



International Committee on
Global Navigation Satellite Systems



Development of Low Cost NavIC Based Environment Monitoring (NEMo) Drifters

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Indian Space Research Organisation (ISRO)

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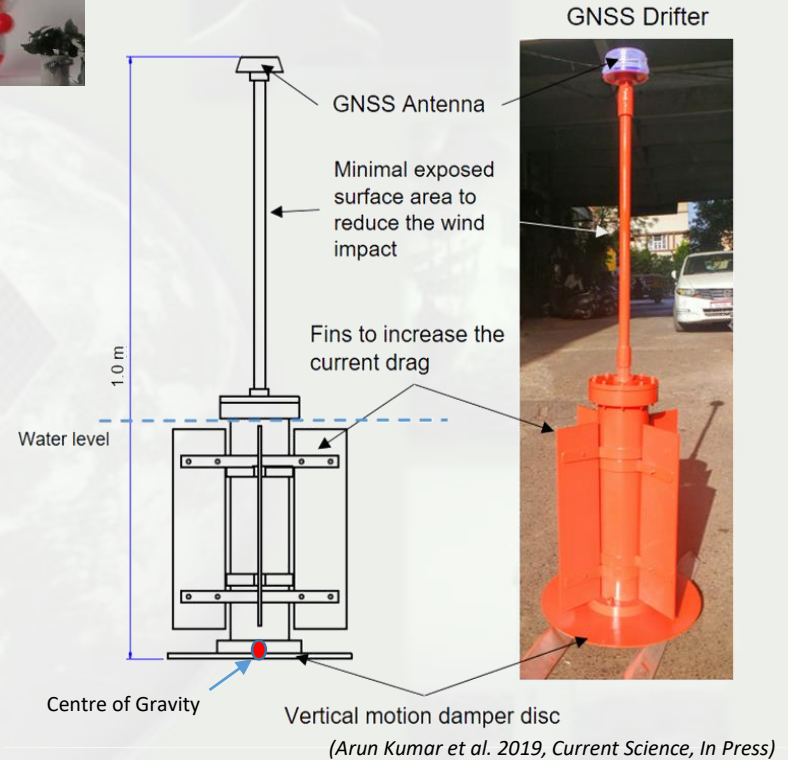
Why NEMO Drifters?

- **Coastal properties:** Extreme temporal and spatial variability.
- **Traditional Techniques:** Localised, Expensive and Risky
- **Available drifters:** Experimental and unavailable for purchase
- Commercial drifters costs more than US \$1 million each and have only GPS.
- Basic measurements of temperature, salinity, DO and pH – unavailable
- These parameters are key **Water quality indicators**.
- To monitor pollution in rivers, lagoons, beaches etc.
- More number of drifters required for detailed maps - Low cost!



Drifter designed @ ISRO

- ✓ Design was inspired from a **Roly-poly toy**.
- ✓ Drifter was made from off-the-shelf PVC parts and low-cost GNSS receiver (EMLID Reach®).
- ✓ GNSS receiver stores raw carrier phase and pseudo range internally from GPS, GLONASS, GALILEO, Beidou, SBAS etc.
- ✓ Flanges were introduced to increase the current drag and bottom circular disc to reduce the wave impact.
- ✓ Minimum surface area above sea surface to reduce the wind impact.
- ✓ Very simple design but efficient at sea..!
- ✓ Also attempted with the NavIC receiver.



Multi-GNSS Antenna



Emlid Reach® M Module

4GB Memory
Intel Edison Processor
Ublox receiver
WiFi, Bluetooth
USB powered

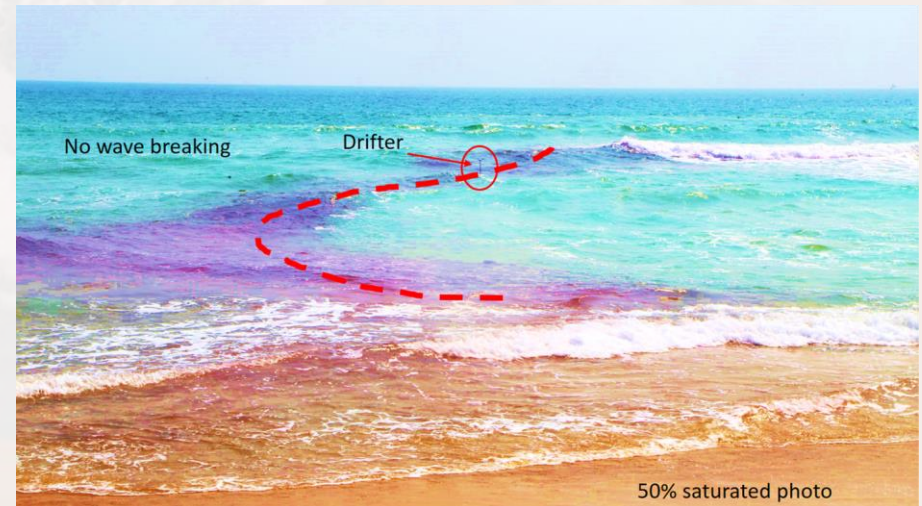
Experiments carried out



*RK Beach,
Visakhapatnam **one of
the dangerous sites of
Rip currents in India***

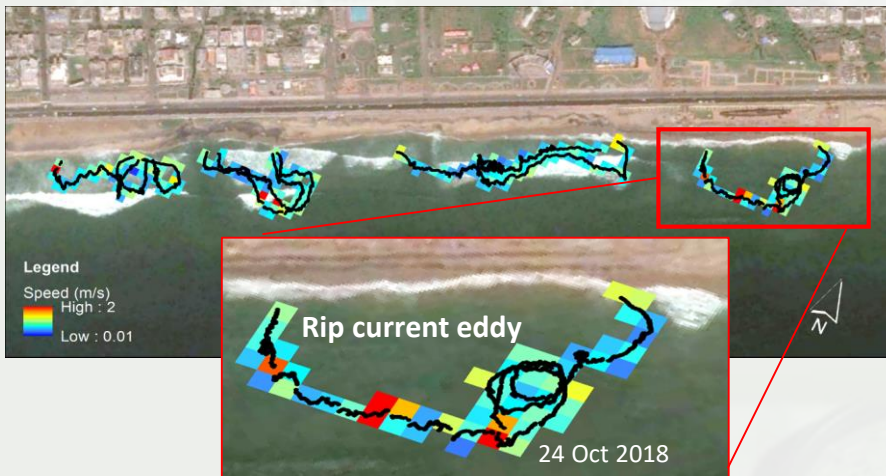


Professional Swimmer released the drifter
in mid surf zone

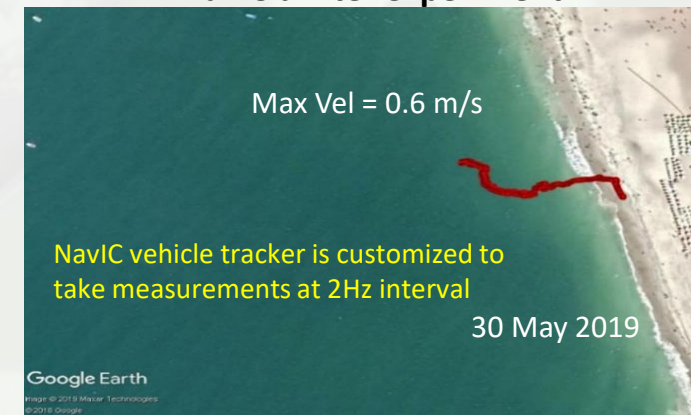


Rhodamine-B dye patch along with drifter
in the rip current

Rip current measurements from GNSS drifters



NavIC drifter experiment



Calangute, Goa

Hardware

- Low-cost multi-GNSS chip connected serially with a micro-controller to provide NMEA data.
- Low-cost pH, temperature, Dissolved oxygen (DO), conductivity (salinity) sensors
- Location and sensor data sent by Sim800 Module/ Satellite Terminal.
- DATA stored to microSD card
- Battery: 12V
- Electronics water-proofed in specially designed PVC enclosure (IP65/67)

Software

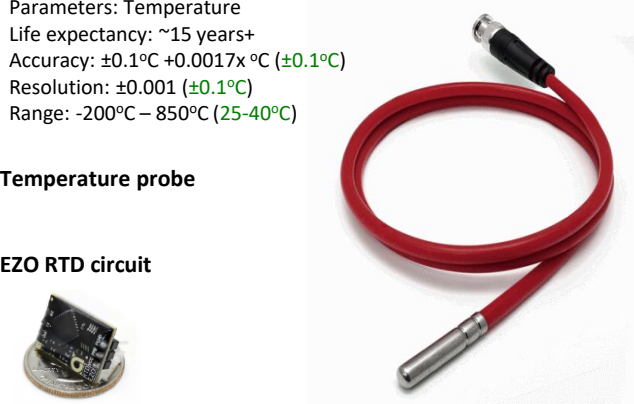
- Code: C++ (Arduino IDE).
- Sampling Frequency: 1 Hz.
- NMEA Data: Date & Time, Latitude, Longitude, Speed extracted and transferred via SPI protocol.
- Data sent via Sim800 when GSM network is available (5 s).
- Data sent via MSS satellite terminal when GSM network is lost/unavailable (1 min) - optional.
- Client application for real-time visualisation and data downloading.

