

# Student-Run Autonomous Vessel for Oceanographic Research

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Mechanical Engineering



CAL MARITIME

# Outline

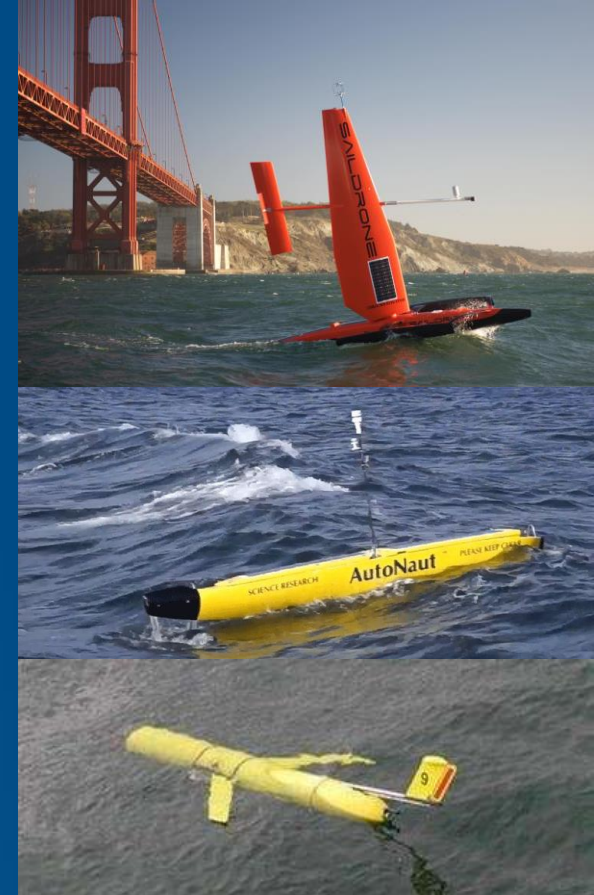
- Autonomous Vessels
- Our project
  - History
  - Mission
  - Design
  - Operation
- Results
  - Typical Data
  - Operational lessons
- Future plans and needs
- Video
- Questions and discussion





# Autonomous Vessels

- Autonomous systems (drones)
  - Dirty
  - Dangerous
  - Dull
- Different from remotely piloted
- Many examples of small vessels
- Active research field
- Autopilots found on most crewed vessels both commercial and private



Images:

[www.saildrone.com](http://www.saildrone.com)  
[www.autonautusv.com](http://www.autonautusv.com)  
[www.who.edu](http://www.who.edu)  
[yacht pals.com](http://yacht pals.com)



