Darwin Initiative: Final Report

To be completed with reference to the "Writing a Darwin/IWT Report" Information Note: (https://www.darwininitiative.org.uk/resources-for-projects/reporting-forms-change-request-forms-and-terms-and-conditions/).

*It is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin Project Information

Project reference	DPR7P\100059
Project title	DPLUS100: Sustainable solutions for Sargassum inundations in Turks & Caicos 2019-2021
Country(ies)	Turks & Caicos
Lead organisation	University of Greenwich
Partner institution(s)	The Turks and Caicos Island Government (TCIG) Department of Environment and Coastal Resources; The School for Field Studies, Centre for Marine Resource Studies, South Caicos; The Chartered Institute of Ecology and Environmental Management (CIEEM) UK Overseas Territories Special Interest Group (OTSIG).
Darwin grant value	£94,618.00
Start/end dates of project	1/4/2019 – 30/9/2021 (note suspension 1/4/2020-30/9/2020
Project leader's name	Professor Debbie Bartlett
Project website/blog/social media	
Report author(s) and date	Professor Debbie Bartlett December 2021

Please note: the term 'sargassum' used in the report refers to *S. natans* 1, *S. natans* VIII, and *S. fluitans* I, the species and morphotypes of the pelagic forms comprising the floating rafts and beached material on the Turks and Caicos Islands.

1 Project Summary

This research project was conducted in the Turks and Caicos Islands, a British Overseas Territory comprising around 40 inhabited and uninhabited low limestone islands and golden sandy beaches, in the Atlantic Ocean, southeast of the Bahamas (Figure 1).

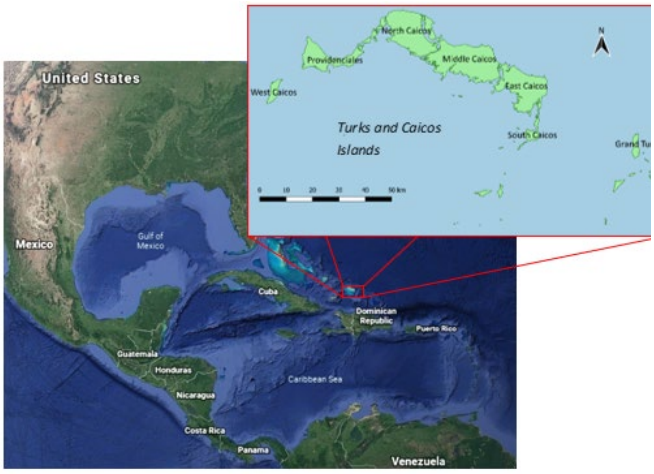

Figure 1 Location of the Turks and Caicos Islands

Sargassum, a genus of macroalgae with over 300 species, is common in the marine environment with the Sargasso Sea so named as it is where the floating (or pelagic) species, *S. natans* and *S. fluitans,* are found as dense floating mats. Small quantities of this material have always washed onto beaches across the Caribbean but, since 2011, large quantities have been observed both floating on the surface of the ocean and washing up onto the beaches. The reason for this dramatic increase is unclear but is likely to be a combination of climactic and environmental factors. Staff in the Algal Biotechnology Research Group, at the University of Greenwich (UofG), published a paper in 2016 suggesting that this seaweed was potentially a commercially viable resource[1]. This led to the Department of Environment and Coastal Resources (DECR), part of the Turks and Caicos Islands (TCI) government, making contact asking for help to find a solution to the sargassum drift on their beaches as this was damaging the important tourist-based economy. Darwin Plus funding opportunity enabled us to respond to this request developing an application with DECR to carryout research.

With regard to biodiversity the TCI Environment Charter (2001) policy #7 is "*to safeguard and restore native species, habitats and landscape features, and control or eradicate invasive species*". Sargassum is on TCI considered to be invasive and a potential threat to biodiversity, particularly the marine environment. The National Tourism Strategy and Policy (2015), acknowledges that natural environment protection is at the core tourism development. As research for this project progressed concerns emerged that floating rafts of seaweed are likely to be affecting seagrass meadows and so have long term negative impacts on the conch (*Strombus gigas*) which breed there and are a significant export product. Conversely the floating masses are themselves fertile breeding grounds for many species, and act as nurseries for others such as endangered sea turtles. This increases marine predators such as shark, tuna and marlin, benefiting the sports fishing industry. Heavy inundations of seaweed washing onto beaches would be likely to impede turtle nesting and the journey of hatchlings into the sea. These aspects all require further research and, although it was planned for the UofG team, with an ecologist from the CIEEM UKOT Special Interest Group, to work on this during second visit, scheduled for summer 2020, this was unfortunately cancelled due to COVID-19 restrictions.

1.1 What poverty challenge was the project designed to address?

Tourism is the principal economic activity on TCI supporting many workers, including economic migrants from other islands, particularly Haiti and the Dominican Republic. Sargassum is unpopular with tourists who visit the TCI in search of white sandy beaches and crystal-clear

[1] Milledge, J.J.; Harvey, P.J. (2016) Golden Tides: Problem or Golden Opportunity? The Valorisation of *Sargassum* from Beach Inundations. *J. Mar. Sci. Eng. 4*, 60. http,s://doi.org/10.3390/jmse4030060

turquoise bathing waters. Reports of inundations on social media have reduced bookings and necessitated regular beach cleaning, as fresh deposits can come in with each tide. This task is not well paid; if a commercially viable use for the material could be found this could create more, better paid, opportunities. Fishing, particularly free diving for conch (*Strombus gigas*) and spiny lobster (*Panulirus argus*), is the second most important economic activity, supporting local livelihoods, with much of the product exported to the USA. The potential long-term threat of floating rafts of sargassum in inshore waters to seagrass meadows, the nurseries for the most important fisheries was identified during this project[2].

1.2 Why are these challenges relevant and for whom? How did you identify these problems?

One of the first activities of this project was to carryout research into the exact nature of the "sargassum issue". This involved listening to stakeholders, particularly those involved in the tourism sector, to generate quantifiable information. The results were compiled, and an initial Impact Assessment Report submitted to DECR in autumn 2019. This revealed a rather more complex picture than previously thought. While the government and resort owners required a solution to prevent sargassum on the beaches as it was reducing their profits, other tourism related businesses, particularly those offering sport fishing, welcomed the floating rafts as these had increased the number of game fish and sharks. The quantifying effect on local fisheries was beyond the scope of this project although there were anecdotal accounts of reduced catch.

1.3 What was the project designed to do to address these challenges?

This project was designed to explore the feasibility of exploiting the sargassum, specifically for anaerobic digestion for biogas, and/or composting, as these are the most obvious alternatives to disposal to landfill or burying the material.

1.4 The partnership

As mentioned above, this project was initiated by the host country, namely the DECR of TCI. All the partners were fully involved in developing the funding application with DECR making a very significant contribution of officer time.

Over the course of this project the roles of the different partners have altered due to a combination of factors such as policy direction, change in personnel and complications related to Covid-19. These have been detailed in the regular reports and resulted in agreement to modify the logframe.

Working with DECR has been a challenge. On the first visit it became clear that, although Dr Salamanca, Acting Director of DECR, was keen to move this project forward there was little enthusiasm for additional work from other DECR staff. The fact that we were not aware that a research permit was required until arriving on TCI will give an idea of the rather difficult nature of the partnership. Despite details of personnel and their time commitment being stated in the funding application no monitoring or sample collection was done by any of the DECR staff. There seems to have been changes in roles and responsibilities within the Department. Concerns that significant quantities of sand were being removed along with sargassum and that this was causing loss of stability and storm resilience may have affected enthusiasm for this project as some hotels owners reported they were banned from removing sargassum on these grounds. Responsibility for monitoring and collecting samples was taken over by School for Field Studies (SFS) staff.

The research collaboration between UofG and the SFS, based on South Caicos, is likely to continue. We have worked together on conference presentations and published jointly authored papers and intend that this will continue.

