



Darwin Initiative: Final Report

To be completed with reference to the “Writing a Darwin Report” guidance: (<http://www.darwininitiative.org.uk/resources-for-projects/reporting-forms>). It is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)

Darwin Project Information

Project reference	DPLUS061
Project title	Protecting herbivorous fish to conserve Cayman Island coral reef biodiversity
Country(ies)	Cayman Islands
Lead organisation	CCMI
Partner institution(s)	Cayman Islands Department of Environment, Smithsonian Institution, The Rare Organisation
Darwin grant value	£249,096
Start/end dates of project	April 2017 to December 2019
Project leader’s name	Carrie Manfrino PhD, Claire Dell PhD
Project website/blog/social media	www.reefresearch.org
Report author(s) and date	Carrie Manfrino, Claire Dell, Gretchen Goodbody-Gringley, March 30, 2020

1 Project Summary

The Caribbean in general has a long history of subsistence fishing, which has led to regional declines in herbivorous fish populations. Such declines have been highlighted as the potential cause of ecosystems shifts from benthos dominated by scleractinian corals to those dominated by macroalgae. The present role of herbivory in maintaining ecosystem function and reducing algal overgrowth has been a longstanding question in ecology. Moreover, how different herbivorous species may differentially impact these interactions remains unknown. Can specific species be considered keystones to maintaining coral cover and biodiversity by preferentially grazing fast growing macroalgae? Understanding how different herbivorous species impact reef structure will provide critical information to guide fisheries management. The aim of this project was to determine which herbivorous species are critical to the Cayman Islands and to use this information to inform a biodiversity action plan that empowers government to establish policies to manage and sustain these ecologically important species.

2 Project Partnerships

The Cayman Islands Department of the Environment (CIDoE) was a key project partner and have been integrally involved in the project from its inception. Partners at the CIDoE assisted with design of the study, helped execute the work and assisted with interpretations. Through a series of in person and virtual meetings, together we developed a new Chapter to the CIDoE Coral Reef Biodiversity Action Plan (BAP) specific to the role of herbivory in maintaining healthy reefs. Specifically, Dr Claire Dell spent 6 weeks working in the CIDoE office in Grand Cayman where she held frequent meetings with our key partner, John Bothwell, as well as other CIDoE officers on various topics related to this grant. Dr Dell also presented an update of the work to the entire

department and in a public lecture at the Cayman Islands National Gallery (**Image 1**). Furthermore, this year we have held two collaborative group meetings to discuss progress of the grant and to hear viewpoints from all our project partners (**Image 2**). Moving forward, this strong collaborative relationship has initiated a new project related to achieving specific aspects of the new section in the BAP. We anticipate a longstanding mutually beneficial relationship.

In addition, local stakeholders were involved with the project through multiple community meetings and outreach events designed to share our findings with the public and gain their input (**Image 3**). These have taken place across the country and have been an excellent way to engage the community and to hear their concerns and experiences. As a Cayman-based organization, stakeholder involvement is of critical importance for our future success and we strive to be transparent and communicative with local entities.

3 Project Achievements

3.1 Outputs

Output 1: Draft biodiversity action plan to protect key herbivores is approved internally by the Dept. of Environment.

This output was achieved and a new chapter, *Herbivory*, was written by project leaders based on the results of the present study and approved by the CIDoE to be incorporated into the Coral Reef Biodiversity Action Plan. In order to do this, partners completed surveys to assess fish communities from 15 reefs across the three Cayman Islands in year 1 (Output **1.1**). Historic reef trends quantified and key species reducing algae growth were identified by the end of year 2 (Output **1.1**). An Herbivorous Fish Focus Group was formed and comprised of 21 representatives from many different demographics including the government, NGOs, local businesses, fishermen and also concerned members of the community, which all contributed to the development of the BAP (Output **1.2**). A copy of the report from the focus group meetings is included as a **Supplemental Document 1** (Annex 7) along with the final Herbivory Biodiversity Action Plan accepted by the DOE (**Supplemental Document 2**, Annex 7). New educational modules about herbivory, aimed to students in grades 5 and 6, were delivered to local schools, reaching over 300 students by the end of year 1 (Output **1.3**; **Table 1**, **Supplemental Document 5**, Annex 7).

Output 2: Spatial map establishes the levels of herbivory and regional connectivity of key herbivorous fish and supports regional benefit of protecting herbivores.

A spatial map was generated based on differential levels of herbivory across sites (Output **2.1**; Fig. 1). Diet analysis from 54 specimen occurred in the Fall of 2019 (see final report, **Supplemental Document 3**, Annex 7), however, we were unable to incorporate genetic connectivity into this analysis (Output **2.2**). Genetic samples were sent to project partners at the Smithsonian, but the DNA was significantly degraded and we were unable to obtain quality sequence reads. A second set of tissue samples was kept at the field station that we hope to send for sequencing in the near future, however, the complete shutdown of the Cayman Islands as a result of the COVID-19 pandemic has resulted in further delays to this analysis. We are still hopeful that we can get some useful information from these samples in the future to incorporate into the spatial map that will be included in a scientific publication.

