Okaloosa County

Project Data Collection Form

RESTORE ACT - Direct Component

BCC Proposal Number

(To Be Assigned by Grant Administration)

INTRODUCTION

The purpose of this data collection form is to assist Okaloosa County in prioritizing projects submitted for Direct Component ("Pot #1") funds allocated from the Gulf Coast Restoration Trust Fund through the Resources and Ecosystems Sustainability, Tourist Opportunities and Revived Economies of the Gulf Coast States Act of 2012 (RESTORE Act).

The following terms are used in this data collection form:

• Applicant or Responsible Entity - the Okaloosa County Board of County Commissioners (BOCC)
• Project Proposer - the individual or organization completing this form

Prior to initiating this data collection form, it is recommended the Project Proposer download and review the entire form to understand the range of required information. Tools/data required to complete this form may include: permits, interlocal agreements, comprehensive plans, evidence of property ownership, and estimated project costs. Completing all required information in the collection form may require many hours; this will be a function of project complexity and proposer preparedness.

This data collection form differs from the U.S. Treasury Application Form (RESTORE Act Direct Component Guidance and Application to Receive Federal Financial Assistance; August 2014). This data collection form is designed to assist Okaloosa County in their task of developing a recommended list of potential projects for inclusion in an amendment to the BOCC's Multiyear Plan.

Projects that are identified for funding in the Multiyear Plan amendment may require additional information from the Project Proposer. If a proposed project is ultimately included in the approved Multiyear Plan, failure of the Project Proposer to provide the required project information may preclude funding for that project.

Per RESTORE Act guidance, the responsible entity shall be solely responsible for the execution of each funded project, including procurement of professional services and/or construction services. The Okaloosa County BOCC reserves the right to delegate these services to sub-entities with the demonstrated capability to comply with all County and Federal procurement processes required by the RESTORE Act.

By proposing a project through this data collection form, the Project Proposer acknowledges there is no guarantee the proposed project will be funded. Further, the Project Proposer acknowledges no reimbursement or compensation shall be provided for completing the data collection form or any other activities associated with proposing a project.

PART A: GENERAL INFORMATION

Incomplete applications will not be considered. By submitting this project proposal, the proposer certifies that the statements herein are true, complete and accurate to the best of his/her knowledge. Any false, fictitious, or fraudulent statements or claims may cause the application to be rejected without the opportunity to re-submit.

A.1 Project Point of Contact: Provide the name and contact info including the mailing address, e-mail address and phone number of the Project Proposer.

Name:	Yuan Wang
Street 1:	120 Chief's Way, Suite 1 PMB 1
City:	Pensacola
State:	Florida
Zip Code:	32507
County:	Okaloosa County
E-Mail:	yuan@amrc.io
Phone Number:	(310) 200-0501

A.2 Proposed Activity / Project Name: Provide the name of the Proposer Activity/Project

Free Public Technology Incubation to Drive Tourism and Aquatic Resource Management

A.3. Requested Funding Amount: How much Direct Component (Pot #1) funding is being requested for this project?

$824,230*

***With the option to scale up or down depending on what project scope the Okaloosa County BCC deems best. See itemized budget (p. 16) for more details on the scale envisioned for the project and how the scope can be adjusted.**

A.4. Qualifying Eligible Activity: Please check the primary eligible activity in the first column and then all other eligible activities that apply in the second column by placing a check mark or selecting the radio button in the column in the row corresponding to the qualifying eligible activity.

Select Primary Activity (Select only one)	Select All Others That Apply	Qualifying Eligible Activity
○	☐	1. Restoration and protection of the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches and coastal wetlands of the Gulf Coast Region
○	☐	2. Mitigation of damage to fish, wildlife and natural resources
○	X	3. Implementation of a federally approved marine, coastal, or comprehensive conservation management plan, including fisheries monitoring
○	X	4. Workforce development and job creation
○	☐	5. Improvements to or on State parks located in coastal areas affected by the Deepwater Horizon oil spill
○	☐	6. Infrastructure projects benefitting the economy or ecological resources, including port infrastructure
○	☐	7. Coastal flood protection and related Infrastructure
○	☐	8. Planning assistance
X	☐	9. Promotion of tourism in the Gulf Coast Region
○	☐	10. Promotion of the consumption of seafood harvested from the Gulf Coast Region

A.5. Claimed in Oil Liability Trust Fund After July 6, 2012: Was this proposed activity included in any claim for compensation paid out by the Oil Spill Liability Trust Fund after July 6, 2012***?***

X No.

☐ Yes. (STOP) This activity is not eligible for RESTORE Direct Component.

A. 6. Location of Activity: Provide the project location. (If there is more than one location for the activity, attach a list of the additional locations).

A.6.1. Address: Provide the actual address for the activity (street address, city/town, county/parish, state, zip code). (If there is no street number, provide the nearest intersection, or note boundaries on map submitted with Question A.6.2.

Latitude/Longitude (if available):	**30.3945° N, 86.5935° W**
Street Address:	**1010 Miracle Strip Pkwy SE**
City/Town:	**Fort Walton Beach**
County/Parish:	**Okaloosa County**
State:	**Florida**
Zip Code:	**32548**

A. 6.2. Map: Provide a map of the project location and describe how the proposed activity will be carried out in the Gulf Coast Region as defined in 31 CFR 34.2.

All activities will be carried out at the Gulfarium Marine Adventure Park (shown above) or other locations (e.g. beaches) in the Okaloosa County area.

(END OF PART A)

PART B: PROJECT DETAILS

B.1 Proposed Scope of Work: Provide a detailed scope of work that fully describes the project or program for which funding is requested. Including:

- Need, purpose and objectives;
- How the project/program meets the identified primary activity designated in A4;
- Specific tasks, milestones and related timeframes (also captured in Milestones Report); and
- Description of all funding sources.

NOTE: The RESTORE Act requires projects designed to protect or restore natural resources to be based on Best Available Science (BAS). (Complete Question B.4 also.)

If additional space is needed attach document. (2,000 characters max)

The American Marine Research Company and the Gulfarium Marine Adventure Park jointly propose piloting a technology incubator to nurture and launch ideas based on cutting-edge technologies such as virtual and augmented reality, robotics, Internet of Things, and artificial intelligence and machine learning. The goal of the incubator is two-fold:

1. Driving a more memorable experience for visitors in a scalable way via technologically-powered immersive experiences that showcase the county's tourism offerings
2. Creating innovative, cost-efficient methods of monitoring aquatic ecosystems to facilitate better fishery management and boost quality of off-shore experiences such as fishing and diving

Successful ideas will garner follow-on investment from both the public and private sectors. Furthermore, by promoting local tourism and regional technological progress, the incubator will also drive regional economic growth and job creation.

The incubator will be built upon an agile, multidisciplinary team of engineers, marine biologists and product developers and utilize rapid prototyping and lean startup principles. Using this team-based structure bundles high incubation costs of individual technologies into a single, multi-faceted team, to exploit synergies in development and increase ROI on every dollar invested. This incubator will function as "R&D as a public service", in which Okaloosa County will be given free and unlimited license to access and use all technology created and data collected.

Examples of proposed projects include crowdsourcing fishery monitoring by building a web app that allows people to upload their dive and snorkel footage for analysis; creating a distributed stock assessment network by using satellite buoys equipped with cheap camera arrays to capture and aggregate data to allow for real-time monitoring of fish populations and artificial reef health; and launching VR & AR based immersive experiences to showcase all that Okaloosa County has to offer, made accessible to all of the county's ~5 million visitors and ~2000 students through smartphone apps.

Below is a sample timeline of project deployment:

- **Summer 2018:**
  - Create and launch virtual reality and augmented reality experiences
  - Design and run complementary educational workshops for local students
- **Fall 2018:**

- Build web app to facilitate crowdsourced fisheries monitoring; design computer vision algorithms that can analyze footage
    - Design satellite buoys for distributed stock assessment network
- **Winter 2019:**
    - Develop new technological-based initiatives to further enhance visitor experience for Summer 2019 based on feedback
    - Finalize satellite buoy design & begin manufacturing; train computer vision algorithms; pilot test web app
- **Spring 2019:**
    - Pilot test distributed stock assessment network
    - Launch webapp for crowdsourced fishery monitoring
    - Develop new exhibit ideas
    - Provide a written report summarizing findings, showing metrics of usership, and recommending further partners and development

B.1.1 Part of a Larger Project: If the proposed project is part of a larger project outside the scope of this proposal, describe the larger project and the proposed project's relationship to it.

The proposed project is not part of a larger project.

B.2 Monitoring: During the project & following its completion, will the project be subject to a monitoring program to evaluate project success?

☐ No

X Yes (provide information on monitoring and evaluation)

To ensure proper monitoring, a team lead will be assigned to each sub-team organized around each project. The team lead will be responsible for tracking team activity and reporting on progress made and milestones reached on a monthly or biweekly basis, based on the agile product development processes described below.

As our goal is ultimately to create technology that will benefit the public good, we are also committed to soliciting and tracking the community's response to the incubator's projects. As such, progress will be measured by collecting user metrics (e.g. age, gender, frequency and time of use) to determine the number and demographics of people actually using and benefiting from technology. The incubator will also include a rating and feedback system to gauge how much users like each project being developed, and provide the community with the means to express which projects they prefer, and suggest modifications or improvements. These metrics provide a clear way for the county to gauge the impact of the incubator's creations and monitor progress.

B.3 Management/Maintenance Program: Will the project be subject to a management/maintenance program to ensure project success?

☐ No

X Yes (Provide information on how the project will be monitored and maintained as well as the party (or parties) responsible for performing these tasks.)

The team will leverage agile product development processes to maximize efficiency and facilitate collaboration with the Okaloosa County government and other regional organizations. Agile development processes have been found to reduce costs of development and time to market, and allows for constant tuning of projects to the needs of the county. The process works as follows: each objective or project will be split into discrete goals to be executed in 2-4 week sprints. At the end of each sprint, the team (or each sub-team's) progress and direction will be evaluated, and future goals and actions will be re-calibrated accordingly. Each sub-team will also present a product increment, or feature that will add value to the product under construction. This management system complements the monitoring program outlined above by providing discrete check-in points in which team progress will be tracked and evaluated, which also functions as a continuous and robust accountability mechanism.

B.4. Best Available Science (BAS), if applicable

Is the proposed activity designed to protect or restore natural resources?

X No ☐ Yes (If "yes" complete this section).

B.4.1 Protection or Restoration Objective(s) of the Project– State clearly the objective(s) below:

B.4.2 Methods Used to Achieve Objective(s) – Describe below:

B.4.3 Methods Based on BAS – Explain in detail how the methods are based on BAS:

B.4.4 Peer Reviewed Information – Summarize the peer-reviewed information that justifies the proposed objective(s) including methods used for the proposed activity below:

B.4.5 Alternative Scientific Information Sources – if Peer Reviewed information is unavailable; explicitly stated this and provide a brief explanation of what sources were used. If sources are publicly available, please also provide a link below:

B.4.6 Literature Sources Used for BAS – if applicable, list the sufficient citations including: Title, Journal in which the literature source appeared, if applicable; Publication date; Author(s); and Web address if downloaded or available online that would apply to the proposed project **B4.4.1**

B.4.7 Conclusion of Literature Sources in B4.6– Summarize the literature sources' conclusions and any uncertainties or risks in the scientific basis that would apply to the proposed project including any uncertainties or risks that were identified by the public or by a Gulf Coast Ecosystem Restoration Council member below:

B.4.8 Gulf Coast Region adaptability, if applicable – Summarize how the method's used reasonably support and are adaptable to the Gulf Coast Region if the information supporting the proposed project does not directly pertain to the Gulf Coast Region below:

B.4.9 Evaluation of Uncertainties and Risks – Summarize an evaluation of uncertainties and risks in achieving the project's BAS objective(s) over the longer term. For example, is there an uncertainty or risk that in 5-10 years the project/program will be obsolete or not function as planned given projections of sea level rise or other environmental changes such as in freshwater inflows to estuaries?

B.5 Project Narrative

Provide a narrative of your project and why this project should be funded. Discuss the following items as a minimum:

1. Explain how the proposed budget supports the proposed scope of work
2. Project Expenditures (long term and short term)
3. Project Revenues
4. Program Income, including nature and source, if any
5. Key personnel involved with the project
6. Will a subrecipient be required to complete the project
7. Specific objectives
8. Permits or land acquisition required
9. Design status
10. Similar project success or if new technology explain
11. Environmental impact (species affected, existing plans supported, etc.)
12. Risks to implement and maintain the activity
13. Jobs Created (short term, long term, and wage scales)

(1,000 characters max)

We have structured funding to support a dedicated team. By sharing the same team to prototype multiple products, all learnings, talent, and research can be recycled and synergized, dramatically reducing prototype cost. As well, this funding structure enables the team to execute on as many projects as possible, including new ideas generated through previous projects or suggested by the community, rather than limiting the team to a defined set of projects. Long term expenditures include labor and computing resources; materials and professional services billed per project (see budget for details).

Key personnel include 2 software engineers, 1 mechanical and 1 electrical engineer (for ROV building), 3 marine biologists and 1 health and safety specialist; 8 jobs will be created with wages in the ~$80-90K range. As all licenses will be provided to the county free of charge, no revenue will be generated.

Detailed proposals and mockups of potential incubator ideas can be found in the appendix.

B.6 Project Budget

In the "Project Budget" table, provide best estimates of the costs and revenues associated with the proposed project during the period of performance.

There are two Project Budget tables below, one is for "Non-Construction" and the other is for "Construction". Both mirror the budget format required for the forthcoming grant application. Complete the one that best pertains to your project.

Expenditures – Line 6.(a-g) – Section B

For each expenditure entered, it must be associated with a task as listed in the scope of work. You will be required to describe and justify the expenditure in the section that follows.

Indirect Charges – Line 6.(i). (if applicable)

Indirect cost rate (if applicable) as determined by 2 CFR Appendix to Part 200.

Program Income – Line 7 (if any)

Program Income means gross income earned by the Non-Federal entity that is directly generated by a supported activity or earned as a result of the Federal award during the period of performance except as provided in §200.307 paragraph. Enter the estimated amount of income, if any, expected to be generated from this project. Do not add or subtract this amount from the total project amount. In the project narrative define the nature and source of income. The estimated amount of program income may be considered by the Federal grantor agency in determining the total amount of the grant. See 2 CFR §200.80 for more details.

Non-Federal Resources – Lines 8-11 – Section C

Restore Direct Component funds DO NOT require matching funds. Enter the total amount of RESTORE Direct Component funds that will be need to execute your project in column 1 Federal. However, if you are receiving matching funds from other sources to complete your project, the source of those funds will be listed separately in column a. on lines 8-11 and the respective amounts in columns b.- e.

For example, if you are proposing a $2 million construction project and are asking for $1 million from RESTORE Direct Component to match a $1 million, you would enter $1 million from RESTORE and $1 million in non-Federal for the Proposer. However, once proposed, accepted and awarded by Treasury, the $1 million in non-Federal proposed funds would then become a required cash match from the Proposer.

Use current year dollars rounded to the nearest dollar.

("Project Budget Information table" is on the next page)

B.6.1 Non-Construction Project Budget table

PROJECT BUDGET INFORMATION – Non-Construction Programs					
SECTION B – BUDGET CATEGORIES					
6. Cost Classification	(1) Federal	(2) Gulfarium Space share	(3) Florida Wildlife Commission	(4)	(5) TOTAL
a. Personnel	$ 581,000	0	$12,500	0	$ 593,500
b. Fringe Benefits	$ 0	0	0	0	$ 0
c. Travel	$ 0	0	0	0	$ 0
d. Equipment	$ 89,740	0	$12,500	0	$ 102,240
e. Supplies	$ 123,290	0	0	0	$ 123,290
f. Contractual	$ 0	0	0	0	$ 0
g. Professional Services	$ 34,100	$ 8,000	0	0	$ 42,100
	$ 0	0	0	0	$ 0
	$ 0	0	0	0	$ 0
h. Total Direct Charges *(sum a-g)*	**$ 824,230**	**$ 8,000**	**$ 25,000**	**$ 0**	**$ 861,130**
i. Indirect Charges	$ 0	0	0	0	$ 0
j. TOTAL *(sum a-i)*	**$ 824,230**	**$ 8,000**	**$ 25,000**	**$ 0**	**$ 861,130**
7. Program Income *(see 2 CFR §200.80)*	0	0	0	0	$ 0
SECTION C – NON-FEDERAL RESOURCES					
(a) Identify Funding Source: (Note: No Matching Funds are Required)	(b) Proposer	(c) State	(d) County	(e) Other	(f) TOTAL
8.	0	0	0	0	$ 0
9.	0	0	0	0	$ 0
10.	0	0	0	0	$ 0
11.	0	0	0	0	$ 0
TOTAL *(sum of lines 8-11)*	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
Reference: OMB Standard Form					

424-A					

B.6.2 Construction Project Budget table – Not applicable

B.6.3 Budget Justification

Explain in detail how the above proposed budget supports the proposed scope of work. Provide specific justification for ALL project budget categories that apply, including a justification of how the proposed costs within each of the budget categories on the above SF-424A are necessary, reasonable, allowable, and allocable. (2,500 characters max)

	Unit Cost	Phase I	Phase II	Phase III	Phase IV	Total Cost
Materials (quoted per unit)						
Cardboard VR headsets + custom printing, 1 headset	$9	$90	$18,000	$13,500	$9,000	$40,590
DIY ROV Parts, 1 kit	$900	$2,700	$5,400	$3,600	$3,600	$15,300
Remote stock assessment kit	$1,400	$2,800	$8,400	$11,200	$11,200	$33,600
Small Tools	$300	$900	$1,500	$1,500	$0	$3,900
Satellite buoys	$1,300	$2,600	$6,500	$10,400	$10,400	$29,900
		$9,090	**$39,800**	**$40,200**	**$34,200**	**$123,290**
Computing (quoted per seat)						
VR-ready development workstation	$2,800	$16,800	$0	$0	$0	$16,800
Cloud computing	$60	$240	$1,200	$6,000	$6,000	$13,440
Desktop 3-D printer	$3,800	$15,200	$15,200	$15,200	$0	$45,600
Development software (animation, CAD, graphics programming)	$4,400	$26,400	$0	$0	$0	$26,400
		$58,640	**$16,400**	**$21,200**	**$6,000**	**$102,240**
Labor (quoted hourly)						
Marketing	$40	$0	$32,000	$32,000	$0	$64,000
Engineering	$40	$60,000	$72,000	$84,000	$72,000	$288,000
Marine Science	$45	$54,000	$67,500	$54,000	$54,000	$229,500
Field Operators	$40	$4,000	$4,000	$4,000	$0	$12,000
		$118,000	**$175,500**	**$174,000**	**$126,000**	**$593,500**
Professional Services (quoted per excursion)						
Charters	$1,700	$5,100	$6,800	$8,500	$8,500	$28,900

Divers	$400	$800	$1,200	$1,600	$1,600	$5,200
Tank rentals	$250	$2,500	$1,500	$1,500	$2,500	$8,000
		$8,400	**$9,500**	**$11,600**	**$12,600**	**$42,100**
TOTAL		$194,130	$241,200	$247,000	$178,800	$861,130

Unit Allocation Used to Calculate Budget:

	Unit Cost	Phase I	Phase II	Phase III	Phase IV	Total Units	Total Cost
Materials (quoted per unit)							
Cardboard VR headsets + custom printing, 1 headset	$9	10	2000	1500	1000	4510	$40,590
DIY ROV Parts, 1 kit	$900	3	6	4	4	17	$15,300
Remote stock assessment kit	$1,400	2	6	8	8	24	$33,600
Small Tools	$300	3	5	5		13	$3,900
Satellite buoys	$1,300	2	5	8	8	23	$29,900
Computing (quoted per seat)							
VR-ready development workstation	$2,800	6				6	$16,800
Cloud computing	$60	4	20	100	100	224	$13,440
Desktop 3-D printer	$3,800	4	4	4		12	$45,600
Development software (animation, CAD, graphics programming)	$4,400	6				6	$26,400
Labor (quoted hourly)							
Marketing	$40		800	800		1600	$64,000
Engineering	$40	1500	1800	2100	1800	7200	$288,000
Marine Science	$45	1200	1500	1200	1200	5100	$229,500
Field Operators	$40	100	100	100		300	$12,000
Professional Services (quoted per excursion)							
Charters	$1,700	3	4	5	5	17	$28,900
Divers	$400	2	3	4	4	13	$5,200
Tank rentals (per hour)	$250	10	6	6	10	32	$8,000

Pursuant of creating a agile, multidisciplinary team as described in project scope and narrative, we meet our staffing needs with the following: qualified engineers in each sub-domain versed in rapid prototyping, development and deployment of various hardware and software products; marine biologists, who will advise on the best way to collect, aggregate and analyze data and aid in educational efforts; and a health and safety specialist to de-risk projects and ensure that all activities meet the highest standards of security. All salaries costed out are median salaries for the relevant position in Pensacola, Florida; AMRC and the Gulfarium will be responsible for salary needs exceeding market rate medians if required to attract higher-level talent. Additionally, all unit costs for materials, computing and professional services are based on market rates.

