Version 28.05.2024

MURC – WUURC 2024

Class: Junior

(11-15 years)

Version 28.05.2024 The requirement to provide technical documentation has been removed. Teams must submit a specification instead (Team Spec Sheet). Added example graphs for task 3.3 and task 4.2.

General

This document is the main rules of the Navigator class of the MURC – WUURC (Multinational Underwater Robotics Competition – World University Underwater Robot Competition). International competition challenges are inspired by MATE ROV competition 2024. To participate in this category, participants must register **on the competition website.**

Date: July 2024
Place: Vladivostok, Verkhneportovaya 66v
Number of team members: 2-5

The competition consists of three steps

- Engineering poster - **50 points**
- Team Spec Sheet **- 20 points**
- Product demonstration - **230 points**

Engineering poster

The purpose of the engineering poster is to present technical information about your AUV in an attractive and easy-to-use format for a wide audience. It is the promotional piece – you must not only present information about your ROV, mission program and your team, but you must also use graphics and design to publicize and “sell” (convince viewers of their value and excellence) your products and people. During the competition, the poster will be evaluated by judges representing various professions (science, robotics, marketing, etc.). While some judges will have a technical background, others will have a communications, marketing, or public relations background. In addition, there will be visitors to the competition who may not completely understand what a ROV is or how it is used.

The maximum poster size is 80x180 cm.

Use the marketing display scoring rubric posted on the official competition page as the guideline for the required components for the Engineering poster.

Team spec sheet

The purpose of the company spec sheet is to provide the judges with a “snapshot” of your company. It includes basic information about your company and vehicle. Companies will receive up to 20 points for submitting a spec sheet that is one page in length, follows the file size and naming specifications, and contains all of the following information:

TEAMS SPECS

- Company and school, club, or community organization name
- Home state and/or country
- Distance required to travel to the World Championship
- History of MURC-WUURC competition participation. Be sure to specify if your company and/or the members of your company are “new” or “returning.”
- Company photo and caption indicating members’ names and roles (e.g. CEO, CFO, Design Engineer, Pilot, etc.). This photo should include all of the members of your company.
- Range of grade/college levels represented by the members of your company

ROV SPECS

- ROV name if applicable
- Total cost. You must include the approximate cost of any donated items.
- Size and weight measurements
- Total student-hours to design and build. This should include the number of hours that each and every member of the company worked on the vehicle.
- Safety features
- Special features
- Photo of the vehicle

REMINDER!!! If all of the above information is included, the specifications for length, size, and naming conventions are followed carefully, and the document is submitted on time, this is an “easy” 20 points! You can find the company spec sheet scoring rubric posted here.

The team spec sheet must be uploaded to the form by July 1, 2024. The download link will be available on the competition website on June 3

Vehicle requirements

- The dimensions of the ROV should allow it to fit into a cube of 50x50x50 cm.
- The ROV weight is no more than 25 kg.
- There should be no batteries or accumulators on the vehicle. The vehicle's power supply voltage should not exceed 15V. The maximum current should not exceed 15A.
- The vehicle should not have any parts installed (sharp, piercing objects, exposed wires, etc.) that could harm the pool or team members.

Weighing bonus

Vehicles weighing 25 kg will not be allowed to carry out the mission. Before starting a mission, the vehicle must undergo a weighing procedure. Weighing takes place at the workstation before the start of the mission. The vehicle is weighed with all input components without taking into account the tether and the surface part (control panel, monitor, etc.). The developed vertical profiling float is not included in the device and is not weighed. The measurement will be carried out using a digital scale.

The weight bonus is calculated as follows:
Weight (in air):
< 15 kg +10 points
From 15.01 kg to 20 kg +5 points
From 20.01 kg to 25 kg +0 points
Devices weighing more than 25 kg will not be accepted for other products.

Product demonstration

Context

As last year, three tasks of the competitive mission in 2024 are devoted to solving problems that are relevant within the framework of the Decade of Ocean Sciences for Sustainable Development (2021 -2030). You will undertake work to scale up the Global Ocean Observing System to protect and restore ecosystems and biodiversity and collect ocean data to address climate change.

This year's mission will include diagnosing an ocean data collection system, installing an undersea cable, rehabilitating a coral reef by replanting new corals, and treating sick corals with probiotics. You will also have to determine the habitat of lake sturgeons and develop a buoy for monitoring ocean conditions

All competition tasks are based on existing research projects and tasks that use underwater robots or developments in the field of underwater robotics.

Work station

The station consists of a table and 2 chairs located approximately 1 meter from the pool. Pool depth ~1,5 m (pool depth may vary depending on the competition site). The team must bring a laptop, monitors and other necessary equipment.

Time

Each team will be given 2 attempts to complete the mission, each lasting 20 minutes.

Each attempt consists of three parts:

- set up at the work station - 3 minutes
- product demonstration- 15 minutes

- break down and exit the work station - 2 minutes

At any time during the product demonstration you may pilot your ROV to the surface and remove it from the water for things such as buoyancy adjustments, payload changes, and troubleshooting. However, the product demonstration clock will NOT stop. The only time the clock will stop is if a judge determines that there is an issue that is beyond your control. Otherwise, the clock will only stop after all of the tasks are successfully completed, the ROV has returned to the surface under its own power so that it touches the side of the pool, and a member of your company at the product demonstration station has physically touched the vehicle.

Task Descriptions

Teams can complete tasks in any order. However, some task steps require sequential execution **(this will be indicated in the task description).**

The mission consists of three tasks:

- Task 1. OOI: Coastal Pioneer Array - **50 points.**
- Task 2. SMART Cables for Ocean Observing - **45 points**
- Task 3. From the Sea of Japan to Baikal: Studying ecosystems and preserving species- **80 points**
  - 3.1. Smart Reefs
  - 3.2. Inland Lakes and Waterways
- Task 4. Robotic buoys GO-BGC - **55 points**

TOTAL: 230 points.

