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State of the Reserve 2024

GUANA NUTRIENTS BUDGETS AND BIVALVES

The Guana Nutrients Project Team


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Photo credit: Allix North, GTM Research Reserve

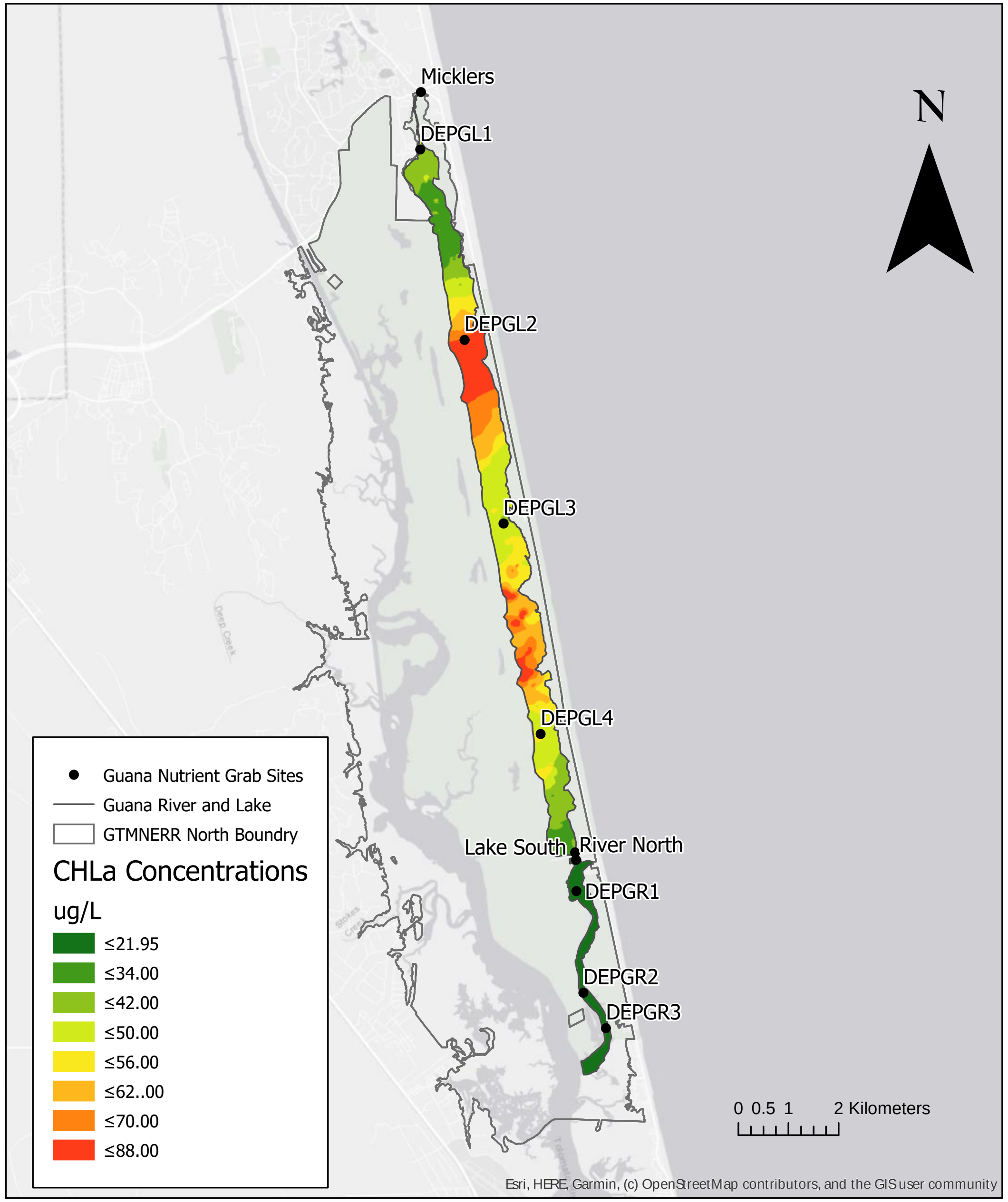
Current threats to water quality

Urbanization	Climate Change	Watershed Management
• Nutrient and organic matter inputs • Emerging contaminants • Hydrology	• Extreme events • Sea Level Rise	• Drainage improvements • Vegetation control • Shellfish management

Too Many Nutrients

- Signs of a problem
- High chlorophyll *a* concentrations
- Impairments
- Management Needs
    - *Inform the Reserve management community of the impact of watershed actions have on water quality...*
    - *Determine the ecosystem benefits and tradeoffs of different management options.*

October 16, 2019 Chlorophyll a Concentrations
(Guana Spatial Survey)



