Darwin Plus:

Overseas Territories Environment and Climate Fund

Final Report

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

Darwin Project Information

Project reference	21-013
Project title	Alternative Livelihood Opportunities for Marine Protected Areas Fisherwomen.
Territory(ies)	Sierra Leone
Contract holder Institution	University of Stirling (UoS).
Partner institutions	Institute of Marine Biology and Oceanography (IMBO), Fourah Bay College, University of Sierra Leone; Njala University, Sierra Leone
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Project leader name	Dr. Francis Murray
Project website/Twitter/blog etc.	https://www.stir.ac.uk/about/faculties-and-services/natural-sciences/aquaculture/research/aquaculture-research-projects/the-darwin-sherbro-oyster-project/
Report author(s) and date	Francis Murray, Jason Hoepfl, Salieu Sankoh, Richard Wadsworth, William Leschen, James Green, Richard Quilliam, Richard Kapindi, Amara Kalone, Nick Shell, Emily Boardman, Emily Rossi, Dimitar Taskov, Alieu Kamara (22 February 2019)

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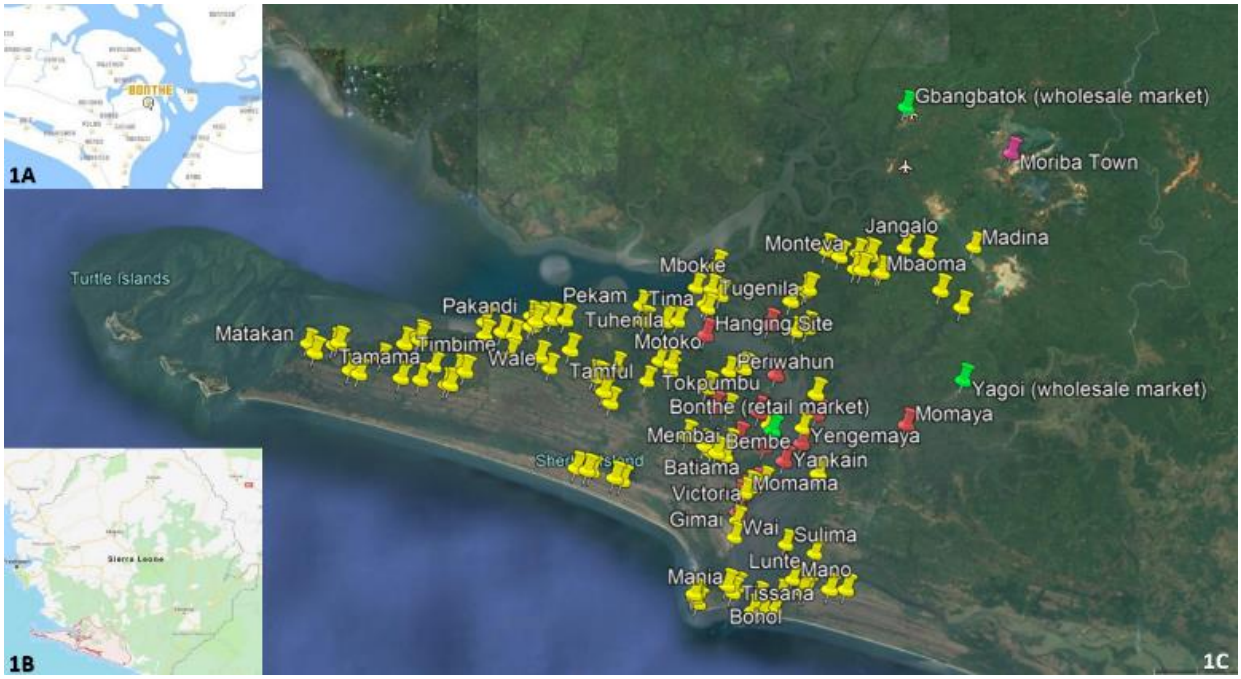
1 Project Overview

Location:

Figure 1 shows the location of the primary research area within the Sherbro River estuary marine protected area (MPA) in Bonthe District, Southern Province of Sierra Leone. At the mouth of the estuary, Sherbro Island is separated from the mainland by the Sherbro River in the north and the Sherbro Strait to the east. The Sherbro Estuary is 32 miles (51 km) long and up to 15 miles (24 km) wide, covering a total area of approximately 230 square miles (600 km2). At the western extremity are the Turtle Islands, whilst the main commercial and administrative centre of Bonthe Town is located to the east at the mouth of the Sherbro River. Fig 1c shows the location of numerous predominantly small (3-10 households) micro-dispersed 'satellite' communities in mangrove stands around Bonthe town, identified from supervised classification of satellite imagery. The project's target beneficiaries, female oyster gatherers and their households, are primarily located within the sheltered inland fringing mangrove stands of the Sherbro Strait with the most favourable environmental conditions for mangrove oysters.



Notes: Yellow markers indicate all identified 'satellite' communities, red markers indicate focal research communities, Green markers indicate the two primary wholesale weekly mainland markets for smoked oysters and retail market for steamed oysters (Bonthe town).

Figure 1. Location of the research area showing focal communities and markets within the Sherbro Marine Protected (mangrove) Area (MPA), Southern Province, Sierra Leone.

Research background:

Sierra Leone is ranked 4th lowest in the world on the IFPRI World Hunger Index. Many Sierra Leonean fisherwomen living in coastal mangrove areas are trapped in a downward spiral of environmental degradation and resource depletion. Because they are poor, have constrained access to education, lack capital and alternative sources of income, they are compelled to harvest oysters in what has become an increasingly widespread and unregulated seasonal activity. Lack of education and livelihood alternatives also mean that there is a higher propensity for children to follow the same livelihoods as their parents, with many becoming involved in fishing and oyster harvesting from a young age. Mangrove settlement patterns are also limited by freshwater availability and the associated lack of agricultural and other livelihood opportunities. It is a hard and dangerous life. Accidental drownings and injuries such as infected cuts from roots and shells are common. Mangrove trees are damaged by harvesting and extensive use for fuelwood and habitat for other species is disturbed. If the oysters are over-exploited from an area, one of the few options left for the women will be to cut the trees for firewood.

In 2012 the Government of Sierra Leone designated 284 km^2 of the Sherbro estuary as the Sherbro River Marine Protected Area (MPA), recognizing its importance to biodiversity and livelihoods. Statues mandated a fishing vessel registration scheme, gear restrictions with co-managed enforcement envisaged through 'Community Management Associations' (CMA's). The MPA statutes do not make any direct reference to oyster management, though female oyster gatherers also depend on canoes used to access to both fisheries and oyster resources. In 2014, nationally some 11,000 boats, mostly un-motorized dug-out canoes were formally registered and licensed. Over half of these boats operate within the Sherbro Estuary.

Most inhabitants are highly dependent on exploitation of primary aquatic and mangrove forest resources. Males are responsible for artisanal fishing and females for more seasonal oyster-harvesting. Post-conflict (civil war) gender ratios remain skewed in favour of females, many of whom function as reproductively independent sub-household units in the mainly Sherbro-Muslim 'satellite' communities where polygamy is still common practice. Although females are relatively autonomous in their oyster production and marketing, access to the dugout canoes needed for most oyster harvesting is prioritised for male fishing normatively viewed as the more 'serious' livelihood activity. Serendipitously, this is offset by synergies in fishing and oyster harvesting windows though women operating from more exposed coastal locations subject to frequent drowning accidents are more constrained in their independent gathering activity. Sherbro MPA statutes also make no explicit provision for regulation or mitigation of post-harvest processing impacts (steaming/ smoking fish and oysters) on mangrove forests. Due to the combination of rapid population growth, lack of alternative livelihoods and weak regulation of the open-access oyster fishery, the project placed special emphasis on market incentives to support improved environmental stewardship.

A native mangrove depletion and degradation problem was identified during 2006/7 by a previous Darwin Initiative project under which two reconnaissance surveys (Wadsworth 2009a & 2009b) were undertaken to consider the possibility of including the mangrove forests as a "biodiversity offset" to a commercial Rutile-mineral mining concession (NACE 2009). However, our research indicated high resilience of the mangrove oyster population to existing fishing effort and practices. Gathering is limited to simple hand-gathering techniques (Annex B3.1) with no mechanised dredging. Most female gathering is limited to 2-3km radius from their homes (where all processing is undertaken) limited by their paddling range in dugout canoes. This also limits over-extraction. Oyster populations are also highly adapted to fluctuating estuarine water quality conditions (Annex B3.2). However, demographic trends (Annex B1.2), coupled with high primary resource dependence point to a looming resource problem. Imprudent oyster harvesting (cutting of roots) and fuel requirements for processing of oyster and fish harvests will place ever growing pressure on mangrove ecosystem services, serving as spawning and nursery grounds for fish and other aquatic species, nutrient retention, storm, flood, erosion and salt-water intrusion control. As one of the most carbon-rich ecosystems on the planet; the high carbon sequestration capacity of mangrove forests also contributes to mitigation of global climate change.

