Indian River Lagoon
What is the lagoon?
• **Valuable**

(East Central Florida and Treasure Coast Regional Planning Councils)
• Complex
  - 3 receiving waterbodies
  - long (156 miles)
  - shallow (~3’ on average)
  - not a river (wind and tide driven)
  - segmented (flushing weeks to months)
  - sensitive
  - diverse
    o ecology
    o politics
    o challenges
Lake O discharges and *Microcystis*
What is a shared challenge?
- Excess nutrients (N and P)
- Total Maximum Daily Load (TMDL)
- Basin Management Action Plan (BMAP) or Reasonable Assurance Plan (RAP)
  - adaptive approach to uncertainty
  - seagrass a key indicator
What are we doing?
St. Johns River Water Management District
“Continuous” water quality

Monthly water quality

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• **Phytoplankton**
  - fortnightly, IRLNEP
  - weekly, FWRI, HAB focus
• **Seagrass**
  - transects, summer and winter
  - maps, each 2 years
• Fisheries independent monitoring, FWC
How are we doing?
St. Johns River Water Management District

Indian River Lagoon seagrass

- Mean tansect length (feet)
- Seagrass extent (acres)

Good management

Vero WWTP discharge

Drought

Min drought

IRFWCD discharge

'04 hurricanes flushing

TS Fay flushing

Good luck

Drought
Chlorophyll-a (μg L⁻¹)

- ML
- BRL
- NIRL

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Year: 1997 to 2011

Chlorophyll-a levels over time.
Recent bloom
St. Johns River Water Management District

- Recent bloom

Satellite View of the Indian River Lagoon
10-15-2020

Satellite View of the Indian River Lagoon
11-25-2020

Satellite View of the Indian River Lagoon
12-06-2020

Satellite View of the Indian River Lagoon
12-09-2020

Fish kill
• Recent bloom
• Changes from 1992 to 2019
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Mean transect length (m)

Areal extent

Transect length

Seagrass extent (ha)

- 1943
- 1992
- 1994
- 1996
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2013
- 2015
- 2017
- 2019

- 0
- 30,000
- 60,000
- 90,000
- 120,000
- 150,000
- 180,000
- 210,000

- 0
- 30,000
- 60,000
- 90,000
- 120,000
- 150,000
- 180,000
- 210,000
• **2012–2013 manatee UME**
  (115 mortalities due to undetermined causes* in 2013)

• **2013 dolphin UME**
  (Mar–Aug ⇒ 3× – 6× higher mortality than 9 year mean)

• **2016 fish kill in Banana River Lagoon**
  (estimated >> 100,000 mortalities)
What happened?
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Loads of nutrients

Eutrophication progression scheme

Increased nutrient delivery

Grazing, Cycling, Binding

Enhanced growth of phytoplankton and macroalgae

Increased shading and benthic respiration

Seagrass loss

Adapted from C.M. Duarte (1995)
Monthly rainfall (mm)

Period of interest

ML  BRL  NIRL
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HSPF model
NIRL
IRLI10
south of NASA causeway
Mean daily temperature (°C)

- **Warm**: 32 °C
- **Cold**: 5-8 °C

Year: 1998 to 2018
Internal source = cold kill (Jan 2010)?

NASA contractors ⇒ 400 tons of fish

Assume 4% N and 0.4% P

⇒ 16 tons N and 1.6 tons P

Triple for total area?
• Internal source = muck?

• °C effect?
  – flux ↑ as °C ↑
  – [P] and [N] ↑ as °C ↑

• pH effect?
  – flux ↑ as pH ↑
  – pH ↑ as algae draw [CO₂] ↓
  – [TPD] ↑ as algal biomass ↑

• Spatiotemporal resolution?
• Internal source = drift
• "Bycatch" ↓
• Mortality ⇒ N and P?
• Cycling change?

Mean drift algal biomass (g DW m\(^{-2}\))

Paperno, FFWCC
• °C + PAR ⇒ stress
• Not mortality
• Cycling change

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Gracilaria at 25 psu

Hanisak, HBOI
NIRL

- “Cycling” visible
- Drift ~parallels seagrass
- Phytoplankton drives
- System “flashier”
Banana River Lagoon

Carbon (mg L$^{-1}$)

- Diatoms
- Dinoflagellates
- Cyanobacteria
- Nanoeukaryotes
- Brown tide

Year:
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
• Smaller
• Turn over faster
• Brown tide has resting stage
• Use “organic” N and P
• Fix N (picocyanobacteria)?
• Top-down control?
  – microzooplankton OK
  – mesozooplankton not at high densities
  – infauna (clams) OK except brown tide
  – epifauna OK except brown tide
How does this egghead stuff help?
Take-homes for managers

- Nutrients $\Rightarrow$ chlorophyll $=$ the issue
Modeled versus measured chlorophyll for June 2011

Graphs showing the comparison of modeled versus measured chlorophyll levels for IRLB02 and IRLB04.
Monthly average chlorophyll for June 2011

Current Condition

TMDL Condition
Take-homes for managers

- Nutrients ⇒ chlorophyll = the issue
- Nutrient cycling complex ⇒ look beyond loads
- New sources of chlorophyll = bad actors
- Data “below” chlorophyll-a ⇒ value
- Superbloom = perfect storm + new norm
- Events matter ⇒ “elbow room” in TMDL
- Ecosystem shift ⇒ challenge to restoration
Investments in improvements

- Internal loads
  - muck
  - groundwater
    (150 m x 10 km
    ≈ 7% of daily St Lucie flow: max)
  - adjust TMDL
- Drift algae
  - role in cycling
  - harvest for N and P
- Phytoplankton
  - life cycles
  - competition
  - N fixation and N:P
  - organic v inorganic N and P

- Filter feeder enhancement
  - type
  - source
  - site selection
  - protection
- Seagrass rehabilitation
  - source
  - site selection
  - planting
  - protection

Prinos and Swain, USGS
IRL NEP project in 2015: develop and validate tools for brown tide monitoring and event response (pre-bloom)

- microscopy
- flow cytometry*
- qPCR**

**Tilney, unpublished

Method validation
**Flow A. lagunensis antibody counts**

**North Indian River and Mosquito Lagoon**

**Flow A. lagunensis**

Date: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

- **3.0E+06**
- **2.0E+06**
- **1.0E+06**
- **0.0E+00**

**Date**: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

**Note**: Two DB observations > 4.5 x 10^6 cells mL^-1 off scale.

**Banana River**

Date: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

- **3.0E+06**
- **2.0E+06**
- **1.0E+06**
- **0.0E+00**

**Date**: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

**South Indian River**

Date: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

- **3.0E+06**
- **2.0E+06**
- **1.0E+06**
- **0.0E+00**

**Date**: 12/14 7/15 1/16 8/16 3/17 9/17 4/18 10/18 5/19 12/19 6/20

- FIM
- SJRWMD/UF
- HAB Volunteer Prog.
Imaging Flow CytoBot: Life cycle and cell physiology??

Brown tide grown in lab

https://mclanelabs.com/imaging-flowcytobot/
Imaging Flow CytoBot: Life cycle and cell physiology

Field samples → lots of diversity in small size classes
• WIZ probe (Systea S.p.A.)
  – ammonia
  – orthophosphate
  – nitrate + nitrite
  – nitrite
Thank you