Map credit: Jessica Lee, GTM Research Reserve

Project Goals

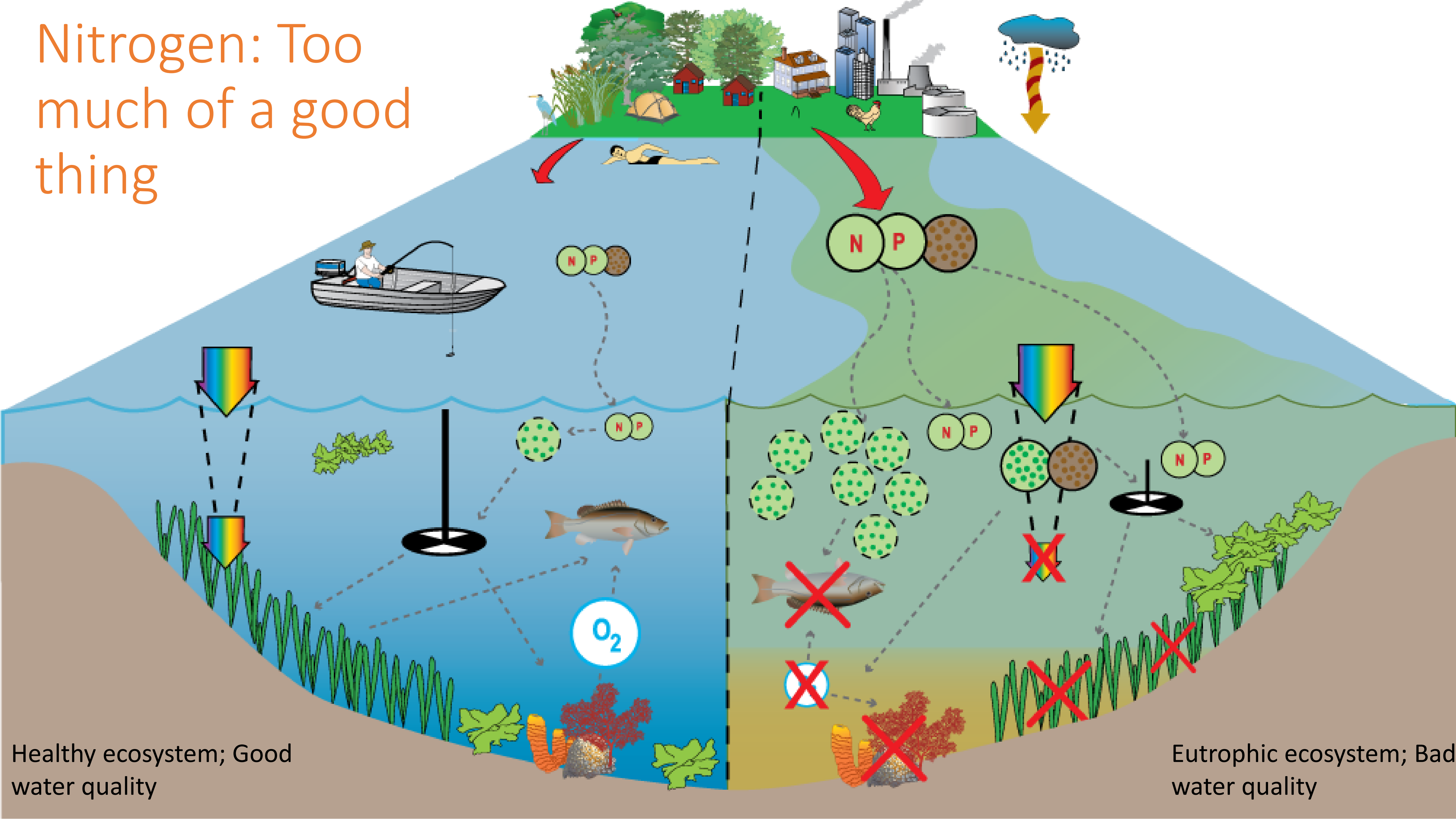
Identify	Identify nitrogen sources into Guana Lake
Understand	Understand how nitrogen moves and changes throughout Guana Lake and into Guana River
Map	Map the current distribution of oysters and mussels
Quantify	Quantify filtration and nitrogen removal by shellfish for ecosystem service evaluations
Evaluate	Evaluate how water quality impacts shellfish-mediated ecosystem services
Develop	Develop recommended water quality targets and restoration goals for a water quality restoration plan

GUANA NUTRIENTS BUDGETS AND BIVALVES

Nitrogen: Fundamental for life, but *hazardous* in excess

- Events that can threaten ecosystems, disrupt livelihoods and/or damage property
- Ecological impacts
  - Nuisance algal blooms
  - Oxygen depletion and fish kills
  - Habitat damage
- Societal impacts
  - Public health
  - Economic impacts

