MODIS

FIM data

- O_2 and % vegetation coverage
- Presence of seagrass, mangrove, macroalgae
- Four sampling gears
- Wind speed

Wavewatch III

- Surface wind shear

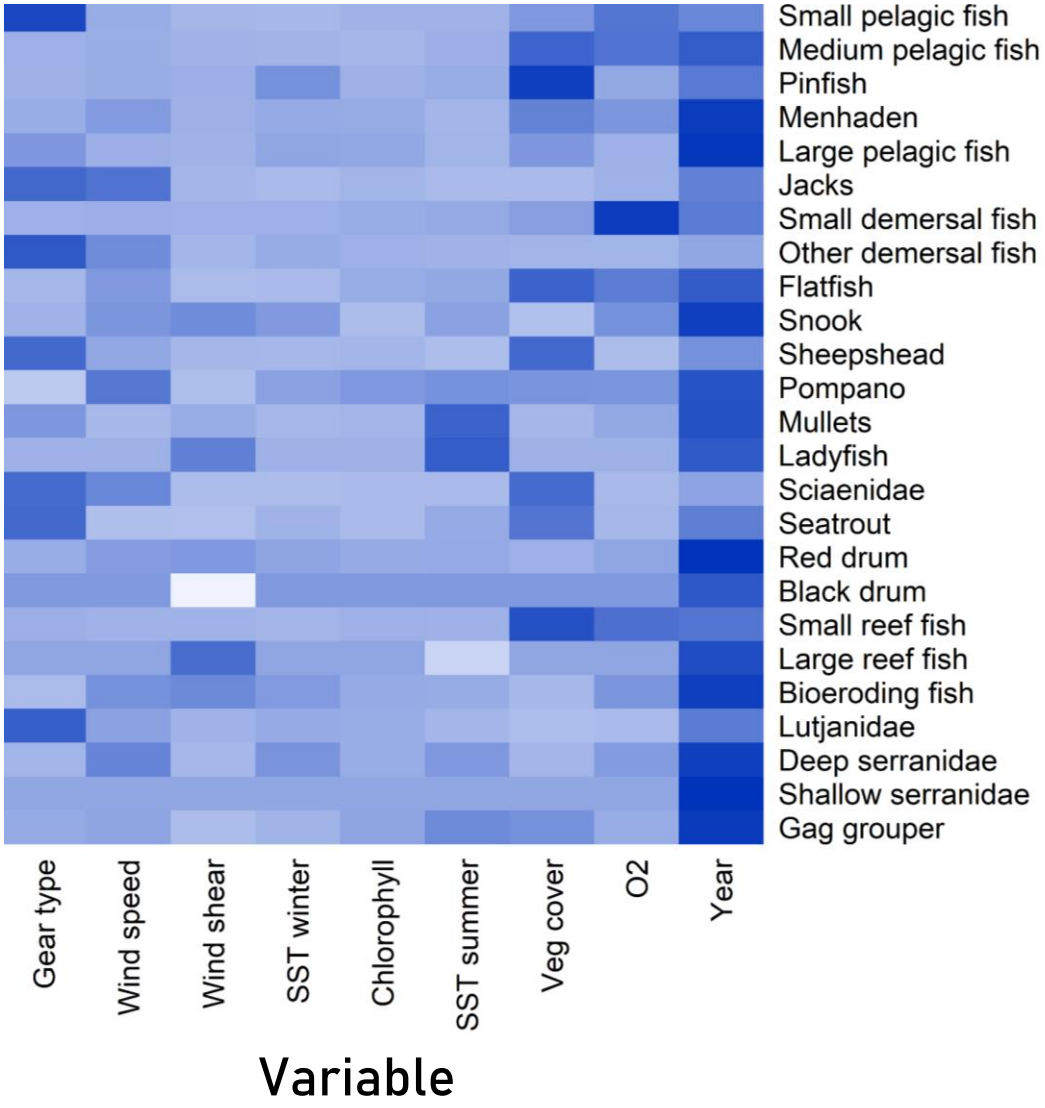
Aqua-MODIS satellite

- SST and Chl A
- Level 3 (gridded) products
- Monthly from July 2002 to November 2023.