This project aimed to support objectives of the MPA by providing alternative livelihoods for local women based on sustainably managed culture, processing and value-added marketing of native mangrove oysters. However challenges to assumptions in the initial log-frame necessitated a major revision part-way through the project, previously delayed due to the Ebola crisis. Trials of suspended oyster culture systems successfully addressed a number of technical constraints. However the relative abundance of wild oysters (suspended on mangrove roots) precluded this as a viable economic option under current resource and market conditions. The ambition to supply live oysters to a small but highly lucrative tourist beach-market around the capital Freetown (potential off-setting gathering pressure processing fuel requirement) was also constrained by (i) severe difficulties operating and maintenance solar-cold chain infrastructure (confirmed by a review of prior development project experiences, Annex B1.1, plate B1.1.15 a-f) and (ii) marketing options in Freetown were constrained by a high risk of bacterial contamination in fresh i.e. un-steamed Sherbro oysters and availability of lower-risk locally sourced 'rock' oysters (Annex B1.1 & B4.1). Consequently a log-frame revision approved in Feb 2017 (Annex A1) placed greater emphasis on market incentivised sustainable resource (oyster and mangrove) management through more localised value-added marketing of steamed and smoked oyster. The production focus scaled-back to assessing potential low input-output enhancements through placement of shell-waste on mud-banks.

Current production and marketing of oysters remains a highly unspecialized and unsegmented activity as a result of remoteness, poor communications and lack of cold-chain infrastructure. Most female gatherers will gather, processing and marketing their own produce. Women in close proximity to local population centres (principally Bonthe Town) have the more profitable option of retailing steamed oysters door-to-door on the day of processing (steaming facilitates shucking but also eliminates any potentially pathogenic bacterial loads; Annex B4.1). However, women in remoter 'satellite' settlements must also undertake secondary processing, smoking their steamed oysters to stockpile for wholesale at weekly mainland markets (Fig. 1C). This also necessitates much higher consumption of mangrove fuel compared to steaming alone. Margin analysis confirmed smoking serves as a preservation rather than value-adding mechanism. This is confirmed by empirical observation i.e. given the opportunity women invariably market steamed rather than smoked oysters. Beyond steamed and smoked products there is negligible product differentiation. Most smoked oysters are wholesaled at just two mainland markets, thus despite their relative seasonal scarcity, oysters are offered as an undifferentiated low-value wholesale commodity. Value-added options for the predominant smoked product category were primarily based on branding and packaging for direct retail in accessible local inland markets.

2 Project Stakeholders/ Partners

In the final year we engaged in implementation activities with three communities identified as having the greatest potential for the collective marketing actions envisaged in the log-frame (Primary Stakeholders below & Annex A1). Female members of indigenous micro-credit institutions took lead roles in developing and producing value-added products adapted to existing practices & resource constraints (Annex B5.2). The same women also co-designed and implemented retail-marketing trials in Moriba Town in 2018. Other innovations introduced by the group included design (and tailoring) of Sherbro Branded marketing attire and ready-to-eat oyster snack recipes (Fig B5.2.9; see section 4.2 (reviewer comments) for further detail.

Project co-ordination and research assistants (RA)

1. Dr Francis Murray: Aquaculture development specialist, UoS (PI)
2. Mr William Leschen: Aquaculture development specialist, UoS (CoI)
3. Dr Richard Wadsworth: environmental science specialist, Njala University, SL (PI)
4. Dr Salieu Sankoh: aquaculture and fisheries specialist, IMBO, SL (PI)
5. Mr. Richard Kapindi: Community outreach & survey expert, IMBO, SL (RA)
6. Mr. Jason Hoepfl, Research Assistant, UoS (RA)
7. Mr Edward (Amara) Kalone: IUU project officer, Environmental Justice Foundation, Bonthe, SL (RA)
8. Ms. Matilda Hai, Bonthe Secondary School Teacher & Enumerator, Bonthe, SL (RA)
9. Ms. Aminata Fodey, Secondary School Teacher & Enumerator, Bonthe, SL (RA)

Project research associates, UK

1. Mr James Green: Commercial oyster aquaculture specialist, Whitstable Oysters, UK
2. Dr Richard Quilliam: food-borne pathogen analyses, UoS, UK

Project MSc students (& research assistants)

1. Mr. Alieu Kamara, Msc project student, IMBO, Fourah Bay College, SL.
2. Ms. Emily Boardman, Msc project student Uos.
3. Ms. Emily Rossi, Msc project student Uos.
4. Mr Nicholas Shell: Sustainable aquaculture MSc project-student UoS.

Project research assistants, Sierra Leone

1. Ms. Mariama "Baby May" Kargbo, Enumerator and assistant, Fourah Bay College, SL.
2. Mr Muhammed John Gbla, Enumerator and assistant, IMBO, Fourah Bay College, SL.

Data enumerators, Bonthe District, Sierra Leone

1. Mr. Sheriff Yabguba, enumerator, Yagoi, SL (Marketing)
2. Mr. Mustapha Kpaka, enumerator & Harbour Master, Yagoi, SL (Marketing).
3. Mrs. Monica Sessay, Chairlady of Tamaraneh Women's Development Organisation (Institutional).
4. Mr. Jonathan Almamy, Bonthe Municipal Council, SL. (Institutional analysis).

5. Ms. Fattmata Modubu, Bonthe, SL. (longitudinal harvest surveys).
6. Mrs. Isatu Suilaman, Bonthe, SL. (longitudinal harvest surveys).

Secondary stakeholders, Sierra Leone

1. Mr. Layemin Joe Sandi, Mayor, Bonthe Town, SL.
2. Mr Sylvester Dangima, Communications Director, Bonthe Municipal Council, SL.
3. Mr Daniel Cuta, Ministry of Social Welfare, Bonthe, SL.
4. Mr Joseph Momoh, Owner-manager Radio Bontico, Bonthe Town,
5. Mr Joseph Lammy, Sherbro MPA Community Management Association (CMA)
6. Mr. Swaihibu Hotta, estuary navigator, Department of Fisheries, Bonthe, SL.
7. Mr. Joseph Mammy, Deputy Director, Department of Fisheries, SL
8. Ms. Senita Bakaar, West Africa Biodiversity and Climate Change (WA-BICC)
9. Dr. Raymond Johnson Director of IMBO, Fourah Bay College, SL
10. Dr Aiah Lebbie, Food scientist, Njala University, SL
11. Mr Mike Solomon, Green Scenery NGO, Bonthe Town, SL.

Primary Stakeholders, Bonthe District

1. Mrs. Pattuh Pieh, oyster harvester & chairlady of the "Victoria Oyster Group, Victoria, SRE, SL.
2. Mrs. Yeamar Keifala, oyster harvester & chairlady of the "Gbongboma Project Association" oyster harvesting association, Gbongboma, Bonthe, SL.
3. Mrs. Rukeyatu Sitta, oyster harvester & chairlady of the "Nyandehun Ngoma Oyster Processing Group", Nyandehun Section, Bonthe, SL.
4. Mrs. Fattmata Sallu, treasurer of "Gbongboma Project Association", Gbongboma, SL.
5. Mrs. Jamie Brima, treasurer of "Victoria Oyster Group", Victoria, SL.
6. Mr. Lahai Kamara, enumerator & Secretary of the "Nyandehun Ngoma Oyster Processing Group", Nyandehun Section, Bonthe, SL.
7. Members of the "Gbongboma Project Association" oyster harvesting association, Gbongboma, Bonthe, SL.
8. Members of the "Victoria Oyster Group" oyster harvesting association, Victoria, Sherbro Estuary, SL.
9. Members of the "Nyandehun Ngoma Oyster Processing Group", Nyandehun Section, Bonthe, SL.

3 Project Achievements

3.1 Outputs:

Output 1.1: Secondary pressure on mangrove populations reduced through more fuel-efficient processing.

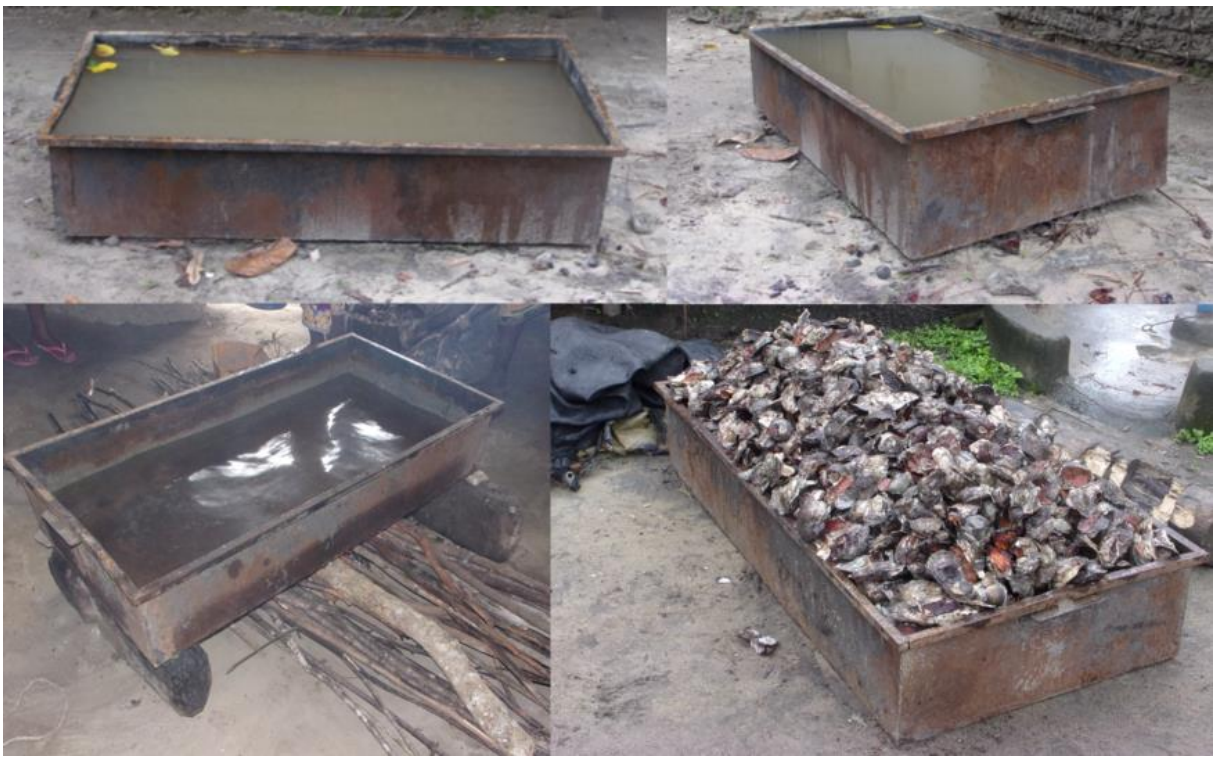
Objectives: to minimise pressure on mangroves by assessing potentials (i) for novel solar-powered oyster steaming vessels and (ii) efficiency improvement of existing oyster smoking methods.