Nitrogen: Too much of a good thing

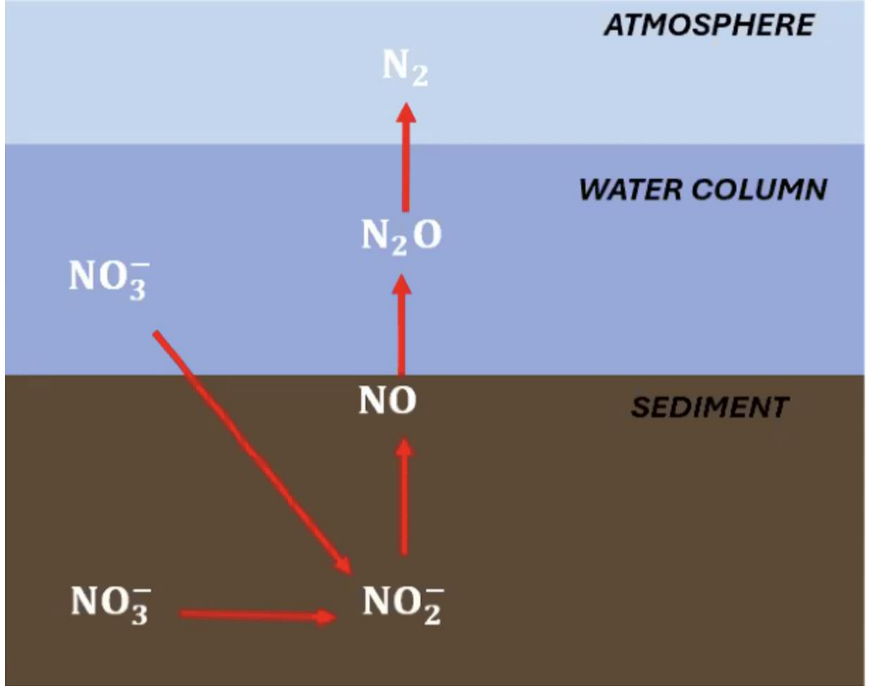


Healthy ecosystem; Good water quality

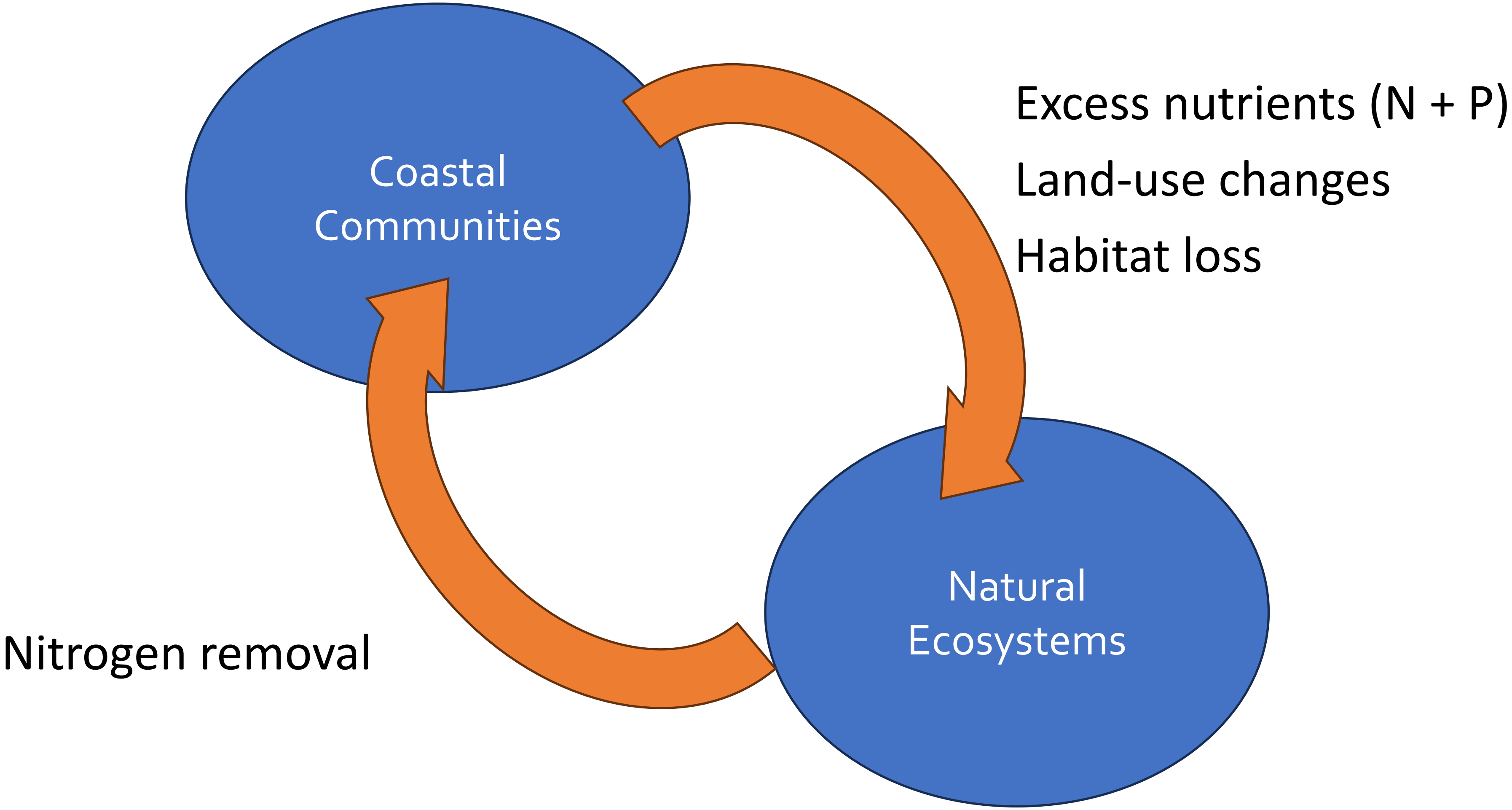
Eutrophic ecosystem; Bad water quality

Natural ecosystems can mitigate water quality hazards

Habitats can store nitrogen and naturally and permanently remove reactive nitrogen via denitrification



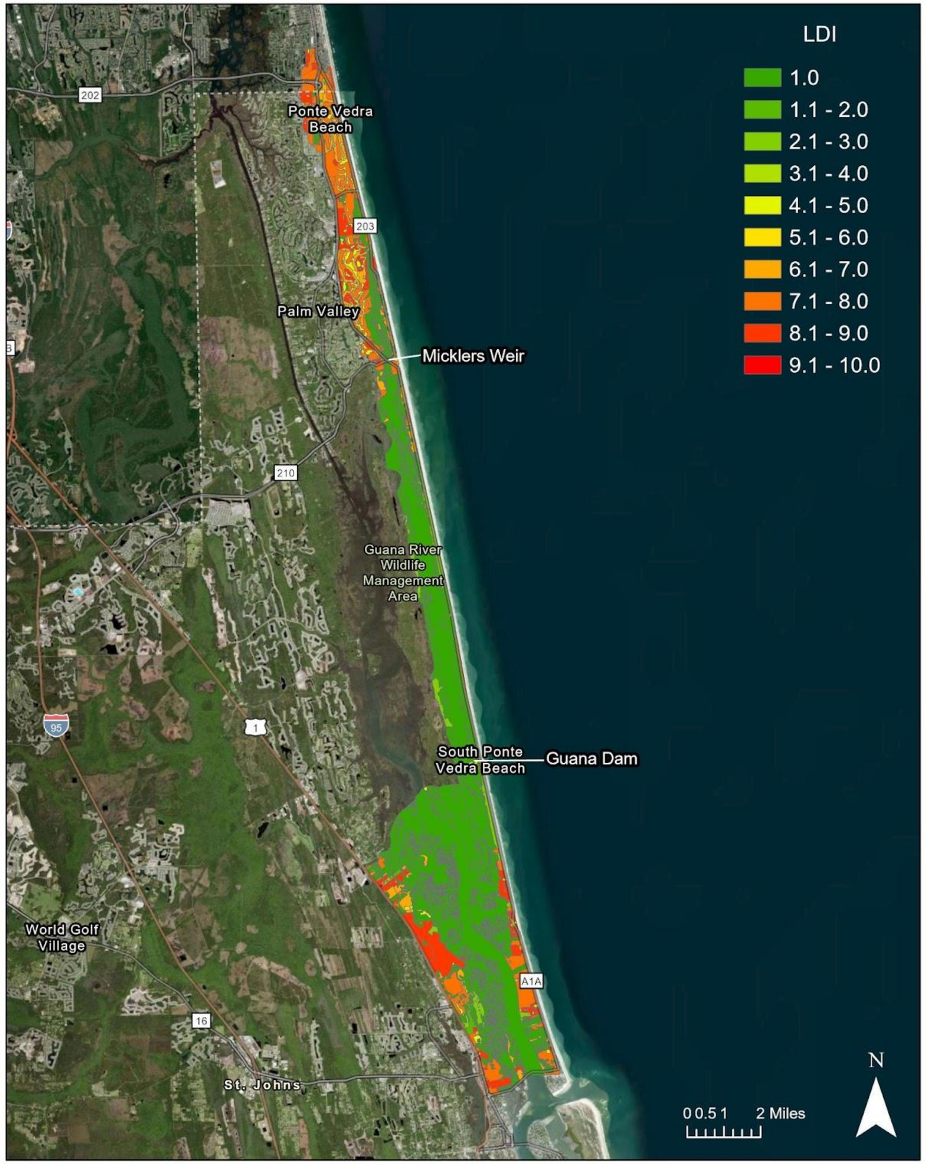
Communities and ecosystems are connected



Nitrogen Sources

- Guana Estuary watershed land use:
  - 2 golf courses
  - 3 wastewater treatment facilities
- Above Micklers Weir
  - 80% developed land
  - 20% natural
- Total nutrient loads according to the Pollution Load Estimation Tool (USEPA)*
  - 56,700 lbs N per year
    - 90% of the N is from urban land uses
    - 6% from forests

