Greensea IQ
Intelligent Ocean Solutions

Intelligent Hybrid Robotics: Revolutionizing Hull Inspection

GreenseaIQ.com

Greensea IQ
Intelligent Ocean Solutions

- Launched 9/1/23
- Merger of 3 Companies
  - Greensea Systems
  - Bayonet Ocean Vehicles
  - Armach Robotics

Defense

EverClean

Science

Energy

Greensea IQ uses the power of robot intelligence to extend our reach into the world's oceans so that our work there may be persistent, efficient, safe, and for the protection of earth and humankind.

EverClean

The Always Clean, Always Inspected Solution
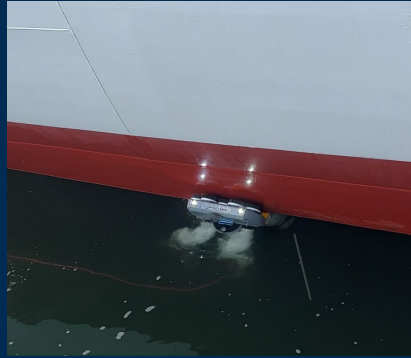For Hull Maintenance

Introducing EverClean

EverClean Service

For the first time in shipping, EverClean offers vessel owners a scalable, viable solution to maintain an always clean hull.

- Subscription Service to a Always Clean Hull

- Intelligent robotics-based service

- Supervised by experts

- Flat rate - agnostic of # of services

Performance Revolution

EverClean creates a new hull performance baseline and lets you discover small issues before they become big problems.

- EverClean is the future of vessel performance and decision making.

- Stop monitoring noisy data looking for key events in perpetually normalizing data sets.

- Removing biofouling as a variable provides a flattened baseline.

EverClean IQ

The data collected by the robot during service provides ship owners with valuable new perspective on the condition of the ship below the water line.

EverClean IQ data enables:

- advanced change detection

- Regular condition monitoring of the coating system

- data-driven predictive maintenance analytics for better drydock planning

EverClean Values

Fuel Savings
- On average customers reduced fuel consumption by 6.4% following an EverClean service.
- 2022 customers averaged 90% 30 day ROIs

Carbon Reduction
- EverClean customers reduced emissions by 6.4%
- Significant financial savings potential for reducing emissions and receiving passing CII rating.

Fleet Readiness
- Extended range on single fueling (simplified logistics).
- Minimize downtime by improving maintenance decisions through collected EverCleanIQ.

Maintenance
- Minimized Dry dock intervals with Intelligence based planning.
- Avoid heavy fouling and harsher cleaning methods extending coating life with continuous maintenance.

Biosecurity
- By habitually removing slime, hard, macrofouling is denied a biologically conducive place to settle & thrive.
- EverClean's approach is backed by academic research.

Greensea IQ

EverClean Robots

ATTRIBUTE	SPECIFICATIONS
Vehicle Length	41 in.
Vehicle Width	22 in.
Vehicle Height	10 in.
Grooming Swath	22 in.
Vehicle Dry Weight	66 lbs.
Max Speed	4.9 f/s
CAPABILITY	**SOLUTION**
Payloads & Sensors	Grooming Tool (5 x 100mm Brush)
	2x Video Cameras
Navigation	Fiber Optic Gyro + Attitude Sensor + Compass
	Doppler Velocity Log
	High frequency sonar
	Pressure Sensor
Architecture/GUI	Greensea OPENSEA/EOD Workspace

Attractor
- Non-Magnetic Hull Attractor
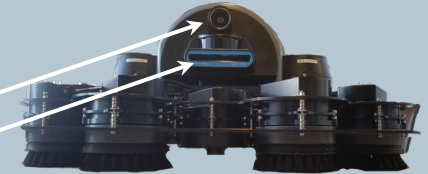- + Operational Flexibility
- Detach For Free Flight Inspections
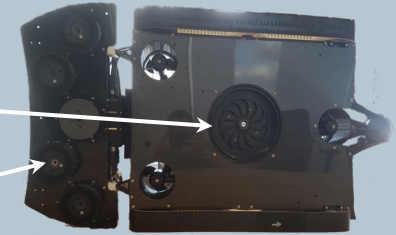
Modular Tool Deck
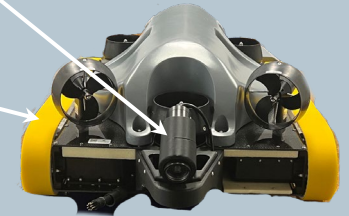- Grooming tool
- Fully customizable for tailored missions