TASK 1: OOI: Coastal Pioneer Array – Relocating ocean observing assets to “answer pressing science questions and gather data”

The Ocean Observatories Initiative (OOI) is an ocean observing network that operates and maintains instruments and sensors that collect and deliver data to better understand the ocean and how it is changing as a result of natural and human-caused processes. Funded by the U.S. National Science Foundation (NSF), OOI connects researchers, educators, and the general public to a wide range of ocean instrumentation through its cyberinfrastructure, all without the need to go to sea. OOI includes more than 900 instruments, and the data collected by these instruments are freely available around the clock in near real-time.

One OOI observatory, the Coastal Pioneer Array, was designed to be re-locatable and suitable for moderate to high winds, waves, and currents on the continental shelf and upper slope. The Coastal Pioneer Array was installed in 2016 off the coast of New England, about 75 nautical miles south of Martha’s Vineyard. The array consisted of moored platforms, such as surface buoys, profiler moorings, and benthic multi-function nodes, and autonomous vehicles. It was maintained by the Woods Hole Oceanographic Institution (WHOI).

1.1 Release the multi-function node (**The steps of this task are performed strictly in order**)

- “Trigger” the release of the multi-function node’s recovery float. - **10 points**

The step is considered completed if the connector is completely removed from the frame and is not in contact with the multi-function node. The connector is not considered waste and can be left at the bottom.

- Visually determine that the recovery float has failed – **5 points.**

The step is considered completed if the team demonstrates to the judge on the screen that the recovery float is not in contact with the multi-function node and floated, but did not reach the surface due to an accident.

- Pull a pin to release the failed recovery float to the surface - **10 points.**

The step is considered completed if the team removes the pin holding the recovery float loop and the recovery float is on the surface.

- Return the failed recovery float to the surface, side of the pool - **5 points.**

The step is completed when the recovery float is removed from the water.

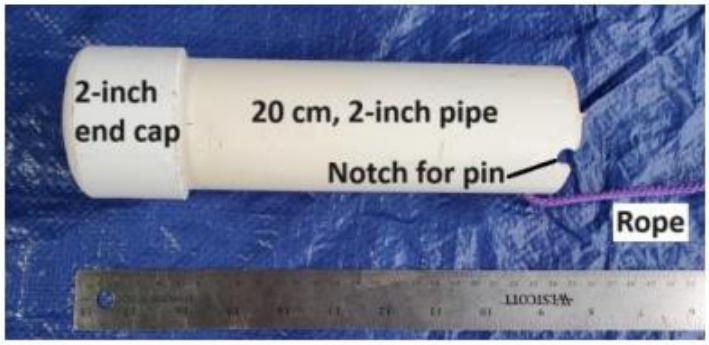
- Connect a recovery line to the bale on the multi-function node for manual recovery - **20 points.**

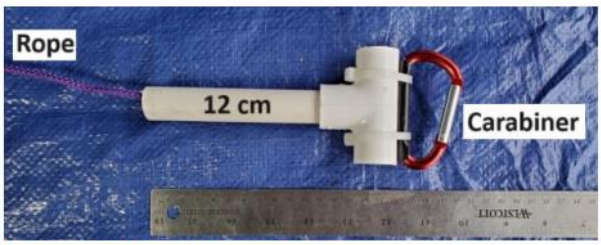
The step is completed if the carabiner is secured to the U-bolt on the assembly multi-function node and does not fall off after installation is complete. The recovery line will be on the surface near the workstation.

Total points = 50 points

Props Description

Type	Photo	Description
multi-function node		The unit frame is made of pipe ppr 20, 4 tees ppr 20, two angles ppr 20, and two transition tees ppr 20 to 25. A U-shaped eye bolt is provided for installing the carabiner. The frame is drilled to a plastic box. The box is weighted and is located at the bottom. To install the buoy, a pipe PPR 90 is provided (can be replaced with a larger diameter) 12 cm long. Under the tube there is a hole for installing a

	 	pin. To keep the pin in the hole of the basket from the inside, it is inserted into the PPR 20 tube.
recovery float		Made from a 20 cm long PPR 63 tube with a plug (can be replaced with a 50 mm tube and a corresponding plug). A rope with a loop at the end is tied to the buoy. The length of the rope is no more than half the depth of the pool (<50 cm). At the end of the rope there is a loop for attaching a pin.There are also slots on both sides of the displacer for installing a pin. Floating material is placed at the top of the buoy to help the buoy float to the surface.
Connector		Made from a PPR 20 tube, 36 cm long, and a D20 tee.

	 Left: The pin holding the recovery float. The recovery float rope is stored inside the float, above the pin. The pin passes through a loop in the rope, holding the rope in place until the pin is removed. Right: Two notches drilled into the bottom of the recovery float hold the pin in place.  The recovery float pin.	The recovery float rope is located inside it, above the pin. The pin passes through a loop of rope, holding the rope in place until the pin is removed. Two notches drilled into the bottom of the buoy hold the pin in place.
recovery line	 The MATE ROV Competition provided recovery line.  The MATE ROV Competition provided recovery line attached to the #310 U-bolt bale on the multi-function node.	Made from a PPR 20 tube 12 cm long and a tee. A rope loop (20 см) is attached to the tube, simulating a cord for lifting. A carabiner is attached to the tee. The part of the carabiner that is attached to the tee is wrapped with electrical tape so that the carabiner is fixed and does not rotate. **Пример карабина:** https://www.amazon.com/dp/B08GFX9PFN/ref=pe_386300_440135490_TE_item

TASK 2: SMART Cables for Ocean Observing

Science Monitoring And Reliable Telecommunications (SMART) Cables is a project that will equip transoceanic telecommunications cables with sensors to collect data on ocean health and monitor seismic activity. SMART Cables are just that – “smart” – in that they use transoceanic cable power and communications infrastructure to collect and transmit temperature, pressure, and seismic acceleration 2024 NAVIGATOR Class 10 data – all of which are important environmental parameters of the deep ocean that are currently undersampled. This data will not only provide valuable information about the state of the ocean, it will also benefit society by improving earthquake and tsunami early warning systems.