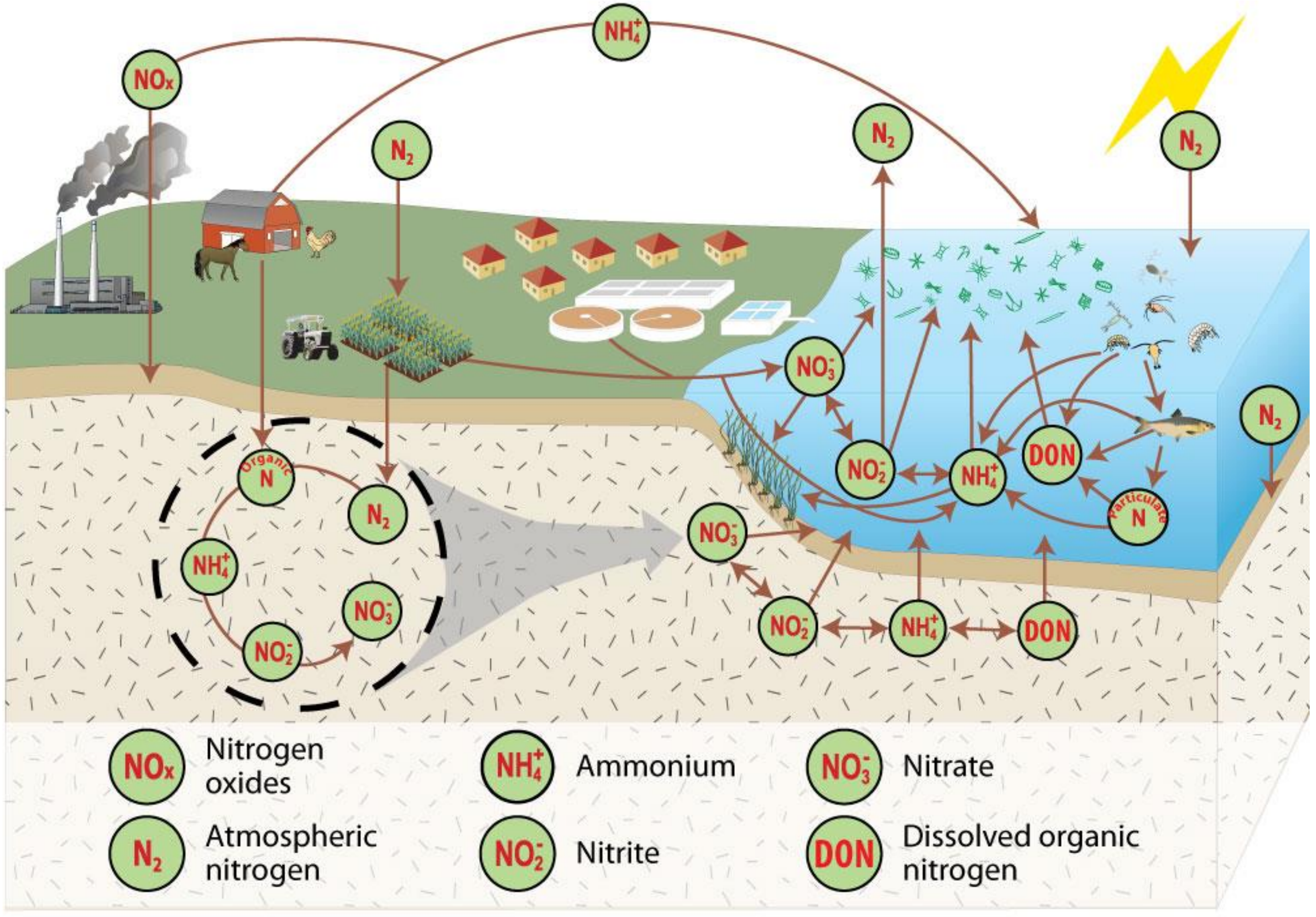
Landscape Development Intensity Index for Lower Tolomato Watershed



Map credit: Savanna Mathis

Nitrogen Sources

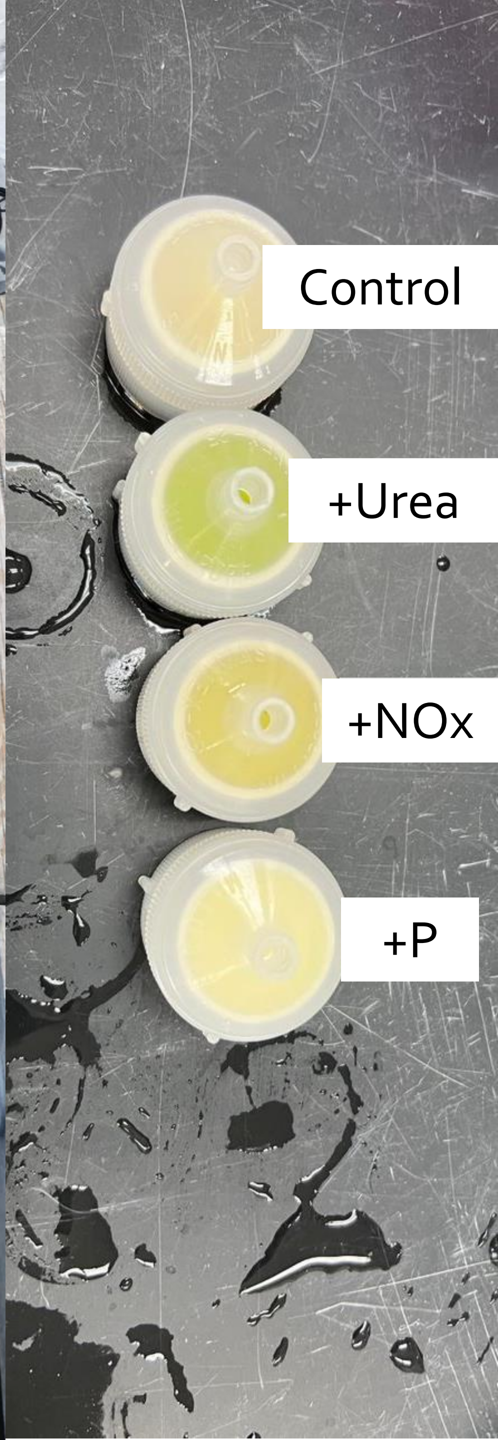
- Nitrogen inputs from upstream come in various forms
  - Inorganic nitrogen
    - Nitrate
    - Ammonium
  - Organic nitrogen



Conceptual diagram illustrating the nitrogen cycle.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L. and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

