The Coastal Kayak Autonomous Surface Vehicle (ASV) Version 2.0

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Abstract

In February 2017 a coral reef mapping survey was conducted with the Remote Sensing Division at the U.S. Naval Research Laboratory (NRL), Washington, DC in Kaneohe Bay, Oahu, Hawaii as part of the NRL/National Aeronautics and Space Administration (NASA)-sponsored Hyperspectral Infrared Imager (HyspIRI) Project using a custom-built autonomous surface vehicle (Coastal Kayak ASV). The Coastal Kayak ASV was able to successfully survey an artificial coral reef in shallow-water while towing a custom sensor package but exhibited some engineering limitations, especially when towing the sensor package in a significant current, wind, or wave field. The current Coastal Kayak ASV is a large platform that can be cumbersome to use in remote field locations. In the fall of 2017, testing and evaluation of the current Coastal Kayak ASV platform was conducted to provide baseline metrics for system improvements. These metrics were set as targets for the development of a next-generation Coastal Kayak ASV version 2.0 design. Engineering design changes were implemented to improve stability, maneuverability, and thrust. The platform was evolved to a more compact platform with an integrated, modular system of components and added functionality. A prototype of the Coastal Kayak ASV v.2.0 was built and successfully tested at the U.S. Naval Academy (USNA), Hendrix Oceanography Laboratory (HOL) near Santee Basin on the Severn River. Future platform development will continue towards a fully-operational Coastal Kayak ASV v.2.0 for use in targeted research missions.

Background

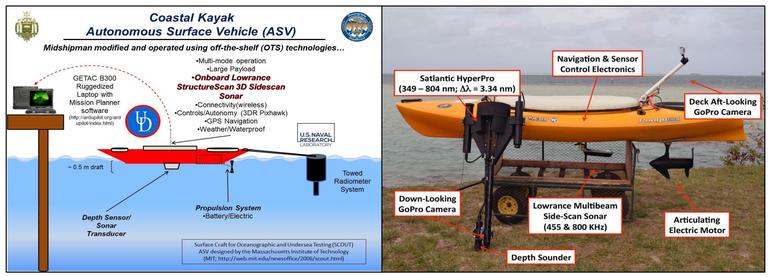

Figure 1. Conceptual diagram of the USNA Coastal Kayak Autonomous Surface Vehicle (ASV) and picture of the Coastal Kayak ASV and towed Hypersled Pro radiometer sled showing field configuration during the NASA HyspIRI in Kaneohe Bay, HI, February, 2017 (*Ackleson et al., 2017*).

The Coastal Kayak ASV (**Fig. 1**) was developed in collaboration with the Robotic Discovery Laboratories (RDL), University of Delaware (UD) based on a SCOUT ASV platform. The ASV surveyed a coral reef in Kaneohe Bay, HI in support of the NRL/NASA HyspIRI project (*Ackleson et al. , 2017*) but results (**Fig. 2A-D**) showed a need for improvements to stability, maneuverability, thrust and sensor integration to make it a more capable platform for coastal surveys, specifically in a significant a current, wave, or wind field (*Laboy, 2017*).

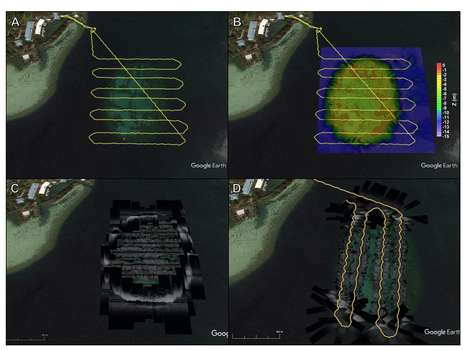

Figure 2. (A) East-west reef survey/mission track (no towed sled) on 12 FEB 2017; (**B**) 2-D bathymetric contour plot; (**C**) Side-scan mosaic (Sonar TRX), and; (**D**) North-south survey/ mission track (with towed sled) and side-scan mosaic on 07 FEB 2017.

Design Goals and Concept for the Coastal Kayak ASV Version 2.0

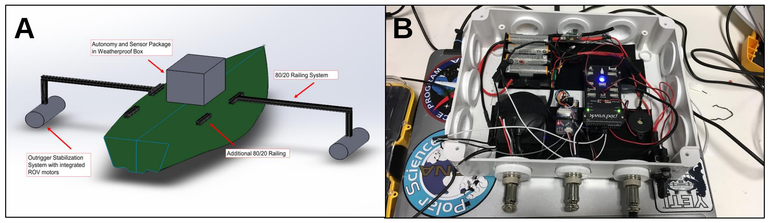

Figure 3. (**A**) Conceptual design rendering of the Coastal Kayak ASV v.2.0 (*SOLIDWORKS 3D-CAD Software*) and (**B**) Image of new, compact autonomous control and navigation box that was integrated into the new ASV platform.

Table 1. Engineering design goals for the Coastal Kayak ASV v.2.0.

Parameter	Metric	Coastal Kayak ASV (Current)	Coastal Kayak ASV v.2.0 (Goal)
Maneuverability	Turn Radius (m)	9	4
Thrust	Max. Acceleration (m/s^2)	0.32	0.64
Thrust	Average Speed (m/s)	1.2	3
Stability	Pitch, Roll, Yaw	Baseline not Measured	Add Outriggers
Useable Space	Footprint (cm^2)	1800	2000
Size	Length (m) x Beam (m)	3 X 0.76	1.8 X 0.6
Weigh (w/ Battery)	Kg total	56	~35

Operations in Kaneohe Bay and baseline testing of the Coastal Kayak ASV in 2017 led to the development of a preliminary design for the next-generation Coastal Kayak ASV v.2.0 (**Fig. 3A**). In addition to design changes to platform weight and size, upgrades to control systems (**Fig. 3B**), sensor integration, and modularity, design goals also included improvements to maneuverability (turn radius), thrust (speed, acceleration, and towing capacity) and stability (limited pitch, roll, yaw). **Table 1** summarizes engineering design goals for the Coastal Kayak v.2.0.

