

Wave Glider® SV2

Launch & Recovery Guide

Revision A
May 2014
Part Number 05926



Wave Glider® SV2 Launch & Recovery Guide

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Revision History

Document Part Number	Revision	Publication Date	Changes
05926	A	May 2014	This is the initial release of this document.

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Definitions

Anti-fouling paint: Paint that contains biocides to prevent marine growth, also referred to as “bottom paint” on boats. Gloves should be worn when handling Wave Glider components that are coated in anti-fouling paint. Refer to the manufacturer’s documentation and the Material Safety Data Sheets (MSDS) for applicable safety precautions.

Boat Pole: A long pole used to reach out and steady the vehicle upon launch or recovery. Preferably light weight and extendable, with room at the end for a carabiner clip holder.

Bundling Strap: LRI provided piece of launch equipment used to hold the Float, Saddle, and Sub together on launch until quick released in the water. When strapped together as described, the Wave Glider is considered bundled. The Bundling Strap is also referred to as “Launch Strap”.

Carabiner clip: A quick attachment clip that positively locks, also called a “mooring clip”, “capture carabiner”, “snap hook” or “clip”. A carabiner clip holder is used to secure a carabiner clip at the end of a boat pole for attaching tag lines to the Wave Glider handles, or for attaching a hoisting cable to the Lifting Bail.

Deployment: The field support operation and mission. In this document, “launch” refers to the physical release of the Wave Glider vehicle.

Fall Restraint Harness: A harness fit to the individual that will be performing an activity near an area where falling from a distance or falling over the side of a vessel is a potential risk. The fall restraint must be load and shock rated to the individual’s body weight and to the particular fall hazard. A fall restraint should be worn when working near open fantails or gunwales without safety lines, or in situations where deck wash-over could lead to a Man Overboard.

Float: Surface component of the Wave Glider. Painted with a hard polyurethane paint, or an anti-fouling paint to prevent marine growth.

Hoist (noun): A generic term in this document to represent a variety of different types of hoisting systems and the associated winching mechanism, block and tackle, such as: A-frame, J-frame, crane, davit, boom, tuggers/winches, and capstans. All hoisting gear should be load rated to 1-tonne Safe Working Load.

Hoist (verb): The action of lifting an object by mechanical means.

Job Safety Analysis (JSA): Detailed risk analysis for entire mission and for on-deck Tool Box Meeting before each operation. Key focus is for all personnel involved in the activity to openly ask and address “How can I get hurt here today, and how can it be mitigated?”

Lift strap: A load rated and stamped lift strap, often referred to as a lift “sling”, is a soft fabricated strap used for hoisting objects, and is helpful to keep heavy hoisting accessories away from direct contact with the Wave Glider components that are susceptible to damage (such as, masts and solar panels).

Lifting Bail: Load-rated lift point on the Float for hoisting the entire Wave Glider. Also referred to as “D-ring”.

Material Safety Data Sheets (MSDS): Procedures for proper handling and storage of potentially hazardous materials contained in a product, including emergency clean-up procedures for spills, and treatment for exposure to workers, or the environment.

Multi-stage hoisting: Lifting an object in more than one hoisting activity with 1 or 2 mechanical hoists. The Float and Sub can be lifted in series to accommodate hoisting height constraints (also referred to as a "two-point pick").

No Entry Zones: Areas established by the vessel crew in which it is unsafe to stand or work. This includes the area under, and within a two meter radius, of a hoisted Wave Glider. No Entry Zones should be clearly identified during the on-deck Tool Box Meeting, and may be physically marked on deck as appropriate.

OSQI: Operational Service Quality Incident Report - a report that captures significant events that introduce jeopardy or compromise to the mission objective(s).

PPE: Personal Protective Equipment - equipment worn to minimize exposure to serious workplace injuries or illnesses. PPE includes, but is not limited to; hard hats, gloves, eye protection, fire retardant coveralls, steel or composite-toed boots, personal flotation devices, etc.

Saddle: The Saddle nests on top of the Sub wings with the Saddle arrow facing forward. The Float rests on top of the Saddle. During launch, the Saddle is recovered back to the launch vessel with the Bundling Strap trip line.

Safe Working Load (SWL): The approved and documented weight that a piece of lifting equipment should not exceed. Generally set at 5x the minimum breaking load rating of the piece of equipment. Safe working loads must be observed for all lifting equipment and maintenance intervals documented.

Sea Catch™: A hoist quick release mechanism for launching the Wave Glider from a support vessel.

Single-stage hoisting: Lifting an object in one phase (also referred to as a "one-point pick").

Stand: A rigid aluminum frame designed to hold the Wave Glider for assembly, disassembly, transportation, and maintenance. The Stand may have (locking) swivel caster wheels, in which case the Stand is often referred to as a "Cart."

Sub: The sub-sea component of the Wave Glider that provides vehicle propulsion. Also referred to as "glider" and "wing rack".

Sub Recovery Device: LRI custom recovery equipment that is used to hoist the Sub by gripping the lowest part of the Umbilical. The device provides a hoist point. Also referred to as "recovery tool".

Team lifting: Refer to regulatory specifications (e.g. National Institute for Occupational Safety and Health in the USA) for proper ergonomics and lifting capacities. The weight of a Wave Glider is more than one person can safely lift - team lifts and/or mechanical lifting devices are required.

Tie-Down Strap: Strap used to secure a load. Ratchet straps are preferred to quickly secure the bundled Wave Glider to the Stand and the entire unit to the deck of a vessel or to the bed of a transport truck for shipping.

Towfish: A sensor, or multiple sensors, housed separately from the Wave Glider and towed from the Sub with a **tow cable**. Also referred to as a **Towbody**.

Umbilical: Mechanically and electrically connects the Float to the Sub, providing power and communication to Sub payloads and the Rudder Module. The Umbilical is black and 4 to 5.8 meters in length.

VOO: Vessel of Opportunity - A ship or boat consigned for Wave Glider deployment. Referred to in this document as **vessel** or **support vessel**. A VOO is a properly vetted platform for safe Wave Glider activities, meeting the specifications for vessel size, hoisting equipment, height over rail, maximum freeboard, etc. For more information see [Appendix G: Nearshore Vessel Requirements](#), [Appendix H: Coastal Vessel Requirements](#), and [Appendix I: Offshore Vessel Requirements](#).

Wave Glider SV2: LRI's branding name for a core vehicle system that consists of a surface Float, a 4 or 5.8 meter Umbilical, and a Sub unit. Also referred to as **Model 08**, **vehicle**, **system**, or **WG**. For more information see [Appendix D: Wave Glider SV2 Product Specifications](#).

WGOC: Wave Glider Operations Center - provides LRI Customer Support 24/7.

Email: support@liquidr.com

Phone: +1 888-574-4574

Website: liquidr.com

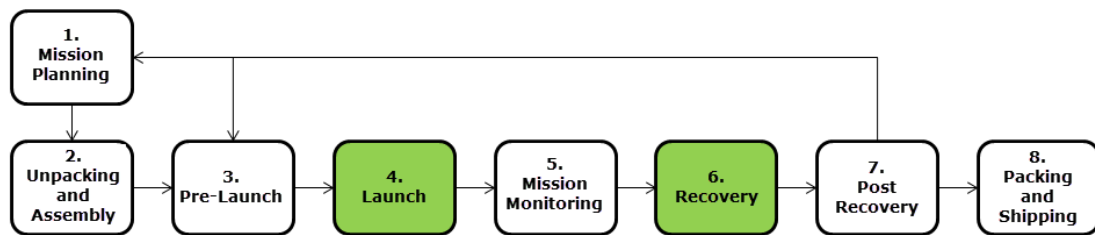
WGMS: The Wave Glider Management System is a licensed, proprietary, cloud-based platform for Wave Glider piloting and communications. WGMS sends commands to the Wave Glider and receives real-time sensor data from the Wave Glider using worldwide satellite communications or a variety of local communications channels.

Chapter 1. Scope

This Launch and Recovery Guide provides information detailing the safe and efficient launch and recovery at-sea, of a Liquid Robotics Wave Glider SV2 (formerly known as Model 08). This document assumes the personnel conducting launch and recovery activities have been properly trained to this procedure by LRI Lead Technicians, and that this activity will be performed by trained personnel only. Each Wave Glider deployment will be unique due to the nature and operational logistics involved with support vessels of opportunity. It is the responsibility of the Lead Technician (person in charge of at-sea activities) to ensure adequate resources and trained personnel are in place prior to attempting launch and recovery. Operations at sea pose high risk elements and the decision to attempt a deployment to conduct Wave Glider launch or recovery operations lies with the Lead Technician and the Captain at the time of the event.

The at-sea procedures outlined in this document cover phase 4 “Launch” and phase 6 “Recovery” of the Wave Glider Operational Workflow ([Figure 1.1](#)). Three options will be covered in the phase 6 recovery procedures representing various hoisting equipment and vessel configurations. The prerequisite to entering each phase is the successful completion of the previous phase.

Figure 1.1. Wave Glider Operational Workflow



Chapter 2. Purpose

The purpose of this launch and recovery guide is to provide a safe procedure for deploying a Wave Glider SV2 ([Figure 2.1](#) and [Figure 2.2](#)). This document outlines the basic methods using the best known safety practices at the time of writing, which continue to evolve. This document will be reviewed annually and is the responsibility of the Liquid Robotics Inc. (LRI) Wave Glider Field Support Operations department.

To ensure the safety of all crew, this procedure incorporates the “No-Touch” philosophy, whereby the personnel conducting the deployment (launch or recovery) take precaution to remain at safe working distances from the equipment during hoisting operations. Due to the use of vessels of opportunity, the deployment team must adjust their deck operations to existing vessel arrangements. No-Touch concepts shall be used wherever possible, and the deck operations must be reviewed and understood by all prior to attempting the deployment.

Figure 2.1. Wave Glider SV2 Unbundled

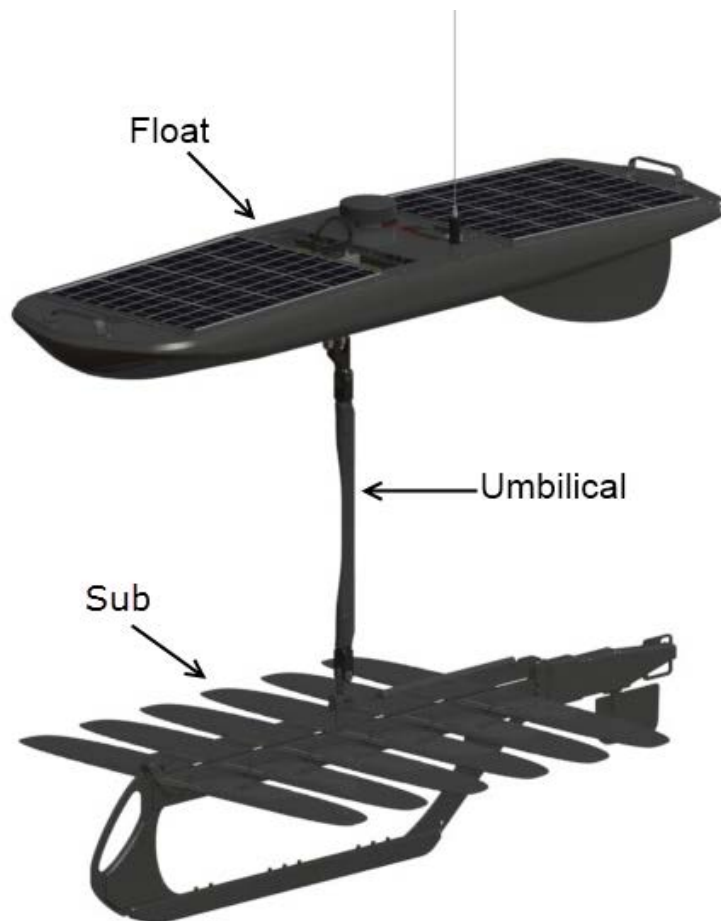
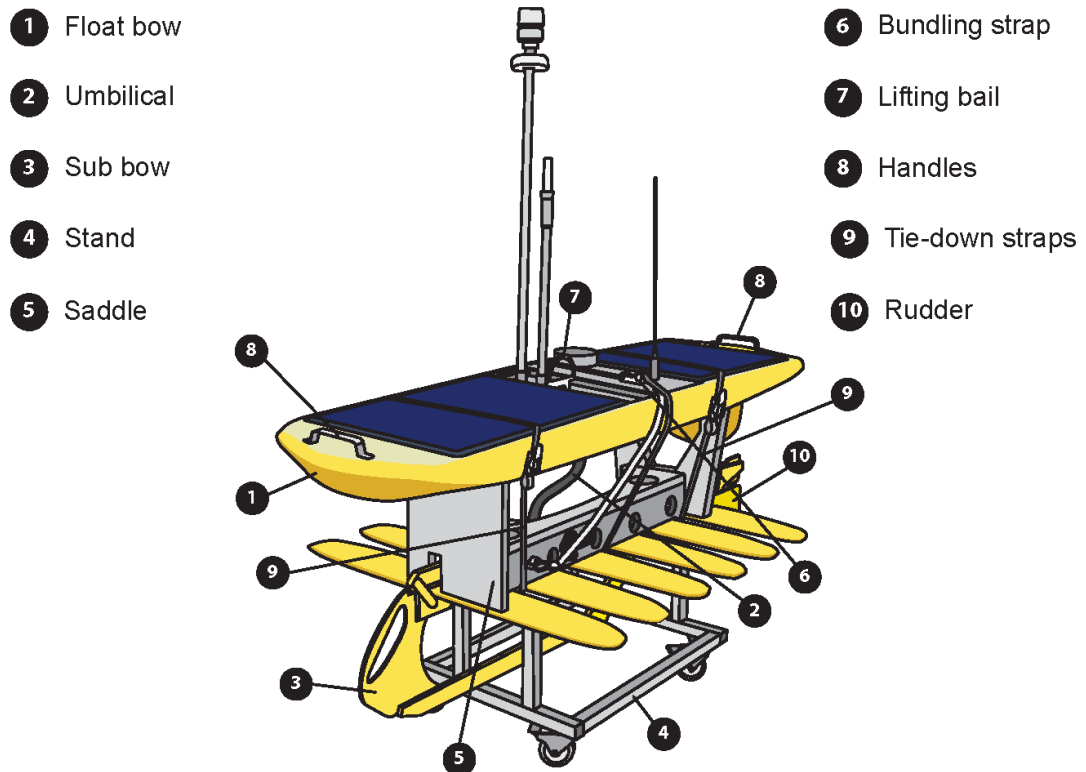


Figure 2.2. Wave Glider SV2 Components



Chapter 3. Personnel - Roles and Responsibilities

Personnel assigned to deployment activities include Liquid Robotics, Inc. Field Operations Technicians and other Operations staff, as well as support vessel personnel. Support vessel command structure and associated communications shall be established before any operations are conducted. A Liquid Robotics trained Lead Technician will command the deck unless the support vessel requires a member of the crew to act in this capacity (such as Deck Boss or Boatswain).

Minimum Personnel Required

The number of persons required for safe operations varies depending on the support vessel, the equipment being deployed, and prevailing sea states. Most at-sea operations require a minimum of a Vessel Operator, Hoist Operator, Lead Tech, and two Deckhands.

Vessel Operator/Captain

The Vessel Operator is typically third party to LRI and is provided as part of the charter agreement.

Job Function: Command and control the vessel with ultimate authority to complete the mission at hand, in a safe manner for all persons on board.

Responsibility: The Vessel Operator is responsible for the vessel and for the safety of all persons on board. This includes constant review of changing sea states and communications with the Deck Boss for safe deck operations.

Deck Boss

The Deck Boss is typically third party to LRI and designated by the Vessel Operator. On smaller vessels with limited crew, the Lead Technician may fill this role as agreed and designated during the Safety Briefing.

Job Function: Ensure deck operations are conducted efficiently, and safely. The Wave Glider Lead Technician or other members of the deck crew may fill this role.

Responsibility: The Deck Boss is responsible for deck activities offshore insuring that all operations are conducted safely, cost effectively and to a high standard of quality. The Deck Boss appoints a point of contact to Hoisting Operations and is a direct line of communication with the Vessel Operator.

Lead Technician (Lead Tech)

Job Function: Point of contact to Deck Boss, and as agreed may fill Deck Boss role. Ensures Wave Glider is prepared and approved for hoisting activities.

Responsibility: The Lead Tech is responsible for all Wave Glider operations, ensuring the deployment activities are conducted safely, cost effectively, and to a high standard of quality. This includes confirmation that the hoisting equipment, devices, and rigging are in good

operating condition. The Lead Tech operates the quick release mechanism(s) during launch and usually will be responsible for using a boat pole to attach the hoisting line to the center Lifting Bail during Wave Glider recovery.

Embarking and Training Requirements: Refer to client and vessel requirements prior to mobilization regarding deck safety, medical, and administrative logistics, before embarking on an excursion. Inquire with local authorities and regulatory agencies regarding travel restrictions and personal safety and security considerations.

In addition to technician skill sets described in *Field Operations Technical Skill Set* (see [Appendix A: Reference Documents](#)), the Lead Tech shall have at a minimum the following training or local certification equivalents, and be current on these credentials before conducting deployment activities:

Contact LRI Customer Support by email (support@liquidr.com), or by phone at: +1 888-574-4574.

- Offshore medical exam indicating fit for duty at sea; Basic Offshore Safety Induction and Emergency Training (BOSIET) and Helicopter Underwater Egress Training (HUET); First Aid, Cardiopulmonary Resuscitation (CPR), and Automated External Defibrillator (AED); minimum recommended vaccinations; Transportation Worker Identification Credential (TWIC); Passport (valid 6 months past the end date for international waters/travels); Valid Driver's License.
- Launch and Recovery Training: includes in-depth working knowledge and training on:
 - [Appendix E: Wave Glider SV2 Pre-Launch Checklist](#)
 - Required launch and recovery equipment
 - Deployment procedures and associated techniques
 - Multiple launch and recovery iterations

This training is administered through Liquid Robotics Inc, and can be completed in one day on the water, assuming the trainee has previous maritime experience (at least 5 years work experience) launching and recovering fragile oceanographic equipment and sensors from similar vessels. **Proficiency in deployment activities is expected after repeated successful launch and recoveries at-sea (typically at least 6-10 events of each). No amount of simulated deployment activities are considered as acceptable substitute.**

- Wave Glider Management System (WGMS) training: This training is administered through Liquid Robotics, Inc. and can be completed in a two-day classroom course.
- Additional Training: depending on the vehicle configuration, mission, and piloting responsibilities, additional training is recommended for specific sensor operations and power management techniques.

Deckhand

Job function: During the launch and recovery phases of at-sea operations, Deckhands attach and tend tag lines as the vehicle is hoisted.

Responsibility: Under the direct guidance of the Lead Technician, Deckhands are responsible for the safe handling of the launch and recovery lines and rigging. During recovery activities Deckhands utilize boat poles to attach tag lines before hoisting the vehicle aboard.

Hoist Operator

Job function: During the load-out, launch, and recovery phases of at-sea operations the Hoist Operator uses the support vessel's hoist(s) to maneuver the Wave Glider on and off the vessel.

Responsibility: Under the direct guidance of the Lead Technician/Deck Boss, the Hoist Operator is responsible for the safe operation and maintenance of the hoist, associated rigging gear, and related equipment.

Other roles may be required on the Support Vessel of Opportunity:

- Rigger
- Safety Observer

Chapter 4. Safety (HSSE)

Health, Safety, Security and the Environment (HSSE) are paramount when conducting any at-sea procedures. Recognizing the inherent dangers involved in launch and recovery of ocean-going equipment, and that a certain level of risk is always present, every effort must be made by all personnel to minimize risk for all of these factors. In preparing for, and conducting these procedures, due regard must be assessed for all dangers, any of which may require a departure from this procedure. The procedures in this document focus on safety, but it is important to identify all facets of HSSE to mitigate associated risks as part of a comprehensive HSSE program, including:

Health:

- Containing the spread of illness and disease with proper training for best hygienic practices, including location-specific vaccinations.
- Medical exam and job function evaluation for personnel to identify specific job tasks that may cause new or recurring injuries that will affect the health and work performance of the individual.

Safety:

- Safety for personnel.
- Avoidance of injury or death due to lack of training, knowledge, expertise, and situational awareness, including improper methods or practices when performing a task.
- Weather and sea conditions.
- Navigation and collision.
- Limitations of the Wave Glider, associated equipment, and/or the support vessel.

Security:

- Security of the US Government, its allies, and their interests.
- Clear policy on unauthorized or suspicious incidents or personnel that present a danger.
- Detection and deterrence regarding access of unauthorized or dangerous personnel to company property or assets.

Environment:

- Protection of the environment regarding hazardous and sometimes non-hazardous substances into the water, land, or air. Mitigated with proper training, reporting, permitting, and responsible practices.
- Prevent negative impacts to vegetation, ground water, humans, animals, insects and marine life.