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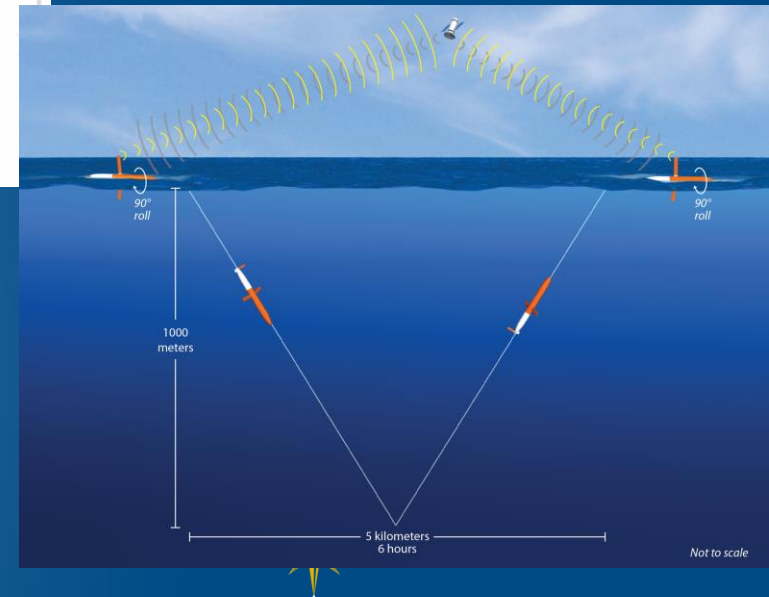
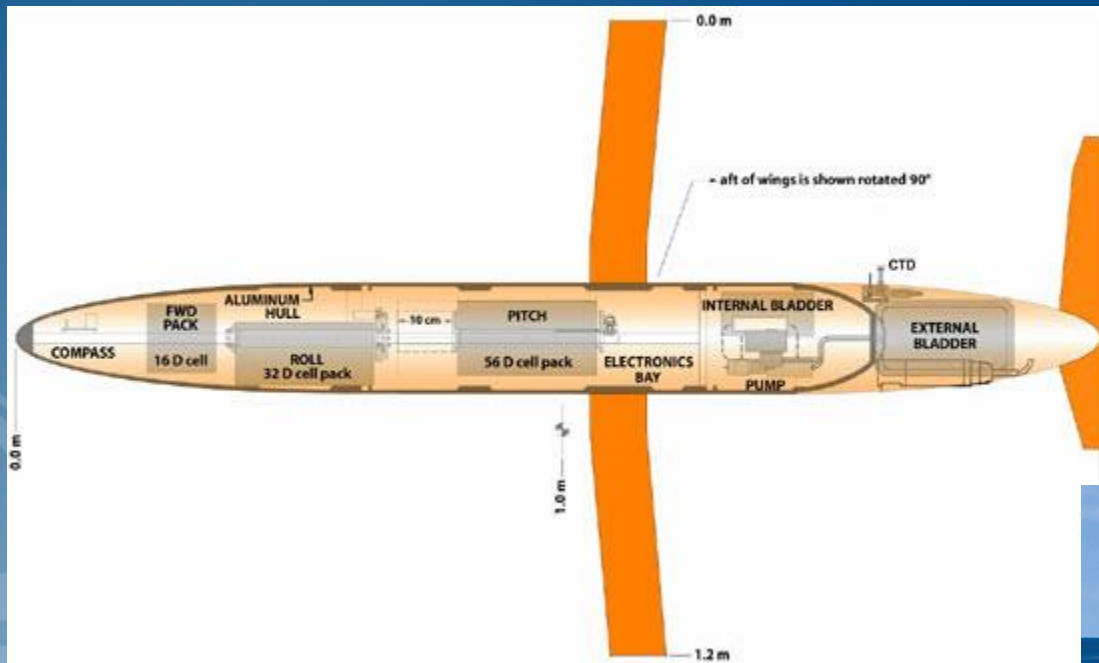
# Sail Powered



<http://abersailbot.co.uk/>

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# Underwater



<http://www.whoi.edu/main/spray-glider>

# Surface Research Vessels



<http://www.autonautusv.com/>



# Autonomous Shipping

- Recent program at Rolls-Royce
- Norway has established a test zone (Trondheimsfjord)
- This scale brings up issues of economics and ethics along with the technological challenges.



# Dumbo Mission

- Built and operated by students
  - Use off-the-shelf autopilot
  - Hobby grade hardware
- One hour voyages in Carquinez Strait
- Deliver accurate oceanographic measurements





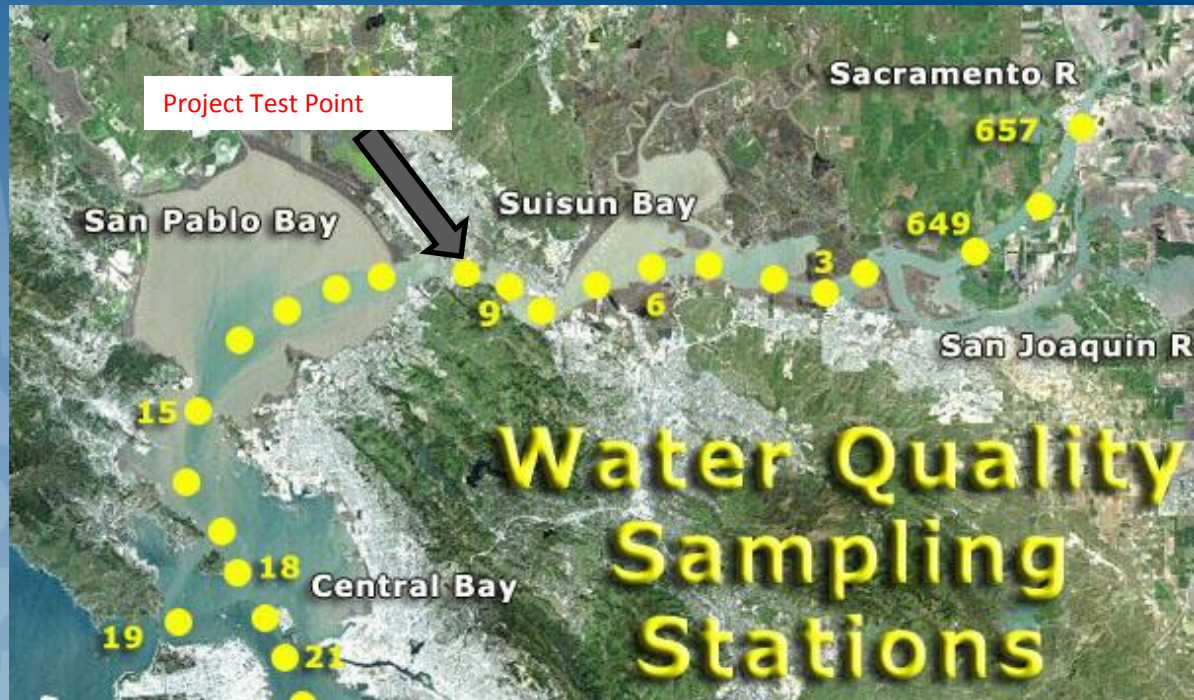
# USGS Survey Vessel (Crewed)