Miniature Water quality sensors (Atlas Scientific®)

Parameters: Temperature
 Life expectancy: ~15 years+
 Accuracy: $\pm 0.1^{\circ}\text{C} + 0.0017^{\circ}\text{C} (\pm 0.1^{\circ}\text{C})$
 Resolution: $\pm 0.001 (\pm 0.1^{\circ}\text{C})$
 Range: $-200^{\circ}\text{C} - 850^{\circ}\text{C} (25-40^{\circ}\text{C})$

Temperature probe

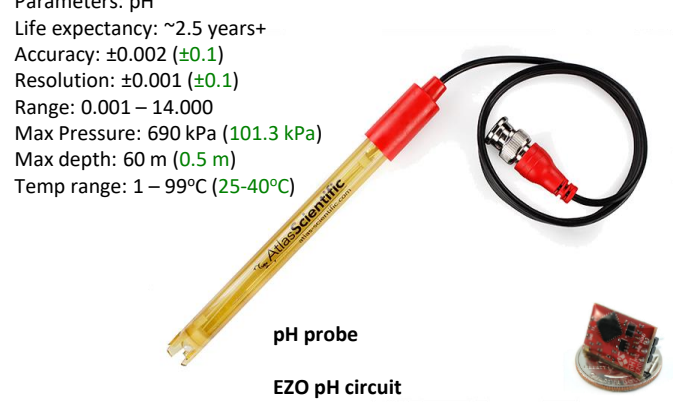
EZO RTD circuit



Parameters: pH
 Life expectancy: ~2.5 years+
 Accuracy: $\pm 0.002 (\pm 0.1)$
 Resolution: $\pm 0.001 (\pm 0.1)$
 Range: 0.001 – 14.000
 Max Pressure: 690 kPa (101.3 kPa)
 Max depth: 60 m (0.5 m)
 Temp range: $1 - 99^{\circ}\text{C} (25-40^{\circ}\text{C})$

pH probe

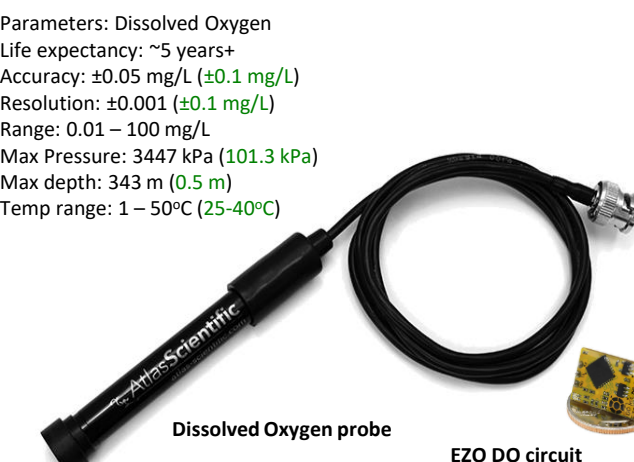
EZO pH circuit



Parameters: Dissolved Oxygen
 Life expectancy: ~5 years+
 Accuracy: $\pm 0.05 \text{ mg/L} (\pm 0.1 \text{ mg/L})$
 Resolution: $\pm 0.001 (\pm 0.1 \text{ mg/L})$
 Range: 0.01 – 100 mg/L
 Max Pressure: 3447 kPa (101.3 kPa)
 Max depth: 343 m (0.5 m)
 Temp range: $1 - 50^{\circ}\text{C} (25-40^{\circ}\text{C})$

Dissolved Oxygen probe

EZO DO circuit

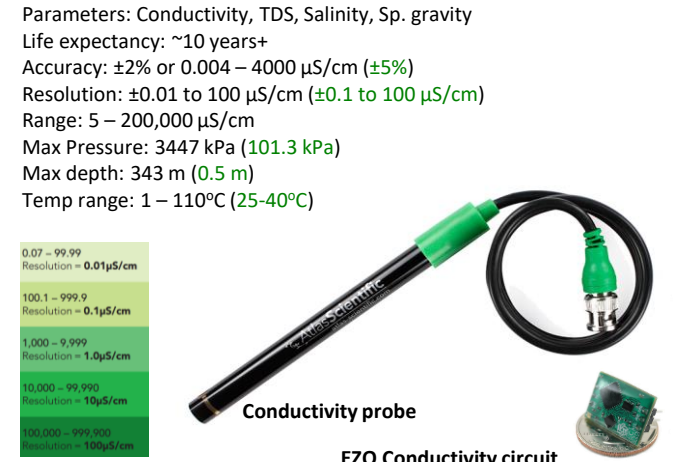


Parameters: Conductivity, TDS, Salinity, Sp. gravity
 Life expectancy: ~10 years+
 Accuracy: $\pm 2\%$ or $0.004 - 4000 \mu\text{S/cm} (\pm 5\%)$
 Resolution: ± 0.01 to $100 \mu\text{S/cm} (\pm 0.1$ to $100 \mu\text{S/cm})$
 Range: 5 – 200,000 $\mu\text{S/cm}$
 Max Pressure: 3447 kPa (101.3 kPa)
 Max depth: 343 m (0.5 m)
 Temp range: $1 - 110^{\circ}\text{C} (25-40^{\circ}\text{C})$