(i) A literature review (Ross, 2017, MSc thesis UoS, unpublished) found that whilst available solar-powered steaming technologies generate sufficient heat to facilitate oyster shucking, they are too low to reliably ensure safe pasteurization of oysters i.e. in contrast to existing mangrove fuel based methods (Annex B4.1). This was of particular concern given the previously identified high risk of bacterial contamination associated with poor sanitation and low residual tidal (flushing) currents in the Sherbro estuary (which also precluded direct raw consumption of Sherbro oysters; Annexes B4.1 & B2.2).

(ii) Absence of clay substrates in this remote mangrove area proved a major constraint to localised construction of low-input smoking stoves. Similarly, economic incentives for adoption of pre-manufactured 'imported' stoves were undermined by the wide availability and low cost of mangrove fuel and the additional labour required to chop wood to the appropriate size for these designs (Annex B3.3).

Consequently fuel-efficiency interventions focused on potential for up-scaled oyster steaming using larger homemade sheet metal troughs introduced by the project; potentially linked to collective processing and/

or pre-processing stock-piling of live-oysters. Six such troughs (Plates 1a-d) commissioned from metal welders in Moriba, a mainland mining town were rolled out as competition prizes during the (June) 2018 Bonthe Oyster Festival & their application assessed through follow-up monitoring over successive months.



Plates 1a-d. Up-scaled steaming troughs rolled out during the 2018 Bonthe Oyster festival

Baseline fuel-efficiency levels were determined from systematic surveys in satellite communities implemented from May 2016 to June 2017 (Annex B3.3, Rossi MSc thesis 2017). The surveys incorporated a mix of recall estimates, direct observation and supervised measurement of fuel consumption for steaming and smoking. Most steaming is undertaken using domestic cooking pots with a few women having access to larger troughs made from folded scrap sheet-steel. The same techniques were used to evaluate the new 'up-scaled' steaming troughs between August and September 2018 (Plates 1a-d & 2a-d). Comparisons were based on a median yield of 60 cups[1] of steamed oysters per 200kg of whole-live oysters (a typical canoe load). Results were normalised for seasonal fluctuations in oyster condition index (CI) being a key determinant of processing yield (Annex B4.3). Compared to domestic-pots, homemade 'folded' and 'up-scaled' project troughs gave average reductions of 46% and 77% in fuel-wood consumption respectively. In the latter case, stacked processing proved more efficient than use of submerged-baskets (Table 1 & Plates 2a-d)

Table 1. Comparison of fuel efficiency of oyster steaming vessels.

Vessel	Pot	Homemade trough	Up-scaled trough
Vessel volume (L)	29	84	207
Vessel oyster capacity (Kg[2])	21.46	74.81	208
Number of batches/harvest[3]	9.32	2.67	1
Total time (mins)	218.55	101.91	76
Total fuel wood used (kg)	66.6	36	20.5
Kg fuel wood/ cup oysters	1.11	0.6	0.34
Efficiency gain on pots (%)		**45.95**	**77**

[1] All local retail or wholesale of oysters (& locally produced food commodities) is based on volumetric measures.
[2] Measured by average weight of whole-live oysters able to fit in vessel.
[3] Number of times steamed oysters must be replaced with whole-live oysters until entire harvest is processed.

Plates 2 a-d. Comparing 'up-scaled trough' processing methods; stacked pyramidal heap (3a&b), submerged baskets (3c&d).

Output 1.2 Contribution to reduction in mangrove clearance rates associated with fuel-efficiency gains and adoption quantified; normalised against historic trends in coverage and population settlement trends

The resolution of Google Earth and Landsat ETM+ imagery (assessed with ArcGIS) proved insufficient to differentiate mid and tall-sized mangroves from denuded stands, precluding reliable quantification of mangrove clearance rates (Annex 1 Supplement B3.1A). Estimates were therefore based exclusively on primary survey data, with mangrove extraction rates for primary and secondary processing were extrapolated from production surveys across 38 sample communities in 2017 (Annex B5.1, Fig. B5.1.1). A total of 52 female harvesters from 9 'focal' communities were issued with materials and appropriate training to record their processing activity over peak production months from March-June. This was augmented with processing recall data from surveys in 29 additional communities. Total extraction rates (min-max ranges; Table 2) were then extrapolated accounting for all identified active harvesters in the 38 communities (identified through key informant interviews) and mean fuel-efficiencies estimated for local processing methods (Annex B3.3). Based on an estimated requirement of 1.1kg and 1.18kg of fuel per cup of steamed and smoked oysters respectively, total wood consumption across the 38 communities between March and June was estimated to be between 738 & 1,140 metric tons, with steaming and smoking respectively accounting for 49% and 51% of the total.

Consequently, the 77% mean reduction in fuel consumption for 'up-scaled' project steaming troughs compared to the commonly used domestic-pots (Output 1.1 above) corresponds with a potential reduction of 274t to 429t across the 38 communities during peak production months of March-June.

Table 2. Aggregate oyster production (cups) & est. mangrove wood consumption (t) from 36 satellite communities Mar-Jun 2017.

Community	Steamed cup No.		Smoked cup No.		Mangrove fuel (t)	
	Min	Max	Min	Max	Min	Max
Focal (9)	123,408	179,920	34,768	42,096	176.8	246.1
Other (29)	377,360	609,760	111,520	181,424	551.7	894.2
Total (38)	500,768	789,680	146,288	223,520	728.5	1,140.3

Output 2: Profitability of female oyster gathering increased through testing and adoption of extended shelf-life and value added processing techniques.

Product development and placement work culminated in retail marketing trials implemented by female oyster-gatherers from three Sherbro Island communities; Gbongboma, Nyandehun (Bonthe) and Victoria. The women were also executive members of active micro-credit associations in the same communities, identified as including large numbers of gatherers in their membership. Trials of branded smoked oysters including packaged snacks were implemented in Moriba Town, a mining service centre 30km inland of the main existing (Yagoi) wholesale market for oysters. Vending from strategic roadside positions also circumvented severe entry-barriers identified for participation in formal retail markets.

Four different package sizes were offered, all including ready-to-eat, light smoked oysters and flavouring ingredients. Cost-benefit analysis (CBA) indicated net margin increases of 108% for the most popular (smallest and lowest-priced) product compared to conventional retail of loose smoked oysters 'by the cup' (182% compared to wholesale). Four marketing scenarios were compared (Annex B5.2, Table B5.2.11) of which the best-selling[4] (Plate 3a) and baseline[5] (loose-cup) products are compared in Table 3.

The smallest package (Plate 3a) was identified as having particularly high market potential. As well as achieving the highest margin it was also very popular with price-sensitive consumers, although volume sales would require a mix of small and larger package sizes. Break-even sales volumes are estimated in Annexe B5.2, factoring in production and additional transportation costs.

Plates 3a&b. Value-added smoked oyster products (including flavourings) developed by female harvesters (highest margin product to left).

[4] Results from sale of best-selling product ("1A") developed by leading women's groups in 2018 placement trial.
[5] Baseline prices were calculated as prevailing wholesale price of smoked oysters by the cup, Le 3,000.

Table 3. Cost benefit analysis of value-added marketing of smoked oysters

Marketing scenario	**Scenario 1**	**Scenario 2**
Product	Loose Cup	1A*
Fixed costs/trip (Le[6])		
Transport, boat	40,000	40,000
Transport, road	NA	30,000
Total fixed costs	**40,000**	**70,000**
Variable costs/unit (Le)		
Packaging	NA	60
Bouillon cubes	NA	63
Toothpick	NA	25
Ground chillies	NA	5
Total variable costs/unit (Le)	**0**	**153**
Retail price/unit, Le	3,000	500
Gross Profit/Unit, Le	3,000	347
Margin on Cup (%)		**108**
Avg. products/cup[7]	1	18
Break-even, cup equivalent	13.34	11.09

Notes: Based on a product-placement trials in Moriba Town by female oyster gatherers from 3 micro-credit institutions.