**US Geological Survey: R/V David H. Peterson**



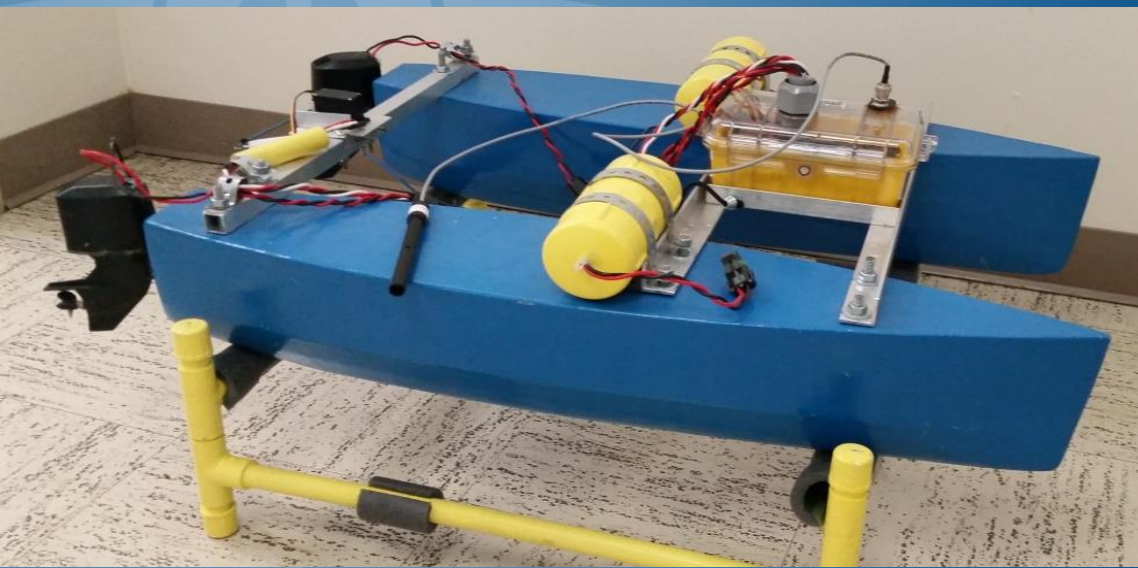
# *Dumbo* Mission Design Test Location



"Where Are Measurements Made? - USGS Water Quality of SF Bay." *Where Are Measurements Made? - USGS Water Quality of SF Bay.* N.p., n.d. Web. 08 Sept. 2016.

# *Dumbo* History

- First version: Mechanical Engineering Capstone project
- Remotely piloted
- Solid foam hulls with externally mounted gear





# History- Rose Hendrix

- 2014 COAST funding to add autonomous systems
- Existing hulls hollowed out to put systems inside



