Glider Operations in the Arabian Sea

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LONG-TERM GOALS

This study contributes to long-term efforts toward developing integrated systems of autonomous platforms capable of characterizing ocean variability across a broad range of scales in regions of difficult or denied access.

OBJECTIVES

Glider program objectives include:

- Provide NASCar investigators with accurate, high-resolution hydrographic data along sections defined to address NASCar's science objectives
- Provide persistent observations in the interior of the Arabian Sea, measuring the equatorial current system and monsoonal changes in circulation and watermass properties.
- Provide measurements to investigate connections between the Arabian Sea and the Bay of Bengal.
- Design and implement an integrated autonomous observing system that exploits floats, drifters, gliders and satellite remote sensing to access a denied region. Apply lessons learned in NASCar to develop approaches for future application of autonomous assets in denied environments.

APPROACH

The NASCar observational plan represents an effort to optimize the match between science objectives and available observing opportunities, given constraints imposed by difficult logistics and geopolitics. Glider operations were restricted to a limited domain, and thus target the region south of Sri Lanka, where they can build on experience gained through the ASIRI DRI, and the mid-basin region between the Seychelles and northern Arabian Sea. Repeat sections along these lines will characterize monsoon-driven variability. Enhancements to the Argo float array and the Global Drifter Program will sample the western boundary current system, and provide distributed observations in the basin interior. Deployments and recoveries will be conducted using ships of opportunity, from the Seychelles and Maldives using local charters, and, possibly, from Oman under the terms of a Memorandum of Understanding with Sultan Quaboos University.

WORK COMPLETED

Efforts for this project have focused on refurbishing ten older-model Seagliders (whose lineage dates to the period of iRobot manufacture and before) to restore them to an operational state. This included careful inspection and rebuilding of vehicle subsystems, along with the updating of selected critical systems to current Seaglider standards. Updated subsystems include transition to unified 15 volt power architecture (improves efficiency of battery usage), new buoyancy engine with high-pressure boost pump (improved efficiency at shallow depths), new high-frequency relays (for switching antenna access between Iridium and GPS), new, faster GPS receivers and upgrades to new mass shifters for improved reliability and larger battery packs.

8 long missions were conducted as part of the NASCar Operations. (Table 1)

Table 1. NASCar missions and statistics

NASCar Mission	Operating area	# dives	Total glider-distance	Total glider-days
sg526_26Apr2016	Sri Lanka 80.5°E	778	2477 km	169 days
sg529_18Apr2016	Arabian Sea Interior	936	3150 km	226 days
sg530_01Nov2016	Sri Lanka 80.5°E	1057	4168 km	270 days
sg528_16Dec2016	Seychelles	766	2692 km	246 days
sg137_17Mar2017	Arabian Sea Interior	795	2507 km	253 days
sg133_17Mar2017	Arabian Sea Interior	827	2969 km	319 days
sg136_18Aug2017	Sri Lanka 80.5°E	40	127 km	6 days
sg128_15Jan2018 (ongoing)	Seychelles	687	3696 km	349 days
TOTAL		**5885**	**21,821 km**	**1830 days**

Arabian Sea Interior Operations

NASCar glider operations began on 18 April 2016, with the deployment of Seaglider 529 in the Northern Arabian Sea from the USNS Henson. Bragg Sherrer and colleagues graciously handled the deployment of SG529 at 15° 24' N, after which the glider was commanded to occupy a section running south, to the Seychelles (Fig. 1). A long meridional section along 60°E crossed inflows from the Persian Gulf and Red Sea, to the Equator. After reaching the Equator, reduced flight characteristics and difficulties in navigating the strong South Equatorial Current led to the decision to turn East and recover in the Maldives. Glider was recovered on 1 December 2016 with the support from the Maldives Whale Shark Research Programme and the Maldives Meteorological Service.

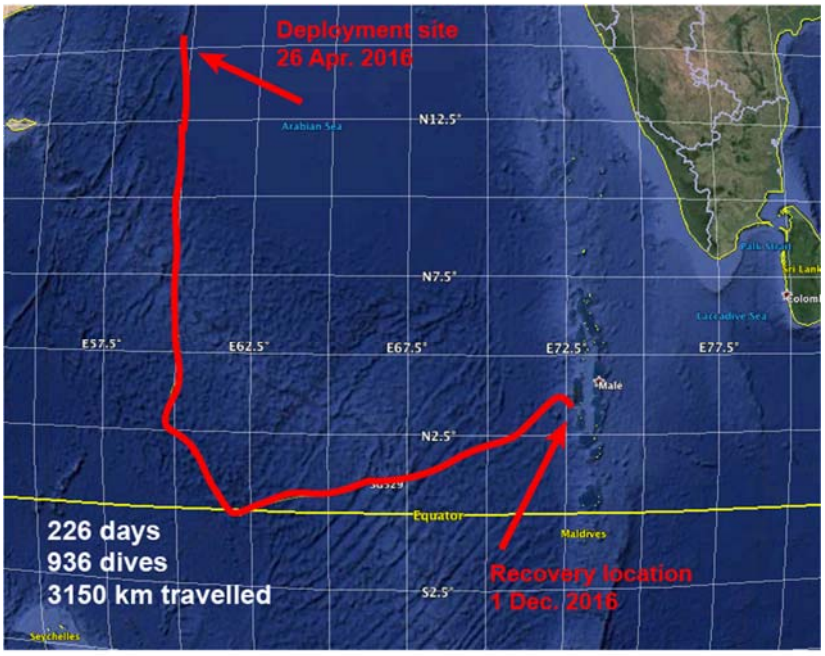

Figure 1: Track of SG529 in the Arabian Sea (red).