High Performance Sensor Suite
- Optimizes autonomy, navigation, & hull intelligence
- Standard Fwd/Aft HD Cameras
- Obstacle Detection, Avoidance, Hull Mapping
- Hi-Res Multibeam

Specialized Treads
- Maximizes operational performance
- Won't damage coatings

Advanced Autonomy
- Powered by Greensea's OPENSEA
- Commonality - EOD Workspace

EverClean Operations

The EverClean robots carry out cleaning operations with unmatched precision, resulting in minimal repetition and accurate data collection to deliver a hull condition report after each service. Offering a distinct "always clean hull" maintenance solution.

EVERCLEAN IQ HULL CONDITION REPORTING

HULL CONDITION DATA COLLECTED DURING SERVICE

![BEFORE EverClean / AFTER EverClean comparison images with Greensea IQ logo]

EverClean IQ

EverClean IQ is EverClean's user portal and dashboard, allowing users to understand the impact of maintaining an always clean hull.

EverClean IQ will primarily feature data collected during cleaning, including stitched images of points of interest, coverage maps detailing where was cleaned, and recommendations by our trained operators on any area of the ship that requires attention.

Frequent hull reporting enables change detection and long-term analysis of the following:
- Fouling rates
- Coatings performance
- Corrosion
- Hull deformation or damage

Data collected also aids in dry dock planning and scheduling as well as post dry dock inspection.

EverClean IQ can also be customized to meet specific data requirements of the customer at additional cost.

EverClean Testing/Research

Floating dock at Port Canaveral (right) allows static immersion of coatings at relatively high fouling pressure year round.

Panels immersed at Canaveral test site to grow biofouling

- Test panels recovered, tested and re-deployed at intervals of increasing fouling severity
- FR10, 20, 40 & 60

EverClean Testing/Research

![Greensea IQ logo]

Disk tester (below)
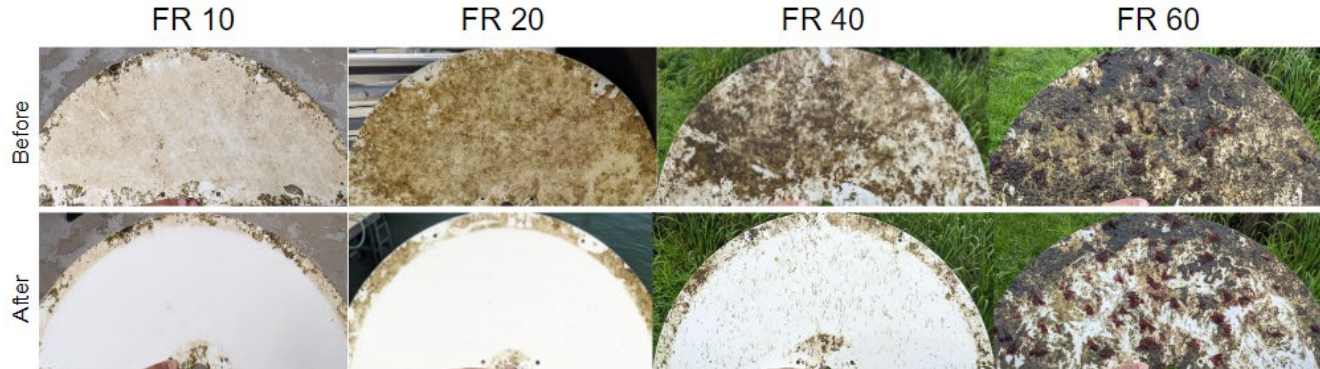
What are we looking for in coatings testing and research?

Ideally we would be able to show that brushes are safe to use on a coating and can effectively remove fouling at manageable service interval

Accelerated Wear Test

- Will brushes damage coating?
  - Will brushed cause visible damage or scratching?
  - Will brushes reduce dry film thickness?

Cleanability Test

- How often do we need to clean the coating?
  - How quickly does fouling accumulate on the coating?
  - What is the maximum degree of fouling brushes can remove?