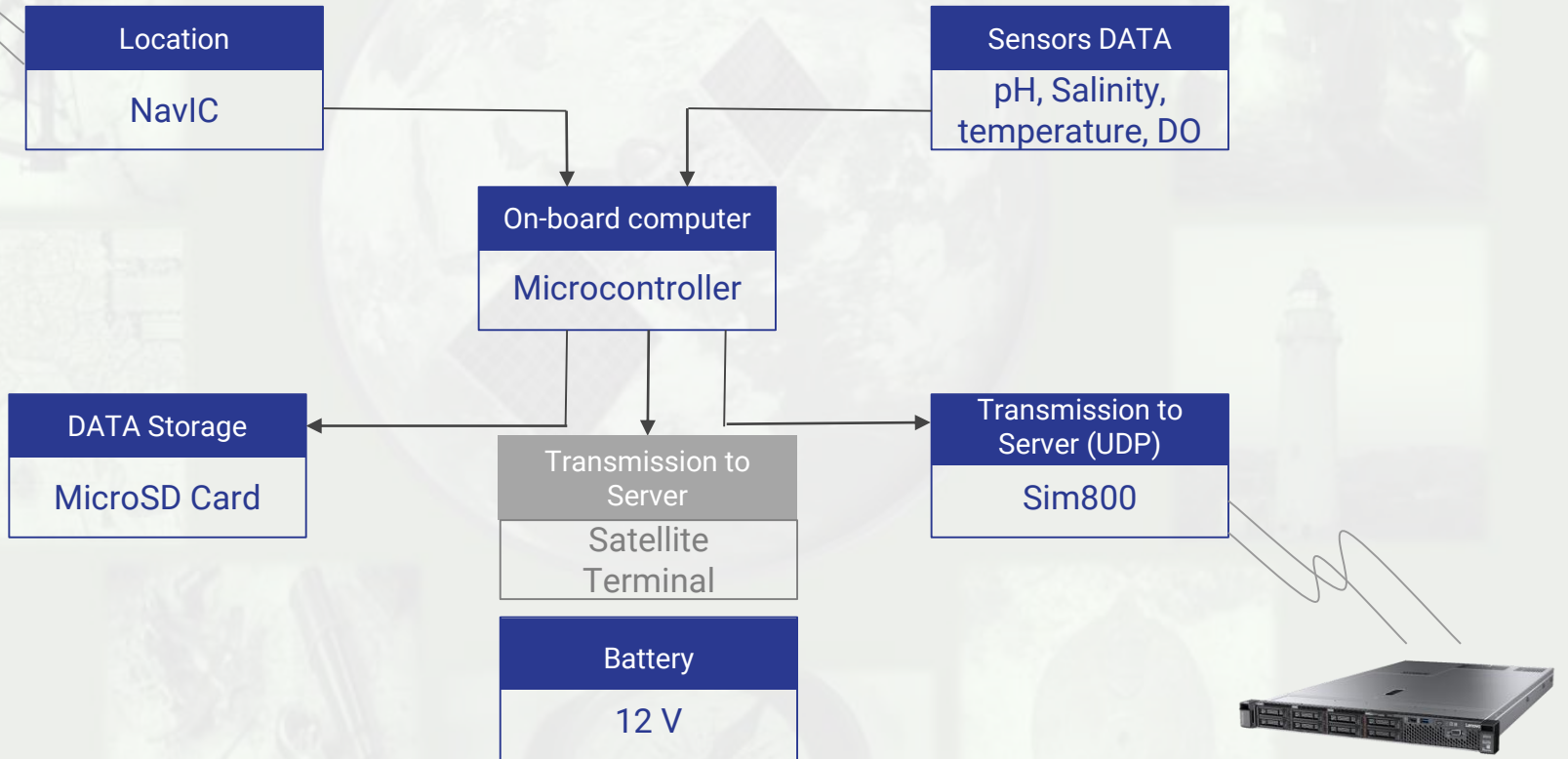
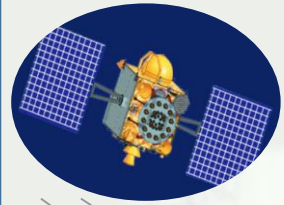
0.07 – 99.99	Resolution = 0.01 $\mu\text{S/cm}$
100.1 – 999.9	Resolution = 0.1 $\mu\text{S/cm}$
1,000 – 9,999	Resolution = 1.0 $\mu\text{S/cm}$
10,000 – 99,990	Resolution = 10 $\mu\text{S/cm}$
100,000 – 999,900	Resolution = 100 $\mu\text{S/cm}$