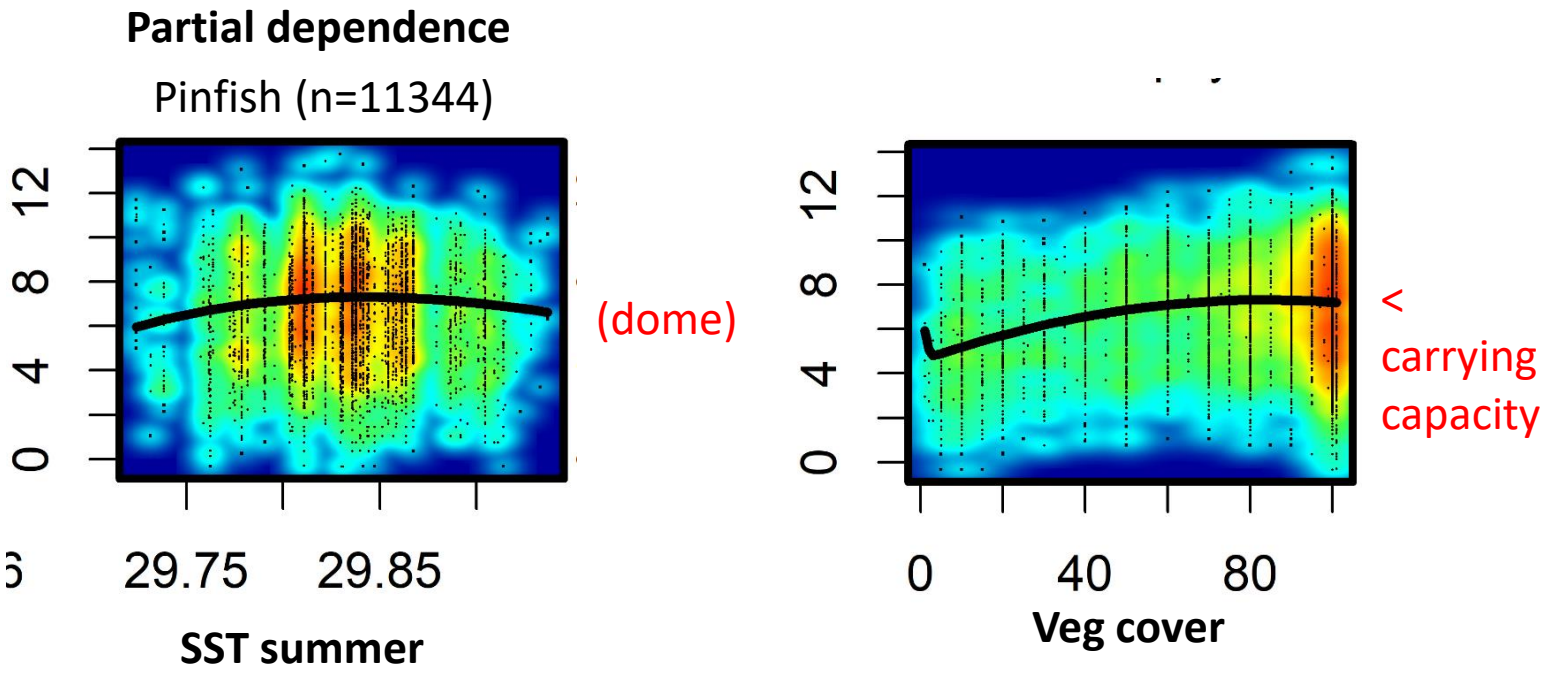
g(CPUE) = βO
+ factor(Year)
+ bs(Wind_shear, k=4)
+ bs(SST_summer, k=4)
+ bs(SST_winter, k=4)
+ bs(SST_spring, k=4)
+ bs(SST_fall, k=4)
+ bs(Chlorophyll, k=4)
+ bs(O2, k=4)
+ bs(Veg_cover, k=4)
+ factor(Shore_type, k=4)
+ factor(Plant_class, k=4)
+ factor(Gear_type, k=4)

Deviance explained

1. **Strong year effect**
   (acts as a catch-all term)
2. **Strong veg cover**
3. **Summer SST more important than winter**
4. **Small bodied fish more influenced by O2** (incl. reef, demersal & pelagic)