At the core of the “smart” innovation is the SMART Repeater, which houses the sensors that measure temperature, pressure, and seismic acceleration and includes a pass-through for the telecommunications cable. The telecommunications cable consists of copper wire, which the sensors tap into for power, and fiber optics for data transmission, which allow the sensor data to be shared in real-time.

2.1. Deploy the SMART cable (the steps of this subtask are performed in the specified order)

- Deploy SMART cable through two waypoints located on the bottom of the seafloor – **5 points each, 10 points total**

The step is considered completed if the cable passes through two points (pipe tubes) of the guide. The SMART cable will be placed on the surface near the workstation.

Waypoint A is an unsuccessful cable lay, as the cable is inside one vertical post only. Waypoint B is a successful cable lay, as the cable is inside two vertical posts. Waypoint C is an unsuccessful cable lay, as the cable is only inside one vertical post (the lower right post only).

- Place the SMART repeater in the designated area - **10 points**

The step is considered completed if the repeater is installed in a blue frame, no part of it protrudes beyond the boundaries of the frame and the repeater is not in contact with the ROV.

- Return the end of the cable to surface, side of the pool. - **5 points**

The step is complete when the cable is routed through two Waypoints, the repeater is installed, and both ends of the cable are on the surface.

2.2 Connect the AUV docking station to the SMART cable repeater (this subtask is performed only after completing the steps of task 2.1)

- Retrieve the power connector from the AUV docking station - **10 points**

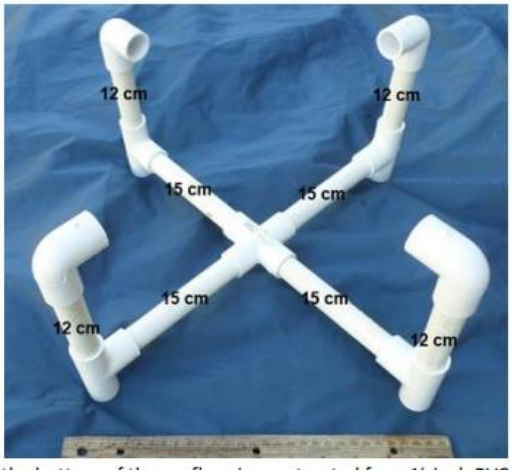
The step is completed if the connector is held by the ROV and is not in contact with the docking station.

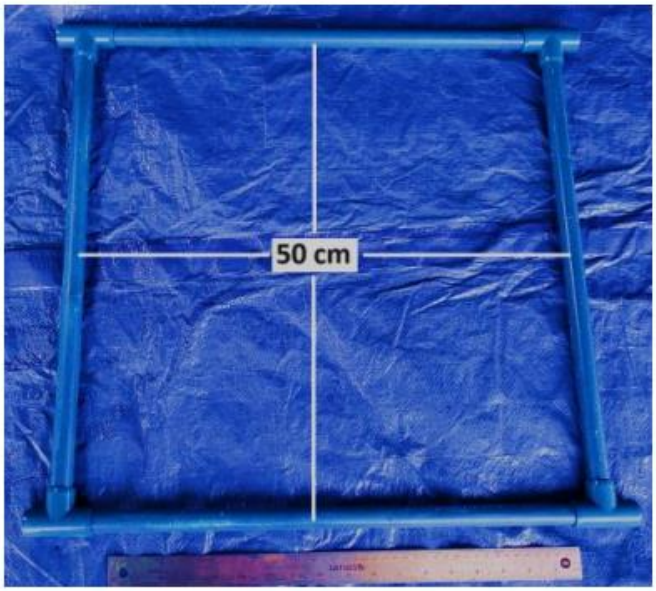
- Install the power connector - **10 points**

The step is considered completed if the connector is not in contact with the ROV and is inserted into the repeater port.

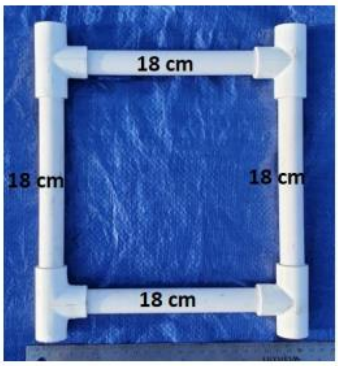
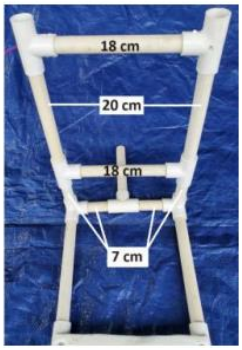
Total: 45 points.

Props Description

Type	Photo	Description
Waypoints (**2**)		Made from pipes ppr 20 and fittings of the appropriate size. The lower part of the structure is weighted.
SMART cable with repeater		Made from pipes ppr 50, two plugs and a tee of the appropriate size. A hook is provided for gripping. A cable is attached to both sides of the repeater. The length of the cable is selected such that the two ends of the cable can be placed on the surface when installing the repeater in the frame. Inside the open hole of the tee there is Velcro tape (loops) for attaching the connector.

frame	 	Made from pipes ppr 20, 4 tees and weighted.
power connector		Made from a PPR 20 tube, a tee and a plug. For ease of gripping, a hook is installed in the tee. A 4 m long rope is attached to the plug (the length can be shortened. The other end of the rope is tied to the docking station. Velcro tape (hooks) is attached to the end of the connector.

	  The power connector inserted into the SMART repeater.	The connector is weighted and is initially located on the docking station platform.

AUV docking station	   	The docking station platform is a square of PPR 20 tubes 18 cm long and four tees. A rectangle made of sheet material (for example, corrugated plastic, fomax, etc.) is fixed on top. The platform is weighted.

TASK 3: Understanding ecosystems and saving species

One of the challenges of coral reef conservation is finding ways to non-invasively treat and prolong the life of corals.