Output 3: Herbivorous fish impact assessment based on levels of fishing

Fishing effort surveys were completed in May 2019 (see final report, **Supplemental Document 3**, Annex 7; Output **3.1**). It was determined by our project partners (CIDOE) that the information that would be most valuable would be from Cayman Brac, and thus our efforts were focused there. These data were incorporated into the fish impact assessment models that directly informed the Herbivory BAP (see **Supplemental Document 2**).

Historical effort and catch data were compiled by end of year 1 (interviews with (6) local Little Cayman fishermen). In addition to these interviews, a further 18 were conducted to quantify current levels of fishing and preference for herbivorous fish species (see final report, **Supplemental Document 3**, Annex 7; Output **3.2**).

Output 4: Dissemination and application of results

Dissemination was achieved through multiple avenues. First, open and transparent communication with the CIDoE has enabled exchange of information. Results were presented to the public through multiple activities, including Reefs Go Live broadcasts and a public lecture series. The Herbivory Biodiversity Action Plan was completed and incorporated into the CIDoE Coral Reefs BAP (Output 4.1). Data were presented at two scientific symposia, one regional and one international (Output 4.2). Two scientific peer reviewed papers have been submitted for publication and currently under review (Annex 5; Output 4.2). Finally, an education module was developed to be taught in conjunction with Reefs Go Live. Reefs Go Live, is an interactive live underwater broadcast that is disseminated globally to primary schools and is a key outreach activity undertaken by CCMI (Output 4.3).

3.2 Outcome

Our intended outcome was to identify the key herbivorous fish species and to inform an action plan that the government can develop to sustainably manage these fish populations effectively. By the conclusion of year two we had collected all the data necessary to commence writing the BAP, which was written in close collaboration with our project partners, the CIDoE. Input to the BAP was also provided by the focus group, who convened twice during the project. We collected all of the samples for genetic analyses to be used to identify the species present and understand the population connectivity across the Cayman Islands. Samples were sent to our project partners at the Smithsonian Institution in July 2019, however they were not able to obtain quality reads from the samples due to degraded DNA in the samples. However, despite not having these data, we were still able to write the Herbivory Action Plan based on the other available data. The survey data, focus group meeting notes, submitted scientific papers, and the finalized BAP, all serve as evidence to the success of this project. Our main outcome, the BAP, will help to guide future research and management practices and will serve as an educational tool to inform the public of the importance of herbivorous species to the health of our coral reefs. Additionally, the data obtained through this project provide a valuable baseline that can be referred to when assessing the success of future reef management plans and specifically the enhancement of MPAs around the Cayman Islands.

3.3 Monitoring of assumptions

The assumptions associated with the main project outcome were monitored throughout the project and relevant actions taken as needed. Specifically, our data conformed with previous studies indicating that herbivorous fish are key to maintaining reef health (Assumption 0.1). Similarly, our analysis of past data from the last 20 years, was made available and used to inform the decision making and execution of the grant as well as completion of the BAP (Assumption 0.2). Based on our interactions with local fisherman, we are confident that they were honest in the interviews to date (0.2). However, we assumed that the establishment of marine protected areas (MPAs) has led to long term increases in herbivorous fish and our data did not support this assumption. This highlights shortcomings in the method of management and indicates more must be done to safeguard our reefs.

The data obtained in this study support the assumption that some fish are more important than others in removing algal cover (Assumption 1.1). Similarly, we found herbivorous populations have changed over the last 20 years, showing an overall decline, which contributed to the recommendations for management suggested in the BAP.

Our assumption that movement patterns can be generalised for a range of herbivorous fishes with similar life history traits to facilitate broad management and conservation plans/action remains unconfirmed due to difficulties achieving the tasks outlined for this objective. Following difficulties with tagging the fishes, we received approval for our change request to replace the telemetry section with other methods. The new strategy was implemented in April 2019, however the results did not prove to be as informative as we'd hoped. Briefly, we found that similar sized aggregations of specific species were continuously sighted at the same sites, and while we can imply from these data that habitat features likely contribute to a certain demographic of fish populations, we cannot confirm that the fish sighted on recurrent surveys were in fact the same individuals, precluding any interpretations relative to site fidelity.

The assumptions outlined in section 3 were addressed through a series of interviews with the fishermen to try to assess if the fishermen were honest when reporting their catch. Receiving incorrect information on this key part of the system could jeopardise the BAP and the protection of these key species. Fortunately, we feel confident that the majority of information we received in these interviews has been honest and accurate. This is because firstly, there has been great overlap in what the fishermen said about their behaviours and about the reasons behind their preference for particular species. Secondly, the information the fishermen gave in the interviews about which fish species they prefer closely matched the data from catches at landing sites. Hence this assumption has held true and assuages concern over this one source of risk.