During the visit to TCI in June 2019 the views of as many local organisations as possible were canvassed to ensure breath of representation. The Sustainable Tourism Association were keen

[2] Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007

to be involved and hosted a focus group, as did the Museum staff on Grand Turk. Had the second visit not been cancelled there would have been greater contact with local organisations and naturalists. The UofG field team (the PI and two MSc students) attended a meeting of the UK Overseas Territories Conservation Forum (UKOTCF) in London in May 2019, prior to visiting TCI, to raise awareness of this project and express our hope for involvement of local naturalists and technical specialists regarding impact of sargassum on wildlife. A poster on the results of the project was presented at the UKOTCF conference 2-3 & 9-10 March 2021[3] (see Annex 3.14b).

2 Project Achievements

Please see Annex 2 for a summary of progress against the revised project logframe.

2.1 Outputs

Internal partnership changes and the emergence of Covid-19 in early 2020 made it clear that the project was not going to proceed as originally planned. A request was made for a suspension of activity between April and September 2020, and all partners had the opportunity to contribute to modifications to the logframe. The revised version was agreed in December 2020 and has been included as Annex 1. Despite the challenges we experienced the outputs have, in the main, been achieved.

Output 1. Integrated Ecosystem Service, Ecological/Environmental Impact and Natural Capital Assessment of the coastal zone. Specific focus will be on the tidal strand line and macroalgae, such as Sargassum spp., deposited as drift.

While cancellation of the second visit to TCI, the lack of students at the SFS, and restriction of monitoring and sampling to just one island, South Caicos, has prevented the field research required to produce an Ecosystem Service and Natural Capital Assessment, the impact of sargassum has been investigated and the results made publicly available (Annex 3.2; Annex 3.14a & b). The open access paper by Bartlett & Elmer (2021) '*The Impact of Sargassum Inundations on the Turks and Caicos Islands*' *Phycology* (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007) includes discussion of the potential impact of floating material on natural capital (seagrass meadows and fisheries) and implications for management.

Output 2. Education and awareness raising of shoreline/coastal environment

The original intention had been to work with the DECR outreach and education officer to involve all TCI schools in monitoring the amount and frequency of sargassum deposits and, with the aid of the ID sheets we produced, collect data on the relative proportions of the different morphotypes. However, contact with Amy Avenant, named as the responsible DECR officer for this in the application, was never established; she was apparently on a year's sabbatical during our visit to TCI. As a result, work with schools was limited to South Caicos. Despite this, and the impact of Covid-19, the indicator figures were all exceeded principally by SFS (see Annex 3.2; 3.4a, b, c & d; 3.5). While there has been limited press coverage with just one article in the local and another in the national press there have been additional podcasts and a web-based case study that have contributed to this awareness raising output.

Output 3 Characterisation of macro-algae, such as Sargassum spp, deposited as drift to identify potential as biomass for fuel and other products.

Despite initial challenges in acquiring samples for analysis, originally envisage as the responsibility of DECR staff, this was resolved by gaining permission to move funds to enable purchase and installation of a small freeze drier at the SFS. Staff then had to travel from South Caicos to the main island, Providenciales, to dispatch samples. A further complication was the closure of all University laboratories with Covid-19 restrictions, meaning no analysis was possible between March and July 2019. Despite this a total of 41 samples were received and analysed by UofG. The characterisation has been successful with multiple samples of each

[3] Conference proceedings https://www.ukotcf.org.uk/wp-content/uploads/2021/06/Staying_Connected_partJ.pdf

morphotype processed, exceeding the target. As high levels of toxic heavy metals, including arsenic, were identified an additional experiment was set up by SFS to determine the effect of weathering. This was required as harvesting could either be of wet, recently deposited sargassum or material that had dried naturally on the beach. There has been great interest in these results as, although there are now many initiatives trying to find a use for sargassum, this project is the only one looking at the chemical composition. Indeed, Desrochers et al (2020)[4], provide an explicit warning regarding lack of evidence of potential toxicity and the need for caution in using sargassum in products that could harm humans, animals, or the environment (page 5). Publication of results in open access journals has made a significant contribution to addressing this although it is disappointing that we have found the sargassum is unsuitable for biofuel. The toxicity, combined with the high salt content, means use in compost would only be possible as a minor component requiring availability of an additional large-scale biomass resource to be practicable.

Output 4 Research outputs developed and shared with other British Overseas Territories experiencing 'golden tides'.

Rather than specifically sharing results with other British Overseas Territories representatives from these who are also working on the sargassum issue have been among the audience at conferences at which we have made presentations (see Annex 3.14b) so reach has extended far beyond that originally anticipated. Specific links to the OTs has been made via the UKOT Conservation Forum (Annex 3.11b). Technical reporting of data and management recommendations has been done via open access peer reviewed journals (Annex 3.11a) rather than as a stand along report ensuring the widest possible readership across the whole of the affected region. These changes have enabled all of those working on sargassum to benefit from the findings, particularly the important toxicity issues. It is hoped that this will prevent any harmful effects on people, livestock, or the environment, as those affected across the whole of the Caribbean region search for a solution.

There were two significant challenges encountered in the delivery of this project and neither had been anticipated.

The first was with the partnership. As explained in earlier reports, and Section 1.4 above, commitment was made in the application document that DECR staff would be responsible for monitoring sargassum deposition on the beaches of the main islands and for collecting samples and dispatching these to the UofG labs. In addition, the DECR education officer was to have been responsible for awareness raising and outreach (Output 2). It is not entirely clear why none of this happened, but it delayed the start of the project and would have severely compromised it had SFS not stepped in to help find a workable solution. Partnerships can be tricky. However, the PI is very experienced in working with multidisciplinary teams and different cultural and political contexts; failure in this instance was particularly disappointing as the project had been initiated by DECR.

The second challenge was Covid-19. Dr John Milledge, lead for the chemical analysis required to achieve Output 3, was an early victim, being hospitalised in March 2019 for a number of weeks. He has recovered slowly but has not been able to resume work and retired on medical grounds. He has remained in close contact with the project and helped with paper drafting. Dr Birthe Neilsen, another chemist in the Algal Biotechnology Research Group, took on John's role, assisted by two PhD students. Covid-19 restrictions affected the project as the University laboratories were closed during the original lockdown period and again in winter 2020. A second visit to TCI had been planned to carry out fieldwork to enable the reports to be prepared for Output 1. This had to be cancelled due to travel restrictions and, concurrently, SFS were without students and subject to local curfews severely curtailing local research. Although Covid-19 has caused disruption for everyone, everywhere, there has been a significant advantage increasing the impact of Output 4 as conferences moved online enabling much

[4] Desrochers, A., S-A. Cox, H.A. Oxenford and B. van Tussenbroek. (2020). Sargassum Uses Guide: A Resource for Caribbean Researchers, Entrepreneurs and Policy Makers. Report funded by and prepared for the Climate Change Adaptation in the Eastern Caribbean Fisheries Sector (CC4FISH) Project of the Food and Agriculture Organization (FAO). Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Cave Hill Campus. Bridgetown: Barbados. CERMES Technical Report No. 97, 172 pp.

wider sharing of our results than would otherwise have been possible and without the cost, time, and environmental impact of international travel.

2.2 Outcome

The original outcome in the funding application was as follows:

> *The detrimental impacts currently experienced by the tourism sector will be alleviated, students will have engaged in STEM activities and the potential for macro-algae as a biomass fuel evaluated*.

This was revised when it became clear that the first phrase in the outcome statement was over ambitious and would have been impossible to achieve without the full engagement of DECR officers, even without the impact of Covid-19. This was revised in the updated logframe to read:

> *Students will have engaged in STEM activities and the potential for macro-algae as a biomass fuel evaluated.*

Involvement of students in STEM activities has been fully achieved, meeting all indicator targets, with the details of MSc projects and SFS students and local schools detailed in Annex 3.2, 3.4a-d and 3.5. Had we not experienced the partnership and Covid-19 challenges we would have done far more in this area and involved schools across TCI rather than just on South Caicos. This is being addressed in collaboration with Marine Conservation Without Boarders (https://marinefrontiers.org), who produce bio-cultural texts for schools across the region. A resource on sargassum, "*Understanding Golden Tides: are these Challenges or opportunities*" has been written, including activities and teacher notes, and publication is planned for early in 2022. This will be translated into local languages and distributed across the Caribbean.

