Department for Environment Food & Rural Affairs

DARWIN INITIATIVE

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Overseas Territories Environment and Climate Fund

Final Report

Important note *To be completed with reference to the Reporting Guidance Notes for Project Leaders: it is expected that this report will be a maximum of 20 pages in length, excluding annexes*

Darwin Project Information

Project reference	DPLUS045
Project title	Mapping Anguilla's 'Blue Belt' Ecosystem Services
Territory(ies)	Anguilla
Contract holder Institution	Cefas
Partner institutions	UKHO, Anguilla DoE, NU, ESL
Grant value	£271,238
Start/end date of project	1st April 2016 to 31st March 2018
Project leader name	Koen Vanstaen
Project website/Twitter/blog etc.	n/a; Updates through Social media Twitter and Facebook
Report author(s) and date	Simeon Archer-Rand, Koen Vanstaen

1 Project Overview

Anguilla is part of the Leeward Islands and is one of the most north-easterly islands in the Caribbean. Due to its position in the island chain Anguilla has a large marine area, or exclusive economic zones (EEZ), spanning over an area of 90,000 km^2 (Figure 1) The waters depths range from the shallow nearshore environment to the abyssal depths of over 7,000 m. The management of this extensive marine area offers some unique challenges. In 2015/2016 the Darwin+ funded Anguilla National Ecosystem Assessment (NEA, DPUS022) held a series of workshops. From these workshops a need was identified to monitor the coastal habitats and resources, as well as changes in sediment regimes caused by the increased incidence and severity of storm events, predicted under climate change scenarios, which can threaten critical ecosystem services.

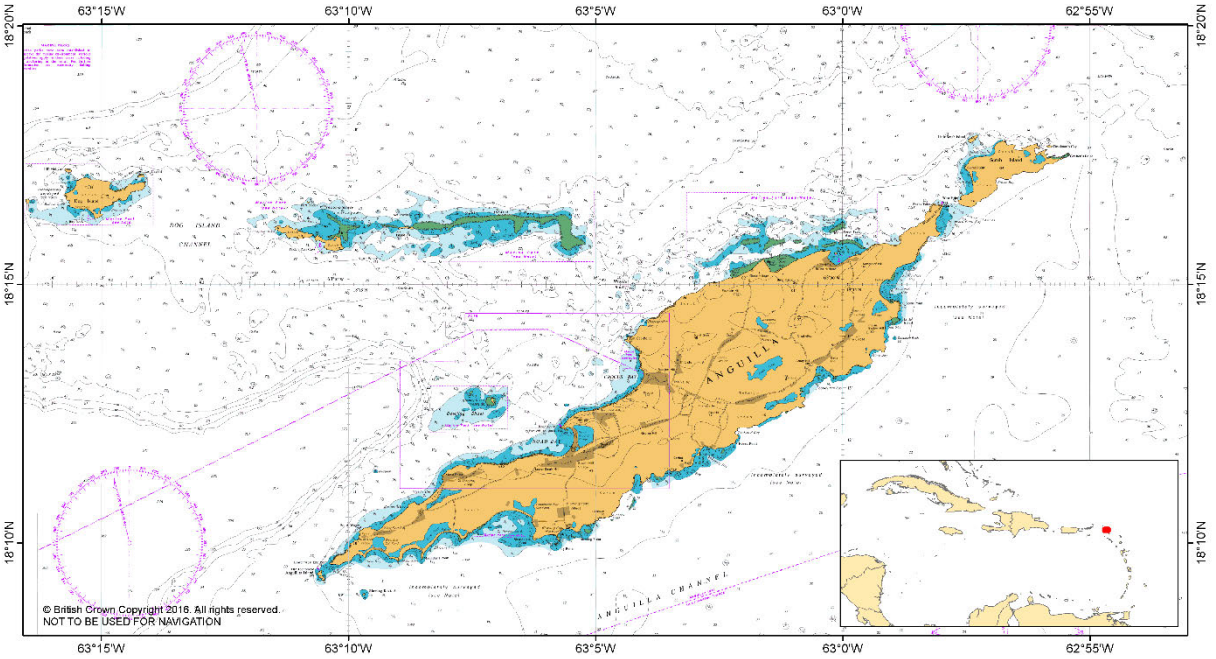

Figure 1. Charted depths around the Anguilla, Caribbean. Many of the depths recorded around the island date back to 1859.

Much of the waters around Anguilla have not been mapped since it was initially done back in 1859, which used lead lines and compasses to assess depth and position. As well as being vitally important for Anguilla in terms of shipping and yacht tourism, having an accurate map of the seabed can help build a picture of the natural marine environment, including corals and seagrasses, and aid in the management and protection of these important biodiversity resources. An initial characterisation exercise was undertaken as part of the NEA for the nearshore marine environments using satellite data. However, the scale of the area and complexity of the habitats surrounding the island, and the extensive deeper waters, meant that the sparse records were insufficient to develop a robust baseline of evidence for management or future monitoring.

The aim of this project was to create the tools needed for the Government of Anguilla to make informed decisions about the placement and management of the marine protected areas (MPA) around the island and to give them the capabilities to monitor the habitats and species into the future. Modern acoustic survey tools, for collecting information on depth and habitat type, would be used to map important areas and give greater detail in the shallow nearshore environment. Using this in combination with new methods of deriving depth and habitat information from satellite data would not only provide a robust baseline map of the Anguilla's marine ecosystem services, essential for management, but also a method of monitoring any changes in the future.

1.1 Project Stakeholders/Partners

Stakeholders played an essential role throughout the project and were involved during all stages of the planning and decision making process. Working with our partners at the Anguilla Department of Environment (DoE) we set-up a stakeholder workshop to kick-off the project in June 2016 (Figure 2). The meeting was well attended by representatives from organisations which have a vested interest in the marine activities around Anguilla (Figure 2). Representatives attended from:

- Governor's office
- Department of Environment
- Attorney General's Chambers
- Department of Physical Planning
- Ministry of Infrastructure
- Customs Department

- Anguilla National Trust
- Department of Fisheries and Marine Resources
- Anguilla Air and Sea Port Authority
- Department of Disaster Management
- Anguilla Chamber of Commerce
- Ministry of Health and Social Development
- Department of Lands and Survey
- SOL Petroleum Anguilla

The stakeholder meeting was opened by Her Excellency, the (then) Governor of Anguilla, Christina Scott and the Honourable Cora Richardson-Hodge, Minister of Home Affairs, Immigration, Labour, Cultural Affairs, Youth Affairs, Human Rights, Gender Affairs, Constitutional Affairs, Information and Broadcasting. After the formal launch of the project, the meeting was devoted to engaging with the stakeholders and identifying what their interests are in the marine environment. With the aims of the project in mind, the group gathered around maps of Anguilla and were asked to mark priority areas for their organisations. Using this information, it was possible to identify where the priorities of the organisations overlapped. Consensus was reached at the meeting that priority areas for hydrographic surveying would be Road Bay and Crocus Bay, while efforts to map habitats should be concentrated around Sandy Island and The Cays.

http://theanguillian.com/2016/06/uk-government-funding-marine-project-in-anguilla-cost-price-270-000-about-ec1-million/

Figure 2: Photo taken at the stakeholder kick-off meeting and published in 'The Anguillian' newspaper for their article about the project and meeting. The photo includes the project team, the Governor of Anguilla and Minister of Home Affairs.

During survey operations members of the project team from Cefas and UKHO worked closely with partners from the DoE, Department of Lands and Survey and the Department of Fisheries and Marine Resources. This collaboration gave us the local knowledge and experience needed to undertake a successful survey programme, while being able to transfer knowledge on our survey techniques, strategies and implementation to local organisations.

A mid-project stakeholder meeting was held in Anguilla with at least one attendee from each of the stakeholders. This meeting was focused on the data collected to date and outlined next steps.

The afternoon session was based on why monitoring is important to places like Anguilla. Several sets of satellite and aerial imagery were supplied to the stakeholders to see the changes in the marine environment over the decades. The large changes to the coastline and marine areas over the decades was also backed by anecdotal evidence from the stakeholders and helped to highlight the need for ongoing monitoring of the coastal and marine environment.

The final stakeholder engagement event happened in February 2018, 6 months after the passing of hurricane Irma. Due to the country still recovering from the devastation caused by the hurricane, a smaller stakeholder meeting was held, where the project team met with the key

stakeholders to go through the final project outputs, how these were produced and how to use these in Anguilla's management context and systems (Figure 3). The project team delivered several hands-on training sessions on the methods used to create the satellite derived bathymetry, the MBES data and the habitat maps. These included practical sessions where the stakeholders where asked to undertake tasks which form part of the mapping process. All the stakeholders were very engaged during the process and were able to bring some fresh ideas to the table how the data would be beneficial in other aspects of monitoring and management of the marine area. Although this project wasn't specifically about the monitoring and management of the marine environment the products and process presented to the group are extremely useful tools for this and an afternoon of the two-day workshop was devoted to the monitoring of the marine environment around Anguilla and how the new products could be incorporated into this.

Figure 3. Tweet from the final stakeholder meeting/workshop where the products of the project were presented to the group and the new tools were worked through with the group.

2 Project Achievements

2.1 Outputs

1. Provide training for local stakeholders in state-of-the-art marine survey techniques and processes

1.1 At least 5 days of training opportunities provided during the lifetime of the project on hydrographic and environmental survey techniques, either classroom based or through practical experience.

Training was undertaken in several stages across the lifetime of the project. This included practical and theory sessions with some 'in-field' training.

During the mobilisation of the hydrographic equipment onto the vessel a day was spent with the team from the Department of Land and Surveys teaching them how to undertake a dimensional control survey of the vessel and how to measure in a tidal gauge. Both processes are essential for reducing the errors associated with hydrographic survey and are a requirement for any future surveys around Anguilla and neighbouring islands.

Participation by stakeholders during the groundtuthing surveys was actively encouraged during the two weeks of survey. During the survey we had stakeholders onboard for a total of 7 out of the 14 days (Figure 4). During their time onboard the Cefas team went through the survey

design, equipment deployment, data recording and how to maintain safety during the trips. Participants were from the DoE, DFMR, Anguilla National Trust and the Governor's Office.