* Product 1A = The smallest of 4 package sizes offered, inc. 12 soft-smoked oysters & flavourings, mean wt 10g, priced 500Le.

Limited cooling capacity of "pot-in-pot" evaporative technologies precluded interventions supporting women in remoter satellites to retail more profitable steamed oysters in Bonthe. A literature review (Boardman, 2017, MSc UoS unpublished) found evaporative cooling to be highly sensitive to fluctuations in relative humidity and thereby more suited to storage of less perishable fruits and vegetables. Under optimal conditions temperature within the pots can be reduced by up to 8^{o}C below ambient, set against annual mean annual temperatures in Bonthe of 26-29 ^{o}C and high humidity levels.

However surveys of communities immediately adjacent to Bonthe revealed "light-touch" oyster smoking practices highly calibrated to preserve the oysters just long enough to extend marketing to the day following processing, whilst the oysters were still soft enough to market as fresh (steamed) oysters. We estimate the technique (which also reduces fuel consumption) to be practicable up to 7km canoe paddling distance from Bonthe. The same strategy was shared with and adapted by the women undertaking the 2018 product placement trial described above (Annex B5.2). Smoking duration was reduced sufficiently to maintain softness and water content and extend shelf life to 2-3 days. This compares with conventional smoking permitting storage from 2 weeks up to 3 months (Annex B1.1), however longer-smoked oysters also require soaking before cooking and consumption. Most of consumers of the trial lightly-smoked oysters consumed the snack at the point of sale when given an accompanying sauce (and were otherwise advised by vendors to consume products on the day of purchase). Further seasonal calibration of demand, production volume and spoilage risk associated smoking duration is still required.

Output 3: Safety and seasonality of female oyster gathering opportunities increased through localised re-use of shell waste for low-input-output culture enhancements on mud banks.

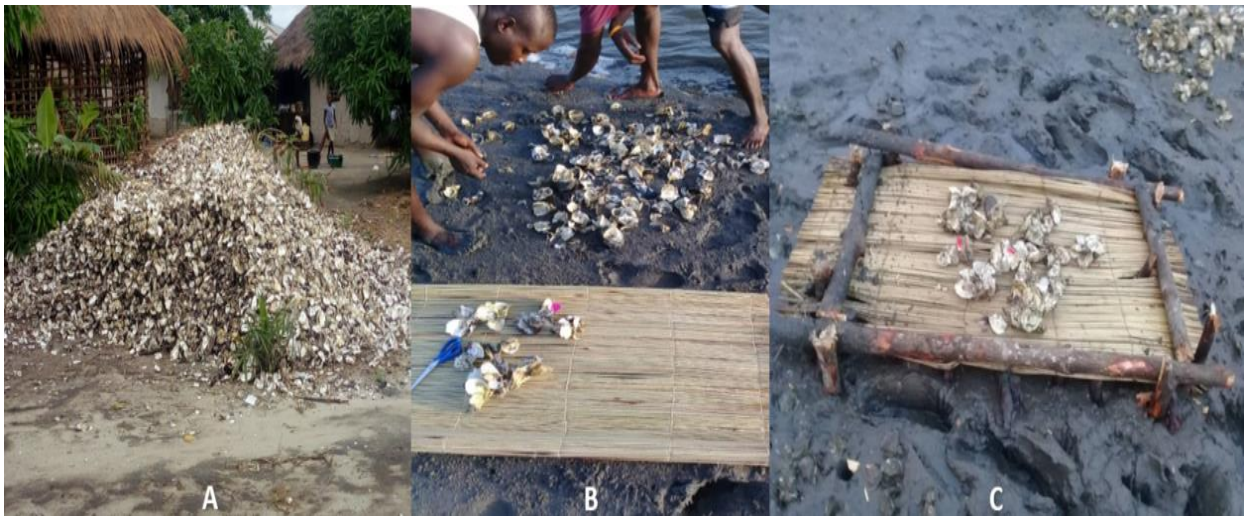
Oysters shell wastes provide an ideal cultch for spat settlement and 'artificial reef' enhancement approach. The establishment of low-input-output mud bank culture was intended to act as a livelihood enhancement for female harvesters having access to banks with favourable residual currents for spat settlement and

[6] Fixed costs for transportation were based on prevailing 2018 prices for round trips to Yagoi (by boat) and Moriba Town (by land) from the target community of Victoria.

[7] Based on average cup weight of 171.95g of cups used in trial (n=5), and average weight of products sold.

growth. Ubiquitous shell middens around satellite communities combined with low opportunity cost for alternative economic uses make shell-waste an abundant and low-cost material for culture enhancements (Plate 4a). The low value and high transportation cost of oyster shells meant that only small-amounts were used in construction and for processing as a poultry feed ingredient.

Early project trials (2016) discounted use of suspended rope culture systems due to rapid degradation of mangrove poles used to hang the ropes (and absence of alternatives; Annex B2.4), but more critically the ready abundance of wild mangrove oysters. Low-input-output reef enhancements (Plates 4a&b) appeared to have greater adoption potential in this context. Following inconclusive pilot trials (2016) a second round coordinated by IMBO commenced in June 2018 at two sites close to Bonthe (near Bonthe Pier and 'Domboko New Site'). IMBO Msc. student, Mr. A. Kamara undertook collection and analysis of data on spat recruitment, sedimentation, fouling and mortality rates of oysters along transects along mud banks accessed by 8 satellite communities in addition to the two enhanced culture sites near Bonthe. The study highlighted the need for awareness and mitigation of potential multiple-use conflicts e.g. with fishermen deploy nets over reefs. It also became apparent that establishment of reefs requires sustained placement of culch over successive years such that benefits are likely to accrue beyond the project life-cycle.

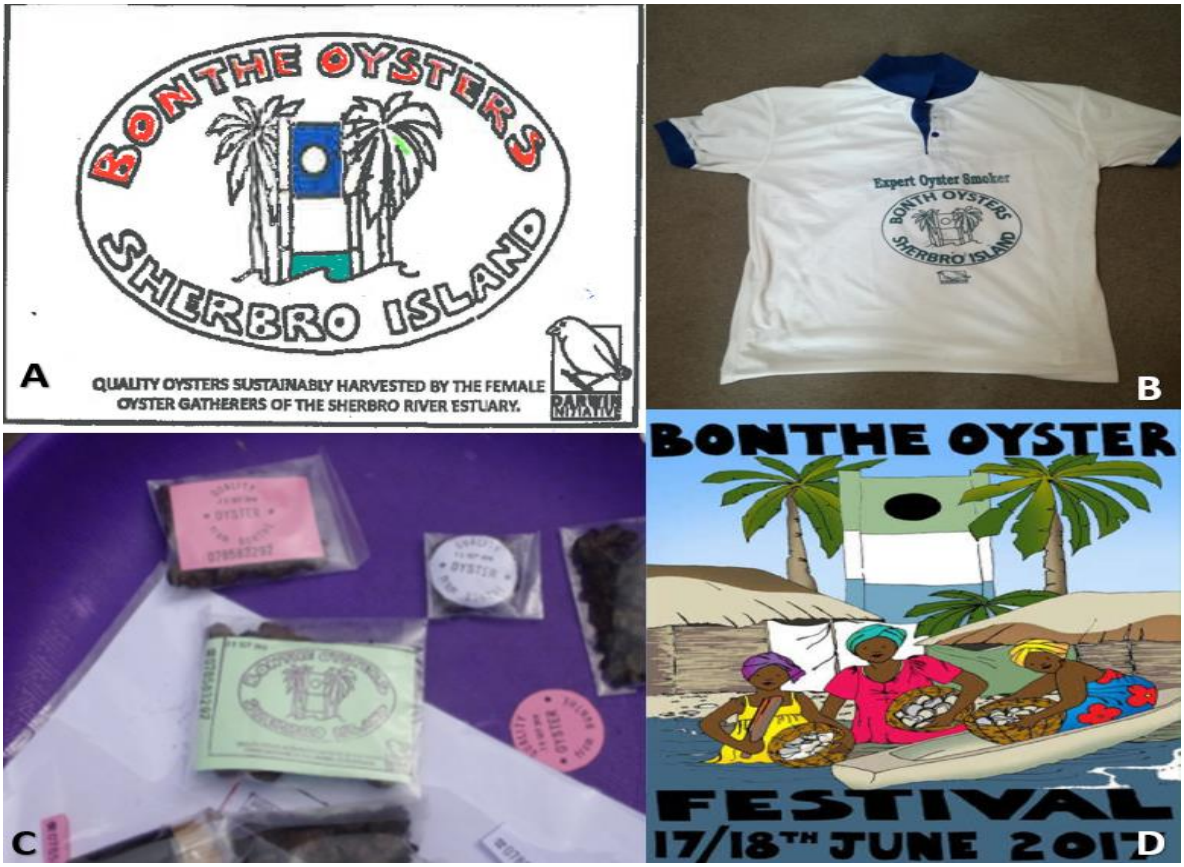


Plates 4a-c. Accumulated oyster shell-waste middens (a), preliminary work on mud bank culture enhancements (b&c)

Output 4: Demand for value-added products created through branding and promotion

The development and adoption of the "Bonthe Oysters: Sherbro Island" branding logo was initiated during the first annual Bonthe Oyster Festival (2017). Based local stakeholder feedback, the logo incorporated iconic symbols connected to the Sherbro MPA including the blue and white clock tower and palm trees on the Bonthe Town sea front, female gatherers and their gathering implements (canoes, pangas). The Darwin Initiative logo was also incorporated in the design. These logo elements were then variously adapted and incorporated in product branding (packaging and vendor uniforms) and other promotional materials including oyster festival posters and flyers (Plates 5a-d). The logo was evaluated in product placement trials implemented by project staff in 2017 and further adapted according the needs and capacities of female harvesters responsible for implementing value-added marketing trials in 2018 (see output 5 below, annex B5.2 & B6.1). The project also supported these activities through provision of packaging materials and logo stamps (Plates 3.6a&c).