The potential for the sargassum to be used as a biomass fuel has been evaluated and the results published in open access papers (Annex 3.11) and presented at conferences and podcasts (Annex 3.14a-b). It is disappointing that, in contrast to some other macroalgae, the potential is not as great as had been hoped. To be viable it would need to be combined with another feedstock; initial investigation has not been able to identify anything other than cardboard packaging material or sewage on TCI; further research is needed to quantify, cost, and assess the practicalities of using these. Although monitoring is taking place across the Caribbean the regularity/predictability/availability of sargassum deposition is still unclear.

2.3 Monitoring of assumptions

While not listed as an assumption in the logframe integral to this project was the assumption that the people named in the application would carry out the roles and responsibilities assigned to them (Section 5, Question 11 Project Staff). That this did not happen may have been due to staff changes and internal agendas, but it was somewhat of a shock and combined with Covid-19 related restrictions, has significantly affected this project.

Output 1 Assumptions
We had assumed that local historical records on sargassum deposition, such as the areas most affected and the time of year it arrived would be available to help to determine a baseline against which to measure change (1.1). For a viable commercial use to be found data on availability of the resource is required and this is now being monitored across the Caribbean Sea using satellite data and published in the Sargassum Outlook Bulletin (https://www.cavehill.uwi.edu/cermes/projects/sargassum/outlook-bulletin.aspx) with local records shared by the Sargassum network (http://sargassummonitoring.com/) both set up after the start of this project. Input from local partners has,
(1.2) has been limited to input from SFS, so limited to South Caicos although some records are being sent into the network via the EpiCollect5 App (https://five.epicollect.net/).

Output 2 Assumptions: engagement with local schools and colleges was to have been led by the DECR Education officer. However, she was on a years' sabbatical when we visited in summer 2019, making establishing contact impossible. Schools on South Caicos showed interest and hosted workshops but engagement by SFS with these beyond the first year of this

project has been restricted due to Covid-19 (2.1). Engagement with local media would probably been greater had the second visit taken place, but international interest in the sargassum issue has increased dramatically over the time frame of this project, evidenced by the number of conferences focusing on it.

Output 3 Assumption: was that suitable representative samples could be collected and dispatched to the UK. It was originally planned that these would be collected by DECR officers on the different islands. Due to the challenges previously mentioned (1.4) a change request was made and approved for a freeze drier to be installed at SFS enabling samples to be collected and dispatched. This meant samples were from just one location, so not necessarily representative of TCI, but with the advantage of detailed characterisation of a time series of material landing at a specific site.

Output 4 Assumptions: a key benefit of the explosion of interest in sargassum, combined with movement of conferences online, has meant that rather than needing to search for an opportunity we have been able to present at several conferences and gained from the interaction and exchange of information with others working on this topic (see Annex 3.14a-b). There has been real interest in our results as the UofG Algal Biotechnology Research Group has unique experience in in this area and this is the only project looking at chemical characterisation. Our results, published in open access papers, are informing other projects.

The assumption relating to holding of a Management Options Appraisal workshop was that there was a) an appropriate forum to convene such a workshop and b) personnel in TCI available to run it (4.6). This assumption remains valid and no such workshop has been held. Draft Management Guidelines for Sargassum have been circulated and this initiative, led by the acting deputy lead in DECR, may result in some long-term progress towards this output.

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

The impact statement in the original logframe was as follows:

> *The macro-algae beach deposits have been assessed from environmental and socio-economic perspectives and viable, sustainable, management strategies benefiting the natural environment and reducing dependence on oil are implemented*.

This was revised to read:

> *The macro-algae beach deposits have been assessed from environmental and socio-economic perspectives and the feasibility of viable, sustainable, management strategies benefiting the natural environment and reducing dependence on oil evaluated*

This project has had impact well beyond TCI with the chemical characterisation providing fundamental information to inform all the various initiatives trying to find ways to use the sargassum resource across the affected region. The analytical results are now freely available (Annex 3.11a), and have addressed a significant knowledge gap, particularly regarding potential toxicity that may prevent potential consequences, both direct and indirect, on health that could result if some of the ideas for products were pursued. These include plans for use as dietary supplements, both human and animal, pharmaceuticals, and beauty products. Use as compost for food production may also be limited. While we had hoped that the sargassum would, like some other types of macro algae, be suitable as a feedstock for biofuel production unfortunately this was found not to be the case (Annex 3.11a; 3.14a).

This project was initiated by concerns on TCI about the negative effect of sargassum on tourism, the principal economic activity of the islands. It was found that, while adverse publicity was a very real fear, the affected hotels and resorts had their own strategies for removing and disposing of the material. This effectively created jobs that had not existed prior to 2011, when the sargassum levels increased dramatically. While this may have reduced profit margins the impact of Covid-19 restrictions on travel is likely to have had a much greater economic impact.

Output 1 was intended to address the impact, both positive and negative, on ecosystem services and natural capital of the coastal zone of TCI. This would have included an assessment of the effect of harvesting both floating and beached material as well as of leaving it in situ. Progress was limited due to cancellation of the second visit and Covid-19 restrictions.

Despite these challenges this research has highlighted the potential negative impact of floating sargassum on seagrass meadows, which are vital as nurseries for the most commercially important fisheries[5]. This could have long-term impact on the livelihoods of TCI residents, many of whom are fishers, emphasising the necessity for a strategic approach to future management.

3 Contribution to Darwin Initiative Programme Objectives

3.1 Contribution to Global Goals for Sustainable Development (SDGs)

Goal 1. No Poverty & Goal 8. Decent work & economic growth
This project, by making information on the chemical composition of sargassum freely available in open access papers, will inform the development of business ventures that result in job creation.

Goal 3. Good health & well-being
Revealing the toxicity of sargassum, particularly the high arsenic levels, will reduce the likelihood of products with the potential to harm humans or livestock being produced and marketed.

Goal 14. Life below water & Goal 15. Life on land
The floating rafts of sargassum have been compared to rainforests in terms of the quantity and diversity of life that thrives in them, including endemics and the early life stages of endangered sea turtles. However, this project has shown a negative effect when the floating rafts shade the seagrass meadows on which many species, including those supporting the fishery industry of TCI, depend. There may also be a similar impact on mangroves while also serve as important breeding areas for marine species. When beached the sargassum becomes a rich resource for detritivores which in turn attract other wildlife such as wading birds. Concerns have been raised about the impact of sargassum deposits on turtle breeding beaches, as when deep this may hamper access to nest sites and the journey of hatchlings to the sea.

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

This is not relevant to this project.

3.3 Project support to poverty alleviation

It is difficult to apply this criterion to this project and there were no indicators directly related to poverty alleviation in either the original or revised logframes. The original rationale was to address the economic impact of sargassum on the hotel and tourism industry. Decrease in visitor numbers would impact on profitability and so employment opportunities, and it should be noted that the majority of those engaged in beach clearance are economic migrants from Haiti and the Dominican Republic. Finding a commercially viable solution to the issue could potentially increase job opportunities and associated wages, not just in TCI but across the affected region. Our results, highlighting the potential toxicity of sargassum may impact wellbeing, by discouraging initiatives to turn sargassum into food supplements and animal feed currently in development (not in TCI but other countries). Raising awareness of the effect of sargassum shading on seagrass meadows will, if management actions are taken, help to ensure the sustainability of the fisheries on TCI, currently the economic activity second only to tourism on TCI.

[5] Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007

3.4 Gender equality

Most of the researchers involved in this project were female (Annex 3.2; Annex 3.11a-b). There were no specific indicators related to gender equality in either the original or the revised logframes.