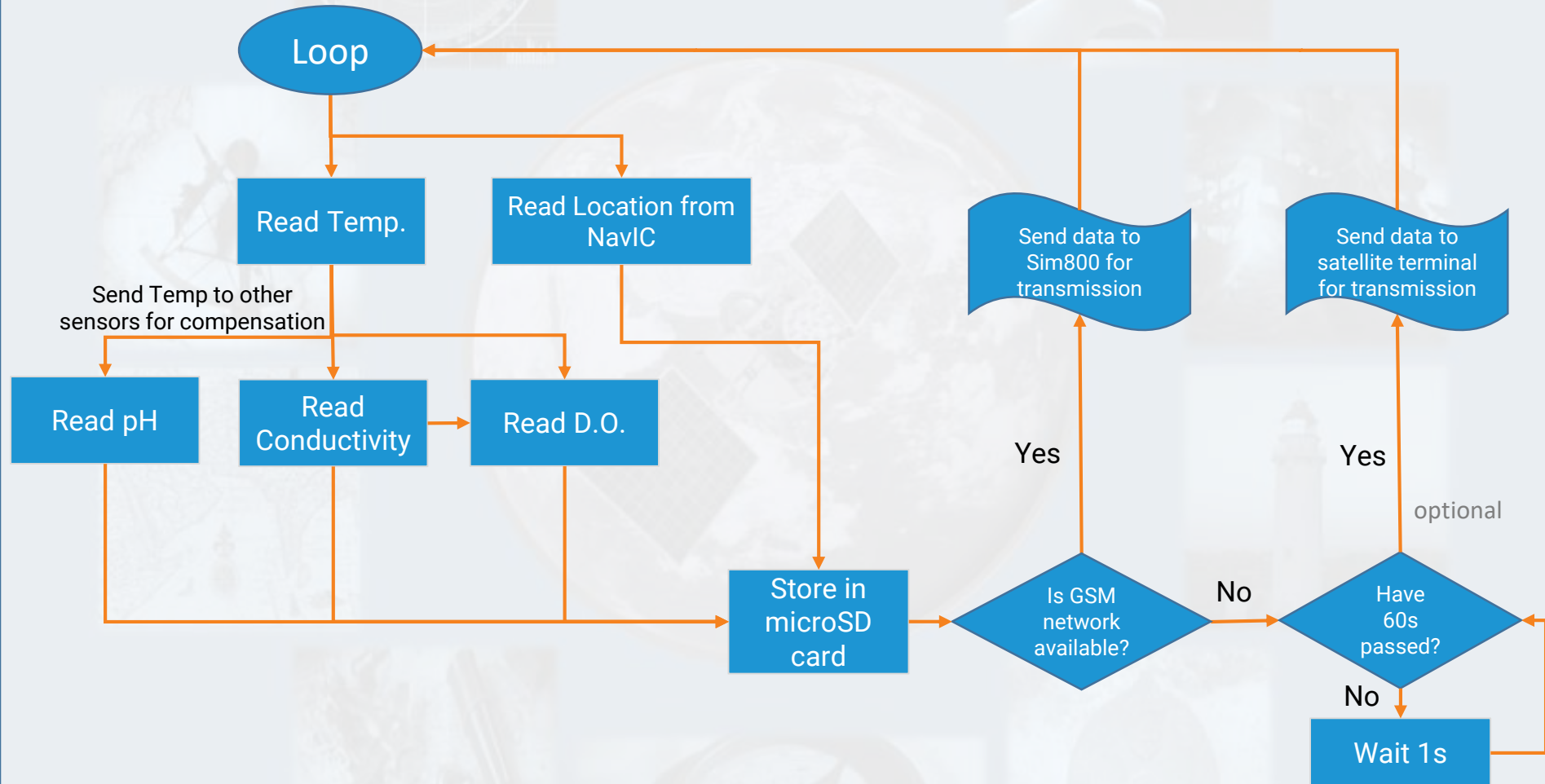
Conductivity probe

EZO Conductivity circuit

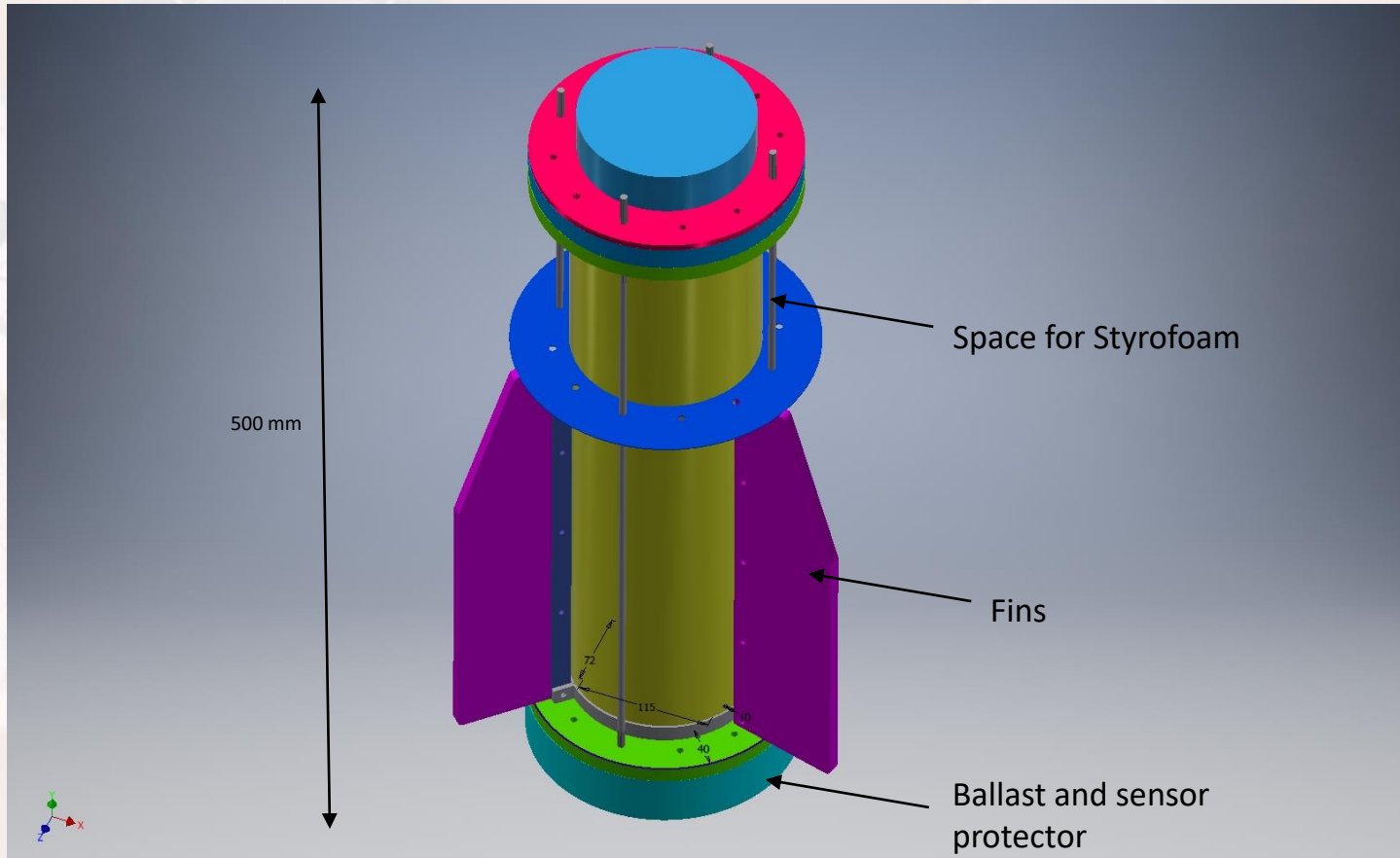


Drifter block diagram

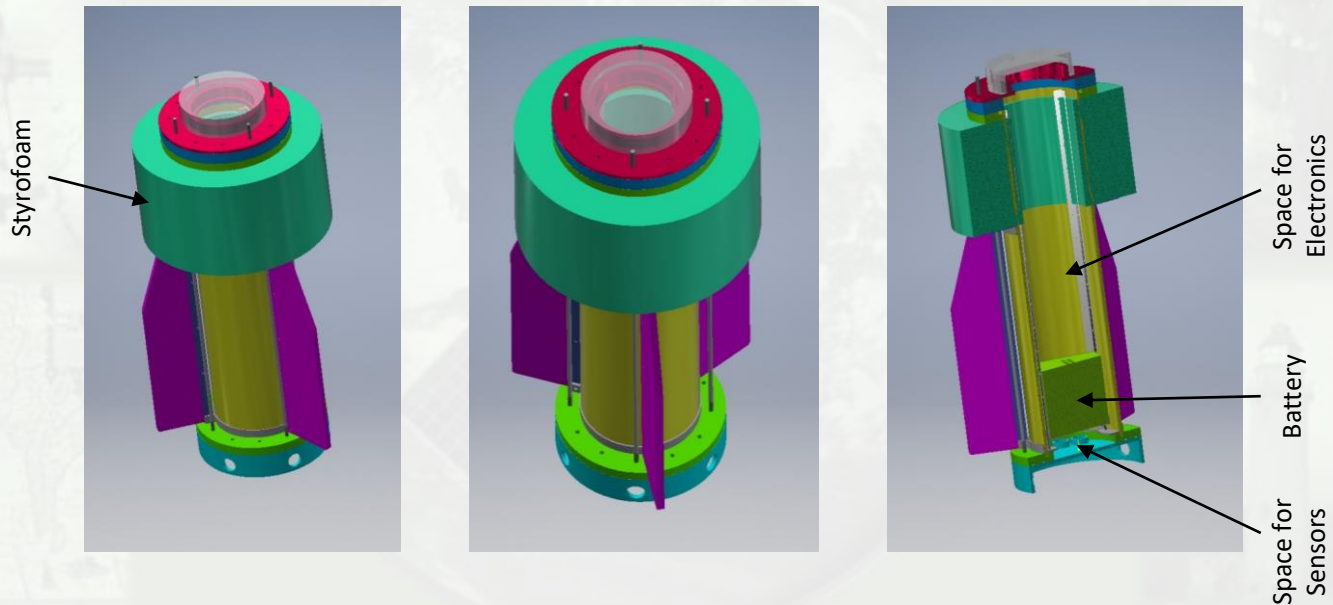




NEMo drifter (Side view)

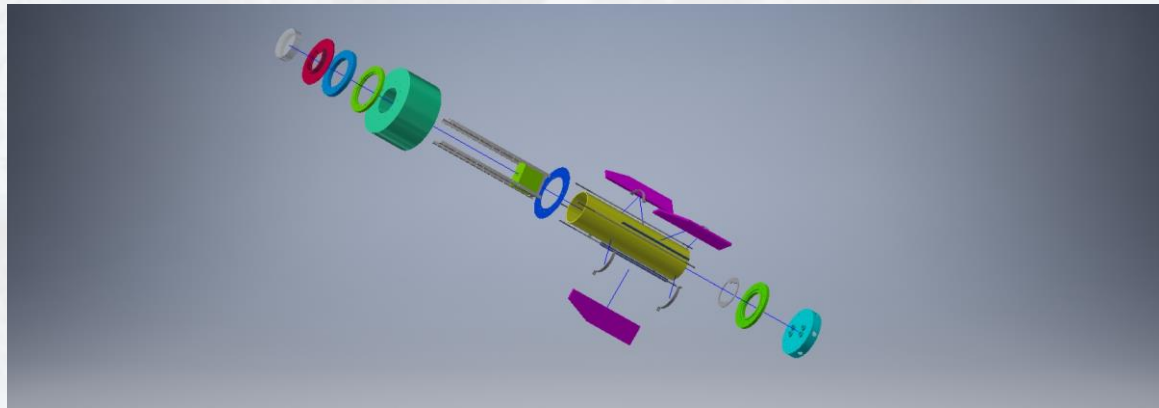
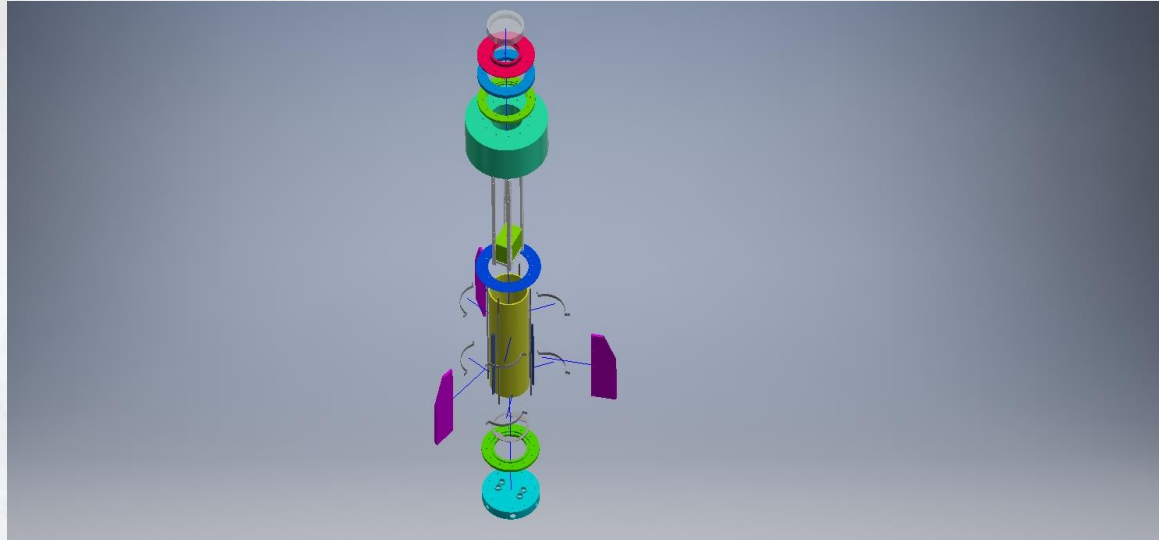


