The Capabilities of Autonomous Marine Robots for Coastal Studies

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What are Marine Robots?

Unmanned, programmable, robotic systems that can drift, drive, glide, interact with bodies of water with/without human remote control.

Remotely Operated Vehicle
(source Oceaneering)

Autonomous Underwater Vehicle
(source Teledyne)

Autonomous Surface Vehicle
(source Chance Maritime)

Glider
(source Geo-matching)

Underwater Manipulators
(source Reach Robotics)

Overview of underwater robots: ROVs and AUVs

Remotely Operated Vehicles (ROVs)

- Connected to a surface ship by tether
- Controlled by a human operator
- Box-shaped, good for station keeping
- Equipped with hydraulic manipulators
- Used for close visual inspections & sampling of environments, equipped with cameras

Autonomous Underwater Vehicles (AUVs)

- Does not use a tethered and is pre-programmed
- Powered by on-board batteries
- Hydrodynamic shapes for drag minimization
- Does not have on-board manipulators
- Used for sea-bed surveys, generally equipped with sonar systems

Commercial underwater vehicles are expensive and require large deploying infrastructures

Overview of surface vehicles

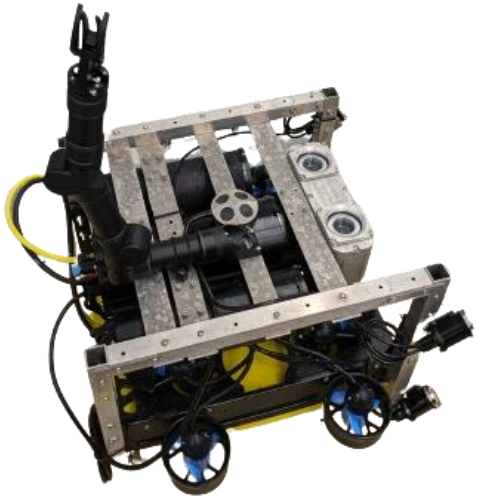
Autonomous Surface Vehicles (ASVs)

- Sit on the water surface recording oceanographic data across a range of variables
- Use various methods of propulsion, principally wave-powered or propeller driven.
- They can employ solar or wind power to enhance or completely supply their continuing power needs

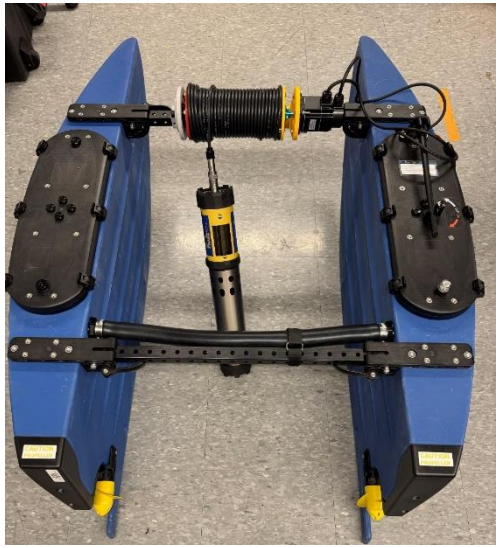
iCORE custom built marine robots

Dory2 hybrid ROV/AUV

DropSphere AUV and Bruce hybrid ROV/AUV



Underwater Vehicle-Manipulator System (UVMS)



Jenny ASV

- Address the need for marine scientists to have access to more affordable underwater robots for ocean exploration
- The miniaturization of marine vehicles leads to the reduction of sensors on board of the systems → **Challenges for autonomy**

Challenges

- Not always having predictive behaviors
  - Highly nonlinear and complex systems.
  - Large uncertainties due to the nature of the environment.
- Power limitations: thrusters usage drain the batteries very fast.
- Surface vehicles:
  - Waves
  - Obstacles and other boats
- Underwater vehicles
  - Localization degradation over short periods of time (no GPS or WiFi)

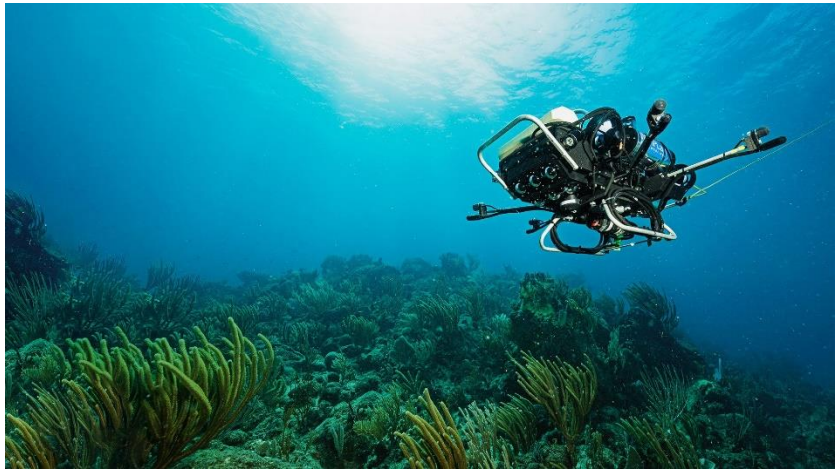
Waves pose challenges to autonomous surface vehicles

AUV survey of shipwreck

Applications for costal protection and restoration

- Environmental Monitoring and Data Collection
  - Seafloor mapping
  - Water quality monitoring
- Erosion Control and Sediment Transport
  - Bathymetric and topographic surveys
  - Modeling sediment movement
- Restoration Operations
  - Planting seagrass or mangroves
  - Deployment of reef structures
- Coastal Infrastructure Inspection
- Disaster Response
  - Post-storm damage assessment
  - Oil spill detection and tracking

ASV ChemYak monitor changes in the Artic
(Photo by William Pardis, WHOI)

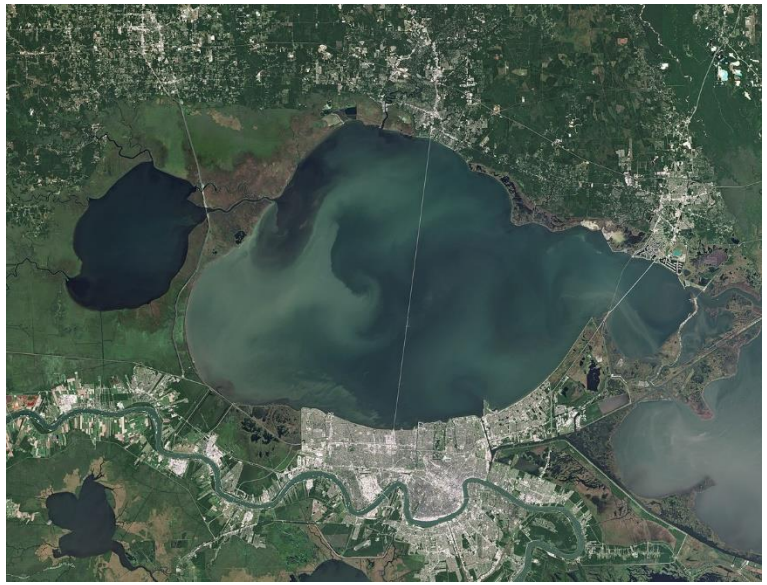


AUV CUREE uses hydrophones to listen to the sounds of coral reefs (Photo by Austin Greene, WHOI)

