Autonomous Marine Vehicles and their Applications in Operational Oceanography

EXPERIENCE IN BRAZILIAN WATERS

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• Founded in 2004, Prooceano is a Brazilian oceanographic company focused in coastal
and offshore environmental services and analysis.

• Spin off from ocean modeling research laboratories, it mainly works with the Oil & Gas
industry;

• Known as a technology-based company, Prooceano has participated and led Research
and Development projects financed by companies and institutions in close collaboration
with universities and national as well as foreign research institutes.

• Since 2012 Prooceano became the Brazilian branch of the CLS Group, a subsidiary of
the French Space Agency (CNES)
SERVICES

• Operational Oceanography;
  • Ocean Forecasts;
  • Action Planning for Marine Accidents Control/Prevention/Reduction;
  • Action Planning for Search and Rescue (SAR).

• Environmental Monitoring;

• Numerical Modeling and Data Analysis;

• Data Visualization and Integration;

• Environmental Risk Analysis;

• Research and Development.
SERVICES

NUMERICAL MODELING + ENVIRONMENTAL RISK ANALYSIS
SERVICES

OPERATIONAL OCEANOGRAPHY + ENVIRONMENTAL MONITORING

DRIFTERS

GLIDERS

PROFILERS
SERVICES

OPERATIONAL OCEANOGRAPHY
+
ENVIRONMENTAL MONITORING

CLASSICAL MOORING LINES
SERVICES

SPILLTRACK
Marine Accidents Control/Prevention/Reduction
Search and Rescue Modeling Report
18/10/2016

Incident: Test
Hydrodynamic Data: MyOcean
Wind Data: GFS/ECFC

Object characteristics
Coordinates: 22.39 345, 41.32 21W
Uncertainty diameter: 3
SRU: 1
Duration (h): 24
Incident time: 01/10/2016 09:00:00 GMT

Search Area
Search area (NMP): 12.78
Vertex A: 41.25 36W, 22.38 41S
Vertex B: 41.33 09W, 22.43 19S
Vertex C: 41.37 42W, 22.36 51S
Vertex D: 41.34 11W, 22.35 13S

SRU positioning
Search grid: Parallel
Cruise speed (kn): 12.00
Search speed (kn): 60.00
Distance to the search area (NM): 18.47
Time to reach search area: 9 min
Data and Time maximum to reach the search area: 01/10/2016 12:00:00 GMT
SRU Endurance: 6 hrs 0 min
SRU Endurance for search trajectory: 4 hrs 39 min

SEARCH POSSIBLE USING THE SPEED PROVIDED. SEARCH SPEED CANNOT BE LOWER THAN 4.71 KN

Number of legs: 5

Vertex coordinates of the SRU trajectory -- Distance, Azimuthal Direction
41.34 01W, 22.36 40S, 3.59 NM, 215.06
41.36 16W, 22.39 37S, 1.00 NM, 129.19
41.35 25W, 22.40 153, 3.59 NM, 35.06
41.33 11W, 22.37 18S, 1.00 NM, 129.19
41.32 21W, 22.37 56S, 3.59 NM, 215.06
41.34 39W, 22.40 53S, 1.00 NM, 129.19
41.33 44W, 22.41 31S, 3.59 NM, 35.06
41.31 31W, 22.38 34S, 1.00 NM, 129.19
41.39 40W, 22.39 12S, 3.59 NM, 215.06
41.32 54W, 22.42 09S

01/10/2016 06:25:44 GMT – Sunrise
01/10/2016 20:45:02 GMT – Sunset

Timeline (Hours passed after the incident)
01/10/2016 09:00:00 GMT – 00h – Component loss
01/10/2016 11:00:00 GMT – 2.0h – SRU departure
01/10/2016 11:00:00 GMT – 2.0h – SRU arrival at the search area
01/10/2016 11:31:00 GMT – 2.5h – End of search
01/10/2016 11:42:00 GMT – 2.7h – SRU arrival at Base
01/10/2016 16:00:00 GMT – 7.0h – End of endurance estimation
AUTONOMOUS VEHICLES

- Robots;

- Navigate (drive, fly, dive,…) with no permanent interaction with a human operator;

- Episodic communication with the operator to receive directives and transmit data;

- Payloads permit a variety of sensors depending on the application.
OPERATIONAL OCEANOGRAPHY APPLICATIONS

- Widen (change) sampling universe:
  - Longer campaigns;
  - None or fewer operational restriction due to sea state;
  - Real-time data transmissions;
  - Wider spatial and temporal.
Reduce vessel usage:

- Lower operation costs;
- Lower operation risks;
GLIDERS

200 m

1000 m
(PROOCEANO’s) EXPERIENCE IN BRAZILIAN WATERS

- PROJETO AZUL 1 [BG-Brasil]
- PROJETO AZUL 2 [Shell]
- PILOTO [PETROBRAS]
- PMPAS [PETROBRAS]
- SEAL [ExxonMobil]
Since March 2013;

50 accomplished missions;

Sampling: Temperature, Salinity, DO, Chlorophyll, Turbidity, Passive Acoustics.
• Longest mission: 139 days – more than 1000 dives and went through 1746 Km;

• Most used Glider: 11 missions

• 2568 sampling days.
OPERATIONAL OCEANOGRAPHY

- 39 transects [March/2013 to December/2014]
- 15 spring/summer transects;
- 25 autumn/winter transects;
- mean $\Delta t = 6.5$ days; max $\Delta t = 13$ days;

from: dos Santos et al. (2015)
OPERATIONAL OCEANOGRAPHY
SACW upper limit
$\sigma_0 < 25.7$ Mamayev [1975]

IAW upper limit
$\sigma_0 < 26.9$ Mémery et al. [2000]
OPERATIONAL OCEANOGRAPHY

h(it) - mean(h)

2013-OCT-21st

2014-OCT-20th

SACW IAW
OPERATIONAL OCEANOGRAPHY

2013-OCT-21\textsuperscript{st}

- Surface drift
- Discounted current
- SVP trajectories

Geostrophic Velocity (m/s)

depth (m)

OCT-3\textsuperscript{rd} - OCT-8\textsuperscript{th} - OCT-12\textsuperscript{th} - OCT-20\textsuperscript{th} - OCT-28\textsuperscript{th} - NOV-5\textsuperscript{th}
surface drift
discounted current
SVP trajectories
FIGURE 7
MSLA (left) and surface chlorophyll (right) maps from satellite at November 10, 2014, during a CFE event. Dashed lines represents the trajectory of an SVP drifter deployed in the eddy center. Glider route is represented by the dotted line from the black circle (November 4, 2014) to the black triangle (November 13, 2014).

FIGURE 8
From top-left to bottom-right, temperature, salinity, chlorophyll, optical scattering, dissolved oxygen, and CDOM vertical cross-section of CFE performed by a Projeto Azul glider from November 4 to 13, 2014. Distance traveled refers to the route described in Figure 7.
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Glider and profiler data assimilation into ROMS;

- 4D-Var

- 1/12° (~8 Km)

- March/2013 to March/2014

from: Fragoso et al. (2016)
PASSIVE ACOUSTICS

- Santos Basin Passive Acoustics Soundscape Monitoring Project;

\[ w = \frac{dz}{dt} \]

[\text{total velocity}]

[\text{u, v (navigation model + currents)}]
dos Santos et al. (ASA, 2016)
NEXT STEPS

- PROJETO AZUL II – ONGOING
- GLIDERS + ASV
  - Wave Measurements;
  - Improve Data Assimilation Skills;
  - Operational and Real-time full 3D Hydrodynamical Modeling with 4DVAR Data Assimilation for Santos Basin.
NEXT STEPS
OBRIGADO!