NEMo drifter (Different angles)

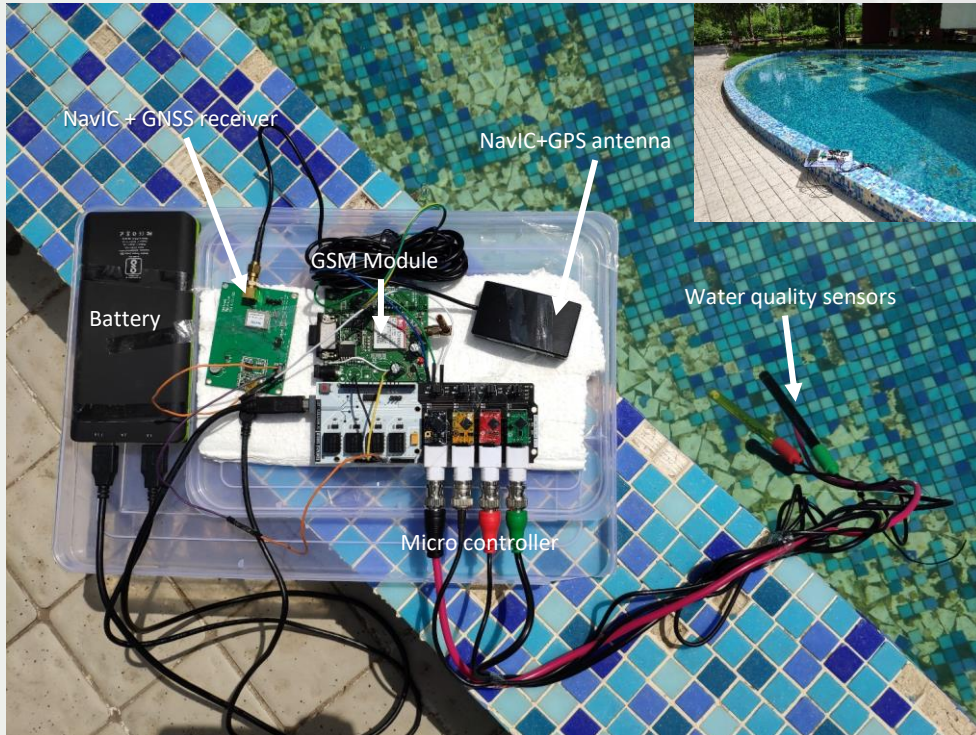


Styrofoam provides additional buoyancy and increases the stability of the drifter in high energetic environments.

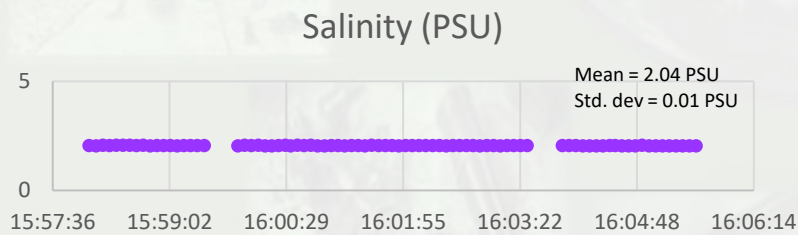
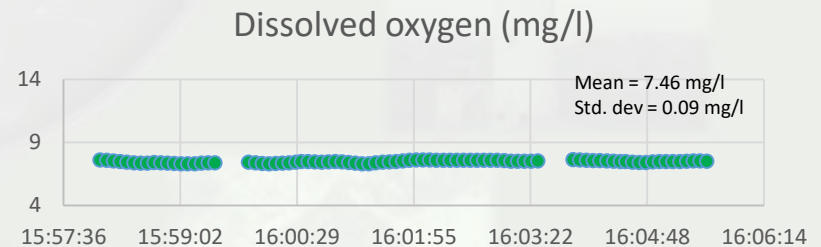
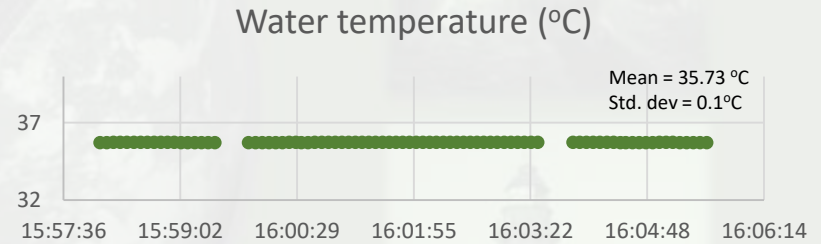
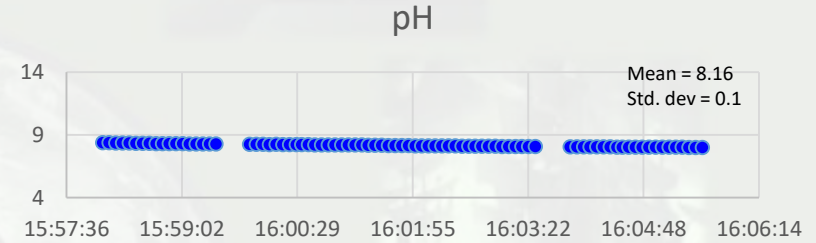
Drifter Exploded view



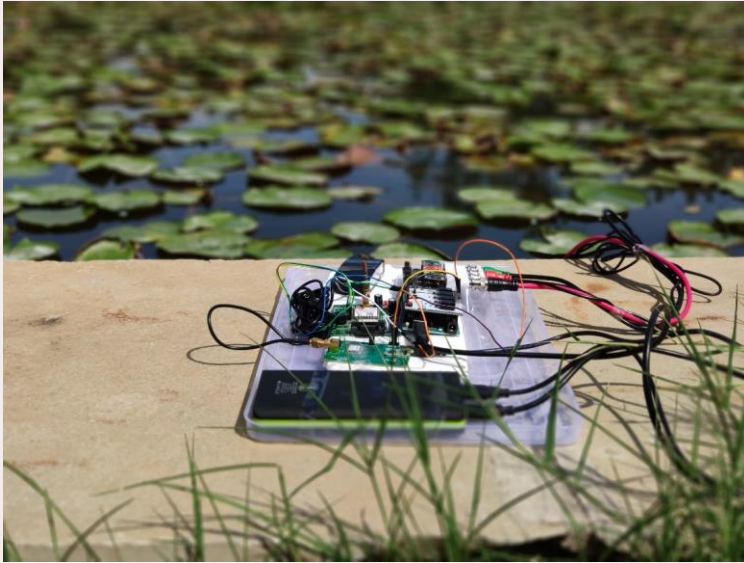
Modules testing



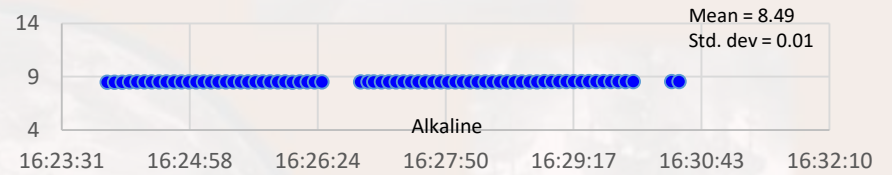
Vikram Hall Pool, SAC (Time series)



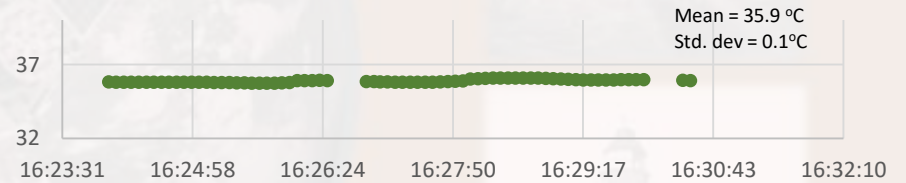
Lotus Pond, SAC (Time series)