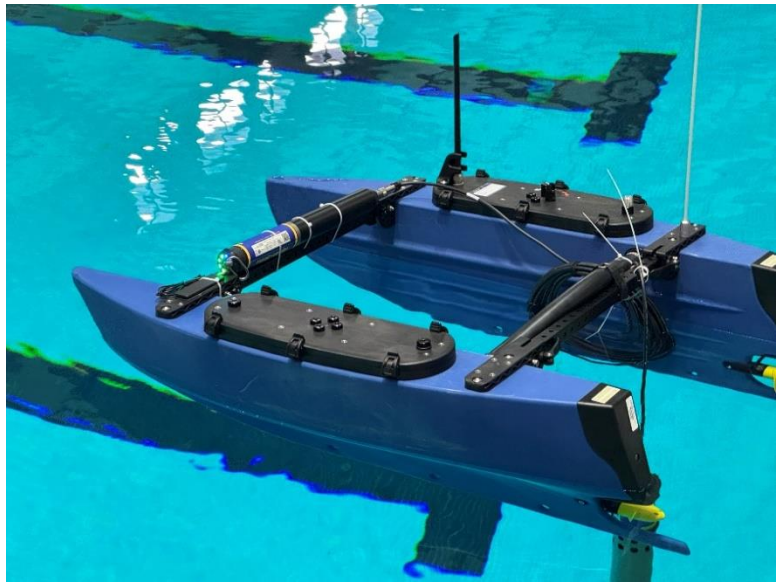
RESTORE Act Center of Excellence

Project goal

Autonomous surface vehicle (ASV) used for data collection to allow the detection of Harmful Algal Blooms (HAB) and to enable the design of predictive modelling techniques for water quality assessments.



Lake Pontchartrain testing



Jenny ASV with environmental sensors

Project started in September 2024

Jenny Autonomous Surface Vehicle (ASV)

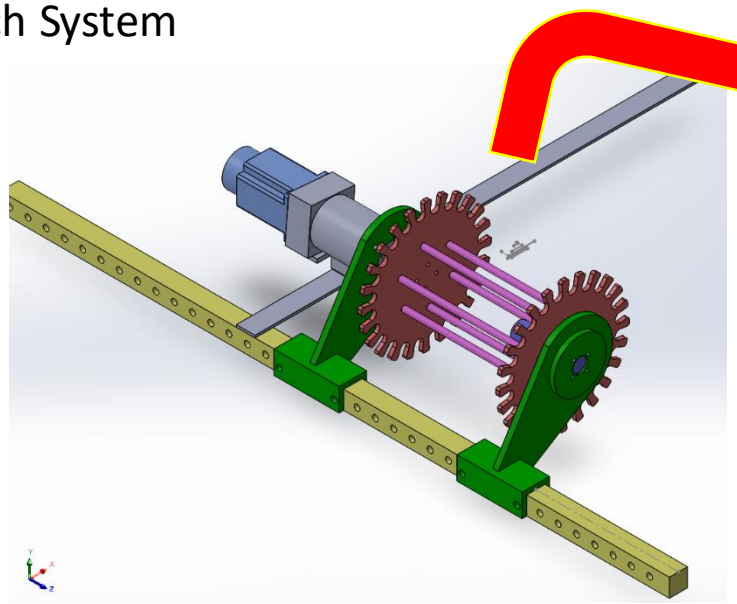
- Dimensions: 47 x 36.5 x 18 in (Length x Width x Height)
- Endurance: 6 hours with payload
- Maximum speed: 1 m/s with payload
- Navigation sensors: 2 GPS; 1 IMU; 1 compass; 1 barometer
- Communication: WiFi
- It has a pre-defined mission on board and performs that mission during deployments (no human interaction)

Jenny ASV performing an autonomous mission in the LSU Lakes

Integrating environmental sensors with Jenny ASV

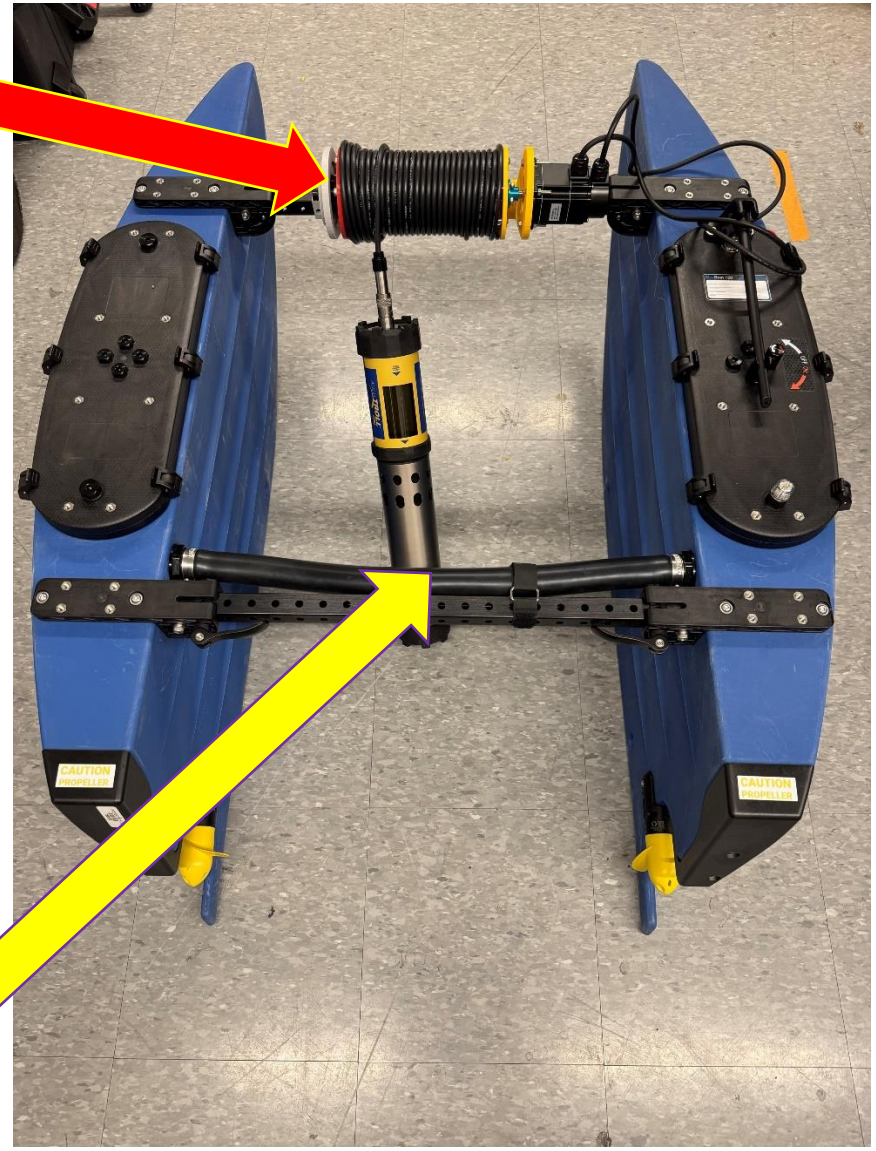
Custom Winch System

- Custom build winch system
- Driven by a stepper motor with an encoder
- Controls the environmental sensors deployment and retrieval