3.4 Impact: achievement of positive impact on biodiversity and poverty alleviation

The fundamental aim and outcome of this project is to determine the key species responsible for maintaining healthy coral reefs. Therefore, the key outcome is to positively impact biodiversity in the Cayman Islands and the Caribbean region. Considering the critical role that coral reefs play in food provision, protecting the island from storms and generating revenue through tourism (0.5 Billion dollars in 2017), losing the reefs would detrimentally impact the nation severely. Nearly 90% of the fish caught in Grand Cayman are from the reef, supporting the importance of this resource for food and economic stability. Likewise, coral reefs serve to protect the coastline from storms and erosion, without which the infrastructure of the island would be threatened. The results of the present study have been used to inform a new chapter in the Coral Reef Biodiversity Action Plan that focuses on the importance of herbivory in maintaining a healthy reef. By following the suggestions outlined in this BAP, we can help sustain this valuable resource and protect biodiversity. Such impacts will ultimately benefit society and the economic stability of the Cayman Islands.

4 Contribution to Darwin Initiative Programme Objectives

4.1 Contribution to Global Goals for Sustainable Development (SDGs)

Fishing in the Caribbean, and the Cayman Islands specifically, is primarily driven by the local market and is often subsistence based. The overall goal is to utilize the resource sustainably to ensure access for future generations. The results of this project directly contributed to development of a special chapter in the overall Coral Reef Biodiversity Action Plan that outlines recommendations to ensure adequate levels of herbivory exist to sustain our coral reef systems. Through presentation of the BAP and targeted guidance, this project will directly contribute to continued sustainable development of commercial and recreational fisheries management in the Cayman Islands.

4.2 Project support to the Conventions or Treaties (e.g. CBD, Nagoya Protocol, ITPGRFA, CITES, Ramsar, CMS, UNFCCC)

Although treaty support is not a direct component of this project, high-quality conservation research such as this naturally supports a number of Aichi Targets (which contextualise the CBD objectives).

Goal A, Target 1, Biodiversity Awareness – The project involved a number of public education and outreach events, as well as focus group dialogues, all of which raised the awareness of the importance of reef herbivores, an often undervalued biodiversity component, with the public, especially segments of the public like fishers or divers who may come into regular contact with the reef herbivores. The project is also producing a public education curriculum with herbivory modules, as one of its specific outcomes.

Goal A, Target 4, Sustainable Consumption – Algal overgrowth of tropical coral reefs is a global and local (to the Cayman Islands) problem. Similarly, the overfishing of reef fish, including the fishing down of trophic and size levels from large predatory fish to smaller herbivorous fish. This project documented the importance of certain small herbivorous reef fish, including the importance of a previously underappreciated species, on local reefs. This documentation therefore bolsters local regulations (or indicates the need for further study and possible

regulation) to keep reef fish consumption sustainable not just from the perspective of the targeted fish species but the roles these herbivorous species play in the tropical coral reef ecosystem.

Goal B, Target 6, Sustainable Fishery – As in Target 4, without this study the importance of particular fish species to the overall health of the coral reefs of the Cayman Islands would not have been as well understood. Previously it would have been assumed that those species could be more heavily fished before negative environmental effects occurred. Without this research, in retrospect, the possibility of unsustainable fishery of certain underappreciated species was higher.

Goal E, Target 19, Technology Transfer – By partnering through this Darwin Project with researchers from outside the Cayman Islands the project was able to introduce the novel use of emerging research techniques, such as source and trophic level stable isotope analysis, to the Cayman Islands which can now be used in future conservation and management projects when appropriate.

4.3 Project support to poverty alleviation

The preservation of a health reef ecosystem ensures access to local food resources that are often critical to lower income individuals. This is particularly important in island societies where imported protein sources can be beyond the economic reach of lower income brackets. This project directly contributes guidance to future management to ensure this resource continues to be available.

4.4 Gender equality

CCMI is a female led organization that strives to promote women and other underrepresented groups in science. The two PIs on the project are female and the majority of staff directly involved with the project were also female.

4.5 Programme indicators

- **Did the project lead to greater representation of local poor people in management structures of biodiversity?**

Not directly

- **Were any management plans for biodiversity developed and were these formally accepted?**

Yes. A new chapter to the Coral Reef Biodiversity Action Plan was written as a result of this project and accepted by the Cayman Islands Department of Environment. See Supplemental Document 2.

- **Were they participatory in nature or were they ‘top-down’? How well represented are the local poor including women, in any proposed management structures?**

Drafting of the management plan was participatory with representatives from the government, research sector, and public focal groups.