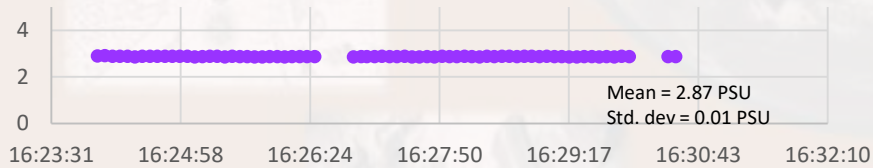
pH



Water Temperature (°C)



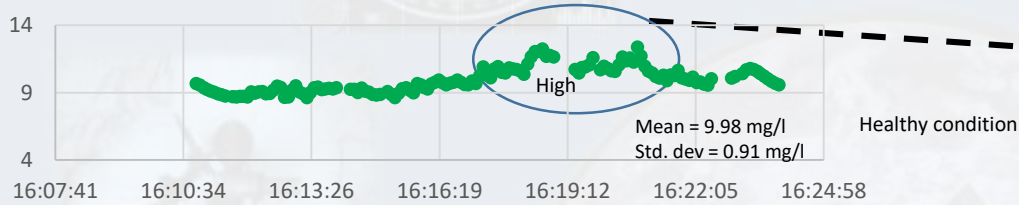
Salinity (PSU)



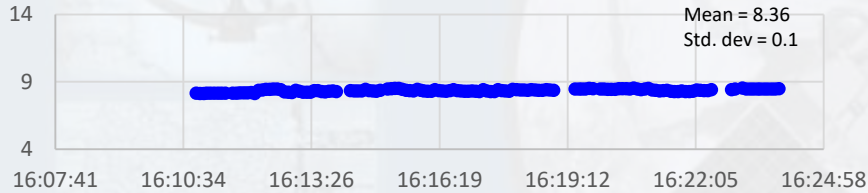
Dissolved Oxygen (mg/l)



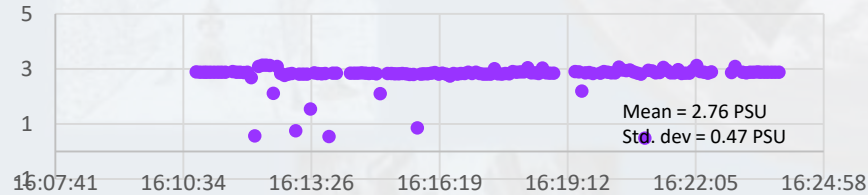
Dissolved Oxygen



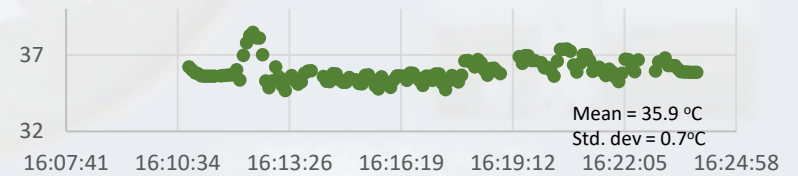
pH



Salinity



Water temperature

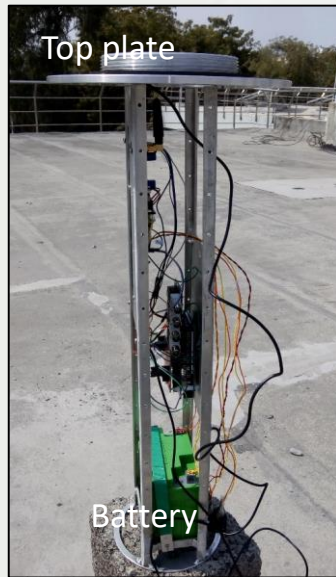


External and Internal view of NEMO drifter

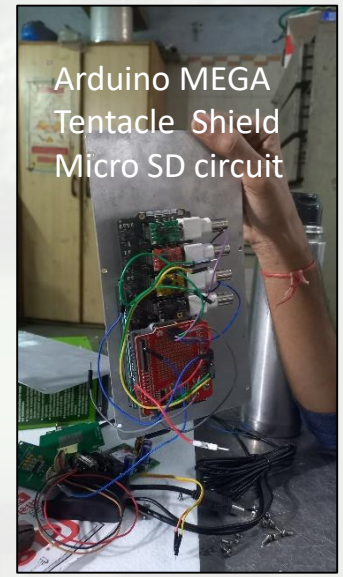
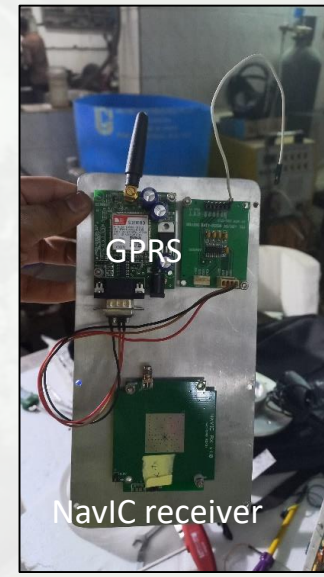


Drifter Side view

Circuit board cage



Top view



NEMO Drifter - Prototype



NEMo (NavIC based Environmental Monitoring) drifter

- Currents
- Temperature
- Salinity/Conductivity
- TDS
- Specific Gravity
- pH
- Dissolved Oxygen

06:24 58%

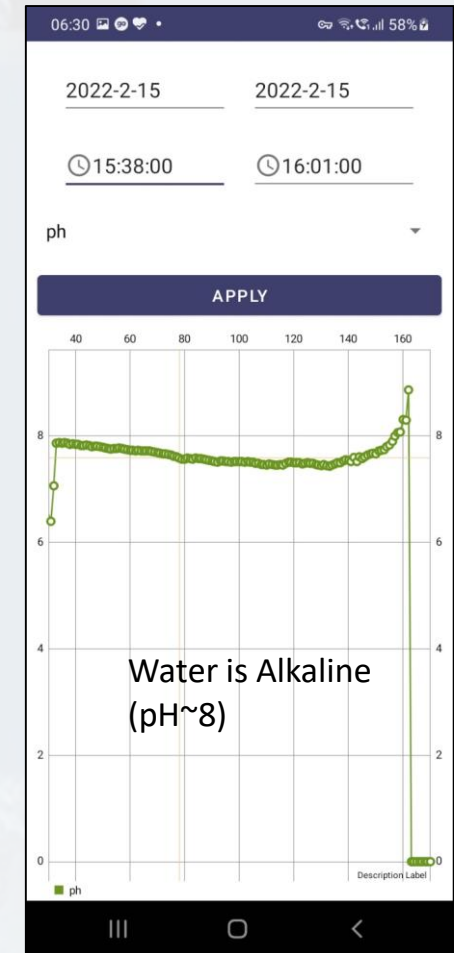
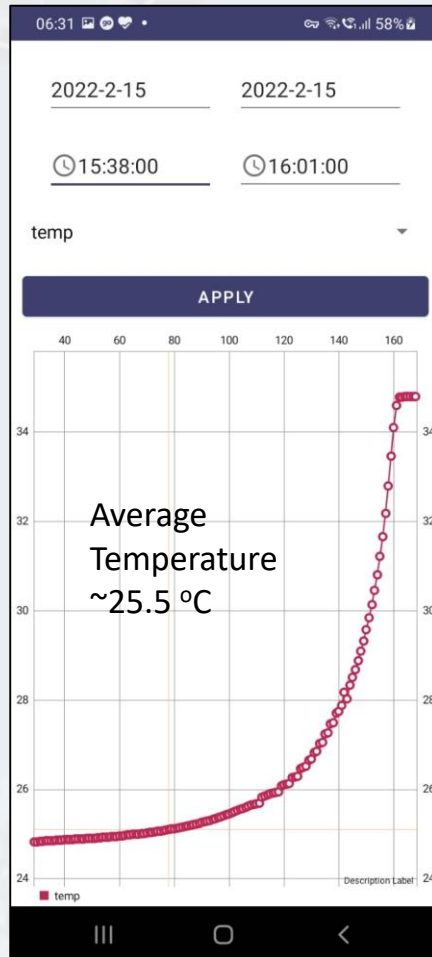
2022-2-15 2022-2-15

