Northeast Sustainable Agriculture Research and Education

DEVELOPING THE OYSTERBOT FOR OYSTER CAGE RETRIEVAL

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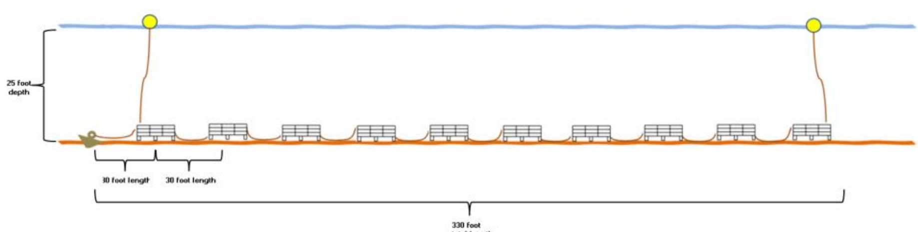
The Problem:

- Vertical lines in the marine environment are under intense scrutiny in areas where there is risk of entanglement with marine megafauna.
  - i.e. buoy marker lines
- As shellfish aquaculture moves into deeper waters, the challenge is to reduce or eliminate vertical lines in those areas
- Case in point:
  - Blue Stream Shellfish has a licensed growing area (Seal Rock Farm) that is in the vicinity of megafauna entanglement risk
    - In the eyes of the regulatory agencies
      - No whales reported in this area over the past 50 years, that I can find
      - Occasional leatherback & loggerhead sea turtles have been observed
  - Federal Army Corps license was conditioned to reduce the number of vertical lines by one-half and remove them entirely if possible.
  - State license required 600 lb breakaway links on vertical lines

Blue Stream Shellfish – Seal Rock Farm

Seal Rock Farm Operations



- Originally proposed
  - 3 x 3 bay wire cages
  - 10 cages per trawl line = 90 oyster bags per line
- Evaluating
  - Four 3 x 3 bay cages merged into one unit = 36 bay cage
  - 3 cages per trawl line = 108 oyster bags per line

Question?

- Can we retrieve cage trawls without any surface buoy markers?

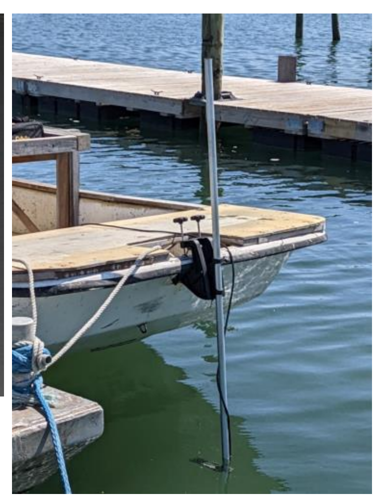
- Option 1:
  - Grapple for the trawl line to retrieve cages
  - A random chance to snag the cage/line
  - Even more random that one snags a targeted line
  - Potential to damage a cage if grappled incorrectly

- Option 2:
  - Locate the targeted cage from the surface
  - Deploy a tool to retrieve the targeted cage
    - Cue the "OysterBot"

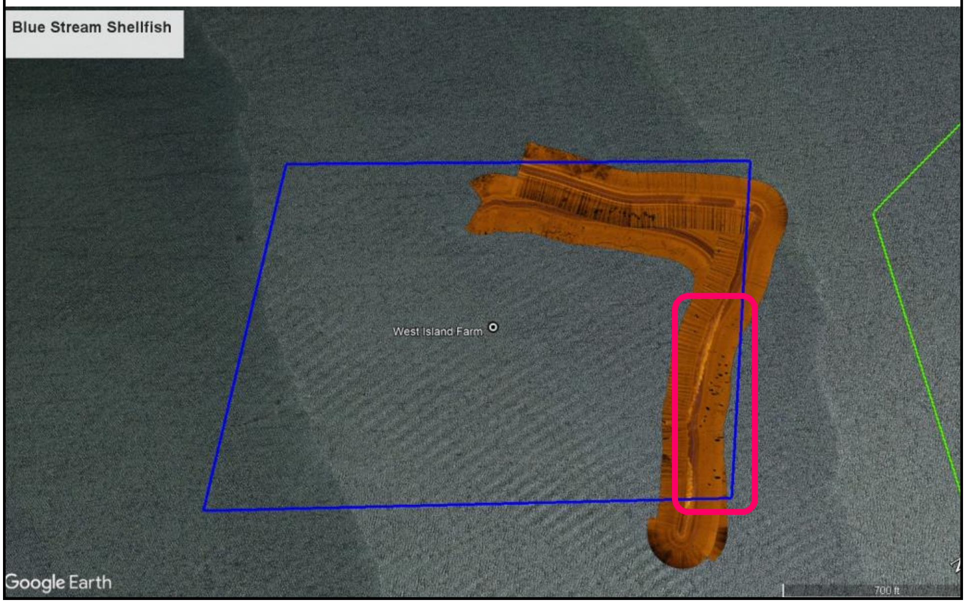
Locate cages from the surface?

