

# Edge-AI Enabled bionic Turtle for under Ocean research studies

We developed these for Ocean research related studies, First study the Ocean and then teach about it !

## Component Specifications & Functions

### 1. Propulsion System (6 Thrusters):

- **Recommended:** 3× M080 underwater thrusters @ 24V system
- **Thrust:** 6.6 kg forward each = 20 (19.8) kg total forward thrust
- **Configuration:** 2 horizontal ( yaw/roll ), 1 vertical ( Forward-backward )
- **Depth rated:** 300m+, fully flooded design (water-cooled, no shaft seals needed)
- **ESC:** 30A continuous per channel with PWM signal compatibility

### 2. Sensor Suite (Ocean Research Package):

Sensor	Function	Depth Rating	Research Application
HD Low-Light Camera (1080p)	Visual biodiversity surveys	300m+	Coral species ID, fish counts
Depth/Temp (Bar30)	Environmental profiling	300m	Thermocline mapping, pressure verification
IMU 6-DOF + Compass	Orientation/navigation	300m	SLAM-based autonomous navigation
pH Probe (optional)	Acidification monitoring	300m	Coral stress indicator
Conductivity/Salinity	Water mass identification	300m	Halocline detection, stratification
Fluorometer	Chlorophyll-a mapping	300m	Primary productivity baseline
Dissolved Oxygen	Hypoxia detection	300m	Biogeochemical cycling
Hydrophone (optional)	Marine soundscape	300m	Fish vocalization, whale migration
3D Scanning Sonar	Obstacle avoidance + mapping	300m	Autonomous navigation, structure quantification

### 3. Power System (Critical for Depth Operations):

- **Battery:** 24V LiFePO<sub>4</sub>, 15Ah nominal (360Wh total energy)
- **Chemistry choice:** LiFePO<sub>4</sub> superior to LiPo for underwater (thermal stability, cycle life)
- **BMS:** 100A management system with cell balancing + over-voltage protection
- **Thermal advantage at depth:** Enhanced cooling efficiency at 6 atm pressure = 10-15% efficiency gain
- **Expected mission duration:** 2-4 hours survey mode, 45-60 min full-thrust operation

- **Safe operating margin:** Limit missions to 25-30 minutes, maintain 20% battery reserve for return

#### 4. Control Architecture:

- **Master Controller:** ESP32-S3 (PWM thruster signals, basic sensor I2C/UART)
- **AI Processor:** Jetson Nano (real-time ML for fish species ID, coral bleaching detection)
- **Data Storage:** 256GB SSD (Jetson internal) for 4+ hour HD video + all sensor streams
- **Communication:**
  - Tethered mode: Hybrid ROV cable (4 twisted pair power + signal)
  - Recovery: Post-mission data download via dockable electronics enclosure

## Innovation, Feasibility & Impact Assessment

### Innovation (Why This Matters):

- **First deep-sea (150-200 ft) turtle-morphology AUV** with Jetson Nano edge AI for real-time biodiversity detection
- **Hybrid tether + autonomous operation** unprecedented in turtle-form factor
- **Mesophotic ecosystem monitoring** addresses gap in ocean observation (satellites can't see it, divers can't reach safely)
- **Patent potential:** Autonomous turtle-form deep-sea biodiversity mapping system

### Feasibility (Timeline & Cost):

- **Technical risk:** LOW (most components proven; sealing/AI are known challenges, well-mitigated)
- **Cost:** \$6,500-10,000 full system (\$3,000-5,000 for hackathon prototype entry)
- **Timeline:** 12-16 weeks design → testing → deployment
  - Phase 1 (PVC prototype): 3-4 weeks
  - Phase 2 (Aluminum test): 6-8 weeks
  - Phase 3 (Carbon fiber production): 12-16 weeks total
- **Scalability:** Design allows 10+ units at reduced per-unit cost (\$4,000 after first)

### Impact (Scientific & Societal):

- **Conservation:** Enables autonomous monitoring for Andaman coral reefs (world's 2nd largest ecosystem, currently undersurveyed)
- **Research publications:** 5-8 peer-reviewed papers on mesophotic biodiversity, coral bleaching detection, fish nursery mapping
- **Policy support:** Data for Indian government Coastal Zone Management, Marine Protected Area designation

- **Hackathon alignment:** Perfect fit for Atmanirbhar Bharat (indigenous technology, ocean conservation, Digital India initiative)
- **Market:** \$500K-1M annually (CZM monitoring contracts), \$50M+ aquaculture monitoring globally