3.5 Programme indicators

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

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

  N/A

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

  N/A

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

  N/A

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

  N/A

3.6 Transfer of knowledge

Knowledge transfer has been highly effective with three high level scientific papers in mainstream peer reviewed, open access, journals (Annex3.11a-b). Presentations have been made at international conferences and webinars including the UK Overseas Territories Conservation Forum conference in 2021 (Annex3.14a-b). There was a high proportion of females actively drafting paper and listed as authors and presenting at conferences. with one female PhD student being from Sri Lanka and another, male, from Bangladesh. Sharing our research in ways that ensure it is freely available to practitioners and policy makers seeking to address the 'sargassum issue', and should assist in the development of appropriate, context specific, management strategies.

Two female students from the UK based their theses on research carried out as part of this project achieving MScs with distinction (Annex3.2) and these and all the other students were from either the UK or USA. Work with local schools and collages was, as previously explained in 2.3 (Output 2) limited. However, the sargassum identification guide has been widely distributed electronically and the educational resource *Understanding Golden Tides: are these Challenges or opportunities*" has been written, including activities and teacher notes, and publication is planned for early in 2022. This will be translated into local languages and distributed across the Caribbean.

3.7 Capacity building

There has undoubtedly been capacity building in the sense that this project has raised awareness of issues associated with the 'sargassum problem' that are wider than the original remit. However, the effect is low key and widespread, from students to conference/webinar participants of mixed gender and a range of nationalities from across the Caribbean region. The involvement of PhD students from developing countries, notably Supattra Maneein (female, Sri Lanka and Mohammad Al Farid (male, from Bangladesh) will be of benefit to their future careers as they are named as paper authors; for Supattra presenting at conferences was an important networking opportunity as she reaches the end of her PhD and is seeking work in this area.

4 Sustainability and Legacy

The results of the chemical analysis will undoubtedly lead to better informed decision making regarding future exploitation of the sargassum resource at regional/national and transboundary level as the problem is widespread across the Caribbean. In the TCI context this project has collaborated with the DECR production of Guidelines for Sargassum Management (still in draft form), and has highlighted the potential impact of floating sargassum on the fisheries on which many local people depend for their livelihoods.

This aspect had provided a direct connection to the Marine Spatial Planning project (DPLUS094) which has mapped habitats, including the seagrass meadows, in the coastal zone. This could be of great benefit enabling targeted management to removal of sargassum from priority areas to conserve the fishery resource.

There have been no staff employed specifically for this project and the only resource purchased has been the freeze drier installed at the SFS. This will continue to be used by students and the research into the impact of sargassum, particularly on the coral reefs and seagrass meadows, will continue.

5 Lessons learned

The partnership has not worked in the way anticipated as commitments made by DECR during the drafting of the proposal were not realised, compromising some aspects of this project. SFS staff have stepped up, contributing significantly more than originally planned in the bid document. In retrospect when the project was approved all the partners should have been asked if anything had changed, whether they still had the capacity to deliver commitments made in the application, and – importantly – if they wanted to continue with the project. While a delay between submission and approval is the norm, in this instance we were told the application had been rejected. This may have led to reallocation of staff to other projects; the decision was later reversed, and we were given the go ahead to proceed.

Much of the first year was spent on trying to get all partners to sign a partnership agreement or MOU. While the UofG standard paperwork could be considered complex, being drafted by lawyers to meet every eventuality, it is a requirement. All partners except DECR signed. In retrospect we should have set up an agreement of some kind before starting work and visiting TCI, rather than assuming commitments made – and signed off - in the application remained valid. On the other hand, it would be reasonable to expect that if a partner found they were unable to fulfil their commitments they would make this clear.

Applications are always written on the basis of best available information, and this is always inadequate. It is the requirement for more in-depth knowledge that is the justification for funding. This almost always means that outputs, outcomes, and activities need to be modified. There are always surprises. In this case, we were unaware of the different morphotypes in the beached deposits and that these would need to be separated with additional surveys to determine if these were present in constant proportions. Four times the original lab work was required to characterise each morphotype and a mixture, as this is how they arrive on the beach. A significant gap in knowledge remains as seasonal and geographical variation is still to be determined.

5.1 Monitoring and evaluation

Monitoring and evaluation is the responsibility of the UofG as lead partner. Revision to the original logframe was requested as it became clear that the outcome and impact would not be achievable (see 2.2 and 2.4 for details of change in wording). It was also clear that some on the original assumptions were inaccurate, including the implicit one that partners would contribute as set out in the application. Suggestions for revisions were discussed and drafts circulated for comment, with agreement reached before submission for approval. The impact of Covid-19 was assessed resulting in a request for a six-month suspension of the project between April and September 2020.

5.2 Actions taken in response to annual report reviews

All reports and the feedback received have been shared with partners prior to submission and SFS, the most active partner, has contributed to this final report.

The points required to be addressed in the **Year 1 Annual Report Review** follow:

• *Sargassum clearance is now illegal – to what extent does this influence the feasibility of the overall project's aims and does any aspect of the project design need to be adjusted to account for this?*

It was difficult to gain clarification on this issue. While it was widely reported by to be the case by resorts removing beached sargassum no specific policy or regulation could be found. We had intended to investigate this further on the second visit, planned for summer 2020, and look in detail at the environmental impact of in-water harvesting compared to removal from the beach. There are an increasing number of different harvesting techniques and DECR have produced draft management guidelines detailing acceptable methods to minimise damage to beach structure, implying it is now – or will be - approved.

• *Provide further information on how this project aligns with the SargNet. In particular, please comment on where your work complements their work vs where there is risk of duplication.*

The Sargassum Network (SargNet) is just one of the organisations that has emerged since this project was initiated. We are all members and share information, so the relationship is collaborative rather than competitive and there is no risk of duplication as this is the only project looking at chemical characterisation of sargassum.

• *The project also identifies potential duplication/overlap with another Darwin project on Natural Capital and should seek to resolve this as soon as possible.*

This project, due to Covid-19 restrictions on travel, made limited progress towards achieving Output 1, with no Ecosystem Service or Natural Capital Assessment carried out. UofG and SFS staff took part in four days of workshops held by the DPLUS094 project, 29/30 Sept & 6/8 Oct 2020, as well as commenting on documents produced subsequently. There is no duplication or overlap but synergy as this project has highlighted the need to prioritise sargassum management where it could damage seagrass meadows. The Marine Spatial Planning project has made maps showing where the meadows are located available on the website.

• *Consider reporting on the gender of students trained through the project*

There were more females than males. The numbers are reported in Annex 3.2, 3.4a, 3.4c and 3.5.

The points required to be addressed in the **Year 2 Annual Report Review** follow:

- *Please ensure you directly respond to feedback received in this and the last Annual Report Review in your Final Report.*

Using the text from each of the ARRs directly as bullet point headings in this report should ensure that all items of feedback are fully addressed.

- *Ensure you provide clear evidence in support of indicators with your Final Report*

The structure of Annex 2 requires progress against output indicators to be reported. Where appropriate cross references to evidence in Annex 3 has been included. This means that, for example, weblinks can be followed to check papers, podcasts and conference presentations exist.

- *Give further consideration to how the various project publications and outputs will be disseminated. Consider who the target audiences are, to what purpose outputs are being shared with them, and whether you can measure any progress towards that overarching goal within the lifetime of the project*

All major publications are open access and have been widely promoted among the community across the Caribbean region including other OTs, affected by sargassum. The same is true of conference presentations. The primary audience for the technical data produced by this project are others involved in sargassum management strategies and in product development. The

secondary audience are stakeholders affected by sargassum, for example tourism businesses and fishers, although these are looking to the first group to provide them with practical cost-effective solutions. The purpose of sharing outputs is so that others can benefit from them.

The logframe was revised after the first year of the project with all partners able to comment prior to submission and approval. This refocused the project on the achievable and we feel the overarching goal of analysis the sargassum to determine whether it was suitable as a feedstock for biofuel or for other commercially viable uses has been achieved with the final set of results published in December 2021.