# History- Jake Steiner

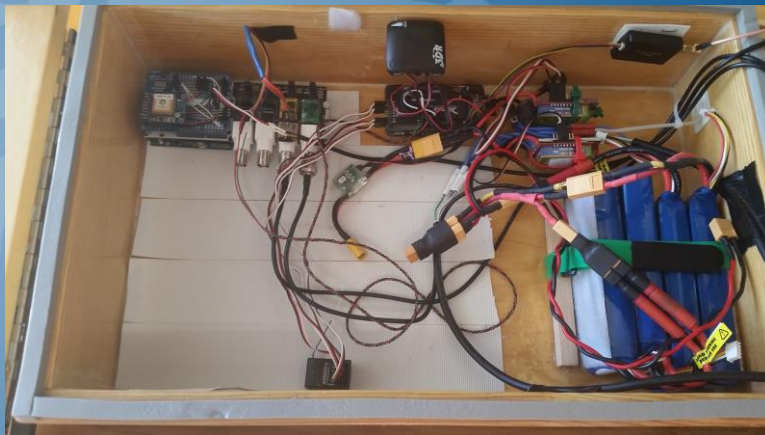


- 2015 COAST funding
  - new hulls
  - new propulsion
  - more sensors



# *Dumbo Construction- Student Built*

- Wooden/fiberglass construction
- Hobby ROV thrusters
- APM open source autopilot system
- Payload system measures Temperature, Salinity, Dissolved Oxygen
- Measurements at specified waypoints
- Data is stored on SD card





# APM (Ardupilot) Autopilot

- Multirotor drone guidance package: GPS, compass, attitude sensors, telemetry
- Ground vehicle firmware for boat
- Several control station options
- Open source hardware and software
- Documentation is disorganized, takes time to understand the complex system



Images:  
<http://ardupilot.org/>

# *Dumbo* limitations

- Only GPS/Compass sensor
  - No collision avoidance (operator responsibility)
  - No route checking (operator responsibility)
- A Captain is required for safe operation
- Configuration is sensitive to debris pickup
- Maintenance and reliability





# Operations: Path Planning





# Planned Path



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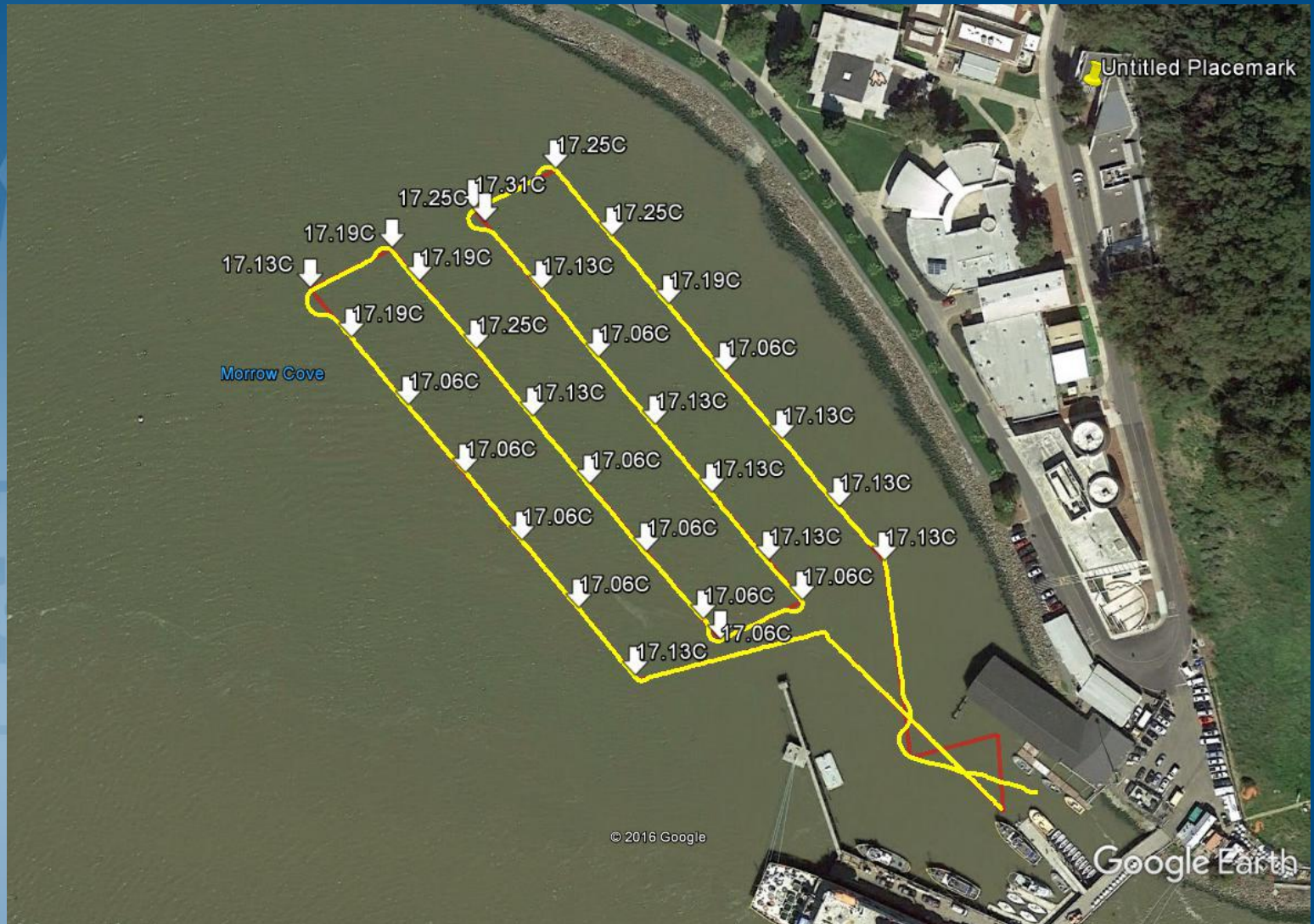
# Navigation Results