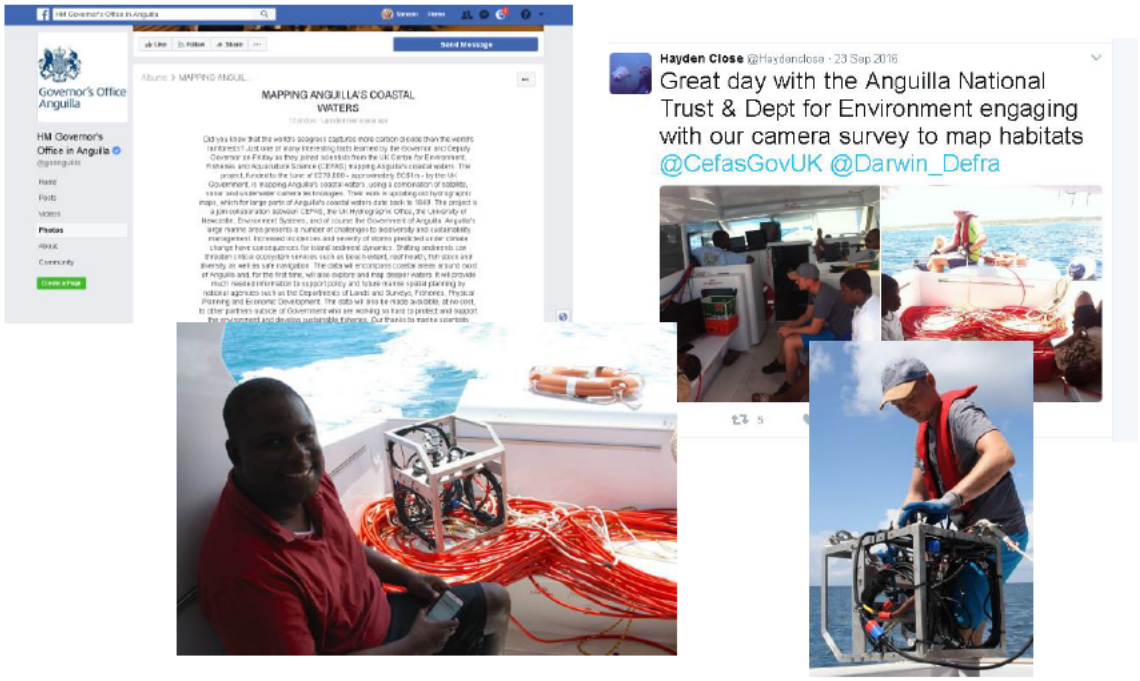

Figure 4. Images from the survey teams time in Anguilla working with and training local stakeholders.

A two-day workshop was held at the end of the project for all stakeholders to attend. As well as presenting the final data products and tools, 1.5 days was devoted to training. This involved working through some of the processes and theory behind marine mapping. Interactive round-table discussion sessions on the importance of marine monitoring were also held centring on the changes identified from the data collected as well as changes created by the passing of Hurricane Irma.

1.2 At least one person attending from each local stakeholder organisation.

Three separate stakeholder meetings were held throughout the lifetime of the project. The initial stakeholder engagement meeting was held in June 2016 and was extremely well attended with representatives attending from all the stakeholder organisations.

The mid project event and the final stakeholder event saw attendees from all of the government departments with an interest in the marine environment as well as representatives from the Anguilla National Trust.

1.3 One DoE staff member participates in researcher exchange, gaining hands-on experience of marine survey techniques onboard Cefas' ocean going research vessel Cefas Endeavour.

The researcher exchange was planned for Autumn 2017, but could not go ahead as originally planned following hurricane Irma severely impacting Anguilla. The revised researcher exchange timing did not allow to combine this with a survey onboard the RV Cefas Endeavour. Instead the researcher exchange was extended to two researchers, one member of staff from the DoE and one member of staff from the DFMR, to take part in 5 days of knowledge exchange. The five days were held between Cefas' laboratories in Lowestoft and Environment Systems offices in Aberystwyth. The two researchers identified a number of subjects which would be most beneficial in their job role, including:

- Habitat mapping
- Video interpretation
- Fisheries Tagging
- MPA management and monitoring
- Satellite data preparation and processing

- Drone video collection and use

A good amount of time was also devoted to looking at future projects and how Cefas and the other project partners could work with the DoE and the DFMR to help further their capabilities and Anguilla's marine environment.

2. High resolution bathymetry data for majority of coastal waters and selected deeper water sites

2.1 Deliver at least 10 days (incl. any weather downtime) of high resolution multibeam echosounder surveys in water depths exceeding 15m.

Many of the nearshore and coastal areas around Anguilla have not been surveyed for over 150 years. With the island seeing an increase in both recreational yacht traffic and commercial shipping, it is imperative that the charts for the waters around Anguilla are up-to-date and contain the latest information on hazards and safe areas. The bathymetry maps can also help inform the location of sensitive habitats and species and are an essential tool in habitat mapping.

Bathymetry data for Anguilla was collected in two parts. Firstly, selected nearshore areas, identified during the stakeholder led workshops, were surveyed using modern multi-beam echo sounders (MBES). A MBES system was mounted to a local vessel and utilises hundreds of beams of sonar to accurately map the depths underneath the vessel creating a picture of the seabed. Secondly, the remaining coastal and nearshore areas where mapped using the latest techniques in deriving bathymetry from earth observation (satellite) data. The MBES data were used to calibrate the satellite derived data.

During the opening stakeholder workshop, the participants were split into groups based on their interest in bathymetry mapping or habitat mapping. Using paper charts each participant identified the key areas around Anguilla for their organisation in terms of charting. Areas where there was most interest were picked for mapping using the MBES systems. The two areas identified were Road Bay and Crocus Bay on the northern coast of Anguilla. These two areas see the majority of traffic from commercial cargo vessels, yachts and cruise ships. Although these areas have been mapped more recently then some of the more offshore areas, the bathymetry data is still over 40 years old.

A suitable vessel was identified by our partners at the DoE and was assessed for its suitability by Cefas and UKHO. Equipment was mobilised and shipped from the UK to Anguilla where it was delivered to the charter company. The charter company, 'Funtime Charters', worked very hard to modify their vessel to fit this unfamiliar equipment. Once the MBES system had been attached to the vessel surveyors from the Anguilla Department of Land and Survey were able to undertake a dimensional control survey on the vessel with guidance and training from the UKHO. The survey measures the accurate relative position of the Global Navigation Satellite System (GNSS) and the MBES head to an imaginary centre point of the vessel to within several millimetres. These accurate measures help reduce the error in the data collection.

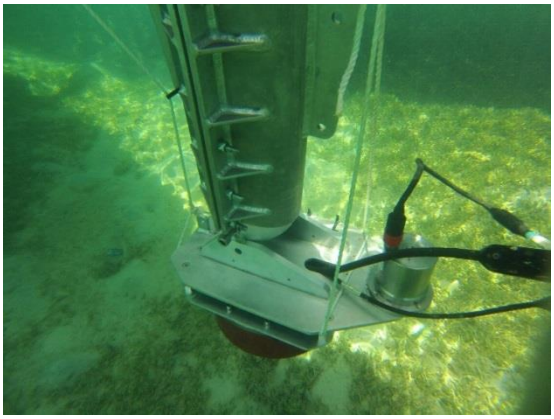

Figure 5. Images taken during the mobilisation of the vessel ready for the hydrographic survey.

Tides are another source of error which can affect the data quality and accuracy. To eliminate the tidal error the team installed a tide gauge onto the pontoon at Sandy Ground. The position and height against the global geoid was measured in by the surveyors from the Department of Land and Surveys. The readings from the tide gauge are used to correct the collected bathymetry data and reduce the readings to what the depth would be at the lowest astronomical tide (LAT).

Data collection began in September 2016 and continued for 2 weeks, exceeding the 10-day target, with data being collected in both Road Bay and Crocus Bay. The data collected covered the majority of both of the bays and included a large area of the deeper water to the west of Sandy Island which had not been surveyed previously and would be beyond the reach of other survey methods. Weather conditions did limit the amount of data that could be collected on some days. The raw MBES data was processed by surveyors from the UKHO and Cefas during the survey to ensure data quality standards were being met.

Several interesting features were identified from the new hydrographic data during examination by the UKHO and Cefas processors. Several uncharted wrecks including a potential plane wreck were identified by the hydrographers. Copies of the data and the location of the wrecks were passed to the DFMR for further examination. One wreck in particular was of particular interest to the staff of DFMR. The survey had potentially found the wreck of the MV Marva W which had been lost several years ago after being sunk intentionally in shallow water but had slipped into deeper water. This wreck has the potential of becoming a new deep-water dive site helping to increase the attractiveness of the Island for this activity.

2.2. Multibeam bathymetry data meets recognised international standards (IHO Order 1a)

Following the survey, the data was returned to the UK where it was passed to the processors at the UKHO who undertook a full review and cleaning of the data. To ensure that the data is suitable for navigation the data must undergo a strict level of quality assurance and be within a set tolerance across the area. The data was assessed against the International Hydrographic Organisation Standards for Hydrographic Surveys Order 1a and Special Order. The data achieved a 99% agreement with Order 1a and 95% agreement with the, even higher standard, IHO Special Order data quality meaning the data met and exceeded the requirements of the project (Figure 6).

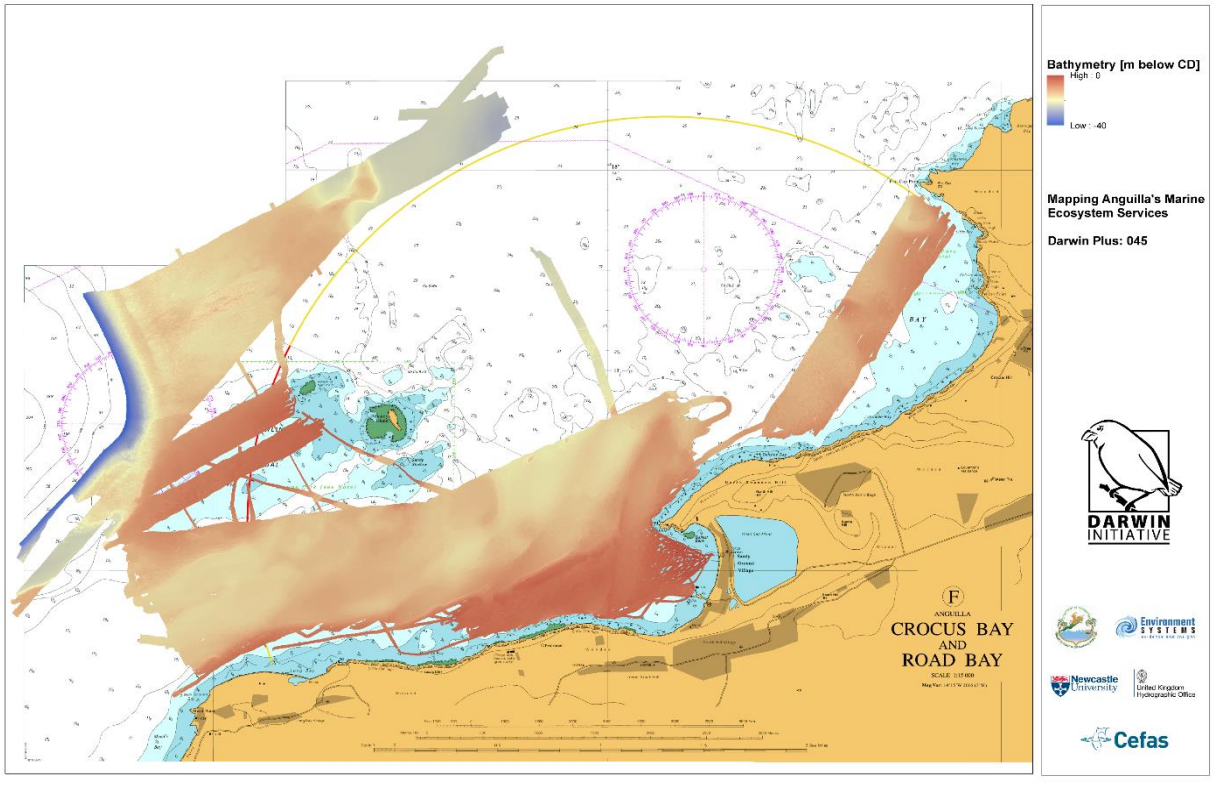

Figure 6. MBES Bathymetry data collected from Road Bay and Crocus Bay, Anguilla

In addition to the data on depths, the MBES system also collects data called “backscatter”. Backscatter is a measure of the intensity of the returning signal from the sonar. It is affected by several different factors including the roughness, the hardness and the intrinsic nature of the seabed. This information is therefore extremely useful when looking at the different habitats and biotopes as substrate preference is a big driver for many of the different species and habitats.