6 Darwin identity

Support from the Darwin Initiative has been explicit in all presentations at conferences, webinars, and podcasts, with the logo clearly displayed. Published papers all acknowledge the support using the wording "*This research was funded by DEFRA Darwin Plus DPLUS100: in partnership with the Department of Environment and Coastal Resources (DECR), Turks and Caicos Islands (TCI) Government; the University of Greenwich (UofG); the School for Field Studies (SFS), South Caicos, and the Chartered Institute of Ecologists and Environment Managers (CIEEM) Overseas Territory Special Interest Group".* The ID resource, widely distributed electronically, bears the Darwin logo as does the educational resource on sargassum due to be published by Marine Conservation without Borders early in 2022.

There is widespread awareness of Darwin projects on TCI as this programme as this has been a significant source of funding for DECR, with several projects running concurrently. However, awareness is limited to those in local government and the direct beneficiaries, such as NGOs, rather than residents and visitors to the islands.

No specific social media accounts were set up for this project. When there is promotion of conference presentations or the publication of papers, for example on LinkedIn, the support of @darwin_defra is acknowledged.

7 Impact of COVID-19 on project delivery

Covid-19 had a very serious impact on this project. Travel restrictions prevented the second field work trip to TCI compromising ability to achieve Output 1. It also restricted SFS monitoring and sampling activities as they had no resident students. The closure of the University of Greenwich laboratories also meant delay in processing and analysis of samples received from TCI. The six-month suspension was vital, enabling work to continue beyond the original timeline. Project staff have also been affected with Dr John Milledge forced to retire after infection with Covid-19.

On the positive side permission was granted to reallocate budget intended for travel and fieldwork to increase the amount of lab work undertaken, particularly important as additional work was required as the potential of toxicity emerged. We were aware of some projects looking at processing sargassum as dietary supplements so establishing the level of toxicity and sharing this information became a priority.

The shift to virtual conferences has been highly beneficial enabling results to be shared more widely – and earlier - than anticipated. It is to be hoped that this will continue in the future.

8 Finance and administration

a. Project expenditure

Project spend (indicative) since last annual report	2021/22 Grant (£)	2021/22 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 (£)
Dr Debbie Bartlett, Principal Lecturer	
TOTAL	

Capital items – description	Capital items – cost (£)
A freeze drier for installation at the School for Field Studies, South Caicos, Turks & Caicos Islands. This enabled samples of sargassum to be sorted, freeze dried, and dispatched to the UK for analysis.	
TOTAL	

Other items – description	Other items – cost (£)
Dr John Milledge, originally named in the application as lead for the chemical characterisation (Output 3) was forced to take medical retiremen in Summer 2020. He was unable to contribute to the drafting of the final paper on the chemical characterisation of sargassum and so this was an additional role undertaken by Dr Birthe Nielsen.	
TOTAL	

b. Additional funds or in-kind contributions secured

Source of in-kind funding for project lifetime	Total $	Total (£)
SFS Vehicle use – 74 field days at ½ - 74 x $per ½ day		
Senior Researcher accompanying UofG team in field work 9 X $80 per day		
Graduate Researcher accompanying UofG team in field work 9 X $70 per day		
Faculty support for sample collection & sorting – 57 x $135 per day		
Senior management supervision 15 x $285 per day		
TOTAL		

In the original application SFS were to be a minor player, providing accommodation for the Uof G field team while on South Caicos and leading the fieldwork for initial assessment and developing monitoring protocols fir use by schools across TCI. The contribution in kind has been far greater, see table above, as they took on some of the roles previously assigned to DECR staff. They intend to continue this research beyond the life of this project and will be continuing to involve their students in survey and monitoring, particularly to determine the impact of sargassum on the reefs and seagrass meadows.

Source of funding for additional work after project lifetime Not applicable	Total (£)

c. Value for Money

The use of the specialised facilities in the University of Greenwich Algael Biotechnology Research Group laboratories has minimised expenditure as the expertise and equipment for detailed analysis of different forms of seaweed is already in place. Involving students in literature review and fieldwork (Annex 3.2), and in analysis and helping to prepare conference presentations andpapers for publication (Annex 3.11a) has not only provided quality at low cost but also added value to their educational experience. The PhD students, Supattra Maneein (female, Sri Lankan) and Md Mahmud Al Farid (male, Bangladeshi) have really appreciated the experience with Supattra giving a presentation at one of the Sargassum conferences, an excellent networking opportunity.

Staff and students at the School for Field Studies have been invaluable, not only providing accommodation free of charge for the UofG team while on the island (as in the original application), but also stepping up and taking on activities originally the responsibility of DECR staff. Without this additional input this project would have been severely curtailed (see 8b).

While the focus of Darwin is the UKOTs the outputs are widely transferable and relevant across the whole of the Caribbean region affected by sargassum. While many are working on different aspects of sargassum this is the only project working specifically on chemical composition. Lack of knowledge in this area had been identified as a research gap and critical to finding a sustainable solution to the ‘sargassum problem’. So, while we have succeeded in developing a viable use for the sargassum biomass this project has provided a robust foundation for others to build on.

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)

This project has produced evidence on the chemical composition of *S. natans* 1, *S. natans* VIII, and *S. fluitans* I, the species and morphotypes of the pelagic forms comprising the floating rafts and beached material on the Turks and Caicos Islands. Lack of this information has been a key barrier to commercial exploitation of Sargassum, not only in TCI and other affected UKOTs, but across the whole of the Caribbean region. The research findings have been widely publicised, with scientific data available in open access journal papers, and the implications have been clearly communicated in webinars and at online conferences. The potential toxicity is of particular importance, adding a note of caution to proposals for using it as food, pharmaceuticals, and animal feed.

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: The macro-algae beach deposits have been assessed from environmental and socio-economic perspectives and the feasibility of viable, sustainable, management strategies benefiting the natural environment and reducing dependence on oil evaluated			
Outcome: Students will have engaged in STEM activities and the potential for macro-algae as a biomass fuel evaluated	0.1 monitoring of deposited sargassum has been carried out to provide data on quantity and seasonality 0.2 4 workshops with students (2) have been held 0.3 50 students have engaged in STEM activities including measuring and taking samples 0.4 a technical report on the monitoring and collection of Sargassum	0.1 ongoing monitoring of Shark Bay, South Caicos by SFS staff and students carried out for 12 months (completed by 30/6/21) 0.2 photographic records, records of student numbers 0.2 student feedback and samples submitted for characterisation (30/6/21) 0.4 report submitted (by 30/9/21)	
Output 1 Integrated Ecosystem Service, Ecological/Environmental Impact and Natural Capital Assessment of the coastal zone. Specific focus will be on the tidal strand line and macroalgae, such as Sargassum spp, deposited as drift.	1.1 Fieldwork reports, including literature/historical information on macro-algae compiled in the form of 2 MSc theses completed in year 1) 1.2 Ecosystem service assessment & Ecological/Environmental Impact Assessment focusing on the socioeconomic and environmental impacts of Sargassum deposits 1.3 Project report, to include evaluation of the impact of Sargassum on the marine. And coastal environment Natural Capital developed from the preceding documents	1.1 2 MSc theses submitted (by 30/9/19 1.2 Draft ESS/EcIA Report submitted to the DPLUS094 project team for comment and to identify how this could contribute to the spatial planning project as well as providing a robust evidence base to strategic environmental opportunities (by 31/3/2021) 1.3 Final project report submitted to TCIG by 30/9/2021	1.1 The availability of historical records – particularly regarding past levels of drift 1.2 Availability of data from local partners