As one option, scientists from the KAUST RSRC research center have proposed the use of probiotics to treat sick corals and strengthen healthy coral ecosystems. Research in this area focuses on the idea that healthy organisms and ecosystems depend on healthy microbiomes. This “microbiome management” is based on the hypothesis that microbes are key members of the “holobiont,” which is a collective term for the host and the many other species that live on, near or within it, and that they connect all ecosystem entities and respond quickly to manipulations with immediate effect and are easier to manipulate than macroorganisms.

To implement this idea, a permanent coral reef research station was developed that includes coral reef sites, research sites where probiotics are introduced invasively into the corals and through a spray system. The station also includes a set of sensors and Doppler receivers for recording environmental parameters.

Similar research methods are used to monitor and conserve fish species diversity. For example, the use of an acoustic sensor system makes it possible to identify potential fish spawning sites.

3A. Smart Reefs

3.1 Probiotics (steps are performed in the specified sequence)

● Place a probiotic irrigation system in the designated location – **10 points.**

The step is complete if the irrigation system is not in contact with the ROV and is completely within the yellow frame.

● Deploy the probiotic sprinkler on coral head – **10 points.**

The step is considered completed if the irrigation system ring is not in contact with the ROV and is placed on the coral.

● Activate the irrigation system – **5 points.**

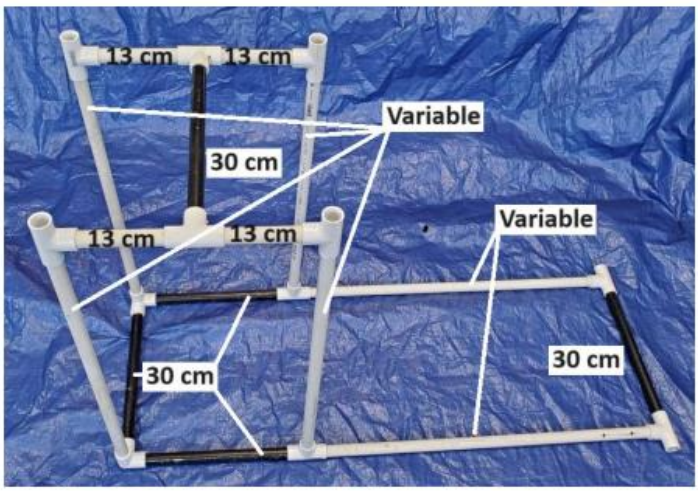
The step is completed if the team rotates the pipe handle 360 degrees and demonstrates this to the judge on the control panel screen.

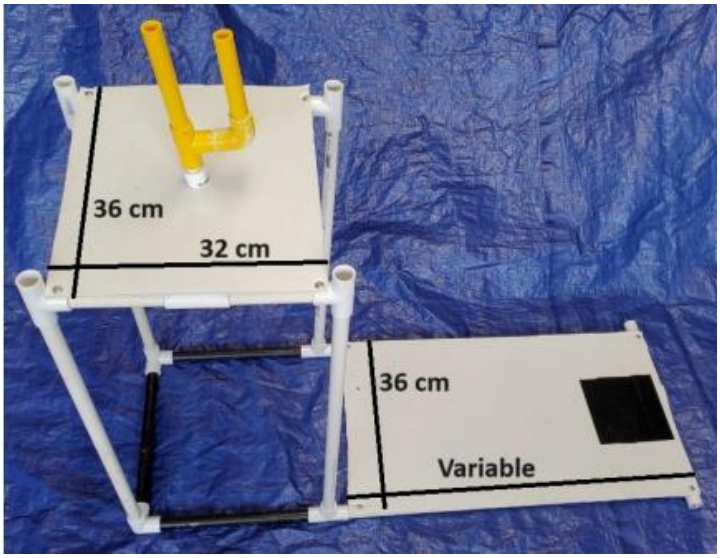
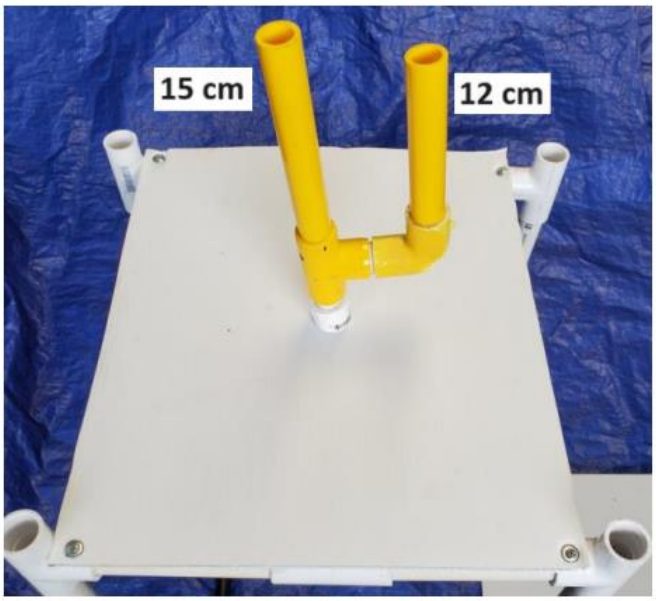
3.2 Coral Restoration