Logistical and geopolitical constraints dictated that the initial round of glider operations stage from Sri Lanka and the Seychelles. Sri Lanka sampling builds upon our long-standing collaboration with NARA with continued joint sampling of the boundary currents near the island. We have established operations from the Seychelles. This includes permission to conduct research within the Seychelles EEZ and local logistics support arranged by the Better Life Foundation. We consolidate equipment from multiple NASCar teams for shipping to facilitate safe, cost-effective, low-risk shipping of instruments and hazardous goods (Li primary batteries).

Two Seagliders also participated to the Mid-Basin Experiment in Winter 2017. SG133 and SG137 were deployed in 4 March 2017 and were tasked to conduct surveys around drifting fast profiling ALAMO floats (Fig. 2). The gliders surveyed for the whole lifetime of the floats 9103 and 9104, about 7 weeks. In late April 2017, one glider (SG137) was started a transit to the Maldives, going near an additional ALAMO float (9107) before the float also stopped working. The other glider (SG133) started going south, first aiming for the Seychelles, then veering for the Maldives.

SG137 came within 50 km of the northernmost atoll in the Maldives, but we were not able to secure a boat for recovery. Colleagues at INCOIS (Hyderabad, India) attempted a recovery in Indian Waters on 9 Feb 2018, but the glider was found to be heavily damaged by 10-15m wide fishing gear, some ocean trash and 1.5m bamboo stick. Glider was lost. SG133 came within 150 km of the Maldives before current reversed and it was pushed back towards the Arabian Sea interior. It stopped diving on 31 Jan 2018, and last call was on 26 Mar 2018. Both gliders dove and collected data for over 11 months, but were ultimately lost. All data was transmitted.

Seychelles Operations

SG528 was deployed on the northern edge of the Seychelles Plateau in December 2016. The glider crossed the Equator and traveled to 5°N. After over 750 dives and 264 days, the glider became impossible to steer and it drifted eastward at the surface along the Equator for nearly 2000 km, before being spotted and recovered by a Sri Lankan fishing boat on 21 November 2017

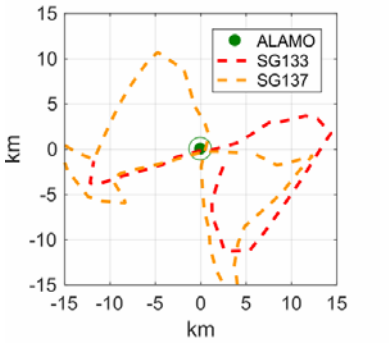

Figure 2: Tracks of the NASCar ALAMO floats (green and orange), and of the Seagliders SG133 and SG137. Gliders were surveying a butterfly pattern in the moving reference frame of the float (white arrows).

at 0°N 78°E. During the entire time, the glider reported its position via satellite communication. On 24 November 2017, the fishing boat returned to land in Adurangola, and our collaborators at NARA went to retrieve the glider.

In January 2018, SG128 was deployed on the northern edge of the Seychelles Plateau. SG128 sampled for almost 2 months near the edge of the Seychelles Plateau, before starting a long transit to the Maldives. It is currently less than 500 km from the Maldives, doing 2-day loiters at depths.

An additional Seaglider was shipped to the Seychelles but was not deployed.

Sri Lanka Operations

Shortly after deployment of SG529 in the Arabian Sea, SG526 was deployed off the southern tip of Sri Lanka. Deployment was executed from R/V Samuddrika as part of a joint US-Sri Lanka research program, with assistance from Priynatha Jinadasa and colleagues (National Aquatic Resources Research and Development Agency (NARA), Sri Lanka). SG526 was directed to occupy a repeat survey line extending southward from Sri Lanka, designed to capture the monsoonal cycle of exchange between the Arabian Sea and Bay of Bengal (Fig. 3). SG526 was recovered in October 2016, and SG530 was deployed in December 2016 to occupy the same line, followed by SG136 in August 2018. SG136 suffered a pressure sensor failure and was recovered after 8 days. The occupation of this line continues as part of the MISOBOB DRI.