2.3. Process available satellite imagery to derive a satellite derived bathymetry data layer with 2m resolution for Anguillan coastal waters.

The second method of analysing depth was to use earth observation data from satellites to derive bathymetry. This is a relatively new method of collecting depth data and has been trialled in a few locations around the world. Satellite derived bathymetry (SDB) works by creating a relative depth map from the difference in the attenuation of blue and green wavelength light through water. As green light attenuates faster than blue the ratio between the two is used to calculate the relative depth. The relative depths are then tied to real depths (from the MBES survey) to create a bathymetry map.

As this is a relatively untired method in large scale survey it was decided that several different sources of data should be used to calculate the depths. The four sensors chosen were Landsat 8 (L8), Sentinel 2A (S2A), WorldView 2 (WV2), Pleiades 1A (PLD). Table 1 contains information about each of the sensor types including the resolution and the cost of the data.

Table 1. Details on the data used during the creation of the SDB maps

	Landsat 8	Sentinel 2A	WorldView 2	Pleiades 1A
Spatial Resolution	30 x 30 m	10 x 10 m	2 x 2 m	2 x 2 m
Swath	185 km	290 km	16.4 km	20 km
Costs	Free	Free	$ 19 / km2 (archived) $ 29 / km2 (tasking)	$ 13 / km2 (archived) $ 23 / km2 (tasking)
Source	https://landsat.usgs.gov/	https://scihub.copernicus.eu	Imagery grant from Digital Globe	Purchased

Previous studies had shown good results for SDB from the WorldView 2 and Pleiades 1A sensor however the high costs of these images can make them prohibitive to doing this on a regular basis. Both Landsat 8 and Sentinel 2A data are free to download making them appealing to organisations and government departments. The comparisons between the datasets were set-up to identify the differences between the SDB and MBES data and to compare the free data sets with the more expensive ones.

The pre-processing and processing of the data was undertaken by Environment Systems and Newcastle University. In their original form the different sensor data arrived with varying levels of pre-processing and corrections applied.

After the data had been standardised the bathymetry was derived using a method developed by Stumpf *et al.* (2003)[1] utilising the ratio between the differences in the attenuation of green and blue light (Equation 1).

[1] Stumpf, R.P., Holderied, K. and Sinclair, M. (2003) 'Determination of water depth with high-resolution satellite imagery over variable bottom types', Limnology and Oceanography, 48(1; NUMB 2), pp. 547-556.

Equation 1

$$Z = m_1 \frac{\ln(nR_W(\lambda_i))}{\ln(nR_W(\lambda_j))} - m_0$$

Where m_1 is a tuneable constant, n a fixed constant (to assure that the logarithm will be positive) and m_0 is the offset.

Although this method works extremely well in very shallow waters, in deeper waters the band ratio becomes constant with increasing depth and can no longer give any useful information. This point is called the extinction depth. For the datasets used around Anguilla the extinction depth was found to be between 10 and 15 m.

After the creation of the four different maps the data were compared to the MBES data to assess the level of accuracy and error from the four different sensors. All four sensors performed well when compared to the MBES data. Between depths of 3 and 9 m the total vertical uncertainty for all four sensors met the criteria for achieving IHO standards 1a/b. Figure 7 displays some of the results of the bathymetric mapping using the Pleiades 1A data.

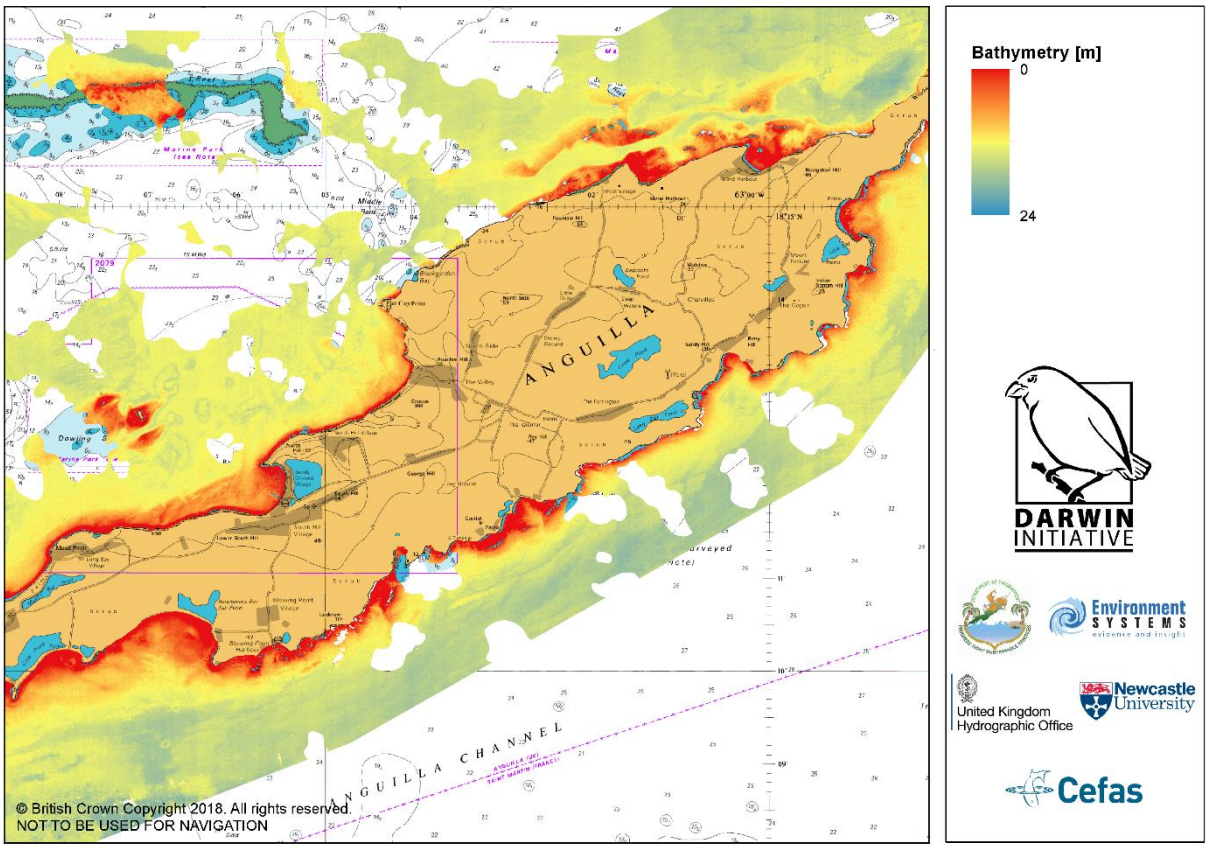

Figure 7. Satellite derived bathymetry from Pleiades 2 data. The holes in the data relate to the presence of clouds or where the data was over an area of water deeper than the extinction depth of the light.

3. Provide detailed coastal habitat layer database to local stakeholders

3.1 Undertake 5-day video characterisation survey of habitats identified in deeper waters.

Habitat mapping is an essential tool when it comes to ecosystem management. Being able to quantify the extent and nature of habitats within the marine environment allows the accurate placement of protection measures and an informed approach to management.

Two sets of habitat maps were produced as part of this project. The first utilises the bathymetric and backscatter data collected as part of the MBES survey. The second map utilises the satellite data and the satellite derived bathymetry layer. Both data sets give useful information about the seabed and the potential habitats present. However, both data types require

groundtruthing data to inform the mapping process and to accurately describe the distribution of the different habitats.

For both data sets groundtruthing was completed using a drop-down camera frame. The frame collected both high definition video and stills of the seabed in carefully selected locations around Anguilla. Using the acoustic data and local stakeholder engagement, stations were positioned around Anguilla to best describe the different habitats and substrates present. The camera system consisted of a Bowtech Video Camera and two GoPro cameras attached to a custom-made frame. At each station the vessel was positioned to the upstream side of the location and the camera was lowered to just above the seabed. The vessel was then allowed to drift over the position while the cameras collected high definition video and stills data. Each camera station lasted for 10 minutes before the camera was recovered and the vessel moved on to the next station.

A total of 10 days, exceeding the 5 day target, of video and camera work were undertaken around Anguilla collecting groundtruthing data from all areas. A total of 3,124 still images of the seabed were collected along with over 24 hours of video data.

As we were able greatly increase the number of survey days through efficient project planning a day was devoted to surveying some of the deeper waters off the Anguilla Bank with members of the DFMR. The Bank is usually out of reach for the DFMR being beyond the reach of their available vessels and below safe diver depth. This potentially important fishing grounds is very understudied and this was a valuable opportunity for members of the DFMR to investigate the habitats present and the current condition of those habitats. The results of the survey have already been utilised by the DFMR for condition reports of the Anguilla Bank and the Outer Cays as well as being used in a scientific publication.

After being shared with the DoE and the DFMR, a copy of the data was taken back to the UK to be analysed by experts at the University of Newcastle. The still and video data were assessed for benthic habitat composition. Benthic habitat composition per photograph was assessed in terms of percentage cover using Coral Point Count® (v4.1); a software tool for determining community statistics of benthic photographs. Percentage cover was derived by randomly assigning 24 points over each photograph and then identifying the species or substrate at each point. Benthic habitat types were selected based upon the classifications derived by Mumby and Harborne (1999)[2] with adaptations for Anguilla's management purposes and habitats specific to Anguilla. The classified still images were converted to GIS points based on the GNSS location of the image with an assigned habitat type. Figure 8 describes the different levels of detail for the two habitat maps and criteria for the classification of the groundtruthing dataset.

[2] Mumby, P.J., & Harborne, A.R. (1999). Development of a systematic classification scheme of marine habitats to facilitate regional management and mapping of Caribbean coral reefs. Biological conservation, 88, 155-163

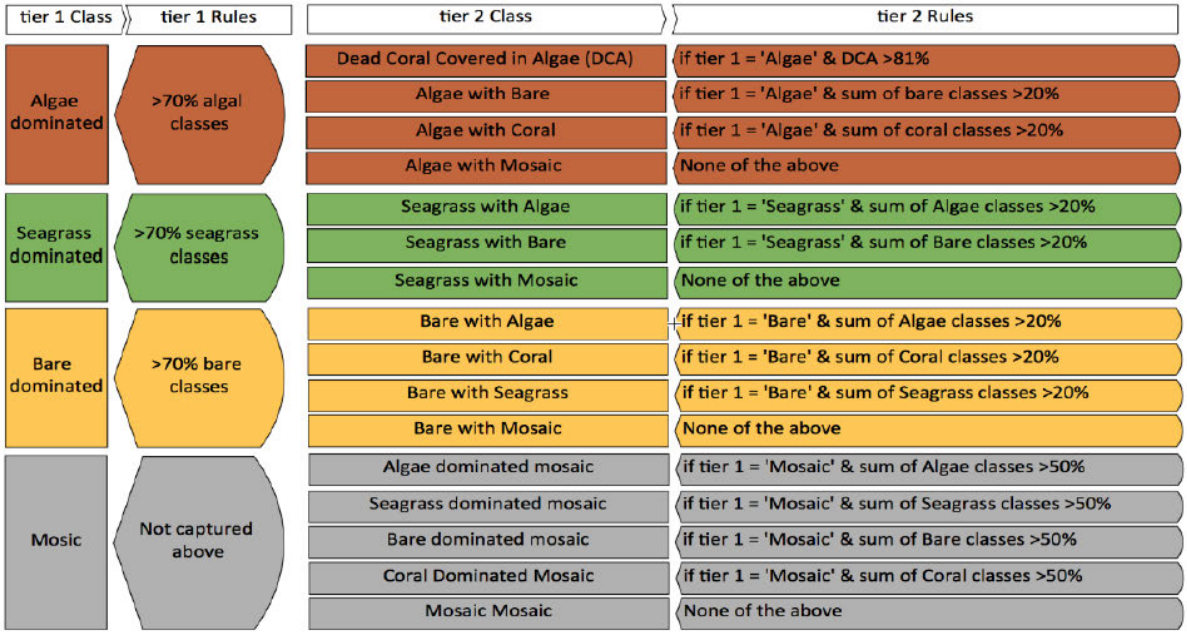

Figure 8. Classification rules assigned to benthic ground truth points based upon habitat composition identified using Coral Point Count.