Personal Protective Equipment (PPE)

The Deck Boss or Lead Tech must ensure that personnel involved with Wave Glider operations have been briefed on the use of PPE and employment of emergency procedures

while at sea or dockside. PPE must meet local regulations, and include as a minimum: protective clothing that is environment appropriate, clearly visible, and has a low risk of becoming snagged such as mustang suits, ANSI rain gear, or coveralls; safety shoes; hard hats; USCG Type V Personal Floatation Devices (PFD) or local equivalent; safety eyewear, and safety gloves. Additional PPE may be required based on local requirements reviewed during the vessel Safety Briefing. Steel or composite-toed safety shoes must be worn at all times while working on deck or during lifting operations. No open-toed shoes are allowed on deck or around the operational area at any time. Hard hats must be worn at all times while hoisting equipment is in use. In the USA, Coast Guard approved Type V PFD work vests must be worn by riggers on the pier, by personnel operating on the pier in close proximity to the water, when conducting launch/recovery operations, when in small boats (at all times), and on larger vessels while on deck. It is good practice to wear a PFD on deck at all times, even when not required by the support vessel. Additional PPE for personnel working near open fantail areas may include tethering and fall restraint harnesses depending on industry, client, or support vessel standards.

Deck Safety

Support vessel configuration, hoisting apparatus, deck crew skill and experience, and sea state affect the success of the deployment. These risks can be mitigated through proper procedures and techniques, but not completely eliminated. It is important to identify potential hazards before commencing operations, such as vessel orientation to reduce swinging loads, pinch points, trip hazards, and confined spaces. Only properly trained personnel should attempt Wave Glider deployments. LRI provides highly skilled, trained Field Operations Technicians to perform deck activities, and adapts techniques to each deployment based on the vessel and hoisting configurations. The described procedure details basic configurations for the most common scenarios, and incorporates concepts to minimize the physical handling of the Wave Glider during a deployment. Hoisting safety is emphasized with the goal to keep personnel from being under the load and clear from No Entry Zones, established during pre-deployment risk assessments. A Permit to Work is a common requirement to ensure deck safety.

Job Safety Analysis

Prior to beginning at-sea operations, the Lead Tech/Deck Boss conducts a safety briefing (Job Safety Analysis or JSA, often referred to as a “tool box meeting”). All deck crew team members and support vessel operators must attend. For a detailed overview of all hazards and associated mitigations, the Lead Tech/Deck Boss must use, at a minimum, a JSA such as the LRI [Appendix B: Job Safety Analysis Form](#), before operations begin. The on-deck tool box meeting before each deck activity reviews the on-scene checklist regarding safe working areas, No Entry Zones, equipment, rigging, roles, and contingencies, in order to be clear regarding the intent, authority, and work instructions. During this brief the Deck Boss and Lead Tech are responsible for reviewing the planned operations, and all safety rules and issues, with a focus on where or how personnel might get injured, and steps to reduce these risks. During all at-sea operations, strict adherence to all launch and recovery procedures and operating protocols must be maintained.

Sea State Considerations

Safe sea state for launch and recovery operations will be in part dependent on the size and type of vessel of opportunity. In general, Wave Glider operations should not be conducted in conditions greater than Sea State 4 (World Meteorological Organization Sea State Code 4/ Douglas Sea State Code 4), which is defined as moderate wind seas (1.25 - 2.5 meters) and

moderate swell (average and moderate wave). This correlates to Beaufort Scale 4 moderate breeze of 5.5-7.9 meters/second wind speed. As you approach wind speeds of Beaufort Scale 5 fresh breeze (8.0-10.7 meters/second), Wave Glider hoisting operations can become difficult to control and unsafe. Unsafe Wave Glider operating conditions often times can be identified by the Captain or Lead Tech before the support vessel departs, and may lead to delays or additional standby time at port. Sea state and prevailing weather are important factors to review when determining best vessel orientation for launch and recovery activities.

No Entry Zones During Deployment Activities

Working in conjunction with the support vessel's Deck Boss, the Lead Tech must identify and agree upon No Entry Zones. Any and all personnel on board are prohibited to enter a No Entry Zone, once the lift has begun. A lift operation has begun once the hoisting line is made secure to the Wave Glider. Where deck space allows, the preferred No Entry Zone around the Wave Glider lift is two meters. No personnel should enter this area without the expressed approval of the Lead Tech and the support vessel's Deck Boss.

Observing the two meter No Entry Zones rule requires proper tag line and/or boat (push) pole use. The Lead Tech and Deck Boss must coordinate best use of tag lines to ensure safe hoisting and control of the load. In concept, the tag lines must be sufficient to control load swing from at least two opposing directions, keeping in mind the Wave Glider is a multi-part vehicle and each piece must be controlled. For safe deployments every person involved must understand their role in controlling the Wave Glider during hoisting operations.

Deck Communications

It is important that all deck operations participants can clearly hear and understand communications between the Captain, Deck Boss, Lead Tech, and Deckhands. This can be accomplished by loud voice commands, hand-held radios, or established hand signals. It is critical that the Lead Tech can communicate to the Deck Boss or directly to the Hoist Operator during hoisting activities, especially during multi-stage hoist situations to ensure recovery gear is applied safely to the Wave Glider. Voice commands must be repeated before an action is taken by the responsible member of the team to affirm the command was understood. Terminology must be agreed upon. For example, the terminology to use to strike an improper command, such as "stop" or "belay my last", as well as how to correct a command repeated incorrectly, such as calling out "command" then repeating the correct command. In situations where ambient noise is too loud for voice commands or radios, the Hoist Operator must have a clear view of the Lead Tech or Deck Boss that is providing hand signals. Preferred deck communications are to be established between all operations participants during the JSA meeting. During the JSA tool box meeting, the deployment team must identify the (only) person to provide commands to the Hoist Operator and the Captain.

Radio Guard Communications

The Lead Tech is responsible for communicating with a shore-based contact (Radio Guard) for deploying at-sea. The Wave Glider Operations Center (WGOC) must hold the radio guard for the at-sea mission for LRI personnel, according to the generally accepted practices noted below:

- The *WGOC Mission Plan* (see [Appendix A: Reference Documents](#)) establishes and identifies the vessel name, Lead Tech name, LRI satellite phone number, and estimated departure and return times of LRI personnel to the dock.

- The Lead Tech shall contact the WGOC to confirm all information before leaving the dock and confirm the time at which the vessel is leaving and a check in time or estimated return time. The vessel should display AIS, if so equipped, for WGOC tracking of mission progress.
- If necessary, upon arrival on location, the Lead Tech contacts the WGOC about launch or recovery operations to communicate commands or instructions for the WGOC to complete.
- The Lead Tech should update the WGOC with the vessel's ETA to the dock, or if AIS is actively being monitored, will call in when back at the dock.
- The Lead Tech contacts the WGOC to confirm all secure upon returning to the dock. If any injuries, damage to equipment, or safety concerns were experienced, the WGOC opens an Operational Service Quality Incident (OSQI) at this time for purposes of immediately reporting any incidents. For more information see [Appendix C: Operations Service Quality Incident \(OSQI\) Report](#).

At-Sea Personnel Transfer

At-Sea transfers of LRI personnel are not advised. In cases where it is absolutely necessary to transfer LRI personnel to another vessel or platform, the WGOC must have the contact information for the new vessel and continued communications for the transport and expected arrival time to shore. Monitoring of the LRI personnel's at-sea position continues through WGOC pilot pass-down shifts until LRI personnel have communicated that they are safely back on shore.

Hoisting Apparatus

Basic hoisting/crane safety guidelines must be followed at all times. Check with the support vessel operator for other vessel specific guidelines. Only qualified personnel shall operate hoists, cranes and other lifting machinery.

- All running rigging and hoisting gear must be inspected for wear.
- Ensure all hoisting gear is properly rated for safe working loads.
- Only one member of the deck crew shall provide hand/verbal signals to the Hoist Operator. The Deck Boss or Lead Tech provides this role.
- Suspended loads must not be left unattended.
- Team lifting concepts are incorporated for all Wave Glider movements other than during mechanical lifts.

Hoisting Apparatus Considerations

A Vessel of Opportunity is vetted and chartered based on appropriate hoisting equipment and experienced equipment operators. The common types of vessel-provided hoisting equipment used in Wave Glider launch and recovery scenarios includes cranes, A-frames, J-frames, davits, booms, and a variety of winch combinations and associated blocks. The vessel configuration determines which lifting gear is used to achieve the safest operation. Procedures and PPE are used to mitigate risk. Several factors affect the risk assessment on which hoisting gear combination to use, including:

- Height over rail, distance outboard, and total suspended load length
- Weight of hoisting hook and/or block and associated equipment tag lines

- Sea state
- Wind speed
- Number and skill of personnel available to assist on deck
- Vessel maneuverability
- Captain's ability to view the operations unobstructed

The hoisting equipment chosen for Wave Glider recovery determines if the operation is a single-stage or multi-stage hoisting evolution and this dictates the No-Entry Zones and tag line use.

Rigging (Block and Tackle) considerations

Additional hoisting equipment considerations include the size and set-up of the hoisting equipment. Large vessels with heavy weight capacity winches, cranes, blocks, and wire rope, may be rigged with blocks, counterweights, and wire rope terminations that may weigh more than the Wave Glider and require additional tag lines to control. Lines and slings may be required to keep vessel blocks, counterweights, and wire rope terminations out of the water, which adds additional height over rail or height over deck for the hoisting operation.

Sub Recovery Device

The Sub Recovery Device is used to hoist the Sub component of a Wave Glider during a recovery where the vessel configuration dictates that the Float and Sub are hoisted on board separately (multi-stage hoisting).

Figure 4.1. Sub Recovery Device with Sling



The Sub Recovery Device is installed on the Umbilical and presents two hazards:

- 1) It may be difficult to install the Sub Recovery Device on the Umbilical without partially getting under the load (if the Float is suspended in air).
- 2) The Sub Recovery Device uses a cam lock that grips the Umbilical as a means to hoist the Sub. This device does not positively lock, posing a risk that the device may slip when hoisted, and this slipping risk is increased if the Umbilical is biofouled.

Proper training is required and provided by LRI to effectively use the Sub Recovery Device. See [“Recovery Rigging Equipment” \(page 20\)](#) and [“Recovery Overview” \(page 38\)](#) for more information.

Hoist/No Hoist Points

The Wave Glider SV2 in a bundled configuration, is designed to be hoisted only from the Lifting Bail located on the float. The handles on the float are **No Hoist Points**. The handles can be used for tag lines or for manual shifting of the Wave Glider Float, but are not load rated for hoisting the entire Wave Glider vehicle (bundled or unbundled).

The Sub can be recovered using a Sub Recovery Device attached to the umbilical, or by attaching a hoist line to the lifting handle at the bow of the Sub. No other place on the Sub should be used as a hoist point.

In a single-stage hoist for recovery, the entire Wave Glider SV2 vehicle can be hoisted (unbundled) by the Lifting Bail located on the Float and nowhere else on the vehicle.

Chapter 5. Support Vessel Considerations

LRI charters independent vessel companies in order to perform Wave Glider deployments, and has established Vessel Of Opportunity (VOO) specifications necessary for safe deployment activities.

Vessels Of Opportunity

The VOO must be purpose built or suitably converted to undertake survey, research, or unmanned vehicle operations in the designated geographical area throughout the calendar year. The vessel must be seaworthy, capable of launch and recovery at 2 knots or less, and supplied fully equipped with current and valid certifications for its classification during the proposed time period.

Deployments of the Wave Glider have been accomplished on many vessel configurations. The VOO Comparison Table details general vessel specifications.

<u>Category</u>	<u>Endurance</u>	<u>Typical Minimum Length</u>	<u>Freeboard</u>	<u>Example</u>
Offshore	Multiple Day, Mission specific, overnight berths for male/female	40m	<3m	Offshore Supply Vessel (OSV)
Coastal	< 5 days; 100 nm offshore	16m	<2m	Research Vessel
Nearshore	Day use only; < 30 nm offshore	8m, depending on mission specifics	1m	Converted Fishing Vessel
Tender/small boat	Ship tender use only	N/A	1m max	Fast Rescue Boat (FRB)

For more information see [Appendix G: Nearshore Vessel Requirements](#), [Appendix H: Coastal Vessel Requirements](#), and [Appendix I: Offshore Vessel Requirements](#).

VOO Hoisting Scenario Considerations

Vetting of a VOO must include full understanding of hoisting rigging and equipment. Procedures for Wave Glider deployment assume the hoisting equipment meets the minimum requirements summarized in this section.

Hoisting operations must be vetted prior to mobilization. Safe working loads must be understood and agreed to. The VOO configuration must be vetted to understand many variables. Critical variables include:

- Dockside accessibility for hoisting.
- Dockside hoisting constraints (1-tonne minimum).

- Deck space, sufficient for Wave Glider(s) and supporting equipment.
- Hoist Operator skill proficiency and certification validity.
- No Entry Zones
- Hoisting equipment type, lifting/travel capacity:
 - Crane, A-frame, J-frame, Davit, or other.
 - Deck to waterline travel capabilities (freeboard).
 - Minimum height-over-rail requirements (3m to 10m depending on scenario).
 - Minimum distance of travel outboard (2m).
 - Minimum distance of travel inboard (2m).

Single-Stage Hoisting (One-point Pick)

Recovery of a Wave Glider is performed by attaching a hoist line onto the Lifting Bail of the Float. The hoist line is attached with a boat pole and carabiner clip, and requires relatively low VOO freeboard to reach the Wave Glider. If the VOO hoisting equipment has sufficient capability, the Wave Glider is hoisted in a single stage using proper tag lines to control the assembly (assumes 9-10m of hoisting height-over-rail to recover a fully extended Wave Glider). To reduce the height-over-rail requirement, use of multi-stage lifting techniques should be employed.

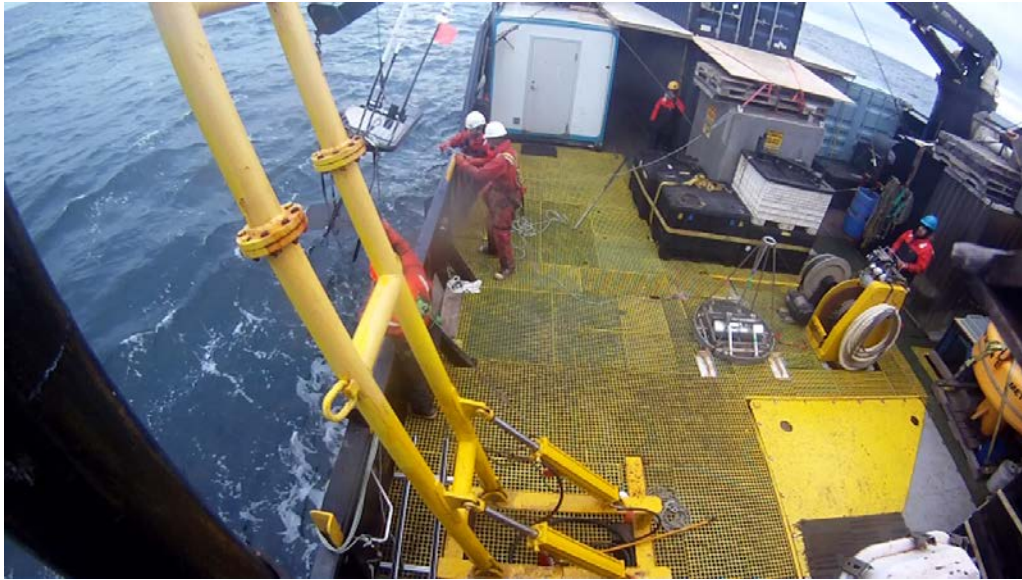
Figure 5.1. Single-Stage Hoisting



Multi-Stage Hoisting (Two-point Pick)

Multi-stage hoisting methods are used to recover the Wave Glider when hoisting height-over-rail is limited. If the hoist does not have ample travel to recover a Wave Glider in a fully deployed length, multi-stage hoisting techniques must be used with either a single hoist, or a combination of two hoists.

Figure 5.2. Multi-Stage Hoisting



The Float is hoisted to a height that the Umbilical is accessible, the Sub Recovery Device is sent down the Umbilical and secured to take the hoisting load from the Float. The Float is brought inboard, lowered to deck and made secure, or secured with the primary hoisting device if a second hoisting device is available for the Sub. For more information see [“Recovery Overview” \(page 38\)](#).

Chapter 6. Hoisting and Rigging Considerations

Specific hoisting and other rigging gear are required for Wave Glider launch and recovery.

Launch Rigging Equipment

- **Liquid Robotics Bundling Strap**

Used to hold the Float and Sub assembly together prior to launch. Pulling the quick release line allows the bundled assembly to separate, and is designed to be activated when the Wave Glider is in water, allowing the sub to descend and begin propulsion. See [“Launch Operations” \(page 28\)](#) for Bundling Strap use procedures.

Figure 6.1. SV2 Bundling Strap



- **Quick Release Shackle and Lift Sling Assembly**

A quick release shackle (for example a SeaCatch), connected to a load rated sling, is used to hoist the vehicle by the Lifting Bail into the water. A minimum safe working load of 1 tonne is required for both the quick release shackle and the lift sling. The lift sling should be of adequate length to locate the Wave Glider a safe distance below hoisting equipment.

Figure 6.2. SeaCatch with Lift Strap



- **(2) 10m or longer 1cm to 2cm diameter Braided Nylon Tag Lines**

Two tag lines to steady the vehicle as it is lifted into the water. The bitter ends must not have any knots or hardware attached and be slipped.

Figure 6.3. Tag Line



- **(6) 3m Tie-Down Straps**

Used to secure the entire Wave Glider assembly to the Stand for storage and transit. At least two tie-down or ratchet straps should be used. In addition, at least 4 tie-down or ratchet straps should be used to secure the Wave Glider assembly and Stand to the vessel deck.

Figure 6.4. Tie-Down Strap



See [Figure 6.5](#) for placement of tie-down straps.

Figure 6.5. Using the Tie-Down Straps



- **Boat Poles**

Push/pull poles and/or boat poles ready with a carabiner clip (also called a mooring clip) attached to one end to secure tag lines, if the launch is aborted and an immediate recovery becomes necessary, or to fend the bundled Wave Glider away from the vessel and orient it prior to releasing the bundling strap, if necessary. Length of boat poles should be appropriate for available deck space and distance to the water.

Figure 6.6. Boat Pole



Recovery Rigging Equipment

- **(2) 15m or longer 1cm to 2cm diameter Braided Nylon Tag Lines**

At least two lines ready to control the vehicle as it is lifted from the water.

- **(2) Boat Poles**

Two boat poles, each with a capture carabiner clip attached to one end to secure tag lines and the lift sling to the vehicle. Length appropriate for size of vessel and freeboard.

Figure 6.7. Carabiner Clip Attached to Boat Pole



Figure 6.8. Boat Pole with Carabiner Clip and Tag Line



- **1m-3m Load Rated Lift Strap with Carabiner Clip**

This assembly is attached to the Lifting Bail to hoist the Float out of the water if there is available hoist height over rail to do so. The lift strap provides a safe distance between the vehicle masts and what may be a large counterweight or heavy hoist hook on the hoisting equipment. Minimum safe working load of 1 tonne required (see [Figure 6.9](#)).

Figure 6.9. Boat Pole with Carabiner Clip and Lift Strap



- **Sub Recovery Device with Lift Strap and Tag Line**

The Sub Recovery Device is attached to the Umbilical by closing a locking gate. Once installed, the device is allowed to gravity-drop down the length of the Umbilical to the Sub. The Sub Recovery Device uses a cam lock to grip the Umbilical to allow hoisting the Sub. A lift strap should be used between the hoisting line and the Sub Recovery device to keep shackles or cable terminations from jamming between the Sub Recovery Device and the Umbilical. The line and lift strap must be long enough to reach the bottom of the Umbilical from the surface, which depends on the Umbilical length (typically 5.8m plus sea state and rail height). An additional tag line can be attached to the Sub Recovery Device and used to control the swing of the Sub from a safe distance. A minimum safe working load of 1 tonne is required on all hoisting equipment, line, and lift strap.

Figure 6.10. Sub Recovery Device with Lift Strap



Chapter 7. Pre-Deployment Activity and Equipment

Unpack and Assemble

Successful launch of a Wave Glider system relies on proper make-ready in the field. The Lead Tech (or designated trained resource) is responsible for ensuring the system is properly unpacked, assembled, mobilized for deployment, and that all pre-launch procedures are completed. Refer to the *Wave Glider SV2 Unpacking & Assembly Guide* for pertinent details (this book is listed in [Appendix A: Reference Documents](#)).