Output 2 Education and awareness raising of shoreline/coastal environment	2.1 Engagement of at least 50 students in project activities 2.2 Recruit 2 Greenwich post graduate students to use this project for their research 2.3 Produce identification sheets to enable identification of the different sargassum morphotypes and I leaflet 2.4 At least 3 local/national media reports on the project	2.1 Photographic evidence, student projects and staff statements (30/9/21) 2.2 Research proposals submitted and accepted as appropriate by 30/4/19 2.3 3 ID sheets and 1 leaflet circulated to partners, approved and disseminated by 31/3/2020 2.4 printouts, tape or video recordings submitted to PI by 31/3/21	2.1 Schools/colleges are interested in this project 2.4 That there is sufficient interest from local/national media
Output 3 Characterisation of macro-algae, such as *Sargassum* spp, deposited as drift to identify potential as biomass for fuel and other products.	3.1 10 samples dispatched from Turks and Caicos 3.2 10 samples received by University of Greenwich 3.3 chemical characterisation completed 3.4 experimental methane potential established	3.1 postal records 3.2 incoming postal records (by 30/6/21) 3.3 & 3.4 technical report submitted to TCIG (by 30/9/21)	3.1That suitable representative samples can be collected and transported to the UK
Output 4 Research outputs developed and shared with other British Overseas Territories experiencing 'golden tides'.	4.1 Circulation of Identification sheets via the SargNet website and to all other projects on request, 4.2 Open access journal article on feasibility for sustainable management of macroalgae such as *Sargassum* spp. 4.3 Conference presentation 4.4 UKOT hosted webinar 4.5 Technical report on potential for sustainable end use such as biogas generation	4.1 Uploaded to the SargNet website by 31/3/20 4.2 Confirmation of acceptance by 31/3/20 4.3 Presentation listed in proceedings and available online (4/11/20) 4.4 20 attending or viewing within two months (by 31/9/21) 4.5 Shared via OT Government network and/or SargNet (by 30/9/21)	4.3 That an appropriate conference is being help within the time frame of the project

	4.6 Management Options Appraisal workshop attended by >20 people	4.6 Sign in sheets, photographs, and workshop report	4.6. That there is a) an appropriate forum to convene such a workshop and b) personnel in TCI available to run it

Activities (each activity is numered according to the output that it will contribute towards, for example, 1.1, 1.2 and 1.3 are contributing to Output 1)

Output 1 Integrated Ecosystem Service, Ecological/Environmental Impact and Natural Capital Assessment of the coastal zone

1.1 partner workshop & scoping exercise
1.2 Developing fieldwork protocol(s)
1.3 Field work
1.4 Collation of data/information
1.5 Report drafting
1.6 collaboration with partners on draft report
1.7 contribution to Final Natural Capital report
1.8 raising awareness of the Caribbean wide Epicollect5 sargassum monitoring initiative
1.9 Ongoing shoreline survey/monitoring

Output 2 Education and awareness raising

2.1 Engaging students in field work
2.2 MSc students contributing background material/literature review
2.3 Developing educational materials
2.4 Workshops for teachers and students on South Caicos
2.5 Evaluation of material re relevance to other OTs
2.6 Engagement with local/national press and media

Output 3 Characterisation of Sargassum spp

3.1 Development & testing of a collection protocol
3.2 Collection & dispatch of samples to the UK
3.3 Characterise the Sargassum arriving at the beach
3.4 Assess the seasonal variability of Sargassum and effects of weather and time
3.5 Establish experimental methane potential of fresh and dried beach-cast Sargassum

Output 4 Dissemination

4.1 Distribution of educational materials to other OTs
4.2 Technical report on suitability of Sargassum for potential biorefining biogas production and Management Options Appraisal for other uses
4.3 Webinar for professionals – OTSIG (including preparation)
4.4 UKOT hosted webinar
4.5 Open Access journal article drafting
4.6 Conference presentation (potentially beyond the timeline)

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

Project summary	Measurable Indicators	Progress and Achievements
Impact: The macro-algae beach deposits have been assessed from environmental and socio-economic perspectives and the feasibility of viable, sustainable, management strategies benefiting the natural environment and reducing dependence on oil evaluated		Completed. 'The Impact of Sargassum on Tourism Related Businesses: Initial Assessment Report' was circulate in October 2019 and this aspect of the project further developed with additional research, presented at conferences and published as an open access paper (Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007). The results of the assessment of the feasibility for viable management commercial exploitation has been presented at conferences and published as open access papers (Milledge J J Maneein S, Arribas López E & Bartlett D (2020) Sargassum Inundations in Turks and Caicos: Methane Potential and Proximate, Ultimate, Lipid, Amino Acid, Metal and Metalloid Analyses *Energies* 2020, *13*(6), 1523; https://doi.org/10.3390/en13061523 & Nielsen B V, Milledge J J, Hertler H, Maneein S, Al Farid M M & Bartlett D (2021) Chemical characterisation of Sargassum inundation from the Turks and Caicos: Seasonal and post stranding changes Phycology 2021, 1, 143–162. https://doi.org/10.3390/ phycology1020011. This research has identified the potential negative impact on the fisheries and so the livelihoods of TCI residents so highlighting the importance of a strategic approach to management. The feasibility for use as biofuel has been demonstrated to be limited, and the high levels of toxic components, particularly arsenic, a limitation for other uses. These results have been widely shared across the affected Caribbean region in conference presentations and open access papers.
Outcome: Students will have engaged in STEM activities and the potential for macro-algae as a biomass fuel evaluated	0.1 monitoring of deposited sargassum has been carried out to provide data on quantity and seasonality 0.2 4 workshops with students have been held 0.3 50 students have engaged in STEM activities including measuring and taking samples 0.4 a technical report on the monitoring and collection of Sargassum	0.1 Originally the responsibility of DECR staff (in the application) it became clear in the first year that this would not take place. Monitoring was taken over by SFS, focusing on a single beach on South Caicos. This began using students but was continued by staff due to Covid-19 restrictions. 0.2 Completed during visit of UofG field team in June 2019, working with schools on South Caicos. 0.3 Completed - SFS students actively engaged in monitoring, measuring and sorting samples during summer and autumn 2019 0.4 Due to limited monitoring of just one site a separate report has not been produced but results included in an open access paper (Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104;

Project summary	Measurable Indicators	Progress and Achievements
Output 1. Integrated Ecosystem Service, Ecological/Environmental Impact and Natural Capital Assessment of the coastal zone. Specific focus will be on the tidal strand line and macroalgae, such as Sargassum spp, deposited as drift.	1.1 Fieldwork reports, including literature/historical information on macro-algae compiled in the form of 2 MSc theses completed in year 1) 1.2 Ecosystem service assessment & Ecological/ Environmental Impact Assessment focusing on the socioeconomic and environmental impacts of Sargassum deposits 1.3 Project report, to include evaluation of the impact of Sargassum on the marine and coastal environment Natural Capital developed from the preceding documents	1.1 Completed 2 MSc students graduated with distinction (for details see Annex 3.2) 1.2 & 1.3 Partially completed. The ESS and EIA research was planned for the second field team visit in summer 2020 but this was cancelled due to Covid-19 travel restrictions. Some aspects have been incorporated into an open access paper (Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007) which includes discussion of the potential impact of floating material on natural capital (seagrass meadows and fisheries) and implications for management.
Activity 1.1 partner workshop & scoping exercise		Completed during visit to TCI in June 2019
Activity 1.2 Developing fieldwork protocol(s)		Completed during visit to TCI in June 2019 working with SFS staff and students
Activity 1.3 Field work		Completed although had it not been for Covid-19 restrictions considerably more would have been possible in 2020, both by UofG working with SFS and by SFS students
Activity 1.4 Collation of data/information		Completed although had it not been for Covid-19 restrictions considerably more would have been possible in 2020, both by UofG working with SFS and by SFS students
Activity 1.5 Report drafting		Completed – drafting open access papers and giving conference presentations has increased impact and made the results available across the affected Caribbean region
Activity 1.6 collaboration with partners on draft report		SFS staff have been closely involved with papers and Fran Elmer and Heidi Hertler, both SFS staff, are named as co-authors
Activity 1.7 contribution to Final Natural Capital report		No Progress – research was interrupted by Covid-19 restrictions. However Uog and SFS contributed to the DPLUS094 MSP workshops 29/30 Sept & 6/8 Oct 2020 and commented on summary documents.
Activity 1.8 raising awareness of the Caribbean wide Epicollect5 sargassum monitoring initiative		Limited progress due to restrictions on contact during 2020. As this has become so widely known across the region and satellite monitoring is now readily accessible with monthly reports distributed it is perhaps no longer relevant.
Activity 1.9 Ongoing shoreline survey/monitoring		Ongoing – SFS will continue the detailed monitoring at Shark Bay, South Caicos, as a student activity into the future.

