photo credit: Ryo Minemizu

# DIVERSITA+

**Extends the ML on Edge Technology to the Underwater World**

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Nov.–Dec., 2018

# Preface

## ABOUT DIVERSITA+

The essence of the Project Diversita was using Machine Learning on Edge technology to recognize specific patterns and react to different results accordingly.

While Diversita was built for land animals, here I propose the Diversita+—an extension of scenarios for the technology framework—for underwater use.

The dataset to train the model could be optical camera images for individual species like shark, ray, barracuda. It could also be sonar reflection pattern.

In general, Diversita+ could be used to assist beach safety monitoring, marine fauna research, and water purity monitoring.

## MENU

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# Concept One: Huntaway

photographer unknown

## PROBLEM IDENTIFICATION

Shark/stingray/barracuda may come to the beach to attack swimmers/surfers.

It is tough for lifeguards to monitor an entire beach, especially when there is a strong sunshine reflection from the sea or high waves beating the beach.

Once the attack happens, the consequence might be lethal.

## USER PERSONA

photo credit: Australian Lifeguard Service

**Olivia**

Gender: female

Age: 31

Occupation: lifeguard at Australia Lifeguard Service

Location: Gold Coast, Queensland, Australia

Work routine: monitors a two km. long beach from 10 am to 5 pm, mainly watches for drowning or shark attack.

Pain point: the beach is crowded, very hard to identify anomaly; in the morning, the reflection of sunshine on the sea surface makes it even harder to monitor.

Quote: “It’s tough to keep vigilance all day long. I know once the shark attack happens, the consequence would be severe.“

# Concept One: Huntaway

## CONCEPT DESCRIPTION

Huntaway is a fencing system deployed at beaches or similar places to monitor and fend off marine species that threaten human life.

A node device of the system can detect aquatic life species by capturing images of nearby animals with its optical cameras and sonar array. The pictures and movement vector pattern will be processed with a pre-trained on-edge neural network to verify if there are target species.

If the captured data triggers the alert rule, the nearby lifeguard will be notified the species identified and its location.

The electrode array could deter shark by emitting electric current to interfere the ampullae of Lorenzini in their noses.


photo credit: Albert Kok

## WORKFLOW & DESIGN REQUIREMENT

### 1. DETECT

use ultrasonic array to generate reflection image;

use optical camera to generate visual image

### 2. ANALYZE

use ML model to recognize threatening species based on imaging results/moving vector pattern

### 3. NOTIFY

notify lifeguard of coming threatening species with wireless connectivity

### 4. INTERVENE

use electric field pulse to expel sharks

### COMPONENTS

- buoyancy provider/intallation basement
- sonar array
- camera array

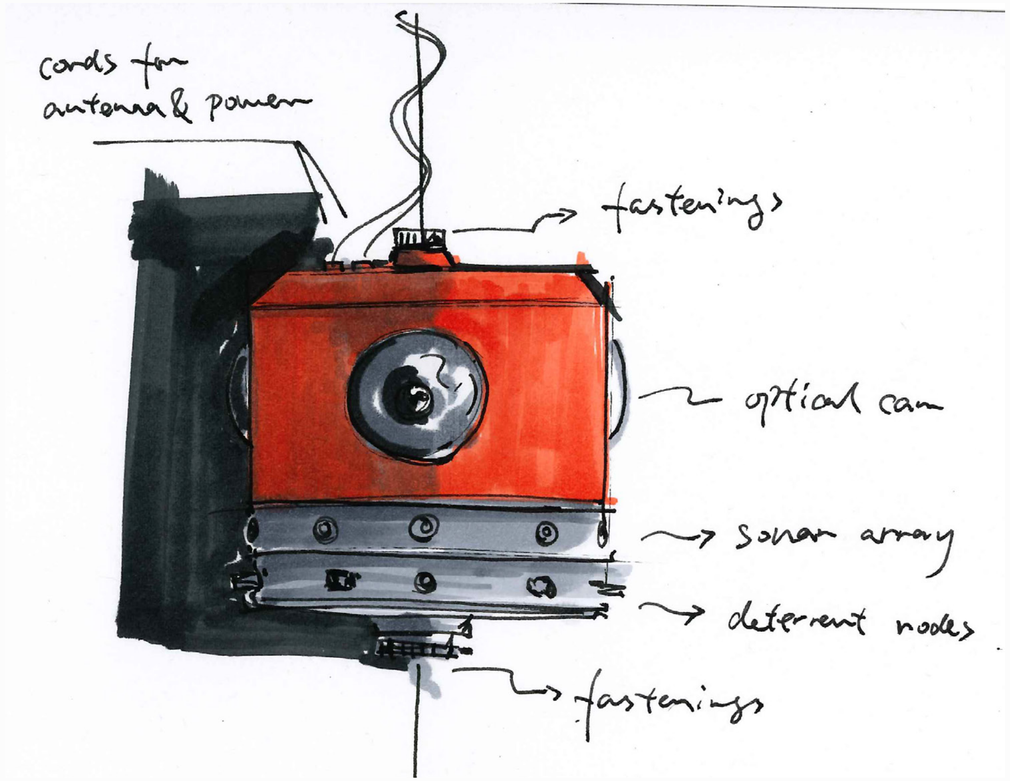
- power source: solar panel/ battery
- computation module
- cooling