Minimum Equipment Requirements

Field Operations Kit

LRI technicians carry extensive equipment on each deployment activity. These kits are available for purchase through LRI, and equipment lists can be forwarded upon request. The kits contain required equipment as well as consumable parts often used during deployment. The level and amount of tools, consumables, and spare parts may vary, based on technician expertise and understanding of the current mission. Several critical components of these kits are required in order to successfully launch and recovery a Wave Glider, and must be available for every deployment. **A Sub Recovery Device must be available during all launch activities where the VOO cannot perform a single-stage hoist recovery, in case the Wave Glider needs to be recovered immediately after launch.**

Minimum Hardware Requirements for Wave Glider Deployment

- **Wave Glider SV2**
- **Satellite Phone** - Due to remote deployments, LRI technicians must have secure communications with the Wave Glider Operations Center (WGOC) to complete deployment checks.
- **Stand and Saddle** - Shipped with the Wave Glider, the Stand supports the Wave Glider for mobilization onto and around the deck of the VOO. The Wave Glider components stack into a bundled state on the Stand, starting with the Sub. The Saddle nests on top of the Sub wings with Saddle arrow facing forward. The Float rests on top of the Saddle. The bundled Wave Glider is configured so it can be hoisted free of the Stand. The Saddle is recovered using the same line that is used to release the Bundling Strap.
- **Bundling Strap** - Used to bundle the Wave Glider Float, Saddle, and Sub during hoisting activity for launch.
- **Tie-Down Straps** - (minimum 6) During mobilization activities, the bundled Wave Glider is strapped to the Stand using at least 2 tie-down straps. Additional tie-downs are used during deck operations to secure the Wave Glider and Stand to the deck using opposing forces as described in International Maritime Organization (IMO) Annex 13, Safe Practice for Cargo Stowage and Securing.

- **Quick Release Shackle** - For example, SeaCatch. A quick release shackle, or the equivalent. Used to connect the hoisting line to the bundled Wave Glider with a quick release mechanism. The release line removes a safety pin and then opens the mechanism, allowing Wave Glider separation from the hoist line. Minimum Safe Working Load (SWL) 1 tonne.
- **Carabiner Clips** - (minimum 3) In sufficient quantity to attach tag lines to the Wave Glider during recovery. LRI provides carabiners with mounting hardware that can be field installed onto boat poles.
- **Sub Recovery Device** - LRI uses a custom fabricated device designed to travel down the Umbilical, providing a Sub hoist point for multi-stage hoisting.
- **10m Tag Lines** (minimum 3)
- **Lifting Straps and Rigging Gear** - To facilitate hoisting clearances and safety. All lifting straps and rigging gear must be stamped with a Safe Working Load of at least 1 tonne.
- **Hand Tools and Torque Wrench** - Associated with proper assembly instructions contained in the *Wave Glider SV2 Unpacking & Assembly Guide*.
- **Troubleshooting Tools** - Xbee dongle, debug cable, battery chargers, dummy plugs, etc.
- **Consumable Parts** - Loctite, lubricant, fasteners, etc.
- **Boat Poles (minimum 3)** - If not supplied by VOO.

In Field Pre-launch Check

After Wave Glider unpacking and assembly, but prior to launch, a pre-launch check of the Wave Glider system by the Lead Tech or by other trained personnel is required using [Appendix E: Wave Glider SV2 Pre-Launch Checklist](#). This checklist is used to ensure the Wave Glider is both mechanically and electrically prepared for deployment. If any issues are found during these checks, the deployment must be postponed until the issues are resolved or are signed off by the Project Manager. Additional pre-launch checks may be required for some payloads or in some operational regions. The Wave Glider must be powered on and have sufficient space to complete a 360 degree spin test in an area with unobstructed access to open sky for satellite communications. Approximately one hour should be allowed for each Wave Glider, to perform a thorough pre-launch check.

WGOC Pre-launch and Launch Checks

The WGOC will perform pre-launch and Launch checks to ensure the vehicle is prepped for piloting and that all systems are a go, before the Vessel of Opportunity and Lead Tech depart the launch vicinity. For more information see [Appendix F: WGOC SV2 Launch, Recovery, and Piloting Checklist](#). An unplanned recovery of the vehicle may be required, if issues are found that cannot be resolved remotely by the WGOC.

Wave Glider Transit and Storage Considerations

Deployment activities may include transporting the Wave Glider across rough terrain, securing the bundled vehicle, and/or storage of the system for an extended period. Care

must be exercised to ensure the system is secured in a standby configuration for deployment, otherwise the system should be disassembled and packed for shipment or long-term storage. Refer to the Wave Glider SV2 Disassembly & Packing SOP (see [Appendix A: Reference Documents](#)).

If the Wave Glider is to be standing by for imminent deployment, several considerations affecting success should be reviewed and addressed, including:

- **Power Management and Solar Charging:**

- Solar panels on-board a Wave Glider provide power to the internal systems and must have clear view of the sky to maintain battery levels while the vehicle is powered up.
- Shorting pin (Power Key) must be inserted for the vehicle to be powered up, and to charge via solar panels or battery chargers.

Figure 7.1. Shorting Pin (Power Key) Installed



- Any obstruction between the solar panel(s) and sky can impact charging. All attempts to minimize obstructions should be given priority to provide optimal charging (even a small strap may adversely affect charging performance).
- During stowage of the Wave Glider on deck, take into consideration items such as upper decks, railings, masts and antennae, all of which may shade the solar panels and affect charging performance.
- Use of battery charging procedures in lieu of solar panel use. This should not be done while the VOO is underway, if the Wave Glider is exposed to a wet deck or the elements. For more information, contact LRI Customer Support. For information on battery charging, see the *Wave Glider SV2 Interface Control Description*.

- **Tie-Down Straps:**

Use of proper load-rated tie down straps must be used for:

Pre-Deployment
Activity and Equipment

- Securing the bundled Wave Glider to the Stand (until just before launch).
- Securing the Stand to deck. Run one strap across the forward solar panel, through the first and second wing, capturing the aluminum stand. The ratchet should be positioned in the space between the Float and the Wings. The aft strap should be positioned similarly between the fifth and sixth wing and also capture the Stand.

Chapter 8. Wave Glider SV2 Launch

Launch Overview

Launching a Wave Glider must be done in a bundled configuration. Depending on payloads, a launch-ready Wave Glider SV2 assembly weighs approximately 115kg-135kg, with overall envelope dimensions of 2.2m x 1.2m x 1.2m (excluding any attached masts). The Sub assembly rests on the aluminum Stand. A polymer Saddle nests on top of the Sub that in turn supports the Float.

The Bundling Strap secures the Sub and Float together for launch and is tethered to the saddle allowing Saddle retrieval after the Wave Glider is away. The Bundling Strap has a quick release mechanism that is activated during the launch. Two Tie-down Straps hold the Wave Glider to the Stand until just before the vehicle is hoisted for launch. The Stand is tied-down separate of the Wave Glider, and remains on deck after the Wave Glider has been hoisted for launch.



Warning

The Wave Glider should never be launched unbundled - the umbilical can easily become twisted and affect vehicle performance. The launch process is well developed and has a high success rate that ensures proper Wave Glider performance.

The Wave Glider is launched utilizing the Lifting Bail by attaching a quick release shackle (for example, SeaCatch) secured to the hoist line. Once lifted clear of the Stand, the assembly is positioned overboard and lowered to the waterline. Care must be exercised by the attending crew to minimize the swinging movement of the assembly during hoisting, by using the appropriate configuration of tag lines. The bow of the Wave Glider must be oriented away from the vessel (45-90 degrees recommended), and the bow tag line must be slipped. At splashdown, the hoisting line quick release shackle is released and then the Bundling Strap is tripped. Once the bundling strap is tripped, the Sub falls down and away, pulling the Float away from the support vessel. The stern tag line is slipped. Once the Float is clear of the vessel and underway, the Saddle and Bundling Strap are recovered back to the deck.



Note

The Wave Glider can be modified to incorporate new and different equipment such as towed sensors (towbody or towfish) and arrays, or acoustic streamers. Launching and recovering this equipment must be carefully reviewed, and techniques determined, before these missions begin. Each case requires safety considerations, given the hardware being used. For more information see [Appendix J: Towfish Launch and Recovery Procedures](#). For assistance, contact LRI Customer Support.

Figure 8.1. Wave Glider SV2 Pre-launch Ready



Launch Operations

Estimated Duration: 20 minutes

Launch - Required Personnel

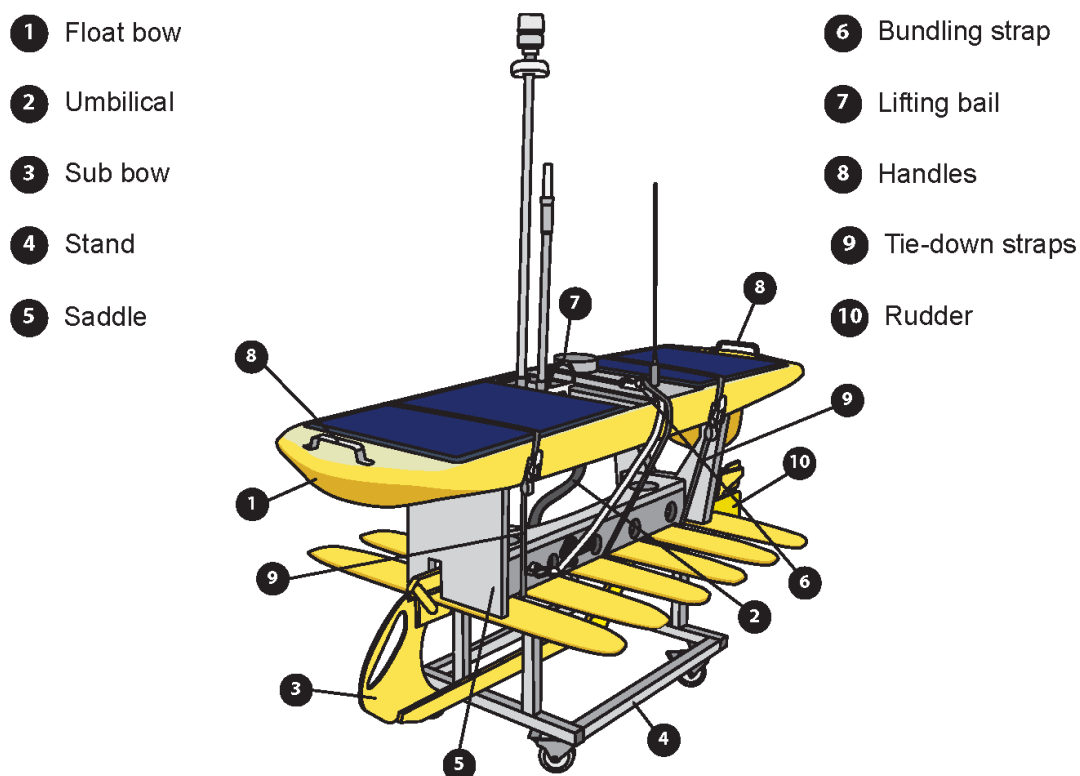
- 2 Deckhands

- 1 Lead Technician (may also be Deck Boss)
- 1 Hoist Operator
- 1 Captain/Vessel Operator

Launch Procedure

Perform safety briefing and related checklists 30 minutes prior to launch. For more information see the LRI [Appendix B: Job Safety Analysis Form](#).

The following figure identifies Wave Glider SV2 components referenced in the launch procedure.

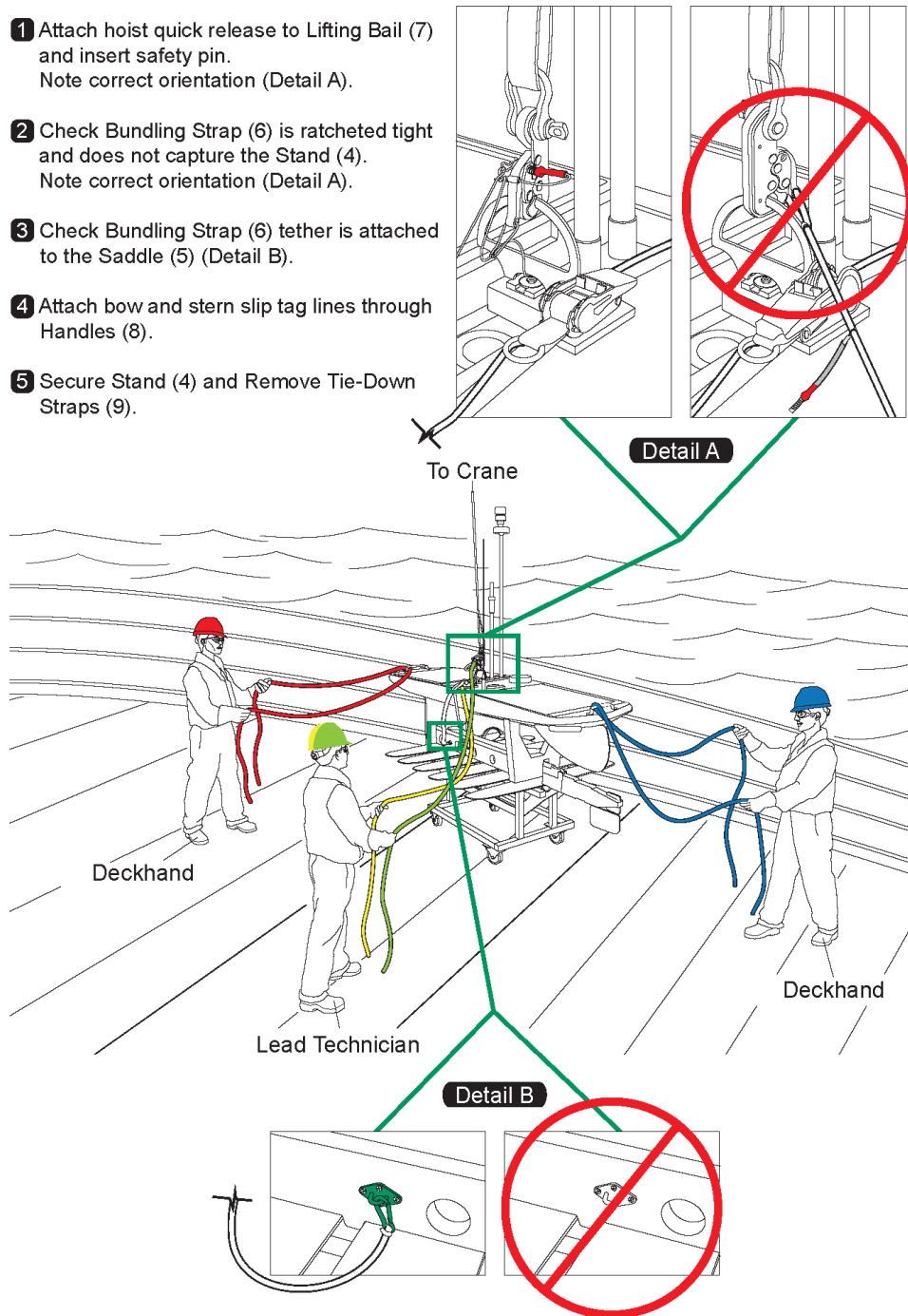


Step 1 - Make Ready to Hoist

1. Attach hoist quick release shackle to Lifting Bail and insert safety pin. Note correct orientation of the quick release to ensure the position of the quick release allows triggering the device from the left (port) side or aft of the Wave Glider. This keeps the quick release rigging away from the masts. Use a sufficient load rated lifting strap to keep heavy hoist counter weights, or the crane hook, away from the Float and its antennas as necessary.

Figure 8.2. Make Ready to Hoist

- 1 Attach hoist quick release to Lifting Bail (7) and insert safety pin. Note correct orientation (Detail A).
- 2 Check Bundling Strap (6) is ratcheted tight and does not capture the Stand (4). Note correct orientation (Detail A).
- 3 Check Bundling Strap (6) tether is attached to the Saddle (5) (Detail B).
- 4 Attach bow and stern slip tag lines through Handles (8).
- 5 Secure Stand (4) and Remove Tie-Down Straps (9).



2. Check that the Bundling Strap is ratcheted tight **and does not capture the Stand**. Note correct orientation of the Bundling Strap (Detail A). The Bundling Strap should be installed aft of the Lifting Bail and Masts with the ratchet centered on the turtle deck (the panel that covers the Command and Control Box electrical connections). The Bundling Strap should be centered to run through the center wings of the Sub. **Be careful to capture the Sub but**

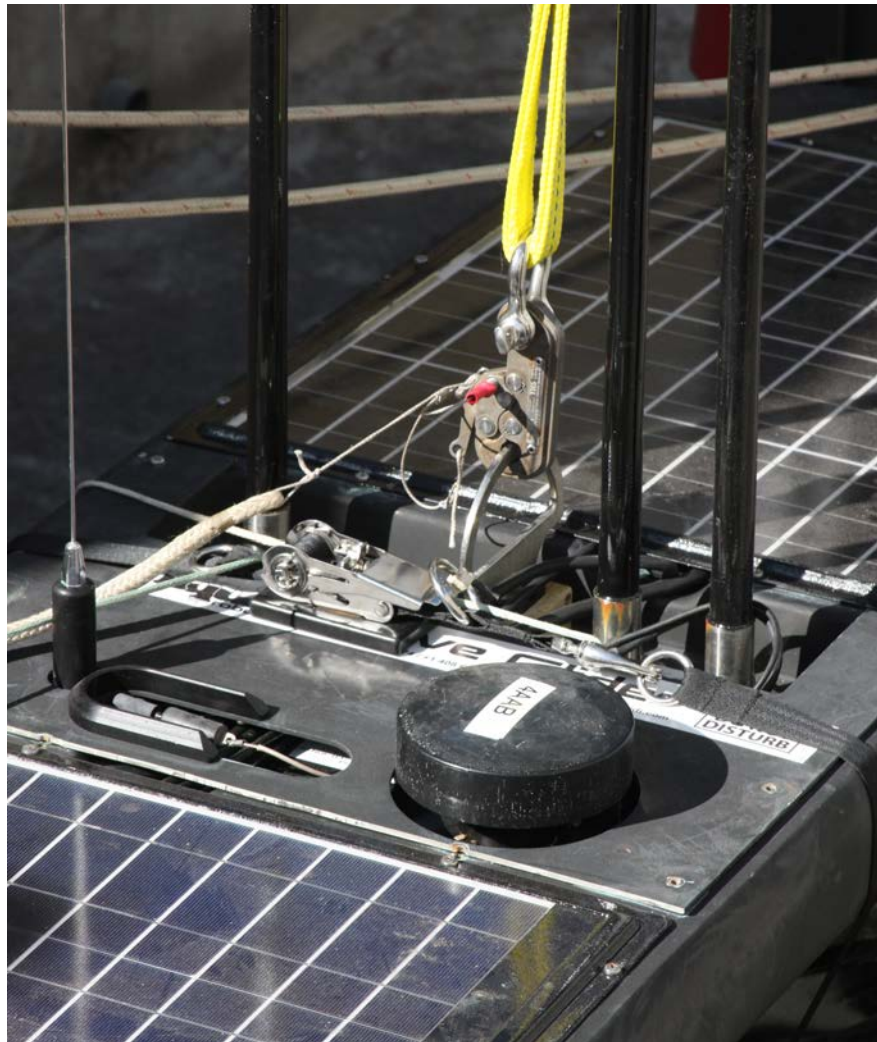
not the Stand. The Bundling Strap **must** be oriented to release when pulling from the left (port) side of the vehicle.

 Warning

If the Bundling Strap is in the reverse orientation, it will be very difficult to release. Incorrect Bundling Strap orientation can pose significant risk of damage to the vehicle.

3. Check that the Bundling Strap tether is attached to the Saddle (Detail B). This tether must be clipped to the Saddle in order to recover the Saddle upon launching the vehicle.

Figure 8.3. SeaCatch with Bundling Strap



4. Insert one bow tag line and one stern tag through the Float Handles. These should be slip lines without any knots or hardware that can bind in the Handles upon release.

Figure 8.4. Slip Tag Line Through Handles

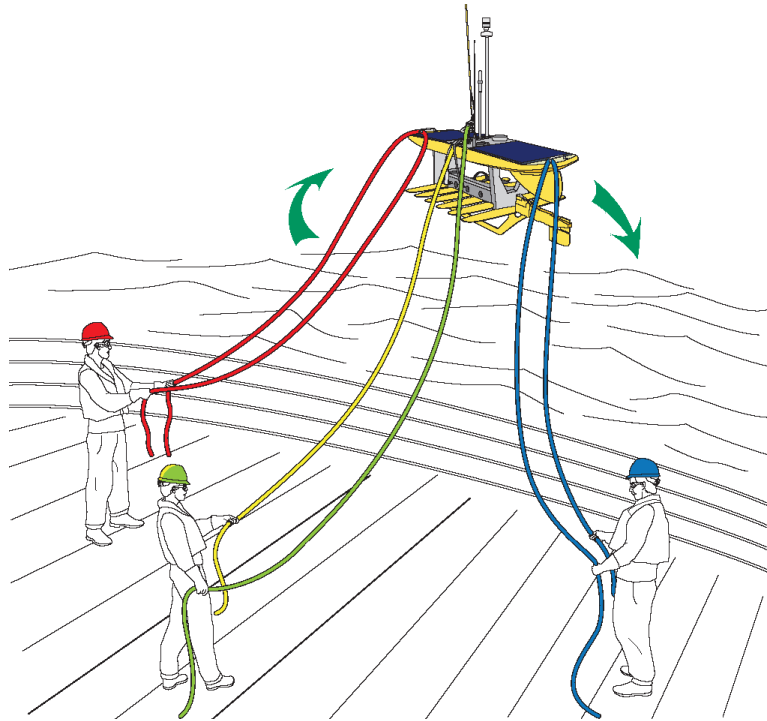


5. Secure the Stand and remove the Tie-down Straps that secure the Wave Glider to the Stand. The vehicle is now ready to hoist while the Stand remains secured to the deck.