Local radio is recognised as the most effective means of mass communication in Sierra Leone, with over 76% of the population regularly listening (BBC 2017). This attribute was exploited in the projects value-added oyster marketing strategy. Staff coordinated 'Darwin Oyster Project' Q&A sessions with the communications office of Bonthe Muncipal Council on local station, Radio Bontico before each of the two Bonthe Oyster Festivals. Simultaneously regular commercials were broadcast promoting the festival and the Sherbro oyster brand. Follow-up surveys confirmed wide outreach to the remotest satellite communities and mainland markets (Yagoi and Moriba Town).



Plates 5a-d. Bonthe Oysters logo (a), branded attire and posters (b&d), and logo in use by local stakeholders for product placement trial (c).

Plates 6a&b. 'Second Bonthe Oyster Festival' June 2018. Runner-up of oyster shucking contest & 2017 winner (a), winning recipe of the 2018 smoked oyster snack contest (b) (Photos Greg Funnel)

Output 5: Sherbro women's oyster gatherer's association established based on mutually beneficial cooperation around processing and marketing interventions

Building on sustainable indigenous institutional forms, 3 women's oyster gatherer's associations were established with a total of 65 active gatherers across three focal communities. The formation of these groups followed an in-depth institutional analysis of indigenous self-governing microfinance institutions or "*osusus*", identified as the most sustainable entry-point for the projects collective marketing objectives. A sample frame 37 such groups was collated from two sources (i) community based organisations (CBOs) formally registered with the local Bonthe Municipality and/ or the Ministry for Social welfare (n=15) (ii) unregistered informal groups identified from key informant snowball sampling (n=22) (Annex B1.3, Fig. B1.3.2).

Of these nine proved most aligned to implementation of oyster processing and marketing actions based on the following indicators: female leadership, female membership (mean 77%), micro-dispersal of members across neighbouring satellite communities and active use of microfinance for productive functions (e.g. petty trading). Three groups (all informal, located in Bonthe[8], Gbongboma[9] & Victoria[10]) with the greatest inclusion of active female oyster harvesters (n=65) subsequently participated in pilot value-added oyster marketing activities (Annex B1.3 & B5.2). Members including leaders of the 3 groups were provided training and marketing materials based on outputs 1, 2 and 4 prior value-added product placement trials in 2018 (Plates 7a-f & 8a&b).

The Victoria Group (with 32 exclusively female harvesters; Fig 2) provided the best institutional model for targeting small micro-dispersed satellite communities, most dependent on smoked oyster production but lacking internal institutional capacity. To be sustainable, trust-based *osusu's* revolve around face-to-meetings on a weekly to (minimum) monthly basis. Thus group membership lists also served as highly practical means of mobility-mapping and indicator of capacity to collaborate on collective marketing objectives (many members already use *osusu* micro-credit loans to procure 'petty-trading' inventory). The Victoria group based in a long established settlement to the S. of Bonthe also included gatherers from three smaller satellite communities within walking and short canoe distance. We recommend that this approach be applied as part of a review of the representation and effectiveness of Community Managed Associations (CMAs), the main institutional vehicle for implementation of MPA objectives.

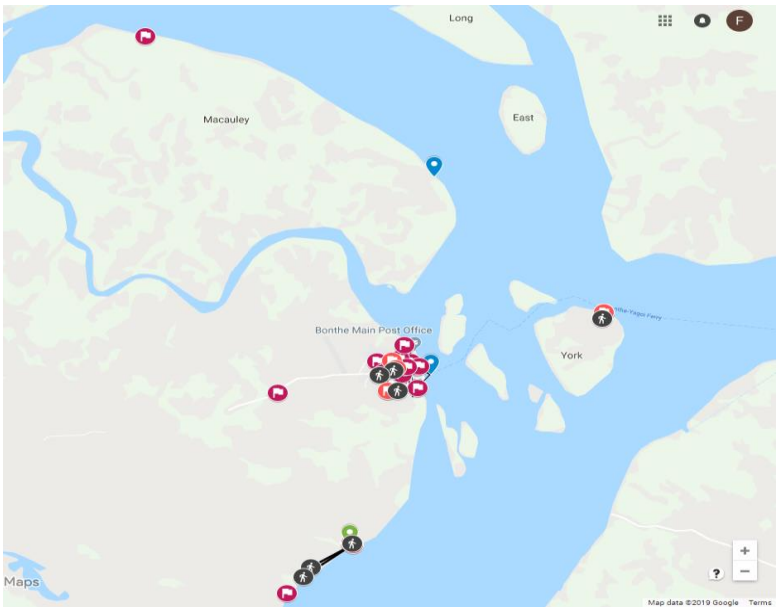
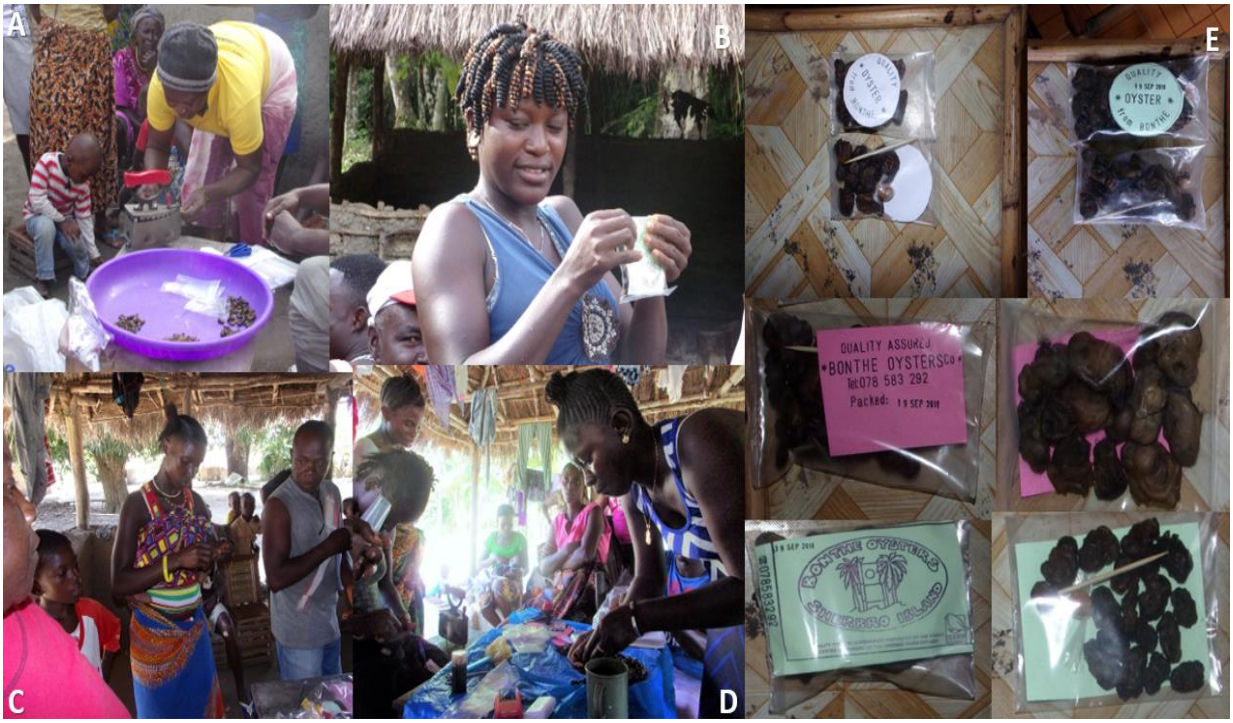
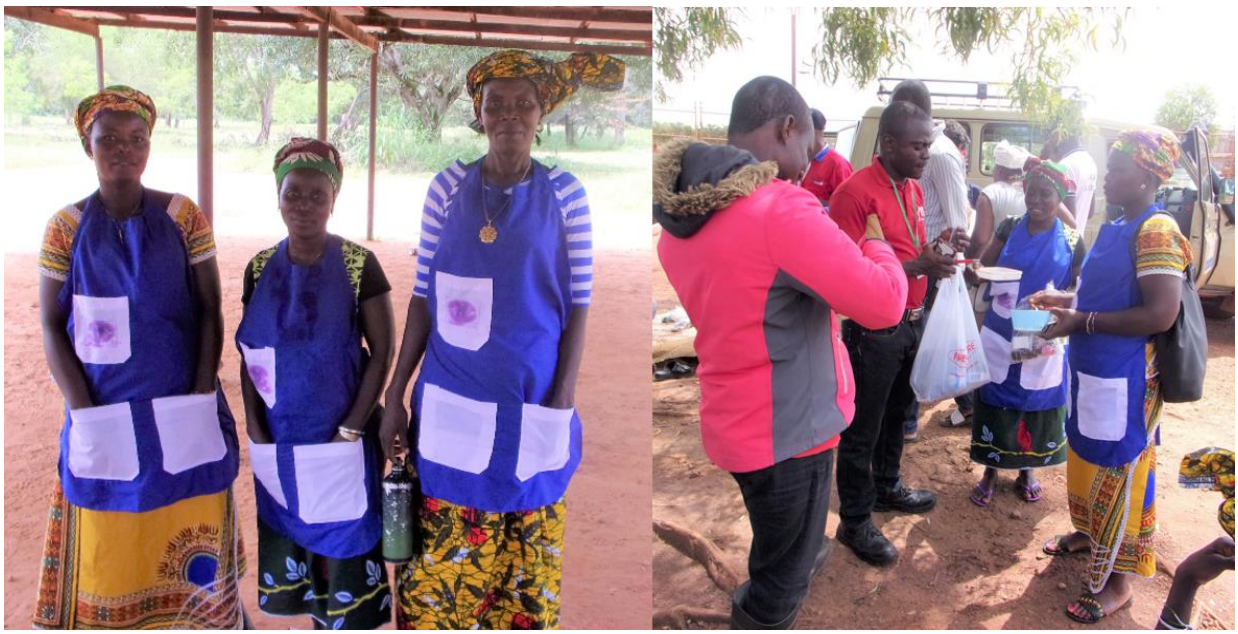