- antenna

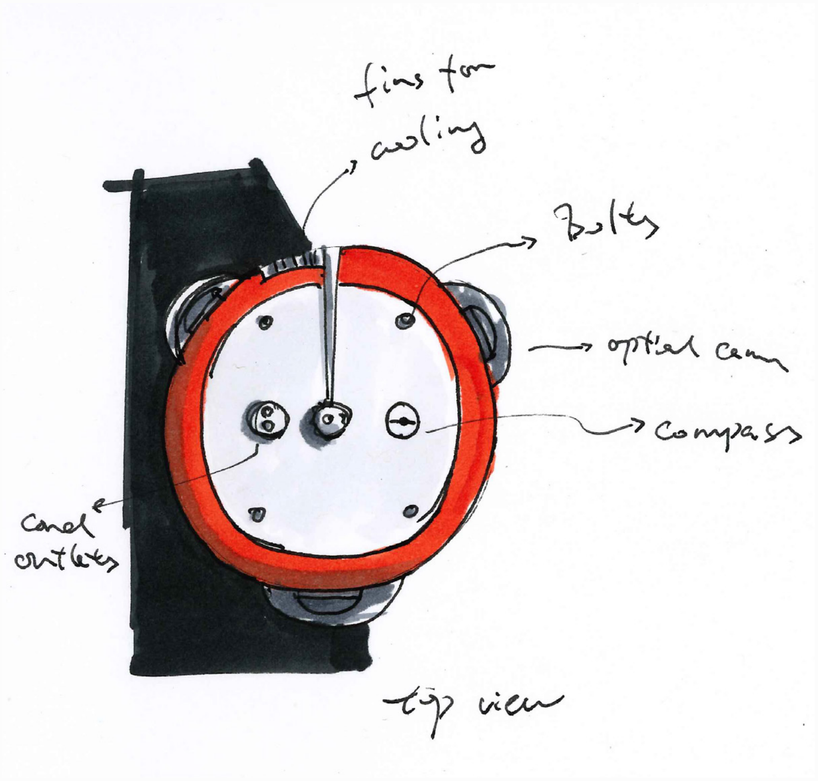
- deterrent module

# Concept One: Huntaway

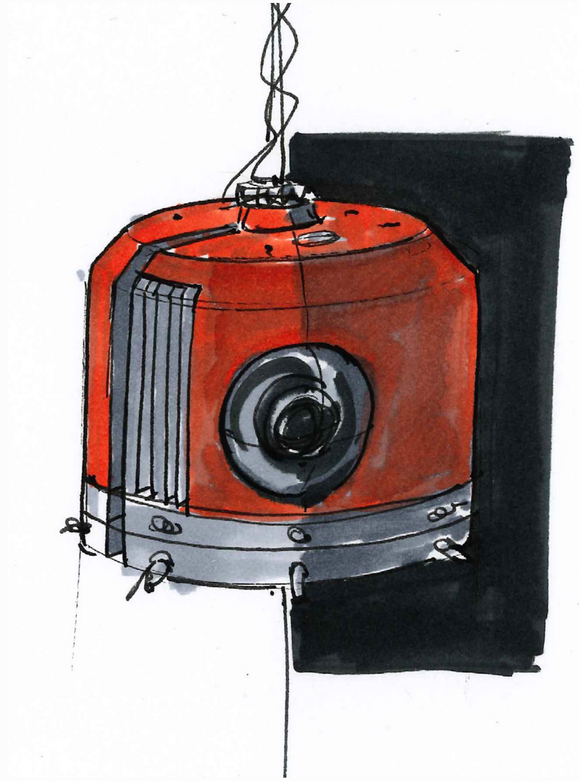
## SKETCHES




front view




top view

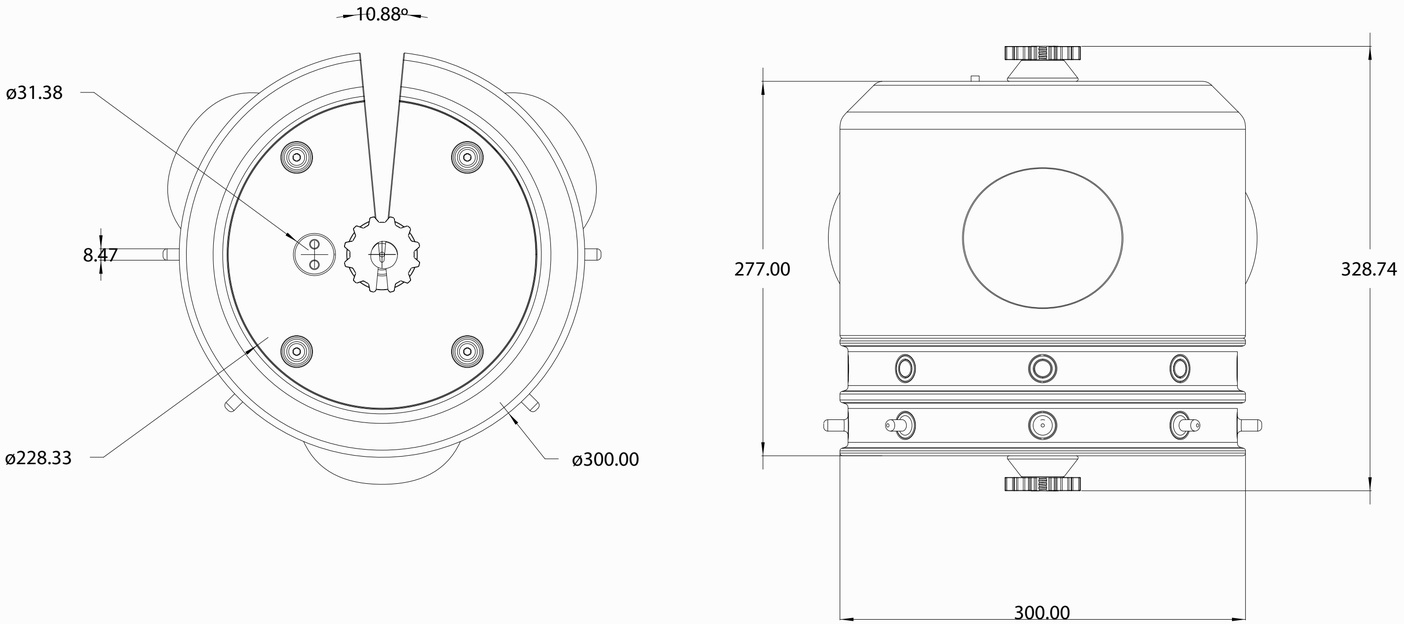


perspective view

Note: the cooling fin was cancelled during the CAD.

# Concept One: Huntaway

## CONCEPTUAL CAD




top/side view with dimensions (mm)

computer graphics rendering

# Concept Two: Remora


## PROBLEM IDENTIFICATION

Researchers spend long hours to manage video trailers and photos for marine life research—most part of the trailer are worthless, and researchers need to pick out sections that capture frames of interests.

## USER PERSONA


**Grace**

Gender: female

Age: 29

Occupation: marine life researcher

Location: San Diego, CA

Work routine: dives at research sites, take photos of marine life underwater and marks the spot; spends long hours organizing research data.

Pain point: most of the research time was spent on collecting and organizing data.

Quote: “Although it’s 2018, we are still working in a Middle Ages way. What if I want to study the trans-pacific marine life distribution, will our team soak in the salt water forever?“

# Concept Two: Remora

## CONCEPT DESCRIPTION

Comparing with the voyage range of a ship, most marine life individuals have a relatively small living circle.

Inspired by remora, a small fish that attach itself to a passing shark/whale, usually on the belly or underside, to take advantage of the large host's protection and food residual during its long-range travel. I propose the Remora concept—an ML on Edge device that is installed at the side of a ship below the ship's waterline, it combines images from an optical camera and a sonar array, recognizes the marine life species and geo-tag the location where the data was collected.

By attaching a species recognition and geo-tagging enabled underwater device to the bottom of a research ship, researchers can collect data on marine fauna distribution ocean-wide. Just like a floating satellite.

photo credit: Simon J. Pierce

## WORKFLOW & DESIGN REQUIREMENT

### 1. SCAN

use ultrasonic array to generate reflection image;

use optical camera to generate visual image

### 2. ANALYZE

use ML model to recognize species based on imaging results/moving vector pattern

### 3. SYNTHESIZE

integrate recognition result with geo information, produce a visualized report on the findings