- Previous NSA talk "Can a fish finder find more than fish?"

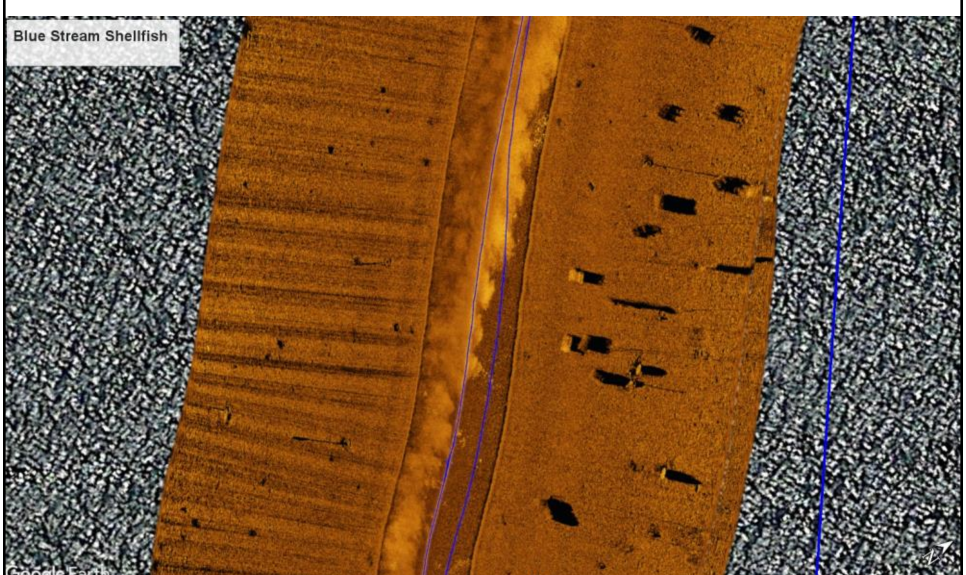
SAR HAWK
FIND WHAT YOU'RE MISSING



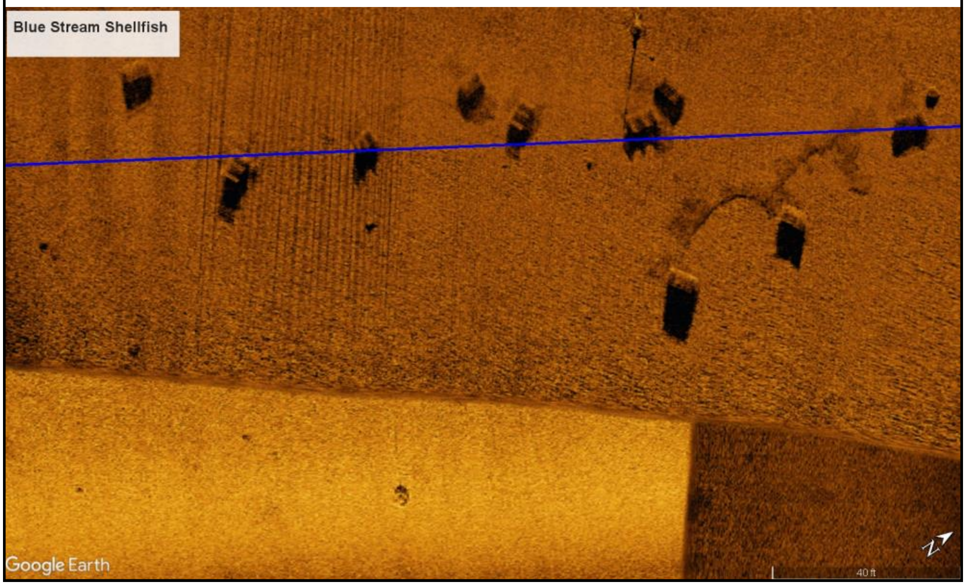
West Island Farm – January 2023



West Island - Seed cages on the bottom



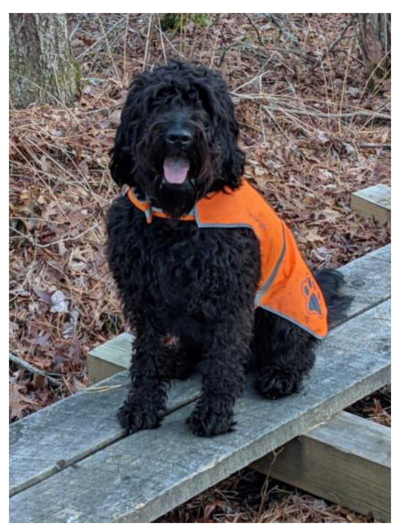
West Island – Trawl line of ten 9-bay cages



Retrieve a Targeted Cage?

- A random walk in the woods with my dog!
  - Encountered another dog walker
  - Exchanged pleasantries and discovered she was a robotics engineer at WHOI
  - Pitched the idea of a cage retrieving ROV and she bought it!
- Funding acquired through USDA Northeast SARE Farmer's Grant

SARE Northeast Sustainable Agriculture Research and Education



The "OysterBot" Wish List

- Weight & Dimensions
  - Weight <20 kg (44 lbs)
  - Dimensions <60 cm (24") in any dimension
  - Tether length ≥25 m (82')
- Sensory Capacity
  - Real-time video display
  - Direction & Speed Sensor
  - Depth Sensor
  - Temperature Sensor
- Mechanical Capacity
  - Onboard manipulator/gripper
- Performance
  - Thruster configuration for maximum maneuverability
    - 4 vectored
    - 2 vertical
  - Payload ~1 kg
  - Maximum depth >10 m
  - Autocontrol for depth, direction, & speed
  - Lighting available
- Battery Duration