EverClean Robot - Hull Inspection Focus

Backed by the power of OPENSEA, plug & play sensors and custom behaviors are simple and the possibilities for bespoke, in-water hull inspection are endless.
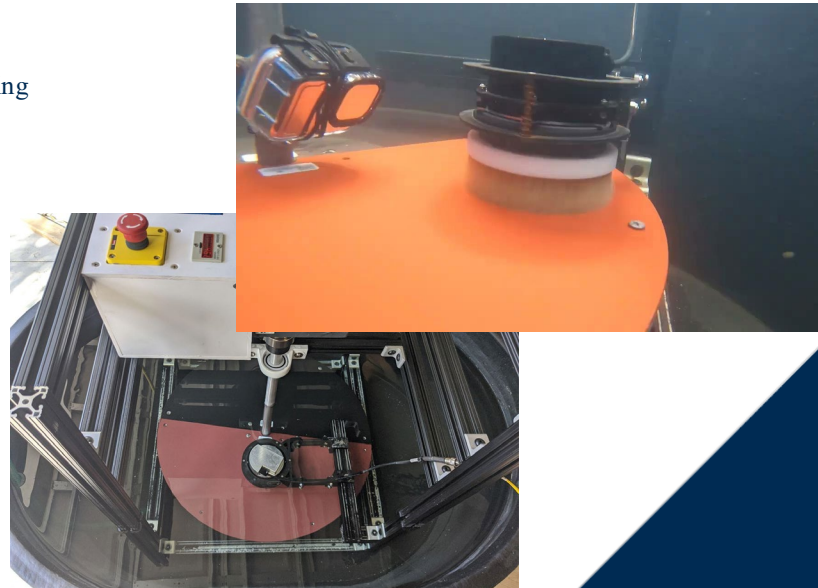
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EverClean Robot Hull Inspection

Greensea IQ

- Precision Navigation
  - Navigate anywhere on hull
    - Robot is firmly attached to hull
    - Currents/Tides/Surge do not impact like an ROV inspection.
  - Operate manually with EOD Workspace
    - Know precisely where you are on hull
    - View real time camera/sonar feedback
    - Search/Detect/ID anomalies
    - Augment diver search missions
    - Navigate to any known hull feature in minutes.
  - Operate semi-autonomously
    - Drag and drop mission planner
    - Increase operational efficiency
    - Use sonar for obstacle detection/avoidance
- High Resolution Sensors
  - During mission - monitor camera and sonar feedback
  - Post-Mission
    - Download and review data
      - Sonar stitched mosaic - Notice inch-sized objects
      - Download raw camera footage for secondary inspection
      - Reacquire any detected object of interest with ease
- Man Portability
  - Small operational footprint - (>1m long & only 60 lbs.)
  - Operate multiple robots at once (single vessel)
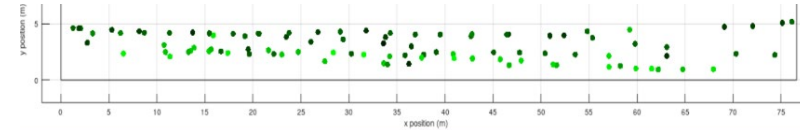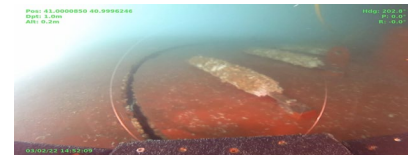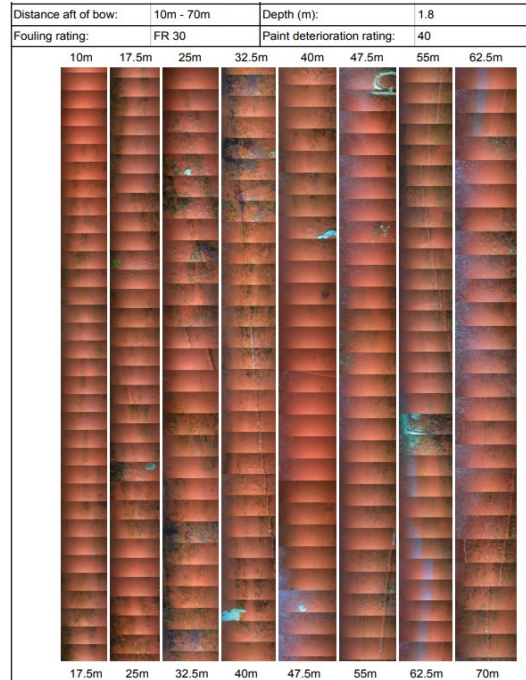   - Expedited search missions - compared to manual searches
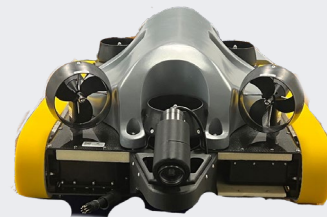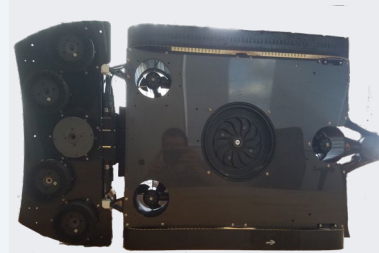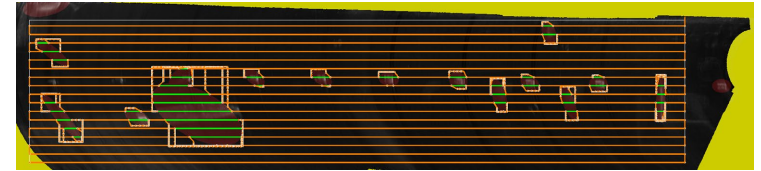
EverClean Robot - ConOps
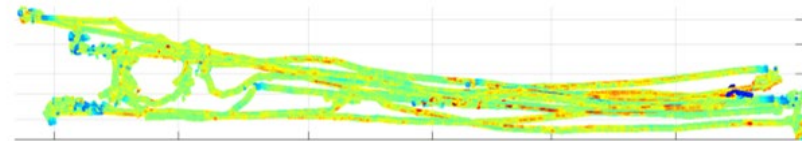
Standard Data Collection