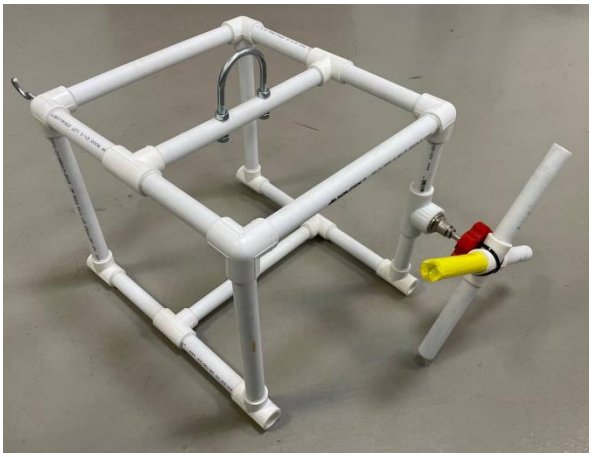
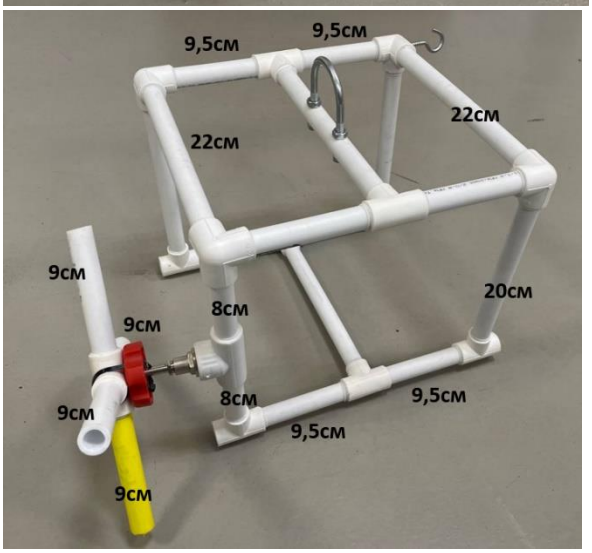
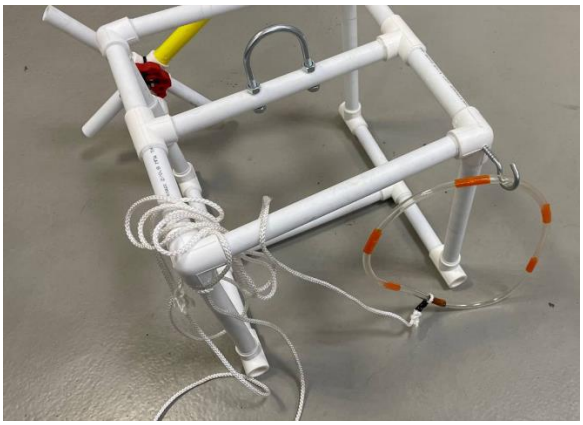
● Transplant brain coral – **10 points.**

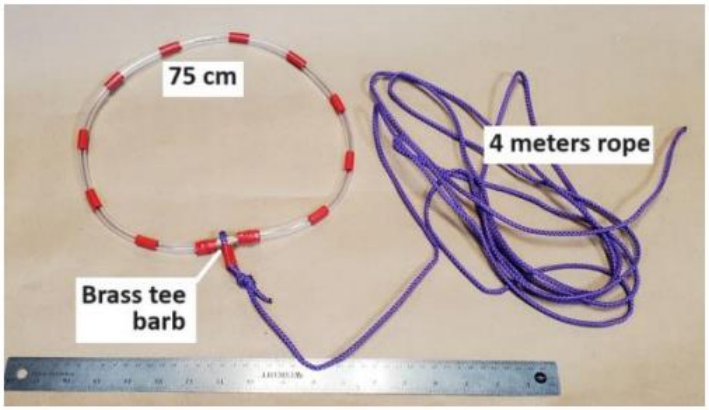
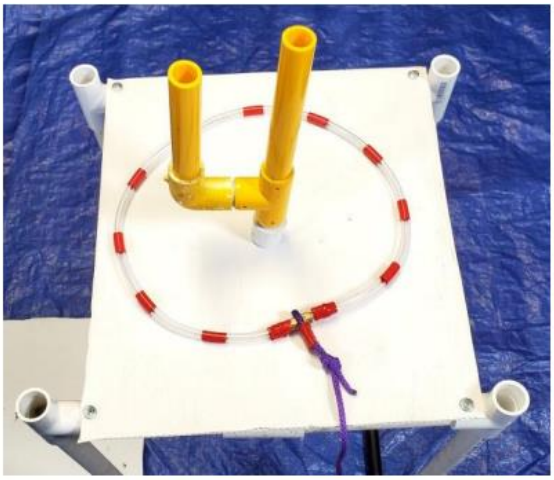
The step is completed when the coral is placed on the square area with Velcro tape. Any part of the bottom of the coral can touch any part of the Velcro square. If at the end of the mission the coral falls off the square area with the Velcro tape and is not returned, then no points are awarded for this step.