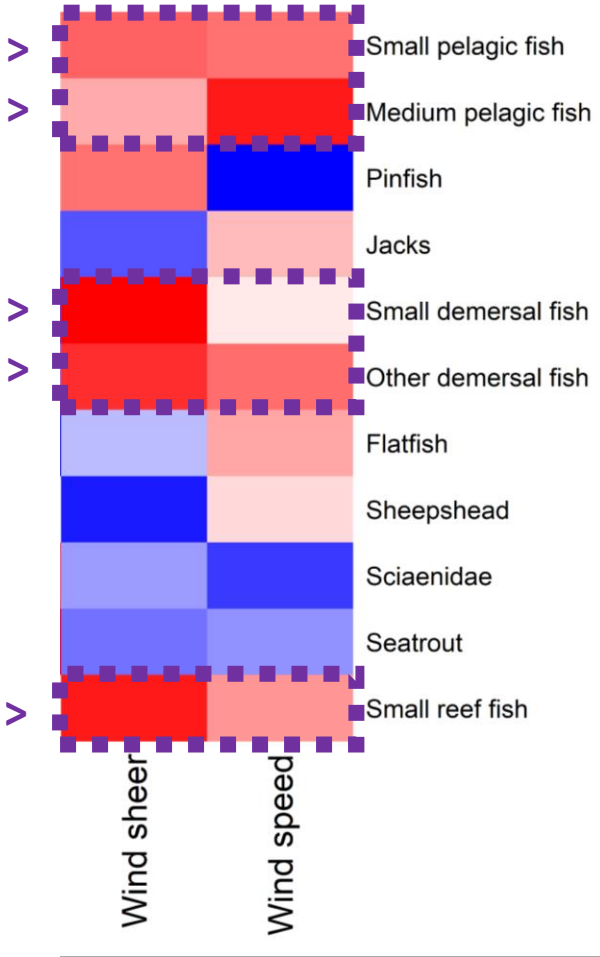
Separating habitat from environmental effects

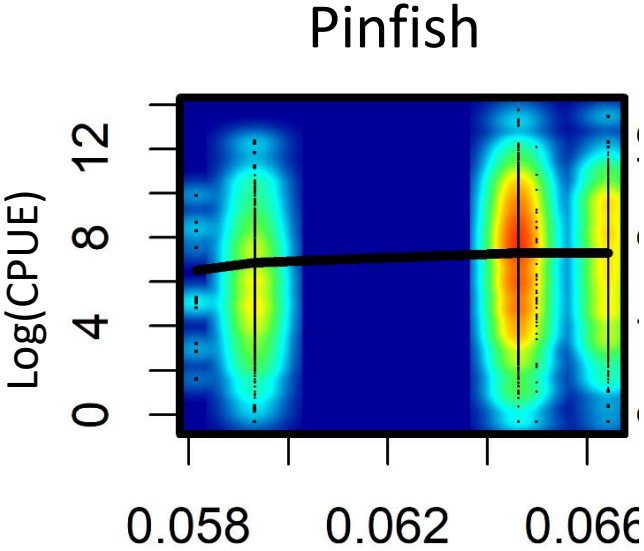


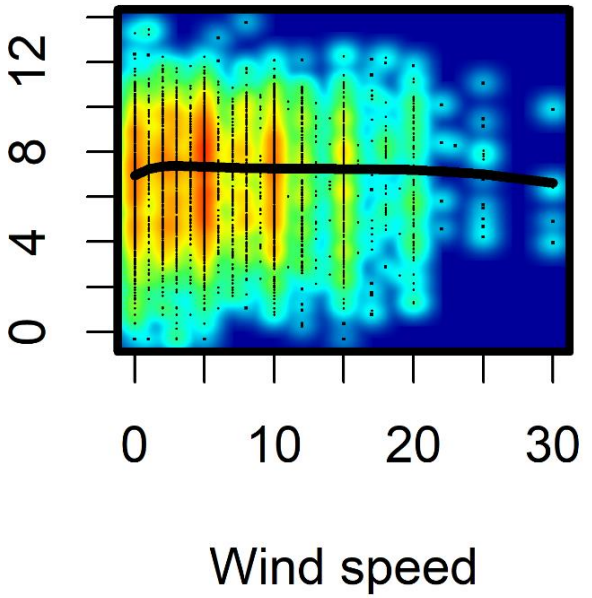
Effect of wave energy

1st coefficient of polynomial spline
Red = positive relationship with wind
Blue = negative relationship