Figure 2. Surveyed indigenous micro-credit groups (*osusu's*) on Sherbro & York Islands (red flags), with Victoria group (green marker) and member communities (black markers) to south.

[8] The "Nyandehun Ngeiya Oyster Processing Group" – Bonthe.
[9] The "Gbongboma Project Association" – Gbongboma.
[10] The "Victoria Oyster Group" – Victoria.



Plates 7a-f. Members of three oyster associations involved in product development: Gbongboma (a&b), Bonthe (c) Victoria (d) & range of value-added products (e).



Plates 8a&b: Leaders of women's oyster associations: Yeamar Keifala, Gbongboma (left), Rukeyatu Sitta, Bonthe (Centre) and Mattu Pieh, Victoria (Right) marketing value-added smoked oysters at a roadside junction in the mainland mining town of Moriba (Annex B5.2).

Oyster genotype (DNA) analysis (Activity 5.4, Annex B3.2) indicated that the two predominant mangrove and mud oyster phenotypes present in the Sherbro MPA were highly likely to be the same species (*Crassostrea. Tulipa*) while rock oysters (sampled from a beach near Freetown) appear to be a different as yet unconfirmed species. These findings highlight the potential role of sub-tidal mud oysters, refractory to prevailing hand gathering methods as a resilient multi-year class breeding pools. Sustainable management of the oyster fishery should therefore incorporate prohibition of intensified fishing practices including mechanised dredge fisheries.

Output 6: Research outputs documented and shared with target audiences

Key policy messages (Activity 6.1) emerging from the project, bulleted below were shared with key stakeholders invited to participate in the second (2018) Bonthe Oyster Festival hosted by Bonthe Municipal Council. These included policy makers, regulators and representatives of development bodies and research organisations (Section 2)[11]. Three of the external invitees also served as impartial competition judges. Despite persistent efforts it proved impossible to meet the Convention on Biological Diversity (CBD) focal point, however this final report will be circulated to them and the aforementioned stakeholders.

Key policy recommendations consistent with sustainability objectives of the Sherbro Marine Protected Area (MPA).

1. There is an urgent need for more proactive future management of the oyster fishery, overlooked in current MPA statutes, linked to demographic trends.
2. This should consider both pre AND post-harvest impacts on mangrove ecosystem health.
3. The cumulative impacts of seafood processing (steaming/ smoking) of oysters AND fish/ shellfish on mangrove health requires particular attention.
4. MPA regulation should preclude exploitation of sub-tidal mud banks which serve as residual multi-year class mangrove oyster breeding pools (e.g. through a ban on introduction of mechanized dredging).
5. Given the limited resources available to the MPA authority to enforce management of this open-access resource; where possible positive behavior change around mutually beneficial collective action should be linked to market incentives.
6. A differentiated outreach approach is required for remoter, micro-dispersed satellite communities with greatest dependence on primary resources and lowest institutional capacity.
7. The structure and management of indigenous micro-credit associations ('*osusu*') offer lessons for improved representation and functioning of grass-roots community management associations (CMA) established to support MPA management.
8. Valued added oyster marketing under the 'Bonthe-Sherbro' brand should be synergistically re-enforced through parallel efforts to promote other local commodities and eco-tourism.

Consistent with the final recommendation (8), the 'Darwin Oyster Project' also collaborated in the 'First Bonthe Agro-tourism Festival' (21st- 24th Dec 2018: Annex B6.2). Inspired by our earlier oyster festivals, the event aimed to promote local produce including ground nut, rough rice, plantain and oysters within a local socio-cultural heritage context. As part of this effort project staff worked with female gatherers to show-cased their value-added oyster products and approach. The opportunity was also taken to assess the market potential of another oyster product, lime powder (white wash) produced from shell waste.

Communication of scientific outputs (Activity 6.2). Following a colloquium at the University of Stirling (2017) scientific findings were communicated through presentations at two international conferences (the Bangor Oyster Symposium 2017 and the Icelandic Seafood Symposium, Reykjavik 2017). A co-authored paper based on this presentation (Annex B7.4) and subsequent outputs is in preparation for submission to an inter-disciplinary peer-reviewed journal (Maritime Studies, Springer). A second more narrowly focussed paper reporting findings of our oyster genotype work and fisheries management implications is also in draft for submission to Ambio (Annex B3.3). Three other project publications are included in report annexes; two trade press articles (in The Grower; Annex B7.1 and Fish Farmer; Annex B7.2) and the Sunday Times Magazine (Annex B7.3).

[11] The Mayor of Bonthe Municipality, Deputy Director of the Department of Fisheries, the local Armed Forces Commander, two NGOs implementing local livelihoods and environmental management projects; Green Scenery anf West Africa Biodiversity And Climate Change (WA-BICC) and senior staff of the Institute of Marine Biology and Oceanography (IMBO) and Njala University.

3.2 Outcomes

3.3 Long-term strategic outcome(s)

The longer term sustainability of this project is predicated on supporting establishment of local marketing groups, representative of and truly embedded within the target local communities. In this context strategic direction must consider opportunities and constraints imposed by the prevailing development culture and trends.

Numerous internationally funded humanitarian and development projects have been implemented projects in the research area since the civil war ended in 2003. Most implementing agencies are head quartered in Freetown with little or no permanent presence in Bonthe District. Rural development projects (RDPs) usually of 1-3 year duration exhibit a strong location bias toward larger settlements, especially Bonthe and York towns and their more accessible neighbouring settlements. Our analysis points to a growing micro-dispersed population in 'satellite' mangrove settlements dependent on harvesting primary resources including oysters (Annex B1.2). Outreach to these communities is complicated by logistical factors (remoteness and lack of motorised transport) and the relative transience of many such communities linked to their poor access to other productive resources (especially freshwater and cultivatable land), insecure property rights and the seasonal nature of aquatic harvesting opportunities. This also leads to a lack of representation of such communities in Community Management Associations (CMA), the principle management platform for achieving MPA objectives (Annex B1.1).

Despite an overt national policy-trend towards more decentralised governance, the Mayor of Bonthe, Layemin Joe Sandi is concerned about the growing marginalisation of Bonthe, once second only to Freetown in economic importance as a coastal trading centre. He states 'The Bonthe and Sherbo Island revenue generation is not in place because we don't have the institutions, viable business enterprises and no large business enterprises in the Municipality."[12]. Many government offices, including health and education have relocated from the Island to the main land town of Mattru Jong. At the same time he highlights poorly conceived structural development initiatives, notably the costly government/ ADB sponsored fisheries landing centre constructed in Bonthe. Intended to boost the district's fishing industry through provision of preservation (ice and smoking), export-manufacturing and provision of youth employment 'the project structure is now eroding and its vision lost in the fog of neglect'[13]. Central to this failure was poor matching of its design and centralised location with needs of the dispersed and relatively immobile user base described above.

It is in this context the Mayor has been highly supportive of the market-based approach adopted by this project. The municipality has providing considerable, on-going support implementing an annual oyster festival in and around its premises, communicating the event and project findings. Nevertheless, whilst the project made significant progress in contextualising the above issues, we too faced the same outreach challenges in institutional capacity building. Most small satellite communities lack even the informal micro-credit groups identified by the project as an institutional entry point. In this respect our engagement with 'Victoria Oyster Group' offers a decentralised 'hub and spoke' intervention model. Its membership centred on long-established 'Victoria' village to the south of Bonthe also includes women from surrounding 'satellite' villages within a paddling range enabling regular face-to-face meeting attendance (Annex B1.3). This is essential in sustaining such trust-based associations.