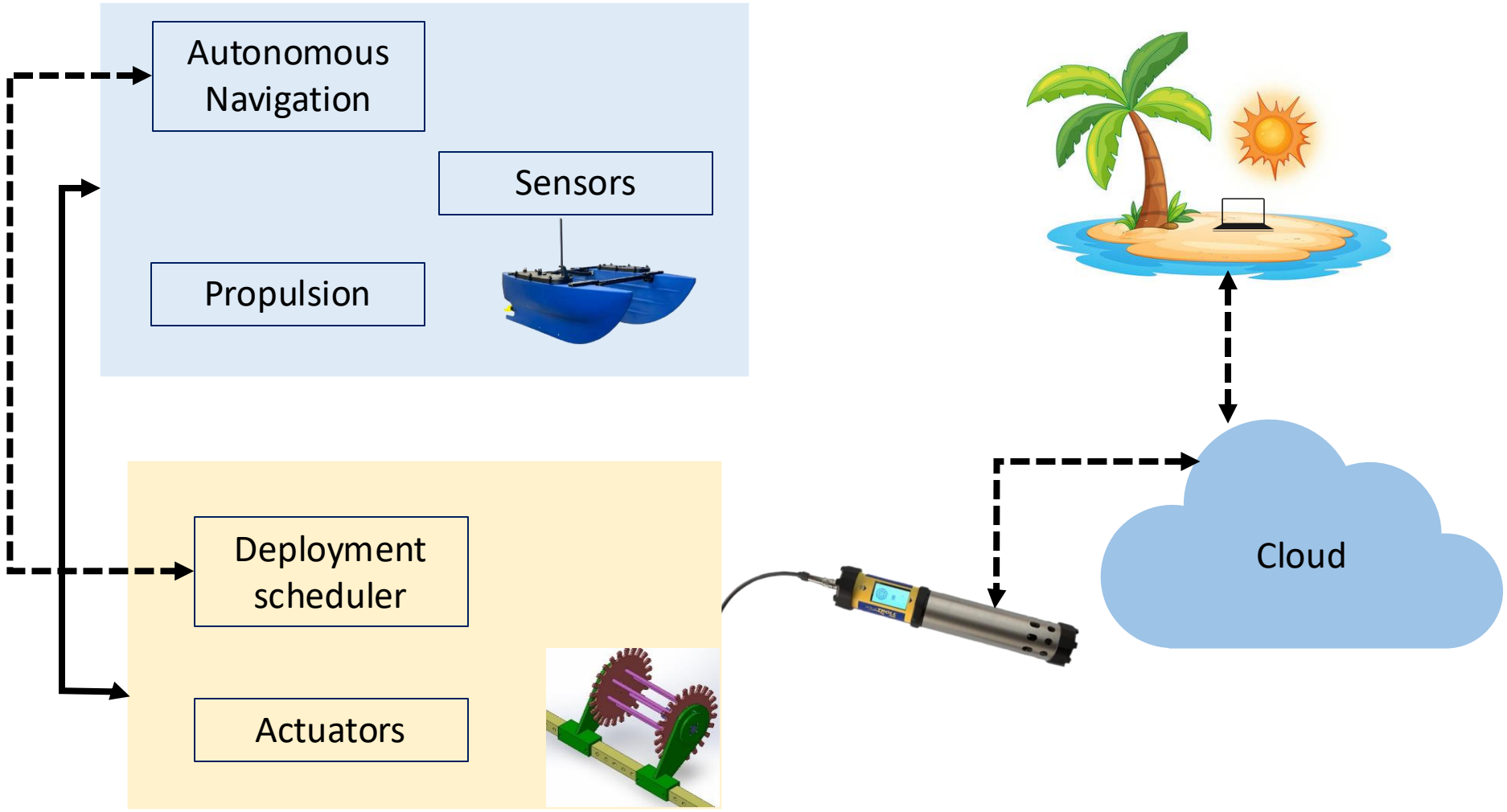


Aqua TROLL 700 Multiparameter Sonde

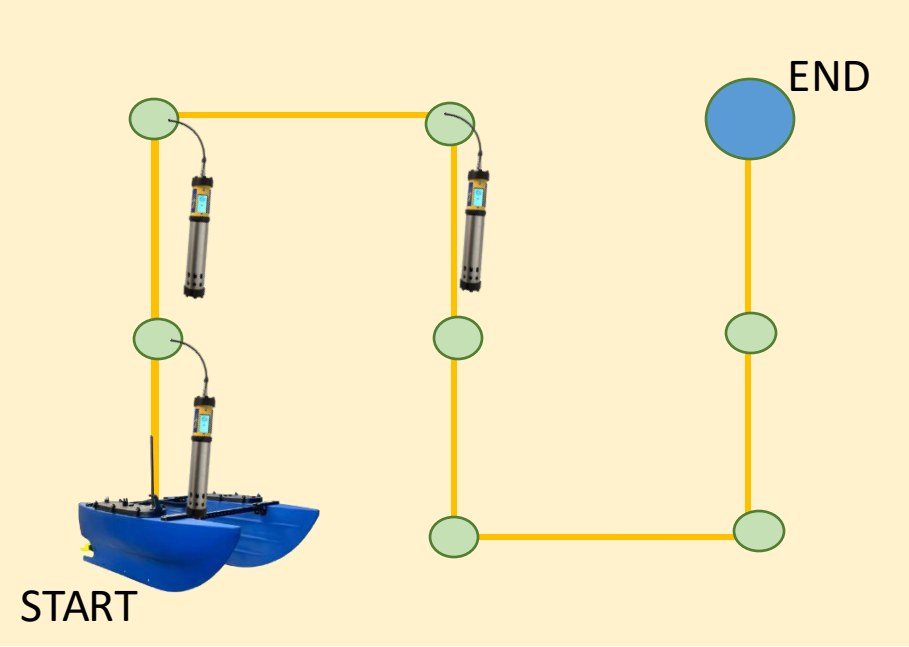
- Chlorophyll
- Phycocyanin (BGA-PC)
- Temperature/Conductivity
- Turbidity
- FDOM