- **How did the project positively influence household (HH) income and how many HHs saw an increase?**

NA

- **How much did their HH income increase (e.g. x% above baseline, x% above national average)? How was this measured?**

NA

4.6 Transfer of knowledge

This project served as postdoctoral training for one individual, who was female (PI Dell). Through the duration of this project, four female research interns were trained to complete field surveys, interview stakeholders, and disseminate results. The results from the project were also shared with the regional and international scientific community through presentations at scientific symposia. Results of this project were also presented to the government in our Herbivory BAP chapter that was accepted and incorporated into the larger Coral Reef BAP. This plan, therefore, is now available to policy makers as well as the general public. Central to CCMI's mission is the transformation of key insights from our research into impactful conservation and outreach. Research methods and discoveries from this project were integrated into lessons and activities for all education and citizen scientist groups which participate in programmes at the Little Cayman Research Centre, such as the Marine Ecology Course (elementary and high school students), the Young Environmentalist Leadership Course (high school and university age students), Diving with Heroes (veteran citizen scientists), the Caribbean Marine Ecology Camp (high school students), Earthwatch groups (citizen scientists of varying age groups), and a number of university groups. Researchers also developed lessons centred upon this project and delivered them to an international audience of thousands of students via CCMI's virtual underwater livestreaming education programme, Reefs Go Live. Dr. Dell delivered project. update lectures on all three of the Cayman Islands to engage and inform the local community and tourists about the importance of herbivorous fish species to the health of reef in the Cayman Islands and their importance to the islands overall. A YouTube video of one of these lectures has been shared via email newsletters and social media posts to engage CCMI's international audience. See Table 1 and Supplemental Document 5 in Annex 7.

4.7 Capacity building

Project partners were from the Cayman Islands and the US, neither of which is a developing country. However, local capacity was built through our extensive outreach, stakeholder engagement, and local educational initiatives.

5 Sustainability and Legacy

The main outcome of the project was drafting of the Herbivory Biodiversity Action Plan chapter that was accepted by the DOE to be incorporated into the overall Coral Reef BAP. This will contribute to management strategies and policies related to ecosystem sustainability into the foreseeable future. As such this project will have a long-standing legacy. Based on the recommendations outlined in our BAP, we are currently working with the DOE to develop new projects and strategies to implement specific management practices, thereby ensuring sustainability of the project.

Both Dr. Manfrino, Dr. Dell and other CCMI employees have appeared numerous times in public talks, in the media and at two conferences where we have spoken about the Darwin Initiative. Likewise, we have promoted the Darwin Initiative frequently in our newsletter (an example of which is here: <https://myemail.constantcontact.com/CCMI-Update--Summer-2018.html?soid=1101597940827&aid=QTIZ07FzDMg>) and in our social media. Additionally, the Darwin Initiative has received media coverage multiple times as a result of CCMI's work and presence in the Cayman Islands. Most recently, Dr Dell was interviewed by a journalist from the Cayman Compass about this project and she was able to discuss the Darwin Initiative then.

Similarly, the education of Cayman's youth is another avenue through which impact is made and legacy is achieved. We have already accomplished the education objectives through CCMI's 'Reefs Go Live' series, but we will be broadcasting an additional episode next month on the work from this project. In this way, the Darwin Initiative has a direct impact on the future of the Cayman Islands by educating and informing the generation who will become the policy-makers and governors of the future. The Darwin Initiative has also been included in CCMI's Healthy Reef

campaign and the International Year of the Reef outreach – both campaigns drive huge awareness for projects trying to improve reef health and the Darwin Initiative has been included in all the sponsor communications.

6 Lessons learned

One interesting element of this work outlined in this project was the finding of the prevalence and overgrowth of an unusual species of algae on Cayman Brac that was not found on the other islands. Based on the results of the present study we were able to determine why this agalal species was growing in certain locations based on the pressure to system by differing rates of herbivory and specifically the presence of certain key herbivorous species. The local population was extremely interested in these results and the overgrowth of algae has resulted in reductions to their potential fishing ground, thereby increasing the cost per unit effort to extract resources from this environment. The results of this aspect of the project were presented locally and internationally, and have contributed to a peer-reviewed scientific paper currently under revision for publication in the open-access journal, *Frontiers in Marine Science*.

On the other hand, the time required to organise the focus group and to hold meetings was underestimated, so one recommendation to future researchers would be to allow extra time to complete this type of outreach and engagement work. Secondly, non-lethally sampling fish (to meet the stipulations of our research permit) has also proved more difficult than was anticipated. Likewise, the fixation method for genetic samples proved to be inadequate and thus additional consultation with the molecular laboratory at the Smithsonian prior to sampling would have assisted with aspect of the research to ensure viable genetic material.