Matching funds are provided by cost sharing of $25,000 with an FWC grant and tank rental donations of $8,000 in value from the Gulfarium Marine Adventure Park.

B.7 Real Property or Land

B.7.1 Property Ownership/Use: If project requires the use of land, provide details of property to include land acquisition, ownership, agreements to use property, permits, easements, etc.

N/A

B.7.2 Attach documentation (i.e. letter of commitment, Memorandum of Understanding, deed, etc.)

B.7.3 Land Acquisition: Will land or interest in land be acquired?

☐ Yes, answer questions B.7.5 – B.7.12.13
X No

B.7.4 Land Improvements: Will land be improved?

☐ Yes, answer questions B.7.5 – B.7.10, B.7.12.4
X No

B.7.5 Legal Rights: What are the legal rights that will be acquired?

☐ Fee Title ☐ Easement ☐ Other (explain):

B.7.6 Easement: If an easement, what is the life or term of the easement?

B.7.7 Title: Will the Project Proposer hold title to the land? ☐ Yes ☐ No

B.7.8 Land Size: What is the total <u>acreage</u> of the proposed property interest to be acquired (easement or fee title)?

B.7.9 Appraisal: Has a recent certified appraisal of the property been obtained?

☐ No
☐ Yes (attach a copy of the appraisal)

B.7.10 Title Opinion or Certificate: Has a recent title opinion or certificate been obtained?

☐ No
☐ Yes (attach a copy of the title opinion or certificate)

B.7.11 Statement: Attach a signed statement from the seller(s) that he/she is a willing seller and has not been coerced into selling or conveying the property interest.

B.7.12 Legal Description & Parcel ID: Attached is the legal description of the property and the parcel identification number.

B.7.12.1 Land Description: Provide a description of the land to be purchased.

B.7.12.2 Federal Interest in Real Property: Are you aware that "Federal Interest" refers to real property that is acquired or improved, in whole or in part, with RESTORE Act Direct Component Funds, which must be held in trust by the recipient for the benefit of the project for the Estimated Useful Life of the Project, during which period Treasury retains an undivided equitable reversionary interest in the real property (i.e. the "federal interest") To document the federal interest, a "Covenant of Purpose, Use and Ownership" (Covenant) will be prepared and recorded against the real property for which the funding was awarded.

☐ No ☐ Yes

B.7.12.3 Use of Real Property with Federal Interest: Are you aware that the property on which there is a federal interest may not be used for purposes other than the authorized purpose for which funding was awarded without prior written approval from Treasury. The property must not be sold, conveyed, transferred, assigned, mortgaged, or in any manner encumbered except as expressly authorized in writing by Treasury.

☐ No ☐ Yes

B.7.12.4 Insurance: Are you aware that the recipient of Restore funds, must at a minimum, provide the equivalent insurance coverage for real property improved with federal funds as required by 2 CFR 200.310.

B.8 Construction Activities

B.8.1 Permits: Does the proposed activity require any federal, tribal, state, or local permits?

☐ No

☐ Yes (If yes, list the specific federal, tribal, state or local permits required for this project and the status of the permits below)

B.9 Relocation Assistance: Will the proposed project cause the displacement of any persons, businesses, or farm operations?

X No

☐ Yes (If yes, as required by Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, explain:

1. the number of displaced persons, including businesses and farm operations;
2. what fair and reasonable relocation payments and advisory services will be provided to any displaced persons;
3. and what provisions will be made to ensure that safe, decent, and sanitary replacement dwellings will be available to such persons within a reasonable period of time prior to displacement.

(End of Part B)

(End of Data Collect Form)

PROJECT RISK ASSESSMENT

Please complete the Direct Component Proposer/Subrecipient Questionnaire which may be found at www.co.okaloosa.fl.us/grants.

The Project Data Collection Form and the Proposer/Subrecipient Questionnaire plus any required supporting documentation must be submitted in order for the project submission to be considered complete.

Project submissions shall be submitted to jevans@co.okaloosa.fl.us.

APPENDICES: Table of Contents

APPENDIX A1: The Incubation Pipeline

By sharing the same team to prototype multiple products, the learnings, talent, and research can be recycled and synergized, dramatically reducing prototype cost.

By sharing intellectual property freely with the public, local entrepreneurs can take validated product ideas and technology and invest in a sustainable way, while simultaneously freeing the prototyping team to return to their core competency.

Research (1-4 mo)

Ideas collected broadly by Gulfarium and AMRC scientists and engineers. Needs indentified and feasibility assessed.

Example: Clips for virtual reality "dives" created, initial user experience tests

Proof of Concept (3-9 mo)

Gulfarium and AMRC team prototypes product rapidly, seeking user adoption. Intractible projects are discarded. Student and volunteer help recruited.

Example: Virtual dives of major wrecks created, distributed to students.

Handoff and Growth

Local entrepreneurs see value-add. AMRC and Gulfarium team hand off technology to operators to sustain.

Gulfarium + AMRC start on a new project, product grows in enterprise value.

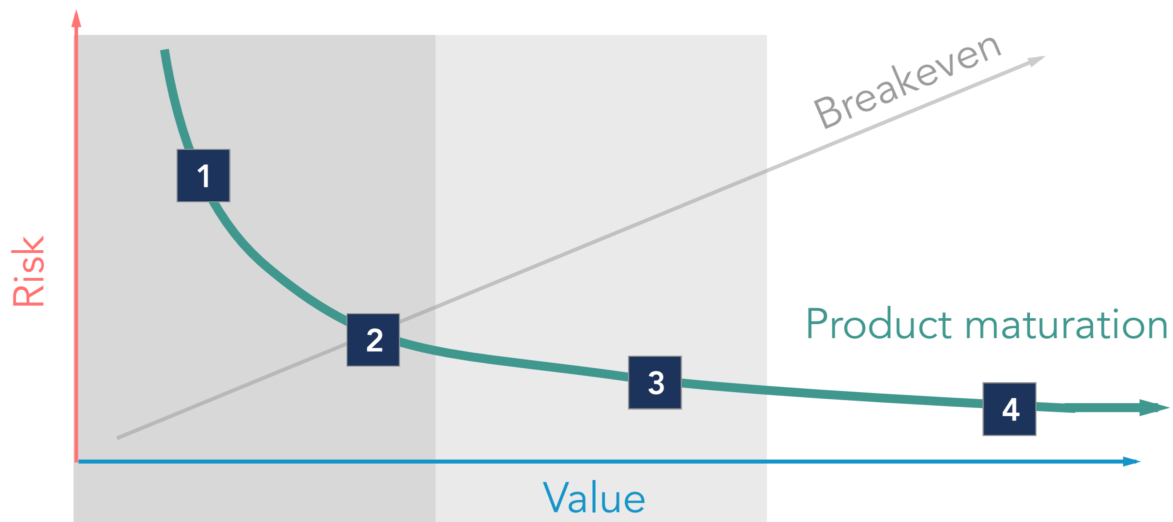
Example: National magazine coverage, local businesses sponsor and brand product.

"Every week I have fishermen and divers come to me with ideas. So many of them sound amazing but nobody knows how to get started."

APPENDIX A2: Why De-Risking Matters

Most technologies won't get developed because the **risk** is too high. Research universities, startup incubators, and occasionally early-stage VCs invest here. Most domains, lacking these **risk-tolerant explorers,** will stop here.

But if technology can be de-risked just enough, businesses and their entrepreneurs will see the value, and invest themselves. By getting technology past its riskiest phase, California's universities created a **cornucopia of innovation** for Silicon Valley.



Early Stage, High Risk

Concept promising but lacks users. Only universities, incubators, and very early-stage VCs invest here.

Resources: Low

Early Development

Ideas show promise but requires further investment. Businesses, entrepreneurs take it from here.

Resources: Moderate

Growth

Value proposition is clear. Growth-stage investment, even investment banks are needed but idea has been sufficiently de-risked.

Resources: High

Examples

1. **Quantum Computing, CRISPR, Distributed Stock Assessment**
2. **Artifical Intelligence, Blockchain**
3. **Virtual Reality**
4. **Cell Phones, Tablet Computers**

APPENDIX A3: FAQ (1)

Why isn't there any office space?

"Build it and they will come" sounds nice, but just doesn't work for innovation. Universities and cities all around the world are building coworking spaces and incubators, but few produce technology of value. On the other hand, America's greatest innovators found space wherever they needed it. The Wright Brothers certainly didn't have an incubator or any coworking space; if the idea is compelling enough, the space will come.

In all this, there is a dichotomy between "need-to-haves" and "nice-to-haves". "Nice-to-haves", like startup tee-shirts, coworking spaces, free coffee, and even tax incentives can make a startup better, but they won't save a bad idea, or a lazy team. "Need-to-haves", like a good idea, a great team, and the right timing are necessities.

That is why working out of libraries, existing space, and if we're lucky, the beach, we'll get all we need.

Where will the ideas come from?

Ideas will be both internally and externally generated. Because we deeply value community involvement, one of the major sources of ideas will be an open innovation platform in the form of a website where members of the community can submit ideas. Submissions will then be vetted and outstanding ones will then be selected for follow-up. (An alternate selection process could invite county residents to vote on the ideas they find most compelling or useful; this would drive greater community engagement and buy-in).

The internal process of idea generation is integrated into the agile product development lifecycle, in which team members are expected to continuously bring suggestions for improvements or add-ons to existing projects with the potential to be spun off into standalone projects; this is in addition to regular brainstorming sessions.

The combination of both internal and external processes allows for synergistic collaboration between the deep technology expertise and nose for value that the team will develop over time, with the on-the-ground wisdom and diversity of ideas that comes from crowdsourcing ideas from the local community. Both feed into the overarching goal of this incubator, which is to be a platform that not only encourages innovative ideas from the community but goes further to build them into a reality.

APPENDIX A3: FAQ (2)

What restrictions will there be on the technology developed?

The county will be given free and unlimited licensing to all technology developed in the incubator. This means that the county can reproduce, make, use, market, modify and/or resell any technology developed. Typically licenses are provided in exchange for compensation and are provided for a limited duration; in this case, we will provide all licenses to the county for free, with no limitation on usage or duration of licenses. In other words, this incubator will function as "R&D as a public service", in which all research efforts are directed towards products that specifically benefit the public interest and created for the government's use. Licenses may also be granted on an application basis to entities seeking to use the technology for public benefit.

All software products produced will be open source under a GNU General Public License (see Appendix D for the full description of a GNU GPL); this will allow other entities to contribute to the upkeep and continued development of source code.

Why use this licensing structure?

When we say our intellectual property we develop is going to be provided free-of-charge to those who want to use it for public benefit, we mean it. In the words of one of our engineers, "I'd rather see a project succeed without me than fail with me". We have three primary reasons:

First, we keep the learnings: If we do our jobs well, the technology that is spun out will make the experience and learnings we gained as researchers and engineers invaluable. Famous instances of this model include Oracle and MongoDB, where their core products offer open-source licenses, now and forever free for all. It is their expertise and refinements that give them the edge in helping their clients succeed.

Second, this is our community too: When this community prospers, we're all uplifted by it. If any of these products can be leveraged for a third party to benefit the public, that is an effort that we whole-heartedly support.

Third, open sourcing code allows a much larger community to contribute to code development and upkeep, thereby facilitating the development of more advanced and useful code.

APPENDIX A3: FAQ (3)

Why Okaloosa County?

We get asked this a lot. It's pretty straightforward:

Ideas: In the form of pitches, banter, and sometimes complaints, fishermen, divers, and visitors consistently throw tons of ideas at us from their own experiences. Each represents a figment of creativity and imagination, capturing a user's need, and an opportunity. Unfortunately, the environment is rarely in place to build on this collective ingenuity. We hope to create a team that will do just that.

Visitors: Okaloosa's positioning as a top destination for experiential tourism gives us an unparalleled platform to test products. Each beach, each season is a focus group, and each tour is an opportunity to build better products. Those visitors will take the experiences--with our beaches, our Gulf, and maybe even our technology--all around the country, even the world.

Talent: Beyond the Gulfarium, the county level scientists in the region bring with them both unmatched experience in the field, along with incredible networks in their fields. Combined with a vibrant recreational and commercial fishing community and a thriving network of divers and diving businesses, few places can offer the foundation for developing technology for experiential marine tourism like Okaloosa can. Collectively, their passion, selflessness, and knowledge are just waiting to be united.

Industry: The diving and fishing ecosystems in Okaloosa offer a strong starting platform for the right initiatives, and we are convinced our proposed projects are among them.

Why an incubator?

The incubator model provides a platform for where ideas can flourish and become concrete - whether ideas come from community members including fishermen and divers, or from internal innovation processes.

This model has become ubiquitous globally due to increasing recognition of its powerful ability to nurture, support, test and thereby de-risk early-stage ideas (see the page titled "Why Derisking Matters"). In fact, governments have begun to leverage the incubator model to drive innovation and accomplish results.

APPENDIX A3: FAQ (4)

Examples include:

(1) UAE Government Accelerator

The UAE Government Accelerator was conceived as a platform for cross-sector government teams to address challenges and achieve "unreasonably ambitious goals" in a short period of time. The goal of this effort was to accelerate the implementation of projects, and instill a culture of entrepreneurship and innovation into governmental agencies and processes. A set of 8 teams worked on government-related projects such as enhancing workplace relations services and reducing waiting time for homeowners and tenants to access the electric grid.

This accelerator was an overwhelming success, with 6 out of 8 teams successfully achieving their stated targets as much as 100 days ahead of schedule. For example, the team responsible for reducing waiting period associated with issuing new residency visas by 50% exceeded their goals to reduce waiting times by 60%.

(2) National Incubator Initiative for Clean Energy (NIICE)

The US government set up the National Incubator Initiative for Clean Energy (NIICE) in order to facilitate innovation in clean energy. They recognized the incubator model as an effective method to encourage an entrepreneurial mindset, leverage resources to drive innovation and generate a high ROI on funding. The incubators provide lab and office space, and provide inventors opportunities to develop and test ideas and engage with customers to refine products.

This initiative has demonstrated impressive results: its supported companies have collectively raised > $1B in follow-on funding, generated $330M in revenue and supported the creation of nearly 3,000 direct jobs.

How will the incubator become self-sustaining?

Technology created in the incubator has huge potential for commercialization to generate profit; in a virtuous cycle, these profits can then be re-invested into the incubator to continue to fund the creation of innovative products.

For example, the VR headset and AR smartphone apps could be used as an advertising platform that could generate millions of dollars in ad revenue.

APPENDIX A3: FAQ (5)

Data generated by the distributed stock assessment system and/or the crowdsourcing of fisheries monitoring could be aggregated into a map that shows the best spots to fish, dive or snorkel (and potentially species present at each spot). This data could be sold to charter boat businesses looking to determine where to take their passengers. Alternatively, these satellite buoys could also be equipped with other kinds of sensors able to transmit information about the weather allowing for the tracking of the location and strength of storms. This has a vast array of applications, from helping fishermen looking to avoid running into storms while out at sea, to functioning as an early hurricane detector and warning system. These applications can be harnessed to generate revenue either through "fee for service" or "subscription" models.

In fact, the money provided by the RESTORE grant can be considered seed funding crucial to jumpstarting an entity that will produce innovations and products that will bring in sufficient revenue to create a self-sustaining, long-lasting organization.

APPENDIX B

Proposed Project Prospectuses

Our projects largely fall into two categories:

(A) promoting visitation and education, with a primary focus on increasing ease of access to maximize engagement. We will generate interest by leveraging immersive technology-driven experiences, and utilizing existing distribution networks such as tourist landmarks such as the Gulfarium Marine Adventure park, beach-front kiosks or hotels to promote these initiatives. The goal is to reach everyone where they are, whether that is the beach or the hotel room.

(B) improving aquatic ecosystem surveillance in a cost-efficient manner, to equip fisheries management with the data needed to make informed choices. Current fish and marine mammal surveys are prohibitively expensive, which compromises geographic and temporal coverage and consequently the quality of data sets and limits the amount of observational data that can be generated. Our goal is to build new databases that can be mined for crucial data points that will assist in resource management.