Step 2 - Hoist to Water

1. Lead Tech confirms with the Captain that the support vessel is at the launch location. Lead Tech ensures Hoist Operator, and Deckhands are ready.
2. Deck positions: One Deckhand tends the stern tag line to stop the Wave Glider assembly from swinging. A second Deckhand tends the forward (bow) Handle tag line. The Lead Tech tends the two quick release lines from the left (port) side of the Wave Glider.
3. Lead Tech requests the Captain bring the vessel to dead in the water (or neutral for smaller craft, or the slowest underway gear possible to maintain vessel steerage for ships) in the preferred orientation, often stern to the seas and /or wind on the launch beam, and requests permission to launch the Wave Glider.
4. The Lead Tech signals the Hoist Operator to lift the vehicle up and into the water.

Figure 8.5. Hoist to Water



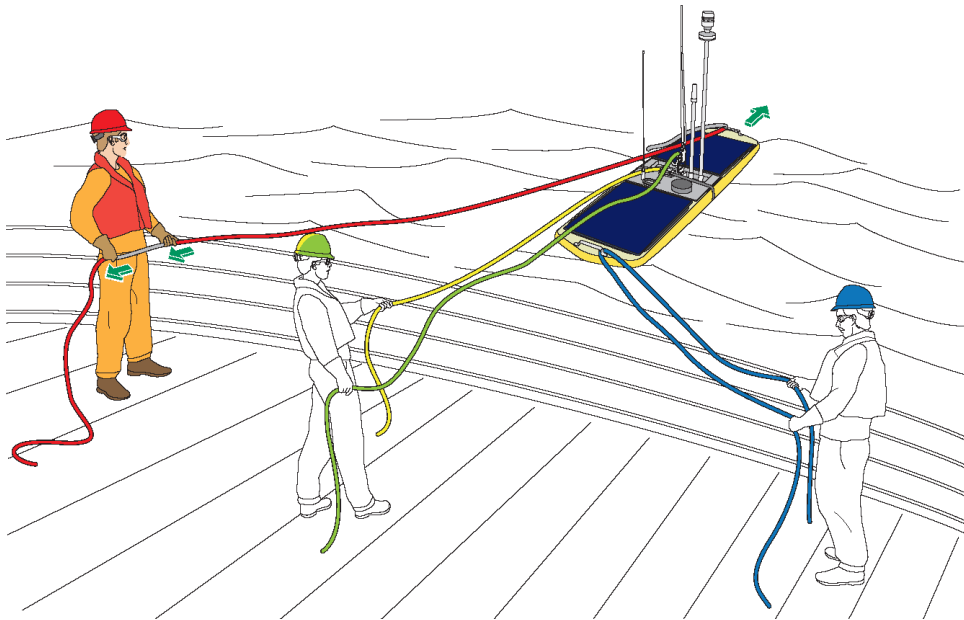
Note

Step 3A - 3D occur in rapid succession and special attention is required.

Step 3A - Release Bow Tag Line

If the Wave Glider is properly oriented away from the vessel (ideally at a 45-90 degree angle from the vessel), the deckhand releases and retrieves the bow tag line. This deckhand has a boat pole ready to assist with orienting the Wave Glider away from the vessel if needed.

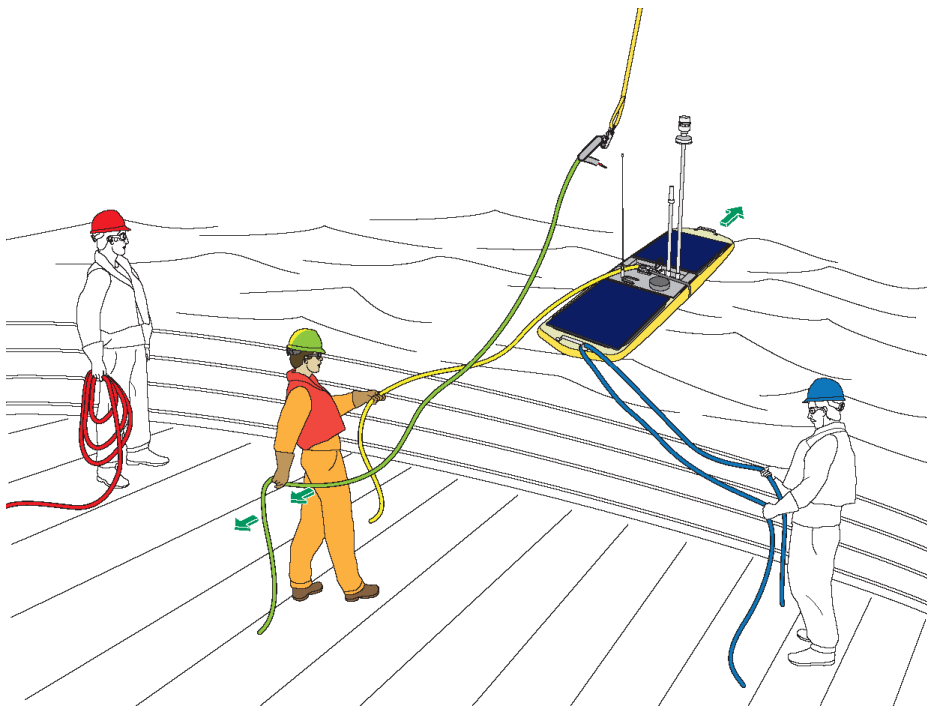
Figure 8.6. Release Bow Tag Line



Step 3B - Release Hoist Line/Cable

As soon as the Wave Glider Float is touching the water (while there is still tension on the hoisting line), the Lead Tech pulls the hoisting quick release mechanism trip line and pulls this line clear of the Wave Glider masts.

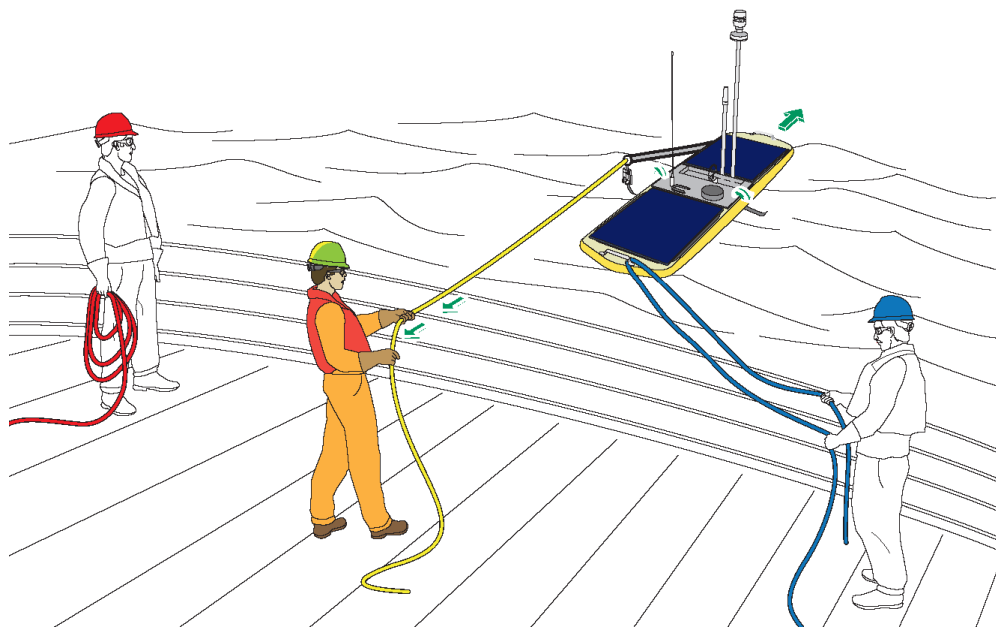
Figure 8.7. Release Hoist Line/Cable



Step 3C - Release Bundling Strap and Pull Saddle Away

When all released lines are free and clear of the vehicle masts, the Lead Tech pulls the Bundling Strap release line. Note: If a line becomes entangled, the Lead Tech ensures all are free and clear (employing deckhand with boat pole if needed) while the vehicle is still floating alongside the vessel, and tended with the stern tag line. Once clear of entangled lines, the vehicle is oriented correctly away from the vessel with boat poles and the stern tag line before tripping the Bundling Strap release line. The Bundling Strap release line is attached to the saddle and pulling it in will recover the Saddle.

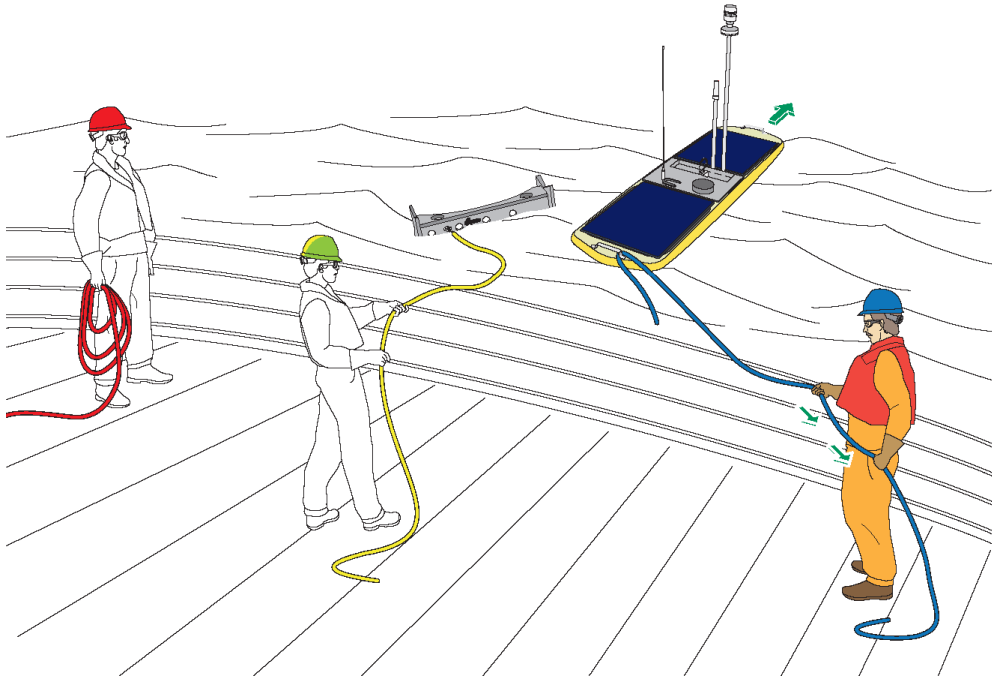
Figure 8.8. Release Bundling Strap and Pull Saddle Away



Step 3D - Release Stern Tag Line

The Deckhand on the stern tag line slowly slips the line as the Wave Glider lunges away from the vessel. (The vehicle will abruptly move forward through the water when the Sub drops after the Bundling Strap is released in Step 3C.)

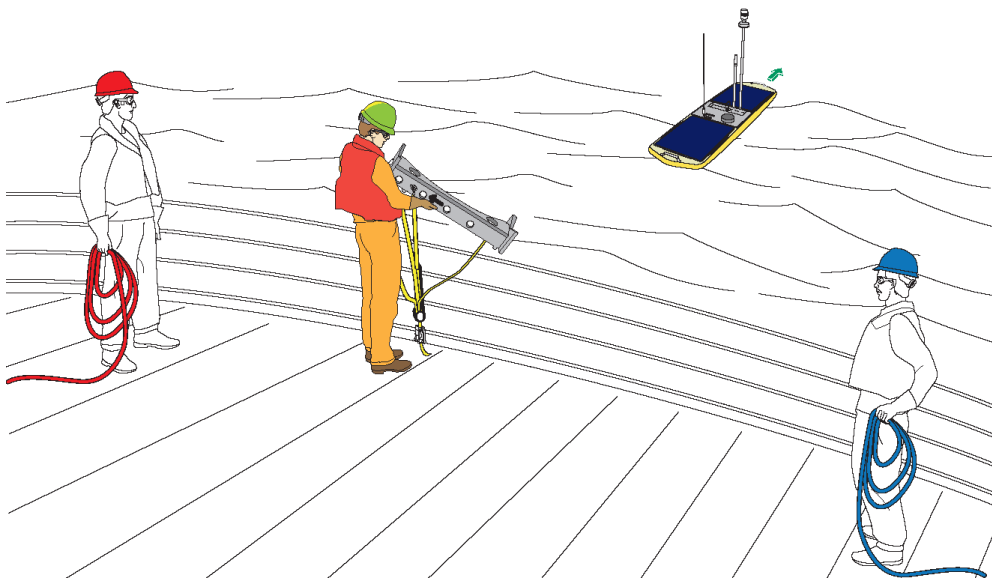
Figure 8.9. Release Stern Tag Line



Step 4 - Retrieve Saddle and Bundling Strap

Once the Wave Glider is clear of the support vessel, Lead Tech retrieves the Saddle attached to the Bundling Strap by hand, to the deck of the vessel.

Figure 8.10. Retrieve Saddle and Bundling Strap



The Lead Tech must check WGMS for alarms, start the vehicle mission, and start the sensors. This step may require calling WGOc, or shore support. Conduct the WGOc Post-launch checklist. For more information see the [Appendix F: WGOc SV2 Launch, Recovery, and Piloting Checklist](#).

Chapter 9. Wave Glider SV2 Recovery

Recovery Overview

The at-sea configuration of the Wave Glider has the Float at the surface with a 4 or 5.8 meter Umbilical to the Sub component. Recovery of the Wave Glider can be accomplished in 3 different ways dependent on vessel configuration and hoisting equipment. VOOs should be vetted in advance of recovery operations to determine the safest recovery option for a particular mission, vehicle configuration, and sea state.

Recovery options include:

- **Single-Stage Hoisting:** Recovering the entire Wave Glider on deck in a single hoisting evolution, using one mechanical hoist, such as a crane. This requires 9 - 10 meters height over rail for a Wave Glider SV2 with a 5.8 meter Umbilical.

Figure 9.1. Single-Stage Hoisting



Warning

Hoisting on Umbilical to raise the Sub component exposes highest risk activities, and all hands must be alert to changing conditions.

- **Multi-Stage Hoisting (2 hoists):** Recovering the Wave Glider in a multi-stage hoisting evolution, using two mechanical hoists, one hoist for recovering the Float and one for recovering the Sub.

Figure 9.2. Multi-Stage Hoisting (2 hoists)



- **Multi-Stage Hoisting (1 hoist):** Recovering the Wave Glider in a multi-stage hoist using one mechanical hoist.

Figure 9.3. Multi-Stage Hoist (1 hoist)



Recovery Procedures Overview

Wave Glider recovery procedures require a vessel to be maneuvered in close proximity to the Wave Glider, allowing tag line attachments to the Float Bow Handle and Stern Handle. The

hoist line is attached to the Lifting Bail. The attachment of tag lines and the hoisting line is often done simultaneously using boat poles with carabiner clips. Hoisting can begin to take-up slack from the Lifting Bail - be careful to minimize swinging action with the Float. Note that the Float is often stern heavy, and tends to orient bow up. Care should be taken to avoid damage to the Float and its antennas as the Float is winched up.

Single-Stage Hoisting: If the height of the hoist allows (9-10 meter height over rail), the whole assembly can be lifted high enough to bring the Sub on-board without using the Sub Recovery Device.

Multi-Stage Hoisting (2 hoists):

1. The Float is hoisted to optimal height to expose the Umbilical to the deck crew.
2. A deckhand attaches the Sub Recovery Device to the Umbilical with a lift strap and hoist line attached, and allows it to rapidly sink to the lowest point on the Sub. Depending on vessel equipment, the hoist line dedicated to the Sub may be able to travel down the length of the Umbilical (4-5.8m). If it is not permissible to submerge this hoist line and associated hook, the Sub Recovery Device should be deployed with a lift strap and/or line attached to it that you can use to hoist the Sub. See [“Multi-Stage Hoisting \(2 Hoists\)” \(page 49\)](#) for photos that illustrate this step in the recovery procedure.
3. A load rated line attached to the lift strap is used as the hoisting line, or to attach to the surface hoist line, space permitting.
4. The Sub is recovered to just below the water’s surface to release any load from the Float caused by the Umbilical.
5. The Float is lowered to the Saddle on deck and made secure.
6. The Sub should be just below the water’s surface. Attach a tag line to the bow of the Sub with a boat pole and carabiner clip.
7. The Sub is positioned on the Stand on deck or simply laid on deck if conditions dictate. The Wave Glider can then be re-bundled on deck using team lifting, or a hoist, to prepare for at-sea storage and vessel transit.

Multi-Stage Hoisting (1 hoist):

1. The Float is hoisted to optimal height to expose the Umbilical to the deck crew.
2. A deckhand attaches the Sub Recovery Device to the Umbilical with a lift strap that has a load-rated tag line attached, and allows it to rapidly sink to the lowest point on the Umbilical.
3. The tag line attached to the Sub Recovery Device is made fast to a cleat or railing on the recovery vessel to take load off of the Float as it is lowered to the deck.
4. The Float is lowered to the Saddle on deck and made secure.
5. The Float hoisting line is transferred from the Lifting Bail to the Sub Recovery Device tag line, and the Sub is hoisted to the just below the surface.
6. A tag line is attached to the bow of the Sub with a boat pole and carabiner clip.
7. The Sub is then recovered and positioned on the Stand on deck or simply laid on deck if conditions dictate. The Wave Glider can then be re-bundled on deck using team lifting or a hoist to prepare for at-sea storage and vessel transit.

Recovery Operations

Estimated Duration: 45 minutes

Recovery - Required Personnel

- 2 Deckhands
- 1 Lead Technician (may also be Deck Boss)
- 1 Hoist Operator
- 1 Captain/Vessel Operator

Vessel Approach

To allow for proper interception and recovery, Wave Glider heading and prevailing sea state must be assessed by the vessel Captain and crew. It may be prudent to change the course of the Wave Glider to allow for a safer vessel recovery orientation in relation to the Wave Glider.



Warning

The Wave Glider is always in motion, on average making way at 1+ knot, and will not stop moving once it is alongside. It is important that the support vessel always be downwind of the vehicle as it approaches for recovery.

Figure 9.4. Side Recovery: Vessel and Wave Glider Orientation

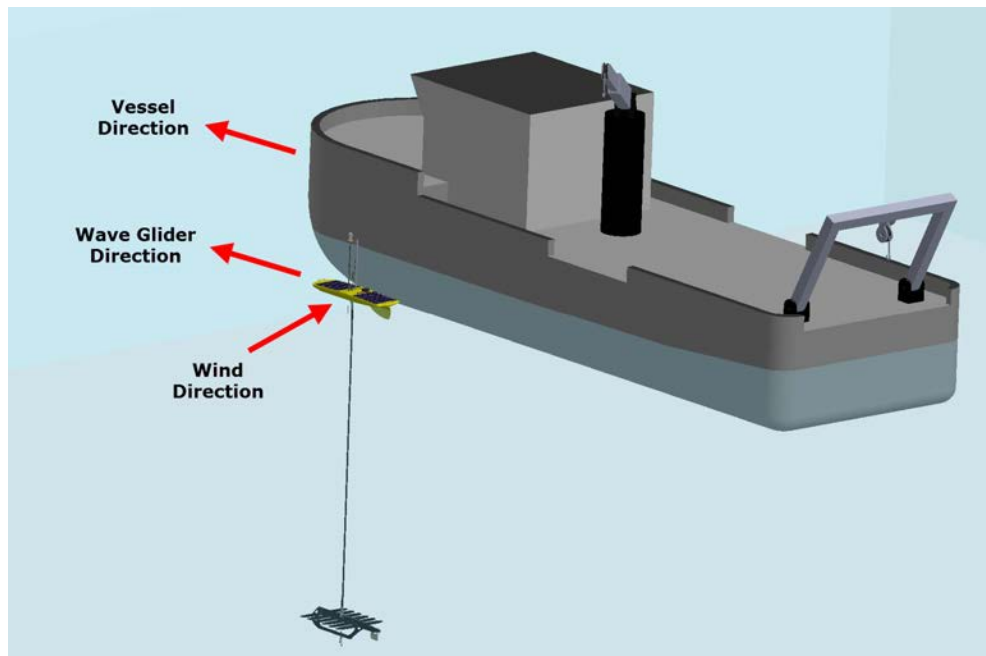
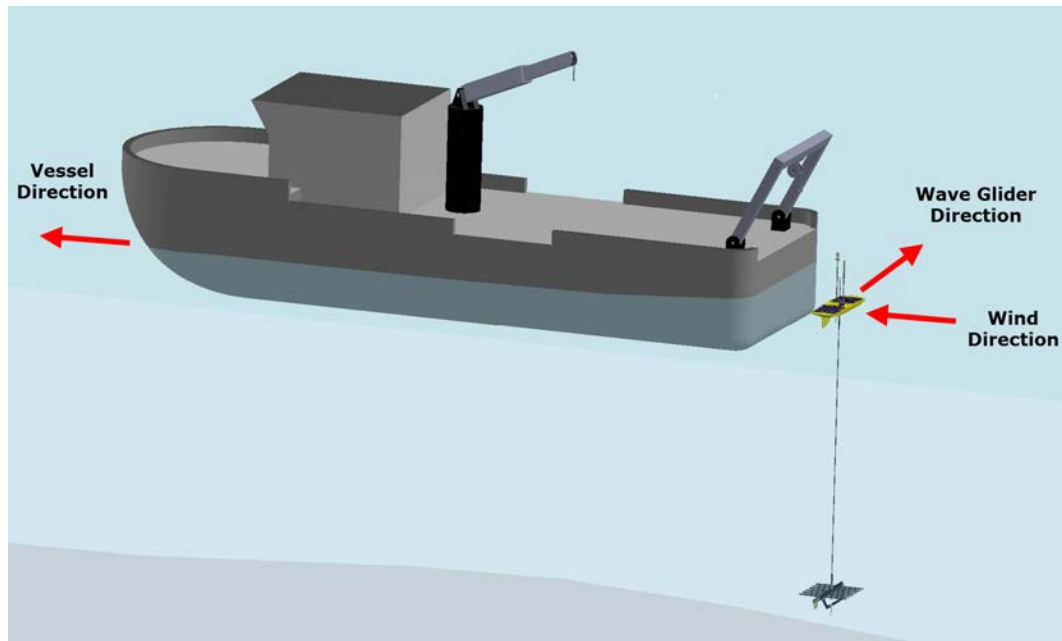


Figure 9.5. Stern Recovery: Vessel and Wave Glider Orientation



Single-Stage Hoisting (1 hoist, 9-10 meters height over rail)

1. Perform safety briefing and related checklist 30 minutes prior to launch. For more information see the LRI [Appendix B: Job Safety Analysis Form](#).
2. Confirm with Captain that the vessel is ready to approach the vehicle.
3. Ensure deck crew and Hoist Operator are ready.
4. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle. Assess vessel orientation to Wave Glider and change Wave Glider heading using WGMS if necessary.
5. Deckhands: Attach one tag line to the Float Bow Handle and a second tag line to the Float Stern Handle with boat poles and carabiner clips.