6.1 Monitoring and evaluation

As has been discussed in previous sections, we worked closely with the CIDoE throughout the project and have sought their input at every stage of the grant. We held quarterly meetings with the CIDoE and others as necessary, so our M&E plan remained unchanged. All project partners were involved at different stages in the M&E work, and we held meetings with project partners and shared our progress with stakeholders via presentations, classes and through our social media. The CIDoE have been pivotal in directing our focus in this regard which ultimately led to the successful completion of the Herbivory BAP.

The data we have collected and analysed has allowed us to evaluate our progress toward addressing the questions outlined for this project. This includes the ecological field work as well as the social and the multiple annexes to this document are indicators that we have achieved success.

6.2 Actions taken in response to annual report reviews

Responses to our previous reports were specifically addressed in several emails with Eilidh Young following submission of each report. There are currently no outstanding issues with prior reports.

7 Darwin identity

As mentioned previously, we have promoted the Darwin Initiative in our public talks, presentations at scientific conferences, focus group meetings, interviews with journalists, through our social media and on the CCMI website. Specifically, the Darwin Initiative logo appears in all presentations and is specifically mentioned in the acknowledgments and funding statements for all publications. This project is recognised as a distinct project in CCMI's work and outreach. Through our efforts, awareness of the Darwin Initiative is growing in the Cayman Islands and the UK Overseas Territories. The media, dive professionals, attendees to our presentations and of course, the many fishermen interacted with as part of this work are all now aware of the Darwin Initiative and this particular project.

8 Finance and administration

8.1 Project expenditure

Project spend (indicative) since last annual report	2019/20 Grant (£)	2019/20 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items (see below)				
Others (see below)				
TOTAL				

Staff employed (Name and position)	Cost (£)
Claire Dell	
Carrie Manfrino	
TOTAL	

Capital items – description	Capital items – cost (£)
N/A	
TOTAL	

Other items – description	Other items – cost (£)
Supplies	
M&E	
Website/Print/promo/design	
Audit	
TOTAL	

8.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
CCMI	
Smithsonian	
Department of Environment	
TOTAL	

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

8.3 Value for Money

This project delivered in terms of expected value for money in several ways, stemming from the operational and personnel costs met by partners and investments already in place:

1. Senior project partners, including the Cayman Islands Department of Environment (DOE) provided support in-kind, keeping project costs lean.
2. The project utilised equipment that was already in place, including receivers, as well as the use of boats (and fuel) for the wider surveys which contributed significantly financially.
3. CCMI year-round on-site staff time is apportioned and allocated based on project needs, this included the project lead and the technician. Having the team in-situ (but only charged to the project when needed) meant costs were kept to a minimum and the team could respond and manage project timeline changes, due to weather or technical difficulties, seamlessly and without adding project cost.
4. Good relationships with stakeholders across the islands led to accommodations and travel costs being kept on budget, with in-kind donations from the DOE supporting the Grand Cayman surveying and interviews stays.
5. Communications and outreach from this project were included in CCMI's wider project budgets, ensuring the project got successful media coverage, including video and social media promotion, which was not included in the Darwin project finances.
6. The CCMI and DoE long-term (17+yr) data sets are an invaluable resource that offers critical baseline data to the project deliverables.
7. The focused conservation effort on key fish species will have a longer-term value and offers an economically leveraged conservation strategy.

9 OPTIONAL: Outstanding achievements of your project during the (300-400 words maximum). This section may be used for publicity purposes

I agree for the Darwin Secretariat to publish the content of this section (please leave this line in to indicate your agreement to use any material you provide here)

The greatest achievement of this project was the extensive collaboration with the Department of Environment and engagement with stakeholders. Throughout the project our researchers met with multiple stakeholder groups, including local fishermen from all three islands. We also engaged the local community through multiple lecture series events and creation of educational content that was shared with local schools through interactive broadcasts. Finally, our results were shared with the scientific community through presentations at international meetings and through two peer reviewed publications. Thus, our work has had an extremely broad reach through local and international stakeholder groups.

Annex 1 Project’s original (or most recently approved) logframe, including indicators, means of verification and assumptions.