Project summary	Measurable Indicators	Progress and Achievements
Output 2. Education and awareness raising of shoreline/coastal environment	2.1 Engagement of at least 50 students in project activities 2.2 Recruit 2 Greenwich post graduate students to use this project for their research 2.3 Produce identification sheets to enable identification of the different sargassum morphotypes and I leaflet 2.4 At least 3 local/national media reports on the project	2.1 Completed during the first 6 months of the project (summer 2019) with a combination of visits to schools on South Caicos and engagement of SFS students. 2.2 Completed prior to the visit to TCI in June 2019 and both carried out fieldwork in TCI and used this as the basis of their MSc theses. 2.3 Completed during the visit to TCI in June 2019, and widely distributed electronically including at the 1st International Conference on Sargassum 23-26th October, 2019, in Guadeloupe. 2.4 Partially completed – with an article in the local 'Times of the Islands' and in the Guardian newspaper.
Activity 2.1 Engaging students in field work		Completed during visit to TCI in June 2019 with the UofG team, including 2 MSc students, working with SFS staff and students (Annex 3 4a, 4b, 4c, 4d & 5)
Activity 2.2. MSc students contributing background material/literature review		Completed – evidenced by submission of 2 MSc theses (A3 2)
Activity 2.3 Developing educational materials		In addition to the ID sheets an educational resource on sargassum, including notes for teachers has been developed entitled 'Understanding Golden Tides – are these a challenge or an opportunity?' This will be translated into local languages, produced, and distributed across the Caribbean by Marine Conservation Without Borders (Annex 3.7)
Activity 2.4 Workshops for teachers and students on South Caicos		Completed during visit to TCI in June 2019 with the UofG team, including 2 MSc students, working with SFS staff and students (Annex 3 4a, 4b, 4c, 4d & 5)
Activity 2.5 Evaluation of material re relevance to other OTs		Completed – all the research data and materials are highly relevant, not only to the OTs but the whole region affected by sargassum. Therefore, the focus has been on conference presentations and producing open access papers (Annex 3.11).
Activity 2.6 Engagement with local/national press and media		Engagement with the press and media has been limited due to restrictions on travel and face to face contact. This would have been facilitated had it been possible to have on site meetings.
Output 3. Characterisation of macro-algae, such as the *Sargassum* spp, deposited as drift to identify potential as biomass for fuel and other products.	3.1 10 samples dispatched from Turks and Caicos 3.2 10 samples received by University of Greenwich 3.3 chemical characterisation completed 3.4 experimental methane potential established	3.1 & 3.2 Completed – 4 samples, one each of the different morphotypes and one an as found mixture were brought back from TCI after the visit in June 2019. Regular samples of freeze-dried material, sorted and mixed, as well as beach decayed, were dispatched by SFS staff and a total of 39 samples received by UofG and analysed, significantly exceeding the indicator number. 3.3 & 3.4 Completed, and results published (Annex 3.11). The methane potential was found to be limited making it unlikely that the biomass could be commercially viable as a fuel source unless as co-digestate could be identified (this requires further research).

Project summary	Measurable Indicators	Progress and Achievements
Activity 3.1 Development & testing of a collection protocol		Completed during the UofG visit in June 2019 in collaboration with SFS staff.
Activity 3.2 Collection & dispatch of samples to the UK		Completed – lab work was completed in late summer 2021 and, in addition to the analysis originally planned additional heavy metal toxicity screening was carried out due to indications in early samples of high arsenic content. This is highly important as projects are emerging using sargassum in food, fodder, pharmaceuticals, and beauty products.
Activity 3.3 Characterise the Sargassum arriving at the beach		This has proved problematic as sorting sargassum into the different morphotypes is time consuming and Covid restrictions have meant that SFS had no students for most of 2020 and 2021. Initial results indicate the proportions of the different morphotypes is highly variable.
Activity 3.4 Assess the seasonal variability of Sargassum and effects of weather and time		Limited to a single location rather than monitoring sites on each of the main islands of TCI as originally planned to be carried out by DECR staff. An experiment to determine the effect on weathering was set up at SFS and the results on chemical composition have been reported (Annex 3.11 Nielsen et al 2021)
Activity 3.5 Establish experimental methane potential of fresh and dried beach-cast Sargassum		Completed. The results have been disseminated at conferences (Annex 3.14a) and in the form of open access peer reviewed papers (Annex 3.11)
Output 4. Research outputs developed and shared with other British Overseas Territories experiencing 'golden tides'.	4.1 Circulation of Identification sheets via the SargNet website and to all other projects on request,	4.1 Completed. The ID sheets have been widely circulated and included in both papers, conference presentations and the educational resource currently in preparation in conjunction with Marine Conservation Without Borders. Distribution has been electronically although printed versions were given out to schools on South Caicos during workshops in summer 2019.
	4.2 Open access journal article on feasibility for sustainable management of macroalgae such as *Sargassum* spp.	4.2 Completed**.** Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands *Phycology* (2021) *1*(2), 83-104; makes suggestions for prioritisation of management operations. This project has also contributed to the DECR draft management guidelines for sargassum (still awaiting finalisation).
	4.3 Conference presentation	4.3.Completed. UoG and SFS staff have presented this project at several international conferences (see Annex 3.14b).
	4.4 UKOT hosted webinar	4.4 Not completed. Cancellation of all travel due to Covid-19 meant that the role of the CIEEM UKOT special Interest Group, who were to assist with fieldwork to assess the environmental impact of Sargassum on natural capital and the effect of harvesting, was not realised. However, two episodes of the Sargassum Podcast focused directly on this project (Annex 3.14a).
	4.5 Technical report on potential for sustainable end use such as biogas generation	4.5 Not produced. The chemical analysis revealed that the potential for biogas is very limited, and the heavy metal/arsenic content severely limits use for human/livestock consumption. These finding – including- technical data have been widely disseminated in conference presentations (Annex 3.14.b) open access papers (Annex 3.11a) and podcasts (Annex 3.14a).
	4.6 Management Options Appraisal workshop attended by >20 people	4.6 Not completed. This would have required hosting by DECR and the most appropriate timing would have been during the summer 2020 visit of the UofG team which was cancelled due to Covid-19 restrictions.

Project summary	Measurable Indicators	Progress and Achievements
Activity 4.1 Distribution of educational materials to other OTs		Completed – dissemination has extended far beyond the OTs as interest in the sargassum issue has increased exponentially since the original funding application was drafted resulting in multiple opportunities to share findings at international conference (Annex 3.14.b) attended by all countries, including the other OTs, affected by sargassum.
Activity 4.2 Technical report on suitability of Sargassum for potential biorefining biogas production and Management Options Appraisal for other uses		Not produced but substituted by production of open access papers (Annex3.11a) and conference presentations (Annex 3.4b)
Activity 4.3 Webinar for professionals – OTSIG (including preparation)		Not completed. Substituted by two episodes of the Sargassum Podcast focused directly on this project (Annex 3.14a) and conference presentations (Annex 3.14a).
Activity 4.4 UKOT hosted webinar		Not completed. Substituted by two episodes of the Sargassum Podcast focused directly on this project (Annex 3.14a).
Activity 4.5 Open Access journal article drafting		Completed (see Annex 3.11a)
Activity 4.6 Conference presentation (potentially beyond the timeline)		Completed (see Annex 3.14b)