For more information on the classification of the video and stills data see Ryley (2017) (APPENDIX 6).

3.2 At least 75% of coastal habitats (<20m) mapped using satellite imagery and habitat map produced from MBES survey area.

Both remote sensing datasets, satellite and MBES, were subjected to a similar method of mapping called object-based image analysis (OBIA). This method is a two-step process which involves the segmentation and then classification of an image. Segmentation works by grouping individual pixels based on similar properties to create 'objects'. The idea behind segmentation is to try and replicate what the human brain does automatically when it sees an image and identifies shapes and patterns. The second stage of OBIA is to then classify these objects into the different habitats present. The groundtruhting data is used to classify the objects based on the habitats/substrate identified. These classified objects are then used as a training dataset by a classification algorithm to classify the remaining unclassified objects.

The MBES data was segmented using the multi-resolution segmentation algorithm within Trimble's eCognition® software (v9.0.0) and classified using a random forest classification algorithm. The map created from the MBES bathymetry and backscatter data was classified to the simpler habitat classification of Seagrass, Algae, Bare and Mosaic (Figure 9). Due to the data type and the very small variations in substrate type between the different habitats in the second and more detailed habitat classification hierarchy it was not possible to spatially discern between the different Tier 2 habitats with confidence.

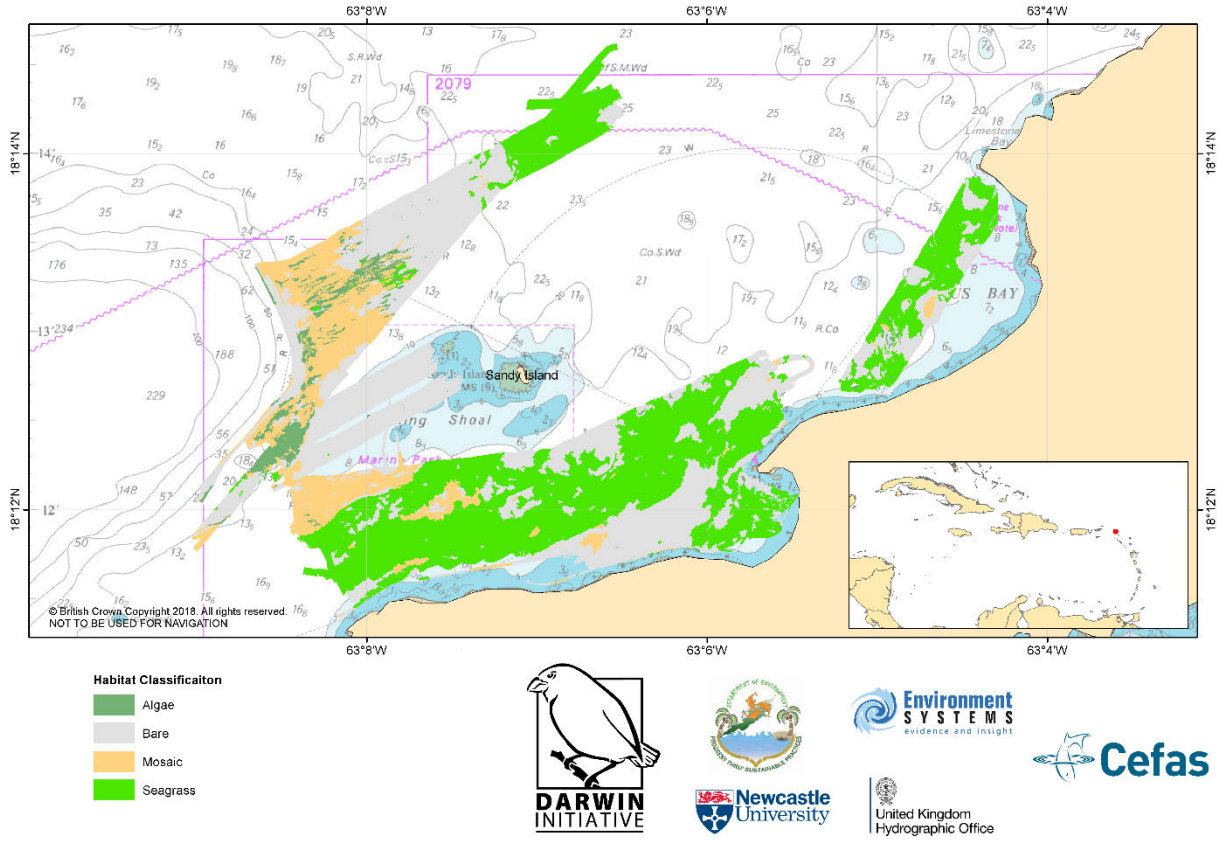

Figure 9. Habitat map crated from the MBES Bathymetry and Backscatter data using the simplified habitat classification scheme.

Two habitat maps were created from the satellite data based on the two levels of detail derived from the groundtruthing data. Before segmentation and classification, the satellite data underwent several different corrections including:

- radiometric calibration,
- atmospheric correction,
- orthorectification,
- land and cloud masking,
- sun glint correction and
- depth correction.

The satellite data was also segmented using the multi-resolution segmentation algorithm within Trimble's eCognition® software (v9.0.0). The objects produced during the segmentation were classified using a mixture of K-nearest neighbour, random forest and support vector machines classification algorithms. All three of these algorithms take the statistics from the training dataset, created from the ground truthing data, and classify the remaining objects based on statistically driven decisions. The full maps can be viewed in Figure 10 and Figure 11 as well as online at http://arcg.is/145X9.

Both maps were validated against a subset of the groundtruthing stations which were left out of the classification. Two error matrices were derived from the classification comparing the actual with the predicted habitats. For the simpler map an overall accuracy of 72.3% was achieved while for the more complex map an overall accuracy of 52.9% was achieved. The lower accuracy achieved for the more complex map is associated with the increased number of classes and the higher chance of a miss-classification. Many of the classes within the more complex hierarchy have similar attributes and are sometimes harder to distinguish from the satellite data.

The total coverage for the two combined maps is 97.80 km^2 which constitutes 79.80% of Anguilla's coastal areas with a depth of less than 20 m. For more details on the methods for the creation of the satellite derived habitat maps and on the data validation see Ryley(2017) (APPENDIX 6).

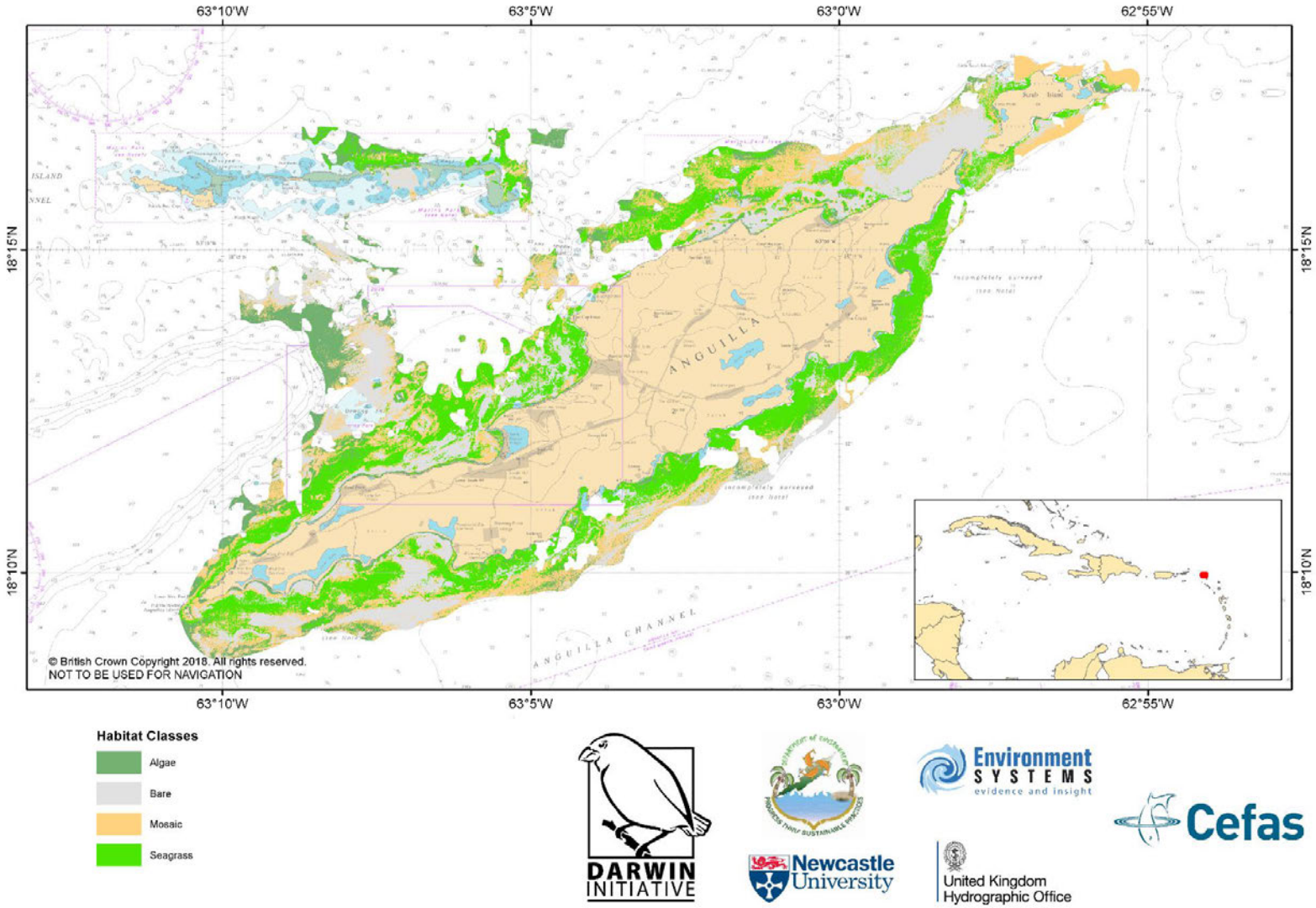

Figure 10: Satellite derived habitat map based on the four simple classes.