Note: Insert your full logframe. If your logframe was changed since your Stage 2 application and was approved by a Change Request the newest approved version should be inserted here, otherwise insert the Stage 2 logframe.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: Targeted management of functionally important herbivorous fish and direct fisheries policies that improve coral reef biodiversity			
<p>Outcome: Herbivorous fish species that are key to maintaining reef health are incorporated into a draft biodiversity action empowering government to establish policies to sustainably manage herbivores.</p>	<p>0.1 Field survey data to indicate key herbivorous fish that is compile and used in a spatial map to inform plans which are endorsed by the Department of Environment managers during a meeting by the end of the second year.;</p> <p>0.2 Creation of a public- private partnership as an expert fish focus group including members from National Trust, environmental, business, and tourism to empower new policy and protection;</p> <p>0.3 Draft Biodiversity Action Plan (BAP) agreed internally and draft of management plan for key herbivores by the end of the project.</p>	<p>0.1 By the end of Year 1, minutes from 2 partner meetings and report describes and quantifies the role of herbivorous fish in reducing competitive algae and improving reef health, and that elucidates species trends over the last 2 decades;</p> <p>0.2 Meeting minutes that record the establishment and meetings of such group;</p> <p>0.3 Final report with meeting minutes and attendee lists from 3 partner meetings (initial, review, final) discussing draft BAP and management plan;</p>	<p>0.1 Herbivorous fish are key to maintaining coral reef health;</p> <p>0.2 Unknown trends for herbivorous fish on all three islands over the last 20 years of data collection will inform the plan and effectively impact decision making;</p> <p>Fisherman will support this effort and provide accurate data;</p> <p>Fish may be overfished in areas unknown to us;</p> <p>MPA has led to long term increases in herbivorous fish.</p> <p>Draft fish species protection plan which has parrotfish included has never progressed so we are starting from 0.</p>
<p>Outputs:</p> <p>1. Draft biodiversity action plan to protect key herbivores is approved internally by the Dept. of Environment.</p>	<p>1.1 Partners assess fish from 15 reefs across the three Cayman Islands; Historic reef trends quantified and key species reducing algae growth are identified by the end of year 2;</p> <p>1.2 Number of members in an expert Herbivorous Fish Focus group by end of year 2;</p> <p>Empower 300 local students through new educational modules about</p>	<p>1.1. Report on herbivorous fish;</p> <p>1.2. Final Report on knowledge gained over duration of project by focus group;</p> <p>Pre and post surveys indicating students empowered with knowledge and utilising CCMI resource;</p>	<p>1.1 Hierarchy of herbivores, with some species playing larger roles in reducing algae;</p> <p>Populations of herbivorous fish species richness and fish biomass has changed over the last 20 years;</p>

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	herbivory, (specifically taught to students in grades 5 and 6) by the end of year 2.		
2. Spatial map establishes the levels of herbivory and regional connectivity of key herbivorous fish and supports regional benefit of protecting herbivores.	2.1 Project data and map is posted and partner media pages and newsletters raise awareness (from 0 to 2000) via partner networks including DoE, CCMI, school groups by end of project; 2.2 Regional connectivity (tagging and genetics) of herbivore fish determined by end project;	2.1 Web analytics and newsletter opens with project views; 2.2. Fish connectivity report with data and photographs;	2.1 Movement patterns can be generalised for a range of herbivorous fishes with similar life history traits to facilitate broad management and conservation plans/action.
3. Herbivorous fish impact assessment based on levels of fishing	3.1 Fishing effort surveyed (data on catch and effort at 6 landing sites across the Cayman Islands by end of year 2. 3.2 Historical effort and catch data compiled by end of year 2 (interviews with (6) local Little Cayman fishermen.	3.1 Report of interviews quantify current levels of fishing pressure by end of year 3.2 Report documenting oral history	3.1 Fishing effort measured at landing sites reflect overall fishing efforts; Illegal fishing does not occur in protected zones; Fishers provide accurate data through face to face interviews. Fishers are reluctant to report fishing effort due to a potential perception of restricted access to certain herbivorous fish species.
4. Dissemination and application of results	4.1 Results incorporated into the BAP. 4.2 Scientific papers (2 submitted for publication, 2 meetings attended by end of project; 4.3 Completion of public education curriculum with herbivory modules for all K-12 CCMI programs;	4.1 Draft of Biodiversity Action Plan. 4.2 Peer reviewed publications; 4.3 Teaching modules and curriculum developed and posted to the CCMI website.	None

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<p>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)</p> <p>Output 1: Draft biodiversity action plan to protect key herbivores</p> <p>1.1 Survey reefs at 15 sites on the north sides of all three islands to determine fish biodiversity and benthic (algae and coral) community structure, abundance, and health, and identify key fish for protection.</p> <p>1.2 Herbivorous Fish Focus stakeholder group meet with partners and expand their knowledge and grow support for a BAP.</p> <p>1.3 Create and deliver new educational modules about herbivory that empowers 300 grade 5 and 6 students.</p> <p>Output 2: Spatial map of key herbivorous fish.</p> <p>2.1 Manipulation experiments determine dietary patterns and key herbivores are identified also using surveys (from Output 1.1).</p> <p>2.2 Tag fish to determine range and impact on reducing algae on the reefs; genetics (fin clips) of selected species expand our knowledge on connectivity across the region.</p> <p>Output 3: Herbivorous fish impact assessment.</p> <p>3.1 12 Fisherman are surveyed for catch and effort data;</p> <p>3.2 Historical fishing effort and catch is documented through oral history interviews which are available online.</p> <p>Output 4: Dissemination and application of results.</p> <p>4.1 Develop draft Biodiversity Action Plan with partners</p> <p>2 Write and submit 2 scientific papers to peer reviewed journals and attend 2 international meetings to present research results.</p> <p>4.2 K-12 Educational curriculum is developed and used for residential programmes; 200 additional students participate by end of project.</p>			