Annex 3 Standard Measures

Code	Description	Total	Nationality	Gender	Title or Focus	Language	Comments
Training Measures							
1a	Number of people to submit PhD thesis						
1b	Number of PhD qualifications obtained						
2	Number of Masters qualifications obtained	2	UK	Female Female	Myers S Distribution and composition of *Sargassum spp.* washed ashore in the Turks and Caicos Islands Lee K Exploring the impacts *Sargassum spp.* landings are having on business and the environment in Turks and Caicos Islands.	English English	Both achieved MSc with distinction
3	Number of other qualifications obtained						
4a	Number of undergraduate students receiving training	77		68 female, 9 male			
4b	Number of training weeks provided to undergraduate students	15					
4c	Number of postgraduate students receiving training (not 1-3 above)	12		11 female, 1 male			
4d	Number of training weeks for postgraduate students	3					

5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification (e.g., not categories 1-4 above)	6		6 female			
6a	Number of people receiving other forms of short-term education/training (e.g., not categories 1-5 above)						
6b	Number of training weeks not leading to formal qualification						
7	Number of types of training materials produced for use by host country(s) (describe training materials)	1	UK	Female	Educational resource on Sargassum	English but will be translated into several local languages	awaited

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 authorities or other implementing agencies in the host country (ies)						
10	Number of formal documents produced to assist work related to species identification, classification, and recording.	1	UK	Female	Sargassum ID guide	English	
11a	Number of papers published or accepted for publication in peer reviewed journals	4	UK & Danish UK & Swiss	3 female 1 male 2 female 4 female	Sargassum Inundations in Turks and Caicos: Methane Potential and Proximate, Ultimate, Lipid, Amino Acid, Metal and Metalloid Analyses The Impact of Sargassum Inundations on the Turks and Caicos Islands	English English	https://www.mdpi.com/1996-1073/13/6/1523 https://www.mdpi.com/2673-9410/1/2/7/pdf

			UK, Danish. Sri Lankan & Bangladesh UK	2 male Female	Chemical characterisation of Sargassum inundation from the Turks and Caicos: Seasonal and post stranding changes Golden Tides – A Collaborative Search for a Sustainable Solution to the Seaweed Inundations on Caribbean Beaches	English English	https://www.mdpi.com/2673-9410/1/2/11/pdf *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management*, 107: p30-33
11b	Number of papers published or accepted for publication elsewhere		UK, Danish. Sri Lankan & American	4 female 1 male	Searching for Sustainable Solutions for Sargassum Inundations in Turks & Caicos	English	https://www.ukotcf.org.uk/ukotcf-online-conference-2021-download-proceedings/
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country						
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country						
13a	Number of species reference collections established and handed over to host country(s)						
13b	Number of species reference collections enhanced and handed over to host country(s)						

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
14a	Number of conferences/seminars/workshops						Presentations have been made at several conferences but none were organised specifically to disseminate findings of this project alone.

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
	organised to present/disseminate findings from Darwin project work						
	Podcasts – added here as no specific measure for these)	2	UK	Male	Sargassum Podcast Episode 5 Turning Sargassum into biofuel? Dr John Milledge broadcast 1/2/21	English	Available at https://anchor.fm/sargassum-podcast/episodes/Episode-5-Turning-Sargassum-into-fuel--With-Dr--John-Milledge-epmqns
			UK	Female	Episode 9 Nature based solutions and social impacts of Sargassum Prof Debbie Bartlett broadcast 1/3/21	English	Available at https://www.youtube.com/watch?v=wWlobc_vXWM
	Web based case study	1	UK		Searching for a sustainable solution to Sargassum on Caribbean beaches Microbiology Society case study	English	Available at https://microbiologysociety.org/our-work/75th-anniversary-a-sustainable-future/circular-economy/circular-economy-case-studies.html
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	6	UK	Female	All on Sargassum: socio/economic/environmental impact and chemical composition	English	MSP workshops 29/30 Sept & 6/& Oct 2020
			UK	Female			Presentations x 2 Technical webinar on the Atlantic Sargassum Belt. European Algae Biomass Association 4/11/20
				Male		English	Poster presentation UKOT Conservation Forum conference 2/3 & 9/10 March 2021
						English	Presentations x 2 Sargassum Golden Tides, a global problem Algae-UK- EBNet – BBNet 26/5/2021
			UK, Danish. Sri Lankan American & Bangladesh	1 male 4 female	Chemical composition: a challenge for exploiting sargassum	English	International conference on harnessing sargassum. Centre of Excellence for Sargassum Research (CESAR) Lagos, Nigeria. 30/11/21

Physical Measures		Total	Comments
20	Estimated value (£s) of physical assets handed over to host country(s)		A freeze drier was purchased for this project and remains on South Caicos in the Field Studies Centre laboratory
21	Number of permanent educational, training, research facilities or organisation established		N/A
22	Number of permanent field plots established	1	Monitoring site at Shark Bay, South Caicos.

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 *(please note that the figure provided here should align with financial information provided in section 9.2)*		Mostly USA	Predominantly female	Monitoring, sample collection & sorting	English	

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.	
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.	
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.	
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.	
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

Provide full details of all publications and material that can be publicly accessed, e.g. title, name of publisher, contact details. Mark (*) all publications and other material that you have included with this report

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)
Journal	Milledge J J Maneein S, Arribas López E & Bartlett D (2020) Sargassum Inundations in Turks and Caicos: Methane Potential and Proximate, Ultimate, Lipid, Amino Acid, Metal and Metalloid Analyses *Energies* 2020, *13*(6), 1523;	UK	UK	Male	MDPI Basel, Switzerland	https://doi.org/10.3390/en13061523
Journal	Bartlett D (2020) Golden Tides – A Collaborative Search for a Sustainable Solution to the Seaweed Inundations on Caribbean Beaches *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management*, 107: p30-33	UK	UK	Female	CIEEM, Winchester UK	
Newspaper article	Anna Turns (2020) How do you deal with 9m tonnes of suffocating seaweed? Guardian newspaper	UK	UK	Female	Guardian, London, UK	https://www.theguardian.com/environment/2020/jun/30/how-do-you-deal-with-9m-tonnes-of-suffocating-seaweed-aoe
Podcast	John Milledge Episode 5 Turning Sargassum into biofuel? broadcast 1/2/21	UK	UK	Male	The Sargassum Podcasr	https://anchor.fm/sargassum-podcast/episodes/Episode-5-Turning-Sargassum-into-fuel--With-Dr--John-Milledge-epmqns
Podcast	Debbie Bartlett Episode 9 Nature based solutions and social impacts of Sargassum. broadcast 1/3/21	UK	UK	Female	The Sargassum Podcasr	https://www.youtube.com/watch?v=wWlobc_vXWM
Web case study	Debbie Bartlett (2020) Searching for a sustainable solution to seaweed inundations on Caribbean beaches	UK	UK	Female	Microbiological Society, UK	https://microbiologysociety.org/our-work/75th-anniversary-a-sustainable-future/circular-economy/circular-economy-case-studies.html
Journal	Bartlett D & Elmer F (2021) The Impact of Sargassum Inundations on the Turks and Caicos Islands. Phycology (2021) *1*(2), 83-104; https://doi.org/10.3390/phycology1020007	UK	UK	Female	Phycology, MDPI Basel, Switzerland	https://www.mdpi.com/2673-9410/1/2/7/pdf

Journal	Nielsen B V, Milledge J J, Hertler H, Maneein S, Al Farid M M & Bartlett D (2021) Chemical characterisation of Sargassum inundation from the Turks and Caicos: Seasonal and post stranding changes. Phycology *1*(2), 83-104; https://doi.org/10.3390/phycology1020007 https://www.mdpi.com/2673-9410/1/2/11/pdf	Danish	UK	Female	Phycology, MDPI Basel, Switzerland	https://www.mdpi.com/2673-9410/1/2/11/pdf

Annex 6 Darwin Contacts

Ref No	DPR7P\100059
Project Title	DPLUS100: Sustainable solutions for Sargassum inundations in Turks & Caicos 2019-2021
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Fax/Skype	
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Partner 1	
Name	Heidi Hertler
Organisation	School for Field Studies
Role within Darwin Project	Scientific investigation/field work
Address	
Fax/Skype	
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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@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.	
If you are submitting photos for publicity purposes, **do these meet the outlined requirements (see section 10)?**	
Have you included means of verification? You should 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 need 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.	