Linking environmental stewardship to market-based incentives, individual and collective proved equally challenging. Whilst significant cost-benefit advantage is required to drive individual adoption of more fuel-efficient production or harvesting methods, cumulative gains from collective-action can arise from more marginal behaviour change. Conversely sustained collective action also requires proportionate returns to

[12] https://awoko.org/2017/11/24/sierra-leone-news-no-real-economy-on-bonthe-island-mayor/

[13] http://www.sierranetworksalone.com/home/index.php/blog/item/993-the-cry-of-bonthe-mayor-says-the-issue-of-bonthe-needs-urgent-cabinet-decision

individual effort; here challenged by free-riding problems associated with the unregulated open-access nature of the oyster and mangrove resource.

3.4 Sustainability and Legacy

The UK and local project PIs have committed to supporting implementation of a 2019 Oyster Festival (already scheduled for the 15th June 19), on-going costs of which will be funded by the Whitstable Oyster Company (WOC) for 5 years. This year's funding will also cover travel/ subsistence cost for project RA Mr Jason Hoepfl (UoS) to support preparatory work with female members of the Victoria Oyster Group', building on the project's most promising institutional and marketing work. A camera crew will also be funded to record the event (following last year's successful Sunday Times article, Annex B7.3). Local beneficiaries will be supported to use outputs to solicit future development donations. We also aim to support an exchange with members of the renowned Gambia 'TRY' Women's Oyster Association[14] to support local capacity building (precluded from the 2018 Festival for logistical reasons). Further detail is provided in section 4.2 (actions taken in response to annual reviews).

Potential to promote improved mangrove stewardship through sale of carbon-credits linked to prudent community-based harvesting and processing methods was also explored; both to re-enforce the Sherbro-oyster marketing message and as a direct economic incentive for strengthening women's marketing associations. To this end a successful community based model in Kenya was benchmarked (see http://www.planvivo.org/plan-vivo-certificates/ including details of audit and brokerage processes). Implementation challenges linked to Sherbro MPA settlement patterns and the highly open-access nature of the resource precluded further implementation progress during the project. However, findings have been shared with the USAID funded West Africa Biodiversity and Climate Change (WA-BICC[15]) operating community-based mangrove projects in Sierra Leone, Liberia and Ghana (Whin Estuary).

Project findings and approach have also been shared with local NGO 'Tacugama Chimpanzee Sanctuary' (https://www.tacugama.com/) attempting to introduce oyster production and marketing as a livelihood diversification strategy for mangrove communities in Moyama District (contiguous with the Sherbro MPA).

4 Lessons learned

The absence of a workable cold-chain solution imposes similar conservation challenges for fishermen in remote satellite communities, their surplus harvests also being smoked to sell at the same weekly wholesale markets as smoked-oysters. Although there is no requirement for the primary processing (steaming) required for all oyster production, there is a far greater (unit and absolute) need for mangrove fuel-wood to smoke much higher biomasses from year-round fish harvests. Thus a more holistic accounting of fuel requirements associated with seafood production (fish and shellfish) together with domestic requirements would constitute a more logical system boundary consistent with the log-frame revisions.

The project would also have benefited from recruitment of a field-based food technologist to work with female gatherers on processing quality assurance issues. Especially with respect to improved understanding of safety and keeping qualities of hot & cold smoked oysters, repeat smoking etc (e.g. microbial contamination risk based water-activity metering, micro and macro-nutrient and contamination risk from carcinogenic smoking by-products; nitrites, nitrates etc).

As one of the poorest regions in a very poor country, the research area had been the focus of many historic and ongoing development projects. An audit of such efforts as a routine preliminary step can offer direct lessons with respect to planned interventions (e.g. such as challenges sustaining a solar-cold chain infrastructure in the current context; Annex B1.1). As in many such development contexts, the prevalence and generally uncoordinated nature of these efforts by a diverse range of donors have also contributed to a dependency-culture challenging longer-term sustainability objectives, especially where these include

[14] http://www.worldwatch.org/node/6475

[15] https://www.usaid.gov/west-africa-regional/fact-sheets/west-africa-biodiversity-and-climate-change-wa-bicc

autonomous institutional capacity building. A review of over 300 local community institutions registered by the local council (a funding eligibility requirement) revealed most to be no longer active i.e. post project. Consequently, in the final year of this project considerable effort was directed at identification of more enduring indigenous institutions as an entry-point. These often serve vital cultural or economic functions that are not effectively addressed by the public or private sector. In this instance the absence of any formal banking sector within the MPA lead us to focus informal savings and credit institutions Annex B1.3).

In a context of weak regulatory capacity of open-access resources, focus should be on providing economic incentives responding to credible researched market incentives. The current research also indicated greatest requirement for post-harvest strategies.

4.1 Monitoring and evaluation

M&E changes associated with modified project interventions were incorporated into a revised project log-frame (Feb 2017). Enumerators recruited from local communities were used with varying degrees of success to collect longitudinal baseline production and marketing data over the project lifecycle. Quality was highly contingent on provision of regular feed-back linked to financial and other performance incentives. Delayed implementation of project interventions associated with the log-frame revision limited our ability to assess development impact during the project period. Interval reviews were also proved very useful assets for project management; detailed responses to the last 2017 review are given in section 4.2 below.

4.2 Actions taken in response to annual report reviews

The authors acknowledge reviewer feedback that preliminary (exploratory) research outcomes used to challenge initial log-frame assumptions and support selection of interventions, were inadequately incorporated in the revised log-frame (also used for final project assessment). To help redress this problem, we have organised all our project outputs under 7 ‘supplementary materials’ annex headings (B1-B7) and mapped them to the 5 outputs in the revised log-frame (see table of contents).

The last project review (Sept 2017) also highlighted the dominance of research activity over development intervention up to that point and need for more differentiated progress and impact indicators. The project has faced various constraints related to the Ebola-crisis, collective-action challenges associated with the unregulated open-access nature of the oyster resource, the remote, micro-dispersed geography of the target beneficiaries and a development history that has reinforced a prevailing dependency culture. Potential for unintended development consequences (e.g. by driving intensified harvesting or secondary smoking effort) associated with this complexity necessitated a more in-depth inter-disciplinary assessment of resource management practices, trends and political economy (i.e. re. production and trade limits with respect to law, customary governance and benefit distribution) than originally envisaged. Although this limited opportunity for direct-uptake (and impact) of interventions during the project lifecycle, 5 years of post-project funding committed by the Whitstable Oyster Company (WOC; Section??) will support further implementation of ‘high-potential’ marketing interventions most prized by target beneficiaries (see below) as a central plank of the projects exit-strategy.

As part of this effort, 3 women’s groups (see below) will be encouraged to take a progressively leading role in implementation of future oyster festivals. As well as re-enforcing the wider Sherbro oyster-branding message, the festivals will move toward a for-profit model to support group marketing and micro-finance activities. We envisage this will also support organic spread of value-added marketing by other Sherbro gatherers. The project documented lessons from a similar successful ‘Bo Gari’ branding and marketing initiative (a locally processed cassava product; Annex B5.2). The previous review also requested greater clarity on the quality of the collaboration between grantee, partners and beneficiaries. Although UK partners were precluded from preliminary field-missions during the Ebola crisis PI’s from UK and SL institutions worked closely together in all subsequent field missions; with 1-2 per year each lasting 5-10 days. Local PI’s also provided supervisory support to four Bonthe based MSc students (one from IMBO and 3 from UoS) contributing research inputs to the project.

A breakdown of the projects principle primary and secondary stakeholders is given in section 2 including roles and institutional affiliations. In the final year, the membership and activity histories of 37 local micro-finance groups ('*osusu'; 15* formally registered with Bonthe Municipal Council and/or the Ministry of Social Welfare, the balance informal groups identified through key informant and 'snow-ball' sampling methods (Annex B1.3). These were envisaged as the most viable entry points for establishment of a sustainable women's oyster marketing group. Of the 37 only 9 groups, all informal, included active female oyster gatherers of which 3 with the most substantial active membership (including 65 female gatherers in total) were directly engaged in implementation activities centred on value-added marketing over the last 8 months of the project. The largest such group located around Victoria village to the south of Bonthe, includes 32 female members who routinely process and smoke oysters for weekly wholesale marketing (Annex B1.3, supplement B1.3.2). Field-level implementation of this work was led by Mr Jason Hoepfl (a political economist; UoS) assisted by two local recruits; Ms Aminta Foday and Ms Matilda Hai, secondary school teachers from Bonthe. Funding of this embedded field support was a primary justification for re-budgeting an underspend of £42,259 to address a short-term presence problem of more formally qualified staff.

These market-lead activities associated with the log-frame revision, replaced farmer-field school interventions described in the initial frame ('targeting uptake of culture activities by at least 30 women in 8 communities). Wider dissemination (and evaluation) of value-added branding/ marketing options were incorporated in the two Bonthe Oyster Festivals (2017 & 2018).

Female leaders of the 3 groups participating in retail market trials (Annex B5.2, figure B5.2.9) identified access to ready (rather than hand) printed branded packaging as a requisite for up-scaling. WOC follow-on funding will also support procurement of biodegradable packaging from commercial printers in Bo and Freetown, as well reproduction of the brand on female vendor uniforms and other marketing materials.