Annex 2 Report of progress and achievements against final project logframe for the life of the project

Project summary	Measurable Indicators	Progress and Achievements
<p>Impact:</p> <p>Targeted management of functionally important herbivorous fish and direct fisheries policies that improve coral reef biodiversity</p>		<p>Data obtained in the present study contributed to the Herbivory chapter in the Coral Reef Biodiversity Action Plan, which was accepted by the CI Department of Environment. Key indicators and suggestions for future management are presented in the BAP that will help to protect biodiversity and ensure sustainability of coral reef resources to local residents.</p>
<p>Outcome Herbivorous fish species that are key to maintaining reef health are incorporated into a draft biodiversity action empowering government to establish policies to sustainably manage herbivores</p>	<p>0.1 Field survey data to indicate key herbivorous fish that is compile and used in a spatial map to inform plans which are endorsed by the Department of Environment managers during a meeting by the end of the second year.;</p> <p>0.2 Creation of a public- private partnership as an expert fish focus group including members from National Trust, environmental, business, and tourism to empower new policy and protection;</p> <p>0.3 Draft Biodiversity Action Plan (BAP) agreed internally and draft of management plan for key herbivores by the end of the project.</p>	<p>0.1 Complete. Evidence in Annex 7, Supplemental Document 3</p> <p>0.2 Complete, see list of focus group participants (Supplemental Document 1)</p> <p>0.3 Complete, see attached BAP (Supplemental Document 2)</p>
<p>Output 1. Draft biodiversity action plan to protect key herbivores is approved internally by the Dept. of Environment.</p>	<p>1.1 Partners assess fish from 15 reefs across the three Cayman Islands; Historic reef trends quantified and key species reducing algae growth are identified by the end of year 2;</p>	<p>1.1 Complete. Evidence provided in Annex 7, Supplemental Document 3</p> <p>1.2 Complete. Evidence provided in Annex 7, Supplemental Document 4</p> <p>1.3 Complete. Evidence provided in Annex 7, Table 1.</p>

Project summary	Measurable Indicators	Progress and Achievements
	1.2 Number of members in an expert Herbivorous Fish Focus group by end of year 2; 1.3 Empower 300 local students through new educational modules about herbivory, (specifically taught to students in grades 5 and 6) by the end of year 2.	
Activity 1.1 Report on herbivorous fish		Completed and included in Annex 7, Supplemental Document 3
Activity 1.2. Final Report on knowledge gained over duration of project by focus group		Completed and included in Annex 7, Supplemental Document 1
Activity 1.3 Pre and post surveys indicating students empowered with knowledge and utilising CCMI resource		Completed and included in Annex 7, Table 1
Output 2. Spatial map establishes the levels of herbivory and regional connectivity of key herbivorous fish and supports regional benefit of protecting herbivores	2.1 Project data and map is posted on partner media pages and newsletters to raise awareness (from 0 to 2000) via partner networks including DoE, CCMI, school groups by end of project; 2.2 Regional connectivity (tagging and genetics) of herbivore fish determined by end project	Completed and included in Annex 7, Fig. 1 Unable to complete due to low quality DNA resulting in poor quality reads and lack of connectivity data.
Activity 2.1. Web analytics and newsletter opens with project views		Completed and included in Annex, Table 1
Activity 2.2. Fish connectivity report with data and photographs		Unable to complete due to low quality DNA resulting in poor quality reads.
Output 3. Herbivorous fish impact assessment based on levels of fishing	3.1 Fishing effort surveyed (data on catch and effort at 6 landing sites across the Cayman Islands by end of year 2. 3.2 Historical effort and catch data compiled by end of year 2 (interviews with (6) local Little Cayman fishermen	3.1 Complete and included in Annex 7, Supplemental Document 3 3.2 Complete and included in Annex 7, Supplemental Document 4
Activity 3.1 Report of interviews quantify current levels of fishing pressure by end of year		Completed evidence included in Annex 7, Supplemental Documents 1 and 3

Project summary	Measurable Indicators	Progress and Achievements
Activity 3.2 Report documenting oral history with photographs		Completed and included in Annex 7, Supplemental Document 4
4. Dissemination and application of results	4.1 Results incorporated into the BAP. 4.2 Scientific papers (2 submitted for publication, 2 meetings attended by end of project; 4.3 Completion of public education curriculum with herbivory modules for all K-12 CCMI programs;	4.1 Complete and included in Annex 7, Supplemental Document 2 4.2 Complete, evidence included in Annex 5 4.3. Complete, evidence included in Annex 7, Table 1 and Supplemental Doc. 5