Groups less abundant in low energy settings

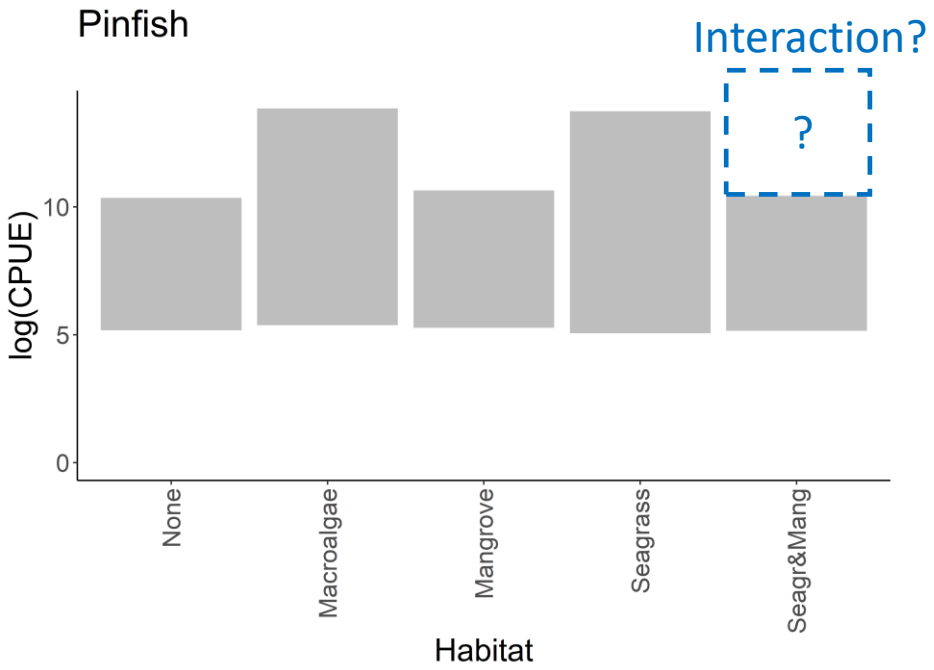


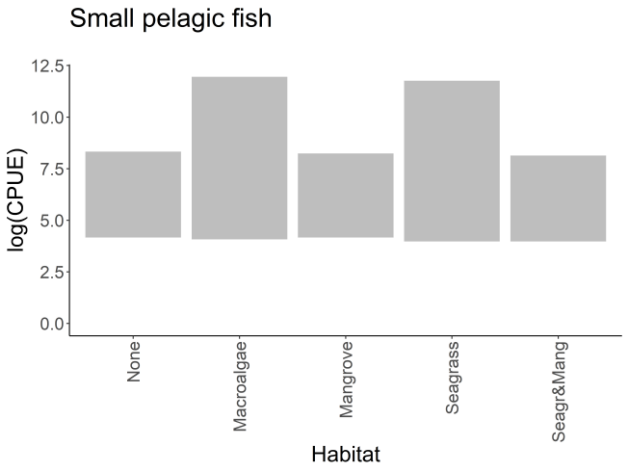


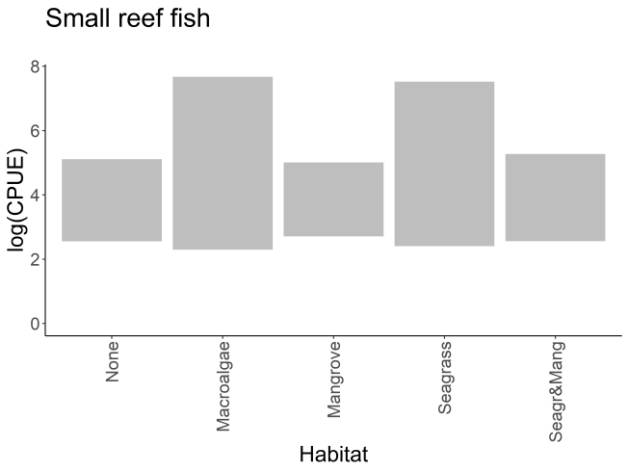


Seagrass-mangrove habitat mosaic effect?

Caution: these results are minutes old







Our ask…

- **Fish community data related to salt marsh, mangroves, seagrass**
- **What questions should we ask the model?**

Thanks!