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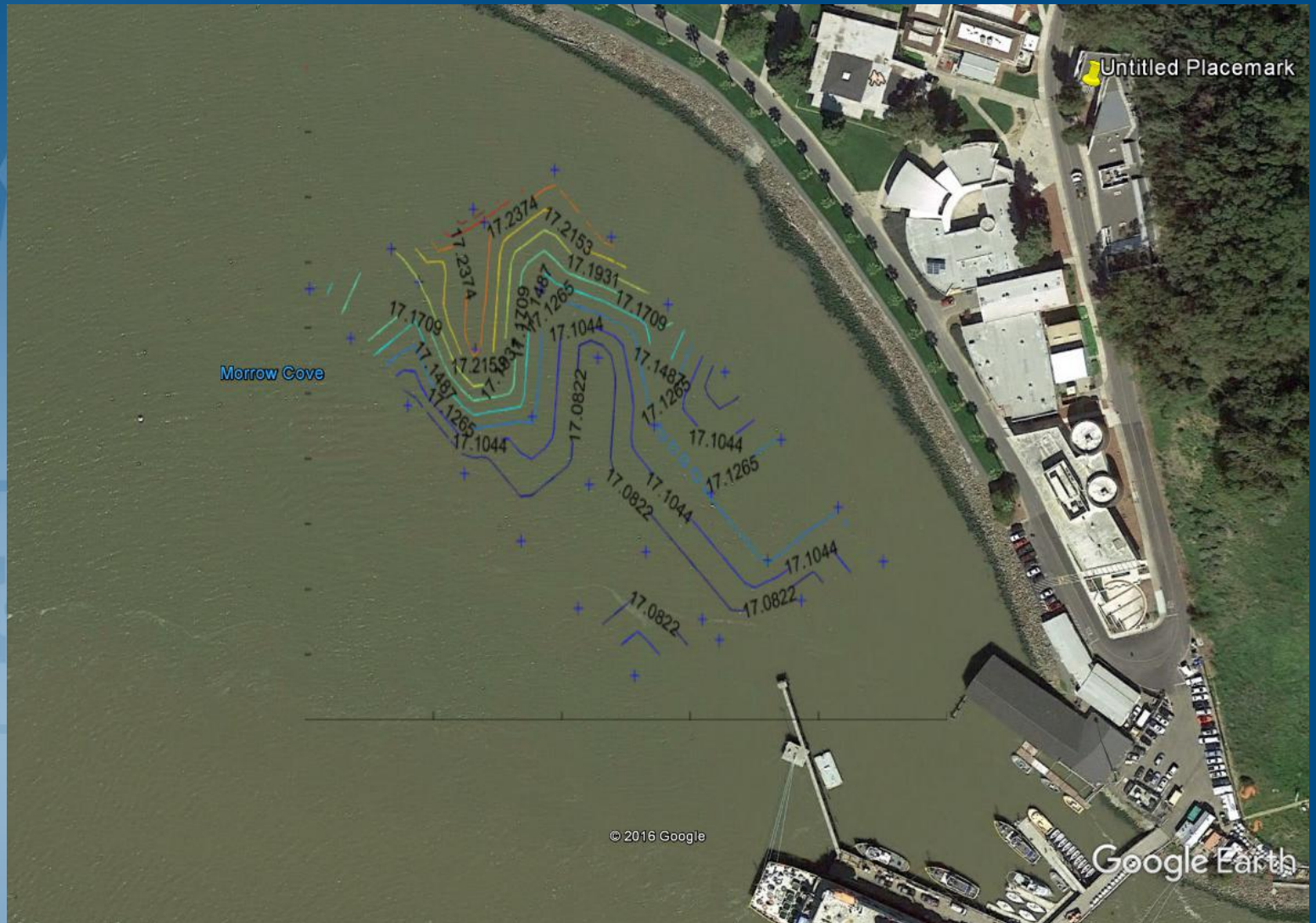
# Oceanographic Measurements (Temperature)