Annex 3 Standard Measures

Code	Description	Total	Nationality	Gender	Title or Focus	Language	Comments
Training Measures							
1a	Number of people to submit PhD thesis	0					
1b	Number of PhD qualifications obtained	0					
2	Number of Masters qualifications obtained	0					
3	Number of other qualifications obtained	0					
4a	Number of undergraduate students receiving training	40	USA (30) Portuguese (1) Chinese (1) Caymanian (4) Australian (2) Dutch (1) UK (1)	22 F 18 M		English	Rutgers University Coral Reef Interns, Reef Research Experience Participants, Ocean Science Scholars, Interns
4b	Number of training weeks provided to undergraduate students	20	USA				
4c	Number of postgraduate students receiving training (not 1-3 above)	4	USA (2), UK (1), Cypriot/Norwegian (1)	4 F		English	Research Interns
4d	Number of training weeks for postgraduate students	48					
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification (e.g., not categories 1-4 above)	0o					

6a	Number of people receiving other forms of short-term education/training (e.g., not categories 1-5 above)	17	USA (11) Dominican (1) Caymanian (1) Italian (1) UK (3)	9 F 8 M		English	Visiting researchers, CCMI field station and education staff who assisted with research fieldwork
6b	Number of training weeks not leading to formal qualification	22					
7	Number of types of training materials produced for use by host country(s) (describe training materials)	4					Two Reefs Go Live lessons with supporting lesson plans, activity sheets, vocabulary sheets (target elementary age students) Two Fish/Coral Identification slide decks (general use)
Research Measures		Total	Nationality	Gender	Title	Language	Comments/ Weblink if available
9	Number of species/habitat management plans (or action plans) produced for Governments, public	1					Biodiversity Action Plan

	authorities or other implementing agencies in the host country (ies)						Participatory process
10	Number of formal documents produced to assist work related to species identification, classification and recording.	0					
11a	Number of papers published or accepted for publication in peer reviewed journals	2					Frontiers in Marine Science; Marine Ecology Progress Series
11b	Number of papers published or accepted for publication elsewhere	0					
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	0					
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	1					DOE
13a	Number of species reference collections established and handed over to host country(s)	N/A					
13b	Number of species reference collections enhanced and handed over to host country(s)	N/A					

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	4	Cayman Islands	Mixed	Herbivory	English	Public Lectures and Seminars

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	2	International	Mixed	Fisheries	English	Scientific Conferences

Physical Measures		Total	Comments
20	Estimated value (£s) of physical assets handed over to host country(s)		
21	Number of permanent educational, training, research facilities or organisation established		
22	Number of permanent field plots established		Please describe

Financial Measures		Total	Nationality	Gender	Theme	Language	Comments
23	Value of additional resources raised from other sources (e.g., in addition to Darwin funding) for project work						

Annex 4 Aichi Targets

	Aichi Target	Tick if applicable to your project
1	People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	x
2	Biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	
3	Incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	
4	Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	x
5	The rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	
6	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	x
7	Areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	
8	Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	
9	Invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	
10	The multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	
11	At least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.	
12	The extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	
13	The genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and	

	implemented for minimizing genetic erosion and safeguarding their genetic diversity.	
14	Ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	
15	Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	
16	The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	
17	Each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	
18	The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	
19	Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	x
20	The mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.	

Annex 5 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. web link, contact address etc)
Scientific Journal	Few Herbivore Species Consume Dominant Macroalgae on a Caribbean Coral Reef, Dell C, et al. 2020	UK	Cayman Islands	F	Frontiers in Marine Science	www.frontiersin.org
Scientific Journal	Why do certain species dominate? What we can learn from a rare case of Microdictyon dominance on a Caribbean Reef, Dell C, et al. 2020	UK	Cayman Islands	F	Marine Ecology	https://onlinelibrary.wiley.com/journal/14390485
White Paper Publication-Special Report	20 Year Report on the Status and Trends of the Coral Reefs in the Cayman Islands 1999 - 2018	USA	Cayman Islands	F	Central Caribbean Marine Institute	https://reefresearch.org/wp-content/uploads/2019/10/CCMI-Reef-Survey-Report-20-Years.pdf

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Annex 6 Darwin Contacts

Ref No	DPLUS061
Project Title	Protecting herbivorous fish to conserve Cayman Island coral reef biodiversity
Project Leader Details	
Name	Dr. Carrie Manfrino
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Fax/Skype	
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Partner 1	
Name	Dr. Claire Dell
Organisation	CCMI
Role within Darwin Project	Co-Principal Investigator
Address	
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Email	
Partner 2 etc.	
Name	
Organisation	
Role within Darwin Project	
Address	
Fax/Skype	
Email	

Checklist for submission

	Check
Is the report less than 10MB? If so, please email to Darwin-Projects@itsi.co.uk putting the project number in the Subject line.	
Is your report more than 10MB? If so, please discuss with Darwin-Projects@itsi.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. However, we would expect that most material will now be electronic.	
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.	