15:46:00 15:57:00

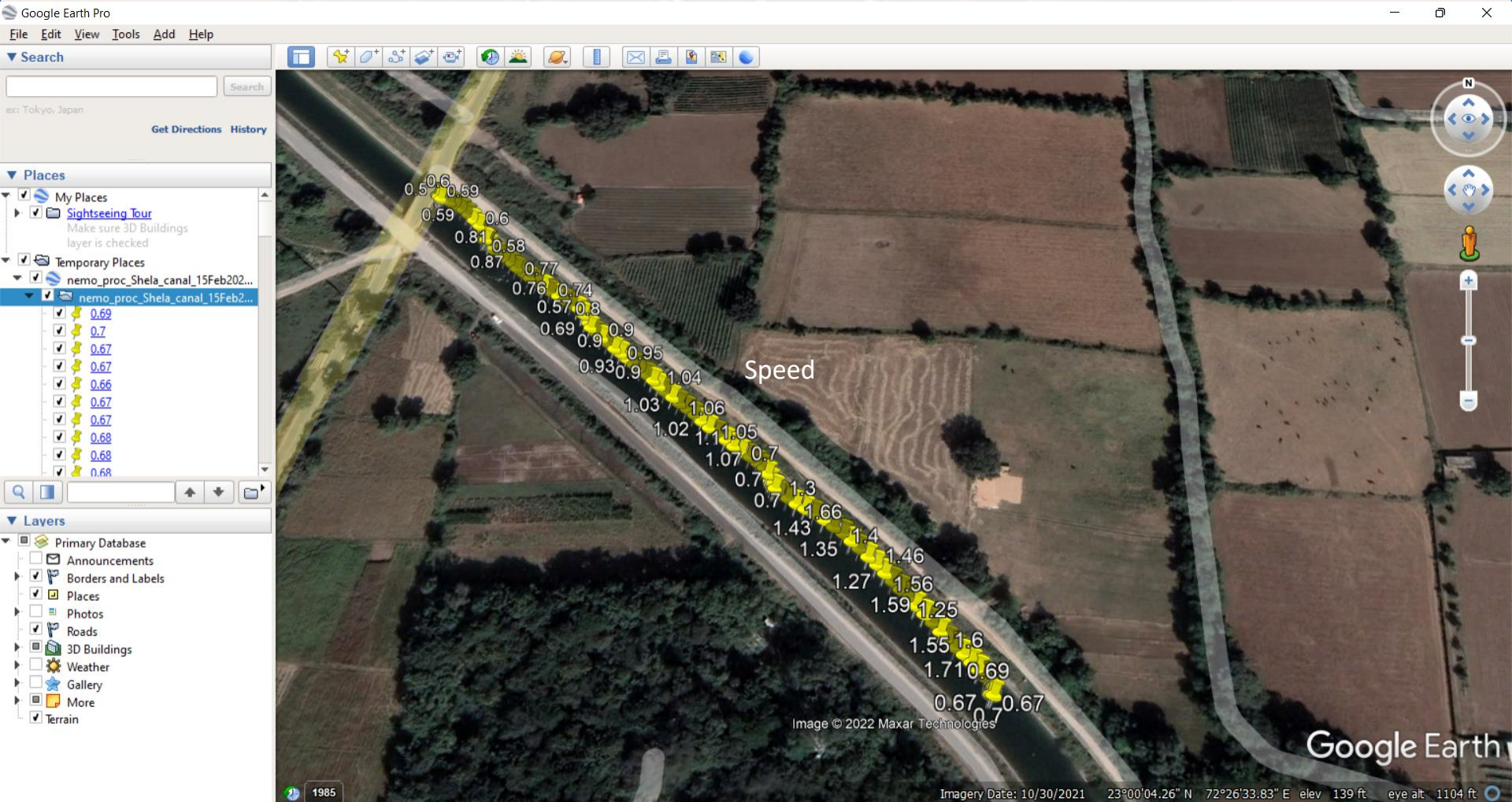
APPLY

Date/Time: 2022-02-15/15:52:04
 Temp: 25.630
 Ph: 7.479
 Ec: 162.700
 Tds: 88.000
 Sal: 0.000
 Sg: 1.000

SHELA

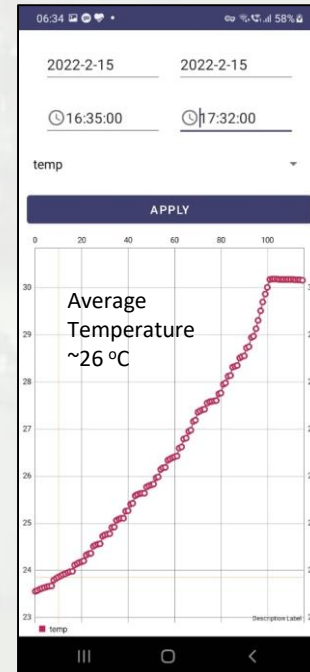
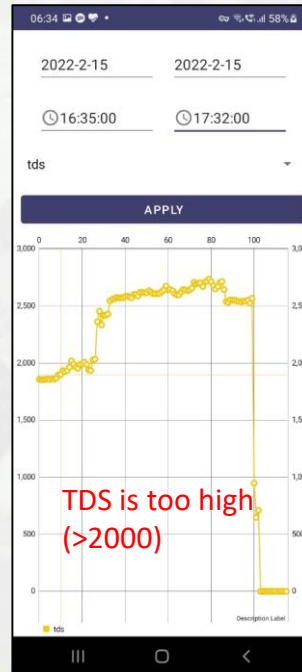
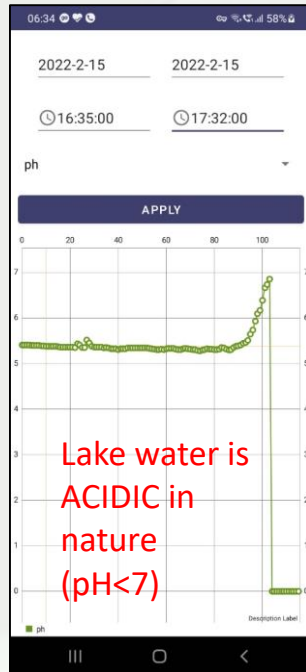