### COMPONENTS

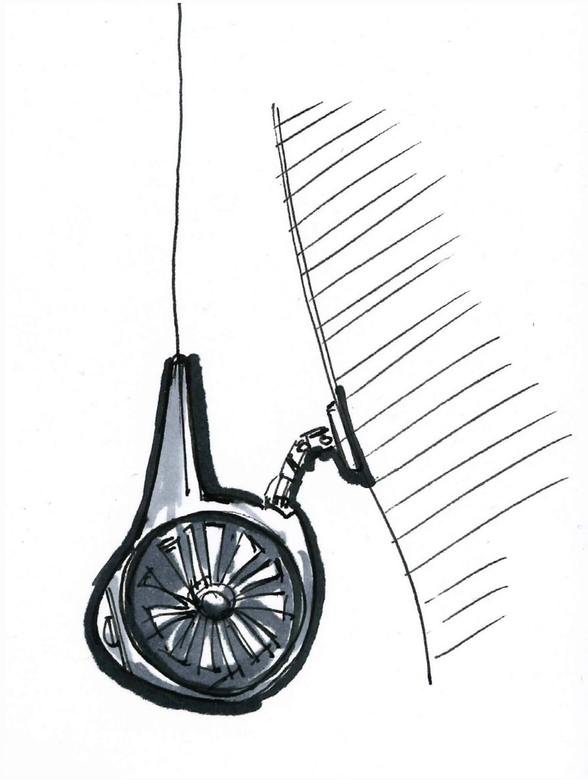
- attaching module: magnet, mounting point for mechanic jack
- sonar array
- camera
- lighting
- antenna