Figure 9.6. Use Boat Pole to Attach Tag Line to Float Handle

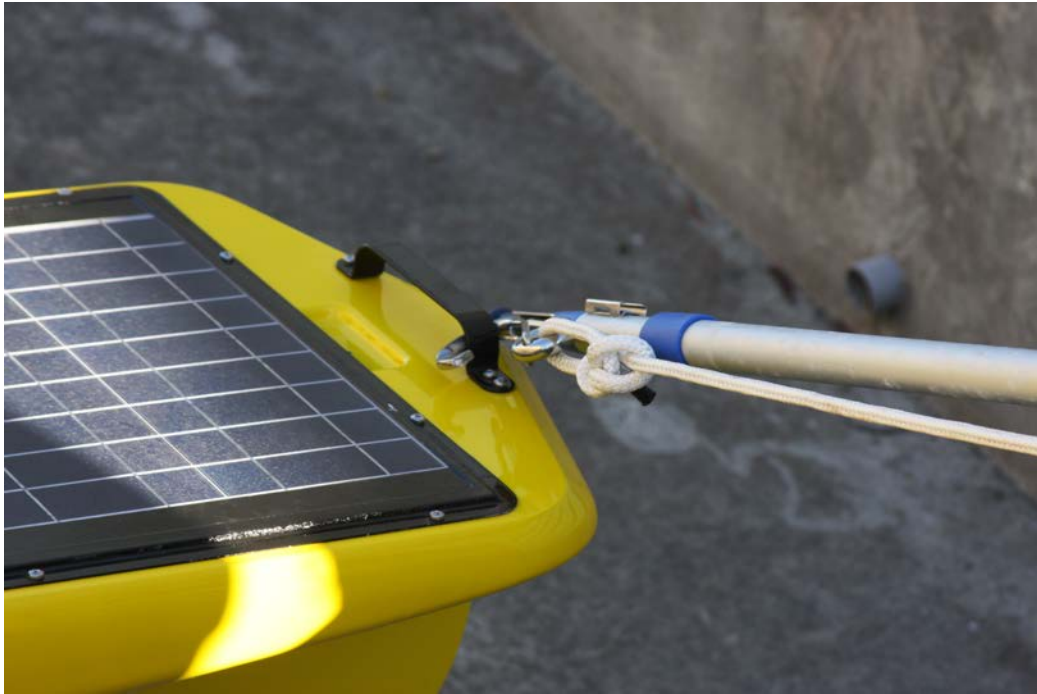


Figure 9.7. Boat Pole Released



6. Lead Tech: Attaches the hoist line with lift strap to the Wave Glider Lifting Bail with a boat pole and carabiner clip.

Figure 9.8. Use Boat Pole to Attach Hoist Line with Lift Strap to Lifting Bail

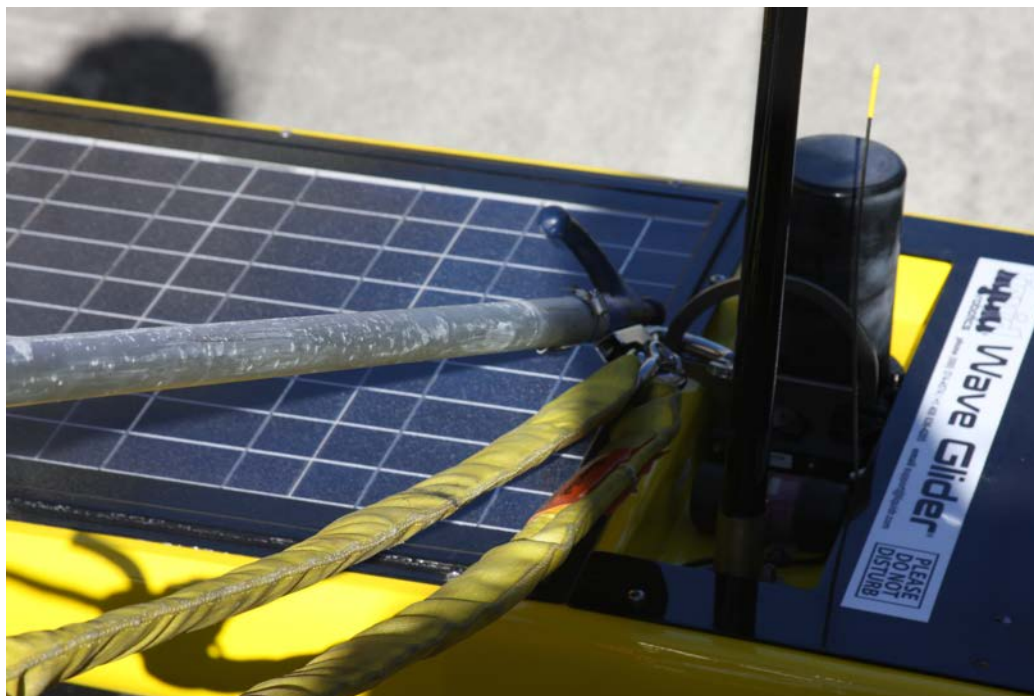


Figure 9.9. Boat Pole Released



Figure 9.10. Begin Hoisting

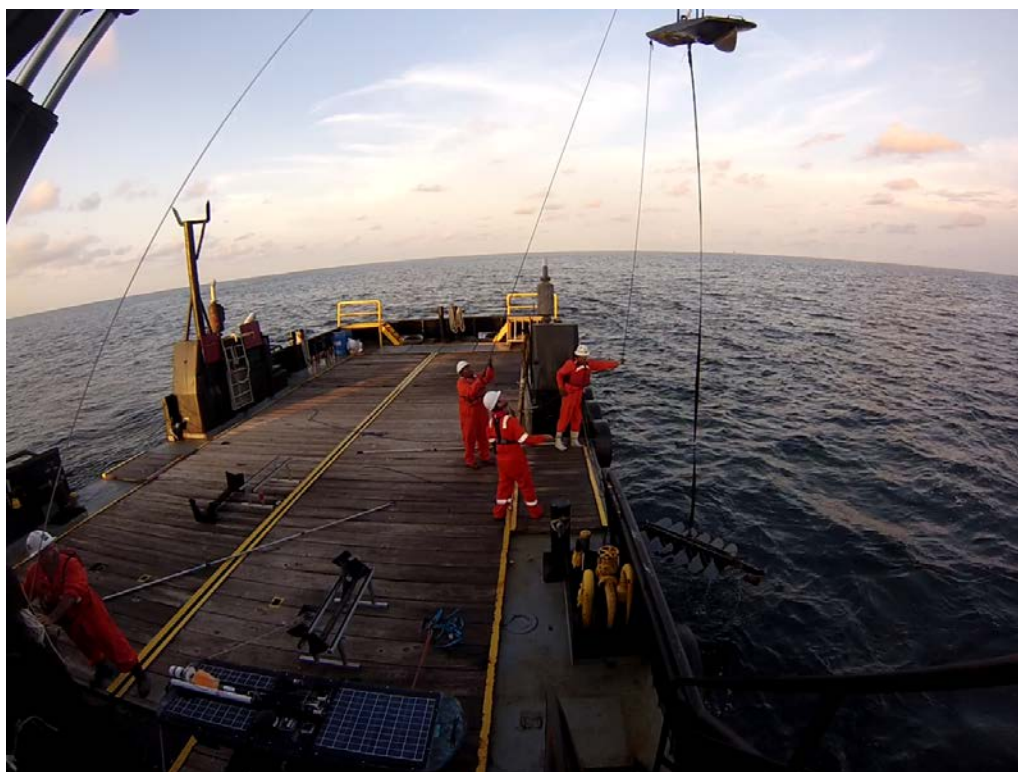


7. Lead Tech/Deck Boss: Signals the Hoist Operator to lift the Float out of the water.
8. Deckhands: Keep tension on the Float tag lines to ensure the Float remains horizontal and to minimize swing. A tag line that is free to move down the Umbilical can be attached (positively or with two bitter ends) to control the Sub, and pull the Sub on deck, keeping personnel out from under the overhead load. The Sub Recovery Device with strap and tag line can be used for this purpose, or a slip line.

Figure 9.11. Attach Tag Line to Umbilical



Figure 9.12. Hoist Sub Out of Water



9. Lead Tech/Deck Boss: Signals the Hoist Operator to stop hoisting when the Sub is just under the surface of the water. If conditions allow, the Lead Tech attaches a tag line to the bow of the Sub using a boat pole with carabiner clip.

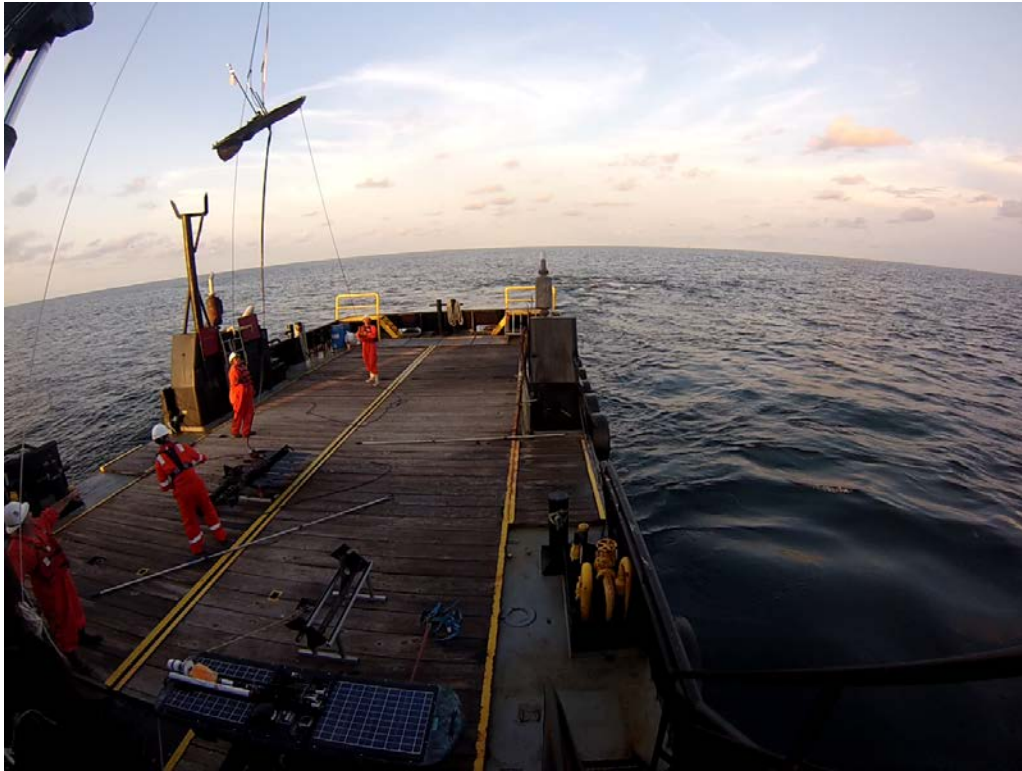
10. Lead Tech/Deck Boss: Signals the Hoist Operator to continue hoisting until the Sub clears the rail or deck.

11. All tag lines should be pulled from opposing directions to minimize swing. Deck personnel must stay out from under the load.

12. Lead Tech/Deck Boss: Signals the Hoist Operator to move the load inboard.

13. Lead Tech: Guides the Sub onto the Stand with tag lines as the Hoist Operator lowers the load to deck (also see [No-Touch Recovery Option](#)).

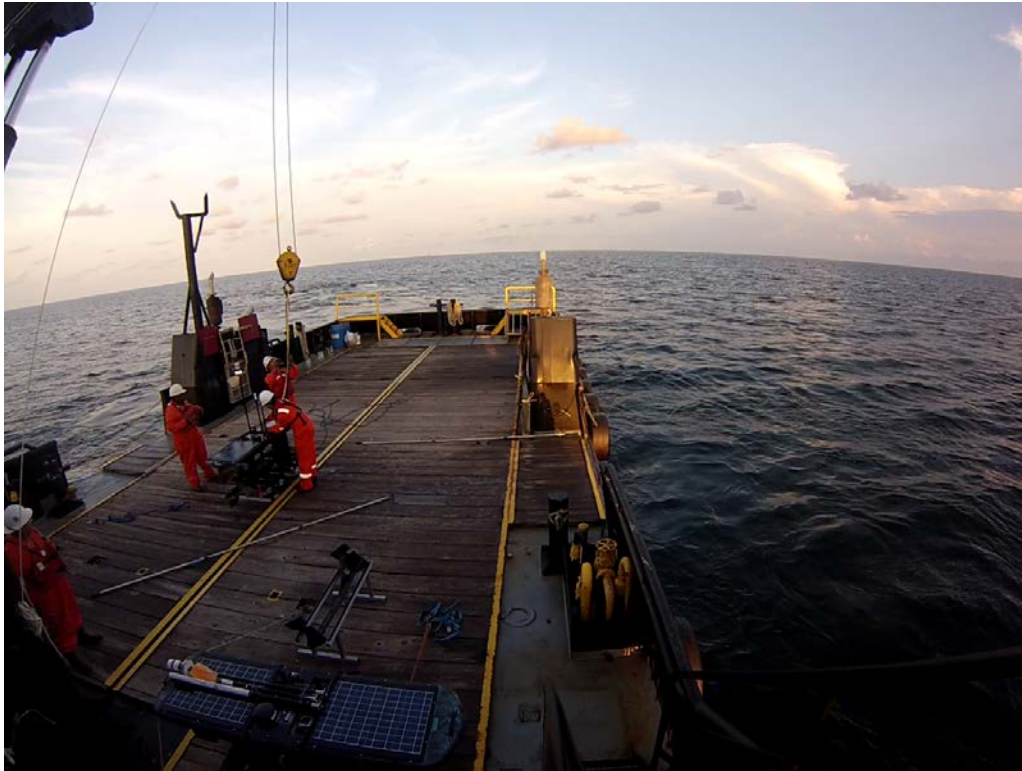
Figure 9.13. Set Sub On Stand



14. Lead Tech: Places Saddle on the Sub with arrow facing forward.

15. Deckhands: Guide the Float on the Saddle as the Hoist Operator continues to lower the load.

Figure 9.14. Set Float on Saddle



16. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in [Figure 9.37](#) and [Figure 9.38](#). The folded Umbilical is held together with a large rubber band and rests on top of the Sub wings. For more information on proper storage of the Umbilical, review the *Wave Glider SV2 Unpacking and Assembly Guide*.

Figure 9.15. Folding the Umbilical for Storage

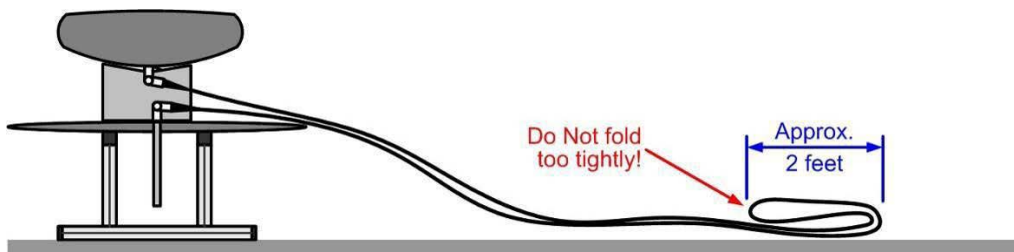


Figure 9.16. Storing the Umbilical



17. Use Tie-down Straps to secure Wave Glider to the Stand.



Warning

Never leave the Wave Glider unattended until the entire bundled assembly has been secured to deck.

18. Remove hoist line from Float.

19. Secure the bundled Wave Glider and Stand to appropriate storage location on deck for transit, routine maintenance, and post-mission cleaning.

20. Call WGOC or shore-side support to confirm Wave Glider recovered and vessel float plan.

21. Follow post-mission procedures for routine maintenance and cleaning. Refer to the *Wave Glider SV2 Maintenance, Inspection, and Cleaning SOP* (see [Appendix A: Reference Documents](#)).

No-Touch Recovery Option. In Step 13, The Hoist Operator lowers the Sub directly to the deck, followed by the Float while Deckhands and Lead Tech use opposing tag lines to steady the vehicle. If the Sub or Float has delicate sensors that may be damaged by setting them directly on the deck, use rubber deck mats, a foam landing pad, or other available bumpers such as a tire to protect the sensor(s) from sitting on deck. Remove the hoisting line from the Float. Use team lifting to set Sub on Stand, followed by the Saddle with the arrow pointing forward, and then team lift the Float to the Saddle. Continue to Step 16.

Multi-Stage Hoisting (2 Hoists)

1. Perform safety briefing and related checklists 30 minutes prior to launch. For more information see the LRI [Appendix B: Job Safety Analysis Form](#).

2. Confirm with Captain the vessel is ready to approach the vehicle.
3. Ensure deck crew and Hoist Operator are ready.
4. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle.
5. Deckhands: Attach one tag line to the Float Bow Handle and a second tag line to the Float Stern Handle with boat poles and carabiner clips.