  - 2 – 4 hours

Basic Platform

- Recommended Provider
  - https://bluerobotics.com/

BlueRobotics

- Base Unit - BlueROV2

BlueROV2 Specifications

Physical		
Length	457 mm	18 in
Width	338 mm	13.3 in
Height	254 mm	10 in
Weight in Air *(with Ballast and Battery)*	11-12 kg	24-27 lb
Weight in Air *(without Ballast or Battery)*	9-10 kg	20-22 lb
Payload Capacity (configuation dependent)	1.2 kg (4 x Lumens) to 1.4 kg (No Lumens)	2.6 to 3.1 lbs
Watertight Enclosure Inner Diameter	102 mm	4 in
Watertight Enclosure Inner Length	298 mm	11.75 in
Cable Penetrator Holes	18 x 10 mm	1 x 0.4 in
Buoyancy Foam	R-3318 Urethane Foam rated to 244 m	
Construction	HDPE frame, aluminum flanges/end cap, & acrylic or aluminum tubes	
Main Tube *(Electronics Enclosure)*	Blue Robotics 4 in series w/ aluminum end caps	
Battery Tube	Blue Robotics 3 in series w/ aluminum end caps	
Buoyancy Foam	R-3318 Urethane Foam rated to 244 m	
Ballast Weight	9 x 200 g stainless steel weights	
Battery Connector	XT90	

BlueROV2 Specifications

Tether		
Diameter	7.6 mm	0.30 in
Length	25-300 m	80-980 ft
Working Strength	45 kgf	100 lbf
Breaking Strength	160 kgf	350 lbf
Strength Member	Kevlar with waterblock	
Buoyancy in Freshwater	Neutral	
Buoyancy in Saltwater	Slightly Positive	
Conductors	4 twisted pairs, 26 AWG	