- computation module

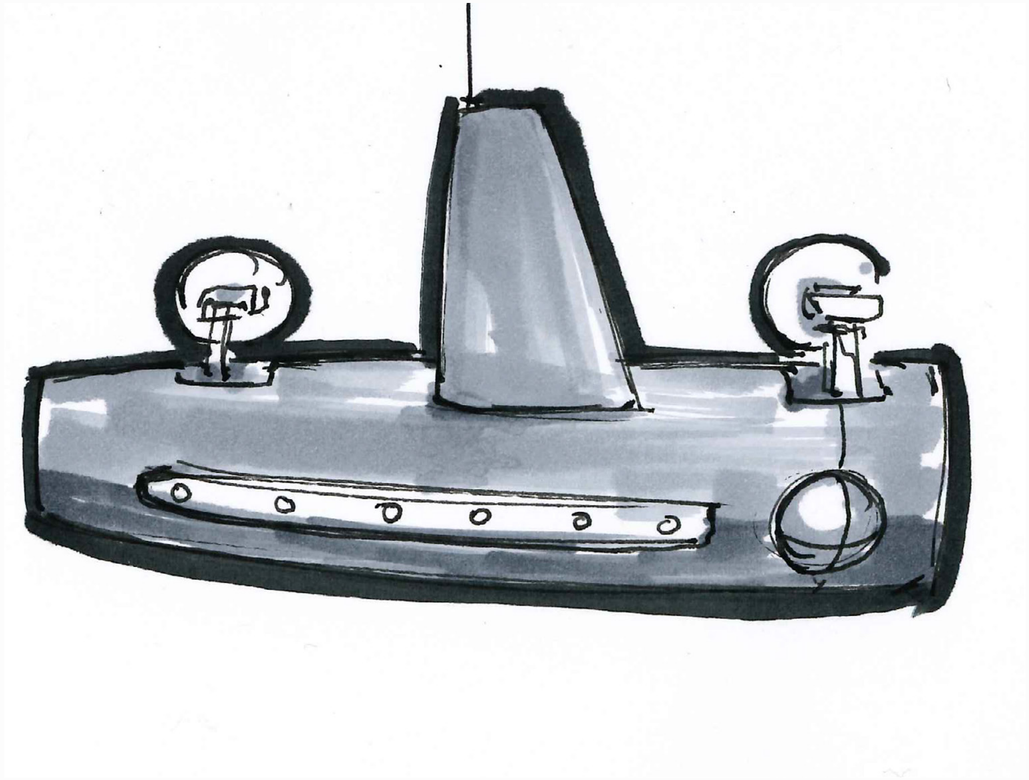
- data processing software

# Concept Two: Remora

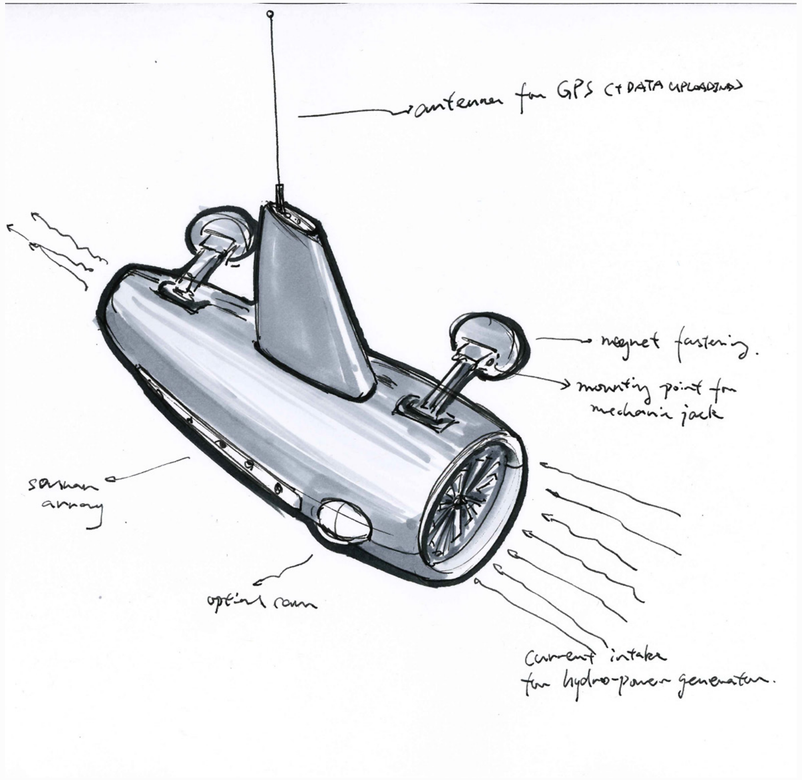
## SKETCHES



front view



side view

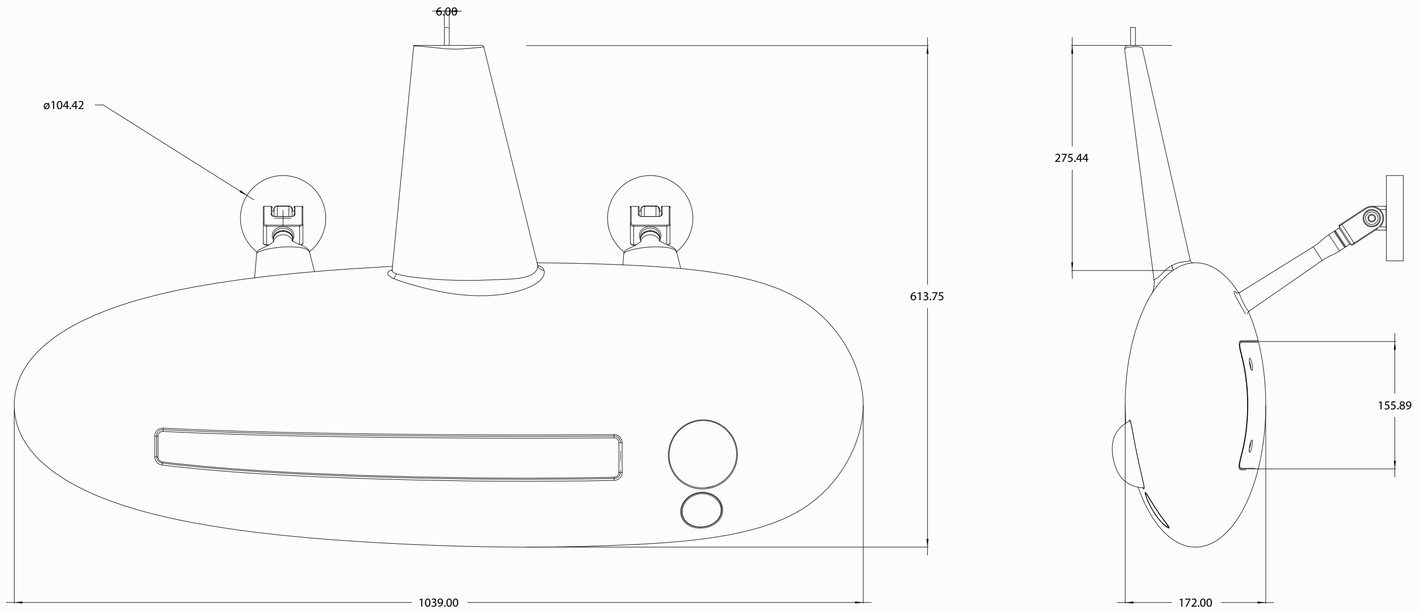



perspective view

Note: the hydro turbine power generator concept was abandoned.

