Distributed Robots for Aquaculture (and some other related technologies)

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Presentation Outline

Topics:

- WHOI vehicles
- Aquaculture tasks (solicit suggestions)
- Low-cost ROVs, AUV, and hybrids
- Autonomous Surface Vehicles
- Imaging systems
- Integrated observing systems
- Coastal Profilers
- Power Generation
- Short range radars

Questions:

- How might these apply to aquaculture?
- What are the needs for different aquaculture domains (inshore, offshore, fin fish, shellfish, etc)?



"throw it against the wall and see what sticks"

Deep Ocean Vehicles Operated by WHOI











The Latest Hot Vehicle: MBARI's Tethys Long-Range AUV

- 2.3 m long, 0.3 m (12") diameter, 110 kg dry weight.
- Propeller-driven: 0.5~1 m/s speed. Buoyancy engine enables neutral buoyancy and drift mode.
- Low-drag and low-power design: 2000 km at 1 m/s, 4000 km at 0.5 m/s.
- Example sensors: CTD, DO2, nitrate, fluorescence/backscatter, ADCP, turbulence sensor, water sampler (in development), and Environmental Sample Processor (in development)





Robotics Tasks and Technologies for Aquaculture

Task	Vehicle Type	Other Technologies
Water column survey/observing	AUV	Integrated observatories, Specialized imaging systems Sampling systems
Inspection (Nets, etc)	ROV, hybrid vehicles	
Mort removal	ROV/AUV?	
Net cleaning	ROV	
Predator detection/removal	ASV	Short-range radar Laser-based devices
Security	ASV	Short-range radar

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Low Cost ROVs (credit Teledyne Seabotix)





Low-cost, Modular AUVs



Bluefin Sandshark



Riptide Autonomous Solutions (\$10k)

Modular, open-source



AUV Docking WHOI and MBARI examples





- Recharges batteries and provides high-bandwidth coms and parking.
- Dock low cost complexity on vehicle.
- Homing successfully demonstrated at sea (2km range).



Autonomous Surface Vehicles



Unmanned Marine Systems

WHOI Jetyak







Waveglider Liquid Robotics



National Deep Submergence Facility AUV Data Products



Fine-scale bathymetry



Near-bottom chemical mapping with Tethys Mass spectrometer



3D photo reconstruction



Plume mapping



AUV Water Column Surveys: Hydrocarbon Plume from the Deepwater Horizon at 1100m depth



MBARI's Gulper AUV maps the deep plume from Deepwater Horizon (NOAA Ship Gordon Gunter cruise GU-10-02, 2010)



WHOI's AUV Sentry maps the hydrocarbon plume with the Tethys mass spectrometer (Camilli and Duryea, 2009)



AUVs can sample!



MBARI's Gulper AUV with sampler



SUPR on Remus (more later from Annette Govindarajan)

SUPR on Sentry



Plankzooka on Sentry



Long range vehicles, improved sensors MBARI Tethys has demonstrated 1800 km missions

Robotic Microbiology Lab (ESP) on Tethys AUV



Scholin, Birch, James Bellingham, and Hobson

Zhang et al, 10th International Mine Warfare Tech Symposium,





Imaging systems



Cpics **Continuous Particle Imaging and Classification System:** Grossmann, Gallager, Mitarai 2015



Imaging Flow Cytobot: Olson, Sosik 2007 Used to detect harmful algal blooms Tech Transfer to McLane



Imaging Systems 2





SIPPER (Remson 2008)



Video Plankton Recorder (Davis)

Net cleaning by robot: possible?



HullBug hull cleaning ROV US Navy



KeelCrab hull cleaning ROV

Many other examples online



Ultrasonic cleaning and monitoring?

The CLEANSHIP project proposes a novel, harmless and cost effective solution for fouling prevention without the need for taking a ship out of service. The solution is to deploy long range ultrasonic plate waves travelling throughout an entire ship hull below the water line in order to be able to (i) prevent or slow down the accumulation of fouling. (ii) achieve a continuous monitoring to allow earlier and cheaper removal.

http://cleanship-project.eu/sample-page/



Autonomous Ocean Sampling Network (AOSN)









Ocean Observing Initiative Pioneer Array



- Located on the shelf break in the Middle-Atlantic Bight south of Cape Cod, Massachusetts.
- AUVs: Sample the frontal region
- Gliders: Resolve mesoscale features on the outer shelf and the slope sea



Coastal Profilers







McLane Profiler



Observatory technology



Ocean Cubes (Gallager et al)



Offshore Power Sources



MBARI PowerBuoy

OOI Pioneer Array Surface Mooring

- Wind
- Solar
- Methanol Fuel Cell



Predator detection/Control

Stingray Automated video/laser delousing:

http://en.stingray.no/page/6024/Video





Predator detection/Control

Automated video/laser delousing:

http://en.stingray.no/page/6024/Video

Integrated laser and parametric acoustic system https://youtu.be/YwnEAu_NheE



Short Range Radars



MIT OCW Course: Build a Small Radar System Capable of Ranging, Doppler, and Synthetic Aperture Imaging







Detecting Birds: Doppler Short-Range Radar

Current uses; law enforcement and motion sensors:



Doppler door opener:



Incredible results when tied to modern signal processing:



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