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# Isotherms



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# USGS Survey Point (#9)





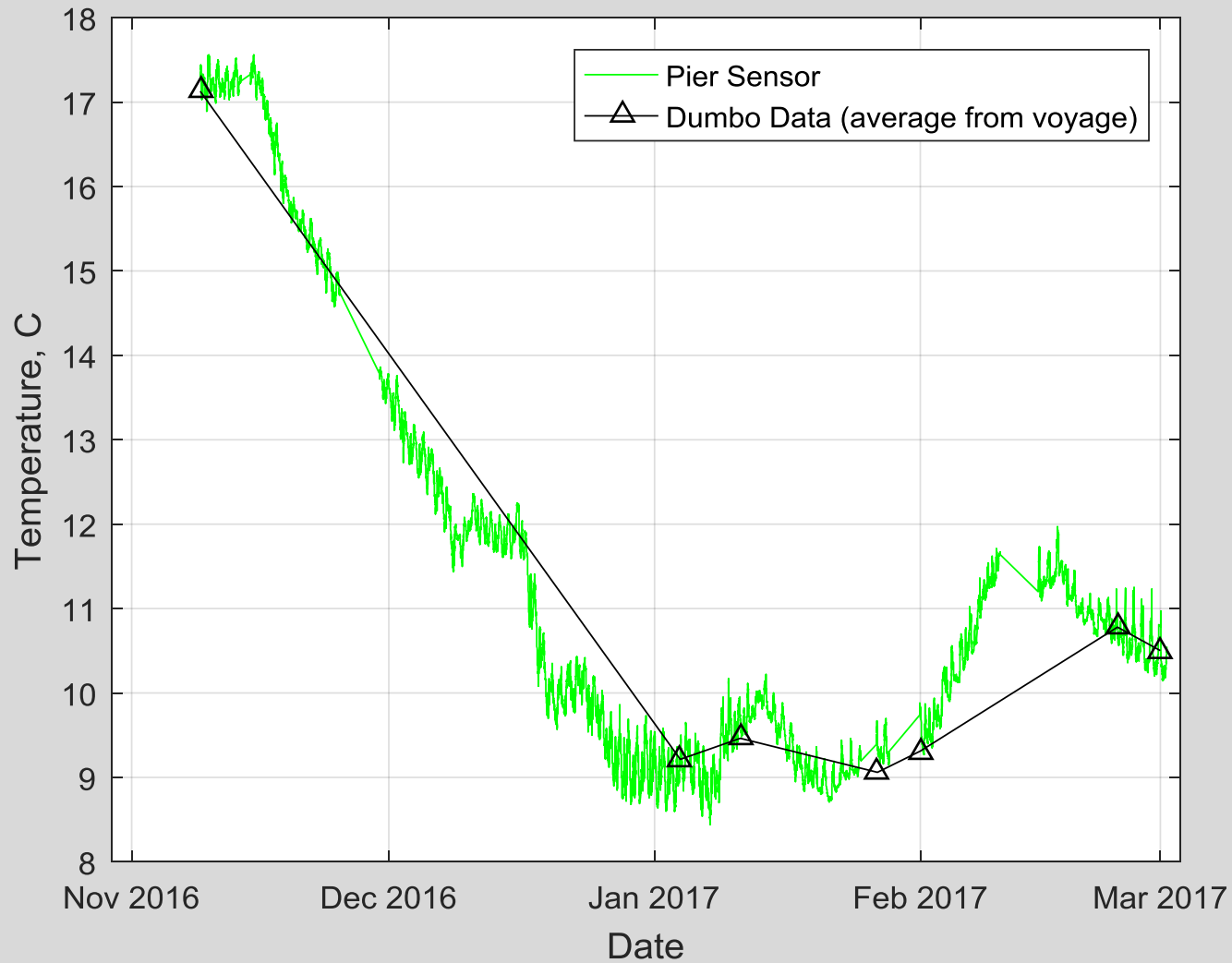
# Operational Observations

- Aiming for weekly operations 2016-2017
- 10 runs in 18 weeks Nov-Feb
- Reliable Boat and Systems
- Operations canceled for:
  - Winter break
  - Busy students or faculty
  - Rain (operator preference-boat is fine)
  - Debris fields