Variability in Water quality parameters

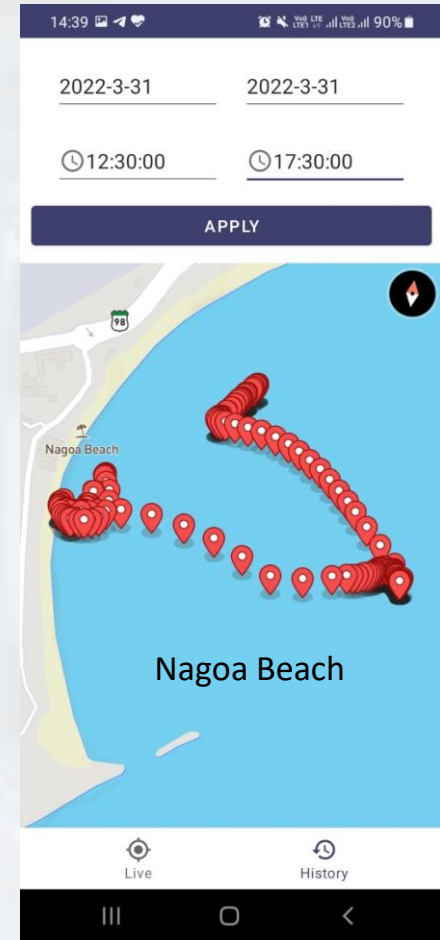
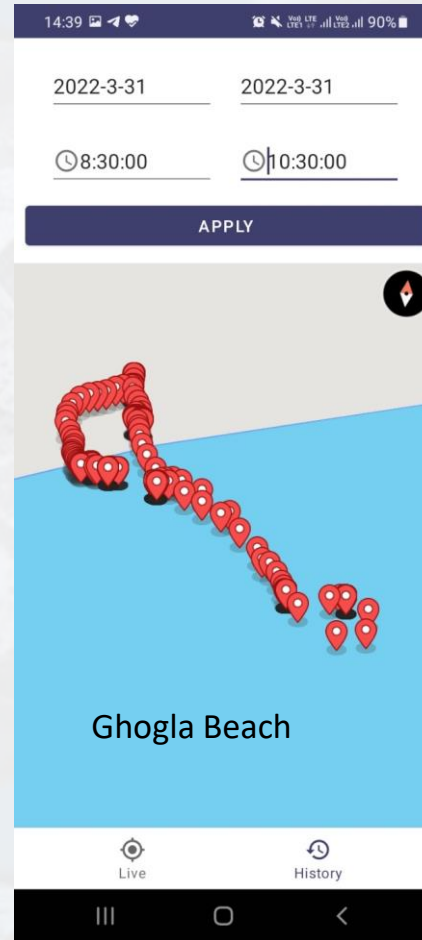
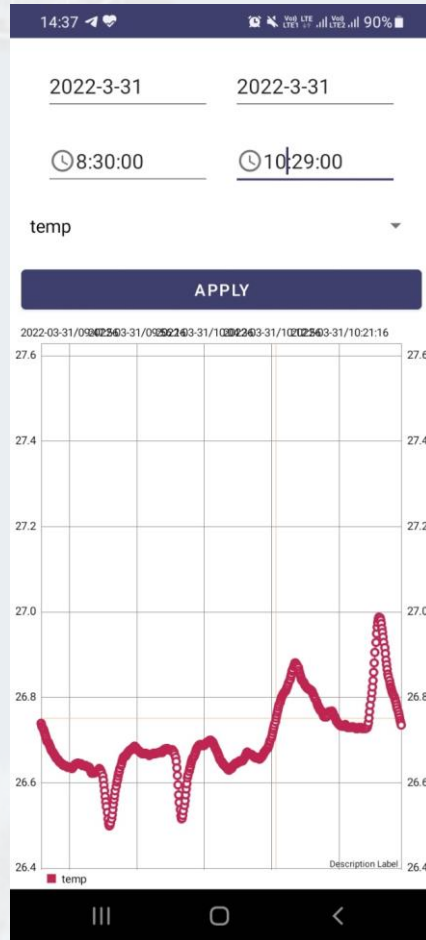


Field Site: Ghuma Lake

Visual observations: Water is greenish in colour, no odour, no flow



Testing in Beaches (Diu)



Testing in Beaches (Diu)

Testing in shallow water (beyond breaker zone)

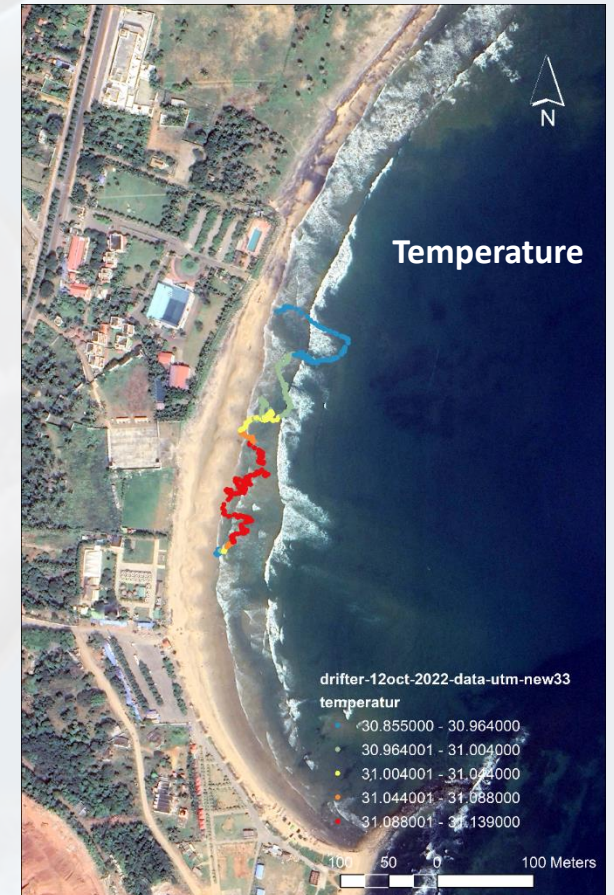
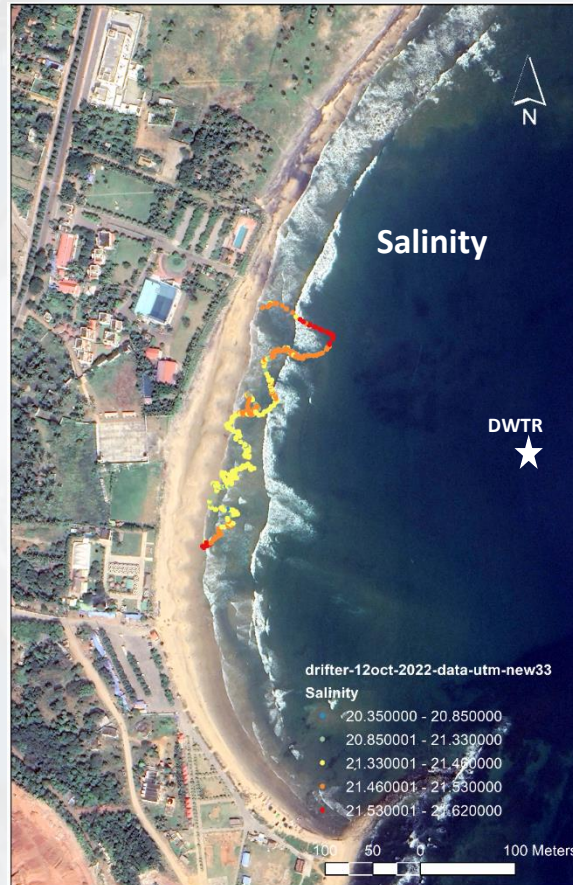
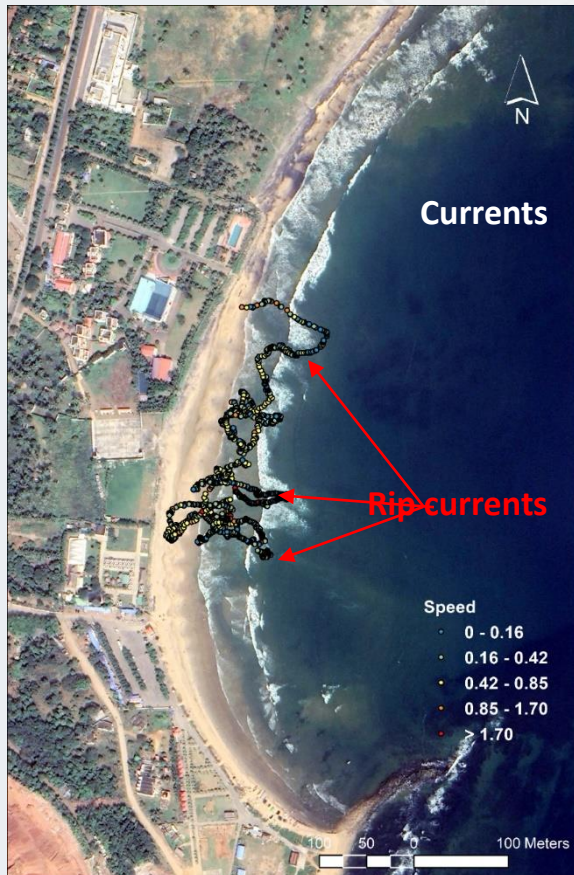


Testing in the Surf zone



NEMO Drifter Observations

12, 13, 19 Oct 2022



- ✓ Rip current dynamics (spatial & temporal structure)
- ✓ Search and Rescue
- ✓ Oil spill monitoring
- ✓ Bloom tracking
- ✓ Pollution dispersion monitoring in the surf zone
- ✓ Bathymetry mapping
- ✓ Nourishment effects
- ✓ River and estuarine flood monitoring
- ✓ Forensic investigation
- ✓ Military and Naval Coast Guard application