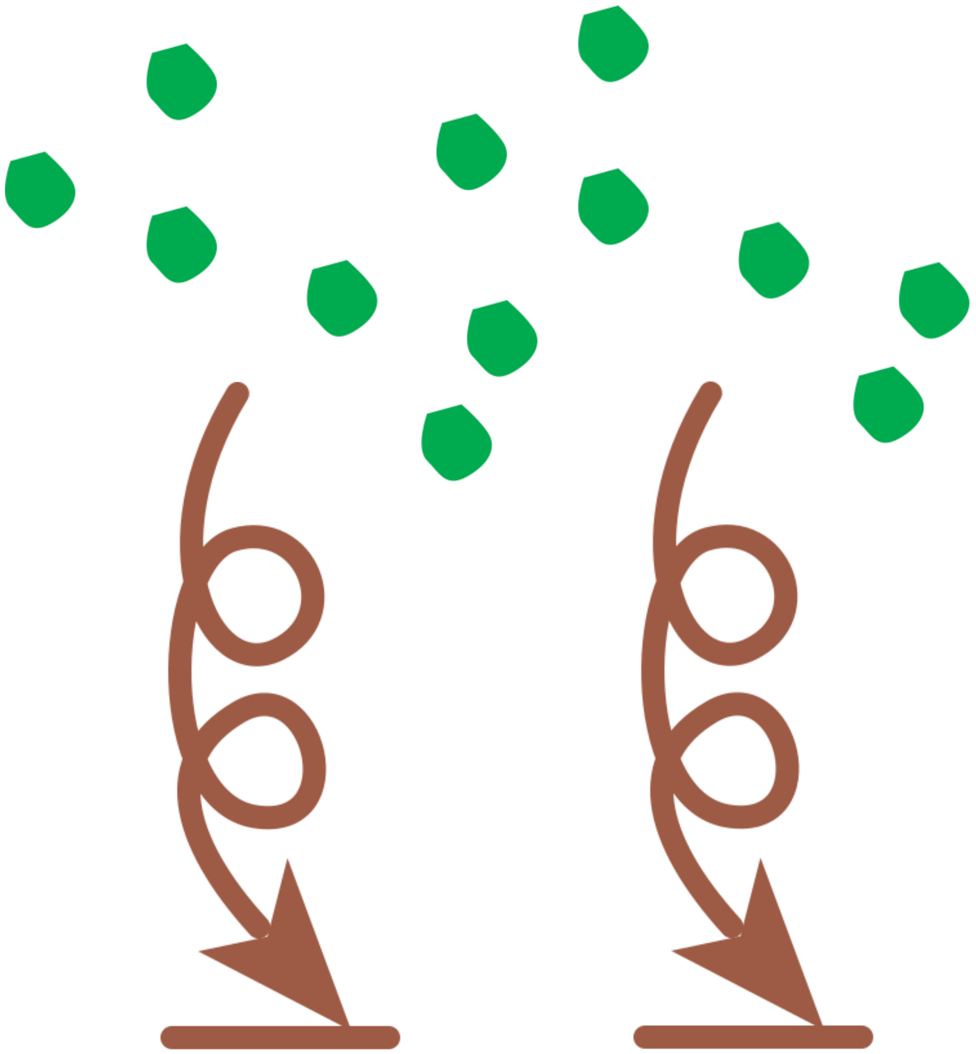
Water Quality Response

- Typical assumption is that DIN is more bioavailable than DON
- Algal nutrient limitation bioassay:
  - Phytoplankton are N limited
  - Particularly responsive to Urea
- Limiting N inputs is important, but focus should include DIN and DON



Feedback in the Sediments

- Sediment respiration removes oxygen from the water column
- Sediments recycle nutrients back to the water column
- Sediment denitrification