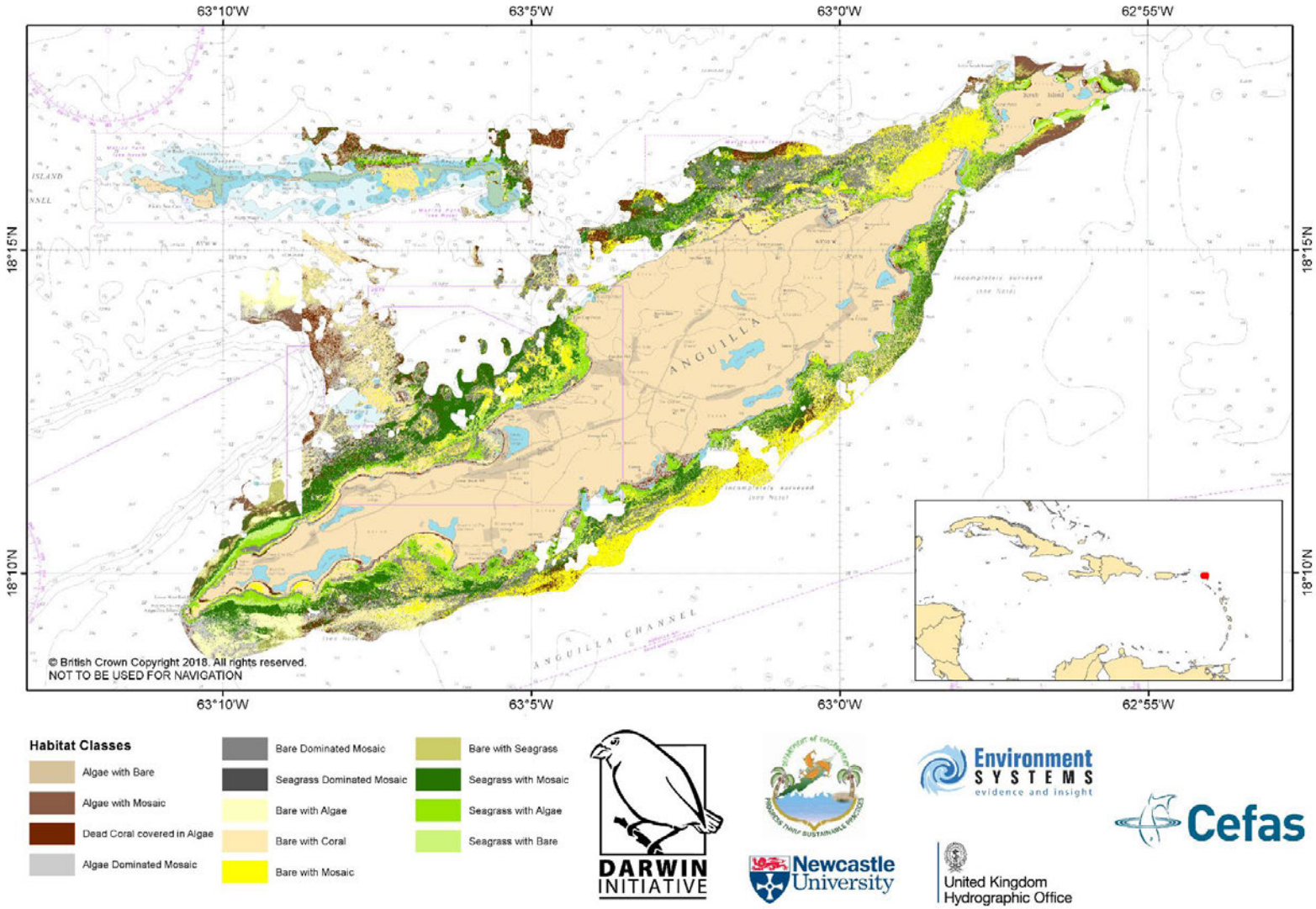

Figure 11. Satellite derived habitat map based on the detailed descriptions of habitats around Anguilla

3.3 Coastal and deeper water habitat data made available to DoE/Anguilla National GIS by end of project and through free online portal.

The maps created during this project were presented to the stakeholders at the final meeting in February 2018. In attendance were representatives from:

- Department of Environment
- Department of Physical Planning
- Customs Department
- Anguilla National Trust
- Department of Fisheries and Marine Resources

The new habitat maps are a significant step forwards with respect to the level of detail and coverage of the coastal areas around Anguilla. The new satellite derived bathymetry maps and the data collected as part of the MBES survey were delivered as Geotiffs to the national GIS database and to the Department of Environment. The habitat map derived from the MBES data as well as the two habitat maps created from the satellite data were packaged up as shapefiles and also delivered to the national GIS database.

In addition, the data can be freely viewed and downloaded from an online portal set-up specifically for this project. An ArcGIS online map was created so that anyone can see and interrogate the data produced as part of this project (http://arcg.is/145X9; Figure 12). From the map the user will be able to follow the links to the Cefas data hub, containing the maps and stills data, and YouTube, containing the video data. At the time of writing this report the data was in the process of being uploaded to the portal. This data will also be fed into the new Anguilla Data Gateway which has been developed by Environment Systems Ltd, one of the project partners of this project.

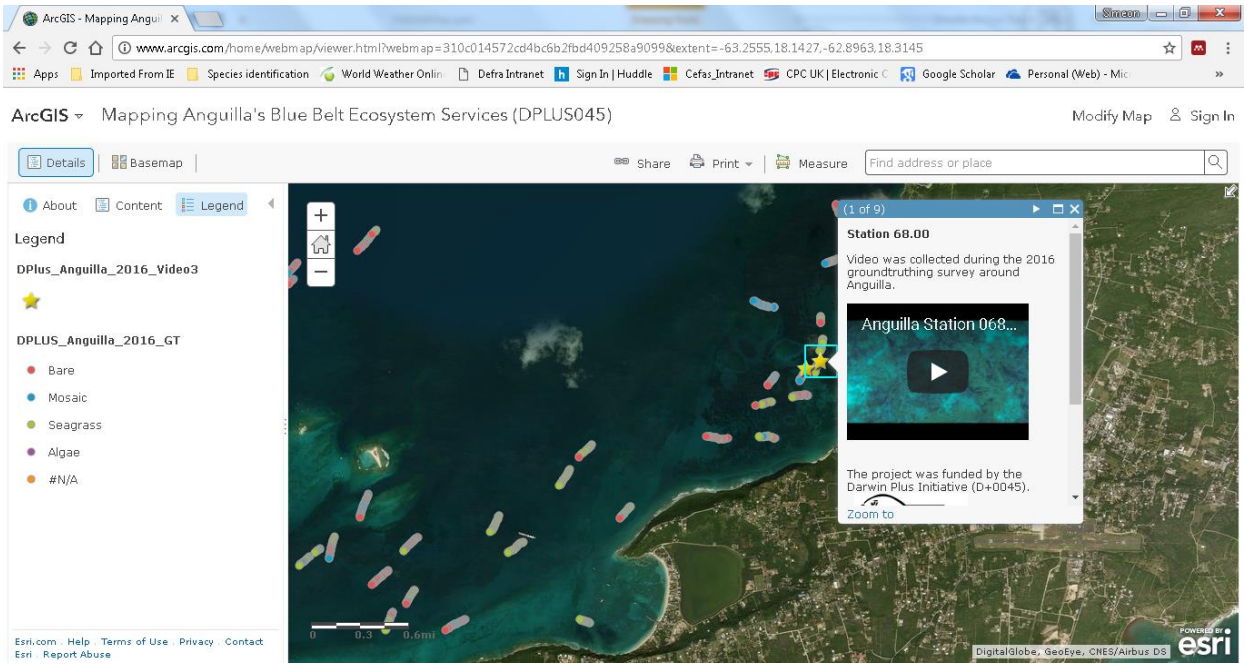

Figure 12. Online GIS portal for viewing video data, interpretation and maps of the data collected during the project (http://arcg.is/145X9)

2.2 Outcome

"To develop marine survey capability and data layers to enhance the ability to protect biodiversity and manage the marine environment and its resources sustainably."

In our assessment the project has achieved the intended outcome as outlined above. With the training made available to the stakeholders throughout the programme and new high-resolution data layers being made available to decision makers and scientists, the territory now has the tools it needs to push on with the conservation of the marine environment around Anguilla.

Training sessions provided throughout the programme will ensure that both the DoE and the DFMR have the skills they need to undertake scientifically robust surveys for the monitoring of the marine environment around Anguilla using the tools available to them. Many of these skills are transferable to other disciplines and are valuable to not only Anguilla but to many of the surrounding countries. Training in how to carry out a dimensional control survey was undertaken by the UKHO during the mobilisation of the MBES system to the charter vessel. This survey accurately measures the position of the centre of the vessel compared to the location of the GPS antenna, the MBES system and the corners of the vessel. As well as being important to MBES operations, a dimensional control survey is also important to all commercial vessels fitted with GPS navigation systems. The results of a dimensional control survey are inputted into a ships navigation system and allow for the accurate and safe navigation of the vessel.

Training provided to the DoE, DMFR, the national GIS team and the Anguilla National Trust in the form of workshops and classroom sessions has provided the teams with new skills specific to marine habitat mapping and a foundation for further study and work into the subject. The techniques we demonstrated during the camera survey and the equipment used are already influencing the way that the DFMR are undertaking their monitoring surveys. Similar equipment and methods have been adopted and have contributed to scientific studies around the island. Several self-published reports and papers have been written on the new techniques being adopted by the fisheries scientists on the islands[3].

The new bathymetry maps created as part of the project give a detailed view of the seabed around Road Bay and into Crocus Bay. The team of hydrographers worked extremely hard to create an accurate and high-quality dataset which would be useful for not only navigation but also for other uses such as habitat mapping and resource assessments. The data was validated against international standards and achieved IHO Special Order status, which is one of the highest standards which can be achieved by hydrographic data.

The habitat maps produced during this project will now feed directly into the marine planning for Anguilla. The maps detail the habitats present with the coastal waters of Anguilla, quantify their expanse and give their location to a high accuracy. These details become especially important when considering conservation, whether through the management of activities or through other active zonal management. The maps give the policy makers and stakeholders a scientifically robust foundation to build their decisions from.

Finally, the project has been able to highlight the need for further monitoring. While viewing all of the data during the final meetings it was highlighted by several of the stakeholders how much the marine environment has changed with some areas being very different to how people remember them 5 or 10 years ago. The passing of Hurricane Irma through the region in September 2017 had a significant impact on the island and likely on the marine environment. Happening after the team had carried out the hydrographic and groundtruthing survey means that the data we held for the completion of the habitat maps may already be out of date. With the skills and tools provided the stakeholders are able to continue to monitor the changes in the

[3] Wynne S.P. & Edwards C.E. (2017). Rapid habitat assessment of the Inner Anguilla Bank and North of the Seal Island Reef System. Anguilla Fisheries and Marine Resources Research Bulletin No 07 (2017)

marine environment. Members of the project team will continue to support the DoE through advice and in the application for further funding opportunities.

2.3 Long-term strategic outcome(s)

The creation of new habitat maps for the coastal areas of Anguilla was identified as one of the key 'needs' by the Darwin + funded Anguilla National Ecosystem Assessment. The maps feed directly into the active conservation of sensitive habitats and species around the island. Having the ability to quantify the area and know an accurate location for sensitive habitats means conservation through area management is backed up by robust science.