The Coastal Kayak ASV Version 2.0 Prototype

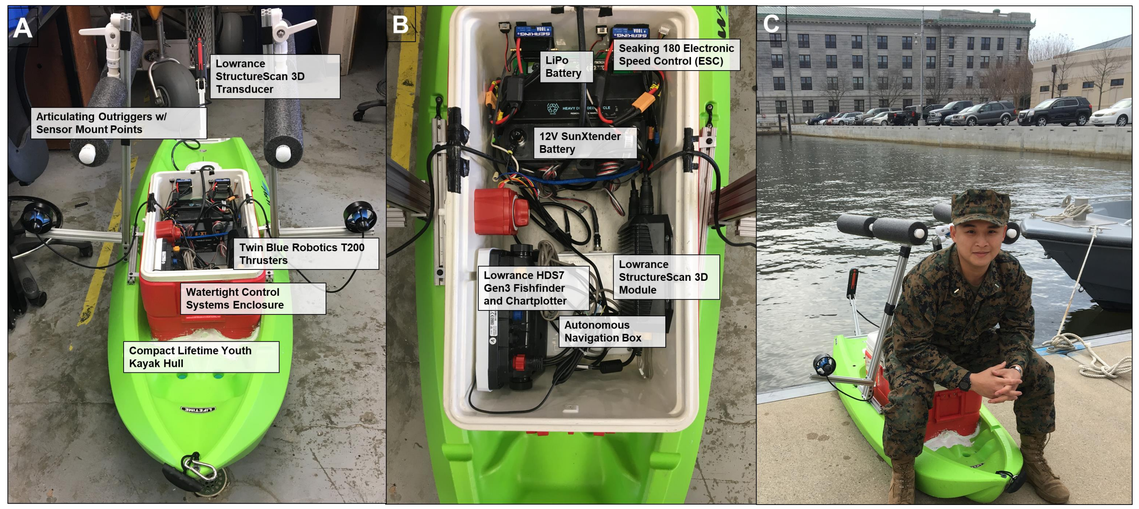

Figure 4. (**A**) Full view of Coastal Kayak v.2.0 prototype showing major design external design changes; (**B**) Top-down plan view of the systems enclosure showing power and control systems as well as the onboard Lowrance HDS7 Gen3 Fishfinder and Chartplotter with StructureScan 3D Sidescan sonar, and; (**C**) MIDN 1/C Ma with the Coastal Kayak v.2.0 during systems testing in Santee Basin.

Figure 4A shows an external full-view of the Coastal Kayak ASV v.2.0. Control, sensor, and power systems are shown in **Figure 4B**. The platform was successfully tested in Santee Basin and the Macdonough Pool (**Fig. 4C**). Design and performance test results are summarized in **Table 2**. After completion of initial testing, the Coastal Kayak ASV v.2.0 was put through initial operational testing, successfully towing a RiverRay Acoustic Doppler Current Profiler (ADCP) sled (**Fig. 5A**) and performing a 90° side-look, single-beam sidescan sonar survey of the HOL pier pylons (**Fig. 5B**).

Table 2. Comparison of the Coastal Kayak ASV and Coastal Kayak ASV v.2.0.

Parameter	Metric	Coastal Kayak ASV (Current)	Coastal Kayak ASV 2.0
Maneuverability	Turn Radius (m)	9	3.3
Thrust	Max. Acceleration (m/s^2)	0.32	1.36
Thrust	Average Velocity (m/s)	1.2	2.0
Thrust (RiverRay in Tow)	Max. Acceleration (m/s^2)	0.28	1.36
Thrust (RiverRay in Tow)	Average Velocity (m/s)	1.04	1.56
Useable Space	Footprint (cm^2)	1800	2300
Size	Length (m) x Beam (m)	3 X 0.76	1.8 X 0.6
Weigh (w/ Battery)	Kg total	56	42

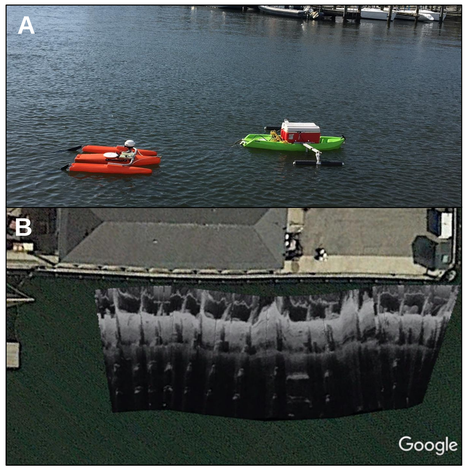

Figure 5. (**A**) The Coastal Kayak ASV v.2.0 underway towing a RiverRay ADCP and (**B**) performing a 90° side-look single-beam sidescan survey of the pier support pylons underneath HOL.

Moving Forward

- ***Fully integrate autonomy control systems into a field capable Coastal Kayak ASV v.2.0***
- ***Integrate additional hydrographic surveying instruments to accommodate a wider array of missions including a Coastal Engineering survey of the USNA Dewey sea-wall***
- ***Modify outrigger and propulsion system to improve hydrodynamics and stability***

Acknowledgements: *Development of the Coastal Kayak ASV is in collaboration with Mr. Timothy Pilegard, Dr. Art Trembanis, and the Robotics Discovery Laboratories at the University of Delaware and Andrew Keppel and Mr. Luis Rodriguez of the USNA Oceanography Department.*