Denitrification

NO_3^- → N_2O → N_2 → atmosphere

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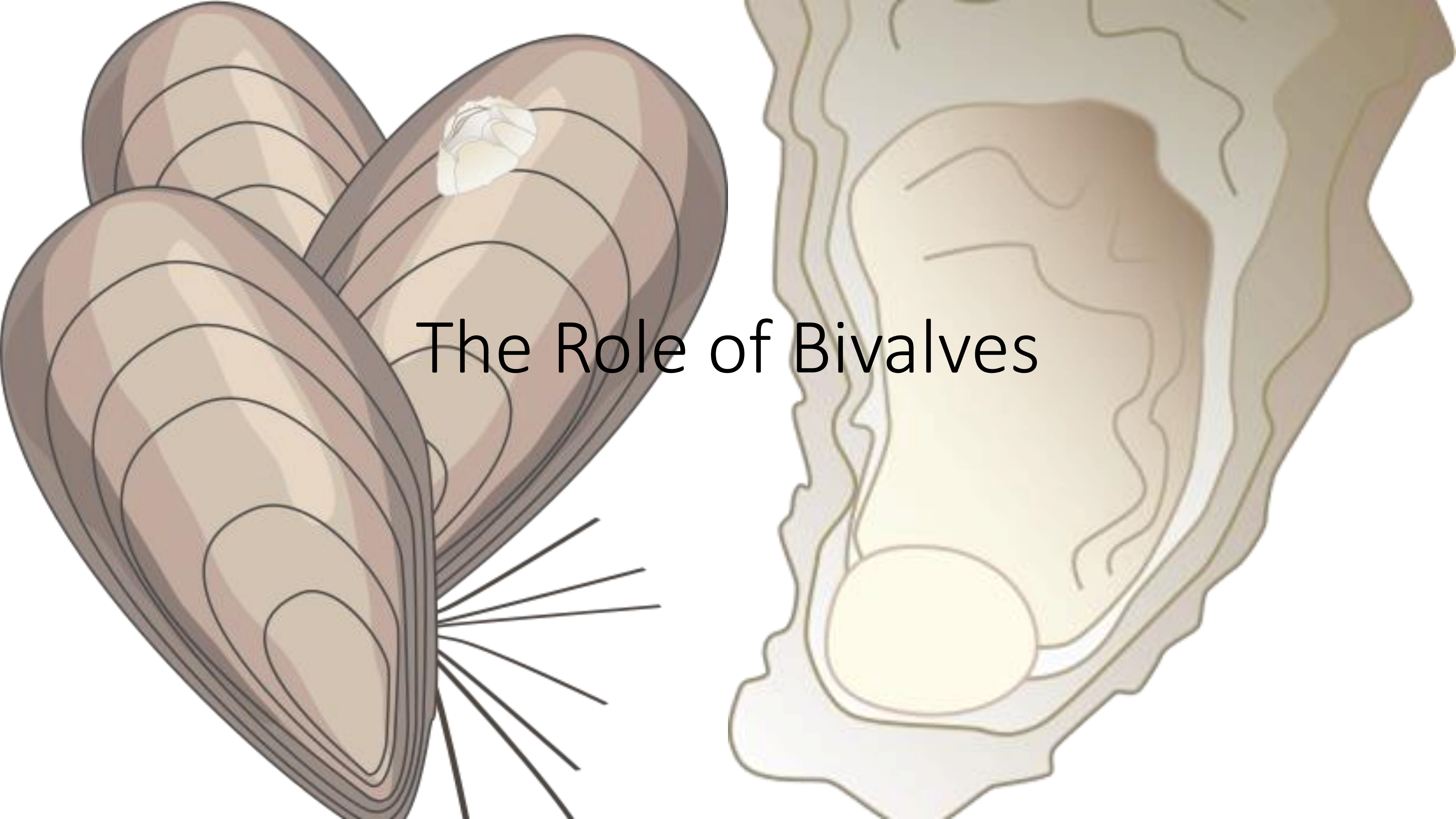
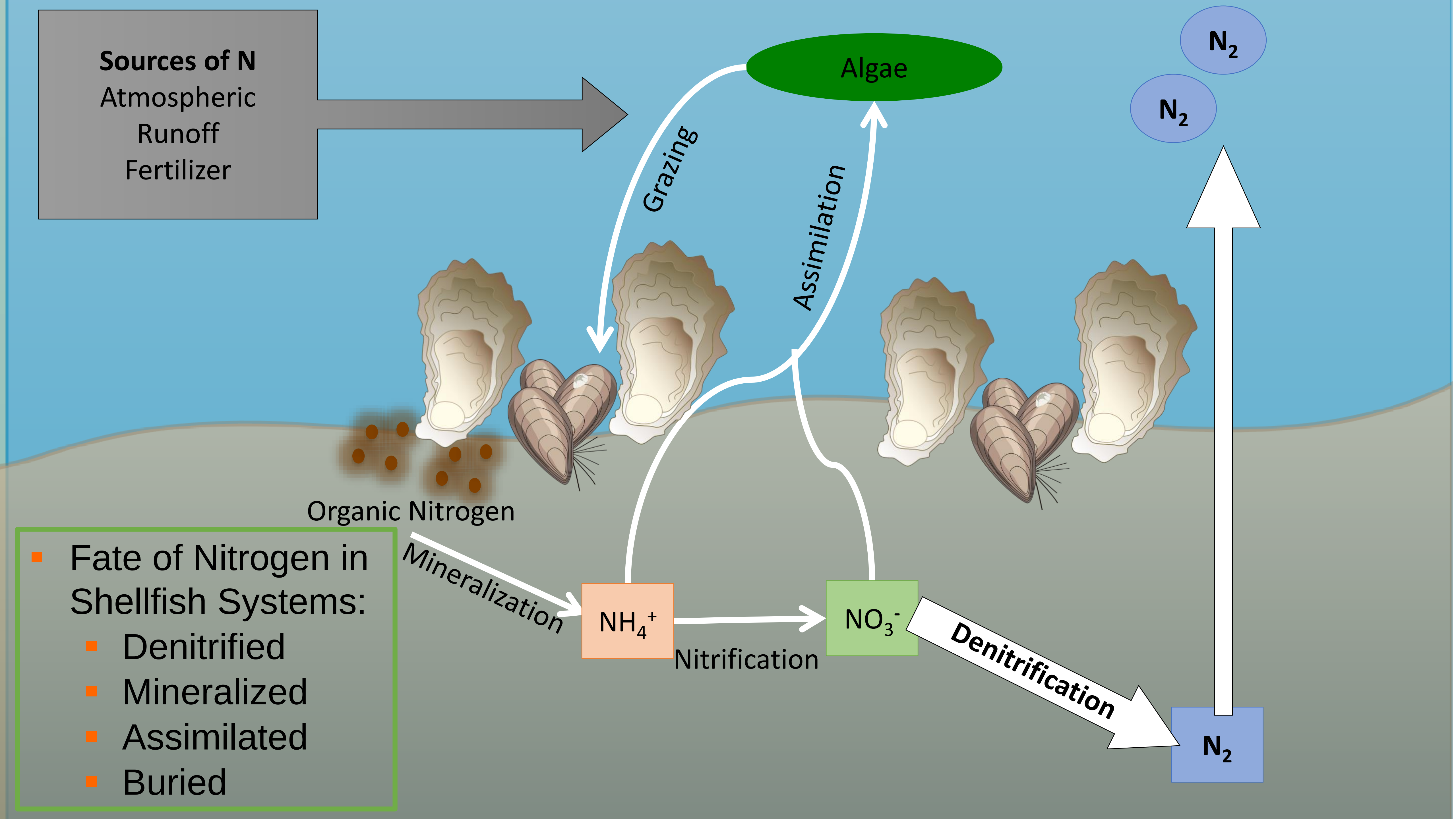
Denitrification

$NO_3^- \rightarrow N_2O \rightarrow N_2$ → atmosphere

The Role of Bivalves




Sources of N
Atmospheric
Runoff
Fertilizer
Algae
Grazing
Assimilation
N₂
N₂
Organic Nitrogen
Mineralization
NH4+
Nitrification
NO3-
Denitrification
N2
Fate of Nitrogen in Shellfish Systems:
Denitrified
Mineralized
Assimilated
Buried

Water Quality Benefits of Bivalves

- How many shellfish are in the Guana Estuary?
- How much water do they filter?
- How much nitrogen is stored in their shell and tissue?
- Do they enhance sediment denitrification?

How much nitrogen is removed by shellfish in the Guana Estuary?

To determine total annual nitrogen removal from a shellfish, we can upscale field measurements*

Denitrification Enhancement + **Storage Assimilation** = **Total Nitrogen Removal from Shellfish**

Denitrification Enhancement

1) Yearly denitrification based on daily light
2) Enhancement relative to background
3) Scaled based on area