Through discussions with stakeholders the project team has been able to highlight the need for further monitoring of the marine environment and a more joined up approach to undertake this monitoring. During the workshops we were able to identify that the vast majority of data needed is already being collected. However, this data is collected by different parties who are not in regular communication and do not have sight of what the other agencies are collecting. At the end of the final workshop there was a desire for the different organisations to work more closely and several meetings were set-up for the following weeks to discuss the distribution of effort and data sharing. The Department of Environment and the Department of Fisheries and Marine Resources have since been brought together under a single Ministry, which is likely to lead to improved cooperation and communication.

The data is also feeding into educational programmes across Anguilla to educate the population on the importance of the marine environment to Anguilla and the wider region (Figure 13).

https://youtu.be/hOr6ysXsJSQ

Figure 13: Educational campaign video developed by the Department of Environment, Anguilla, using data collected by the Darwin+ project.

3 Sustainability and Legacy

Several notices to Mariners have been issued for the safe navigation around Anguilla based on the new hydrographic data which has been collected as part of this project. This includes the relocation of a chartered wreck position within Crocus Bay[4]. The location of several other

[4] https://www.admiralty.co.uk/WeeklyNMs/Year%20-%202018/16wknm18_week16_2018.pdf

previously unchartered wrecks has led to initiatives by the DFMR to investigate these as future dive sites for visiting tourists (Figure 14).

This funding support represented a single distinct project. However, project partner organisations are involved in other projects on and around Anguilla which are likely to contribute to the final outcomes and legacy of the project. Building on the contacts and knowledge gained as part of this project, funding became available late in 2016 for the UKHO to undertake a marine Light Detection and Ranging (LIDAR) survey across the marine areas of the island. This survey was undertaken in February 2017 using aircraft mounted equipment, collecting bathymetry data to a depth of 15 m. The high resolution multibeam echosounder data collected as part of this project was used to validate LIDAR data, and the LIDAR data can also act as a useful validation tool against the satellite derived bathymetry maps created as part of this project. Due to the prohibitively high cost of performing a LIDAR survey, it is unlikely that repeat surveys will be undertaken as part of any monitoring surveys. Validation of the satellite based methods developed as part of this project, will therefore provide the necessary evidence and confidence as part of the development of an affordable and effective monitoring programme.

The data collected as part of this project is already contributing to another Darwin Plus funded project on achieving sustainable fisheries management within the Caribbean (DPLUS067). The data is being used to assess the lobster stocks around Anguilla by habitat type. The habitat maps produced are then used to extrapolate by habitats to create an overall assessment for the lobster communities within the coastal waters around Anguilla.

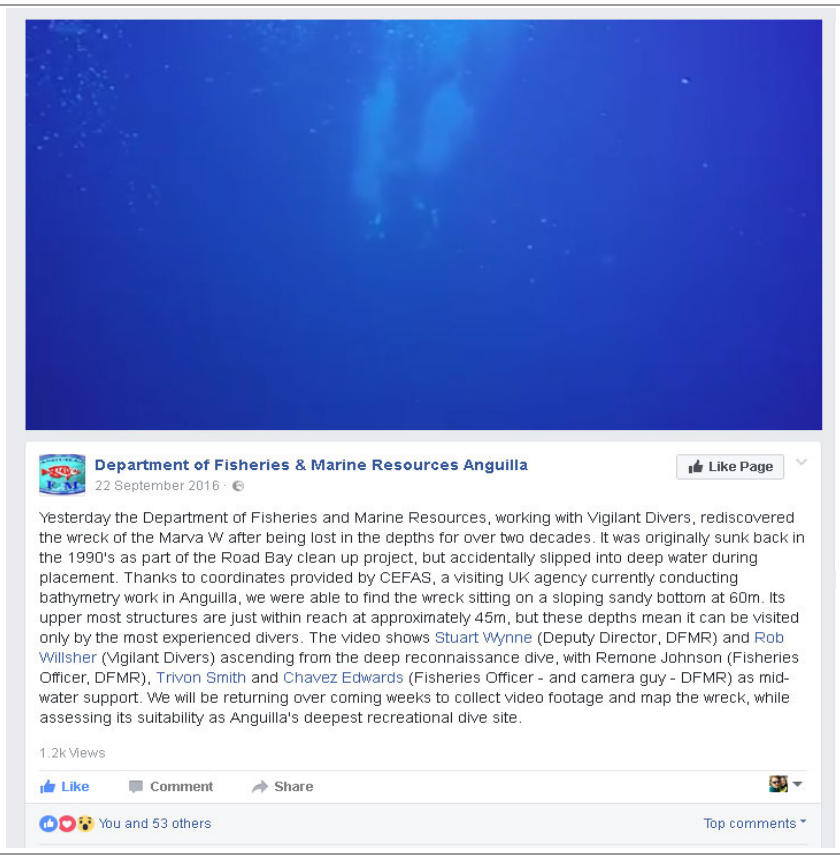

Figure 14: Facebook post on the discovery of the Marva W.

4 Lessons learned

What worked well?

- During the planning stage of the survey we had anticipated that survey times would be restricted by long shipping times, vessel mobilisation problems and vessel operators potentially not working weekends. We had been told about the limited resources on the island including having no fabrication facilities and limited access to raw materials. These fears were instantly allayed when the equipment arrived in Anguilla and with the help of our partners at the DoE was rapidly brought through immigration and delivered to the boat yard ready for mobilisation. The vessel charter company we worked with were extremely proactive and showed great initiative even though this was something completely new to them. Mobilisation of hydrographic equipment can be very complicated and needs to be very precise. The work completed was to an extremely high standard and perfect for our survey requirements.
- Running the surveys in August and September came with several risks associated with it, being in the middle of hurricane season. However, the time of year was beneficial for the project with a reduction in costs for accommodation, rental and vessel charter. The weather was also very good with only 3 days of survey lost to weather downtime.

What didn't work well

- Several pieces of equipment including the tide gauge suffered under the extreme heat and high salinity conditions. This meant that tidal data had to be estimated based on the results of a permanent tide gauge on the neighbouring island of St Martin. Provisions in the future will have to be made to source equipment or housings which are able to withstand the extreme conditions especially when working in remote locations where spares/other data sources may not be available.
- Cefas incurred costs over and above the project grant due to the extreme currency fluctuations between the British Pound and US Dollar. The surveys were planned at the beginning of June 2016 and commitments made. Following the EU Referendum in Britain, currency changes led to cost increases of almost 20%, which the project budget could not accommodate.
- In September 2017 Hurricane Irma passed through the region causing wide-spread devastation to several of the islands, including Anguilla. As well as having a significant impact on land it is likely that the high levels of wave and tidal energy caused by the hurricane would have also had a significant impact on the marine environment. By this point the project had collected and bought all of its data. This meant that there were no funds available for the collection and analysis of new data to quantify what impact the hurricane had had on the marine environment. The project team have tried to mitigate this by providing sufficient training, both in Anguilla and in the UK, for the stakeholders to collect and analyse their own data and monitor the impact of the hurricane.

4.1 Monitoring and evaluation

Cefas follows ISO9001 project management structure. As part of this commitment, meetings between project manager and project sponsor occurred once a month. This ensured that all elements of the project were under control and discussions took place at an early stage when issues arose.

The project has managed to far exceed the number of survey days proposed, greatly increasing the quantity of data available for mapping and for distribution to the stakeholders. The increase from the 5 days in the application to a total of 10 days for the groundtruthing

survey allowed the project team to collect data from all the coastal areas around Anguilla as well as stations further out on the Anguilla Bank.

Bathymetric data was collected and processed to international standards (International Hydrographic Organisation – Standards for Hydrographic Surveys – Special Publication S44 Edition 5) and validated by UKHO bathymetry analyst. The data collected achieved a 99% agreement with IHO Order 1a and 95% agreement with IHO Special Order data quality.

Stakeholder engagement with the project has been extremely good with a very high attendance at the kick-off meeting and continued good attendance at the mid-project stakeholder meeting and the final stakeholder meeting (Table 2).

Table 2: Attendance of opening and mid-project stakeholder meetings

Meeting	Date	Attendance
Opening Kick-off meeting	June 2016	28
Mid-project Stakeholder meeting	March 2017	20
Final Stakeholder Meeting and Workshop	February 2018	19

An external Audit is scheduled for the end of the project in line with the project funding requirements.

5 Darwin Identity

The identity of the Darwin Initiative has been key to all the activities carried out as part of this project. Progress during survey activities and stakeholder engagement has been captured on Twitter and Facebook by both Cefas and stakeholders. Social media engagement has always made clear links to the Darwin Initiative by including @Darwin_Defra (Figure 15). Posters provided for the stakeholder events along with promotional literature have all included prominent branding of the Darwin Initiative (Figure 16).

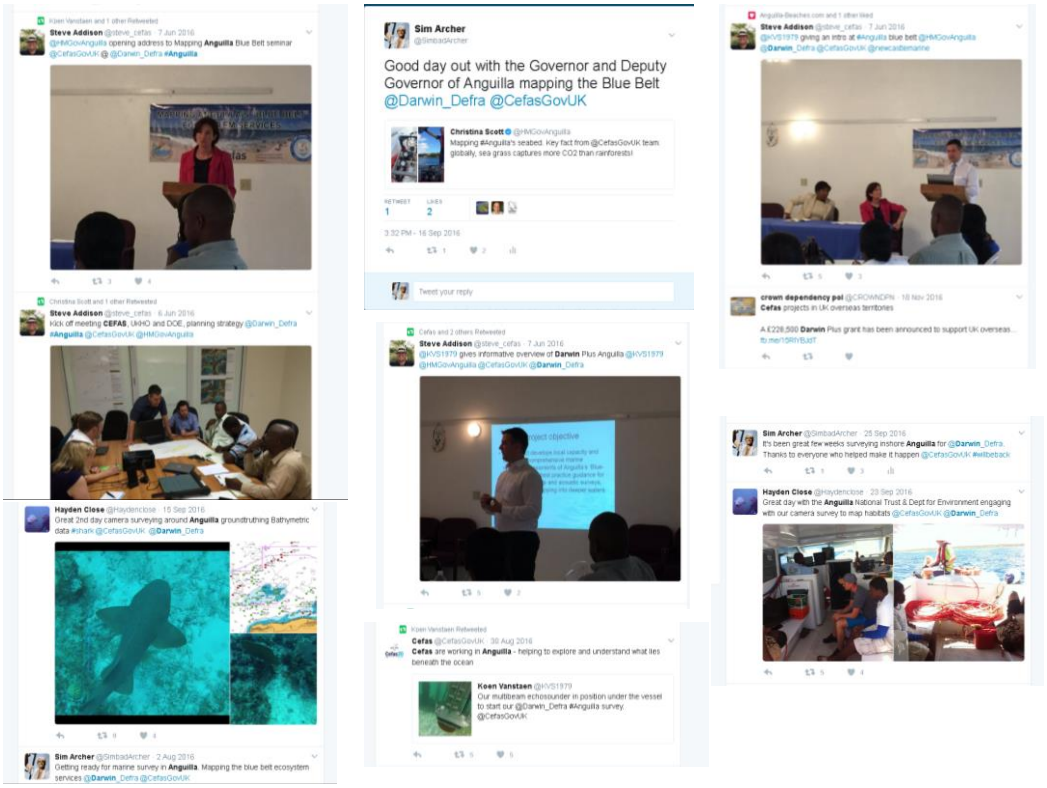

Figure 15: Social media engagement promoting the project and the Darwin Initiative.