# Concept Two: Remora

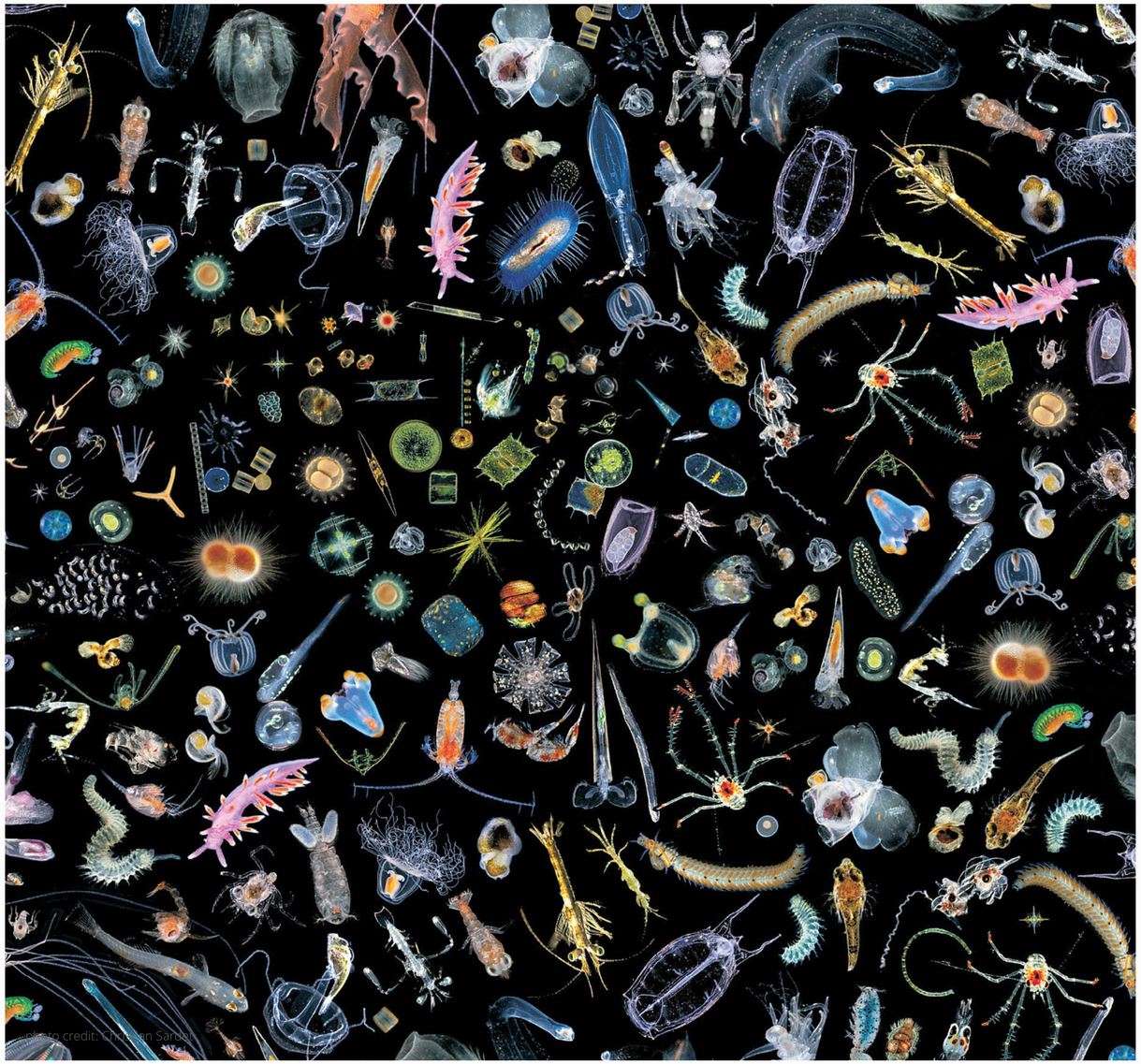
## CONCEPTUAL CAD




side/front view with dimensions (mm)

computer graphics rendering

# Concept Three: Seahorse



## PROBLEM IDENTIFICATION

Phytoplankton are important parts of the marine biological energy and carbon circulation system.

By now, researchers need to travel to research spots to sample tubes of liquid material periodically. The time spent en route and lodging at the research site costs research fund but have no direct contribution to research itself.

## USER PERSONA


**Valier**

Gender: male

Age: 34

Occupation: plankton scientist at NOAA

Location: Seattle, WA

Work routine: samples water in the Elliot Bay every two weeks, uses a microscope to identify plankton species and counts their quantity.

Pain point: traveling to the research spot takes considerable time and consumes the research fund.

Quote: “What we need is just the data of the sample. Last year we went to the Aleutian Islands just for some water samples, but it cost us $700K—most were paid for the research ship.“

# Concept Three: Seahorse

## CONCEPT DESCRIPTION

Seahorse is a device that integrates an electronic microscope with an edge computing module.

It can sample plankton periodically as programed. Images captured will be processed by local computing power. ML models for plankton recognition will interpret the images and generate a research log recording the species, density, and time of capturing.

The result can either be collected via wireless Internet or storage media.

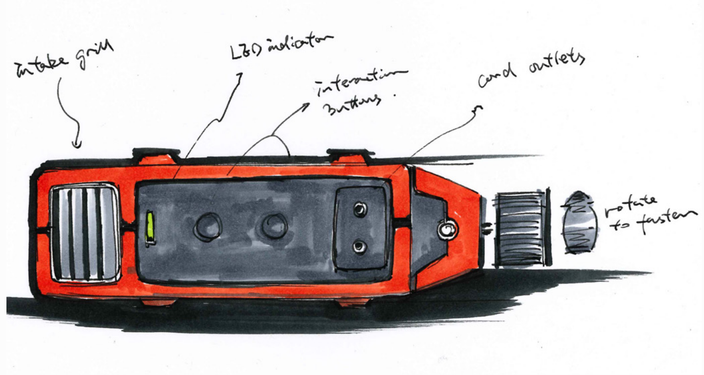

## WORKFLOW & DESIGN REQUIREMENT

| 1. TAKE IN | 2. LOCK | 3. CONDENSE | 4. SCAN | 5. RELEASE | 6. ANALYZE |
|---|---|---|---|---|---|
| The device takes in 10 mL of sample at one time. | After taking in the sample liquid, the sample chamber will be locked. | The device will filter excessive water from the sample with a semipermeable membrane, to get the sample ready for microscope scan. | A microscope inside the device will scan the sample under constant flash lighting. | When the scan completes, the device evacuates the sample chamber, archives the used semipermeable membrane and washes the sample chamber for next sampling. | The device analyzes the scanned image with ML model trained with plankton dataset, then generates a sampling record. |

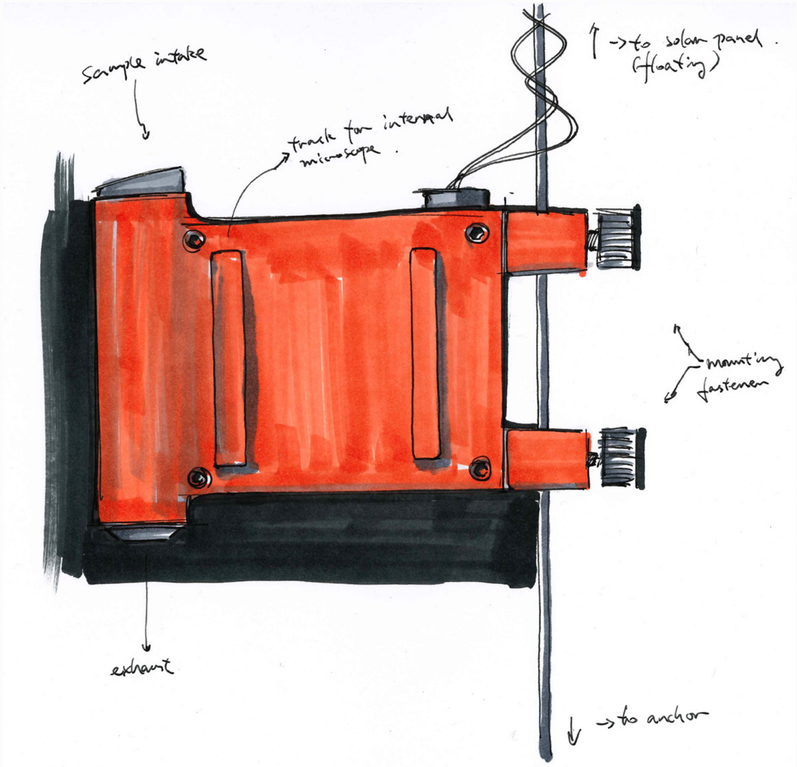
| COMPONENTS | | | | | |
|---|---|---|---|---|---|
| • sample intake | • chamber lock | • compression mechanics | • flash light<br>• internal microscope scanner | • exhaust | • computation module<br>• antenna |

# Concept Three: Seahorse

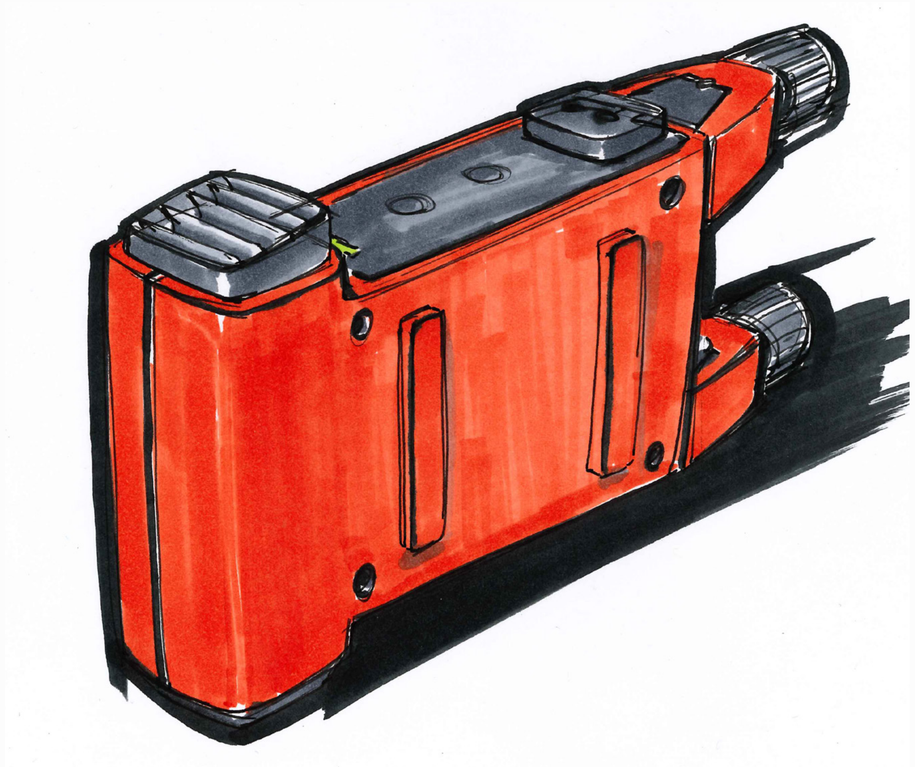
## SKETCHES




top view



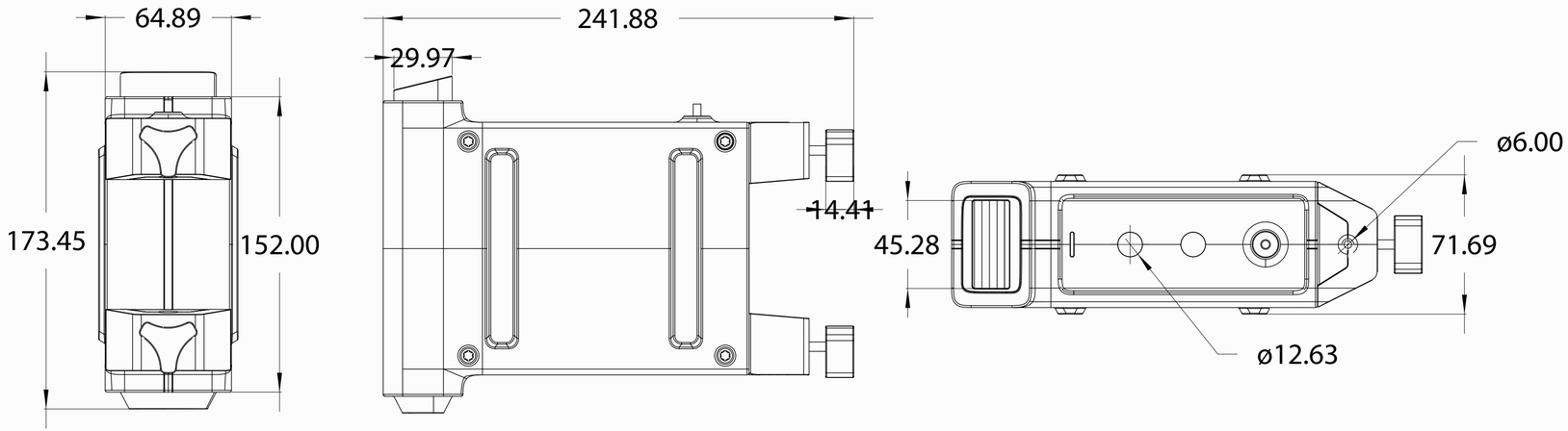

side view



perspective view

# Concept Three: Seahorse

## CONCEPTUAL CAD




top/side view with dimensions

computer graphics rendering

# Appendix

## REFERENCE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3. Monaco, A., Prouzet, P. (2015). Marine Ecosystems-Diversity and Functions. Hoboken, NJ: John Wiley & Sons, Inc.
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## RISKS AND PROBLEMS TO BE SOLVED

**Huntaway**

- The consequence of a false negative might put someone's life into danger.
- How to clean the lens?

**Remora**

- The surface of a ship's underwater part may have biological attachments, which will make the mounting not reliable.
- If the speed of the ship is high, vacuum bubbles may interfere with sonar/optical camera.

**Seahorse**

- How to retrieve the device back?
- How to keep the device relatively stationary in the deep ocean (thousands of meters deep) where there is nothing to attach the device?