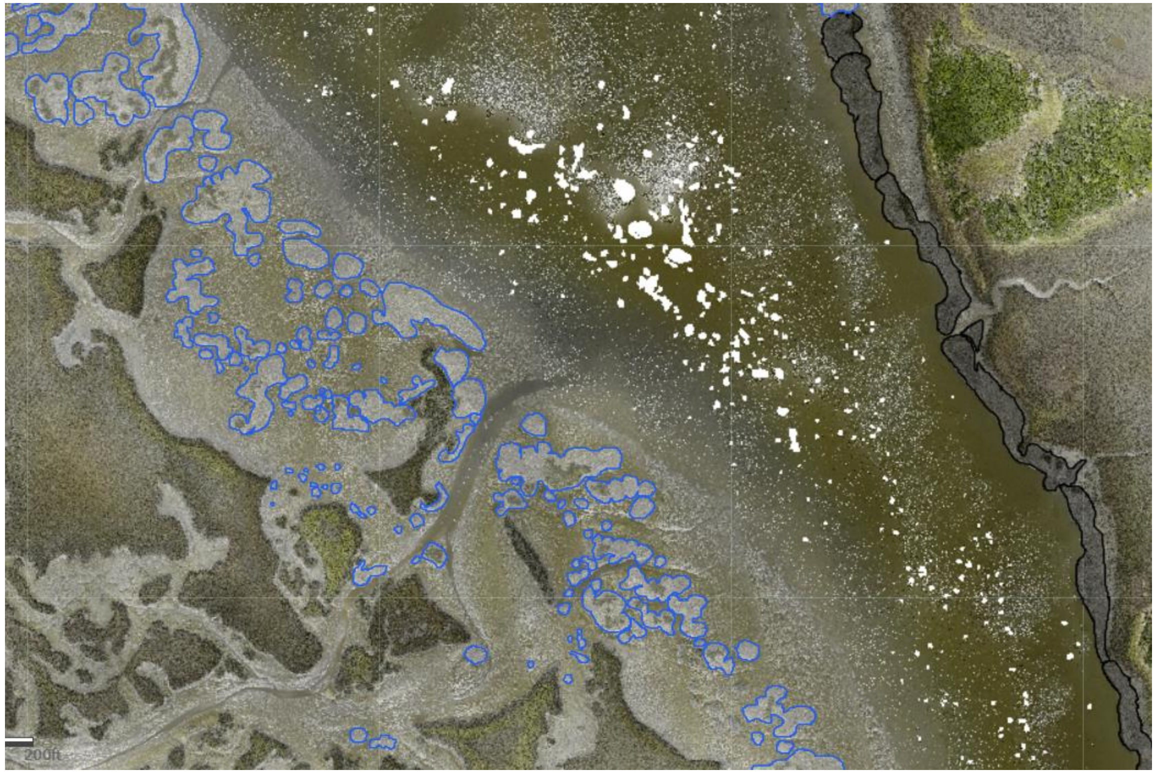
Storage Assimilation

1) Nitrogen content per individual
2) Scaled based on density

*Many, many assumptions, for illustrated purposes only

Guana River Oysters

- We collected drone imagery of the Guana River and manually delineated all oysters
- Oyster reefs were identified as consolidated or unconsolidated
  - Consolidated=high density reefs with clear reef borders; often patch reefs (shown in blue)
  - Unconsolidated=low density reefs with oyster clusters dispersed over mudflats; often fringing reefs (shown in black)



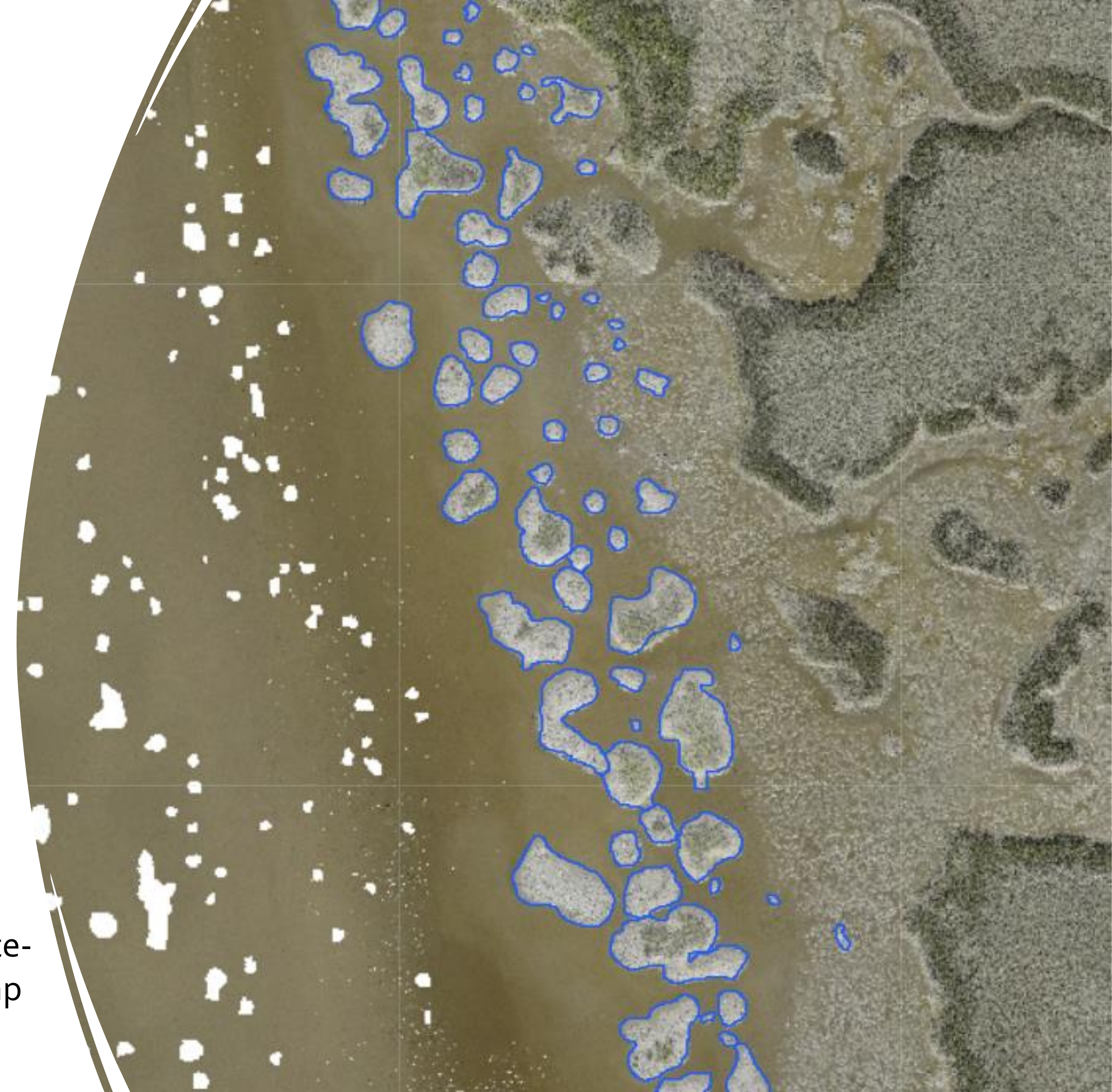
Hallie Fischman

Guana River Oysters

- Consolidated reefs occupied an area of 83,857m^2
- Unconsolidated reefs occupied an area of 33,792m^2
- These oyster maps are included in FWC's state-wide oyster bed map