Figure 9.17. Use Boat Pole to Attach Tag Line to Float Handle

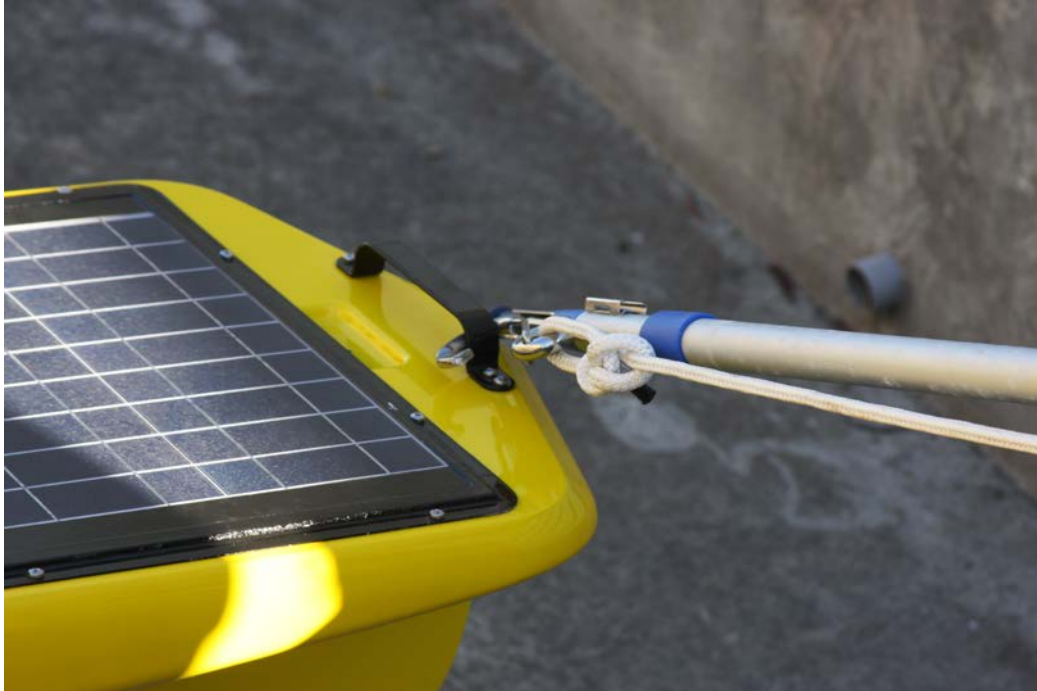


Figure 9.18. Boat Pole Released



Figure 9.19. Attach Tag Lines and Hoist Line to the Float



6. Lead Tech: Attaches the hoist line with lift strap to the Lifting Bail with a boat pole and carabiner clip.

Figure 9.20. Use Boat Pole to Attach Hoist Line with Lift Strap to Lifting Bail

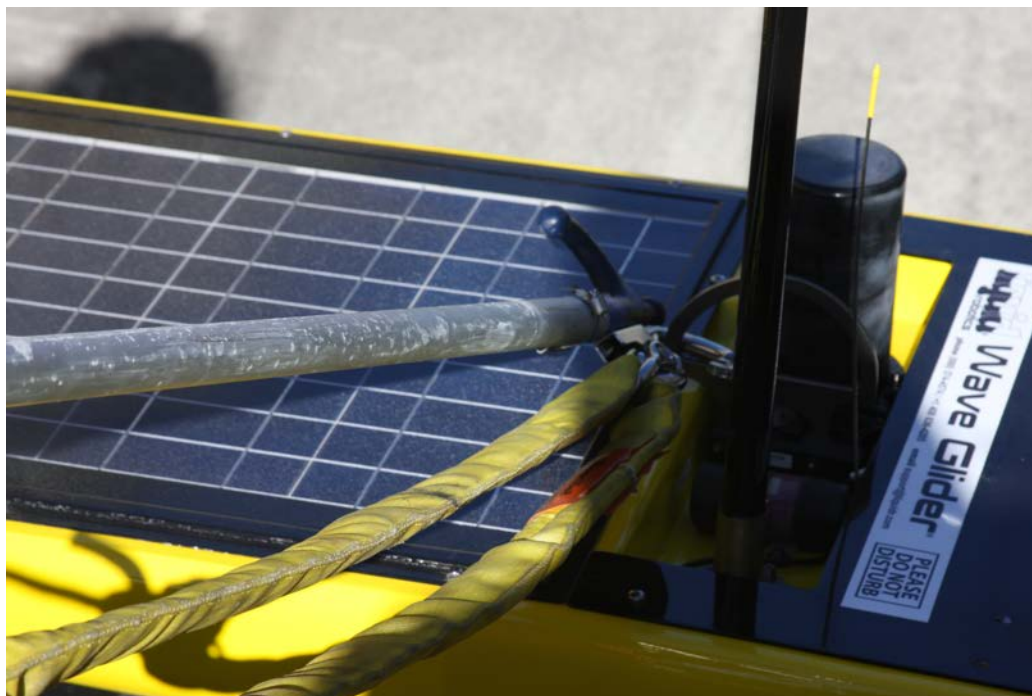


Figure 9.21. Boat Pole Released



Figure 9.22. Hoist Line is Attached to Lifting Bail



7. Lead Tech/Deck Boss: Signals the Hoist Operator to lift the Float out of the water.

Figure 9.23. Hoist Operator Lifts the Float out of the Water



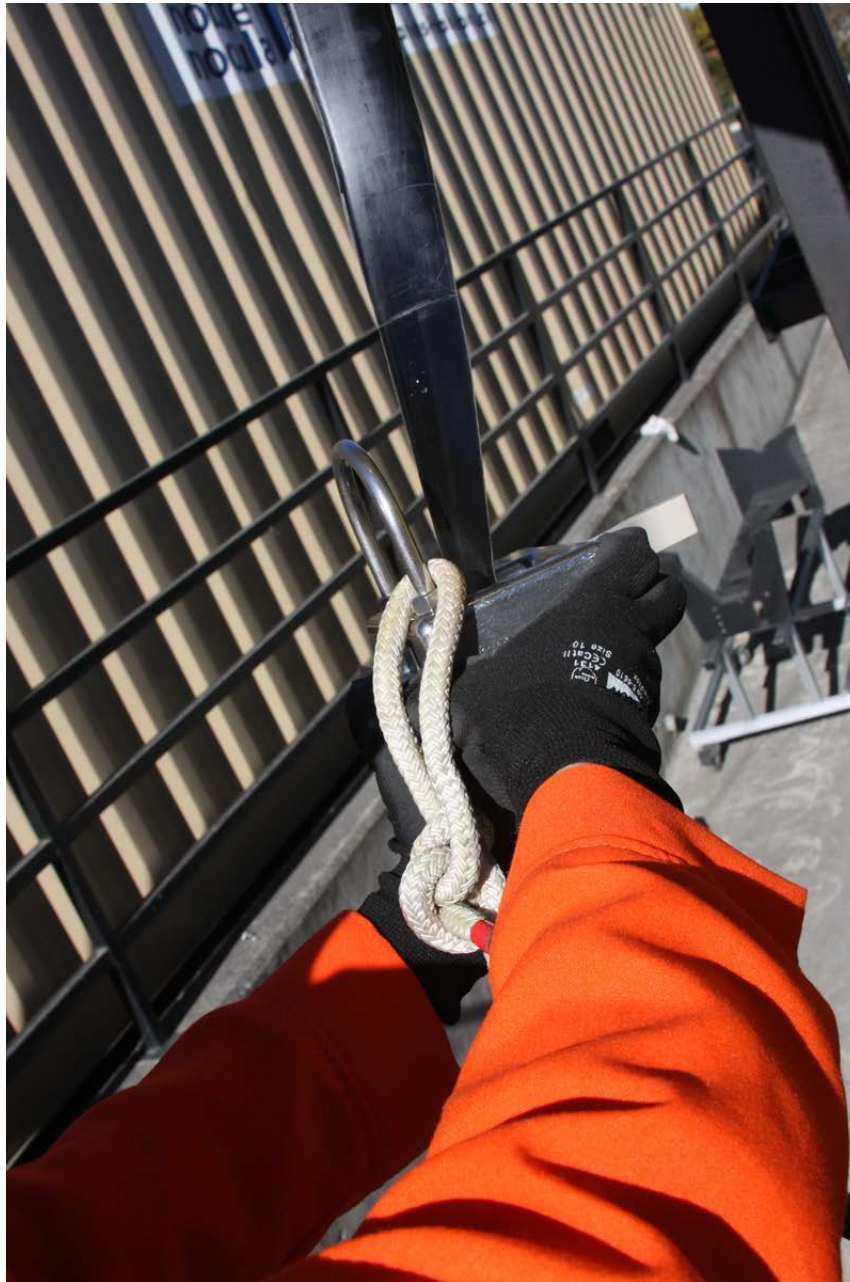
8. Deckhands: Keep tension on the Float tag lines to ensure the Float remains horizontal (or that the masts are clear of hoisting rigging).

9. Lead Tech/Deck Boss: Signals the Hoist Operator to stop hoisting when the float is as high in the air as possible without entangling Wave Glider masts in hoist rigging, or posing an overhead load risk. A short lift strap may be necessary to lift the Float to the appropriate height to reach the Umbilical.

10. Lead Tech: Attaches the Sub Recovery Device to the Umbilical with lift strap and tag line (or second hoist line).

- a. With cam gate open, insert Umbilical into device slot (see [Figure 9.24](#)).

Figure 9.24. Attaching Sub Recovery Device to Umbilical 1



- b. Close gate with plastic latch flipping away from the device slot (see [Figure 9.25](#)).

Figure 9.25. Attaching Sub Recovery Device to Umbilical 2



- c. Send Sub Recovery Device down as far as it will travel (to the bottom of the Umbilical).



Note

Give the Sub hoist line a hard tug to ensure the Sub Recovery Device cam is gripping the Umbilical. Re-set if necessary.

Figure 9.26. Send Sub Recovery Device Down Umbilical to Hoist the Sub



11. Lead Tech: Connects the second hoist line to the Sub Recovery Device lift line (if not already attached).
12. Lead Tech/Deck Boss: Signals the Hoist Operator to lift the Sub to just below the water's surface.
13. The Sub Recovery Device tag line can be used to manage Sub motion in air, and/or a second tag line may be attached with a boat hook to the bow of the Sub for better management of Sub motion.

Figure 9.27. Attach Tag Line to Sub Bow Handle



14. Lead Tech/Deck Boss: Signal Hoist Operator(s) to move the suspended loads inboard.
15. Lead Tech: Guide the Sub onto the Stand with tag lines as the Hoist Operator lowers the load to deck (see [No-touch Recovery](#)).

Figure 9.28. Lowering the Load to the Deck



16. Lead Tech: Remove the Sub Recovery Device from the Umbilical and place Saddle on the Sub with arrow facing forward.

Figure 9.29. Placing the Saddle on the Sub



17. Deckhands: Guide the Float on the Saddle as the Hoist Operator continues to lower the Float.

Figure 9.30. Guiding the Float on to the Saddle



18. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in [Figure 9.31](#) and [Figure 9.32](#). The folded Umbilical is held together with a large rubber band and rests on top of the Sub wings. For more information on proper storage of the Umbilical, review the *Wave Glider SV2 Unpacking and Assembly Guide*.

Figure 9.31. Folding the Umbilical for Storage

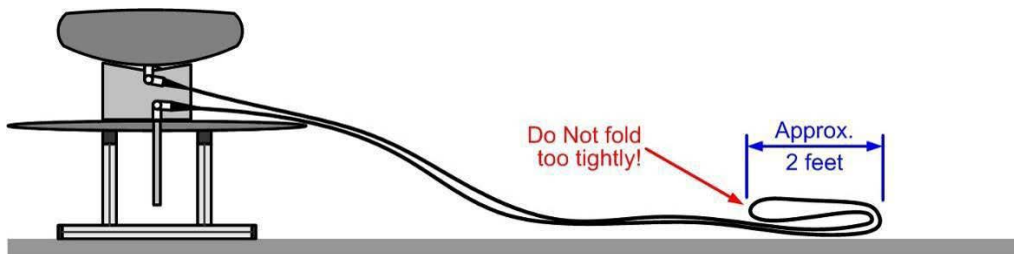
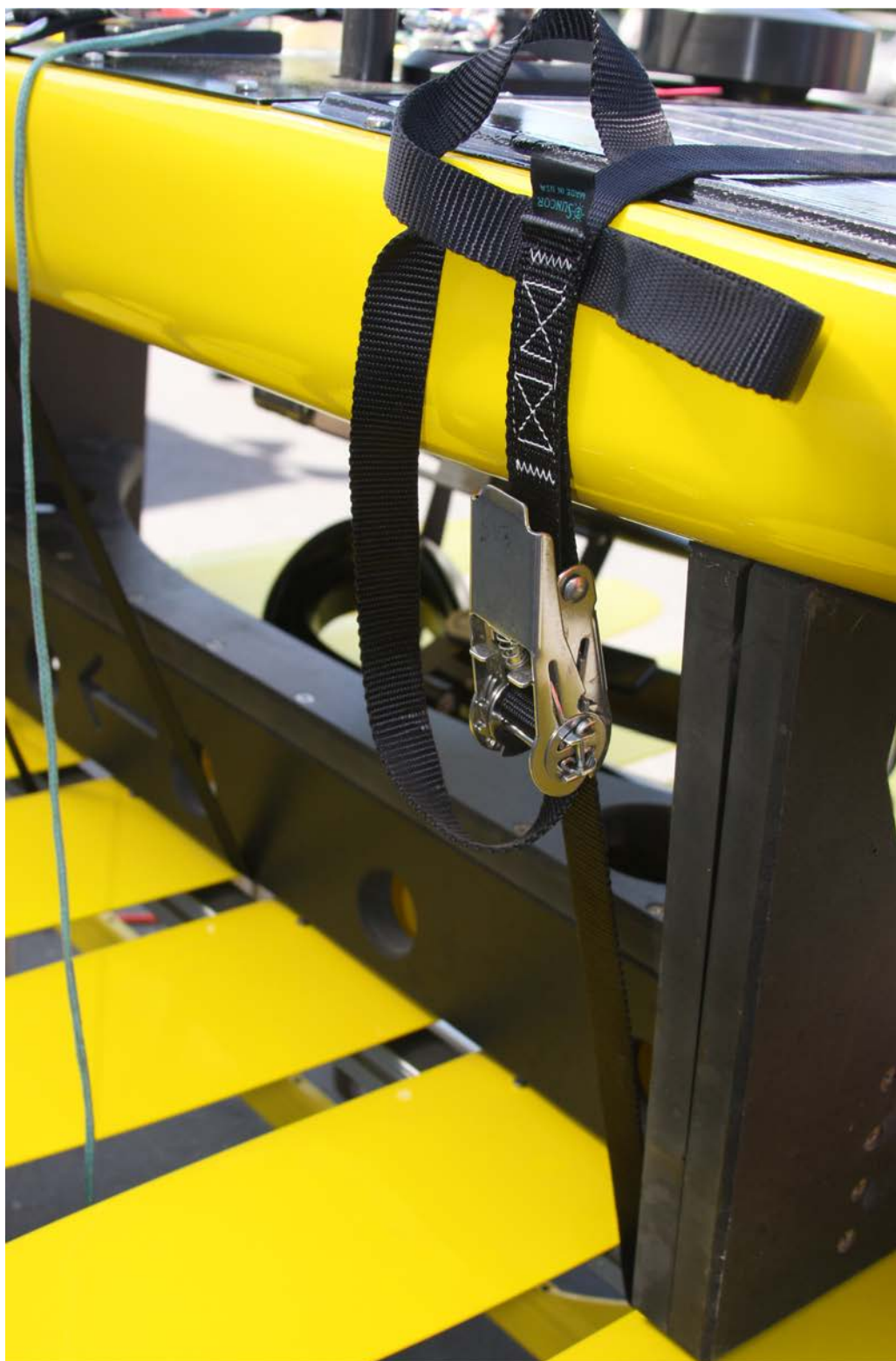


Figure 9.32. Storing the Umbilical



19. Use Tie-down Straps to secure the Wave Glider to the Stand.

Figure 9.33. Using the Tie-Down Straps





Warning

Never leave the Wave Glider unattended until the entire bundled assembly has been secured to deck.

20. Remove hoist line from Float.
21. Secure the bundled Wave Glider and Stand to appropriate storage location on deck for transit, routine maintenance, and cleaning.
22. Call WGOC or shore-side support to confirm Wave Glider recovered and vessel float plan.

No-touch Recovery. In Step 15, a No-touch Recovery would have the Sub lowered directly onto the deck, followed by the Float, while Deckhands and the Lead Tech use opposing tag lines to steady the vehicle. If the Sub or Float have delicate sensors that may be damaged by setting them directly on the deck, use rubber deck mats, a foam landing pad, or other available bumpers such as a tire to protect the sensor(s) from sitting on deck. Remove the hoisting lines from the Float and the Sub Recovery Device. Then use team lifting to set the Sub on the Stand. Place the Saddle on the Sub, then team lift the Float to the Saddle. Then complete Steps 18 to 22 above to complete the recovery.

Figure 9.34. No Touch: Lower Sub Directly to Deck, Followed by Float



Multi-Stage Hoisting (1 Hoist)

1. Perform safety briefing and related checklist 30 minutes prior to launch. For more information see the LRI [Appendix B: Job Safety Analysis Form](#).
2. Confirm with Captain the vessel is ready to approach the vehicle.
3. Ensure deck crew and Hoist Operator are ready.
4. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle.
5. Deckhands: Attach one tag line to the Float Bow Handle and a second tag line to the Float Stern Handle with boat poles and carabiner clips.

6. Lead Tech: Attaches the hoist line with lift strap to the Wave Glider Lifting Bail with a boat pole and carabiner clip.

Figure 9.35. Begin Hoisting



7. Lead Tech/Deck Boss: Signals the Hoist Operator to lift the float out of the water.

8. Deckhands: Keep tension on the Float tag lines to ensure the Float remains horizontal.

9. Lead Tech/Deck Boss: Signals the Hoist Operator to stop hoisting when the float is as high in the air as possible without bumping a mast. A short lift strap may be necessary to raise the Float the appropriate height.

10. Lead Tech: Attaches the Sub Recovery Device with lift strap and tag line to the Umbilical and sends it down as far as it will travel (to the bottom of the Umbilical).

11. Lead Tech: Makes the line attached to the Sub Recovery Device lift strap fast to the support vessel (cleat or deck pad eye). This line takes the weight of the Sub as the Float is lowered to deck.

12. Lead Tech/Deck Boss: Signals the Hoist Operator to bring the Float inboard. As the Float is lowered, the load is being suspended on the Sub Recovery Device line.

13. Deckhands: Guide the Float onto the Saddle and secure the Float and Saddle to the deck with ratchet straps.

14. Lead Tech: Removes hoisting line from the Lifting Bail.

15. Lead Tech: Connects the hoisting line to the Sub Recovery Device tag line.

16. Lead Tech/Deck Boss: Signals the Hoist Operator to lift the Sub out of the water.

Figure 9.36. Connect Hoisting Line to the Sub Recovery Device and Hoist the Sub



17. The Sub Recovery Device tag line can be used to manage Sub motion in air, and/or when the Sub surfaces, a second tag line can be attached with a boat hook to the bow of the Sub for better management of Sub motion.

18. Lead Tech: Guides the Sub onto the Stand with tag lines as the Hoist Operator lowers the Sub to deck (see [No-Touch Recovery](#)).

19. Lead Tech: Removes the Sub Recovery Device from the Umbilical.

20. Deckhands: Unstrap the Float and Saddle, then use a team to lift up the Float so the Saddle can be removed.

21. Lead Tech: Pulls Saddle from under Float, and places on the Sub with arrow facing forward.

22. Deckhands: Shift the Float back to the Saddle.

23. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in [Figure 9.37](#) and [Figure 9.38](#). The folded Umbilical is held together with a large rubber band and rests on top of the Sub wings. For more information on proper storage of the Umbilical, review the *Wave Glider SV2 Unpacking and Assembly Guide*.

Figure 9.37. Folding the Umbilical for Storage

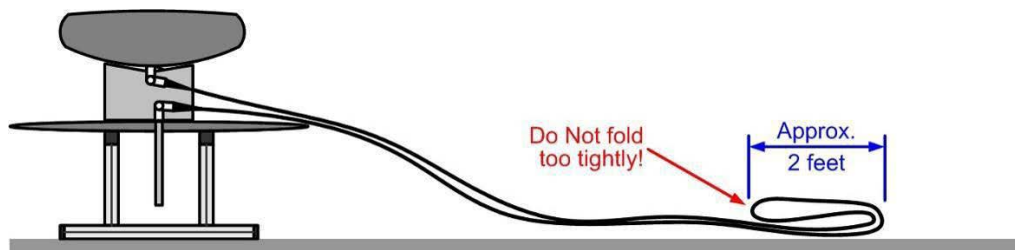


Figure 9.38. Storing the Umbilical



24. Use Tie-down Straps to secure Wave Glider to the Stand.



Warning

Never leave the Wave Glider unattended until the entire bundled assembly has been secured to deck.

25. Secure the bundled Wave Glider and Stand to appropriate storage location on deck for transit, routine maintenance, and cleaning.

26. Call WGOC or shore-side support to confirm Wave Glider recovered and vessel float plan.

No-Touch Recovery. In Step 18, the Hoist Operator lowers the Sub directly to the deck. The entire vehicle is now on deck. If the Sub or Float have delicate sensors that may be damaged by setting them directly on the deck, use rubber deck mats, a foam landing pad, or other available bumpers such as a tire to protect the sensor(s) from sitting on deck. Remove the hoist line and Sub Recovery Device. Use team lifting to set Sub on Stand. Continue to Step 20.

Appendix A. Reference Documents

For access to the documents listed below, Contact LRI Customer Support at:

Email: support@liquidr.com

Phone: +1 888-574-4574

- *Field Operations Technician Skill Set*
- *WGOC Mission Plan*
- *Wave Glider SV2 Unpacking and Assembly (P/N 01497)*
- *Wave Glider SV2 Maintenance, Inspection, and Cleaning SOP*
- *Liquid Robotics Mission Plan*
- *International Maritime Organization (IMO) Annex 13, Safe Practice for Cargo Stowage and Securing*

Appendix B. Job Safety Analysis Form



Job Safety Analysis (Example)		Date:
Title of Job/Operation:		Log Number:
Employee Name and Job Title:		Analyst and Date:
Field Team:		Approved By and Date:
Personal Protective Equipment:		
Sequence of Basic Job Steps	Incidents / Hazards*	Recommended Safe Job Procedures
Deck Rigging for Transit: Safely positioning VWave Glider on deployment deck. Safely connecting VWave Glider on Glider stand to the Deck. Properly securing all associated shackles with safety wire.	Damage to equipment and personnel from unsecured lifting practices. Heavy loads create pinch points and can lead to muscle strain. Pinching, muscle strains and slips, trips and falls. Associated gear becomes loose and loss of equipment becomes a potential.	Use safe lifting techniques with proper equipment. Use tag lines to secure lift. Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and connectors ready. Work at safe pace. All connecting gear will have safety wire secured after all connectors have been checked for tightness.
Deployment: <u>Wave Glider</u> 1-Attach quick release bundling strap used to tie the float and glider together during the lift. Attach a minimum of 2 tag lines. Using a second quick release device, safely lift the bundled VWave Glider over the side of vessel with crane 2-Using a well-choreographed effort, the crane operator lowers the VWave Glider to the sea surface while the tag lines are managed to correctly orient the wave glider. To avoid developing slack in the hoisting line, as soon as the wave glider touches the water, the crane quick release mechanism is released and the crane can be secured. 2b-Spotter watches winch cable to ensure proper amount of winch line remains on drum. 3-As soon as the bundled	Damage to equipment and personnel from unsecured lifting practices Pinch points, overhead loads and entanglement hazards can lead to injury and equipment damage. Risk of entanglement or being caught in bite of control lines. Overhead loads. Damage to equipment. Entanglement of wave glider in ship propulsion. Over the side operation risks MOB potential Improperly managed tag lines or improper piloting leading to uncontrolled swing of suspended wave glider	Proper lifting communication. Rated gear - multiple tag lines to control swing. Stay out from under crane load. Keep communications clear. Know your path to safety, and work at a efficient and safe pace. Stay out from under crane. Captain keeps vessel properly oriented. Crew keeps clear path for gear to egress vessel. Keep deck clear of all potential objects of conflict. Good communication and know safe zones. Captain gives final go command after crew communicates readiness. Everyone has the right and responsibility to stop operation for any concerns, questions or suggestions that may make the operation safer and or more efficient. Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and

Job Safety Analysis Form



wave glider is released from the hoisting gear, the nose of the wave glider should be oriented away from the ship, the front tag line slipped first, the bundling strap triggered, and finally the aft tag line allowed to slip as the wave glider moves away under its own power. 4-Wave glider saddle is then pulled back to ship. Tag lines are pulled in. Winch line is then re-spooled and crane stowed by crane operator		connectors ready. All connecting gear will have safety wire secured after all connectors have been checked for tightness. Proper tending of all lines over the side to manage potential in water wave glider or ship entanglement. Proper piloting and weather limitations Use of appropriate boat poles. Tethered deck hands.
Retrieval: 1-Wave glider is put on desired course that will best allow ship to approach the wave glider at close range. 2-Crane is positioned over the edge of the vessel with as little scope as possible. The crane line or cable is attached to a quick release retrieval hook that connects to the end of a boat pole. 3-As soon as the vessel is within range of the boat pole, the hoisting line is attached to the center lifting point of the float, and slack is removed from the hoisting line to avoid entanglement in Wave Glider antenna's, and to assist in maintaining control of the float near the vessel. 4-Fore and aft handle on the Wave Glider are hooked with tag lines. 5-The crane operator lifts the float out of the water up to rail height. Once the umbilical is accessible, a tag line is placed around the umbilical. 6-The crane continues to lift the float until the glider	Damage to equipment and personnel from unsecured lifting practices Pinch points, overhead loads and entanglement hazards can lead to injury and equipment damage. Risk of entanglement or being caught in bite of control lines. Overhead loads. Damage to equipment. Entanglement of wave glider in ship propulsion. Over the side operation risks MOB potential Improperly managed tag lines or improper piloting leading to uncontrolled swing of suspended wave glider	Proper lifting communication. Rated gear - multiple tag lines to control swing. Stay out from under crane load. Keep communications clear. Know your path to safety, and work at a efficient and safe pace. Stay out from under crane. Captain keeps vessel properly oriented. Crew keeps clear path for gear to egress vessel. Keep deck clear of all potential objects of conflict. Good communication and know safe zones. Captain gives final go command after crew communicates readiness. Everyone has the right and responsibility to stop operation for any concerns, questions or suggestions that may make the operation safer and or more efficient. Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and connectors ready. All connecting gear will have safety wire secured after all connectors have been checked for tightness. Proper tending of all lines over the side to manage potential in water wave glider or ship entanglement.



reaches the surface of the water. A tag line is attached to the nose of the wave glider while the wave glider is still in the water. 7. Once a tag line is on the glider, the entire assembly is lifted high enough to get the glider onto the vessel deck. The glider is set on the deck as gently as possible, followed by the float being brought to the deck and placed on the float cradle. 8-After the float and glider are on the deck of the vessel and all tag lines and the crane are secure, the entire Wave Glider Assembly is restacked on the proper stand, and is then strapped to the deck for stability until ready to re-crate for transport.		Proper piloting and weather limitations Use of appropriate boat poles. Tethered deck hands.
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Appendix C. Operations Service Quality Incident (OSQI) Report

OSQI Report



Operations Service Quality Incident (OSQI) REPORT		
Date of incident/hazard (report ID): OSQI [yymmdd description - rev. yymmdd]	Time: [hh:mm UTC]	Location (lat/lon; address): []
Report Author :		
Name: []	Telephone: []	
Title: []	Email: []	
Injury Information (if applicable):		
Name(s) of injured: []	Telephone: []	
Description of injuries: []		
Treatment details: ☐ None ☐ First Aid ☐ Medivac/EMS ☐ Return to Work		
Medical Facility Details(name, address, telephone #): []		
Vessel Related Information (if applicable):		
Name of Vessel(s) involved: []	Vessel ID or Doc # (USCG): []	
Name of Vessel Operator/Captain: []	Telephone: []	
Name of Vessel Owner: []	Telephone: []	
Last Known Speed & Course: []	Sea State (Douglas Scale): []	Wind/Waves: []
Brief Description of Incident, Known Damage or Near Miss: []		
Wave Glider or Equipment Related Information (if applicable):		
Name of Wave Glider(s) or Equipment involved: []	Last Known Speed & Course: []	
Name of Wave Glider Pilot/Program Manager/Customer: []	Telephone(s): []	
Confirmation of LNM and other permits of operations: []		
Brief Description of Incident, Known Damage or Near Miss: []		
Description of Incident or Hazard (chronology of events):		
[00:00z], [Event] [00:00z], [Tier2 engaged] [00:00z], [Subject matter expert, PM, and client engaged as applicable] [00:00z], [Text notification to executive staff, PM, and WGOC as applicable... followed by hourly updates] [00:00z], [Remedy and closure communications]		

OSQI 140107 Template.rev3

Operations Service Quality
Incident (OSQI) Report

OSQI Report



Witness Names (Witness Statement Forms Attached, if applicable):	
Witness 1:	Telephone:
Witness 2:	Telephone:
Witness 3:	Telephone:
*All witness forms to be filed with supervisor no later than COB on day of accident/incident.	
Agencies Contacted:	
☐ 911/EMS ☐ Coast Guard ☐ Harbor Authorities/DOT ☐ Other	
LRI Accident Investigation Coordination & Escalation:	
LRI Primary Coordinator Contacted (Supervisor, Manager, Director, VP): 	Telephone:
LRI HR Contacted: 	Telephone:
Insurance Rep Contacted: 	Telephone:
Legal Rep Contacted: 	Telephone:
HAZMAT Response Summary: 	
Signatures:	
Author Signature:	Date:
Supervisor Signature:	Date:
*Report to be filed with LRI Primary Coordinator no more than 24 hrs following incident/accident.	
Incremental Reporting (other agencies and or LRI business systems), and or Copy To:	
Ref Forms Attached: ☐ Witness Statement(s) ☐ Injury at Sea ☐ CG2692 ☐ HSSE Impact ☐ OSHA/HAZMAT ☐ Economic Costs (incident; ongoing risks) ☐ Client Feedback	☐ Lessons Learned & Closure ☐ Legal Counsel ☐ Insurance Carrier ☐ NetSuite Case# ☐ JIRA Case# ☐ Other(s)
Additional Information	

Appendix D. Wave Glider SV2 Product Specifications

The LRI Wave Glider SV2 Product Specifications sheet available at the time when this Launch & Recovery Guide was published is included below. If the SV2 Product Specifications sheet is revised, the most recent version will be available at: <https://liquidrb.box.com/shared/static/twonk8piyv1cpzhrzk38.pdf>

Liquid Robotics
Product Specifications



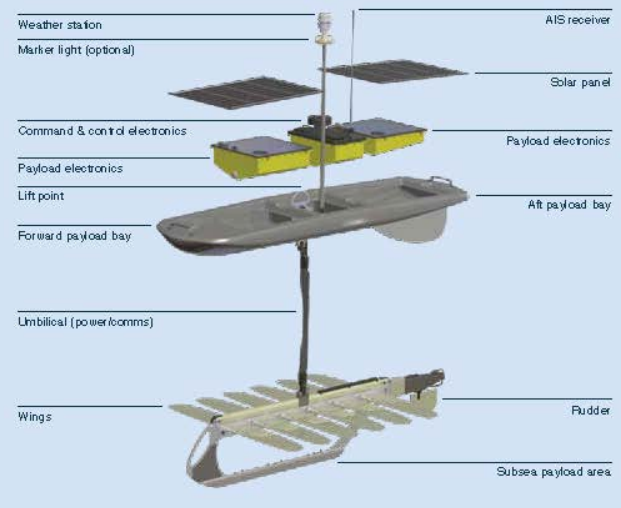
Wave Glider SV2



Wave Glider SV2

Proven
With over 200 Wave Glider SV2s produced, five hurricanes and three cyclones survived, and over 300,000 nautical miles under its belt, the SV2 platform's rugged performance has brought the revolutionary Wave Glider technology to bear on the success of over 100 customer missions to date.

Optimized
The Wave Glider SV2 is optimized for individual or small group deployments carrying preconfigured suites of sensors for specific science and security missions. With enough power to support a broad array of cross-compatible sensor payloads, WiFi and cellular communications options, as well as significant onboard processing power, the Wave Glider SV2 is a reliable and flexible long-endurance platform.



- Weather station
- Marker light (optional)
- Command & control electronics
- Payload electronics
- Lift point
- Forward payload bay
- Unibulb (power/comms)
- Wings
- AIS receiver
- Solar panel
- Payload electronics
- Air payload bay
- Rudder
- Subsea payload area

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Wave Glider SV2

Product Specifications

Wave Glider SV2: Basic specifications

GENERAL

Vehicle configuration
Sub & Float joined by 4m (13ft) tether

Dimensions

Float:
210cm x 60cm (83in x 24in)
Sub:
40cm x 191cm (16in x 75in)
Wings:
107cm wide (42in)

Weight

90kg (200lb)

Endurance

Operate for years at sea (with regularly scheduled maintenance)

Water speed

0.5kts (SS1) - 1.6kts (SS4)

Depth rating

Continuous wash and spray
Brief submergence to 2m (6.5ft)

Observability

Silent propulsion system
Visibility mast with flag and marker light
Radar target enhancer

Transportation & shipping

Air freight compatible
Ships in 3 wooden crates
Crate dimensions: 305cm x 61cm x 61cm (10ft x 2ft x 2ft)
Crate 1: 118kg (260lb)
Crate 2: 98kg (215lb)
Crate 3: 73kg (160lb)

POWER

Propulsion
Mechanical conversion of wave energy into thrust

Battery

665 Wh rechargeable Li-Ion

Solar power

112W (peak)

SAFETY

Emergency location

Shore-activated light
Redundant RF beacons
2-Year redundant Iridium® tracker

Health sensors

Pressure, temperature & leak sensors

Battery compliance

Individual batteries isolated from each other
Automatic charge/discharge cut-off (for temperature and/or voltage)

NAVIGATION

Heading

Solid state magnetometer

GPS

12 channel WAAS capable

Accuracy

3m radius CEP50

Station keeping

40m radius CEP90
(SS3: current <0.5kts)

PAYLOAD

Architecture

Standard mechanical, electrical & software Modular Payload Unit (MPU) architecture for easy integration and configurability

Base integration

Water speed sensor
AIS receiver
Radar reflector, light, and flag

Continuous available power

System max.: 10A
Continuous at 13.2V

Payload ports

Float: 3; Sub: 1
8-pin 5/8" wet mateable connector
13.2V, 3A, RS232/422/485, GPS, PPS

Power expansion ports

Float: 1
6-pin 5/8" wet mateable connector
13.2V, 6A

Max. discrete payloads

2 (Payload boxes in float)

Max. payload weight (float)

18kg (40lb)

Max. payload volume (float)

40L (1.4ft³)

Peak payload power

40W

OPERATION

Mission control

Chart-based GUI
Multi-vehicle display
Waypoint & course generation

Status monitoring

Text & visual status indicators accessible via web interface
SMS and email alerts
Programmable inclusion & exclusion zones

Autonomous navigation

Programmable waypoint course
Follow course and hold/loop
Station keeping at target

COMMUNICATIONS

Over-the-horizon

Iridium® 9602
RUDICS (option)
Cellular (option)

Local

802.11g WiFi

All specifications are accurate at time of printing and are subject to change without prior notice.



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Appendix E. Wave Glider SV2 Pre-Launch Checklist



SV2 Wave Glider Pre-Launch Checklist				
Date:		Glider Name:		
Operator:		Payload:		
Ship/Op Area:		Project:		
Communication				
Item/Procedure	Readings		Specifications	Initials
Xbee Connection			Coms Established	
WGMS Updating			Coms Established	
Configuration				
Print xbee commands			<CR>,26,27,97 (attach to this doc)	
RDF Frequency	Top:			
	Bottom:			
Tracker name/#				
Float name				
Glider name				
Drybox name				
Vehicle Status				
Battery Wh			> 550 Watt-hours	
Solar Power Indicators:	Panel 1	Panel 2		
			> 1000 mW	
Environmental:	Pressure	Temp		
C&C Drybox (Float)			> 135 kpa, < 35° C	
C&C humidity			< 50%	
Rudder Module (Sub)			< 105 kpa, < 35° C	
Payload 1			> 135 kpa, < 35° C (Plastic PL ~100 kpa)	
Payload humidity			< 50%	
Payload 2			> 135 kpa, < 35° C	
Payload humidity			< 50%	
Mechanical Checks				
Float				
Wet-mates connected/lubed				
Connector covers secure			30 in/lbs	
Drybox secure			30 in/lbs	
Turtleneck secure			30 in/lbs	
Contact info secure				
Remove RDF magnet			Top & Bottom RDF	
Orange flag attached to mast				
Cable tie on shorting pin			Secure shorting pin	
Glider				
Line Terminator secure			Rubber mallet treatment	
Umbilical visual inspection			Free of voids/defects	
Roll pin inserted				
Vehicle Functionality – WGMS				
Tracker report rate/reporting	Time	Yes/No		
Light on/off				
IPIB sensors powered on			Check all IPIB sensors; Current Draw ~350mA	
Rudder moves 360				
Rudder center				
Rudder left				
Rudder right				
Fixed heading test (spin)			Heading used	

Technician Signature: _____

Note: Once vehicle is launched the following tasks must be completed

1. Clear alarms
2. Vehicle on mission
3. Create *LAUNCHED* comment into WGMS.
4. Upload photos to box.com with album name: *YYYY-MM-DD VehicleName*

Appendix F. WGOC SV2 Launch, Recovery, and Piloting Checklist

Liquid Robotics – Wave Glider Operations Center Launch / Recovery Checklist



WGOC Pilot-in-Charge: Please complete this form and add it to the appropriate Mission Folder.

Wave Glider Pre-Launch & Launch			
T-24 Hours	Yes	No	Comments
Environmental Window Confirmed :	☐	☐	
Operational Logistics Confirmed:	☐	☐	
Pre-launch Checklist Submitted (FieldOps):	☐	☐	
Departure and Deployment Area ETAs:	☐	☐	
Shore-side Instructions Acknowledged:	☐	☐	
Launch Authorization:	☐	☐	
T-30 Minutes	Completed/Comments		
Launch Crew ETA Notification and Pilot-in-Charge WGMS UI Settings:	☐ ETA to launch area(s) ☐ Check special shore-side support needs & execute accordingly ☐ Confirm all payloads powered on (except for those that must be wet 1 st) ☐ Engage PIC map options (vehicle selections, RV obstacles, pilot tools, current layers, nautical charts) & escalation lists ☐ Retrieve fresh Power Control Status ☐ Scan OpArea & validate device reporting ☐ WGMS comment on developments ☐ Set TRR to 2 minutes just prior to deployment		
T-0 (Verified By Water Speed)	Completed/Comments		
Note: Inform vessel/crew of any attention required throughout the process.			
Establish Safe Navigation:	☐ Verify FMBC is On ☐ Light on, set course for desired OpArea, line-following on, all devices on ☐ Confirm desired/sub heading alignment ☐ Post ACKD of commands, retrieve fresh Power Control Status		
Vehicle/Payload Performance Check:	☐ Conduct core system and device validations (current draw on PLs, IPIB, umbilical, light; battery power; CCDB/RM/PL pres/temp/humidity; device data validation) ☐ Navigational validation (45° path adj. using pilot tool), then back to course		
Begin Mission:	☐ Begin mission engaged (appropriate mission selected) ☐ Set TRR to 5 minutes, light off ☐ Release vessel and launch crew ☐ WGMS comment (successful deployment by vessel, time in water) ☐ Distribute communications to key stake holders ☐ XBee off ☐ Engage alarm generation on Op Polygons upon reaching given boundaries ☐ Activate Encrypted Comms ☐ Update NS case		

WGOC SV2 Launch, Recovery,
and Piloting Checklist

**Liquid Robotics – Wave Glider Operations Center
Launch / Recovery Checklist**



Wave Glider Pre-Recovery and Recovery			
T-72 Hours	Yes	No	Comments
Set Tracker Rate to 6 hours:	☐	☐	
T-24 Hours	Yes	No	Comments
Set Track Rate to 15 minutes:	☐	☐	
Environmental Window Confirmed:	☐	☐	
Operational Logistics Confirmed:	☐	☐	
Confirm Vehicle Staged or In Route to Recovery Area:	☐	☐	
Departure and Recovery Area ETAs:	☐	☐	
Shore-side Instructions Acknowledged:	☐	☐	
T-60 Minutes	Yes	No	Comments
ETA/Coordinates Update with Crew	☐	☐	
T-30 Minutes	Completed/Comments		
ETA/Coordinates Update with Crew, Prepare Vehicle for Recovery	☐ ETA/Coordinates update with crew ☐ Check special shore-side support needs & execute accordingly ☐ WGMS comment on developments ☐ Light on, set TRR to 2 minutes ☐ Power down payloads (other than AIS, speed, weather, light)		
T-0 (Verified By Water Speed)	Completed/Comments		
Recovery:	☐ Light off, all devices off ☐ Disengage alarm generation on Op Polygons ☐ Remove any vessels from the MMSI Ignore List ☐ Lock center rudder ☐ Set TRR to 5 minutes		
End Mission:	☐ End mission engaged ☐ WGMS comment (successful recovery by vessel, time out of water) ☐ Deactivate encrypted communications ☐ XBee on ☐ Obtain recovery crew 1 st article inspection ☐ Originate vehicle RMA for SL1 servicing, update NS case ☐ Distribute communications to key stake holders		

For further information, please contact the Liquid Robotics WGOC staff at support@liquidr.com or +1 408-636-4205.

WGOC SV2 Launch, Recovery, and Piloting Checklist

Liquid Robotics – Wave Glider Operations Center Launch / Recovery Checklist



WGOC Pilot-in-Charge: Please follow this checklist during shift.

Wave Glider Operations Center Daily Piloting Tasks	
Start of Shift	
Pilot Prep:	- Review AML Pass-down - PICCHANGE - Escalation lists armed - Address piloting priorities discovered in the pass-down
Vehicle Check(s):	- Confirm course heading/alignment, power management - Confirm OpPolys, current vectors, TRR = 5 min - Perform check using Script Reader - Correct or report anomalies (both operational or telemetry)
During Shift (regularly)	
Vehicle Management:	- Check vehicle course management/marine traffic regularly - Check payload operations and power management regularly - Check RUDICS call in 4 times per day (If Applicable) - Check all vehicles' Sensor/Device functionality twice per day (use excel sheet guidelines) - Respond to all alarms within 10 minutes; rectify or escalate - Document actions accordingly
Mission Specifics:	- Check LNM for each district of operation - Check mission specifics (RUDICs, sensor data accuracy, etc) if necessary - Update Mission Plans accordingly
Evasive Action	
Upon threat notification:	- Turn light on - Set status TRR = 2 mins - Send fixed heading command (90 degrees from threat) - WG path may alter with current velocity/heading - Keep watch on threat in case of a heading change, adjust accordingly
When threat has passed:	- Turn light off - Set status TRR = 5 mins - Put WG back on original course (use soft turns of 90 degrees) - Acknowledge alarms and manage OpPolygons while navigating
End of Shift	
Pilot Release:	- Final vehicle check(s) - Complete/Update AML Pass-down (file should be locked while edits occur)

Appendix G. Nearshore Vessel Requirements



Liquid Robotics

Nearshore Wave Glider Mission Operations - Vessel Requirements for SV2 and SV3

1. General	
The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period.	
Length	8m minimum depending on Mission specifications
Endurance and Navigational Limits	Less than 1 day and less than 30nm offshore.
Speed	Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery
Classification	ABS, Lloyds, SOLAS A or equivalent
Vessel Control	Ability to maintain steerage at 1 to 3 knots.
Navigation	Minimum Instrumentation Requirements: • Magnetic compass • Satellite positioning receiver • Marine echosounder, with hull-mounted transducer
Communications	Minimum Instrumentation Requirements: • Multi-channel Marine VHF R/T • Cellular phone (or Satellite Phone if operating outside cellular service areas)
Pier-side facilities or Vessel supplied support	Minimum mobilization/demobilization requirements: • Minimum 1 tonne hoisting capability required to load vehicle and related support equipment at pier. • Ability to load a fully assembled wave glider from shore to vessel or vice versa: ◦ Assembled Wave Glider Size and Weight: ▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts. Maximum 200kg. ▪ SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg.
2. Vessel Facilities	
Toilets	Marine toilet for missions greater than 4 hours
Freshwater	Reasonable amount of potable water available for all crew members for expected mission duration
3. Vessel Lab Space	
Electrical Power	120VAC/60Hz, or 220V/50Hz power desirable. Power and outlet type to be noted.
4. Vessel Working Deck	
Free Board and Rail Height	1m maximum on working decks, as low as possible without being awash preferred. Max rail height 1m, or removable safety lines.
Working Space	Minimum 2m from working rail or stern, by 4m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.
Storage Space	Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or recovery of any vehicles. Minimum storage dimensions per Wave Glider are: • SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts • SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts



Hoisting/Lifting Gear	Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for lifting/hoisting to be included and noted. • Minimum "Distance Outboard": 1m • Minimum "Distance Inboard": 1m • Minimum SWL: 1-tonne • Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred. • Maximum weight of cable counterweight: 15kg • Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static • Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static. • Minimum Hoist "Height Over Rail" Requirement: ◦ Minimum Single Pick Height Over Rail: 9.0m ◦ Minimum Double Pick Height Over Rail: 3.0m ◦ Minimum Hoist Cable Length: 15m + "Height Over Water" + Length Required to Maintain Safe "Minimum Scope"
Visibility	Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be visible from the vessel controls and communications via line-of-sight
5. HSSE (Health Safety Security and Environment)	
Requirement	The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.
Staffing	Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.
Survival suits	In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working in latitudes above 32 degrees north and below 32 degrees south.
Notices	Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel's crew will be in English for all safety notices and procedures.
Briefings	Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.
PPE	All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc): • Safety toed shoes • PFD • Hard hat
Vessel Response Plan	The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf. For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.

Appendix H. Coastal Vessel Requirements



Liquid Robotics

Coastal Wave Glider Mission Operations - Vessel Requirements for SV2 and SV3

1. General	
The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period.	
Length	16m minimum depending on Mission specifications
Endurance and Navigational Limits	Less than 5 days and less than 100nm offshore
Speed	Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery
Classification	ABS, Lloyds, SOLAS A or equivalent
Vessel Control	Twin screw with ability to maintain steerage at 1 to 3 knots. Dynamic positioning, Z-drive, bow thruster or alternative station keeping controls are desirable.
Navigation	Minimum Instrumentation Requirements: • Magnetic compass • Marine radar • Satellite positioning receiver • Marine echosounder, with hull-mounted transducer • Electronic charts (e.g. Nobeltec) • Bridge control of engines and thrusters
Communications	Minimum Instrumentation Requirements: • Multi-channel Marine VHF R/T capable of working all frequencies and with a dual watch facility • Satellite communications telephone, e-mail, data and facsimile desirable • Cellular phone (or Satellite Phone if operating outside cellular service areas) • Voice two-way communications system linking the Vessel bridge, deck, and Wave Glider operation room/dry lab • Hand-held radios for operating in areas of the Vessel not covered by the internal communication system
Antenna Masts	Mission specific ability to mount multiple antennas (e.g. GPS, RF, etc).
Pier-side facilities or Vessel supplied support	Minimum mobilization/demobilization requirements: • Minimum 1 tonne hoisting capability required to load vehicle and related support equipment at pier. • Ability to load a fully assembled wave glider from shore to vessel or vice versa • Mission Specific: Secure storage space of LRI assets for mobilization, demobilization and to accept LRI equipment shipments. Shipping crates to be stored in a secured area during the duration of the mission, in addition to a minimum of 1 week before and after the mission for mobilization and demobilization. ◦ Shipping Crate Size and Weight: Float, Glider and Parts crate to ship for each vehicle required for mission. Tow-Body crate is a mission specific requirement. Crates can be stacked 3 high. ▪ SV2 Float: 2.3m x 0.8m x 0.8m, 135kg – 225kg ▪ SV2 Glider: 2.1m x 0.5m x 0.5m, 75kg ▪ SV3 Float: 3.0m x 0.9m x 0.6m, 163kg – 225kg ▪ SV3 Glider: 2.3m x 0.5m x 0.5m, 135kg ▪ Parts Crate: 1.5m x 0.8m x 0.6m, 90kg – 225kg ▪ Tow Body: 1.5m x 0.8m x 0.6m, 90kg – 135kg ◦ Assembled Wave Glider Size and Weight: ▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts.



	Maximum 200kg. - SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg. • Assembly and Disassembly Space: - Minimum 3m x 4m of clean, dry space, with access to 110V to 220V power outlet within 15m of location. Power and outlet type to be noted. - Internet access via WiFi or 3G cellular service. Cellular data providers available on-site to be noted. - Area must allow for the delivery of shipping crates via forklift, pallet jack, or similar. Direct access to shipping crate storage area preferred. - Area must allow a fully assembled vehicle to be rolled in and out. - Climate controlled space preferred.
2. Vessel Facilities	
Wave Glider Crew Accommodations	For Missions greater than 18 hours, individual berths should be available for each member of the wave glider mission crew. Maximum occupancy of 8 persons per room.
Male-Female Facilities	For overnight missions, male/female staffing must be accommodated including bunk and head privacy between men and women. Head/shower must have a locking door.
Toilets and showers	1 toilet per every 8 persons for single day operations. 1 toilet and 1 shower per every 6 persons for overnight operations.
Freshwater	Sufficient potable water in the form of storage tanks and water making facilities such as to ensure adequate supplies for all personnel for a minimum endurance 1.2 times the mission length. Additional drinking water is required for warm climates.
Galley	Large enough for half the ship's complement at one sitting and a cooking staff for 24-hour operation. Three meals a day and cold food snacks for 3 rd shift.
3. Vessel Lab Space	
Wave Glider Control Space	Minimum 1.0m x 0.5m per wave glider mission crew member, of well-lit countertop or desk space. Area must be clean, dry, well-ventilated and air-conditioned, with access to power and satellite network connections. Space shall include a cable run allowing antenna cables to be routed into this space. Area must be allocated for exclusive use by the wave glider mission crew for the entire mission, and cannot be used for other operations or tasks. Space cannot be cleared for routine vessel servicing tasks and should only be disturbed by Vessel crew in emergency situations.
Electrical Power	7Kva of clean 120VAC/60Hz, or 220V/50Hz. Power and outlet type to be noted.
4. Vessel Working Deck	
Free Board and Rail Height	2m maximum on working decks, as low as possible without being awash preferred. Max rail height 1m, or removable safety lines.
Working Space	Minimum 3m from working rail or stern, by 5m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.
Storage Space	Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or recovery of any vehicles. Minimum storage dimensions per Wave Glider are: - SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts - SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts
Hoisting/Lifting Gear	Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for lifting/hoisting to be included and noted. - Minimum "Distance Outboard": 2m - Minimum "Distance Inboard": 1m - Minimum SWL: 1-tonne - Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred. - Maximum weight of cable counterweight: 15kg



	• Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static • Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static. • Minimum Hoist "Height Over Rail" Requirement: ○ Minimum Single Pick Height Over Rail: 9.0m ○ Minimum Double Pick Height Over Rail: 3.0m ○ Minimum Hoist Cable Length: 15m + "Height Over Water" + Length Required to Maintain Safe "Minimum Scope"
Visibility	Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be either visible from the vessel controls and communications via line-of-sight or good quality closed-circuit TV pictures of such areas
5. HSSE (Health Safety Security and Environment)	
Requirement	The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.
Staffing	Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.
Survival suits	In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working in latitudes above 32 degrees north and below 32 degrees south.
Notices	Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel's crew will be in English for all safety notices and procedures.
Briefings	Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.
Drills	For missions greater than 48 hours, a lifeboat and fire drill will be undertaken on passage to site at the commencement of a Wave Glider cruise. Safety drills will be programmed to ensure practice in a variety of potential emergency response procedures.
Personnel training	All personnel are to be trained and certified in sea survival, fire fighting, first aid/emergency medical skills to IPITO, UKOOA, STCW or equivalent internationally recognized standards.
PPE	All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc): • Safety toed shoes • PFD • Hard hat
Vessel Response Plan	The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf . For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.

Appendix I. Offshore Vessel Requirements



Liquid Robotics

Offshore Wave Glider Mission Operations - Vessel Requirements for SV2 and SV3

1. General	
The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period.	
Length	40m minimum depending on Mission specifications
Endurance and Navigational Limits	Mission specific
Speed	Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery
Classification	ABS, Lloyds, SOLAS A or equivalent
Vessel Control	Twin screw with ability to maintain steerage at 1 to 3 knots. Dynamic positioning, Z-drive, bow thruster or alternative station keeping controls are desirable.
Navigation	Minimum Instrumentation Requirements: • Gyrocompass in addition to magnetic compass • Marine radar • Satellite positioning receiver • Marine echosounder, with hull-mounted transducer • Electronic charts (e.g. Nobeltec) • Weather fax or internet access for near real-time weather updates • Bridge control of engines and thrusters
Communications	Minimum Instrumentation Requirements: • Multi-channel Marine VHF R/T capable of working all frequencies and with a dual watch facility • Ship-Shore R/T with a minimum range of 300 kilometers, or capable of communicating with the nearest offshore support base offering emergency response facilities, whichever is the greater range • Satellite communications telephone, e-mail, data and facsimile • Voice two-way communications system linking the Vessel bridge, deck, and Wave Glider operation room/dry lab • Hand-held radios for operating in areas of the Vessel not covered by the internal communication system
Antenna Masts	Mission specific ability to mount multiple antennas (e.g. GPS, RF, etc).
Pier-side facilities or Vessel supplied support	Minimum mobilization/demobilization requirements: • 24 hour access to dockage equipped Vessel shore power. • Minimum 1 tonne hoisting capability required to load vehicle and related support equipment at pier. • Forklift (minimum 1 tonne) available during mobilization and demobilization. • Secure storage space of LRI assets for mobilization, demobilization and to accept LRI equipment shipments. Shipping crates to be stored in a secured area during the duration of the mission, in addition to a minimum of 1 week before and after the mission for mobilization and demobilization. ○ Shipping Crate Size and Weight: Float, Glider and Parts crate to ship for each vehicle required for mission. Tow-Body crate is a mission specific requirement. Crates can be stacked 3 high. ▪ SV2 Float: 2.3m x 0.8m x 0.8m, 135kg – 225kg ▪ SV2 Glider: 2.1m x 0.5m x 0.5m, 75kg ▪ SV3 Float: 3.0m x 0.9m x 0.6m, 163kg – 225kg ▪ SV3 Glider: 2.3m x 0.5m x 0.5m, 135kg



	▪ Parts Crate: 1.5m x 0.8m x 0.6m, 90kg – 225kg ▪ Tow Body: 1.5m x 0.8m x 0.6m, 90kg – 135kg ○ Assembled Wave Glider Size and Weight: ▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts. Maximum 200kg. ▪ SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg. • Assembly and Disassembly Space: ○ Minimum 3m x 4m of clean, dry space, with access to 110V to 220V power outlet within 15m of location. Power and outlet type to be noted. ○ Internet access via WiFi or 3G cellular service. Cellular data providers available on-site to be noted. ○ Area must allow for the delivery of shipping crates via forklift, pallet jack, or similar. Direct access to shipping crate storage area preferred. ○ Area must allow a fully assembled vehicle to be rolled in and out. ○ Climate controlled space preferred.
2. Vessel Facilities	
Wave Glider Crew Accommodations	For Missions greater than 18 hours, individual berths should be available for each member of the wave glider mission crew. Maximum occupancy of 8 persons per room.
Male-Female Facilities	For overnight missions, male/female staffing must be accommodated including bunk and head privacy between men and women. Head/shower must have a locking door. For long duration missions greater than 14 days, rooms and heads should be separated by hard doors that lock.
Toilets and showers	1 toilet per every 8 persons for single day operations. 1 toilet and 1 shower per every 6 persons for overnight operations.
Freshwater	Sufficient potable water in the form of storage tanks and water making facilities such as to ensure adequate supplies for all personnel for a minimum endurance 1.2 times the mission length. Additional drinking water is required for warm climates.
Galley	Large enough for half the ship's complement at one sitting and a cooking staff for 24-hour operation. Three meals a day and cold food snacks for 3 rd shift.
Laundry	Washers and dryers available to the Wave Glider crew for missions over 7 days.
3. Vessel Lab Space	
Wave Glider Control Space	Minimum 1.0m x 0.5m per wave glider mission crew member, of well-lit countertop or desk space. Area must be clean, dry, well-ventilated and air-conditioned, with access to power and satellite network connections. Space shall include a cable run allowing antenna cables to be routed into this space. Area must be allocated for exclusive use by the wave glider mission crew for the entire mission, and cannot be used for other operations or tasks. Space cannot be cleared for routine vessel servicing tasks and should only be disturbed by Vessel crew in emergency situations.
Electrical Power	7Kva of clean 120VAC/60Hz, or 220V/50Hz. Power and outlet type to be noted.
4. Vessel Working Deck	
Free Board and Rail Height	3m maximum on working decks, as low as possible without being awash preferred. Free board greater than 2m may require a small boat to assist in recovery operations. Max rail height 1m, or removable safety lines.
Working Space	Minimum 3m from working rail or stern, by 5m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.
Storage Space	Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or recovery of any vehicles. Minimum storage dimensions per Wave Glider are: • SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts • SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts



Hoisting/Lifting Gear	Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for lifting/hoisting to be included and noted. • Minimum "Distance Outboard": 2m • Minimum "Distance Inboard": 1m • Minimum SWL: 1-tonne • Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred. • Maximum weight of cable counterweight: 45kg • Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static • Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static. • Minimum Hoist "Height Over Rail" Requirement: ◦ Minimum Single Pick Height Over Rail: 9.0m ◦ Minimum Double Pick Height Over Rail: 3.0m ◦ Minimum Hoist Cable Length: 15m + "Height Over Water" + Length Required to Maintain Safe "Minimum Scope"
Visibility	Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be either visible from the vessel controls and communications via line-of-sight or good quality closed-circuit TV pictures of such areas
5. HSSE (Health Safety Security and Environment)	
Requirement	The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.
Staffing	Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.
Survival suits	In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working in latitudes above 32 degrees north and below 32 degrees south.
Notices	Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel's crew will be in English for all safety notices and procedures.
Briefings	Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.
Drills	A lifeboat and fire drill will be undertaken on passage to site at the commencement of a Wave Glider cruise. Safety drills will be conducted at not less than seven days intervals thereafter. Safety drills will be programmed to ensure practice in a variety of potential emergency response procedures.
Personnel training	All personnel are to be trained and certified in sea survival, fire fighting, first aid/emergency medical skills to IPITO, UKOQA, STCW or equivalent internationally recognized standards.
PPE	All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc): • Safety toed shoes • PFD • Hard hat
Vessel Response Plan	The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf. For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is



	either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.
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Appendix J. Towfish Launch and Recovery Procedures

A Towfish (also referred to as a Towbody) is a sensor package that is towed from the Sub of the Wave Glider with a tow cable. A Towfish includes acoustic sensors such as streamers and arrays. The type of Towfish and the vessel configuration determine the preferred launch and recovery procedures. The tow cable can range in length from 5-8m, and is ballasted to tow horizontally below the Wave Glider Sub.

The following three examples are typical of Towfish used for a variety of Wave Glider applications.

1. **Small Towfish:** 15 kg or less, 1 person hand-deployable, such as a light weight magnetometer.

- **Requirements:**

- a. 1 person (dedicated crew member).
- b. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched.
- c. Daylight and visibility to monitor the Towfish.
- d. Vessel shall be dead in the water.
- e. Sea state 3 or less.

- **Launch:**

- a. Crew member 1: Hold Towfish in one hand, and tend the tow cable with the other hand to ensure it does not tangle in the Wave Glider wings upon launch. Stage the Towfish to be close to the water for release.
- b. Follow Wave Glider Launch Procedure (release hoist line and Bundling Strap).
- c. Crew member 1: Allow the Sub to gently pull the small Towfish into the water upon release of the Bundling Strap.
- d. Exercise extreme caution to avoid Towfish contact with the side or stern of the vessel.

- **Recovery:**

- a. Follow Wave Glider Recovery Procedure and hoist the Sub 1-2 m outboard to keep the Towfish clear of the vessel. Depending on tow cable length and height over rail, recover the Towfish before recovering the Sub to ensure it is safe.
- b. Crew member 1: Use a boat pole to grab tow cable as the Sub is hoisted to the surface.
- c. Crew member 1: Retrieve Towfish by hand, be careful to not hit the Towfish on the side of the vessel.

- d. Crew member 1: Place Towfish on purpose-built cradle or foam, clear of the recovery operations, and continue to tend the tow cable.
 - e. Resume Sub hoisting and Wave Glider Recovery Procedure.
2. **Large Towfish:** Greater than 15 kg, 2-person or mechanical hoist deployable, such as echosounder transducers, turbidity sensors, or fluorometers, in a torpedo shaped housing
- **Requirements:**
 - a. 1-2 personnel (1 dedicated crew member).
 - b. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched.
 - c. Daylight and visibility to monitor the Towfish.
 - d. Vessel shall be dead in the water.
 - e. Sea state 3 or less.
 - **Launch:**
 - a. Vessel arrives on station and orients for Wave Glider launch.
 - b. Stage Wave Glider at launch location on the vessel.
 - c. Request permission from the Captain to launch Towfish, confirm all participants are ready to launch.
 - d. Crew members 1&2: Carefully lower Towfish into the water and tend the Towfish with the tow cable and a boat pole if necessary. Hold onto tow cable.
 - e. Follow the Wave Glider Launch Procedure; hoist the Wave Glider into the water.
 - f. Crew member 1: Release tow cable once the Wave Glider is in the water. The tow cable and Towfish should sink below the level of the Sub.
 - g. Immediately release the Wave Glider from the hoisting cable and trip the Bundling Strap release. The Wave Glider pulls away from the vessel.
 - **Recovery:**
 - a. The following procedure assumes a robust and heavy Towfish. If the sensor is very sensitive to damage, follow the Small Towfish Recovery Procedures.
 - b. Follow Wave Glider Recovery procedures.
 - Do not set the Sub directly onto the tow cable attachment/port on deck, this can damage the cable.
 - Regardless of the recovery method used, the tow cable and Towfish can be pulled onto the deck by hand last (after the entire Wave Glider is on deck). 2 crew members are required for heavy Towfish.

3. **Acoustic Streamer:** Length will vary (30m or longer), 1-2 person hand deployable from a coil on deck, or a mechanical spool.

- **Requirements:**

- a. 2 personnel (1 dedicated crew member).
- b. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched.
- c. Daylight and visibility to monitor the streamer to ensure it is not being fed into the vessel's propeller(s).
- d. Vessel shall be dead in the water.
- e. Sea state 3 or less.

- **Launch:**

- a. Vessel arrives on station and orients to allow best drift of the streamer away from vessel.
- b. Stage Wave Glider at launch location on the vessel. This can be at the stern of the vessel, where the streamer is payed out directly aft, or against one of the aft rails where the streamer is payed out as far aft as possible.
- c. Request permission from the Captain to launch streamer, confirm all participants are ready to launch.
- d. Crew member 1: Hold the end of the streamer and pay out several meters of streamer with assistance from Crew member 2 to feed the streamer into the water.
- e. A large loop forms providing drag on the streamer which assists in paying the streamer away from the vessel. Toss the end of the streamer into the water once the streamer is clearly floating and/or sinking away from the vessel. If the streamer starts drifting under the vessel, or is being carried into the stern due to current, retrieve the streamer to the deck, reorient the vessel, and repeat.
- f. Once the streamer is completely deployed in the water, Crew member 1 tends the tow cable that attaches the streamer to the bottom of the Wave Glider Sub by hand to ensure it does not tangle in the wings as the vehicle is hoisted into the water.
- g. Follow the Wave Glider Launch Procedure; hoist the Wave Glider into the water.
- h. Crew member 1: Release tow cable once the Wave Glider is in the water. The tow cable and streamer should sink below the level of the Sub.
- i. Immediately release the Wave Glider from the hoisting cable and trip the Bundling Strap release. The Wave Glider pulls the streamer away from the vessel, and if properly ballasted, the streamer should not be visible on the surface.

- **Recovery:**

- a. Follow Wave Glider Recovery procedures.

Towfish Launch and Recovery Procedures

- Use caution in approaching the Wave Glider as the streamer may not be towing directly behind the Sub. It is best to try to pilot the Wave Glider on a course to intercept the vessel while the vessel maintains the most stable position for recovery, going dead in the water at close proximity to the Wave Glider.
 - Do not set the Sub directly onto the tow cable attachment/port on deck, this can damage the cable.
- b. Regardless of the recovery method used, the tow cable and streamer can be pulled onto the deck by hand last (after the entire Wave Glider is on deck). 2 crew members are required for a large diameter streamer, so they can hand coil the streamer on deck.