Lights	
Brightness	2 or 4 x 1500 lumens each with dimming control
Light Beam Angle	135 degrees, with adjustable tilt

Camera	
Resolution	1080p
Camera Field of View	110 degrees horizontally
Tilt Range	+/- 90 degree camera tilt *(180 total range)*
Tilt Servo	Hitec HS-5055MG

BlueROV2 Specifications

Sensors

- 3-DOF Gyroscope
- 3-DOF Accelerometer
- 3-DOF Magnetometer
- Internal barometer
- Blue Robotics Bar 30 Pressure/Depth & Temperature Sensor *(external)*
- Current and Voltage Sensing
- Leak Detection

Battery *(can be changed in about 30 seconds)*

Battery Life *(Normal Use)*	2 hours w/ 18Ah battery
Battery Life *(Light Use)*	6 hours w/ 18Ah battery

BlueROV2 Specifications

Performance

Maximum Rated Depth *(Acrylic)*	100 m	330 ft
Maximum Rated Depth *(Aluminum)*	300 m	990 ft
Maximum Forward Speed	1.5 m/s	3 knots
Thrusters	Blue Robotics T200 with WLP	
ESC	Blue Robotics Basic 30A ESC	
Thruster Configuration	6 thrusters	
	- 4 Vectored	
	- 2 Vertical	
Forward Bollard Thrust (45°)	9 kgf	19.8 lbf
Vertical Bollard Thrust	7 kgf	15.4 lbf
Lateral Bollard Thrust (45°)	9 kgf	19.8 lbf

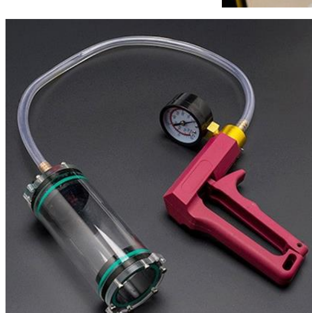
The Parts List

Item	Vendor	Est. cost
BlueROV2 Kit	Blue Robotics	$3,490.00
Fathom ROV Tether – 50 m	Blue Robotics	$ 375.00
Lumen Subsea Light x 2	Blue Robotics	$ 325.00
Fathom Tether Spool	Blue Robotics	$ 680.00
BlueROV2 Heavy Configuration Retrofit Kit	Blue Robotics	$ 740.00
Payload Skid	Blue Robotics	$ 279.00
Newton Subsea Gripper	Blue Robotics	$ 590.00
Low light HD USB Camera	Blue Robotics	$ 99.00
Mount for USB Camera	Blue Robotics	$ 4.00
Camera Tilt System	Blue Robotics	$ 60.00
Bar30 High Resolution 300m Depth/Pressure Sensor	Blue Robotics	$ 85.00
PCB for Bar30 High Res Depth/Pressure Sensor	Blue Robotics	$ 50.00
JST gH to DF13 Adapter, 4-pin	Blue Robotics	$ 10.00
Celsius Fast-Response Temperature Sensor	Blue Robotics	$ 70.00
I^2C Bus Splitter	Blue Robotics	$ 14.00
Lithium-Ion Battery (14.8V 15.6Ah) x 2	Blue Robotics	$ 330.00
H6 PRO Lithium Battery Charger	Blue Robotics	$ 160.00
H6 PRO Battery Charger Cable	Blue Robotics	$ 10.00
Battery Cell Checker	Blue Robotics	$ 15.00
BlueROV2 Spares Kit	Blue Robotics	$ 289.00
SOS Leak Sensor	Blue Robotics	$ 32.00
SOS Probe Tips	Blue Robotics	$ 3.00
T200 Thruster (spare)	Blue Robotics	$ 200.00
Speed Controller: Basic ESC (spare)	Blue Robotics	$ 36.00
Xbox Series X|S Wireless Controller	Target	$ 59.99
VISIONHMD Bigeyes H3 Portable 2.5K (optional)	Amazon	$ 129.00