To demonstrate the breadth and depth of activities we plan to engage in, we have included project proposals for ideas that span the technology areas that we propose the incubator focus on:

Appendix B1 (Virtual Reality): Immersive VR “Scuba Diving”

Appendix B2 (Augmented Reality): Interactive Augmented-Reality Based Aquarium Tour

Appendix B3 (Rapid Prototyping): Build-Your-Own ROV Educational Workshops

Appendix B4 (Artificial Intelligence / Machine Learning): Crowdsourced Fisheries Monitoring

Appendix B5 (Internet of Things): Distributed Stock Assessment Network

APPENDIX B1

Immersive VR experience

The goal of this virtual reality experience is to give guests a taste of the beauty of the reef aquatic ecosystem off the coast of Okaloosa County. Virtual reality allows for total immersion into a new environment, giving users the feeling of being physically present in a non-physical world. This perception is created by surrounding the user with images and sound that provide an engrossing environment. As users look around at their environment, their movements are sensed and translated into moving images, further solidifying the impression of real presence. Furthermore, the advent of cheap VR headsets pioneered by products such as Google Cardboard mean this experience is cost-effective and scalable, accessible to anyone with a smartphone.

In this case, 360 degree footage taken by scuba divers exploring aquatic life off the coast of Okaloosa County will be processed for VR apps. The virtual reality experience can be downloaded through a VR app on a user's smartphone. There will be the option to select from a range of different sets of footage; footage can be selected by criteria such as location or aquatic species present.

Fig 1. View of underwater reefs through cardboard VR headsets

Fig 2. Headsets will have QR codes on the side that link to specific offers or websites by local businesses

APPENDIX B2

Augmented Reality Gulfarium exhibit

The goal of this project is to develop an augmented reality based self-guided tour through the Gulfarium aquarium that can be delivered through a smartphone app. This app will leverage computer vision algorithms to identify species of animals and provide background on species and behavior, and integrates with quizzes and photo filters to increase interactivity and social media sharing.

Fig 1. Mockup of AR app using computer vision to identify species observed in aquarium tank and provide further information to user

Fig 2. Example of aquarium-themed photo filters to encourage social media sharing (Source: Shedd Aquarium)

AMRC

APPENDIX B3

Build-your-own-ROV educational workshops

This will be a educational mini course geared towards middle school and high school students. This course aims to educate students in some of the fundamental, engineering concepts that go into the design and fabrication of ROV's. Students will be provided a "Build Your Own ROV" kit that will contain everything needed to create their very own ROV. Once completed the students will then have the opportunity to pilot their newly created ROV exploring the depths of the Gulfarium's tanks. See mockups below for our designs of the "Build Your Own ROV" kit.

<u>Cost Breakdown:</u>

$15.00 - 3D Printed Frame & Motor Cowlings
$100.00 - Electronics Package
$100.00 - Waterproof Housing
$35.00 - Thruster Motors
Total = $250.00

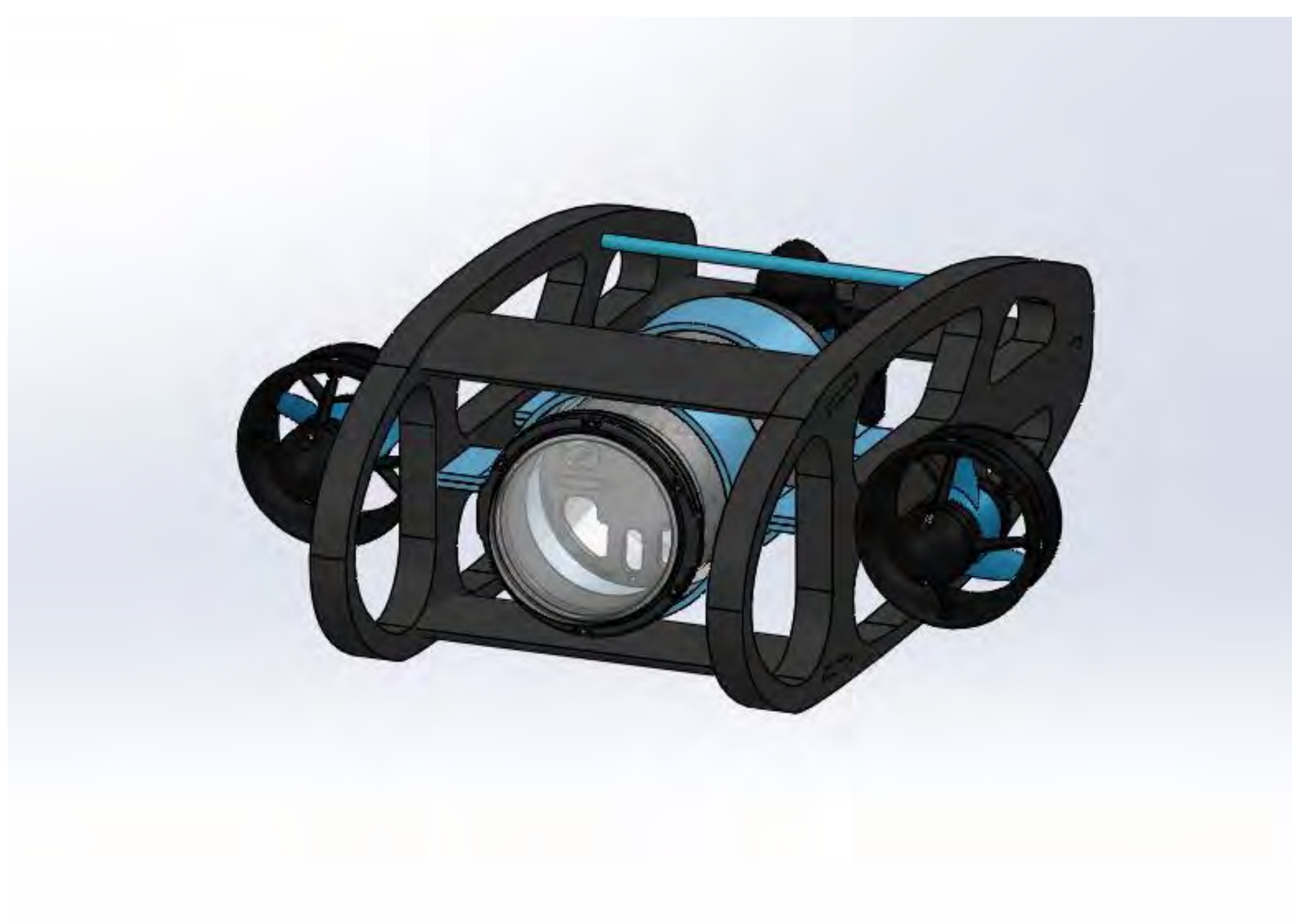


Figure 1: Isometric view of assembled Gulfarium Build Your Own ROV. This is a simple easily assembled, high quality ROV design. The frame can be 3D printed allowing for low cost per unit and easy, on-demand production.

APPENDIX B3 (cont'd)

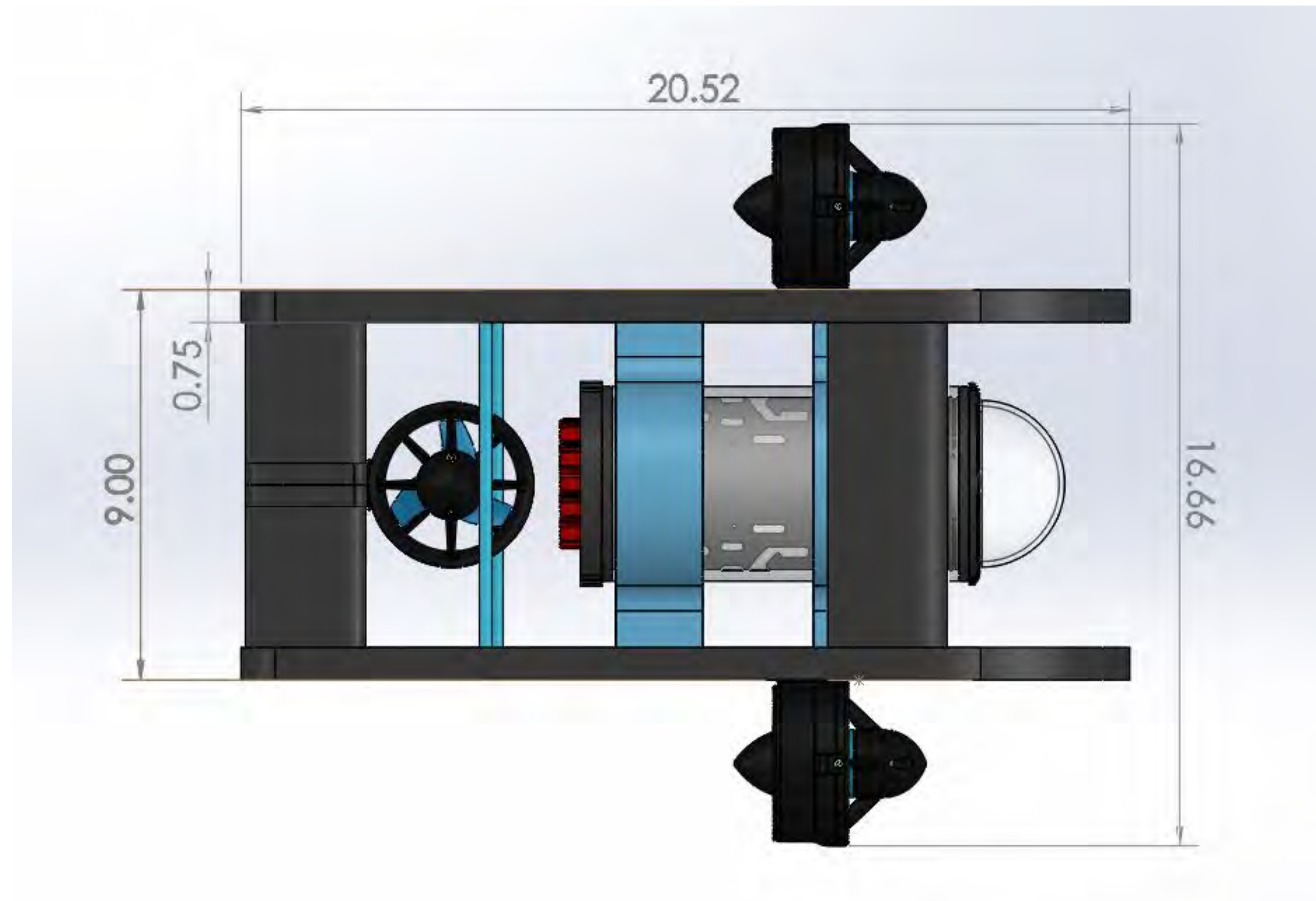


Figure 2: Top view of Gulfarium Build Your Own ROV. This design incorporates 2 thrusters oriented horizontally, parallel to the direction of motion, giving the ROV great speed. An additional thruster is vertically oriented allowing the ROV to adjust the pitch of the nose. This allows the ROV to be highly maneuverable.

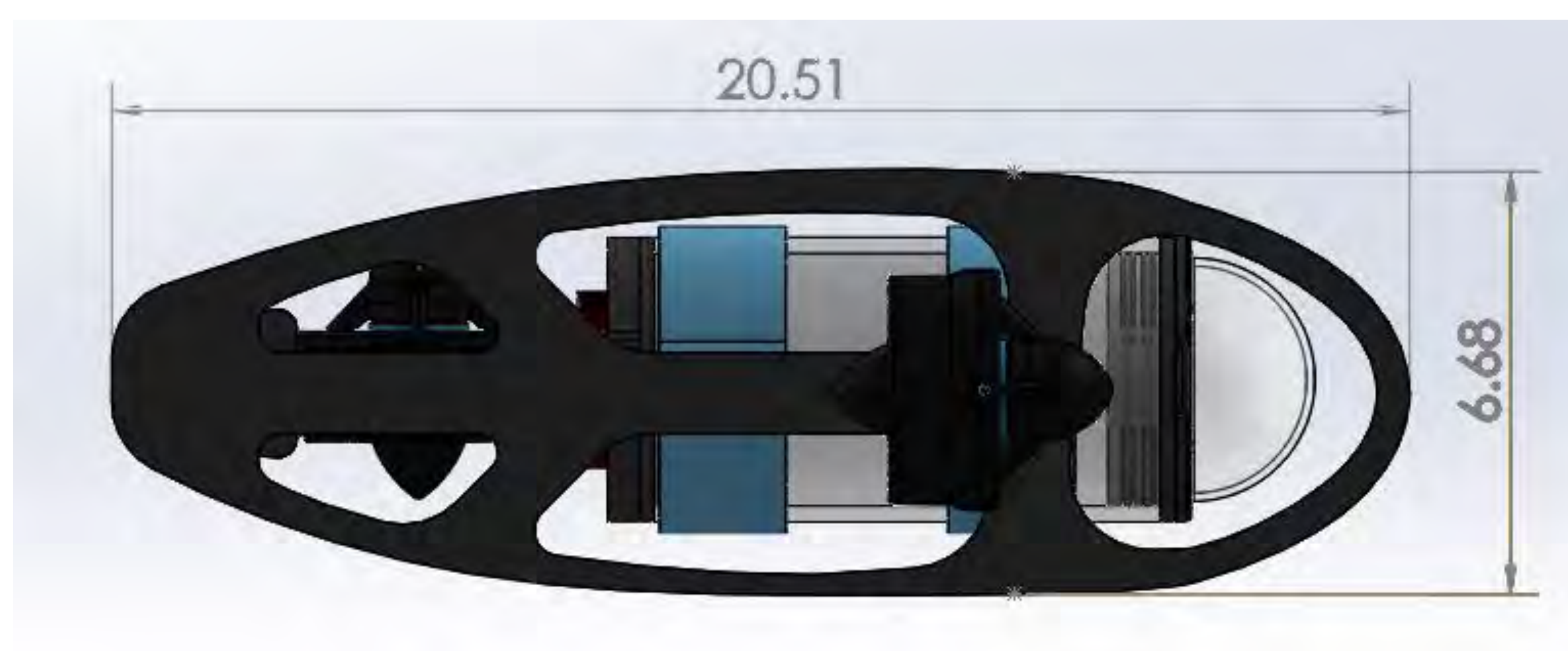


Figure 3: Side view of Gulfarium Build Your Own ROV. The front of the ROV will contain a camera that will allow the student to see from the perspective of the drone's camera. This can be coupled with the VR headset to give a unique underwater experience.

Figure 4: Front view of Gulfarium Build Your Own ROV.

APPENDIX B4

Crowdsourcing fisheries monitoring via aggregation of dive and snorkel footage

Given the amount of diving and snorkelling - both recreational and professional - that occurs on a regular basis, and the increasing advent of underwater sport video cameras such as GoPros, the volume of underwater footage captured is exponentially mounting. This footage presents a form of "outsourced" surveillance of the underwater world - in other words, a wealth of data that can be leveraged to mine insights on ecosystem health. Thus, the goal of this project is to crowdsource fisheries monitoring by building a web app that allows people to upload any underwater footage (whether from diving or snorkeling) for analysis.

Fig 1. Example of annotated dive footage, with boxes indicating identified fish

Location	Date	Time	Species	Count
30.5773° N, 86.6611° W	05-03-18	9:00	Lutjanus campechanus	10
30.5745° N, 86.34611° W	05-03-19	9:05	Pterois volitans	21
33.5773° N, 96.6611° W	05-03-20	9:10	Stenella frontalis	1
30.5745° N, 86.34611° W	05-03-21	9:15	Epinephelus itajara	1
30.5745° N, 86.34611° W	05-03-22	9:20	Grampus griseus	2
30.5745° N, 86.34611° W	05-03-23	9:25	Pterois volitans	32
30.5745° N, 86.34611° W	05-03-24	9:30	Seriola dumerili	7
30.5745° N, 86.34611° W	05-03-25	14:00	Coryphaena hippurus	1
30.5773° N, 86.6611° W	05-03-26	14:01	Anchoa mitchilli	21
30.5773° N, 86.6611° W	05-03-27	15:01	Lutjanus campechanus	4
30.5773° N, 86.6611° W	05-03-28	16:01	Mesoplodon densirostris	1
30.5773° N, 86.6611° W	05-03-29	17:01	Seriola dumerili	5
33.5773° N, 96.6611° W	05-03-30	17:00	Pterois volitans	45
33.5773° N, 96.6611° W	05-03-31	18:00	Seriola dumerili	9
33.5773° N, 96.6611° W	05-04-01	19:00	Coryphaena hippurus	2
30.5745° N, 86.34611° W	05-04-02	20:00	Anchoa mitchilli	7
30.5745° N, 86.34611° W	05-04-03	21:00	Lutjanus campechanus	4
30.5745° N, 86.34611° W	05-04-04	10:25	Pterois volitans	5
30.5745° N, 86.34611° W	05-04-05	10:30	Epinephelus itajara	2
30.5745° N, 86.34611° W	05-04-06	10:35	Anchoa mitchilli	18

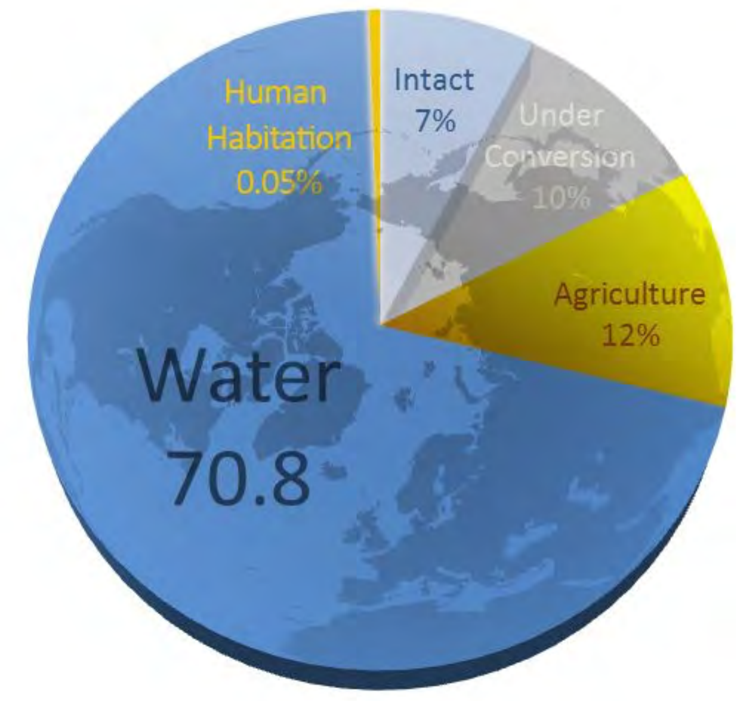
Fig 2: Sample database (e.g. GPS location, time of day, name and count of species spotted)

Uploading of footage will be incentivized by providing the uploader with annotations of the footage that informs them of aquatic species observed; this serves to enhance their underwater experience by increasing the knowledge of wildlife encountered. Additionally, since the quality of their annotations depends upon the quality of the video, there is an added incentive to capture high quality video that will in turns increase the quality of data that can be captured on underwater ecosystems.