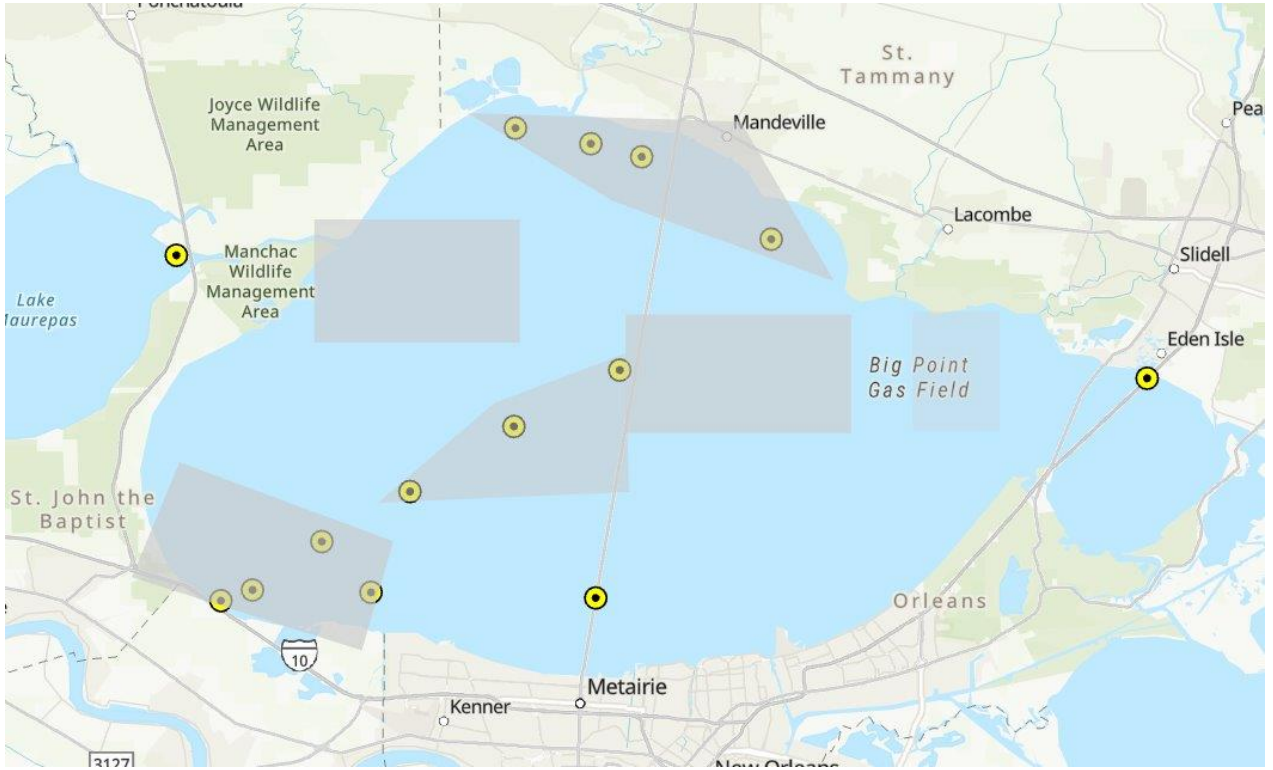


Components coordination



Deployments and Data Collection

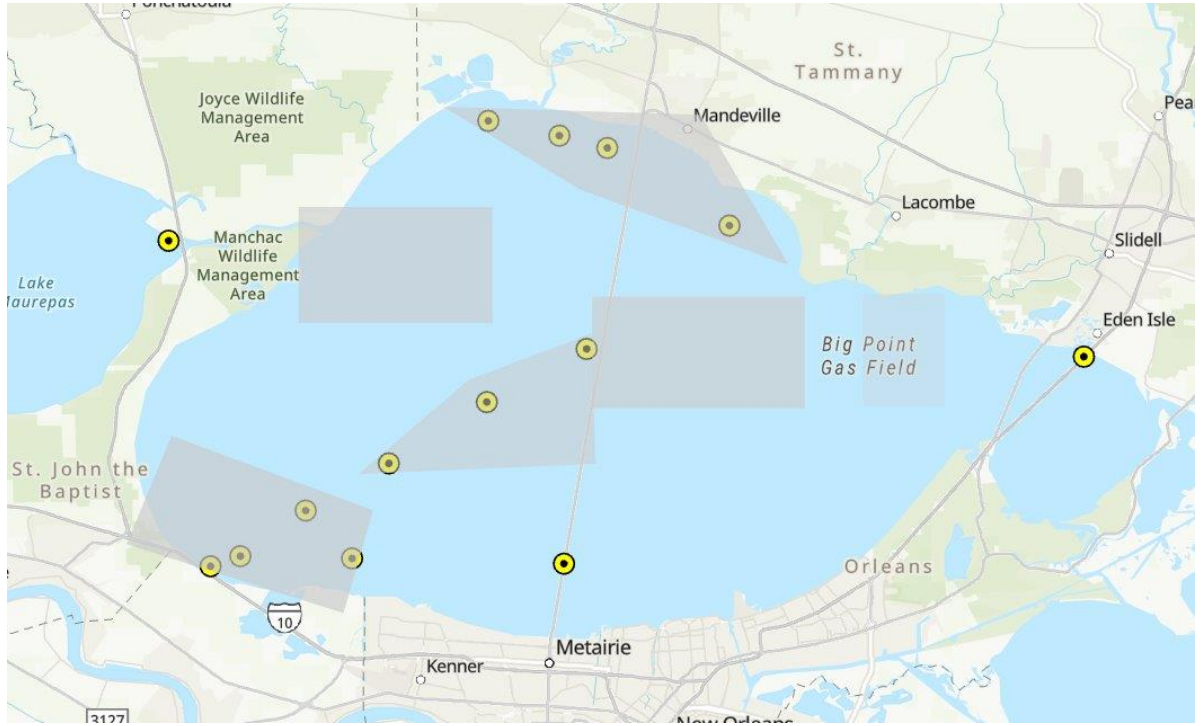




Data collection points

Deployments and Data Collection

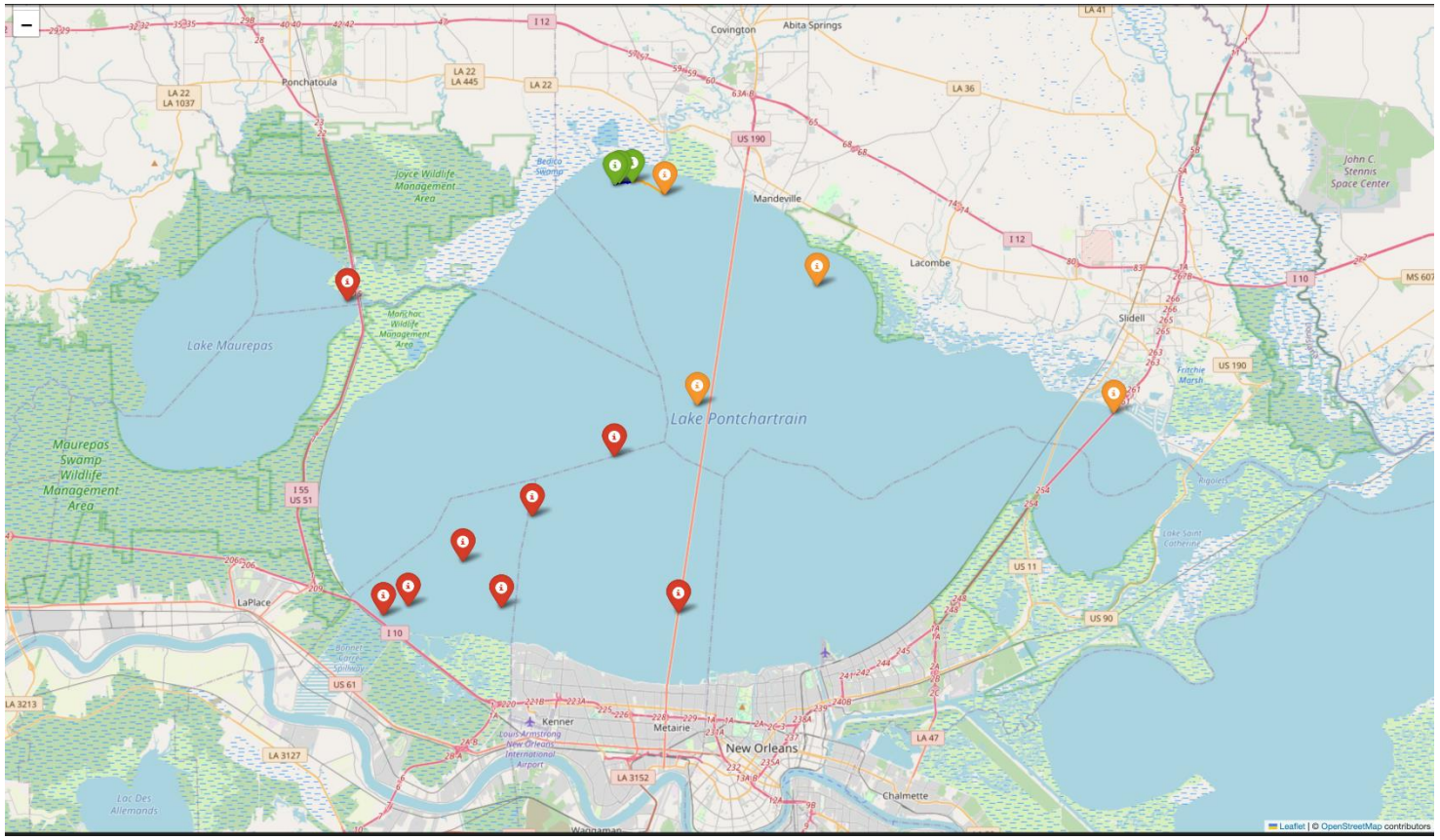
- Data collection on site in Lake Pontchartrain
- 6 areas, 14 locations, 9 waypoints per location
- Sampling at 3 different depths
- Maximum 6 hours deployments per day.
- Several deployments during the year.