- **EverClean IQ/Intel offers a multi-layered inspection view like you were standing in dry dock.**
  - Extend time between dry dock.
  - Shorten time in dry dock.
- **Monthly data collection and analysis of the following:**
  - Fouling Rate
  - Fouling Composition
  - Fouling Mass
  - Coating Damage, including blistering
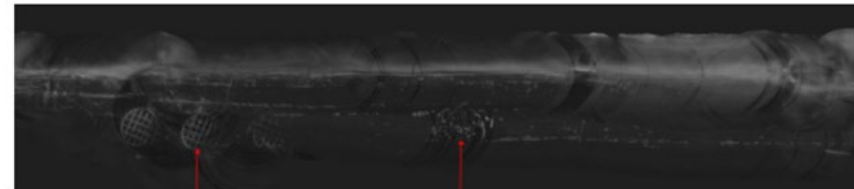 - Corrosion Detection
  - UT Thickness

| Distance aft of bow: | 10m - 70m | Depth (m): | 1.8 |
| Fouling rating: | FR 30 | Paint deterioration rating: | 40 |

UT Thickness Gauge   -   Hull Inspection Data

Proof of Coverage/Feature Library

Brush Torque Feedback

Sonar Mosaic

EverClean Robot's Future

- **Point Cloud Image Mosaicking**
  - Raw camera data auto-stitched together into hull composite
  - Measure any object on hull with inch-accuracy
- **Advanced Change Detection**
  - Review historic data sets (digital twins of hulls)
  - Simple anomaly/change detection
- **True Autonomy**
  - Greensea is currently developing true EverClean Robot autonomy
  - Robot plans/executes search mission autonomously
- **Auto-Target Recognition**
  - Develop known MLO library
  - Machine learning would allow auto-detection of anomalies/MLOs
- **Payload Customization**