# Temperature Data 2016-2017



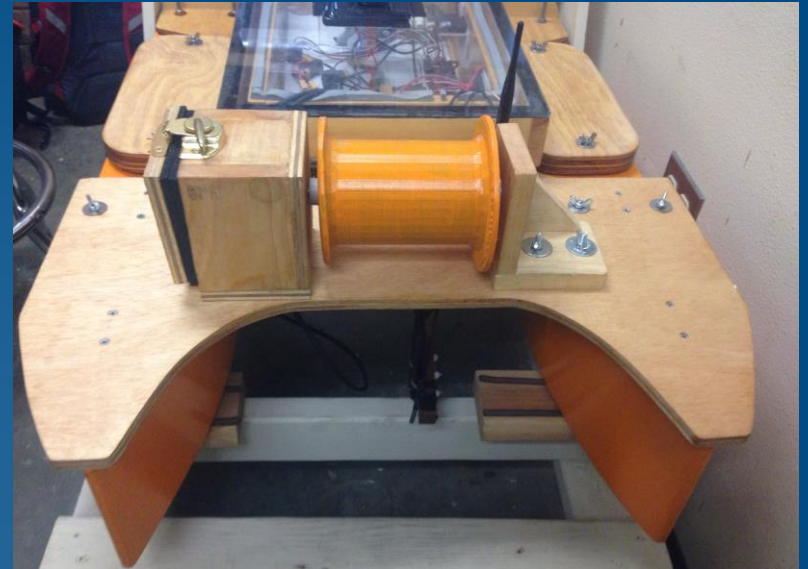
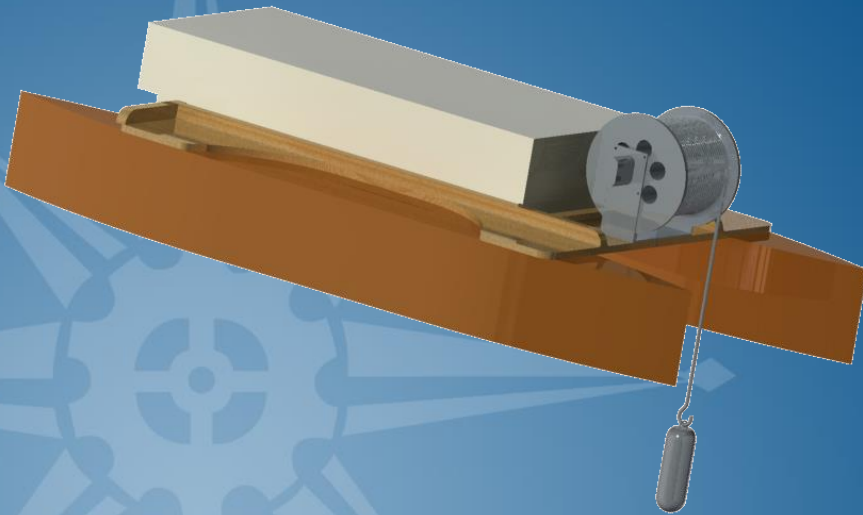
# Future Goals

- Volunteers welcome: [mholden@csum.edu](mailto:mholden@csum.edu)
- Students to operate the boat regularly
  - Quality oceanographic observations for scientists
  - Record of operations/maintenance for engineers and economists



# Future Work

- 2016-17 Capstone project
  - New sensor payload for measurements at depth



- Next boat: what is your mission?



# Follow the voyage



# Thanks

- Students
  - Rose Hendrix
  - Jake Steiner
  - Alec Safreno
  - Brian Haug
  - Jordan Escarcega
  - Brian Kuan
  - Kaelan Schorger
- CSU COAST
  - Alex Parker
  - Rich Muller
- Boathouse staff
  - Bob Brown
  - Leo Baclig
  - Jack Lavariega
  - Oleg Kilafly