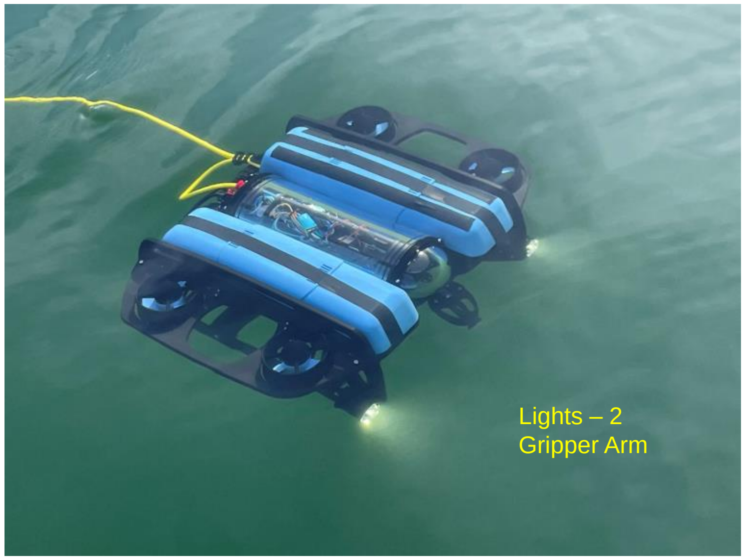
The Down Side!

- Someone has to put it together!
  - I naively thought it was a relatively simple task
  - Molly!

- And test it!
  - The scary part
  - Molly!



OysterBot on the Farm (December 2022)



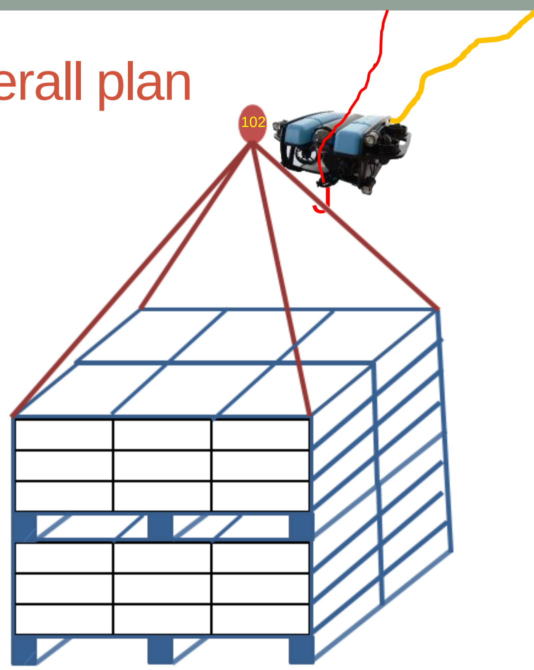
OysterBot on the Farm - Operations

- Need to work through a few glitches
  - Autodepth control needed to be dialed in better
  - Visibility was difficult in full sunlight
    - Vision HMD Bigeyes video goggles (not VR)

OysterBot on the Farm

OysterBot on the Farm

The overall plan



OysterBot on the Farm

F/V Phoenix

Work to be completed

- Develop the hook apparatus
  - Add buoyancy to make neutral in seawater
  - Use light-weight high-strength Spectra-type lifting line to Phoenix
- Test out Bigeye goggles for visibility in bright sunlight
  - Without inducing motion sickness?
- Evaluate ability to find and engage bottom cages for lifting
- Train crew in the use of the system
  - Uses X-Box controller to fly ROV

Lessons learned to date

- The components to be used for assembling the OysterBot are off-the-shelf technology that is non-proprietary in its application and readily available.
  - Estimated cost is about $8,000 for all the parts
- It has become obvious that assembly of an ROV from component parts is not something that can be routinely completed by an individual with limited experience in mechanical and electronic assembly.
  - The levels of cleanliness and attention to detail required during assembly may be problematic for an inexperienced assembly person.
- Debugging the assembled OysterBot has proven to be necessary as mechanics, firmware, and software controls need to be adjusted for the individual build.
  - While these tasks are not insurmountable, it does take a technical person to make these final adjustments and, again, are probably not achievable by an inexperienced assembler.
- However, the resulting operational ROV appears to be very successful in advancing our goal towards ropeless cage retrieval, at this point in our preliminary evaluation.

Thank you

- SARE Progress Report available
  - https://projects.sare.org/project-reports/fne22-018/

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