Supplemental

Model development

PARAMETERIZATION

- Diet Fish Res 179: 237–250
- Diet Ecol Model 284(2014): 60–74
- Parameters NMFS-SEFSC-676 149 pp
- Distributions Fish Res 210: 89–105 (2018)
- Distributions Bull Mar Sci 4: 473–496
- Distributions Mar Ecol Prog Ser 602: 255–274
- Distributions Front Mar Sci (2018)
- Distributions PLoS ONE 8(5): e64458
- Distributions Bull Mar Sci 4: 473–496
- Seagrass & distributions NOAA Tech Memo

FLRACEP

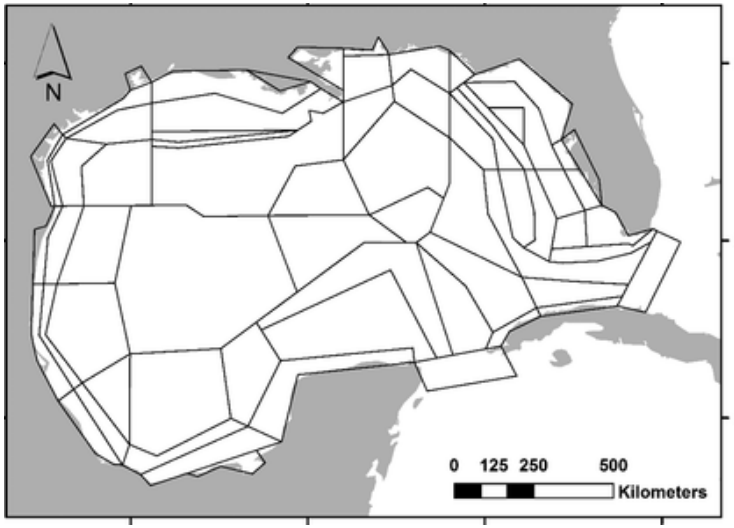
APPLICATIONS

- Dose response Mar Poll Bull 109(1): 259–266
- DWH simulations PLoS One, 13(1):e0190840
- DWH uncertainty Ecosys Serv 33: 187–198
- Arctic spills Springer
- DWH vs. IXTOC Springer
- Hypothetical spills Springer
- DWH/fisheries interaction Springer
- Indicators Ecol Ind 74: 516–525
- MSE Mar Coast Fish 10(1): 24–39
- MOSSFA Env Poll 316(1): 120450
- Larval dispersal Deep Sea Res Part II Top Stud Oceanogr
- Turtle feeding Ecol Model (in review)

FLRACEP

2024 NOAA Tech Memo

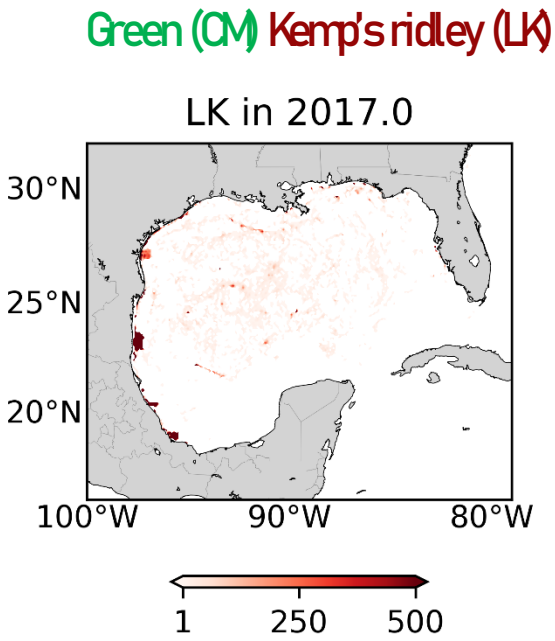
- New seagrass code
- Updated legacy to trunk code
- Updated Windows to Linux build
- Updated 62 species distributions



ICHTHYOP modeling

Nathan Putman LGL

- Green turtle & Kemp's ridley
- 1996–2017 passive particle tracks at known nesting sites & population sizes
- Nathan Putman LGL & Kate Mansfield UCF
  - Green turtles experience >20% mortality in 1995 and 2015
  - large supply of propagules from Caribbean (84% of green turtle production is exogenous)



Now studying resulting **turtle feeding** in Atlantis
(incl. HAB data from Chuanmin Hu)