  - EverClean Robot is purpose-designed for modularity - OPENSEA allows rapid integration of new technologies
  - Sensors or Hardware (ex. manipulators - aid mine inspection/neutralization)
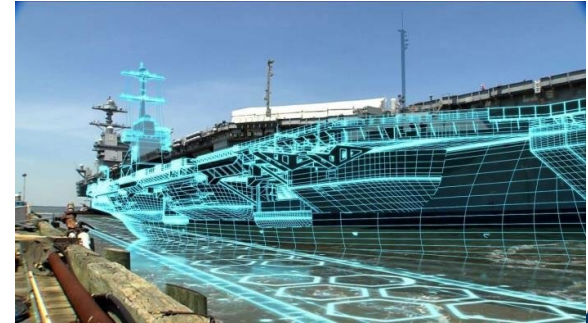
Future EverClean IQ - Mosaicking & Digital Twins
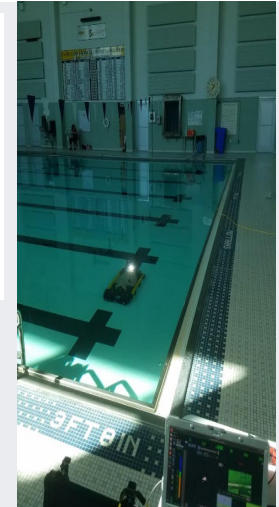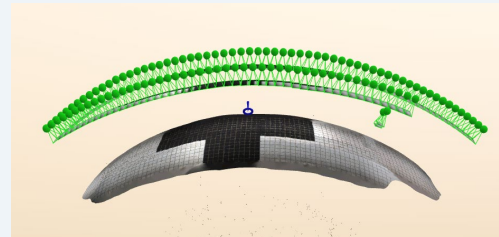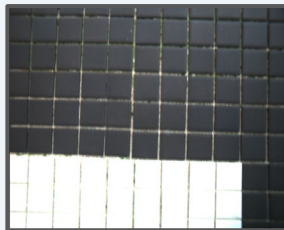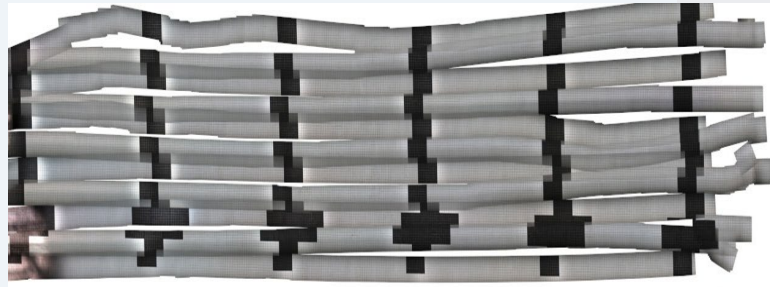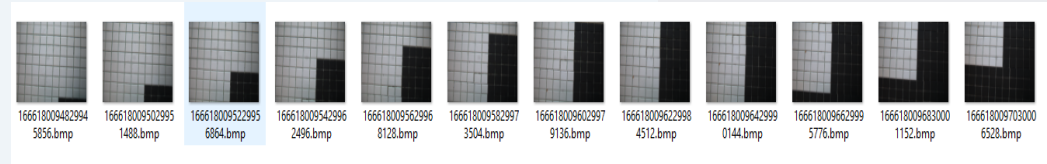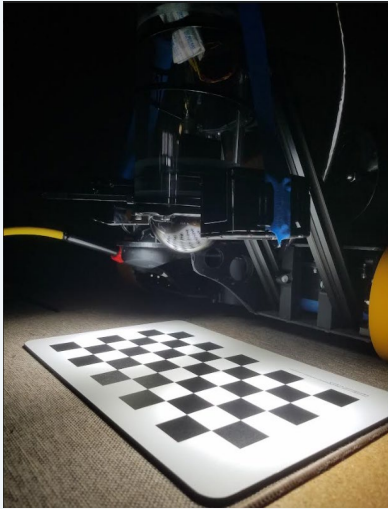
Bottom Line

- Greensea IQ's EverClean Robot can support any number of Defense objectives
- EverClean Robot offers precision navigation and on-hull stability, unlike any ROV
  - Simplify missions
  - Improve search mission efficiency
  - Improve safety - No divers
  - Collect improved data quality to expedite classification/ID efforts
- EverClean Robot is small, lightweight, and capable of operating from any class vessel
- Greensea IQ & Greensea are capable of customizing this crawler technology to achieve Defense goals/objectives
  - Eager to demonstrate
  - Eager to support development projects

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+1-508-367-3959
sales@GreenseaIQ.com
akern@greenseaiq.com
GreenseaIQ.com