Figure 16: Posters and promotional literature for the project

6 Finance and administration

6.1 Project expenditure

Project spend (indicative) since last annual report	2017/18 Grant (£)	2017/18 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs	£[redacted]	[redacted]	4%	
Consultancy costs				
Overhead Costs	£[redacted]	[redacted]	37%	This was caused by a reduction in the overheads charged by Cefas from when the application was put in.
Travel and subsistence	£[redacted]	£[redacted]	-4%	
Operating Costs	£[redacted]	£[redacted]	-5%	
Capital items				
Others				
Audit costs	£[redacted]	£[redacted]		
TOTAL	£[redacted]	£[redacted]		

Staff employed (Name and position)	Cost (£)
Simeon Archer-Rand	£[redacted]
Riccardo Arosio	£[redacted]
Nicki Hawkes - Project Manager	£[redacted]
Callum Scougal	£[redacted]
Serena Wright	£[redacted]
Katie Medcalf - Environment Director	£[redacted]
Samuel Pike - Remote Sensing Consultant	£[redacted]
Elsa-Kristin Naumann - Environmental Analyst	£[redacted]
Mrs PC Lightfoot	£[redacted]
Dr C Fitzsimmons	£[redacted]
TOTAL	£[redacted]

6.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
Cefas	£[redacted]
Environment Systems	£[redacted]
Newcastle University	£[redacted]
UKHO	£[redacted]
TOTAL	**£**[redacted]

Source of funding for additional work after project lifetime	Total (£)
TOTAL	

6.3 Value for Money

It was felt by the project team that the project offered good value for money. Within the application we proposed a set number of days of survey which could be expected for the money available. Through the use of cost saving exercises and efficiency we were able to increase the number of survey days from a total of 15 days as set out in the application to a total of 24 days between the MBES and groundtruthing survey. The main savings came with shipping the equipment out in one go and utilising the same vessel for both surveys back to back. This decreased mobilisations costs significantly and we were able to get a good price on the vessel charter for block booking.

Running the surveys in August and September meant that we were able to get off-season prices on accommodation, car-hire and vessel charter. This allowed us to keep cost down and gave us the ability to run additional survey days. Although this time of year is classified as 'hurricane season' it is actually the best time to undertake these kinds of surveys due to the normally low wind strengths and small waves (with the exception of when a hurricane passes through the region). For much of the year this area of the Caribbean experiences strong winds meaning the sea state is not good for undertaking the precise measurements needed.

Annex 1

Project's original (or most recently approved) logframe (if your project has a logframe), including indicators, means of verification and assumptions. N.B. Insert your full logframe. If your logframe has changed since your application and was approved by a Change Request the newest approved version should be inserted here, otherwise insert the logframe from your application. If your application's logframe is presented in a different format in your application, please transpose into the below template. Please feel free to contact Darwin-Projects@ltsi.co.uk if you have any questions regarding this.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: To provide the Anguillan Government the necessary skills and tools for effective management of marine biodiversity, fisheries resources and monitor coastal change. (Max 30 words)			
Outcome: To develop marine survey capability and data layers to enhance the ability to protect biodiversity and manage the marine environment and its resources sustainably. (Max 30 words)	0.1 Publish a territory wide database of coastal habitats. Increase habitat knowledge in waters exceeding 20m compared to baseline 0.2 Anguilla Government staff are confident and have the skills to implement and maintain good marine surveys.	0.1 Area coverage (km^2) increased compared to 2004 baseline. 0.2 Two-way knowledge exchange has been undertaken between local managers and UK domain specialists. Anguilla staff attended UK based knowledge exchange. Course certificates issued.	0.1 Good quality satellite imagery is available for the area of interest. Weather allows new multibeam echosounder data collection 0.2 Training and knowledge exchange will give staff skills and confidence needed.
Outputs: **1**. Provide training for local stakeholders in state-of-the-art marine survey techniques and processes	1.1 At least 5 days of training opportunities provided during the lifetime of the project on hydrographic and environmental survey techniques, either classroom based or through practical experience. 1.2 At least one person attending from each local stakeholder organisation. 1.3 One DoE staff member participates in researcher exchange, gaining hands-on experience of marine survey	1.1 Training course registers 1.2 Training course register 1.3 Participation in knowledge exchange.	Local staff are able to participate in knowledge exchange events. DoE are able to participate in researcher exchange and are able to obtain necessary seagoing and medical qualifications.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	techniques onboard Cefas' ocean going research vessel *Cefas Endeavour.*		
2. High resolution bathymetry data for majority of coastal waters and selected deeper water sites	2.1 Deliver at least 10 days (incl. any weather downtime) of high resolution multibeam echosounder surveys in water depths exceeding 15m. 2.2. Multibeam bathymetry data meets recognised international standards (IHO Order 1a) 2.3 Process available satellite imagery to derive a satellite derived bathymetry data layer with 2m resolution for Anguillan coastal waters.	2.1 Daily progress reports produced during survey. 2.2 Data verified and accepted by UKHO Bathymetry Data Centre 2.3 More than 75% of coastal waters (<20m) covered by high resolution SDB data.	Weather conditions suitable for survey activities to be undertaken during time in country. Quality of satellite imagery allows bathymetry down to 20m to be extracted. Bathymetry extraction routines can be applied successfully to the satellite imagery.
3. Provide detailed coastal habitat layer database to local stakeholders	3.1 Undertake 5 day video characterisation survey of habitats identified in deeper waters. 3.2 At least 75% of coastal habitats (<20m) mapped using satellite imagery and habitat map produced from MBES survey area. 3.3 Coastal and deeper water habitat data made available to DoE/Anguilla National GIS by end of project and through free online portal.	3.1 Number of survey days delivered, evidence from daily progress reports. 3.2 Area covered by habitat data layers 2.6 Confirmation of delivery of data to Anguillan Government. Mechanism in place to make data freely available to end-users and interested parties.	Weather conditions suitable for survey activities to be undertaken during time in country. Correlation between satellite/echosounder data and ecological communities can be established.
4.			
Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1) 1.1 Project kick off meeting, mid-project and final project stakeholder meetings 1.2 2 day acoustic survey techniques and analysis training course 1.3 2 day video survey techniques and analysis training course			

Project summary	Measurable Indicators	Means of verification	Important Assumptions
1.4 1 day data interpretation and mapping training course 1.5 Researcher exchange 2.1 Stakeholder meeting to identify priority survey area(s) (align with activity 1.1 kick off meeting) 2.2 Vessel and equipment mobilisation 2.3 Hydrographic survey of deeper water habitats and bathymetry 2.4 Data processing 2.5 UKHO validation against IHO standards 2.6 Processing of multibeam backscatter data for habitat mapping 2.7 Acquisition of high resolution satellite imagery 2.8 Data processing of satellite imagery to derive bathymetry 2.9 Calibration of satellite derived bathymetry against multibeam echosounder data 2.10 Review of satellite derived bathymetry by UKHO assessment team 3.1 Review multibeam echosounder data and design video characterisation survey 3.2 Undertake 5 day video characterisation survey 3.3 Analyse and quantify physical characteristics and biological communities from video and photographs. Qualitatively describe reef health. 3.4 Undertake object based image analysis of satellite and multibeam echosounder data and combine with in-situ observations to develop habitat characterisation data layers. 3.5 Share habitat layers with local stakeholders 3.6 Make data freely available to data archive centres and through online portals. Data available to UK and local Government to inform Blue Belt assessments, where necessary.			

Annex 2 Report of progress and achievements against final project logframe for the life of the project (if your project has a logframe)

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Impact: To provide the Anguillan Government the necessary skills and tools for effective management of marine biodiversity, fisheries resources and monitor coastal change.		The new maps created for this project give the DoE and the Anguillan Government a robust scientific basis to form future decisions on their marine ecosystem. The maps greatly increase the resolution of the seabed mapping around Anguilla and in combination with other data which led on from this project give Anguilla the tools it needs for the future. The skills demonstrated and taught to the teams at the DoE, DFMR and Anguillan National Trust give them the ability to further the management of the marine environment around Anguilla. This has already led to several other investigation and projects being set up by the agencies using the skills and data provided by this project.
Outcome To develop marine survey capability and data layers to enhance the ability to protect biodiversity and manage the marine environment and its resources sustainably.	Publish a territory wide database of coastal habitats. Increase habitat knowledge in waters exceeding 20m compared to baseline Anguilla Government staff are confident and have the skills to implement and maintain good marine surveys.	The maps produced as part of this project have contributed to a much greater understanding of the marine environment around Anguilla. The resolution of the data is greatly increased and with the addition of the new Lidar data from the UKHO makes the coastal areas around Anguilla one of the most extensively mapped in the Caribbean. All the data collected and all the new maps derived from the data have been made available to the DoE as well as being incorporated into a dedicated online GIS mapping tool for easy data interrogation and download by the wider public. The 10 days of training given to the various stakeholders over the course of the project has given them many skills essential to the future monitoring of their marine environment. In combination with the wealth of expertise on the island already Anguilla is in a good place to successfully manage their marine environment.
Output 1. Provide training for local stakeholders in state-of-the-art marine survey techniques and processes	1.1 At least 5 days of training opportunities provided during the lifetime of the project on hydrographic and environmental survey techniques, either classroom based or through practical experience. 1.2 At least one person attending from each local stakeholder organisation. 1.3 One DoE staff member participates in researcher exchange, gaining hands-	Over the course of the project the team from the UK has undertaken a total of 10 days of training in the form of classroom sessions and training in the field using the equipment. The in-the-field training was undertaken with members of DoE, DFMR, National trust and the Department of Land and Surveys. This included training in the mobilisation of hydrographic equipment, the planning of camera groundtruthing surveys, the undertaking of camera surveys and the safe use of equipment while on the vessel. Additional training was undertaken as part of classroom sessions with hands on experience of using the data collected in the field. These were well attended with at least on participant attending from each of the stakeholders involved in the marine environment around Anguilla. By the end of the sessions the

	on experience of marine survey techniques onboard Cefas' ocean going research vessel *Cefas Endeavour.*	attendees had an understanding of the processes involved in creating the maps and were much more confident is using the data for future decisions. In March 2018 one member of the DoE and one member of the DFMR staff attended a researcher exchange week at the Cefas Laboratory in the UK as well as travelling to the ESL offices for some additional training. Due to change in timing and survey schedule we were unable to offer a berth onboard the RV Cefas Endeavour but the training and opportunities to talk to other researchers within Cefas were felt to be very valuable to the researchers from Anguilla.
1.1 Project kick off meeting, mid-project and final project stakeholder meetings		All stakeholder events were well attended with at least one attendee from each of the stakeholders involved in marine activity being present. The total number of attendees for each meeting is presented in Section 4.1.
1.2 2 day acoustic survey techniques and analysis training course		Acoustic survey techniques training was undertaken during survey operations, involving the Department of Land and Surveys, and through classroom based exercises involving all of the stakeholders. The training involved the mobilisation and setting up of equipment on a vessel, the fundamentals of data collection, data processing and finally how to analyse and use the data.
1.3 2 day video survey techniques and analysis training course		Local stakeholder participated on 7 days of video data collection where training was provided. One member of staff from the DoE and one from the DFMR were able to attend a week long researcher exchange in the UK.
1.4 1 day data interpretation and mapping training course		Members of the project team from Cefas, NCL and ESL undertook a half day workshop in 2017 and a two-day workshop in 2018 going through the basics of data interpretation and mapping. The training took the form of lectures and classroom based exercises on how to interpret bathymetry and video data for mapping and the basics of satellite data interpretation.
1.5 Researcher exchange		Two members of the Anguillan government attended a week of talks, presentations and practical training at Cefas and ESL in the UK. Topics covered included habitat mapping, satellite data interpretation. fish tagging and monitoring.
Output 2. High resolution bathymetry data for majority of coastal waters and selected deeper water sites	2.1 Deliver at least 10 days (incl. any weather downtime) of high resolution multibeam echosounder surveys in water depths exceeding 15m. 2.2. Multibeam bathymetry data meets recognised international standards (IHO Order 1a)	The hydrographic survey of the area within Road bay and Crocus Bay was undertaken in August 2016. In total 11 days of successful data collection was achieved with 3 days of weather downtime. The total area covered was 14.7 km^2 to a resolution of 1m by 1m. The data was processed and assessed by the UKHO and was found to be of very high quality. The data achieved a 99% agreement with Order 1a and a 95% agreement with IHO Special Order data. Satellite data was processed by Newcastle University and Environment Systems using the methods stated earlier in this report. The methods were used to create a