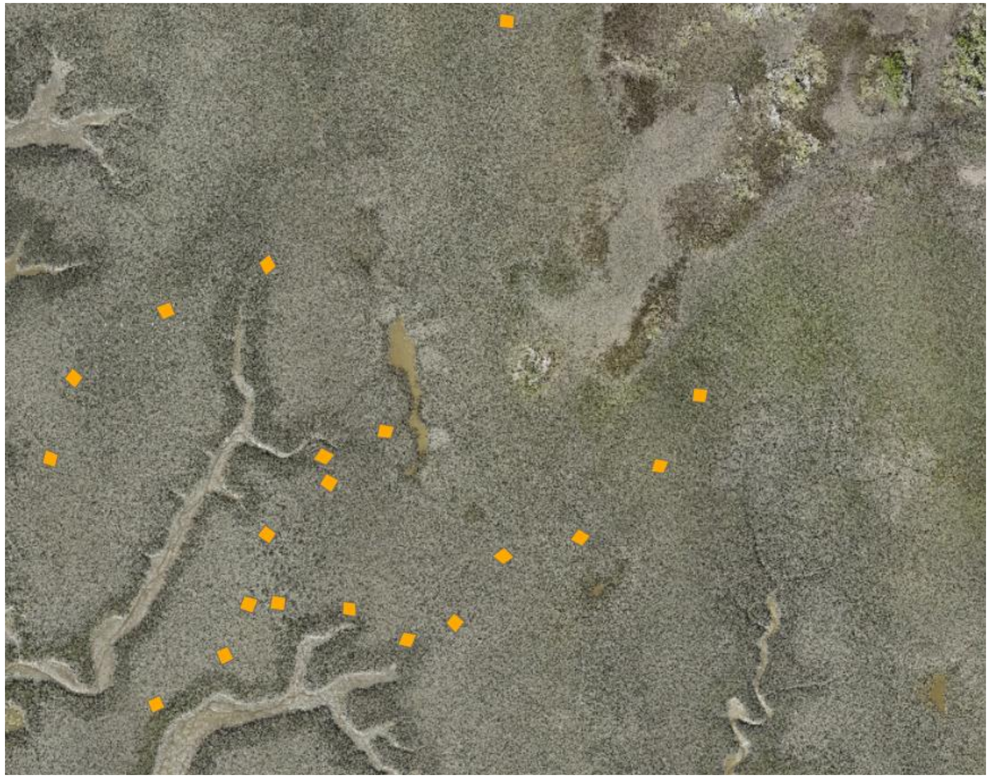
Guana Oyster Layer

FWC state-wide map



Guana River Mussels

- Because the mussels cannot be identified from the drone, we conducted manual surveys and are estimated density based on those surveys
- Counted all mussels in 100, $9m^2$ plots



Potential solutions

- Enhance Natural Processes
  - Denitrification
  - Assimilation
- In-Water Management Options
  - Vegetation management
  - Water levels
  - Harvesting, recreation

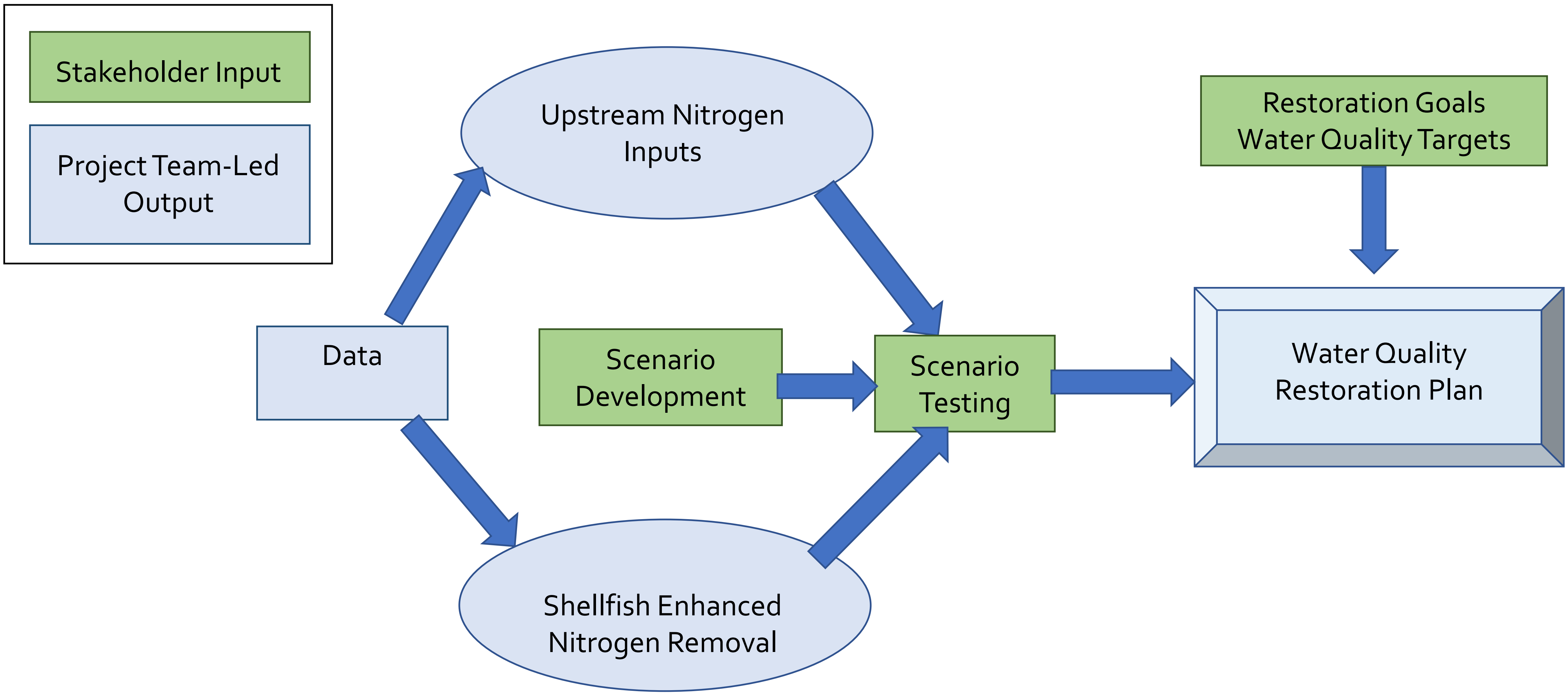
Control nutrients at the source

- Need to deal with the source of the problem, not the symptoms
- What opportunities do we have to reduce the sources of water quality problems?

Looking forward for solutions

- How can we work together to protect water quality in the Guana Estuary?
- Develop alternative future scenarios based on conversations with you all
  - What watershed management options are likely?
  - What development is likely?
- We can then test how changes would affect nitrogen inputs to the Guana Estuary.

Restoring Water Quality



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Learn more about the project:

http://www.nerrssciencecollaborative.org/project/Smyth20

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