New seagrass model

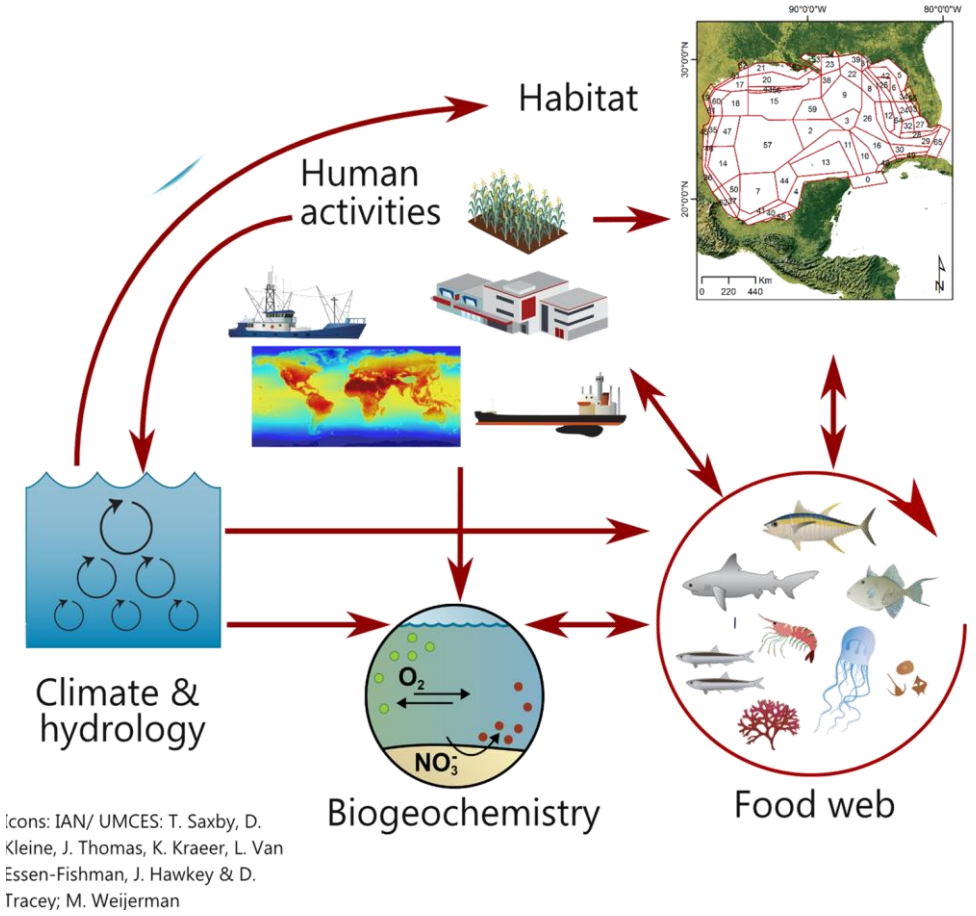
- Divides seagrass into 3 pseudo "age classes"
  - Roots/rhizomes (slow re-growth)
  - Leaves
  - Epiphytic plants
- Represents manatee as habitat organizers/keystone

Atlantis

A bridge from low to high trophic levels

Physics & chemistry important to estuary dynamics:

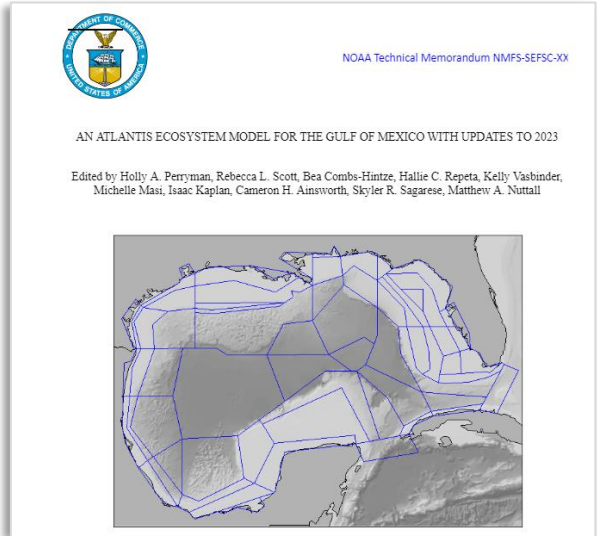
- Light
- Nutrient
- O_2
- Salinity
- Space limitation
- Larval supply
- Biogenic habitats



NOAA Tech Memo 2024

FLRACEP updates

- Modernized GOM Atlantis
  - Code to trunk
  - OS to Linux
- New abundance distributions
- New diet data
- Larval dispersal
- Seagrass dynamics



NOAA Technical Memorandum NMFS-SEFSC-XX

AN ATLANTIS ECOSYSTEM MODEL FOR THE GULF OF MEXICO WITH UPDATES TO 2023

Edited by Holly A. Perryman, Rebecca L. Scott, Bea Combs-Hintze, Hallie C. Repeta, Kelly Vasbinder, Michelle Masi, Isaac Kaplan, Cameron H. Ainsworth, Skyler R. Sagarese, Matthew A. Nuttall