	2.3 Process available satellite imagery to derive a satellite derived bathymetry data layer with 2m resolution for Anguillan coastal waters.	satellite derived bathymetry map for the majority of the coastal waters around Anguilla. A total of 78% of the coastal waters were mapped with the satellite derived bathymetry to a resolution of 2m by 2m.
2.1 Stakeholder meeting to identify priority survey area(s) (align with activity 1.1 kick off meeting)		During the project kick-off meeting in June 2016 the second half of the meeting was put aside for local stakeholders to identify areas of high priority for high resolution Bathymetry. The approaches to Road Bay and the Coral Reefs to the South of the Cays was identified as an area of high traffic and importance to tourism. Similarly, Crocus Bay was identified as an area of importance with the area being more regularly frequented by large cruise ships.
2.2 Vessel and equipment mobilisation		With the help of local stakeholders, a suitable vessel to undertake the MBES survey was chosen and local partners to help with the mobilisation were identified. Equipment for the survey arrived in Anguilla at the beginning of September 2016 and was mobilised onto the vessel with the assistance of the Department of Lands and Survey.
2.3 Hydrographic survey of deeper water habitats and bathymetry		A total of 11 days of hydrographic survey was undertaken collecting bathymetry data between Sandy ground and The Cays and within Crocus Bay.
2.4 Data processing		Data processing of the MBES bathymetry data was undertaken by UKHO and completed in March 2017. Data will be made available to the other partner organisations in April 2017
2.5 UKHO validation against IHO standards		The bathymetry data was processed in accordance with the International Hydrographic Organisation (IHO) Standards for Hydrographic Surveys - Order 1a (Special Publication 44, Edition 5). The data achieved a 99% agreement with Order 1a and a 95% agreement with Special Order data.
2.6 Processing of multibeam backscatter data for habitat mapping		Processing of the MBES backscatter data was conducted by Cefas and was made available to the Partner organisations in December 2016.
2.7 Acquisition of high resolution satellite imagery		Environment Systems acquired high resolution Pleiades satellite imagery in January 2017.
2.8 Data processing of satellite imagery to derive bathymetry		Satellite derived bathymetry was derived from the datasets by Newcastle University and Environment Systems.
2.9 Calibration of satellite derived bathymetry against multibeam echosounder data		A total of 3,885 data points from the MBES data were used to calibrate the SDB. Additional data points collected using fish finders by Newcastle University from around the island were also used for the calibration and validation of the data.

2.10 Review of satellite derived bathymetry by UKHO assessment team		A review of the process was undertaken between UKHO, Environment Systems and Newcastle University to investigate the integrity of the data produced. All parties concluded that the idea
Output 3. Provide detailed coastal habitat layer database to local stakeholders	3.1 Undertake 5 day video characterisation survey of habitats identified in deeper waters. 3.2 At least 75% of coastal habitats (<20m) mapped using satellite imagery and habitat map produced from MBES survey area. 3.3 Coastal and deeper water habitat data made available to DoE/Anguilla National GIS by end of project and through free online portal.	Due to savings in mobilisation and vessel charter costs the groundtruhting survey was able to be extended from 5 to 10 days allowing a much wider characterisation of the coastal areas to occur. This included working on the southern coast of Anguilla which is relatively poorly surveyed. The new habitat maps created from the satellite and MBES data cover 79% of the coastal areas around Anguilla. The areas not covered by the new maps are where cloud cover impeded the satellite data. The data has been made available to the DoE and the Anguillan National GIS during the final stakeholder event. The data is also due to go live on the Cefas data hub, where the data can be downloaded for free by any interested parties. The data can also be viewed through a free to access online GIS portal where the maps can be viewed with other data available online.
3.1 Review multibeam echosounder data and design video characterisation survey		Preliminary processing of the hydrographic data was undertaken by the surveyors during the data collection. This data was provided to the marine scientists from Cefas as layered tiff files. Stations were positioned based on the interpretation of the acoustic data (bathymetry and backscatters) and on knowledge gained from local stakeholders who attended the survey planning meetings and joined us during the surveys.
3.2 Undertake 5 day video characterisation survey		In September 2016 a 10-day groundtruthing video survey was undertaken by the project team around Anguilla. The survey was able to cover not only the areas of new bathymetric data but all along the north coast of Anguilla, out onto the Anguilla Bank and along the less accessible southern coast.
3.3 Analyse and quantify physical characteristics and biological communities from video and photographs. Qualitatively describe reef health.		Interpretation of the video and stills data was undertaken by Newcastle University. Using a specialist software package images were analysed for species present and substrate type. The species distribution and substrate types were then used to classify each of the images based on the classifications described in Section 2.1. The positional information for each image was then used to create a training dataset of GIS points for the classification algorithms to use.
3.4 Undertake object based image analysis of satellite and multibeam echosounder data and combine with in-situ observations to develop habitat characterisation data layers.		Object based image analysis (OBIA) was undertaken on the MBES data and the satellite data to first segment the raw layers and then classify those segments using the training datasets created through the interpretation of the video and stills data.

	the layers created give different levels of detail and are based on the two different sets of habitat classes described in Section 2.1.
3.5 Share habitat layers with local stakeholders	At the final stakeholder meeting the habitat layers created were shared with the stakeholders and the processes used to create them was gone through in detail.
3.6 Make data freely available to data archive centres and through online portals. Data available to UK and local Government to inform Blue Belt assessments, where necessary.	The data has been made available to the stakeholders and the wider community through several different avenues. The data was shared with the DoE and the national GIS database during the final stakeholder meeting and will feed into their data centres. The habitat and bathymetry data is available through the Cefas Data Hub where the data can be downloaded by all. Video data from the groundtruthing survey has been uploaded to a project specific YouTube channel meaning the data is easily accessible to all. Maps from the project can also be viewed from the online GIS portal created for the project (http://arcg.is/145X9).

Annex 3 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1	Number of (i) students from the UKOTs; and (ii) other students to receive training (including PhD, masters and other training and receiving a qualification or certificate)	
2	Number of (i) people in UKOTs; and (ii) other people receiving other forms of long-term (>1yr) training not leading to formal qualification	
3a	Number of (i) people in UKOTs; and (ii) other people receiving other forms of short-term education/training (i.e. not categories 1-5 above)	19
3b	Number of training weeks (i) in UKOTs; (ii) outside UKOTs not leading to formal qualification	(i) 2 Weeks (ii) 1 Week
4	Number of types of training materials produced. Were these materials made available for use by UKOTs?	
5	Number of UKOT citizens who have increased capacity to manage natural resources as a result of the project	6
Research Measures		
9	Number of species/habitat management plans/ strategies (or action plans) produced for/by Governments, public authorities or other implementing agencies in the UKOTs	
10	Number of formal documents produced to assist work in UKOTs related to species identification, classification and recording.	5 Three habitat maps One bathymetry map MSc Thesis
11a	Number of papers published or accepted for publication in peer reviewed journals written by (i) UKOT authors; and (ii) other authors	
11b	Number of papers published or accepted for publication elsewhere written by (i) UKOT authors; and (ii) other authors	
12b	Number of computer-based databases enhanced (containing species/genetic information). Were these databases made available for use by UKOTs?	2 Anguilla National GIS database Cefas Data Hub

Code	Description	Totals (plus additional detail as required)
13a	Number of species reference collections established. Were these collections handed over to UKOTs?	
13b	Number of species reference collections enhanced. Were these collections handed over to UKOTs?	
Dissemination Measures		
14a	Number of conferences/seminars/workshops/stakeholder meetings organised to present/disseminate findings from UKOT's Darwin project work	2
14b	Number of conferences/seminars/ workshops/stakeholder meetings attended at which findings from the Darwin Plus project work will be presented/ disseminated	4 Stakeholder workshops, CARICOM Presentation,
Physical Measures		
20	Estimated value (£s) of physical assets handed over to UKOT(s)	£[redacted] (generators)
21	Number of permanent educational/training/research facilities or organisation established in UKOTs	
22	Number of permanent field plots established in UKOTs	
23	Value of resources raised from other sources (e.g., in addition to Darwin funding) for project work	£[redacted] From 'in-kind' contributions from Project partners

Annex 4 Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. weblink, contact address, annex etc)
All Project Data	DPLUS045 Project Data. Simeon Archer-Rand, 2018	British	British	Male	Cefas, Lowestoft	http://data.cefas.co.uk (At the time of writing this report some data was still in the process of being uploaded)
Online GIS	DPLUS045 Online GIS, Simeon Archer-Rand, 2018	British	British	Male	Cefas, Lowestoft	http://arcg.is/145X9
Video Data	Anguilla-Underwater Video, Simeon Archer-Rand, 2018	British	British	Male	Cefas, Lowestoft	https://www.youtube.com/channel/UCZRSjw2xiJIdHdgcCOt7Tkg/featured
Twitter Feed	Koen Vanstaen, 2018	Belgian	British	Male	Cefas, Lowestoft	https://twitter.com/KVS1979
Project Flyer	Project kick-off flyer, Simeon Archer-Rand, 2016	British	British	Male	Cefas, Lowestoft	
Educational Video	Ecosystems of Anguilla, Carencia Rouse, 2017	Anguillan	Anguillan	Female	DoE, Anguilla	https://youtu.be/hOr6ysXsJSQ

Annex 5 Darwin Contacts

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Role within Darwin Project	
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Checklist for submission

	Check
Is the report less than 10MB? If so, please email to Darwin-Projects@ltsi.co.uk putting the project number in the Subject line.	
Is your report more than 10MB? If so, please discuss with Darwin-Projects@ltsi.co.uk about the best way to deliver the report, putting the project number in the Subject line.	
Have you included means of verification? You need not submit every project document, but the main outputs and a selection of the others would strengthen the report.	
Do you have hard copies of material you want to submit with the report? If so, please make this clear in the covering email and ensure all material is marked with the project number.	
Have you involved your partners in preparation of the report and named the main contributors	
Have you completed the Project Expenditure table fully?	
Do not include claim forms or other communications with this report.	