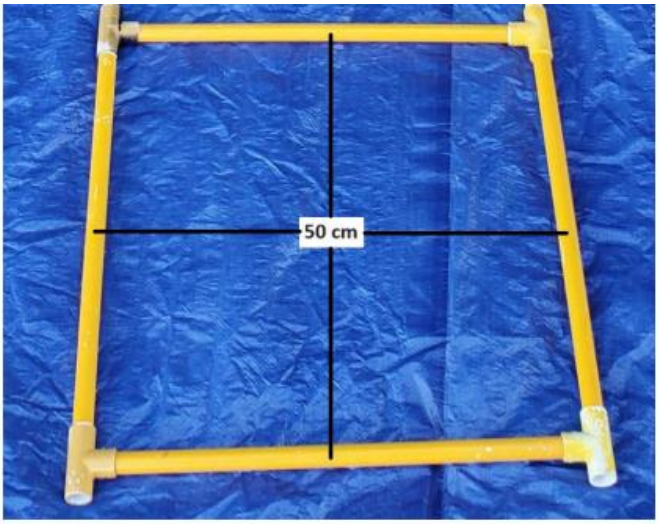
Props description

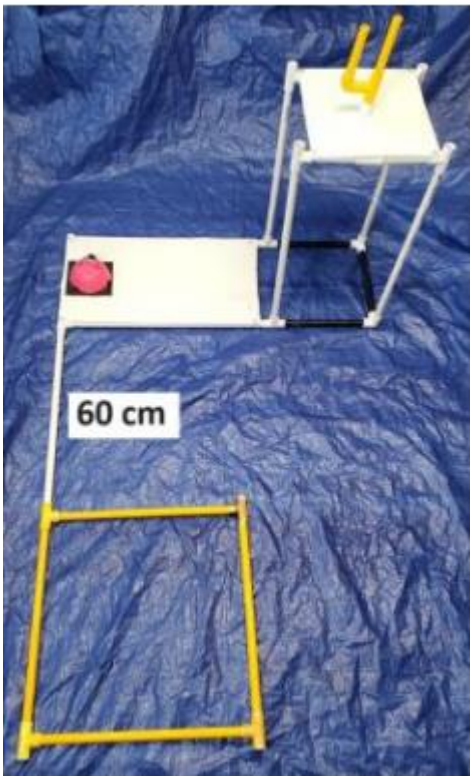
Type	Photo	Description
The coral restoration area		Made from pipes ppr 20, weighted. Height no more than 40 cm. Rectangles of sheet material (corrugated plastic, fomax, etc.) are attached to the frames.

		
Elkhorn coral		
The transplant location for the brain coral		

irrigation system	  	black tube will be changed to the PPR tube D20mm with U-bolt

The sprinkler system	  	

irrigation system designated area		Frame made of pipes ppr 20 and 4 tees. Weighted
brain coral	  	Plastic bowl with a diameter of 12-15 mm. For carrying, there is a 30 cm loop with attached buoyancy. Velcro tape (loops) is glued along the edges. The bowl is weighted (a stone attached to Velcro is used as a weighting agent, but other materials can be used as a weight.



3Б. Inland Lakes and Waterways

3.3 Determine the location of sturgeon spawning grounds

● Recover an acoustic receiver – **10 points.**

The step is completed when one of the three acoustic receivers is removed from the water.

● Determine the location of a potential spawning site – **up to 15 points.**

  ○ Create a graph of sturgeon locations from the acoustic receiver data – **10 points**

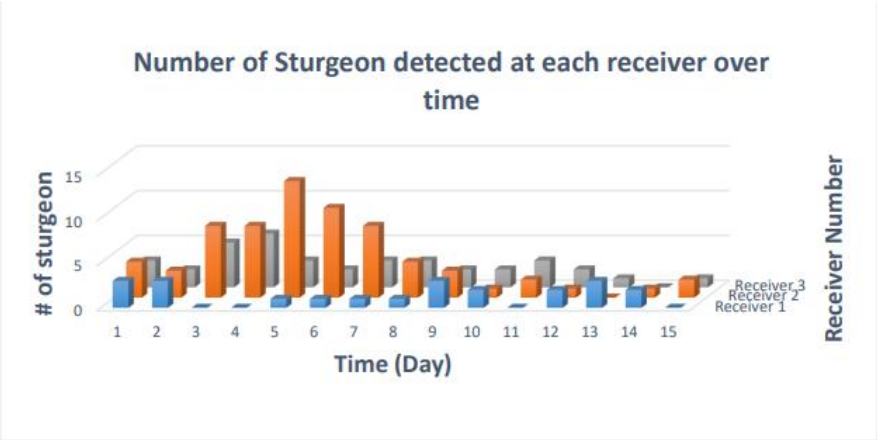
  ○ Determine the potential spawning site - **5 points**

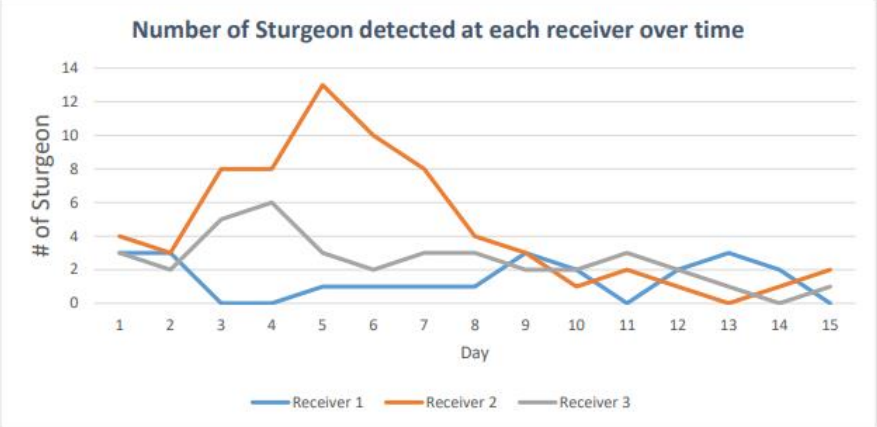
After removing the acoustic receiver, the judge gives the team a table with data on the number of sturgeon recorded per day by each sensor for 8 days.

After constructing the graph, the team must determine near which sensor there is the highest concentration of sturgeon, which is a potential spawning site, and report its decision to the judge.

	# of sturgeon														
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Receiver 1	3	3	0	0	1	1	1	1	3	2	0	2	3	2	0
Receiver 2	4	3	8	8	13	10	8	4	3	1	2	1	0	1	2
Receiver 3	3	2	5	6	3	2	3	3	2	2	3	2	1	0	1

A table showing the sturgeon data recovered from the acoustic receivers. The data represents the number of sturgeon detected per day at each acoustic receiver.





Two graphs displaying sturgeon numbers for each day at three different acoustic receivers. Either graph would successfully display the sturgeon locations from the acoustic receiver data.

3.4. Characterize the habitat at potential spawning site (steps are performed in any order and can be performed independently of 3.3).

- Place an ADCP – **10 points.**

The step is considered completed if the receiver is completely located within the orange frame at the intended spawning site and is not in contact with the ROV.