## Recommended Implementation Roadmap

**Weeks 1-2:** Component sourcing (critical long-lead items: carbon fiber, thrusters, Jetson Nano)

**Weeks 3-4:** Phase 1 prototype assembly (PVC hull) + pressure testing

**Weeks 5-8:** Phase 2 prototype upgrade (aluminum) + 50 ft depth validation

**Weeks 9-12:** Phase 3 production system + AI vision model training

**Weeks 13-16:** Sea trials + sensor calibration + hackathon submission documentation

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## Understanding the Target Operating Environment (150-200 feet / 45-60 meters)

### Physical Ocean Parameters at Your Target Depth:

- **Pressure:** 5.4-6.0 atm (55-61 kPa gauge pressure)
- **Sunlight Penetration:** Minimal to no visible light (mesophotic/twilight zone)
- **Temperature:** 8-15°C (depending on latitude and season)
- **Salinity:** ~35 ppt (practical salinity units) with halocline variations
- **Visibility:** 5-20 meters (depending on water clarity)

This depth range (150-200 ft) is critical because it captures the **twilight/mesophotic zone** where coral reefs transition from sunlit ecosystems to deep-sea biodiversity. This zone hosts:

- **Vulnerable coral species** adapted to low light
- **Cryptic benthic fauna** invisible to surface monitoring
- **Fish nurseries** for juvenile populations
- **Thermal stratification zones** critical for ocean modeling
- **Deep-water biodiversity hotspots** requiring protection designation

## Microcontroller & Processing

Item	Supplier	Cost (USD)	Qty	Total	Lead Time	Notes
<b>ESP32-S3 Development Board</b>	Amazon / Aliexpress	\$15-25	2	\$30-50	1-2 weeks	2x for redundancy
<b>Jetson Nano Developer Kit</b>	NVIDIA Official / Reseller	\$100-150	1	\$100-150	1-3 weeks	For AI/vision processing
<b>ROV Autopilot (Navigator)</b>	Blue Robotics Store	\$150-200	1	\$150-200	1-2 weeks	Pre-configured IMU/compass/barometer

Item	Supplier	Cost (USD)	Qty	Total	Lead Time	Spec
<b>Carbon Fiber Fabric</b>	CompositesUK / Amazon	\$20/m <sup>2</sup>	1	\$50	1-2 weeks	3K plain weave, 200gsm
<b>Epoxy Resin (Marine)</b>	Wessex Resins / Amazon	\$40	1	\$40	1-2 weeks	WEST System G/Flex 650 or equivalent
<b>Acrylic Rod/Dome</b>	Online Industrial Supplier	\$80	1	\$80	2-3 weeks	Cast acrylic, 100mm diameter, 40mm thick
<b>Stainless Steel Rod (316)</b>	McMaster-Carr	\$50-70	2-3m	\$100	1 week	16mm diameter for frame
<b>Fiberglass Cloth</b>	CompositesOne / Local	\$15	1	\$15	1-2 weeks	Glass fiber reinforcement

## Sealing & Penetration

Item	Supplier	Cost (USD)	Qty	Total	Lead Time	Spec
<b>WetLink Penetrators</b>	Blue Robotics Store	\$12-25	8	\$96-200	1 week	Compression gland, 950m rated
<b>Viton O-Rings</b>	McMaster-Carr	\$1-3 ea	20	\$20-60	3-5 days	75 Shore A, various sizes
<b>Marine Epoxy (2-part)</b>	Home Depot / Amazon	\$15-25	2	\$30-50	1 week	G/Flex 650-K or equivalent
<b>Silicone Potting Compound</b>	Dow Corning supplier	\$40-60	1	\$40-60	2-3 weeks	1-2577 or equivalent
<b>Sikaflex 291</b>	Home Depot / Marine supply	\$12	2	\$24	1 week	Marine sealant, waterproof

The Robotic Turtle-2 designed for ocean research at 150-200 feet depth Will collect data focusing on biodiversity assessment, environmental parameters, spatial mapping, and optionally genetic molecular data.

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**Biodiversity Data (Critical)**

**Environmental Parameters (Critical)**

**Spatial Mapping (High Priority)**

**Genetic/Molecular Data (Optional Advanced)**

## **Robotics turtle has several valuable use cases:**

- 1. Mesophotic Coral Ecosystem Monitoring**
- 2. Fish Nursery and Habitat Mapping**
- 3. Ocean Acidification and Water Quality Assessment**
- 4. Autonomous Environmental DNA (eDNA) Sampling**
- 5. Marine Protected Area (MPA) Enforcement and Management**
- 6. Aquaculture Environmental Monitoring**
- 7. Scientific Research and Education**