From a data perspective, the uploaded footage can be analyzed by image recognition and/or computer vision algorithms that can examine videos frame by frame to identify and count aquatic species. This data can then be cross-referenced with GPS and date/time data to build huge, aggregated datasets that can provide insight into the state of local wildlife populations (see Fig 2 for sample database).

APPENDIX B5

Creation of a distributed stock assessment network



According the National Oceanic and Atmospheric Administration, as of 2017, we have explored less than 5% of the ocean [1]. The ocean makes up 70% of the world, which implies that if we were to have explored all land masses on earth, as of 2017, we would have explored a total of only 33.5% of Earth, at best.

Recent advancements in technology have driven down the cost of large scale manufacturing of IoT chips, particularly for long range wireless communication. In particular, Low Range Low Power (LoRa) wireless chips have emerged as powerful sensors for checking the integrity of infrastructure. These chips are capable of up transmitting data up to 15 km and use such little power that their battery life can extend up to 10 years [2]. We propose deploying a mesh network of buoys that leverage LoRa chips into the ocean to collect data on underwater activity, marine life and weather pattern. This would enable us to gain real-time insight into life underneath sea, shedding light on this vastly unexplored territory; allow fisherman to more efficiently plan their fishing routes to maximize their fish collection; provide accurate weather readings and function as an early warning system for extreme weather; and potentially even detect unauthorized entry into waters for defense purposes. Additionally, we plan to also utilize the future FAD network proposed to be deployed using Triumph and RESTORE funds in order to maximize cost sharing.

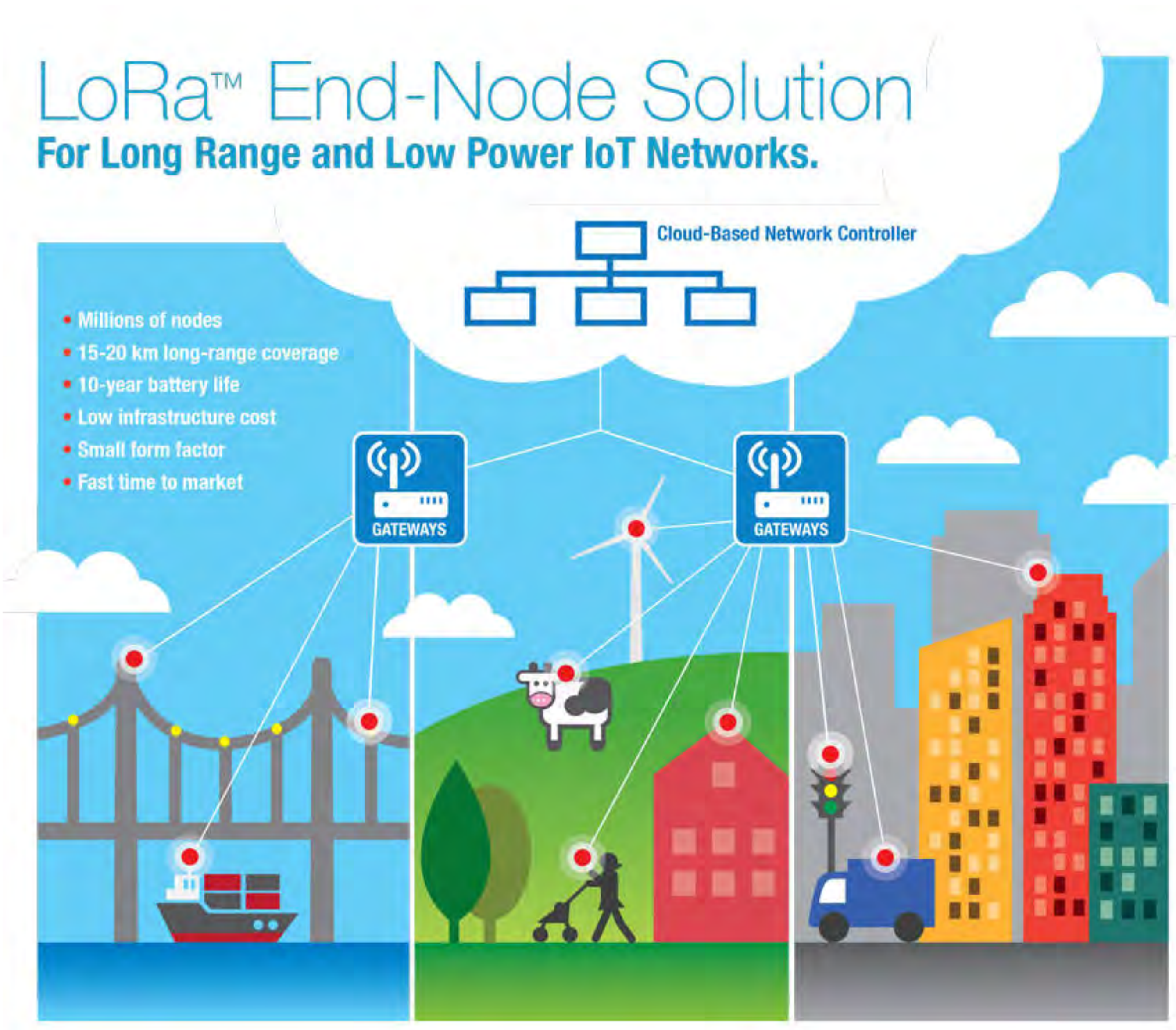


Fig 1. LoRa network systems are long-range, low-power Internet of Things networks

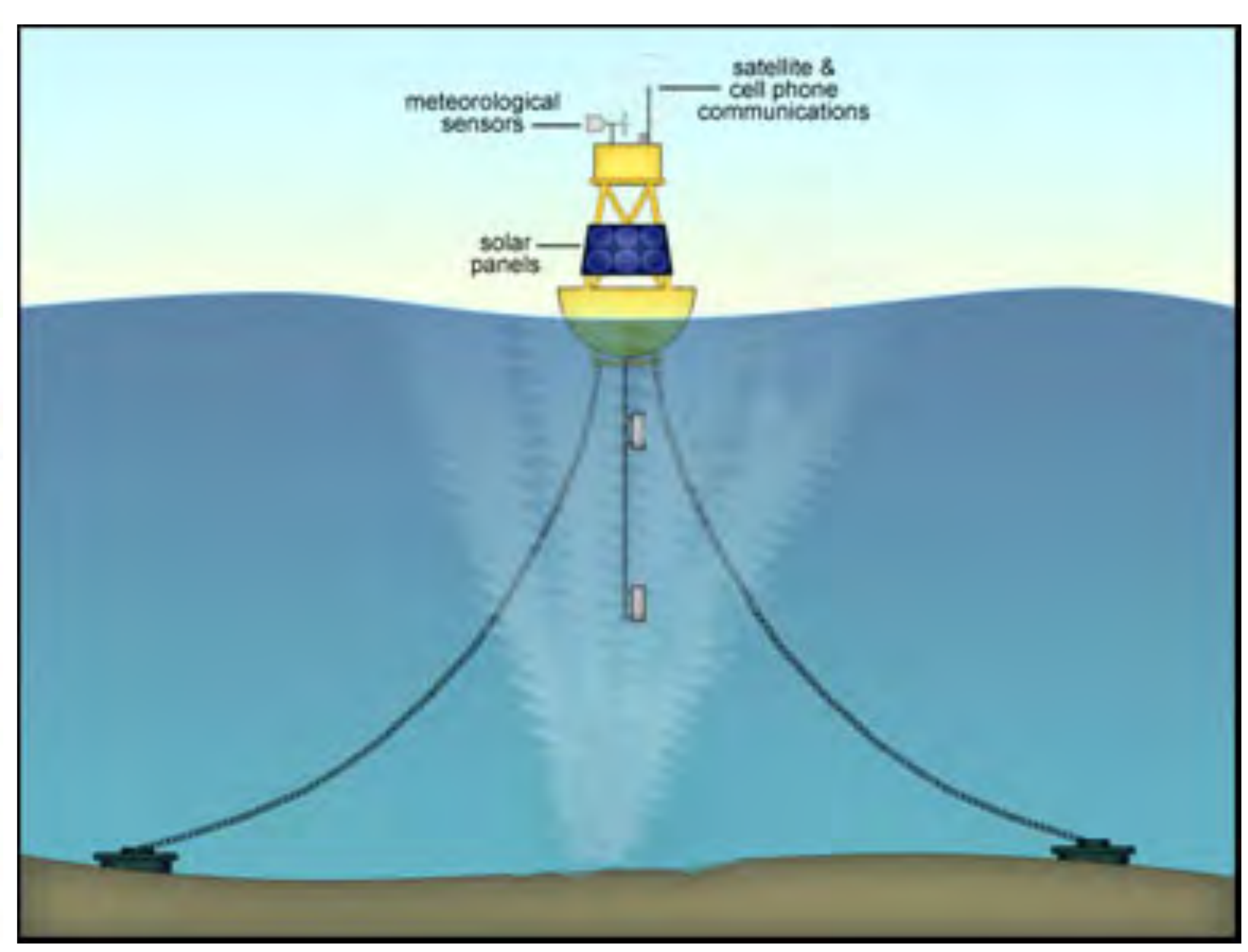


Fig 2. Example of an anchored, solar-powered buoy that can communicate information gathered through sensors via satellite & cell phone networks

APPENDIX B5 (cont'd)

Design

Fig 3. Traditional LoRa Network System

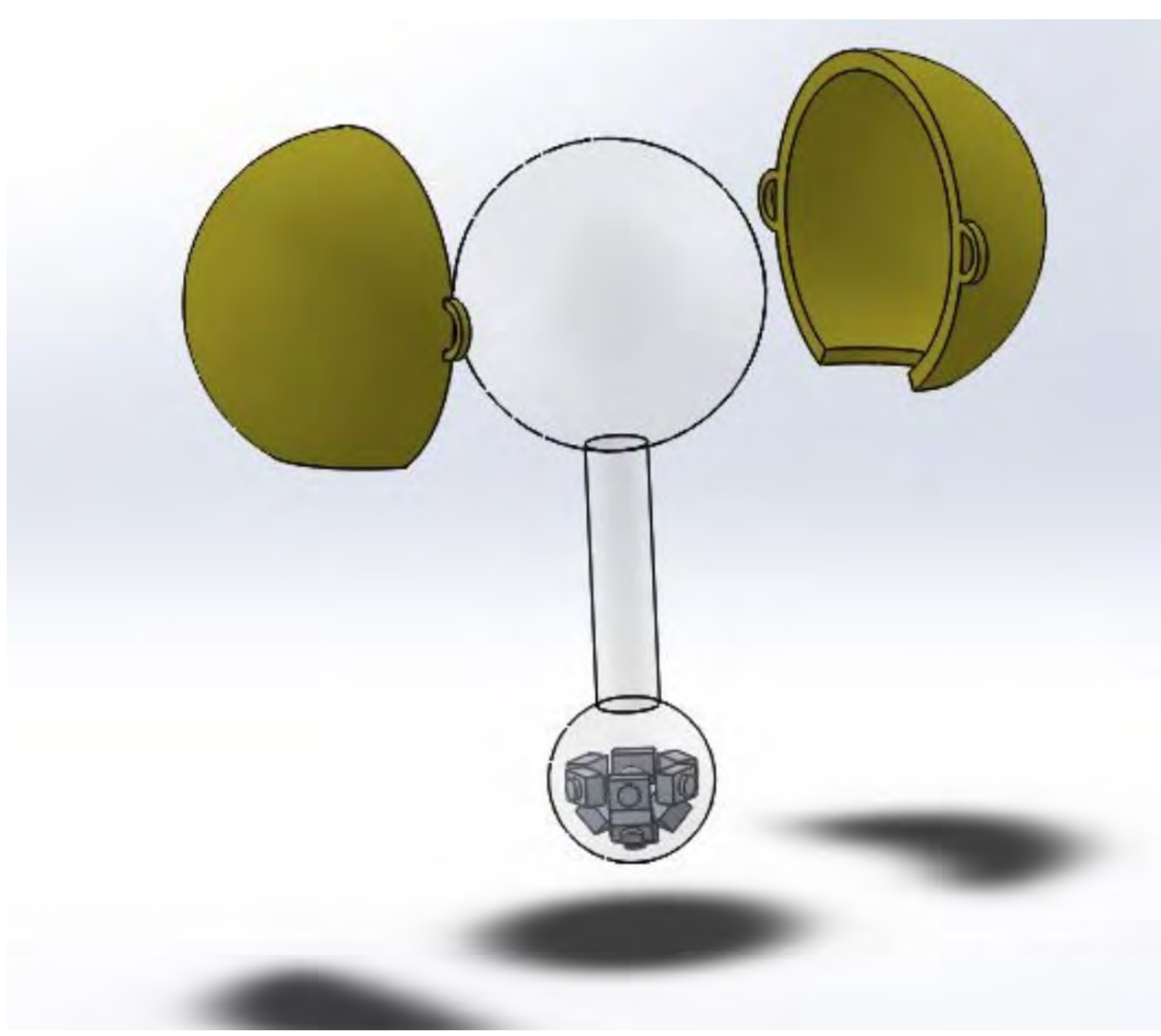


Fig 4. Computer-Aided Design (CAD) representation of buoys that would be a substitution of the Sensor Nodes in the figure above

APPENDIX B5 (cont'd)

Functionality:

Buoys with GPS and LoRa receivers will be dispersed throughout the ocean. These buoys will transmit data from atop the surface of the water to both a land gateway transmitter and to one another. LoRaWan receivers can establish bidirectional communications with the gateway transmitter to send data such as the buoy's location, aggregate fish count, types of fish in the area, etc.

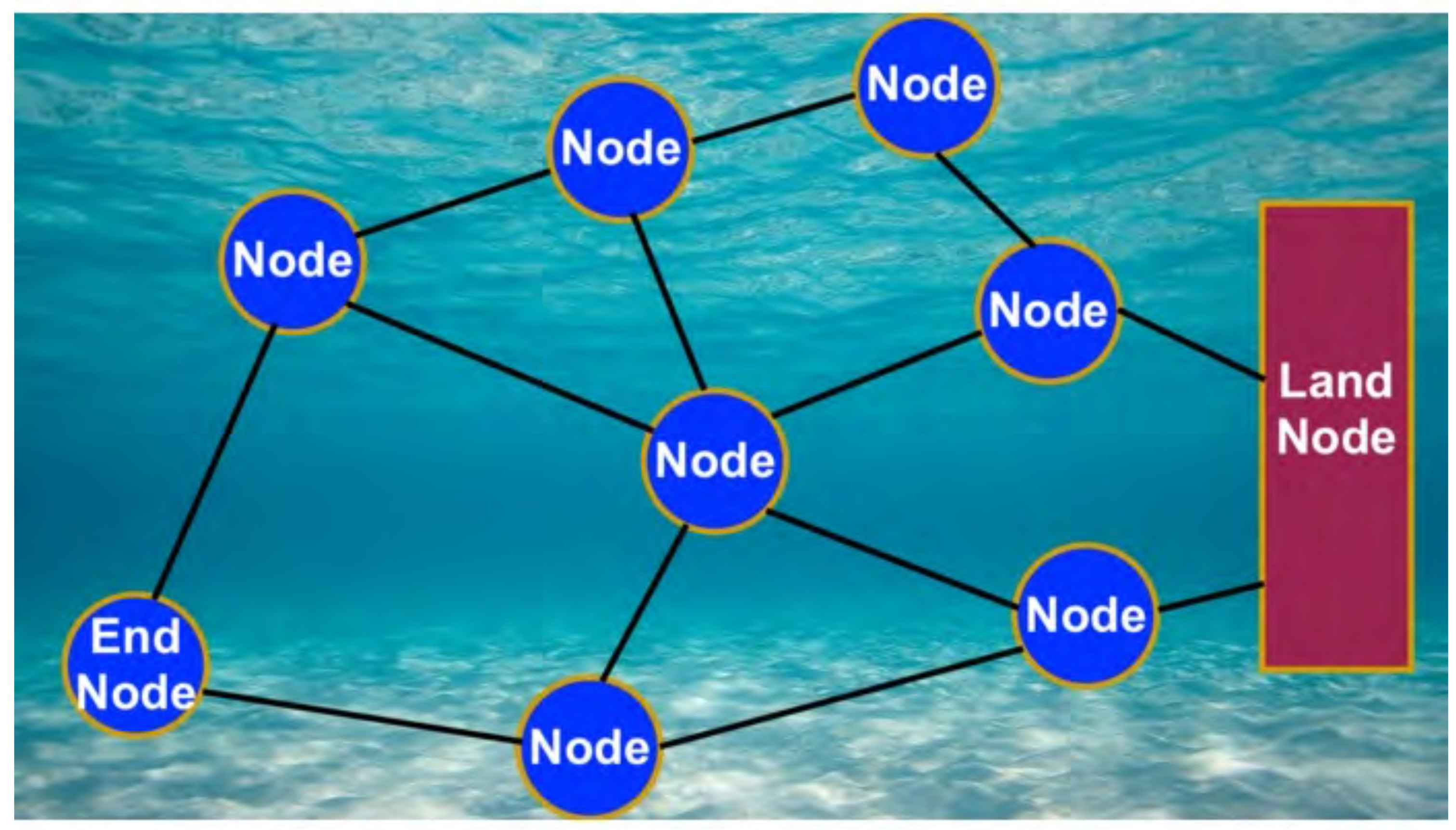


Fig 5. Proposed Mesh LoRa Network System

Identification/tracking of fish and count would be accomplished by leveraging the open source OpenCV library. In a case study, AI and computer vision have matured to the point that is is possible to achieve 100% accuracy in detecting 11 out of 20 species of fish and 70% of in 17 of the 20 species of fish [3]. It is inevitable that accuracy of fish detection and tracking will only improve by deploying the purposed mesh of network buoys, as they will collect large sets of data for the AI algorithms to train on.

The data collected by the gateway will be feed a server connected to the internet and passed onto the cloud. Once stored safely in the cloud, the information can be post processed and disposed to all fishermen and other interested parties.