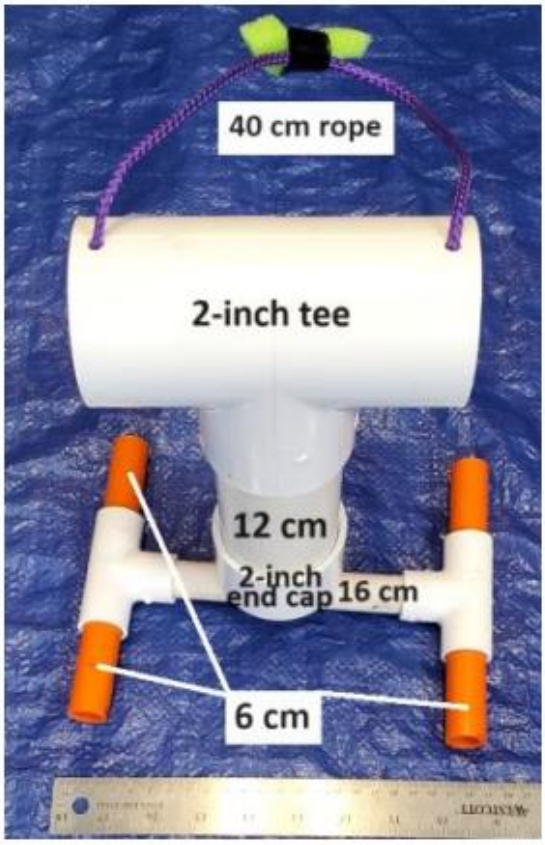
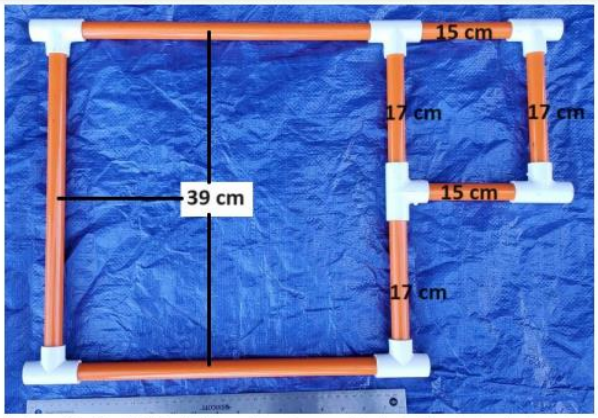
- Recover a sediment sample – **10 points.**

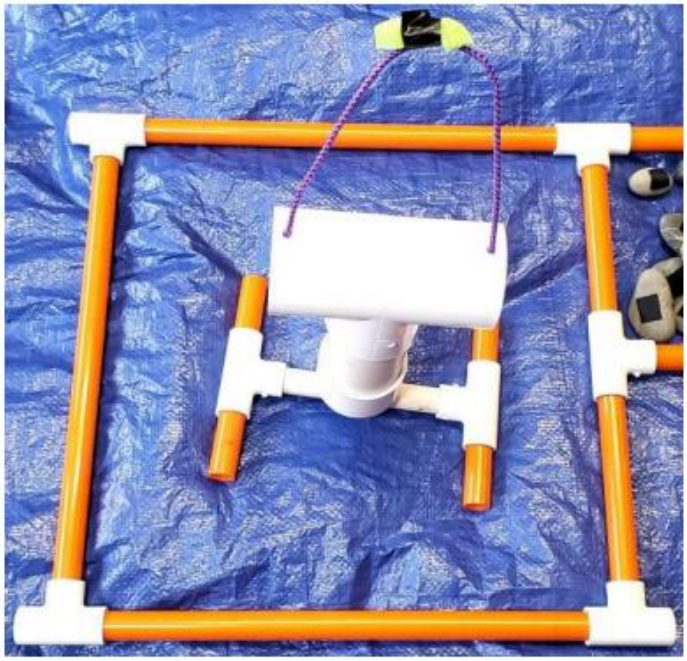
The step is completed when one of the five sample stones is removed from the water.

Total points: 80 points.

Props description

Type	Photo	Description
Acoustic receiver (3)	  	

The Acoustic Doppler Current Profiler (ADCP)		
designated area for the ADCP with the sediment area	 The designated area for the ADCP with the sediment area attached. The designated area is constructed from ½-inch PVC pipe.	

		
sediment sample		The sediment sample consists of Beach Pebbles with Velcro hooks attached.

Task 4: Robotic buoys GO-BGC.

The goal of the GO-BGC project is to create a global network of chemical and biological sensors that will monitor the health of the ocean. The network of robotic buoys already includes more than 100 ocean observation devices around the world, and the planned number of buoys is 500! We suggest that you develop such a buoy and collect data using it.

4.1. Design and construct an operational vertical profiling float

Company design and construct a vertical profiling float:

- Prior to the competition, design and construct a vertical profiling float with a depth sensor – **to 10 points.**

- Design and construct a vertical profiling float – **5 points.**
- Include a depth sensor – **5 points**

The step is considered successfully completed if the team brings a vertical profiling float to the station that meets the minimum requirements and demonstrates its operation on land to the judge.

- Deploy the float into a designated area – **5 points.**

The step is considered successfully completed if the vertical profiling float is delivered to the area marked with a green marker and does not come into contact with the ROV.

- Float completes a vertical profile – **15 points.**

The step is considered completed if the vertical profiling float performs a full vertical profile. Vertical profile: any part of the buoy is on the surface of the water, the buoy begins to sink, any part of the buoy touches the bottom, the buoy begins to rise to the surface, any part of the buoy appears on the surface of the water.
Once the profile is complete, the team can retrieve the buoy themselves.

- Float collects depth data and displays them and time on the screen– **to 15 points.**

The step is considered completed if the vertical profiling float performs a full vertical profile. Vertical profile: any part of the buoy is on the surface of the water, the buoy begins to sink, any part of the float touches the bottom, the buoy begins to rise to the surface, any part of the buoy appears on the surface of the water.
Once the profile is complete, the team can retrieve the profiling float themselves.

OR

Company does not design and construct a vertical profiling float or the float does not contain a depth sensor: The team is provided with a mock-up of the profiling float.

- Deploy the float into a designated area – **5 points.**

The step is considered successfully completed if the float mock-up is delivered to the area marked with a green marker and does not come into contact with the ROV.