Advantages of using an ASV:

- Consistency in data gathering
- Exact location sampling
- Repetitive sampling
- Can be extended to very large survey times (if integrated with solar panels)

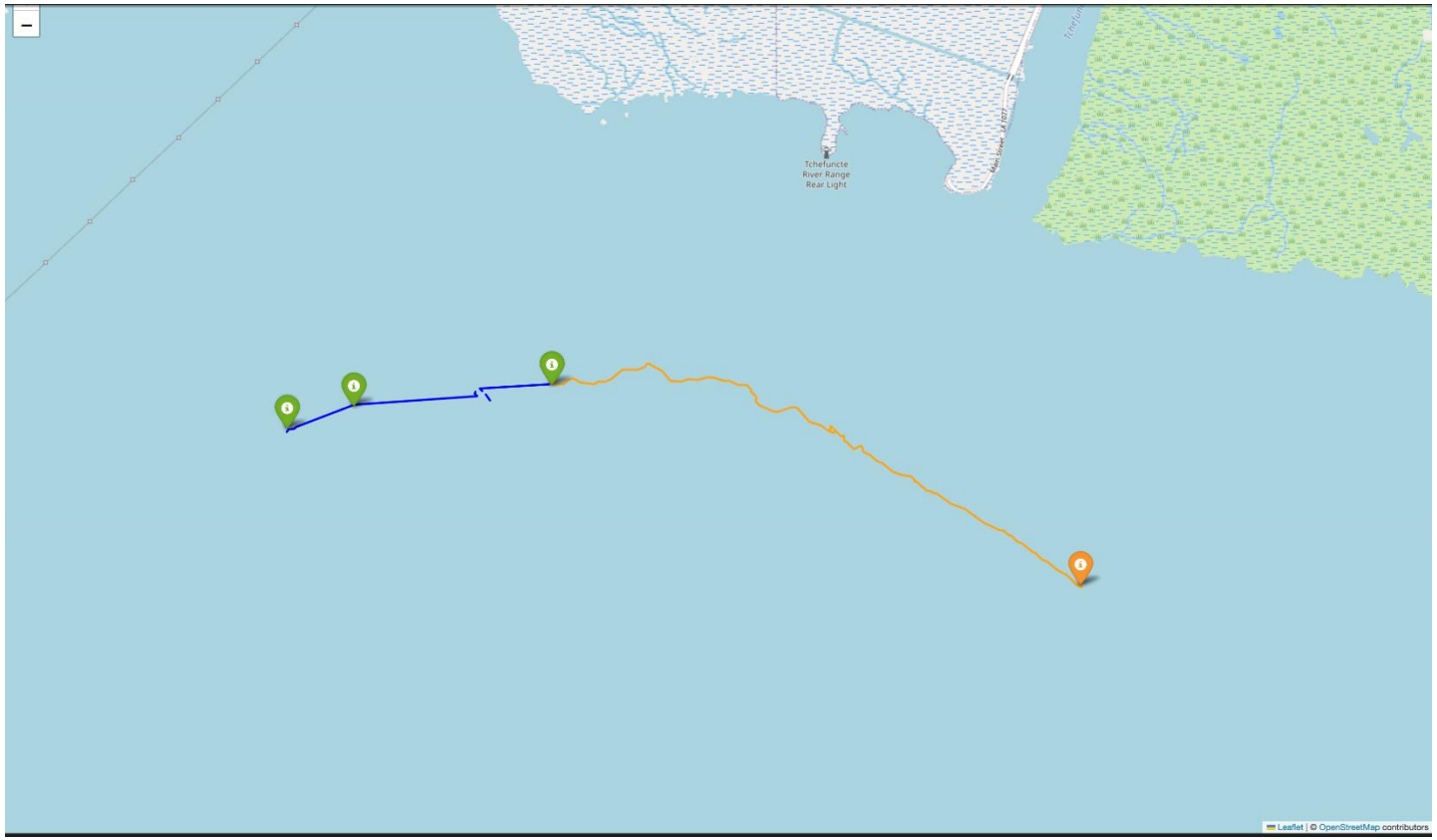
Jenny ASV Sampling @ Lake Pontchartrain



The locations planned for survey:

- Autonomously surveyed (green)
- Manual surveyed (orange)
- Not surveyed in this day (red)

Jenny ASV Sampling @ Lake Pontchartrain



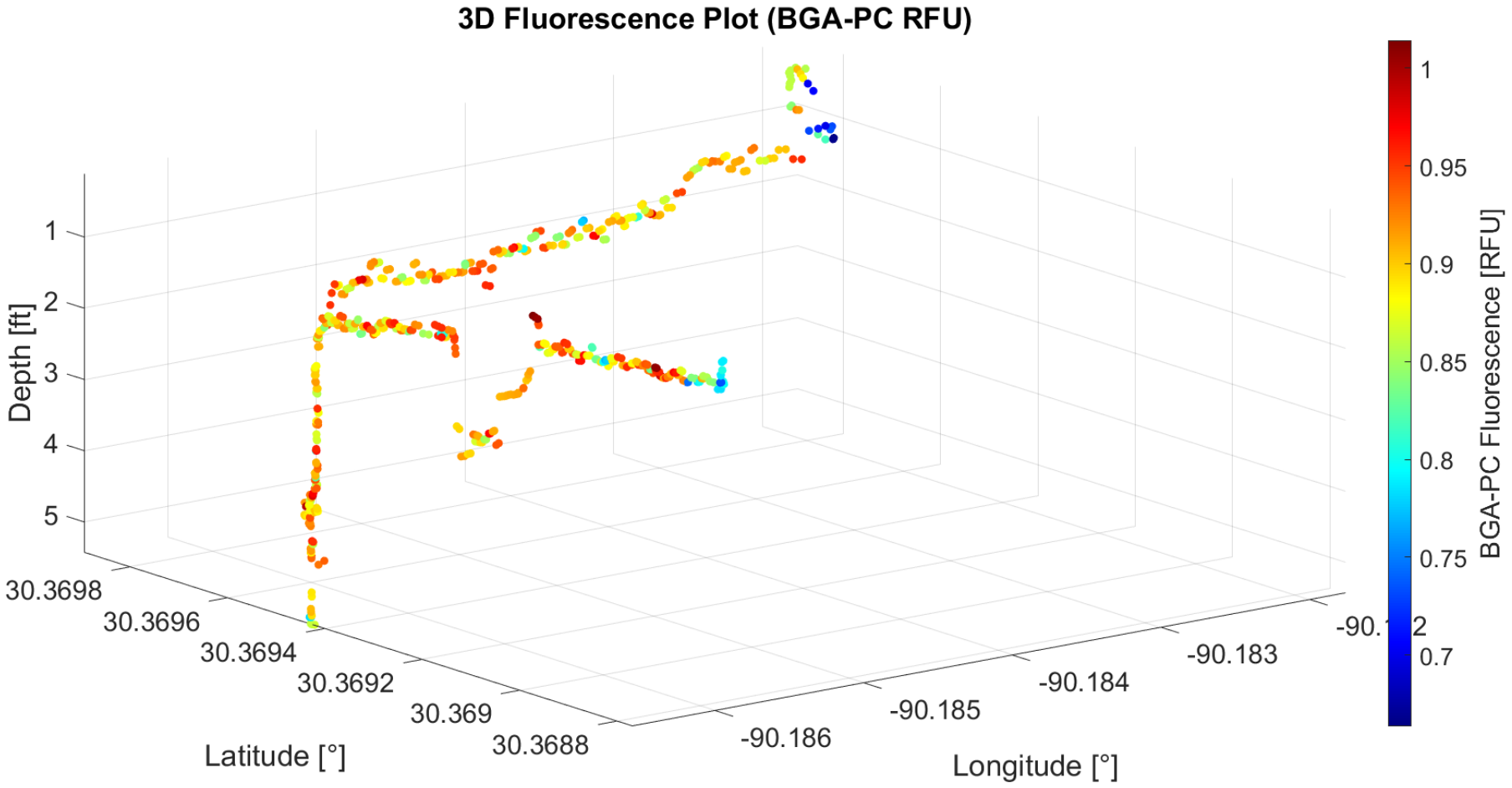
Zoomed-in on the autonomous survey:

- Autonomously path (blue)
- Tele-operated (orange)

Jenny ASV Sampling @ Lake Pontchartrain

Example of data collected on April 29th , 2025 for detecting Harmful Algae Bloom

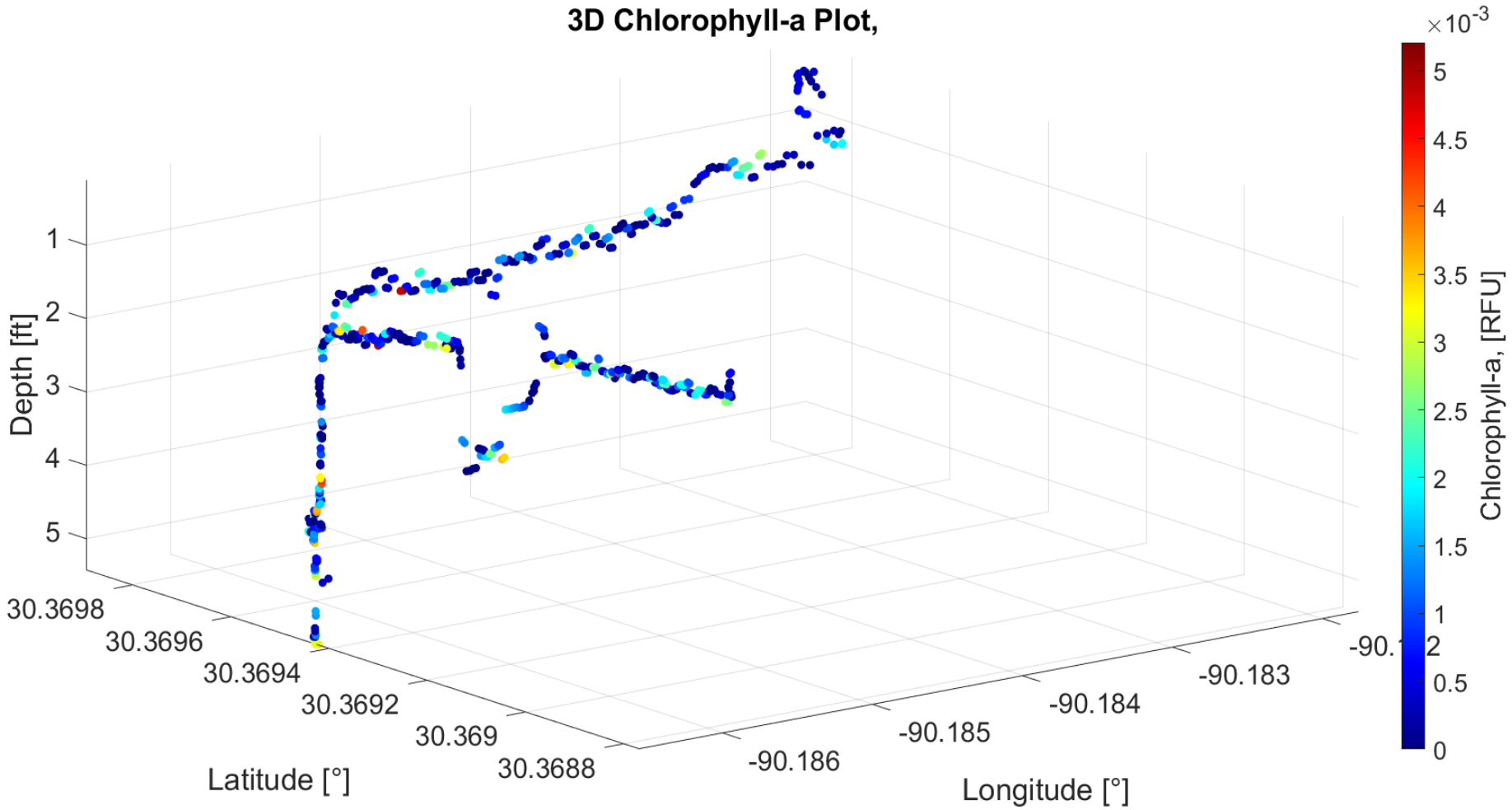
Blue-Grean-Algae Sensor Data



Jenny ASV Sampling @ Lake Pontchartrain

Example of data collected on April 29th , 2025 for detecting Harmful Algae Bloom

Chlorophyll-a Sensor Data



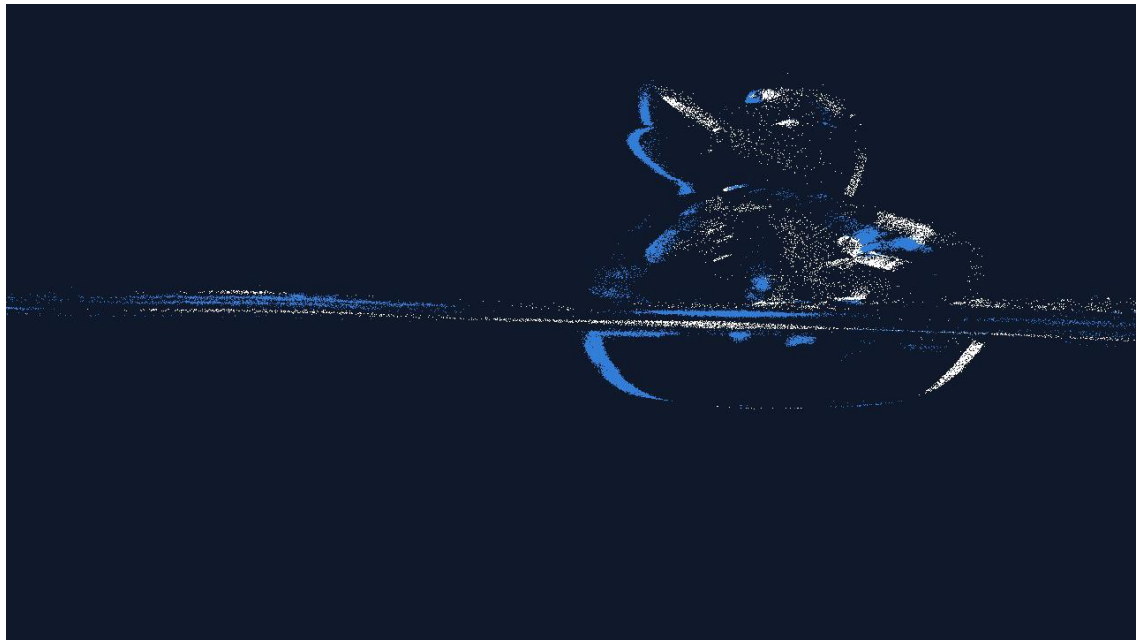
Modeling using ASV recorded data

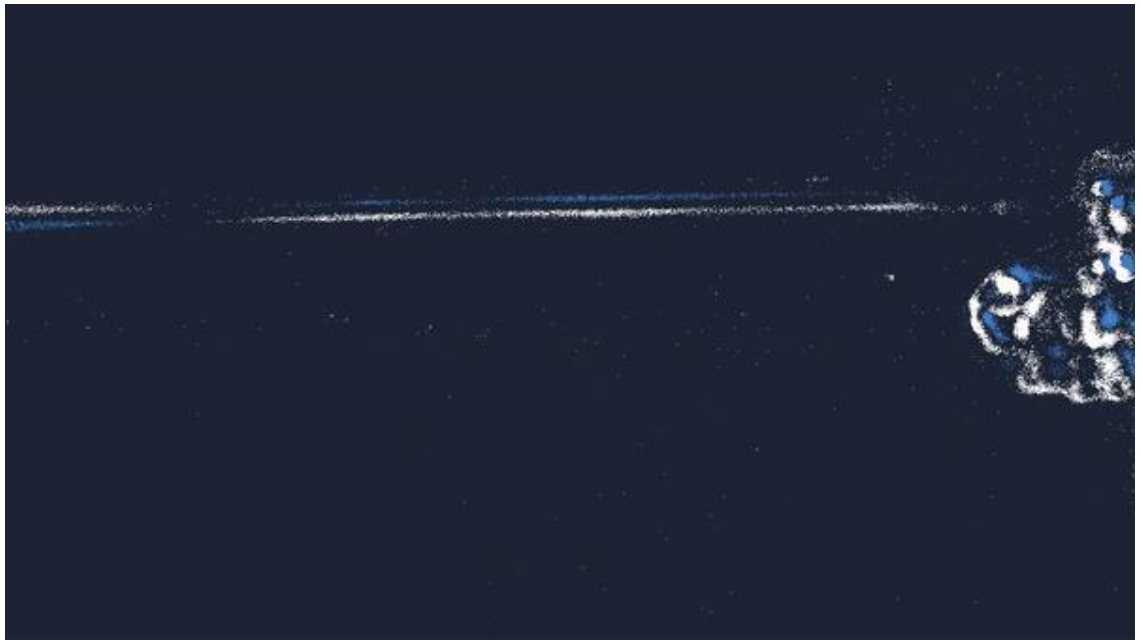
- Currently developing systematic operation plans for data centralization, synthesis, and analysis (from the various sensors)
- At the moment working on:
  - The generation of data-driven models (i.e: multiple linear regression model, Kriging Interpolation)
  - The development of a dilute species diffusion model in larger water bodies using Comsol Multiphysics and available bathymetry and GIS data for Lake Pontchartrain, as well as estimated tributary inflows.

Work lead by the Co-PIs of the project

Next steps

- Advance the software capabilities of Jenny ASV
- More data collection in Lake Pontchartrain
- Continue data analysis – modeling
- Incorporate an event-based camera into the Jenny ASV





Project team

Corina Barbalata
Assistant Professor , Department of Mechanical Engineering
Expertise: marine robotics, perception systems

Sibel Bargu Ates
Associate Dean of Academics, CC&E and Shell Professor in Oceanography/Wetland Studies, Department of Oceanography & Coastal Sciences
Expertise: Freshwater, Estuarine and Marine Phytoplankton Ecology, Harmful Algal Blooms

Dorin Boldor
Charles P. Siess Jr. Professor, Department, Biological and Agricultural Engineering Department
Expertise: bioprocessing, biofuels, and microwave heating and chemistry

Andrei Tarfulea
Assistant Professor in the Department of Mathematics
Expertise: hydrodynamics with thermal effects

W. David Constant
Emeritus Department Head & Zaki Bassiouni Professor, Department, Biological and Agricultural Engineering Department
Expertise: transport of chemicals in the environment, hazardous materials, waste sites, and water quality

Nenyi K. Dadson
Graduate student, Mechanical Engineering
Focus: vehicle/robot autonomy

Anthony Vozza
Graduate student, Biological Engineering
Focus: environmental modeling

Anthony Mocanu
Undergraduate student, Mechanical Engineering
Focus: mechanical design

Jean Paul Gonzalez
Undergraduate student, Electrical/Computer Engineering
Focus: electrical design

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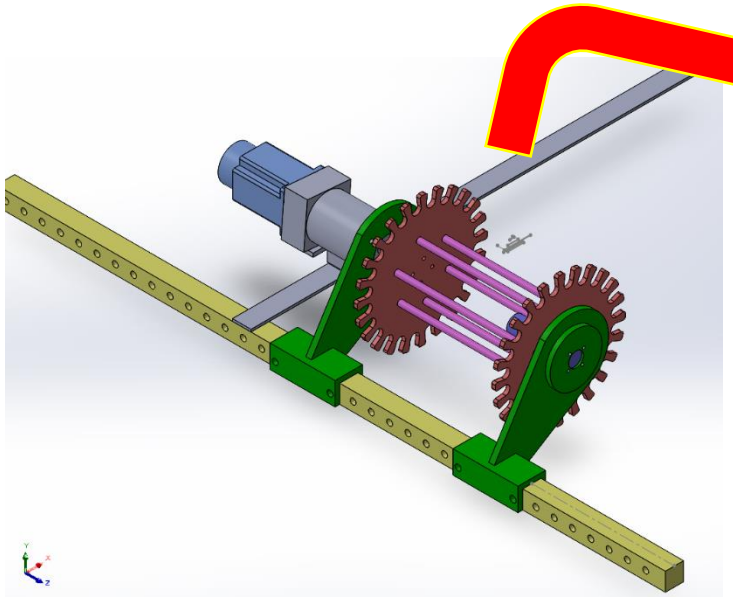
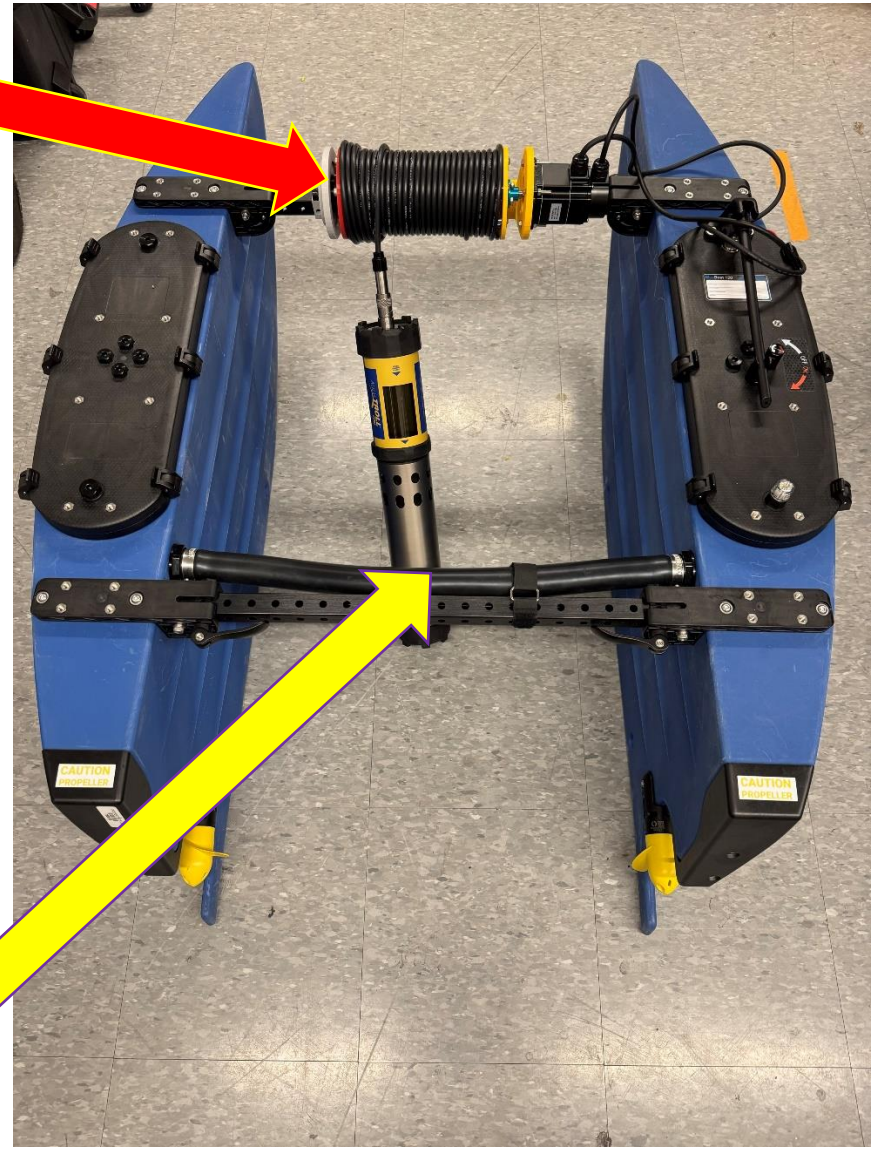
Appendix

Integrating environmental sensors with Jenny ASV

- Chlorophyll-a Fluorescence (RFU),
- FDOM Fluorescence (RFU),
- Turbidity (NTU),
- Actual Conductivity (µS/cm),
- Specific Conductivity (µS/cm),
- Salinity (PSU),
- Resistivity (Ω * cm),
- Density (g/cm^3) ,
- Total Dissolved Solids (ppt),
- BGA-PC Fluorescence (RFU),
- Nitrate ([NO_3^- -N) (mg/L),
- Nitrate (mV),
- Temperature (◦F),
- Barometric Pressure (mm Hg)
- Pressure (psi), Depth (ft),
- External Voltage (V),
- Latitude/Longitude measurem

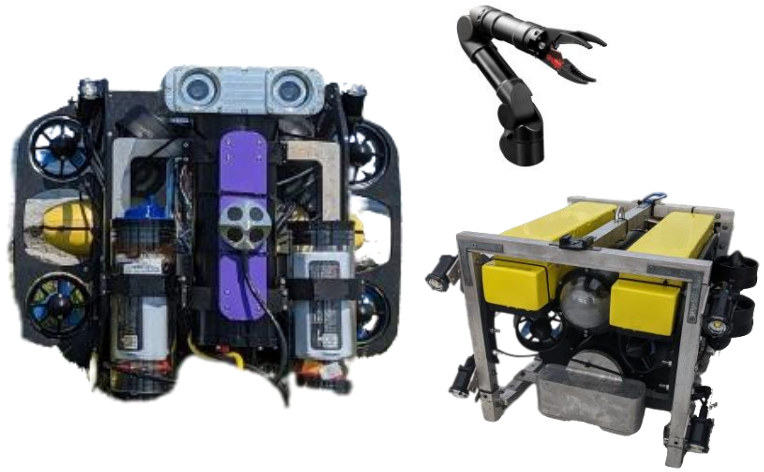


Aqua TROLL 700 Multiparameter Sonde

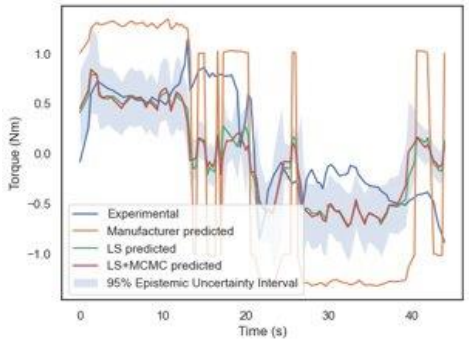


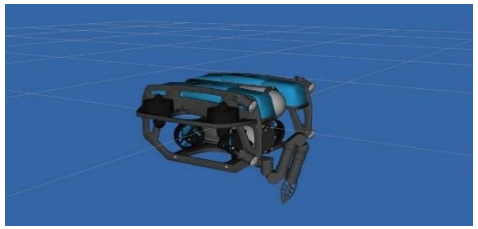
Autonomous Marine Robotics Research @ LSU

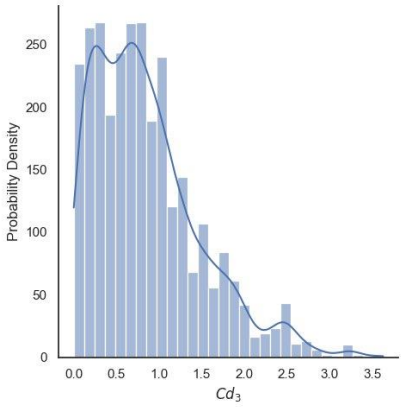
System integration and customization



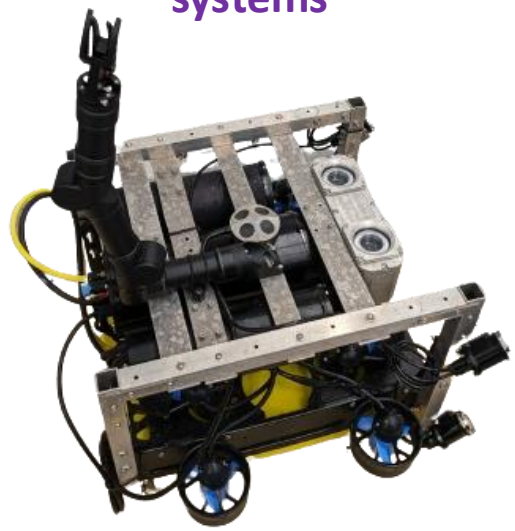
Dynamic modeling



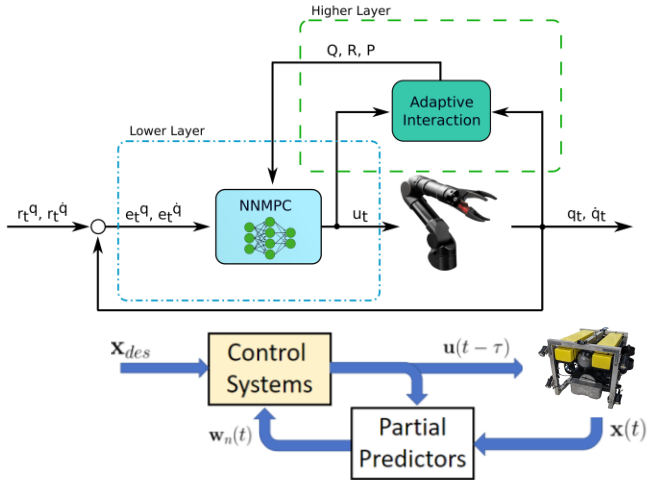




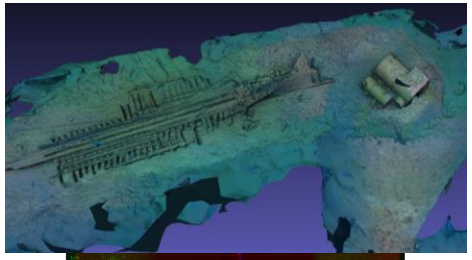
Autonomous energy-efficient small-sized underwater vehicle-manipulator systems

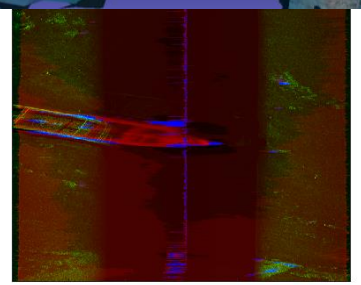


Model-based control systems



Perception systems for enabling autonomy





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