Fig 6. Example of data satellite buoys could detect and transmit to land

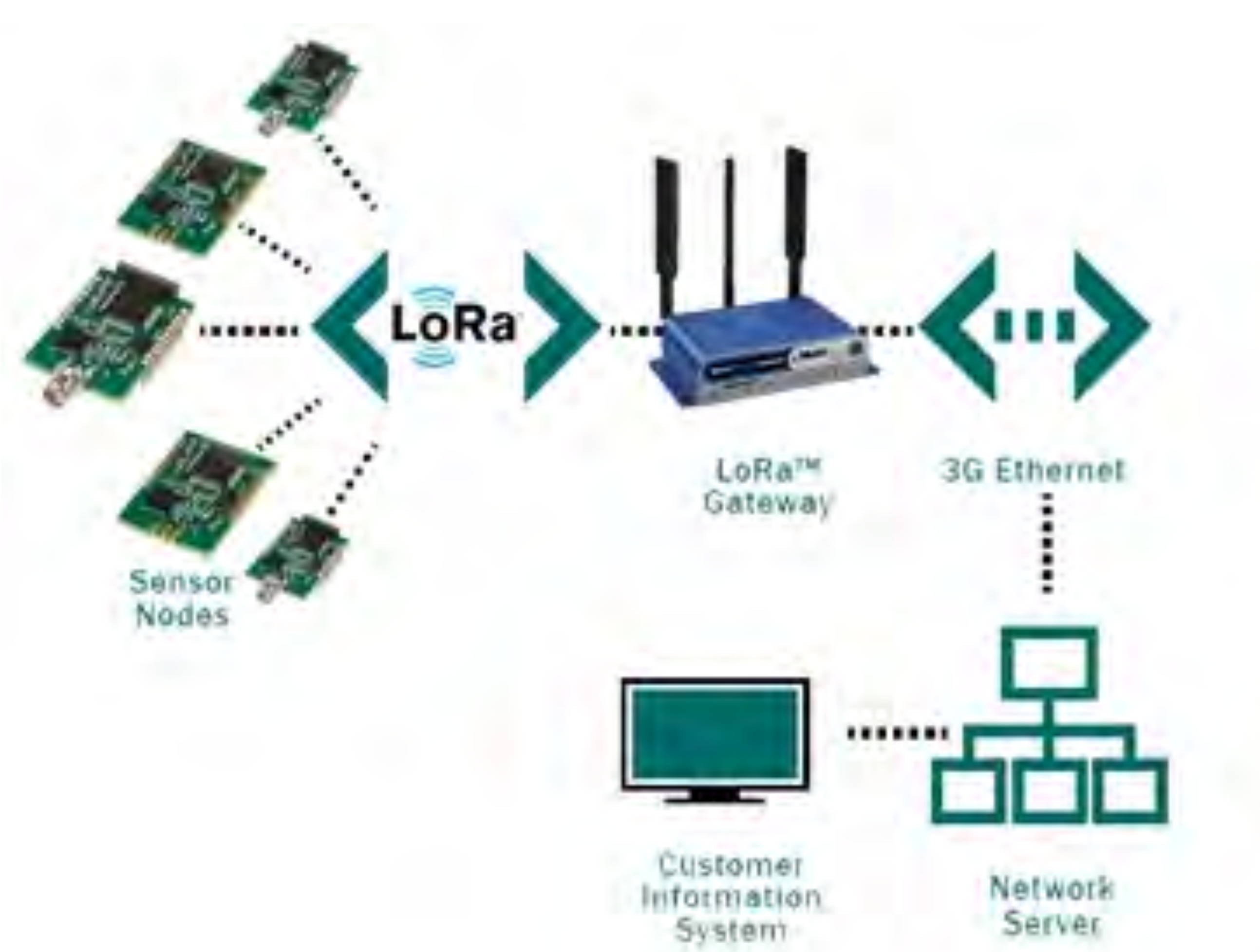


Fig 7. Illustration of stock assessment network based on LoRa technology

APPENDIX B5

Materials Cost per Buoy:

$700 - average cost of Buoy (can be reduced to utilizing 3D printing)
$20 - Arduino
$270 - 6x low light ELP cameras
$132 - LoRaWAN module for Arduino/Raspberry Pi from Cooking Hacks
$70 - Sparkfun GPS Copernicus II DIP chip
$50 - ADDTOP Powerkpac Waterproof Solar charger + Battery Pack

Total: ~$1242 max per Buoy

References:

1. https://oceanservice.noaa.gov/facts/exploration.html
2. https://www.digikey.com/en/articles/techzone/2016/nov/lorawan-part-1-15-km-wireless-10-year-battery-life-iot
3. https://www.cooking-hacks.com/documentation/tutorials/lorawan-for-arduino-raspberry-pi-waspmote-868-900-915-433-mhz/
4. http://www.cs.uwc.ac.za/~jconnan/publications/86.pdf
5. http://www.microchip.com/design-centers/wireless-connectivity/embedded-wireless/lora-technology
6. http://www.fishing-nc.com/offshore-nc-buoys.php
7. https://devpost.com/software/buoy-mesh-network-hack
8. http://ieeexplore.ieee.org/document/7944798/?reload=true
9. http://www.ferret.com.au/c/Elecom-Electronics-Supply/Multitech-Ultra-low-power-long-operation-range-900MHz-LoRa-Module-p2512629

APPENDIX C

American Marine Research Company History

The American Marine Research Company (AMRC) was founded in March of 2017 by Yuan Wang, then a senior undergraduate student of mathematics and computer sciences at Princeton University. Prior to the founding of AMRC, Yuan has worked on several rapid prototyping projects at technology start-ups and research laboratories. These experiences provided him with broad understanding of the state of robotic and information technologies. Following extensive research, Yuan identified the use of marine robotics for precision fishing and its potential application for invasive species control in an economically sustainable way as a promising approach to redirecting talent and resources of America's high-tech sector towards socially meaningful work. Facilitated by events at MIT intellectual salons and networking with organizations like the Stanford Space Initiative and 1517 Fund, Yuan was able to access a network of young technologists and entrepreneurs. In the Spring of 2017, under the guidance of a volunteer council consisting of Princeton University alumni engineers and faculty, Yuan assembled a core team of young talents.

Since late May, AMRC has received multiple angel investment offers from investors, including an unnamed but high profile angel syndicate. AMRC's strategic decision to postpone fundraising reflects its concern of venture hijacking of the firm's core mission, substantial increases in operating costs and overhead, and premature dilution of employee equity. AMRC remains connected to prospective investors and talent necessary to scale, and has developed modeling tools to work with creditors in potential debt financing arrangements.

Working with its advisory board and new-found partners at the University of West Florida, the team recruited 14 engineering interns in Pensacola over the course of the summer. These interns made meaningful engineering contributions, with some interns joining the team on 20+ hour shifts. In particular, two interns, Kiara Korkuc and Brian Arnold were selected to join the team as permanent members who now lead the build effort in Pensacola.

APPENDIX C (cont'd)

Core Technical Capabilities

A. Rapid Prototyping and Small Scale Manufacturing

Thanks to the team's extensive experience in a variety of 3D printing tools and materials and professional familiarity with manufacturing technology, AMRC can design and manufacture a robot within hours. AMRC relies on a suite of custom-modified QIDI Technology desktop printers and large scale beta testing 3D printers from Filament Innovations. Custom modifications, relationships with 3D Filament Innovations, and strong technical skills enable AMRC to deploy a wide range of exotic materials beyond the standard ABS and PLA, unlocking elastics, high-strength polymers, and more. This, coupled with the firm's experience designing for its in-house manufacturing capabilities, as well as its tight-knit collaboration between manufacturing and design, mean that AMRC technology can be reproduced and maintained with relatively low capital costs.

B. End-to-end Design and Production

AMRC's diverse engineering capabilities enable it to design and manufacture a wide range of custom components in-house, including custom printed circuit boards (PCBs), deployment-ready ROV chassis, 3D printed elastics, and more. From electrofishing units to motion control systems to control firmware to computer vision software, AMRC's mastery over every detail of its design enables it to deliver superior products that are truly specialized for the task at hand, and at a cost far lower than can be achieved with disjoint engineering and manufacturing shops.

C. Competitive Creative Design

AMRC's engineering team includes a number of decorated competitive engineers, from which AMRC inherits a strong ethos of fast, iterative and innovative design. AMRC relies on SolidWorks Professional for its design and simulation needs, and share its designs via GrabCAD.

D. Engineering Fundamentals

AMRC's team and advisory board boast strong and rigorous backgrounds, which shows in the team's engineering efforts. In-house and access to experts in biology, physics, engineering, and computer science equip the team to reason about problems from first principles to overcome engineering challenges. In particular, the team's combination of theoretical and practical backgrounds combine to enable AMRC to understand and deploy customized electrofishing technology, in-house computer vision and artificial intelligence software, among other technologies requiring strong academic training.

APPENDIX C (cont'd)

Team Members

Yuan Wang, Software Engineer and President

Yuan is a project manager, software engineer and mathematician who brings tech entrepreneurship experience and data-driven strategy to AMRC. A deeply curious and eclectic polymath, Yuan offers both technical and nontechnical experience as well as a faith-driven mission to the group. While an undergraduate in the math department at Princeton University, Yuan studied mathematics, winning $60,000 in prizes for puzzle solving and wrote an undergraduate thesis in validated numerics. Prior to founding AMRC, Yuan had worked on a variety of dorm room startups, including a thin client computing platform, an algorithmic medical triage system, and a robotic bartender, through which he has won top prizes in leading entrepreneurship, pitch, and programming competitions, and served as a mentor to other students at top hackathons coast-to-coast. His successes have won him membership in selective investment communities, including 1517 Fund, Peter Thiel's early stage fund whose student portfolio founders have raised over $40M since 2015 under two partners. In his network, he has met with investors from venture firms including Greylock Partners, NEA, First Round Capital, Sequoia Capital, Y Combinator, and Susquehanna Growth Equity. In private industry, Yuan has worked in data modeling, software engineering, and product management capacities at high powered firms including NASA-JPL, MuseAmi, a top computer vision firm, and Bridgewater Associates, the world's largest hedge fund managing $160 billion in systematic global macro strategies. For all the breadth of his experience, Yuan delivers a strong grasp of strategy in the tech industry and has a strong track record of identifying and galvanizing top talent. As a dynamic leader, Yuan maintains strong relationships in a range of close-knit venture investment communities and is prepared to mobilize venture resources at the right opportunity. At the same time, Yuan's software engineering background, work with artificial intelligence and marine learning, and rapid prototyping experience allows him to begin the automation of AMRC robotics, and has proven himself capable of filling a wide range of roles critical to the project's success.

APPENDIX C (cont'd)

Janelle Tam, former Management Consultant at Bain & Company
Janelle Tam worked as a management consultant at Bain & Company developing analytic, data-based solutions to the major challenges faced by Fortune 500 companies today. A graduate of Princeton University with a degree in molecular biology, she has an impressive background in scientific research: her research has been featured in media publications in 16 languages across 34 countries. She was named one of Canada's future leaders under 25 by Maclean's magazine, and is a five-time keynote speaker at the Congress for Future Medical Leaders, where she shares her experiences in research with over 8,000 attendees.

Brian Arnold, Mechanical Engineer and Build Lead
Brian Arnold is Pensacola native and co-leads with Kiara the team's build efforts in Pensacola. As a roboticist, Brian has had experience in project management, engineering and implementation in marine robotics through UWF's autonomous boat team, a competitive robotics program where Brian demonstrated both strong engineering intuition and excellent leadership ability. As the owner of a fishing resources supply business and as an avid fisherman himself, Brian brings strong intuition and boots-on-the-ground expertise to the team.

Zachary Pennington, Mechanical Engineer and Build Lead
Zachary hails from our very own Pensacola and joined AMRC as an intern in his final semester at the University of South Alabama before joining full-time in January of 2018. A talented engineering mind with both design and implementation skills, Zach has driven key design decisions with a keen eye to resourcefulness.

Kiara Korkuc, Mechanical Engineer and Build Lead
Kiara Korkuc was AMRC's first intern and now co-leads the team's ongoing build efforts in Pensacola, FL. She is currently finishing her undergraduate studies at the University of West Florida. Although a relatively new entrant to the world of tech startups and applied engineering, Kiara proved herself a fast learners and excellent implementer, where her grit and intelligence make her an invaluable asset to the firm's ongoing development.

APPENDIX C (cont'd)

Board of Advisors

Steve Gittings, PhD, Chief Scientist for NOAA's Office of National Marine Sanctuaries

Dr. Steve Gittings has been Chief Scientist for NOAA's Office of National Marine Sanctuaries since 1998, and served as manager of the Flower Garden Banks National Marine Sanctuary from 1992 to 1998. He received a B.S. in Biology at Westminster College (PA) and M.S. and Ph.D. degrees in Oceanography at Texas A&M University. Dr. Gittings has broad experience in conservation science, including ecosystem characterization and monitoring, damage assessment, recovery and restoration, and spill response. He has specialized in coral reefs, biofouling, and taxonomy and biogeography of barnacles. He has helped establish monitoring programs in a variety of marine ecosystems, as well as a standardized reporting system for conditions in marine protected areas. He helped characterize the reefs and banks in the northern Gulf of Mexico; investigated the effects of brine discharges of the Strategic Petroleum Reserve; did investigative work for the National Transportation Safety Board; and led reef damage assessment and recovery studies after ship groundings and anchoring. He has extensive field experience in scientific diving, ROV operations, and submersible use. Recently, Dr. Gittings has been developing traps designed to catch lionfish in waters beyond scuba depth. The traps minimize by-catch, prevent ghost-fishing, and could create new opportunities for fishermen to help create a steady supply of lionfish to seafood and other developing markets.

APPENDIX C (cont'd)

Alex Fogg, Marine Resources Coordinator of Okaloosa County, FL

Alex Fogg is the Marine Resource Coordinator for Okaloosa County, Florida. His background in marine resource management stems from the implementation of an invasive lionfish life history study which required broad collaboration with Federal, State and local governments as well as local businesses and stakeholders throughout the Gulf of Mexico. Alex began his work career with NOAA in Pascagoula, Mississippi working on numerous Gulf of Mexico fisheries surveys following the Deepwater Horizon Oil Spill. Alex then transitioned to the University of Southern Mississippi where he earned his MS degree in Coastal Sciences in 2016. During Alex's time with the Florida Fish and Wildlife Conservation Commission, he was the project manager for the largest artificial reef project in the history of Florida's artificial reef program and upon completion will have deployed more than 3,000 new artificial reefs across northwest Florida. Alex recently transitioned to his new position with Okaloosa County and is involved in numerous projects from artificial reef construction and monitoring, sea turtle lighting initiatives as well as beach restoration and the development of an estuary program for Choctawhatchee Bay. These projects will provide numerous recreational opportunities to visitors as well as residents of the Emerald Coast.

APPENDIX C (cont'd)

Professor David S. Wilcove, Professor of Public Affairs and Ecology and Evolutionary Biology at Princeton University

David S. Wilcove is Professor of Public Affairs and Ecology and Evolutionary Biology at the Woodrow Wilson School, and lends the team his years of experience in conservation work, applied ecological research, and the economics of conservation. Professor Wilcove's research interests focus on the conservation of biodiversity. He and his students and postdocs have worked in Southeast Asia, the Himalayas, New Zealand, East Africa, South America, Central America, and North America. Their work typically combines ecological research with economics and other social sciences to address issues such as deforestation, commercial logging, agriculture, and the wild animal trade. From 1991-2001, Dr. Wilcove served as Senior Ecologist at the Environmental Defense Fund in Washington, DC where he focused on developing economically and scientifically sound policies for protecting endangered species. From 1986-1991 he was Senior Ecologist for The Wilderness Society, where he helped to develop the scientific foundation for the Society's arduous and successful campaign to protect the ancient forests of the Pacific Northwest. Prior to joining the staff of The Wilderness Society, he was a Research Scientist in Zoology for The Nature Conservancy. Professor Wilcove has served on the board of directors of the American Bird Conservatory, Rare, the Society for Conservation Biology, and on the editorial boards of Conservation Biology and Ecological Applications. Dr. Wilcove is the author of two books and numerous scientific publications, book chapters, and popular articles dealing with conservation biology, endangered species, biogeography, and ornithology. A 1980 graduate of Yale University, David Wilcove holds advanced degrees from Princeton University (M.A., Biology, 1982 and Ph.D., Biology, 1985).

APPENDIX C (cont'd)

Fred Garth, Editor-In-Chief at the Guy Harvey Magazine

Fred Garth is a 30-year veteran of the media industry, mostly in the marine and adventure sports genre. During his career, Garth has launched 14 magazines, dozens of websites, and has been published on numerous news outlets from CNN to National Geographic. Garth began his career as a rookie sports writer for a daily newspaper in Florence, Alabama and went on to work for publishing giants such as the New York Times, Gannett and EMAP. After his stint in Florence, he was hired as editor of Scuba Times magazine in Pensacola, Florida. In that role he traveled the planet for 15 years reporting on ocean environments from the Caribbean to the Indo Pacific to Africa and to Europe. He advanced to publisher of Scuba Times and in 2000 the company was acquired by Petersen Publishing in Los Angeles. Garth ran Petersen's watersports sector for three years before being lured back to Florida by Gannett to spearhead their Florida magazine division. In 2006, after launching eight magazines for Gannett, he semi-retired for two years to complete several novels. As a longtime leader in the ocean community, Garth has collaborated with myriad influencers and explorers such as Jacques Cousteau and his son Jean-Michel, as well as Dr. Sylvia Earle, Dr. Bob Ballard and Dr. Guy Harvey. In 2010 Garth and Harvey launched Guy Harvey Magazine, which they still publish today, along with its companion website. For several years Garth sat on the board of directors of the international Diving Equipment and Marketing Association and from 2009-2017 was on the Board of the Perdido Key Chamber of Commerce. He served as Chairman of that chamber from 2009-2011. He currently is on the board of directors of Coast Watch Alliance and volunteers for several other civic organizations.These days Garth spends his time consulting, writing, as a husband to his wife of 25 years, and as a father to their two daughters ages 18 and 22. The family splits their time between their homes on Perdido Key, Florida and Crested Butte, Colorado.

APPENDIX C (cont'd)

Daniel Johnson, CPA, Tax Manager at Ernst and Young

Daniel Johnson is a Pensacola native advising the team in a pro-bono capacity as business mentor. Currently working as a tax manager at EY, Daniel specializes in working with early to mid-staged tech startups, leveraging his strong analytical abilities, passion for technology, and strategic mindset. Moved by the engineering team's passion, Daniel guides the firm on its path to business operationalization, mentors the team for compliance, and is prepared to mentor AMRC's core team on proper business practices for engaging with government partners.

MATT GAETZ
1ST District, Florida

ARMED SERVICES COMMITTEE

COMMITTEE ON THE BUDGET

COMMITTEE ON THE JUDICIARY

Congress of the United States
House of Representatives
Washington, DC 20515

WASHINGTON OFFICE
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WASHINTON, DC 20515
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DISTRICT OFFICE
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6TH FLOOR
PENSACOLA, FL 32502
(850) 479-1183

https://gaetz.house.gov

October 11, 2017

Re: Letter of Support, American Marine Research Company

To whom it may concern:

I am writing to enthusiastically support the American Marine Research Company in their endeavors to make our beautiful waters of the Gulf Coast safe again. The infestation of lionfish in waters has threatened our native species, and in return, has proposed an immense threat to the tourism and development in which our local economy thrives.

Earlier this year, I introduced H.R. 2560, *the Reef Assassin Act*, a bill which provides incentives for fishermen to remove lionfish by rewarding them with tags to catch coveted reef fish such as red snapper, triggerfish, etc. However, the quantity of Lionfish is overwhelmingly massive. For this reason, I was greatly encouraged when approached by Mr. Yuan Wang and the American Marine Research Company.

Mr. Wang and his team came to our district with innovated ideas on how to trap and remove large quantities of lionfish from our waters. In addition to their ideas they had established the proper mechanics and strategies required to convert those ideas into action. Mr. Yuan Wang has clearly shown he and his team are the right fit for the job.

I appreciate your consideration of the American Marine Research Company. Please feel free to contact me if I can be of service.

Sincerely,

Matt

Matt Gaetz
Member of Congress

Office of the President
11000 University Parkway
Pensacola, FL 32514-5750

September 18, 2017

Subject: Letter of Support

To Whom It May Concern:

This letter is intended to express my support for Mr. Yuan Wang and his team of researchers at the American Marine Research Company (AMRC). In the brief time that I have known them, Mr. Wang and his colleagues have demonstrated strong intellectual curiosity, high aptitude for applied research, and a passion for resolving the scourge of lionfish in the Gulf of Mexico before irreparable harm is done to the marine environment that is at the heart of our way of life along the Gulf Coast of Florida.

It is difficult to overstate the magnitude of the problem that is presented by the invasive lionfish – a non-native species to the Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico, whose population is expanding dramatically because a single lionfish can lay up to 2 million eggs per year, and yet they have no known natural predators outside of their native Indo-Pacific habitat. At the same time, lionfish are notoriously difficult to catch using traditional fishing methods, with spearfishing by recreational and commercial divers being effective in removing only a small number at a time. As a result, the species is threatening the stability of native fish populations and the entire reef ecosystem that is so vital to the health and vitality of our local waters and coastal communities.

Having recognized the challenge from afar, Mr. Wang and his associates committed themselves to pursuing a novel approach to redressing the lionfish dilemma. By applying their engineering skills, Mr. Wang and his team set about using advanced technology to construct an autonomous vehicle that would act as a synthetic predator that would identify, target, and capture lionfish that would then be sold to wholesale seafood dealers. Upon relocating to Pensacola in pursuit of their vision, Mr. Wang and his compatriots quickly ingratiated themselves with the city gentry. Personally, I remain impressed by their intelligence, passion, and intestinal fortitude – a view shared by virtually everyone with which the AMRC team has encountered.

While it is very likely that no single solitary method will solve the lionfish problem, it is also clear that only through a keen sense of purpose and an enduring spirit of innovation and entrepreneurship will we achieve the goal of population management or outright eradication. Mr. Wang and his teammates are the physical and intellectual embodiment of these traits, and we owe it to ourselves to support and promote them to the extent possible. I would, therefore, encourage you to do the same.

I hope this letter has provided you with the necessary insight to advance your understanding of Mr. Wang and AMRC's capacity for applied research and technology development. Please advise if I may be of further assistance.

Sincerely,

Martha D. Saunders
President

March 20, 2018

To Whom it May Concern:

I first met Yuan Wang in 2017 when he and his team were developing an underwater remotely operated vehicle (ROV) to capture lionfish. It was energizing to see so much young talent and passion focused on a pervasive problem facing our oceans.

Since then I've grown to respect Yuan even more for his extreme dedication, intellect, creativity, and ability to inspire and attract other extraordinary talent such as Janelle Tam and others to AMRC.

I have reviewed their proposal in great detail and I believe it includes several projects that are essential to the health and restoration of our marine ecosystem - especially the stock assessment and fish identification aspects of their plan. Additionally, their unique business model, which essentially quantifies the potential success of a business concept, then offers that intellectual property to the community for free, is a tremendous benefit to any community looking for economic growth and more jobs, particularly in the technology sector.

As editor and publisher of *Guy Harvey Magazine*, president of Lost Key Media, and a lifelong entrepreneur, I wholeheartedly support their proposal and highly recommend that it be adopted.

Sincerely,

Fred Garth

Fred D. Garth, Editor/Publisher
Guy Harvey Magazine

418 W. Garden Street., Ste. 312 | Pensacola, FL 32502 | 850.380.6680 | Fred@GuyHarveyMagazine.com

Emerald Coast Reef Association

www.ecreef.org

From: Candy Hansard, President March 20, 2018

To: Okaloosa County Restore Program Administrator

Subject: Support for AMRC Technology Development Program

This letter is to express our support for the AMRC Technology Development proposal.

In our County, the Military and Tourism are our two largest job creators, providing our communities with economic prosperity. As our County Commission is aware, from time to time, we must fight to keep the Military Presence to insure employment opportunities for our citizens.

Our Natural Resources, especially the Gulf of Mexico, is a huge tourist draw creating jobs for thousands in our County. The Gulf of Mexico is experiencing tremendous stress from the lionfish. The lionfish is an invasive species with no natural predator, a voracious appetite for our native fish and reproductive capabilities that are overwhelming the natural balance of our native ecosystem. AMRC, in developing artificial intelligence and robotics for lionfish control, are spearheading a permanent solution to this scourge and have shown considerable skill, passion, and selflessness in their work.

It is critical that we support all efforts to find ways to control the lionfish population while searching for an environmentally safe eradication method. AMRC is in the process of developing exciting new technology that could very well help save our native fishery from an eventual collapse, while also lending their technical prowess and passion to share powerful technologies to revolutionize marine conservation, education, and research.

So often, grants are given for studying a problem. At the end of the study, you still have a problem. AMRC is solving problems and their approach is innovative, and they are uniquely generous and creative in the coalition-building.

In closing, we believe this collaborative effort has the potential to produce valuable methods to address the most serious threat our native fishery has ever faced while simultaneously creating immediately valuable technology for our county's tourism sector.

Thank you for giving this proposal serious consideration,

Candy Hansard

Candy Hansard
President, Emerald Coast Reef Association Inc.
www.ecreef.org
P.O. Box 273 ~ Niceville, FL 32588
O: 7-850-729-7619 C: 850-582-1359

Dreadknot Charters, LLC
508 Mountain Dr.
Destin, FL 32541
Phone: 850-542-8700
Fed. ID #472566166 Cage #7WMM8
Duns #080658358

DREAD KNOT

March 20, 2018

Mr. Yuan Yang
Software Engineer and President
120 Chief's Way
Suite 1PMP1
Pensacola, FL 32507

Dear Mr. Yang,

I am writing to express my commitment to participate in the project "AMRC and Gulfarium's Public Technology Incubation to Drive Tourism and Aquatic Resource Management Proposal" being submitted. I hold commercial and for-hire recreational Reef fish and Pelagic permits in the Gulf of Mexico and derive a large percentage of my livelihood from reef fish fisheries in this region. As a commercial spear fisherman, I am well able to contribute expertise as specified in the proposal for capturing gray triggerfish samples needed in this study. My crew and I have worked with Okaloosa County on several projects and we have a great working relationship. As a commercial and for-hire recreational captain, I am committed to the conservation and the wise use of reef fish resources. I am proud to be part of this proposed study as it promises to add critical life history information to improve management of these important fisheries.

Please do not hesitate to contact me with any questions.

Sincerely,

Capt. Josh Livingston
Dreadknot Charters, LLC

Provisional Application for United States Patent

Title: Synergistic Baler-Inspired ROV for Selective Fish Harvesting

Inventors: Yuan Wang (Pensacola, FL), Duncan Michael (Needham, MA), Ian Switzer (Ithaca, NY)

Owner: American Marine Research Company, LLC (Pensacola, FL)

[0001] BACKGROUND

[0002] Field of the Invention

[0003] The present invention is directed to the efficient and selective harvest of fish with a robotic remote operated vehicle (ROV) without the need for a human diver operator.

[0004] Description of the Related Art

[0005] Existing tools in commercial and recreational fishing lack either precision or range, limiting their ability to efficiently harvest marine life in a highly selective manner. This has led to the unintentional entrapment of large numbers of non-target marine species, which poses an existential threat to endangered species such as sea turtles and is one of the leading causes of overfishing. Furthermore, they have proven ineffective against invasive species such as lionfish which have become a menace to native marine life and coral ecosystems. Currently, attempts to cull these populations of invasive species are laboriously conducted by human divers, but this method is dangerous for divers and too limited by massive logistical and economic constraints to happen on an effective scale. Remotely operated aquatic vehicles present a natural and potentially effective tool with both superior precision and range capable of controlling populations of invasive species.

[0006] To date, a number of attempts at a remotely operated vehicle (ROV) have been made, but all face operational difficulties and are not scalable. The first deploys the bait via a hook and line method, but the bait attracts many different kinds of fish, and can only capture a limited number of fish (one per baited line) or risk being violently carried away as captured fish attempt to escape. Another ROV developed for lionfish control stuns fish with twin electrode panels and sucks the fish into an attached bucket. However, the device's capacity is limited to the size of the bucket, and the large frontal profile of the bucket chassis severely limits the agility of the device. Together, these two features force a tradeoff between agility and mobility: increased power to the thrusters of the device to overcome losses in agility then dramatically increase the weight, power draw, and displacement of the ROV, driving costs up and decreasing the mobility of the system. Scalability is also limited to a few fish because the presence of a fish in the cylinder interferes with the suction mechanism. Another type of ROV uses a retractable spear to stab fish and pull them back into a container, but the large frontal profile and size of the bucket again force a sharp tradeoff between agility and capacity, and the mechanical complexity of the design makes reliability and cost difficult to improve.

[0007] SUMMARY

[0008] A robotic remote operated vehicle (ROV) is provided for the precise and scalable harvest of fish in both open ocean and aquaculture settings. The ROV utilizes an agile motion control mechanism to maneuver to targeted specimens, and may incorporate electro-stun panels to selectively incapacitate target, a suction mechanism to entrap fish, and a trapdoor which vastly increases the efficacy and scalability of the fishing unit by separating the capture and containment segments of the device, allowing for continuous capture without encumbrance from prior captures. The embodiments of the invention are modular and utilize equiangular drive thrusters mounted around a cylindrical chassis. Propellers behind and around the channel of the chassis and/or forward motion facilitated by the drive thrusters will move the device around the targeted specimen such that the specimen travels into a rear containment unit.

This ROV is distinct in its modularity, with a central chassis to which enhancements like lights, weapons, additional batteries, sensors, and other implements can be attached. These enhance the device’s effectiveness and allow for customization of the ROV for different functions. The ROV also displays a unique agility that is derived from the specific orientation of thrusters and propellers around the chassis and facilitated by the hydrodynamic minimal frontal profile of the device. Finally, the use of a rear containment unit coupled with a trapdoor mechanism facilitate the continuous harvest of large numbers of fish, as opposed to one at a time, increasing yields. Together, these added design elements result in a dramatically higher harvesting range than other ROVs and human divers. Additionally, the digital controls of the device enable remote operation by a human operator at the surface, while also providing the platform for programmatic control and automation; this reduces or even eliminates the need for advanced training and skill to entrap fish. Finally, the straightforward, economical manufacturing process used makes production of this ROV affordable. These factors eliminate bottlenecks such as the need for advanced training or complex equipment that hinder fish capture from scaling to higher volumes.

[0009] In one embodiment of the present invention, a robotic device and method is presented for selectively and efficiently harvesting marine life in an underwater environment via digital controls. The system employs a cylindrical chassis featuring a large central channel through which targeted specimens are trapped in a containment unit attached to the rear of the device. The chassis may feature a large number of openings throughout in order to reduce the drag when moving through the water. These features improve the device's hydrodynamics, lending it agility and speed underwater. It also allows for energy efficiency, which in turn decreases the frequency of battery changes needed. The device captures the fish by moving the chassis around the fish so that the fish passes through the center channel of the device into the rear containment unit. This allows for a continuous, uninterrupted harvest of specimens into a containment unit in the direction of the device's forward motion, enabling the device to achieve yields far exceeding those of methods in prior art. Mounted to the cylindrical chassis will be equiangular thrusters, each in two radially symmetrical arrays, one array facing forward, the other backwards. In each array, the thrusters are angled slightly inwards, so that the device has maximum degrees of freedom. The motion of the device will be controlled by a computer contained in a watertight container mounted on top of the cylindrical chassis with a dovetail attachment. Forward-facing lights are mounted to the front of the chassis body to provide lighting in areas of poor visibility, and to attract fish, and a forward facing camera attached to the entrance of the chassis will provide vision capabilities to the computer. The device can be attached to a tether, allowing it to be connected to devices at the surface which may be programmatically or operator controlled. To capture a fish, the operator (either human or autonomous) will move the device such that a targeted fish is in view of the device, and proceed to drive the device forward so that the fish passes through the central channel of the device and into a rear containment unit, either a net or a cage. This operational concept is described in greater detail in later sections, and is illustrated in Figure 11.

[0010] This device is modular: the chassis can accommodate attachments and modifications to its hull and the electronics package can accept additional modules including but not limited to sensors, weapons, and specimen storage units. Attachments may include a pair of extended arms with electrodes, which are part of an electro-stun weapon controlled by the electronics package. This weapon will deliver pulsed electrical shocks which will interfere with the fish's nervous system, incapacitating it. The operator may use this weapon to subdue the fish for easier capture. In an advanced stage, the device may not have a tether or a human operator, and instead be autonomously operated by purpose-built software. This will eliminate the encumbrance of a long subsea tether, as well as the inefficiency of human error.

[0011] In another embodiment of the present invention, the system employs a cylindrical chassis featuring a large central channel through which specimens targeted are trapped in a containment unit attached to the rear of the device. The chassis may feature a large number of openings throughout in order to reduce the drag when moving through the water. Inside the channel will be a rim-driven propeller, which can generate flow through the central channel, pulling fish through the channel and into the rear containment module, which can be either a net or a cage. Mounted to the cylindrical chassis will be equiangular thrusters, each in two radially symmetrical arrays, one array facing forward, the other backwards. In each array, the thrusters are angled slightly inwards, so that the device has maximum degrees of freedom. The motion of the device will be controlled by a computer contained in a watertight container. A forward mounted camera will provide vision capabilities to the computer. Forward-facing lights are mounted to the chassis to provide lighting in areas of poor visibility and to attract fish. The device accepts a tether, which will enable it to be connected to devices at the surface. At the surface, an operator may remotely control the device. To capture a fish, the operator will move the devices that a targeted fish is in view of the device, and proceed to drive the device within range of the fish. The device will use the rim driven propeller to generate flow that moves the fish through the central channel.

[0012] In another embodiment of the present invention, the system employs a cylindrical chassis featuring a large central channel through which specimens targeted are trapped in a containment unit attached to the rear of the device. The chassis may feature a large number of openings throughout in order to reduce the drag when moving through the water. To the rear of the channel will be a hinged trap door, which may be controlled by the electronics unit. This trap door will feature a central hole in which another thruster is mounted, this trapdoor mounted thruster may be activated to generate flow to suction the fish into the channel. Equiangular thrusters are mounted to the cylindrical chassis, each in two radially symmetrical arrays, one array facing forward, the other backwards. In each array, the thrusters are angled slightly inwards, so that the device has maximum degrees of freedom. The motion of the device will be controlled by a computer contained in a watertight container. A forward mounted camera will provide vision capabilities to the computer. Forward-facing lights are mounted to the chassis to provide lighting in areas of poor visibility and to attract fish. The device accepts a tether so it can connect to devices at the surface. At the surface, an operator may remotely control the device. To capture a fish, the operator will move the devices that a targeted fish is in view of the device, and proceed to drive the device within range of the fish. The device will use the trapdoor mounted thruster to generate flow to suction the fish through the central channel. A sensor located in the channel will initiate the opening of the trapdoor when a fish is in the central channel to allow it to pass through the channel and into the rear containment unit. The trapdoor will then close to trap the fish within.

[0013] These devices may also exist in fully autonomous embodiments, whereby the tether to the surface is removed and the device is equipped with the computing machinery and software necessary to autonomously target, incapacitate and harvest selected specimens. This will eliminate the encumbrance of a long subsea tether, as well as the inefficiency of a human error in operation.

[0014] BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The features and advantages of the present invention are made clear by references to accompanying drawings and labels. We describe the drawings first, and provide a key for labels.

[0016] Description of drawings

[0017] Figure 1: The view the device from an angle off the front. This device has a rim driven propeller, and the arrows [1] and [2] show flow and direction of harvesting fish.

[0018] Figure 2: As in figure 1, this is the invention equipped with rim driven propeller, with key components labelled.

[0019] Figure 3: This is a drawing of chassis showing the rim labeled on the chassis, where the rim driven propeller can be mounted.

[0020] Figure 4: Drawing of chassis showing the interior of the devices highlighted.

[0021] Figure 5: Drawing showing the rear rim of the device, to which a flap can be attached. The flap closes when the mounted thruster is active as the thruster pulls the flap closed and pulls water into the device.

[0022] Figure 6: Drawing of a flap, to be attached to the exit face of the device.

[0023] Figure 7: Example of thruster body with angled dovetail mounting interface.

[0024] Figure 8: Comparison of exploded and composted views, some large components co-identified across views to track them across views.

[0025] Figure 9: Planar slice of the device, showing hollow battery containers.

[0026] Figure 10: Exploded view of device, with some smaller components identified

[0027] Figure 11: Operational concept of robot

[0028] Figure 12: Example of cage containment unit

[0029] Figure 13: Example of containment sleeve netting

[0030] Description of Labels

[0031] 2. Incoming flow of water and specimens through towards the front face of the robot
[0032] 4. Outgoing flow of water and harvested specimens out the back of the robot
[0033] 6. Battery containers mounted to the device chassis
[0034] 8. Forward array of equiangular thrusters
[0035] 10. Cylindrical chassis of robot
[0036] 12. Dovetail grooves for mounting thrusters and other attachments
[0037] 14. Electronics container with control unit inside, featuring a computer and camera
[0038] 16. Optional rim driven propeller for generating flow as in [1]
[0039] 18. The front rim of the chassis, to which an optional rim driven propeller can be attached
[0040] 20. The rear rim of the chassis, to which an optional suction-enabled flap can be attached
[0041] 22. The opening to the flap to receive a thruster
[0042] 24. Body of the flap
[0043] 26. Hinge of the flap
[0044] 28. The interior of the device's cylindrical chassis
[0045] 30. A thruster cowl with a male dovetail mount
[0046] 32. Thrusters on the robot
[0047] 34. Cylindrical chassis
[0048] 36. Batter container with a hydrodynamic cap
[0049] 38. Interiors of battery containers
[0050] 40. Optional hydrodynamics enhancing caps to battery containers
[0051] 42. Mounting holds for battery and electronics containers
[0052] 44. Acrylic enclosures serving as battery and electronics containers
[0053] 46. Seat for battery containers
[0054] 48. Male dovetail mounting device for thrusters to the chassis
[0055] 50. Thruster

[0056] DETAILED DESCRIPTION

[0057] The invention provides a configurable system for for the precise and scalable harvest of fish in both open ocean and aquaculture settings. It utilizes equiangular drive thrusters mounted around a cylindrical chassis that is attached to a rear containment unit. The central chassis is modular and enhancements like lights, weapons, additional batteries, sensors, and other implements can be attached. The device may incorporate electro-stun panels to selectively incapacitate target, a suction mechanism to entrap fish, and a trapdoor which vastly increases the efficacy and scalability of the fishing unit by separating the capture and containment segments of the device, allowing for continuous capture without encumbrance from prior captures. Propellers behind and around the channel of the chassis and/or forward motion facilitated by the drive thrusters will move the device around the targeted specimen such that the specimen travels into a rear containment unit. Additionally, the digital controls of the device enable remote operation by a human operator at the surface while also providing the platform for programmatic control and automation; this reduces or even eliminates the need for advanced training and skill to entrap fish.

[0058] In one embodiment, the invention employs a tubular chassis with a large central channel [28]: the forward opening accepts specimens, and the rear opening connects to a containment unit. An array of thrusters are mounted to the exterior wall of the chassis [8] [32] [50]: half of the thrusters on the front of the cylindrical chassis and the other half thrusters on the rear, each oriented 45 degrees relative to the center point of the circular frame. There thrusters allow for precise control of the motion of the apparatus and increased maneuverability. The device moves fish from the front of the device [2] through the central channel [28] and into a containment unit attached to the rear. This is achieved in operation by driving forward towards the target specimen and encapsulating it in the central channel [28] of the device to funnel it into the containment unit. Figure 11 illustrates this operational concept. The captured fish will remain in the rear mounted containment unit, either a net or a cage, depending on the terrain of seafloor above which the device operates, and the ROV will drive towards the next fish. As lionfish are relatively docile fish that tend to remain stagnant, this is method of capture has proven to be effective. The control unit, where the controls and computing are centralized, [14] is mounted to the top of the device, and features a computer, which controls the thrusters and other systems on the device, as well as cameras, which can be located inside a transparent containment unit, and/or mounted outside the device. Thrusters, lights, and other devices are connected to the control unit by cables. The control unit may also feature an accelerometer and/or gyroscope and other firmware that will allow the device to detect its orientation and make small adjustments via its thrusters to hold a given position and orientation. Battery containers [6] [38] [44] are mounted to the sides and underbelly of the device to provide power to the device. These containers may be optionally fitted with a nose [40] to improve the flow of water against the surface of the water when the device is in motion, thereby reducing drag. Indexed dovetail grooves and rails that accept attachments [12] are placed around the chassis to allow for quick, secure and precise modification. Dovetail interfaces [48] allow thrusters equipped with them [30] to be mounted securely and quickly to the device. Other attachments may be joined via these same rails and grooves, or additional rail systems, and dovetail interfaces [48] are secured to the grooves [12] with screws. A containment module, either a net or a cage, is mounted towards the rear of the chassis [20]. The containment module will hold captured fish during the course of the device's operation. Attachments, including but not limited to lights, weapons and sensors may be mounted via rails and dovetail grooves. In particular, the device may feature two protruding arms from the sides of the chassis which extend opposing electrodes in front of the device. These electrodes are connected to an electro-stun weapon system mounted to the bottom of the chassis. This weapons system is controlled by the control unit and may deliver electric pulses between the electrodes, which incapacitate the targeted fish by interfering with its nervous system. All said attachments connect with the the main chassis via modular interfaces, namely dovetail joints and indexed rail systems secured by screws, and connect to the electronics via the control unit, enabling modularity and rapid and easy replacement of parts. The electronics and batteries are contained within clear acrylic containers which are have removable caps to allow for easy replacement. Desiccants such as silica gel are included in the acrylic containers in order to absorb condensation which may form on the container’s walls when the ROV is operating at colder depths. The container caps feature holes out of which waterproofed cables can run, with the gaps sealed by marine epoxy. Additional holes are added and plugged with removable vacuum plugs to provide the option of including additional electronics attachments in the future. Clamps around container caps reinforce the containment, although these caps rely largely on the pressure of the surrounding water to prevent slippage and accidental removal.

[0059] A number of modifications and attachments may be made to enhance this base model, which are described in various more advanced embodiments. In one embodiment, the tubular chassis features a rim driven propeller [16] that generates flow to pulls specimens into the channel of the device, accelerating the progression of the fish into the containment unit. The propeller may also be coupled with a trap door

[26] that secures fish already in the containment unit while allowing additional fish to enter. The chassis may also be augmented with a means of incapacitating the targeted specimen, such as through twin electrode equipped arms mounted to the side of the chassis that use an electric pulse to stun fish. This electrofishing unit may be a standard electrofishing unit modified to accept digital controls and connected to the central electronics unit. Instruments like a camera are mounted to the chassis, along with batteries and an electronics package [14] that supports the remote operation of the device. This electronics package [14], with its forward facing camera and digital controls, allows for remote or autonomous operation of the device.

[0060] In another embodiment illustrated in figures 8 and 10, the device also employs a cylindrical frame [10] [34] without a rim driven propeller which has holes and gaps in its chassis in order to reduce the drag in lateral movement. The electronics package [14] and battery enclosures [16] [36] [38] are attached to the outside of the chassis, as before. This embodiment also traps fish by moving the chassis and containment unit around the fish, similar to the operational concept illustrated in Figure 11.

[0061] In another embodiment illustrated in figures 1 and 2, the device employs a cylindrical chassis [10] [34] with an interior diameter of about 16” and an exterior diameter of about 18”. The device has a wing-profile chassis as in Figures 1-4, and a rim driven propeller [16] mounted to the interior rim of the chassis [18]. A simple sleeve of netting attached to the rear rim of the chassis [20] serves as the containment unit. The sleeve of netting can extend for long distances, allowing for continuous operation of the ROV without the need to surface to empty the containment unit, and therefore significantly increases harvest yields. There are numerous equiangular thrusters [8] [32] [50] arranged around the rims of the chassis at a 15 degree angle to the surface of the chassis, battery enclosures [6] [36] [38] attached to the sides and bottom of the chassis, and an enclosure with the device's electronics package [14] mounted to the top of the chassis. The rim drive [8] activates to pull fish through the central channel [28] of the device and into the rear containment unit. The electronics package controls all of the motors and provides vision capabilities to the device, providing an interface for digital controls by an operator above the surface, or for programmable, automated operation.

[0062] In another embodiment, the device employs a cylindrical chassis [10] [34] equipped with a flap mounted thruster (instead of a rim driven propeller) attached to a smaller opening [11] which is part of a hinge mounted [12] flap [13] that generates flow through the central channel [14]. As with the rim driven propeller, this rear flap-mounted thruster accelerates the travel of the fish into the rear containment unit. The flap may, either by its own buoyancy or via an actuated hinge, lift up when in forward motion in order to reduce its frontal profile and improve the hydrodynamics of the ROV.

[0063] In other embodiments, the device may have a simpler cylindrical chassis [17] without wing-profile contouring as illustrated in figures 8, 9 and 10. These embodiments again rely on the operational concept illustrated in Figure 11 whereby the devicedrives its chassis around the targeted specimen such that it enters into the rear containment unit, ingesting the specimen into containment. This embodiment is useful for quickly and easily capturing large numbers of fish floating in a water column.

[0064] The containment units described above fall into two categories: cages and nets. Cages are constructed from rigid material that form a basket with holes optimized to minimize drag generated by the unit while preventing fish from escaping. Figure 12 provides an example of a cage containment unit implemented with plastic fencing material and a PVC frame comprised of an octagonal frame encased in nylon netting constructed with 4 way connectors. The frame can also be constructed from aluminium and expanded to accommodate larger fish or a greater number of fish. Net-based containment units feature long sleeves of flexible netting which are spooled around the edge of the chassis and released as netting is used up in order to increase the capacity of the net; this enables the ROV to travel forward without being weighed down by the weight of previously captured specimens.

[0065] The device may be constructed in a number of ways, though the embodiments described are optimized for rapid construction via 3D printing and subsequent assembly by a human worker. Figure 10 shows an example of a deconstructed assembly of the device, in which all components other than the motors, electronics and battery containers, and screws can be 3D printed. None of the components presented, however, necessitate additive manufacturing; traditional manufacturing methods may be utilized in scaled production when the need for high on-demand availability for replacement parts and attachments decreases. This modular construction also simplifies maintenance, whereby individual components can be quickly changed in the field in the event of damage, attachments--namely lights, weapons systems, additional batteries, and sensors--can be included or removed as operating conditions require.

[0066] In currently produced embodiments, the ROV is built using 3D printed materials produced by a FDM printer utilizing PLA filament. The chassis is a skeleton system made of PVC, and could alternatively be constructed with fiberglass, carbon fiber, PLA, ABS, aluminum, steel and titanium. Clear acrylic containers are purchased from a third party and house an electronics assembly consisting of a Raspberry Pi computer, requisite ESCs to support the thrusters on board, a forward-facing camera, a Pixhawk controller with an onboard gyroscope and accelerometer. It is connected to a 300m tether which itself is connected to a laptop utilizing QGroundControl and a video game controller which functions as the operator interface. A modification to ArduSub firmware is used to provide autopilot capabilities, which include balancing and control mapping.

[0067] CLAIMS

[0068] What is claimed is:
[0069] 1. A modular remote operated underwater vehicle system comprised of:
[0070] a chassis with a large central channel and indexed dovetail grooves and rails used to affix attachments to the chassis;
[0071] a containment unit attached to said chassis;
[0072] oriented equiangular thrusters attached to said chassis;
[0073] a control unit attached to the chassis including a computer that controls the device's systems
[0074] means for viewing attached around the chassis to facilitate viewing and sensing of fish;
[0075] battery packs to power vehicle attached to the chassis.

[0076] 2. A modular remote operated underwater vehicle system as in claim 1 wherein said chassis is equipped with a rim driven propeller to generate suction into the central channel and containment unit.

[0077] 3. A modular remote operated underwater vehicle system as in claim 1 wherein said chassis is equipped with a flap mounted thruster to generate suction into the central channel and containment unit.

[0078] 4. A modular remote operated underwater vehicle system as in claims 2 and 3 wherein said containment unit is equipped with a trap door to secure fish within the containment unit

[0079] 5. A modular remote operated underwater vehicle system as in claim 4 wherein said containment unit is also equipped with a trap door mounted thruster to generate suction into the central channel.

[0080] 6. A modular remote operated underwater vehicle system as in claims 1-5 wherein the front of the chassis is equipped with an electro-stun weapon to immobilize fish to aid in capture.

[0081] 7. A modular remote operated underwater vehicle system as claims 1-6 that has an efficient and precise method for capturing fish comprising the steps of:
[0082] descending to an appropriate depth via the propulsion of attached thrusters;
[0083] transmitting live video feed to operator to begin surveying the site for target specimens;
[0084] once target has been identified by operator, navigating to the appropriate depth and distance necessary to capture the target;
[0085] when target is within the capture range, executing a sequence of capture maneuvers to bring the target into the drone's capturing cavity;
[0086] once sufficient fish have been captured, returning to surface to off-load harvest.

[0087] 8. A modular remote operated underwater vehicle system as in claims 1-6 that has an autonomous method for capturing fish comprising the steps of:
[0088] descending to appropriate depth via the propulsion of attached thrusters;
[0089] surveying the site for target specimens and identifying target;
[0090] once target has been identified, navigating to the appropriate depth and distance necessary to capture the target;
[0091] when target is within the capture range, executing a sequence of capture maneuvers to bring the target into the drone's capturing cavity;
[0092] once sufficient fish have been captured, returning to surface to off-load harvest.

[0093] 8. A modular remotely operated underwater vehicle system as in claims 1-8 wherein said capture maneuvers further comprises accelerated motion to capture the fish in central chamber of chassis and driving forward to funnel target specimen into the containment unit, and may include:
[0094] activation of rim driven propeller listed in claim 2 to suction target specimen into central chamber of chassis;
[0095] activation of flap mounted thruster listed in claim 3 to suction target specimen into central chamber of chassis;
[0096] opening and closing of trap door listed in claim 4 to prevent escape from containment unit;
an electrical shock from electro-stun weapons listed in claim 5 to stun fish into immobility if necessary.

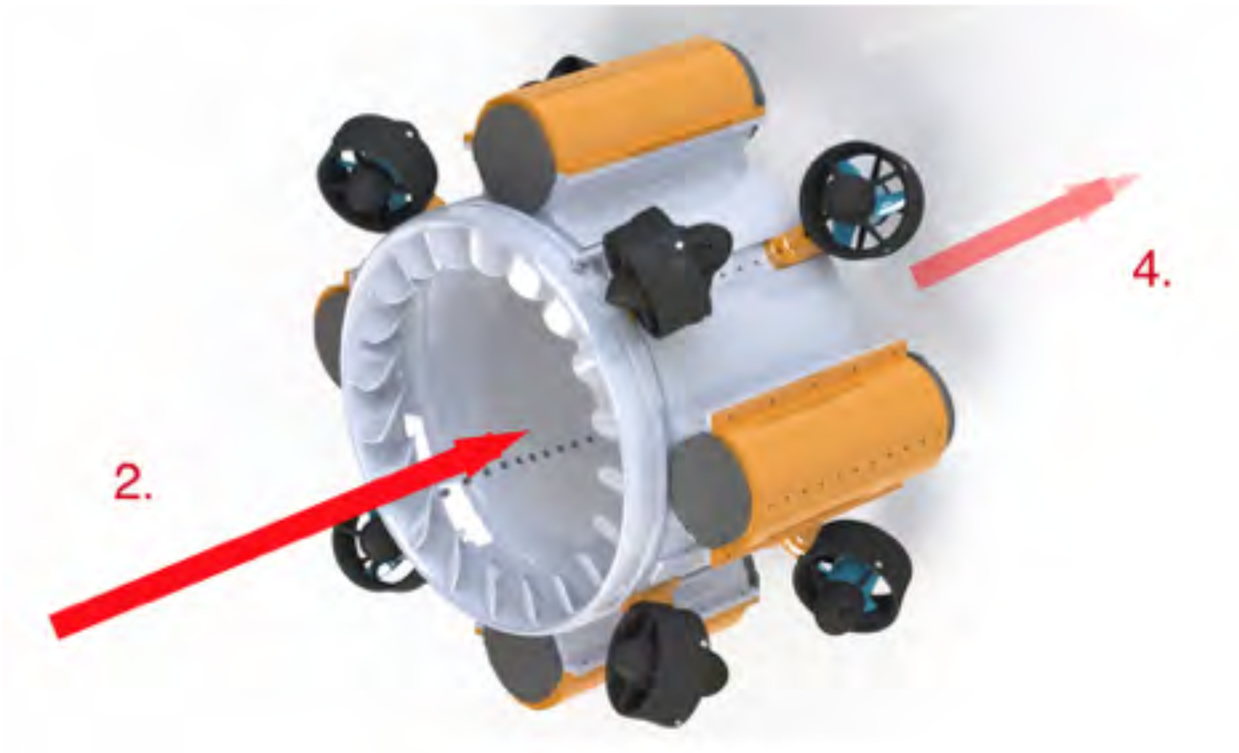
[0097] 9. A modular remote operated underwater vehicle system as in claims 1-8 wherein means for viewing include cameras, lights, and other sensors in various combinations.

[0098] 10. A modular remote operated underwater vehicle system as in claims 1-9 wherein said chassis is cylindrical.

[0099] DRAWINGS

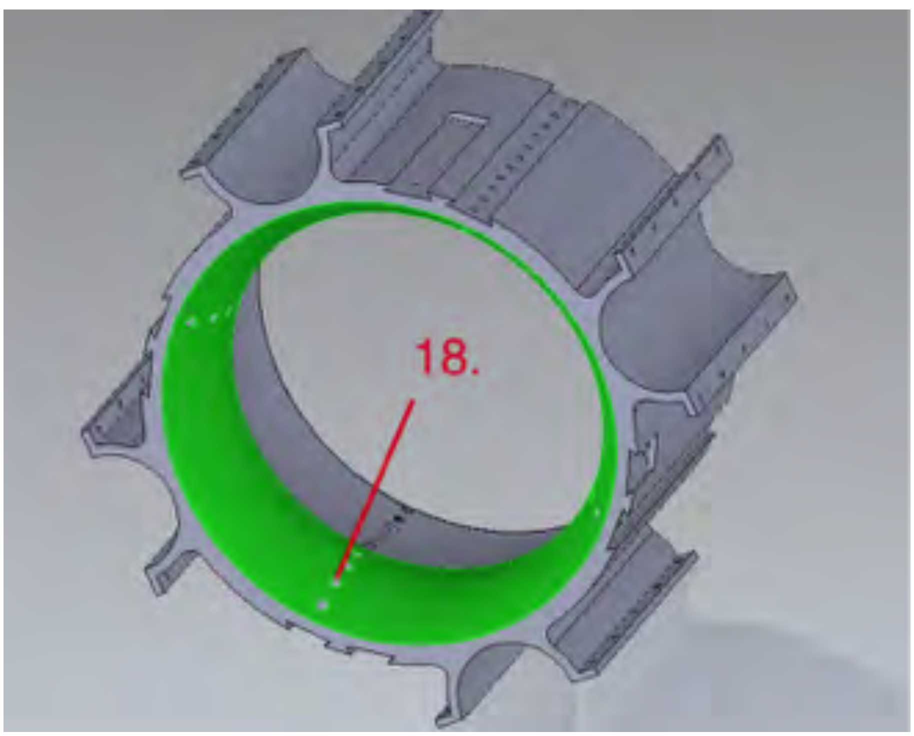
[0100] We have presented a device designed to capture fish in an aquatic environment by way of a baler motion of moving a fish through the central channel of the device's chassis into a containment unit.

[0101] Figure 1: Robot with rim driven propeller showing flow and direction of harvesting fish as the device moves forward

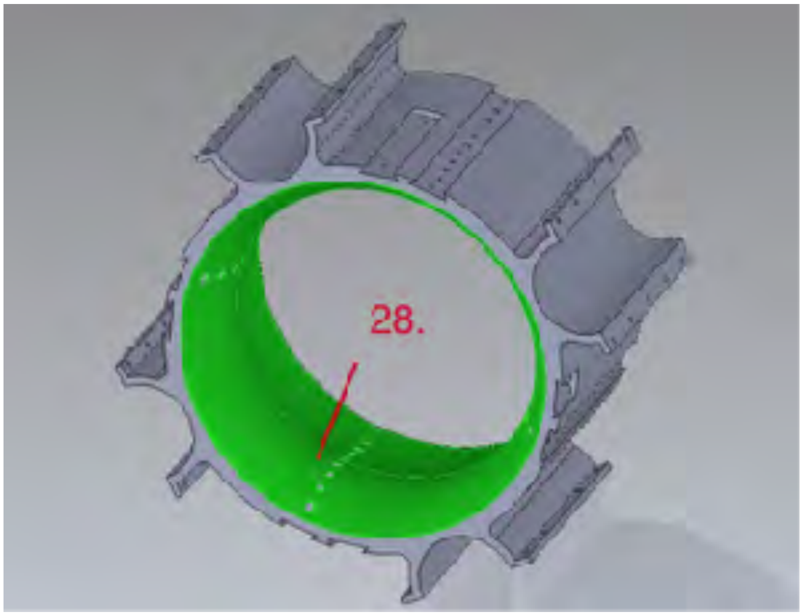


[0102] Figure 2: Robot with rim driven propeller

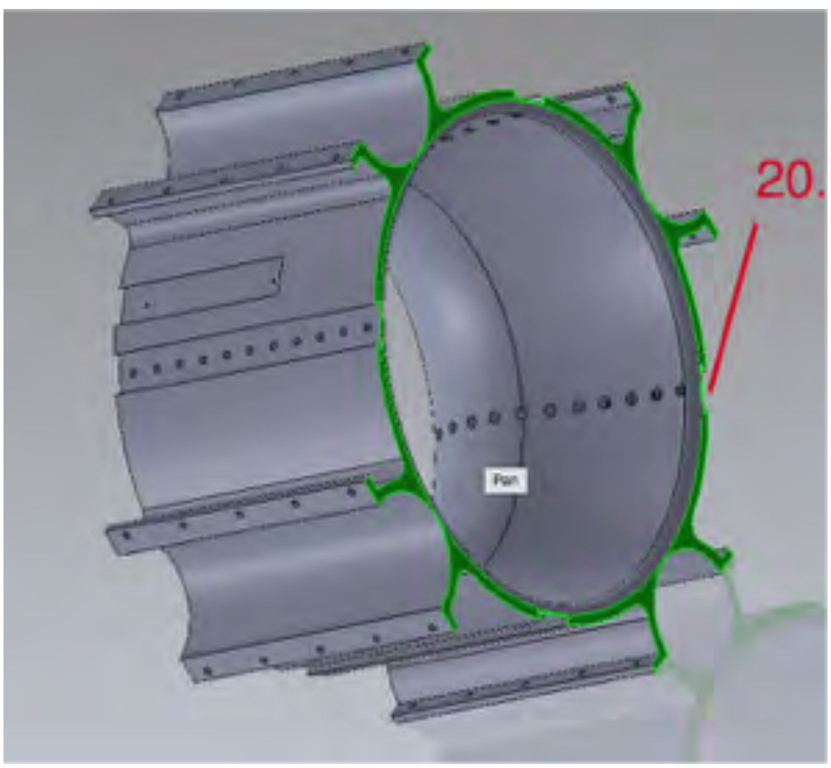
[0103] Figure 3: Drawing of chassis showing the rim labeled on the chassis, where the rim driven propeller can be mounted.



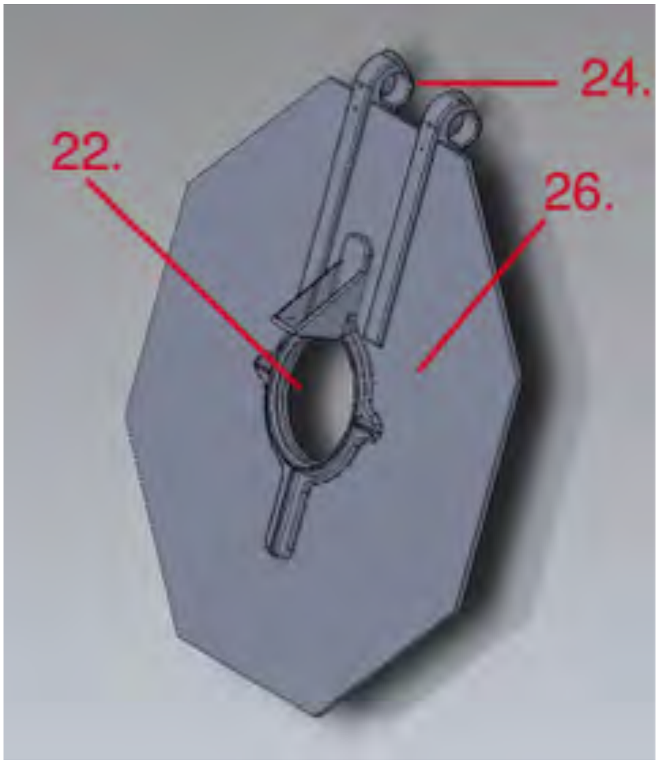
[0104] Figure 4: Drawing of chassis showing the interior of the device.



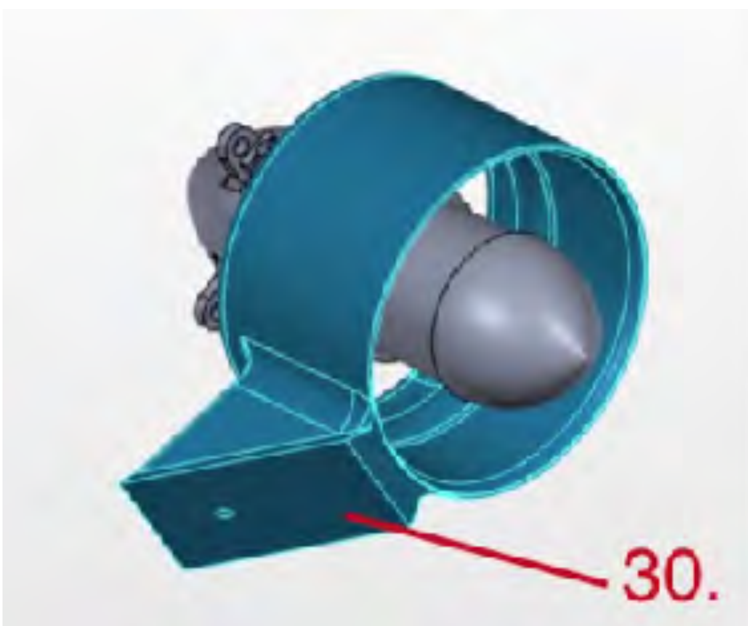
[0105] Figure 5: Drawing showing the rear rim of the device, to which a flap can be attached. The flap closes when the mounted thruster is active as the thruster pulls the flap closed and pulls water into the device.



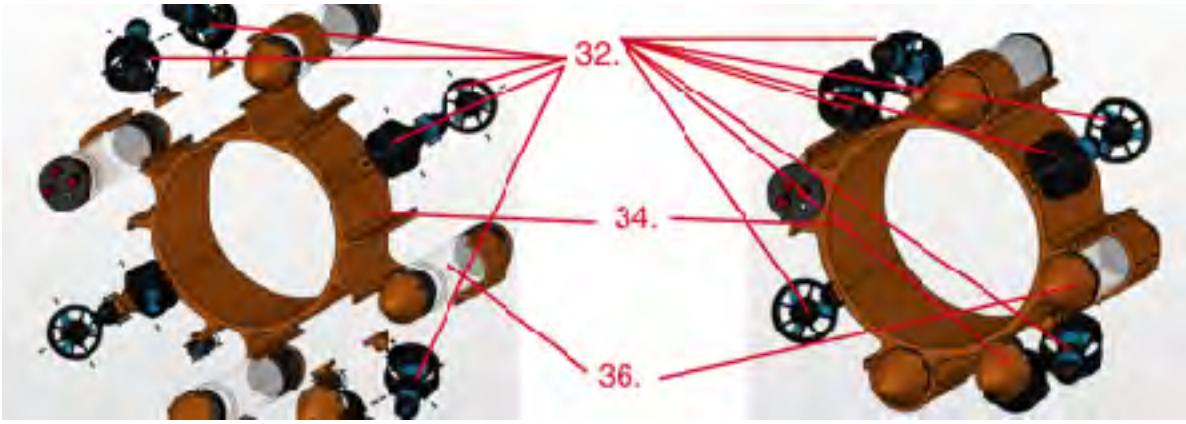
[0106] Figure 6: Drawing of a flap, to be attached to the exit face of the device.



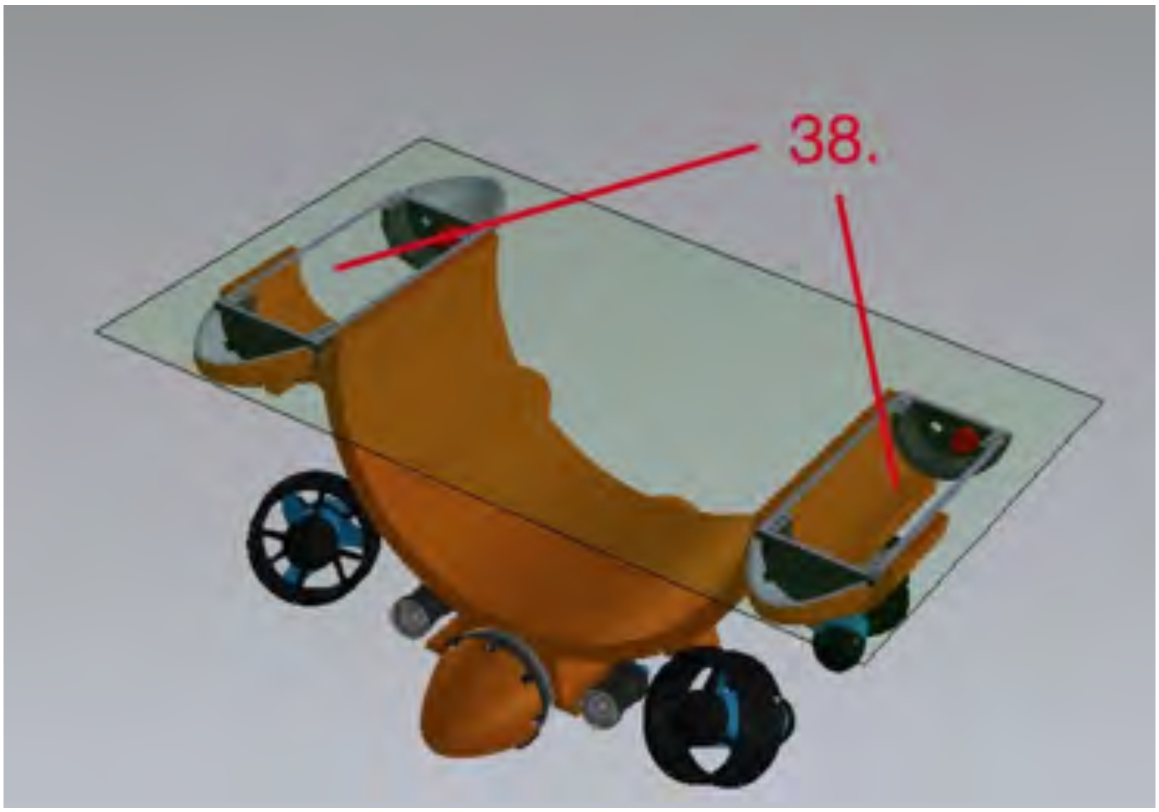
[0107] Figure 7: Example of thruster body with angled dovetail mounting interface.



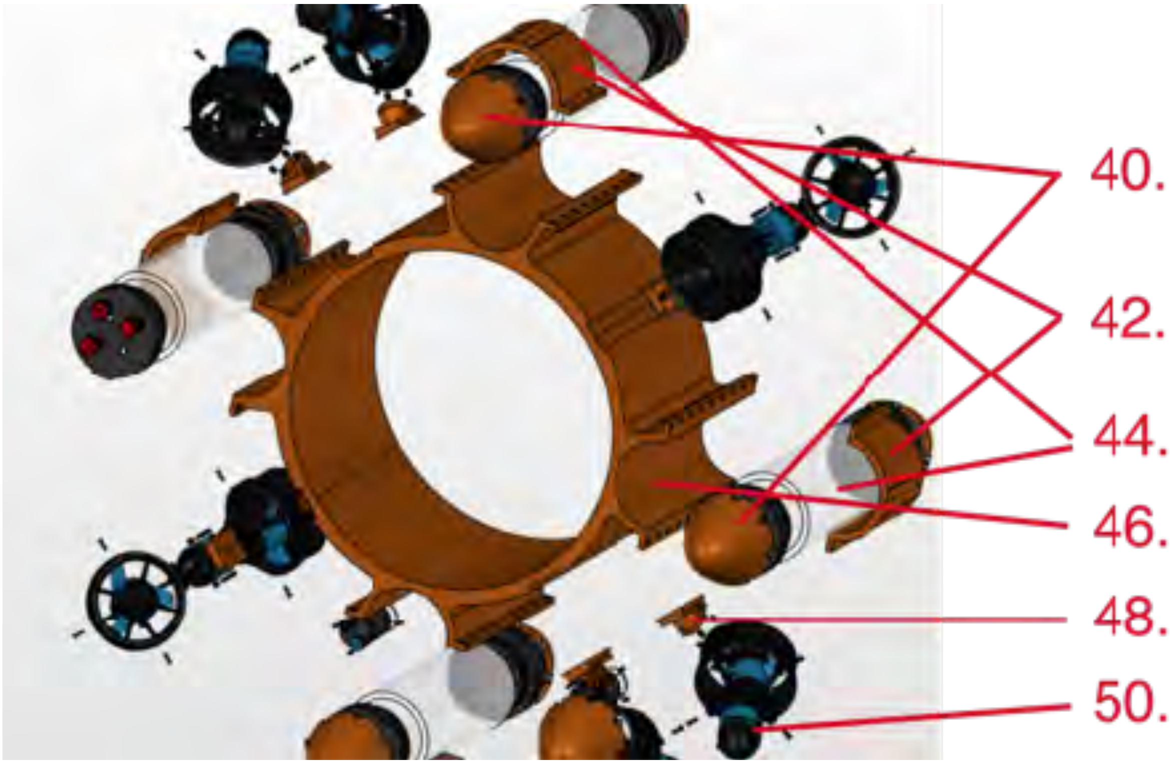
[0108] Figure 8: Comparison of exploded and composted views, some large components identified across views



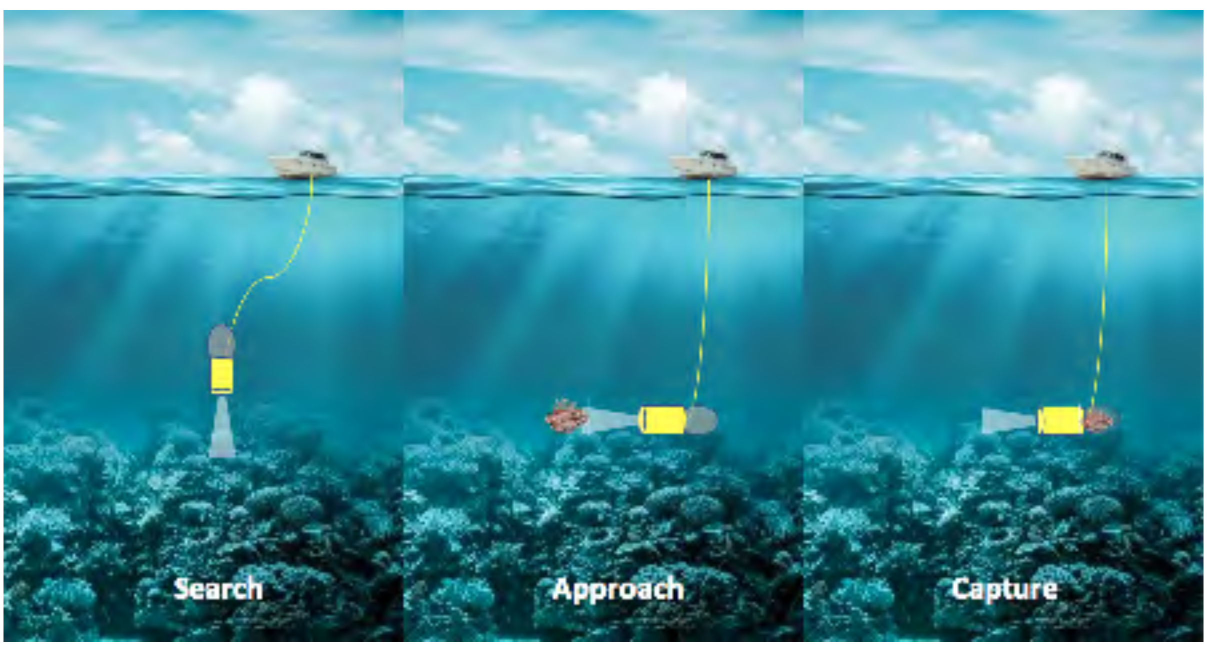
[0109] Figure 9: Planar slice of the device, showing battery containers.



[0110] Figure 10: Exploded view of device, with some smaller components identified



[0111] Figure 11: Operational concept of robot



[0112] Figure 12: Example of cage containment unit

[0113] Figure 13: Example of containment sleeve netting (Source: Pursell Manufacturing)

[0114] ABSTRACT

[0115] A hydrodynamic and modular robotic system for selective fish harvest by a remote or autonomous operator is implemented via a system utilizing a cylindrical chassis and optional rim driven or rear mounted ingestion propellers, equiangular arrays of thrusters about the chassis exterior, a control tether connected to an operator at the surface, and battery and electronics containment units mounted to the chassis exterior. It generates minimal drag in forward motion and facilitates continuous ingestion of targeted specimen in front of it into a rear mounted containment unit, all while reducing operational hazard to human operators. The modularity of the system facilitates high maintainability and enables rapid in-field modification to meet dynamic operational requirements. Its digital control platform and agility provides a platform for fully autonomous harvest, reducing error, risk and costs associated with human operation.

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Version 3, 29 June 2007

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