4.2. Plotting a graph of temperature versus depth.

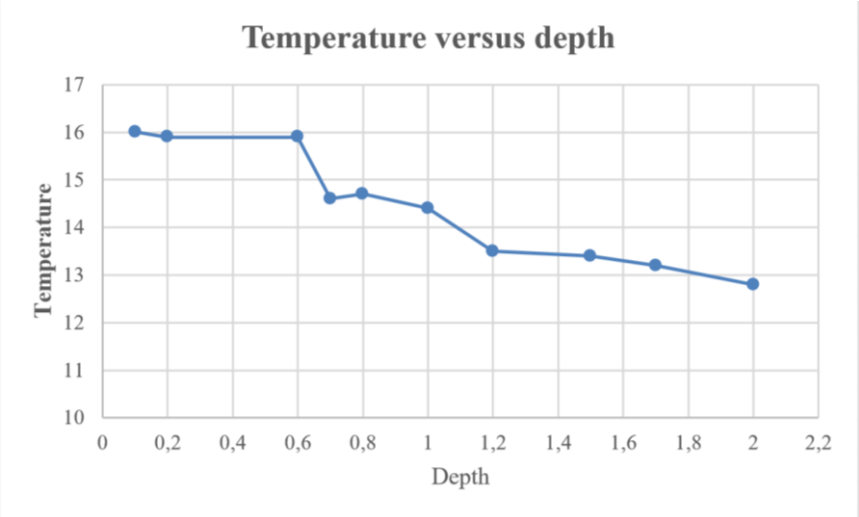
- Plotting a graph of temperature versus depth –**10 points.**
  - Graph is plotted using a computer program – **10 points.**
  - Graph is plotted on graph paper – **5 points.**

After delivering the buoy (or its model) to the research area, the judge gives the team a table with data on the depth of the reservoir and temperature at different levels. The team must plot a graph of temperature versus depth. A laptop, graph paper, and pen are not provided at the station. The team must come with their own tools to complete the task.
The step is considered successfully completed if all points on the graph are marked correctly.

Total = **55 points**

Example of a data table

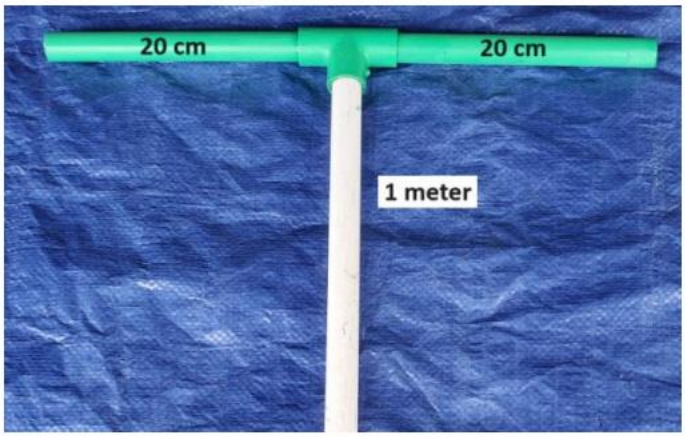
Depth, m	0,1	0,2	0,6	0,7	0,8	1,0	1,2	1,5	1,7	2,0
T, C°	16	15,9	15,9	14,6	14,7	14,4	13,5	13,4	13,2	12,8



Requirements for a profiling float

- The **profiling float** must follow one vertical profile. Vertical profile - the device goes down to the bottom and floated to the surface.
- The power supply to the device must be on the surface.
- The maximum voltage should not exceed 12V, current should not exceed 6A.
- A team can only use one propulsion unit to move.
- When moving, the vertical profiling buoy must transmit data about the depth and time of its operation to the workstation.
- Overall dimensions of the **float** (Overall dimensions of the buoy (diameter/length/width) must be no more than 12 cm). The height of the buoy with all components should not exceed 50 cm.
- The **float** must operate independently of the ROV. Those. during the vertical profile, the **float** should not contact any part of it with the ROV. The buoy is controlled and powered independently of the ROV control panel.
- It is allowed to use one propulsion device to move through the water column. As an alternative method of movement, other lifting and lowering methods, such as a float motor, can be used.
- The propellers must be located inside the **float** frame or covered with a protective casing and netting. The screw must not touch any surface of the pool. Otherwise, the **float** will not be allowed to be tested in water.
- The **float** can perform a vertical profile both autonomously and manually (using a control panel).

Props description

Type	Photo	Description
green mark		Made from PPR 20 tubes, and attached to the side of the pool near the starting area (located on the surface).

Penalty points:

Safety: During the mission, the team must follow the safety rules established on the site. In case of violation, the team receives 5 penalty points
Tether: A team member may not pull on the ROV tether to move or rotate it. If this rule is violated for the first time, the referee issues a warning to the team. For subsequent violations, the team is awarded 5 penalty points.
Communication: During the mission, team members are prohibited from communicating with each other regarding the location of the vehicle and the need to turn it. Communication between the pilot and the cable manager regarding cable position and feed is allowed. If this rule is violated for the first time, the team is given a warning. For subsequent violations, the team is awarded 5 penalty points.
Diver Assistance: In the event that the team requires the assistance of a diver to lift and/or release the ROV, the team has the right to request assistance. The time of trying with help does not stop. The team is awarded 5 penalty points.

Communication with judges

Product demonstration judges and other competition officials will only communicate with students. Judges and officials will NOT communicate with mentors, parents, or other non-student members regarding product demonstration information, challenges, or other issues except during pre- and post-competition briefing sessions. Companies that wish to issue a challenge during the product demonstration run should immediately communicate this challenge to the product demonstration judges. The judges will discuss and 2024 NAVIGATOR Class 56 attempt to resolve the issue. If a decision cannot be made, the product demonstration judges will consult with the head judges and competition technical manager to resolve the issue.

NAVIGATOR class product demonstration set up: