CASEE Report

Using small AUVs to map the reefs of Bonaire

Dr Daniel Jones – National Oceanography Centre, Southampton

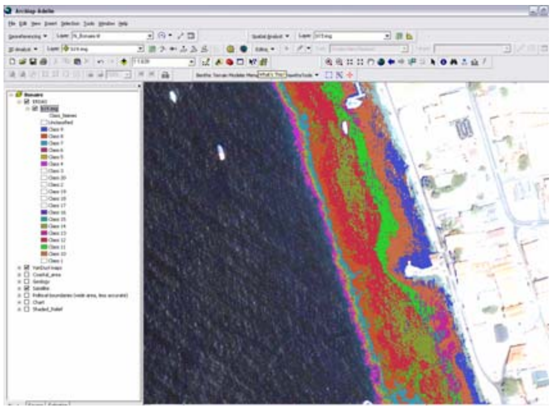
Preparatory work at VIMS

I arrived at the Virginia Institute of Marine Science on the 3rd October 2007 and met up with Mark Patterson, my AUV mentor for the next two months. Fetch, the AUV I would be using, was in pieces and had a serious fault with the tachometer, vital to allow reasonably accurate dead-reckoning of the vehicle. Over the next two weeks we worked to put Fetch back together and find the fault, this involved a steep learning curve for me and was a great introduction to using this system. We narrowed the fault down to the Hall effect sensor (a magnetic system that registers a voltage when a companion magnet on the rotating propeller comes past it) circuitry and eventually to a blown fuse on the Analogue to Digital converter printed circuit board.

The Fetch AUV (Length 2 m, weight 70 kg). Sensors: O2 / pH, temperature, salinity, depth, altitude, side-scan sonar, GPS, tachometer, compass.

I took the opportunity to learn from Mark some Labview programming, as the vehicle control software is Labview based it was extremely useful to understand this language for fault finding and to better understand how each component of the system worked. I developed some software for controlling the video system on Fetch remotely from a computer which we hoped would allow video operations to be completed more quickly and without opening up the vehicle to access the tapes. Once all systems checked out we were able to test Fetch in the York River outside VIMS. I also presented a talk on my work at NOC at VIMS and completed the check-out procedure for the VIMS dive team at Lake Rawlings, VA.

I developed a Geographic Information System database while at VIMS for our future work in Bonaire and gathered all the available datasets for the island and its surrounding seas. Using the high resolution Quickbird satellite imagery that had been purchased for the project I processed and experimented with classification of the imagery using ERDAS Imagine for unsupervised classification based on colour information in the image bands. This information was useful in designing our survey of Bonaire on the second field mission of this work.



ArcGIS database of a section of the Bonaire coast showing unsupervised classification of the Quickbird satellite photograph

During the last week at VIMS we packed the vehicle and other equipment for the first field work of this bursary, using the Aquarius Underwater habitat as a platform for AUV use. I drove the equipment down to Florida from Virginia.

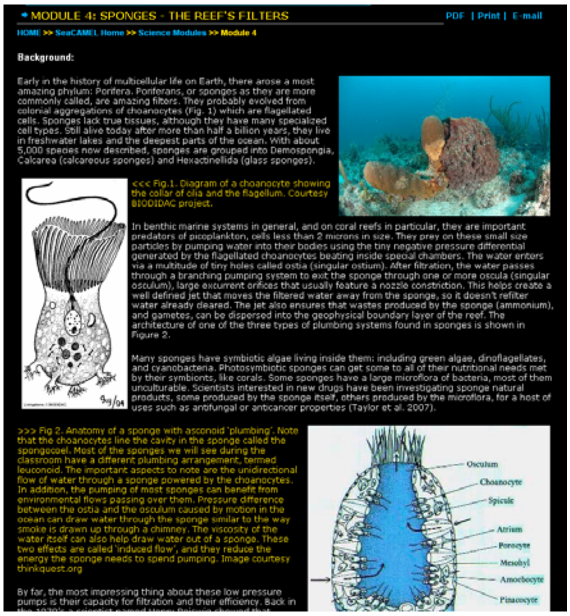
Expedition to Florida for project SEACAMEL

In November 2007 we took the Fetch AUV on the first field work mission of the bursary down to Florida to work as part of a project sponsored by the Living Oceans Foundation. The main part of the work was to conduct six live "underwater classrooms" which took place sixty feet below the surface of the Atlantic Ocean on the coral reefs of the Florida Keys. The live classroom broadcasts were used by many university level classes around the world live and archived for continued use. During this operation, scientists and a cinematographer lived submerged at forty-five feet underwater in NOAA's Aquarius habitat, called America's "inner space station". I served as top-side dive coordinator and AUV operator, using my new-found skills to use Fetch around Aquarius.

The Aquarius Underwater Habitat, Key Largo, Flordia

The first week I was in Florida I trained as an Aquanaut, one of the saturation divers, in case any of the others were unable to saturate. With a short and time critical mission like this it was important that there was a backup diver was available. This also gave me an important insight into the Aquanaut operations that was very useful when leading the top-side dive activities.

I presented one of the 6 science modules from inside Aquarius by diving, entering the habitat, presenting the module and leaving again within my maximum bottom time. The module entitled "Sponges – the reef's filters" involved me presenting the aquanauts injecting dye into sponges to show and calculating rates of pumping; they measured oxygen levels around of the water passing into and out of a sponge to calculate rate of metabolism. We investigated how sponge size affects metabolism and where they fit on the mouse-elephant curve of metabolic rate vs size.



Part of the Living Ocean Foundation SEACAMEL website showing module 4 – sponges presented by Daniel Jones in aquarius

We achieved a world first in AUV technology whilst in Flordia, a high-school student Michael Crocket took control of Fetch remotely, over the internet, surface-drove the robot, programmed a mission and send the AUV on the mission to collect data.

This story was featured in several newspapers in Virginia.

Virginia debriefing and Bonaire preparation

After returning from Florida we serviced Fetch, prepared it for shipping and packed the vehicle and other necessary equipment for Bonaire. We also used the lessons learned to prepare for Bonaire. I left Virginia on the 30th November and resumed my normal work at NOC until the Bonaire expedition.

Bonaire 2008 background

Map of Bonaire, Dutch Antillies

Bonaire, Netherlands Antilles, is arguably the most pristine coral reef environment in the Caribbean. Percent coral cover is the highest and percent algal cover the lowest compared to other Caribbean reefs and thus its reef environment represents a strong baseline. Although the shallow leeward environment near Bonaire between 10-20 m was mapped in the 80's (van Duyl 1985), little to no survey work has been conducted on the deeper reef (60-100 m) or into deeper water (100-300 m). The shallow water survey (van Duyl 1985) provides a rich database against which to assess decadal changes. A recent meeting of the International Coral Reef Initiative, an effort of the United Nations Environmental Program, identified mapping of the reefs of Bonaire a top priority in a regional context (ICRI 2005), and the government of Bonaire has provided strong support for our proposed expedition. Bonaire, Curacao, Las Aves, and Los Roques have recently been proposed for United Nations World Heritage Status given the pristine marine environments and high degree of endemism.

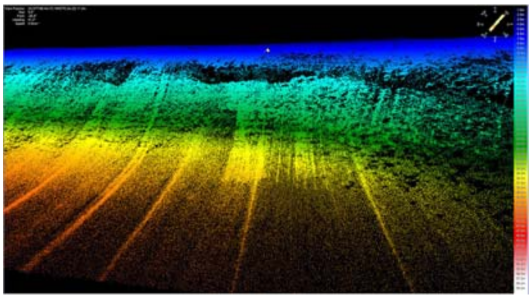
Expedition outline

The Fetch AUV in operation at 20 m water depth, collecting data at the north-west of Bonaire.

During this expedition our team surveyed the unique marine environment of Bonaire over a greater depth range than can be reached with compressed air SCUBA using 3 Autonomous Underwater Vehicles (AUVs) and deep Trimix diving. This unique mapping of the biological and physical environment has allowed documentation of patterns of biodiversity shallow and deep. Because the AUVs can fly in close proximity to the bottom in terrain following mode, they provide a superior method of imaging using side scan sonar, multibeam sonar, and digital video, while simultaneously measuring water column velocities near the bottom, dissolved oxygen, chlorophyll a, pH, conductivity, and temperature. Because the AUVs can work 6-12 hours/day depending on survey speeds, a cooperative seafloor sonar mapping rate of 10 km track/day was achieved using all three vehicles. This mapping effort was complemented by ground-truthing by compressed air and trimix SCUBA divers using underwater video and photography. This re-mapping of the shallow reefs of Bonaire using new tools and the explorations into deeper water using AUV technology will provide an important resource for this island state in the form of a detailed snapshot of shallow and deep reefs. The shallow reef mapping will be compared to the 1984 van Duyl snapshot. The deeper reef mapping will serve as a new snapshot against which future explorations can compare. This reef mapping expedition, with the Geographic Information System database on bottom type, species composition, and overlying water quality, will help the government of Bonaire continue to protect this unique ecosystem and help guide efforts to create Fishing Protected Areas and gain international protection. The expedition itself provided a great opportunity for public and educational outreach. It served as a poster expedition for the launch of the international year of the reef and was covered in a number of national and international press reports. The expedition was also selected as a National Oceanographic and Atmospheric Administration (NOAA) Office of Exploration signature expedition and formed a highlight of the award winning NOAA OE web site.

Expedition highlights

We were the first expedition to use three AUVs simultaneously. This photograph shows the two Gavia systems. (Length 2.5 & 3 m, weight ~50 kg). Sensors Gavia 1: Chlorophyll, temperature, salinity, depth, altitude, GPS, Doppler velocity log, tachometer, compass, side-scan sonar, forward-looking sonar, colour camera. Gavia 2: Geoswath swath bathymetry and side-scan sonar system, GPS, Doppler velocity log, inertial navigation system, tachometer, temperature, depth, altitude, forward-looking sonar, monochrome camera.



We created extremely high resolution acoustic maps of the reef (geoswath image shown of the reef slope) using the geoswath and side-scan units on the AUVs

Trimix dives were conducted down to 90 m (photo shows the divers returning) and AUV operations to 240 m.

The AUVs were capable of precision mapping of benthic habitats with good depth holding and terrain following

The expedition highlighted the value of this high-technology in marine mapping, particularly in the ability to generate high resolution maps of complex topography such as found at Bonaire.

CASEE perspective

This expedition was an extremely useful learning experience for me; the chance to be involved in a major expedition using three AUVs of different makes was unrivalled. I learned a lot about Fetch operations through 10 dives where we collected oxygen, pH, temperature, salinity, depth and side-scan data down to 50 m water depth. I also got the experience of working with two commercially produced Gavia vehicles and spent several days with the teams from University of British Colombia and Iceland learning to use their systems and seeing them in action. These experiences highlighted the importance of some of the integral AUV systems, particularly navigation, for successful operations, useful data collection and, most importantly, not loosing the vehicle. It was also a superb opportunity to meet, work with and talk in depth to some of the world-class scientists involved on this expedition. The experiences learned from using multiple vehicles and mission planning in complex topography were also important and will be valuable in proposing and planning future work with Autosub 6000 or other AUVs.

Simulataneous operation of Fetch and a Gavia system. We were able to successfully use three AUVs simultaneously on this expedition, as far as we know, the first time this has been done.

The majority of the expedition team in Bonaire