Utilization of the Bottom Stationed Ocean Profiler for West Florida Shelf Coastal Ocean Observing Applications

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Abstract

The Bottom Stationing Ocean Profiler (BSOP) is an autonomous, freely drifting, vertically profiling vehicle designed for applications on the continental shelf. By parking on the bottom in between profiles BSOP tends to maintain station under typical continental shelf conditions. Designed and developed by the University of South Florida's Center for Ocean Technology, BSOP carries sensors, collects, stores, and transmits data via a bi-directional satellite link, and may be reprogrammed in situ to alter mission objectives. During the past several years, extensive offshore use in a multitude of deployment scenarios has demonstrated the operational uses and limitations of the platform. BSOP performance characteristics and reliability illustrate the utility and importance of profiling vehicles for continental shelf applications as part of coastal ocean observing systems.

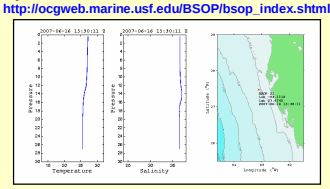
Funding Provided By:

Technical Background

Bottom Stationing Ocean Profiler, A Coastal Profiling Platform

- An autonomous coastal profiling vehicle
- Free drifting platform with station keeping by bottom rest between cycles
- Average deployment 20+ days, longest to date 55 days
- Drift rates for entire deployments typically one to five km
- Over 90 offshore deployments on West Florida Shelf
- Over 4400 data casts and 10,000 m of coastal water sampled over past 1.5 years at 10-25m per profile
- Over 95% recovery rate; GPS, RF, and acoustic location
- Bi-directional (near real-time) low cost satellite communications for data communications and mission parameter changes
- Ascent / descent rates @ up to ~0.8 m/s, fully controllable, hovering capable
- Expandable sensor packages
- Webpage updates hourly with data and GPS positions transmitted back from deployed units.

http://ocgweb.marine.usf.edu/BSOP/bsop_index.shtml

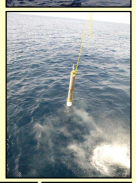


Specifications:

- Size: 8" Dia x 66" (+ antennas)
- Weight: ~ 90 lbs
- Power: 380 Whr (Lead Acid Battery Pack) or 800 Whr (NiMH Battery Pack)
- Deployment duration: 50-150 cycles - dependant upon battery pack and deployment parameters
- Storage: 128 kb expandable
- Low power sleep mode, <2 mA
- Up to 8 analog, unlimited serial inputs for sensors/payload
- Communications: ORBCOMM (standard), IRIDIUM
- Robust hydraulic buoyancy engine for controlled profiling
- RF beacon and acoustic pinger for retrievability
- ~ $20k + sensors to build
- Fleet: 15 profilers operational, 10-15 more being built

Standard Mission Synopsis

- Deployment, unit sinks to sea floor
- Internal alarm initiates mission, sensors are activated
- Buoyancy is adjusted, unit ascends at controlled rate
- Unit reaches the surface and establishes satellite communication, data and GPS fixes are transmitted and automatically posted to website (~15 min)
- Sensors activated, buoyancy adjusted for descent
- Profiler reaches the seafloor and shuts down until the next programmed wakeup
- Cycles continue until unit retrieved



Payloads / Sensors fully incorporated to date:

- CTDs (all BSOPs) - Falmouth, Applied Microsystems, RBR
- Fluorometers - Turner, WetLabs
- Dissolved Oxygen - Aanderaa
- USF's SEAS (High res. chemical sensor)
- USF's LARS (Passive acoustics)
- Mote Marine's BrevBuster

Other payloads deployed:

- YSI SONDE 6600
- Nortek ADCP
- Video

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Utilization Strategies and Results

2004 Time Series

- Deployments started on April 20 and continued through September 12
- Three locations 15m, 25m, 35m isobaths wee initially occupied (Figure 1)
- These were reduced to one location after one month (25m isobath)
- 141 of 145 continuous days of BSOPs in the field
- 5 profilers conducting a total of 12 missions
- No units lost
- Almost 950 vertical data casts
- Hurricane Charley (08-15-04) and TS Frances (04-07-04) both passed within 60 miles of deployed profilers (Figure 3)
- Average deployment ~40 cycles

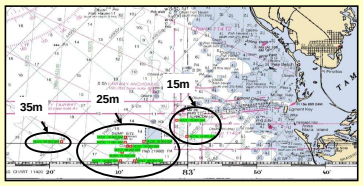


Figure 1: Locations of 2004 Time Series BSOP Deployments

The data collected in the summer of 2004 in the 25 m depth zone during the nearly five-month operational experiment (Figure 4) showed the spring transition from cool, well-mixed winter conditions, to warm, stratified spring conditions, to eventually depth uniform warmer summer conditions. Starting near the end of May, a very well developed thermocline was evident and as the summer progressed through July and early August, it deepened to about 20 meters depth. The well-defined stratification succumbed to rapid mixing with the passage of Hurricane Charley (08-14-05). By the middle of August, just after Hurricane Charley, conditions were very warm (29°C) and well mixed with no thermocline present. These extremely warm well-mixed conditions persisted through the end of August and the first few days of September until Tropical Storm Frances passed (09-05-04). With Frances, the entire water column cooled by surface heat flux. A sharp rebound in water temperatures then occurred by advection in response to downwelling favorable winds as the storm passed to the north.

Analysis and interpretation were aided by additional data provided by the COMPS buoy array. The C12 COMPS buoy provided wind velocity measurements for the entire BSOP deployment duration (Figure 2). Water column velocity measurements during this time assisted in the understanding the thermodynamics involved. Figure 5 shows the water velocity at nearby stations on the West Florida Shelf when Frances was at its closest position (5a) and after the storm had moved north of the Bay area (5b). These observations, in addition to heat flux information provided by BSOP and COMPS buoys indicate cooling of approximately 3°C as Tropical Storm Frances advanced across the inner shelf. This consequence primarily of surface heat flux quickly reversed itself after the storm tracked northward. The currents reversal to downwelling and subsequent warming of the water column was due primarily to ocean advection.

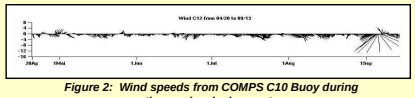


Figure 2: Wind speeds from COMPS C10 Buoy during time series deployments

Figure 3: Trajectories of H. Charlie and TS Francis relative to deployed BSOPs

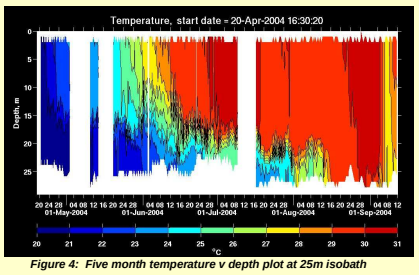
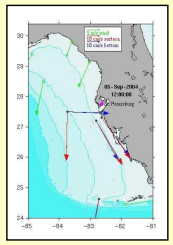


Figure 4: Five month temperature v depth plot at 25m isobath



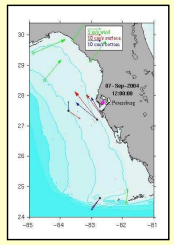


Figure 5: Surface and bottom currents and winds observed as TS Frances approached and departed the WFS

2006-07 Time Series

- Two locations:
  - 25 miles offshore, ~25m isobath, 05/30/06 to 11/20/07
  - 15 miles offshore, ~12m isobath, 09/19/06 to 09/27/07
- Units sequentially deployed for long time periods in same general location
- During durations, units deployed over 70% of time
- Operations crew - one full-time, one part-time personnel
- 8 profilers conducting a total of 34 missions
- Over 3600 vertical data casts, over 650 BSOP days at sea
- Average deployment ~20 days and 55 cycles

Operational and reliability deployments of the BSOP platform demonstrates the robustness and ease of use of the platform. All deployments include CTD data, some with FL and DO. Map demonstrates drift patterns of deployed profilers (Figure 6). Chart shows time line of BSOP units in the water at two locals (Figure 7).

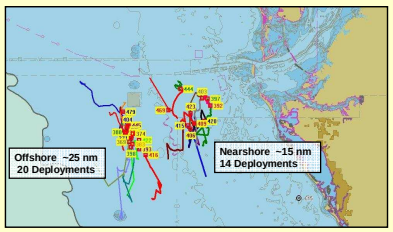


Figure 6: Locations of 2006-07 Time Series BSOP Deployments

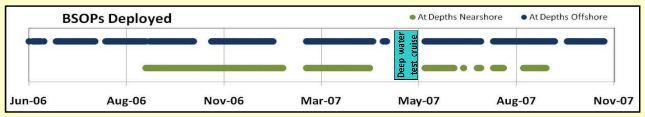


Figure 7: Chart of BSOPs Deployed Druing 2006-07 Time Series

Model Validation

BSOP data and model results are displayed on the web for dissemination and validation. Three figures below demonstrate BSOP utility in model validation. The WFS model displays user specified water properties. Shown is SST, a vertical temperature section across the shelf, and a several day BSOP data and model result time series comparison at the 80m isobath. Analysis reveals the BSOP was deployed at the edge of a Loop Current filament. The model represents this filament, but shifted slightly (several km) in position. This shift accounts for the model being 3° C colder despite the model representing the filament. Thus the vertical profiles appear quite different even though the error in the model is minor and correctable via data assimilation. BSOP and glider mappings will be used in the future for this purpose.

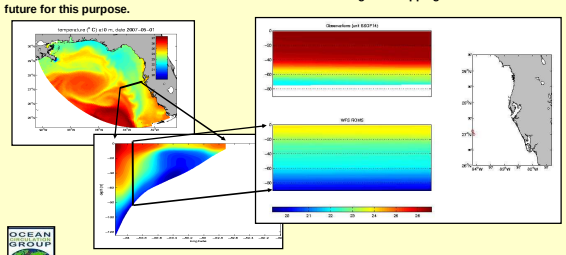
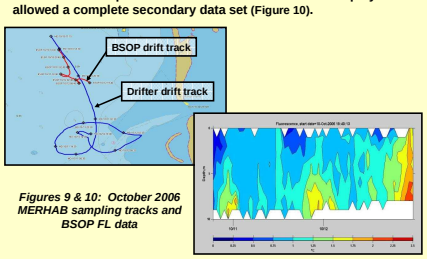


Figure 8: Web data products comparing BSOP collected temperature to WFS ROMS model predictions

Event Response, HAB Monitoring and Tracking

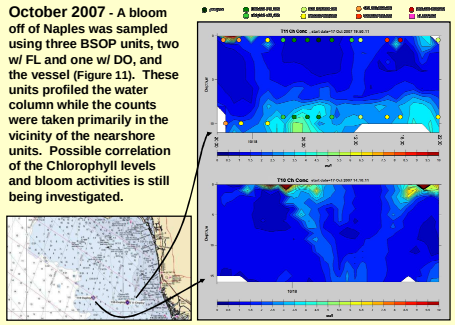
MERHAB experiments with FWC and Mote Marine Lab utilized BSOPs to expand bloom coverage during cruises. Profilers deployed w/ Fluorometers and BreveBusters performing hourly cycles in the bloom vicinity provide increased data coverage to monitor red tide blooms.

October 2006 - Deployment utilized BSOP w/ fluorometer for over two days. Both a drifter and the profiler were deployed together and allowed to move at their own rates (Figure 9). The ship followed the drifter sampling along the way, with water samples, CTD casts, and flow through analysis. Periodic returns to the BSOP site provided added context. The BSOP deployment allowed a complete secondary data set (Figure 10).



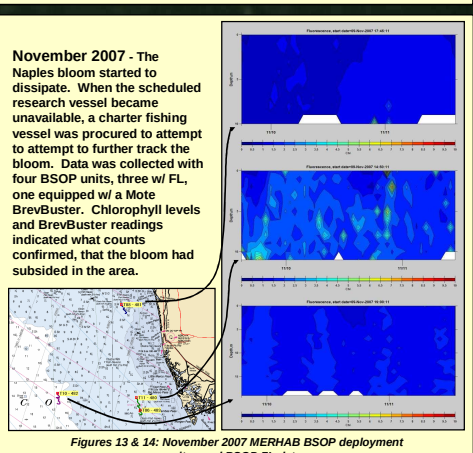
Figures 9 & 10: October 2006 MERHAB sampling tracks and BSOP FL data

October 2007 - A bloom off of Naples was sampled using three BSOP units, two w/ FL and one w/ DO, and the vessel (Figure 11). These units profiled the water column while the counts were taken primarily in the vicinity of the nearshore units. Possible correlation of the Chlorophyll levels and bloom activities is still being investigated.



Figures 11 & 12: October 2007 MERHAB BSOP deployment sites and BSOP FL data w/ sampled Karinia Brevis counts overlaid

November 2007 - The Naples bloom started to dissipate. When the scheduled research vessel became unavailable, a charter fishing vessel was procured to attempt to attempt to further track the bloom. Data was collected with four BSOP units, three w/ FL, one equipped w/ a Mote BrevBuster. Chlorophyll levels and BrevBuster readings indicated what counts confirmed, that the bloom had subsided in the area.



Figures 13 & 14: November 2007 MERHAB BSOP deployment sites and BSOP FL data