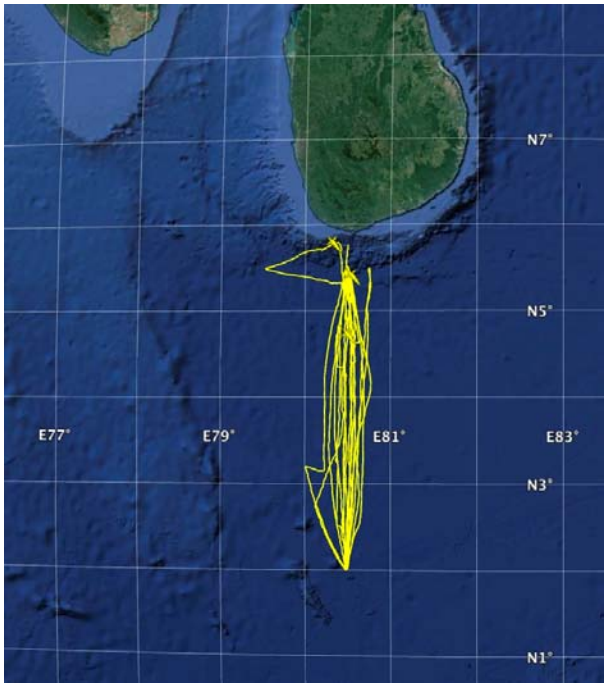

Figure 3: Track of SG526, SG530, and SG136 South of Sri Lanka.

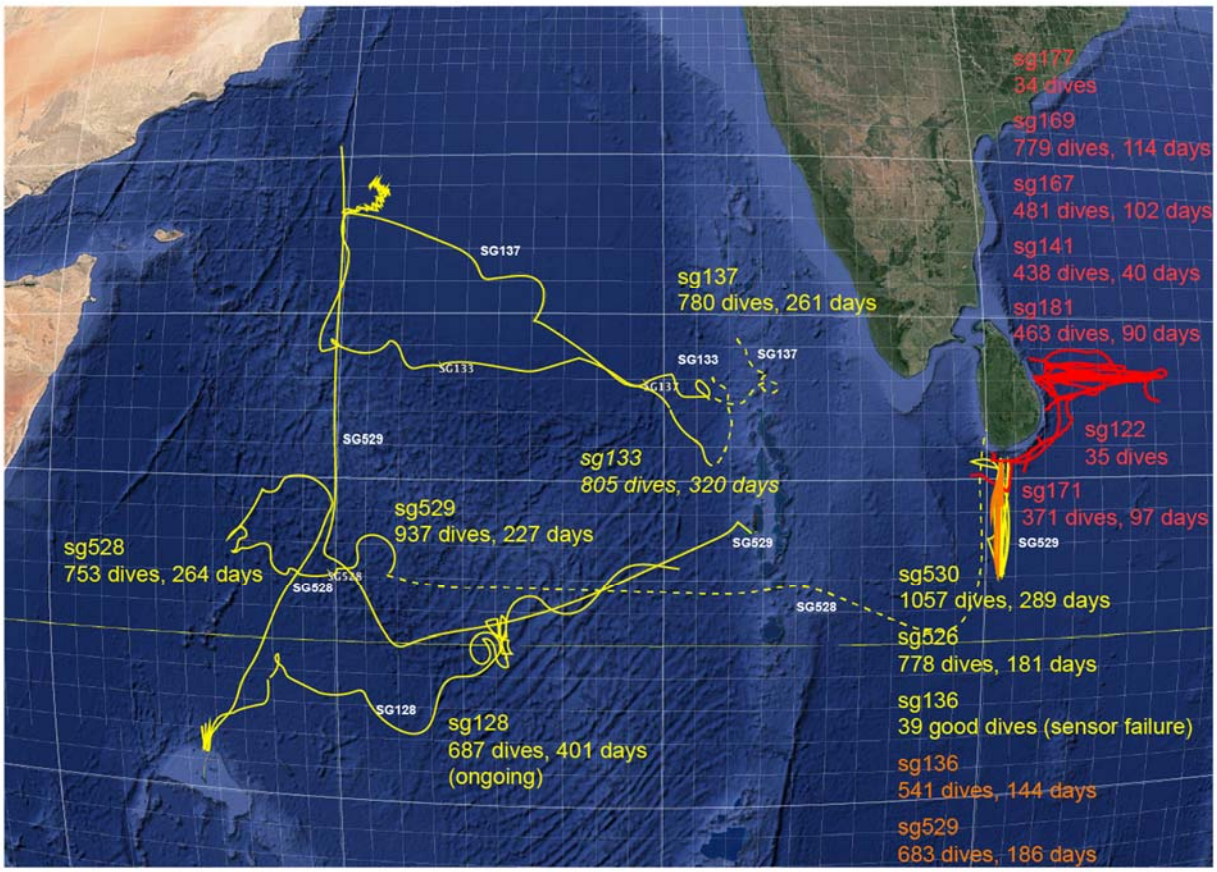

Figure 4. Summary of the ASIRI (red), NASCar (yellow) and MISOBOB (orange, ongoing) Seaglider Programs, showing the sampling tracks (dashed if drifting at the surface) and mission statistics.

RESULTS

As this grant funded only the operation of NASCAR gliders, no science results are reported here. Data collected by the NASCAR gliders are available to NASCar team members on request. NASCar glider data collected in international waters were also placed on the GTS.

IMPACT/APPLICATION

None yet.

RELATED PROJECTS

Please see the other operational and science projects that form the NASCAR DRI.