Reviewer comments on progress towards outputs & impact (revised log-frame)

Output 1 (fuel efficient processing): A literature review of fuel-efficient processing options (along with primary survey data on existing practice) is documented in Rossi et al (MSc thesis, UoS unpublished 2017 see annex A4). This informed selection of interventions for later pilot testing by target beneficiaries, reported in Annex B3.3.

Output 2 (value-added processing techniques): Due to unforeseen (tragic) circumstances external provision was required to implement marketing activities initiated by local partner IMBO. Under supervision of Dr. F. Murray (UoS), Mr. D. Taskov (UoS) and Mr Jason Hoefl implemented market field-work with local partners required to verify achievements against indicators 2.1, 2.2 and 2.3 (Mr Taskov's time constituting and in-kind contribution from UoS). This work focussed primarily on value-addition through packaging and branding. Regrettably, input from a suitably qualified local food-technologist to support in-depth quality assessment of extended-shelf life processing options was not available. This is a gap-area identified for future value-addition work.

Output 3 (low input-output mud-oyster culture using shell-waste): Building on preliminary situation analysis outputs (Annex B1.1, Annex B2, Annex B4.1), work on implementation challenges became the focus of a local MSc project reported in Annex B2.5. Development of such 'artificial reefs' requires sustained multi-year effort, meaning impact assessment was not possible within the remaining project lifecycle.

Output 4 (Value-added through branding and promotion): See comments re. LF output 2 regarding the staff recruitment value (the project benefited from substantial internal marketing expertise).

Output 5: (Sherbro Women's Oyster Gatherers Association): Considerable effort was focussed on identification of suitable institutional entry points (described above) culminating in engagement of 3 women's (micro-credit) groups in assessment of marketing interventions. The largest of these the Victoria Women's Oyster Group' was identified as having greatest potential for value-added retail marketing of smoked oysters.

Output 6 (Dissemination of research outputs): The annual oyster festival and associated public radio broadcasting have proved highly successful in communicating project findings to a local (non-academic audience. This approach will be sustained post-project with Municipal council participation and WOC funding support.

Reviewer comments on contribution to SDGs: We agree that the main project contribution relates to understanding pressures on human well-being (1&2) and marine resource use (14 and 15). Sustainable aquaculture development in much of sub-Saharan has been limited by an overly narrow historic production focus. Project learning and recommendations regarding post-harvest value-chain marketing constraints and options are therefore highly generalizable to this wider domain.

5 Darwin Identity

The Darwin Initiative was acknowledged in a Sunday Times article 'When Your World is the Oyster' (2/Sep/2018) describing the project collaboration with the Whitstable Oyster Company (WOC) in implementation of two oyster-festivals held in Bonthe town as part of the projects wider objectives (Annex B7.3). The Darwin logo featured on all festival publicity including posters and flyers (Annex B6.1, Figure B6.1.3). The initiative was also highlighted on pre-festival local radio announcements including two radio Q&A sessions with project and council staff (Annex B6.1, supplement B6.1.B). WOC funding will also support efforts by the Victoria Women's Oyster Association' to market Sherbro Branded Oysters, the packaging of which also carries the Darwin logo.

6 Finance and administration

6.1 Project expenditure

Project spend (indicative since last annual report	2017/18 Grant (£)	2017/18 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs			0	
Consultancy costs			0	
Overhead Costs			0	
Travel and subsistence			0	
Operating Costs			0	
Capital items			0	
Others			0	
TOTAL				

Note: No variance was recorded as UoS supported the project with additional financial support above this budget.

Staff employed (Name and position)	Cost (£)
Francis Murray, Research Fellow	
Jason Hoepfl, Research Assistant	
Balram Dhakal, Research Assistant	
University contribution	
TOTAL	

Consultancy – description of breakdown of costs	Other items – cost (£)
Institute of Marine Biology and Oceanography (IMBO) – staff salaries, Overhead, Travel and Subsistence, other Njala University – staff salaries, overheads, office rental, travel, field work expenses, misc.	
TOTAL	

Capital items – description	Capital items – cost (£)
NA	
TOTAL	

Other items – description	Other items – cost (£)
Audit	
TOTAL	

6.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
Whitstable Oyster Company, support to implementation of suspended culture trials, publicity and product branding materials (inc. graphic design of festival posters & product branding)	
University of Stirling, 2.5 man months additional RA support for (i) D. Taskov - marketing analysis & product placement work in Sierra Leone (ii) R. Shilland, Prof John Taggart – PCR analysis of oyster phenotype samples.	
University of Stirling, 1 man month by Dr Richard Quilliam to implement oyster microbiological contamination risk assessments including 2 field missions to the research area	
University of Stirling 4 days by Professor Trevor Telfer to support implementation of a hydro-geographic survey of residual current patterns.	
Bonthe Municipal Council; air-time for project Q&A on weekly publi communication 'Council Hour' on local radio (Radio Bontico)	
TOTAL	

Source of funding for additional work after project lifetime	Total (£)
Whitstable Oyster Company- £5,000/year for 5 years (post-project) successive 'Bonthe Oyster Festivals' as institutional capacity building support to a women's oyster marketing association	
Univiersity of Stirling – 2 man-months on-going phenotypic analysis	
TOTAL	

6.3 Value for Money

The project has achieved value for money through sourcing additional funding during and after the project life time respectively totalling £x and £x (Section 6.2). These fund were used to support implementation of a number of activities over above our log-frame commitments including (i) an assessment of oyster microbiological contamination risk associated with poor sanitation; Annex B4.1 (ii) a hydro geographic survey to determine residual current patterns in the Sherbro MPA; Annex B2.2 (iii) primary productivity (chlorophyll-a) analysis; Annex B2.3 (iv) proximate (nutritional) analysis of fresh and processed mangrove oysters; Anne B4.2 (v) a second Bonthe Oyster Festival implemented in 2018; Annex B6.1. Value for money was also ensured through the project effectively addressing its major assumptions, leading to a significant log-frame revision in 2017 - and project outputs with greater local and regional potential for sustainable adoption.

7 Administrative Annexes (A):

Annex A1: Project Logframe.

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

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: Improved wellbeing of local communities and reduced pressure on mangrove populations resulting from improved sustainability of mangrove-oyster harvesting and processing practices and value-added marketing in the Sherbro Marine Protected Area (Bonthe District, Sierra Leone).			
Outcome: Environmentally sustainable mangrove-oyster harvesting and value-added processing and marketing options for female gatherers evaluated and rolled out in the Sherbro Marine Protected Area (Bonthe District, Sierra Leone). Prudent harvesting and fuel-efficient processing also reduces pressure on mangrove populations with associated biodiversity gains.	(i) Income from oyster processing and marketing activity of at least 30 female gatherers in 8 communities increased by at least 10% by end of project. (ii) Rate of mangrove degradation (and associated botanical and invertebrate diversity) relative to overall oyster-gathering livelihood dependency, reduced by at least 8% across 8 study sites as a result of improved oyster (and potentially fish) harvesting, processing and collective marketing practices by end of project.	(i) Household survey reports - 2017 (baseline) and 2018 (monitoring) (ii) Household baseline and monitoring survey reports (see MoV (i)) and analysis of satellite imagery of Sherbro MPA prior to 2017 and 2018	Even if disaggregate 2015 census statistics finally become available in 2017, data deficiencies likely to be associated with the remoteness of the Sherbro research area will necessitate validation efforts and/ or alternative approaches to estimating population trends (Activity 1.5). Realistic quantification of impacts at outcome level will be contingent on these estimates.
Outputs: **1**. Secondary pressure on mangroves populations reduced through more fuel-efficient processing	1.1 Most promising technologies evaluated with stakeholders in satellite communities increase fuel-efficiency of primary and secondary processing by at least 50% and 10% respectively by project end.	1.1 End of project technical report on iterative demonstration trials with target beneficiaries and household baseline (2017) and monitoring survey outcomes (2018) - inc. photographic evidence.	1.1 Appropriate technologies' are adaptable to target stakeholder needs and resource constraints. Secondary processing (smoking) of oysters and fish harvested by males are often undertaken concurrently. Technology options must also reflect gender-roles and female decision-making autonomy

	1.2 Contribution to reduction in mangrove clearance rates (over last decade) associated with fuel-efficiency gains and adoption quantified; normalised against historic trends in coverage and population settlement trends.	1.2 End of project technical report on survey (Activities 1.3, 1.4, 1.5) and associated modelling outcomes.	around such joint-activity. There is also potential to multiply environmental benefits if the fuel efficiency of both activities can be increased with mutual benefits to females and males. 1.2 Increased fuel-efficiency does not also lead to intensified resource extraction. Note: in the absence of effective regulation (formal or informal) our working hypothesis is that access to un-motorised dug-out canoes and safety issues around harvesting remain the first limiting production factors for most female gathers. Whilst more profitable value-added options may attract new entrants - this could ultimately be a precursor for simple oyster fishery enhancements (e.g. Activity 3) followed by more intensive aquaculture interventions.
2. Profitability of female oyster gathering increased through testing and adoption of extended product 'shelf-life' and value added processing techniques.	2.1 Cost-benefit analysis indicates an increased net margin for value-added products of at least 7% on retail of 'loose' smoked oysters 'by the cup'. 2.2 Volume and/ or number of women currently capable of selling steamed oysters to the market in Bonthe increased by at least 10% by project end. 2.3 As result of 2b - a concomitant decrease in fuel-use for secondary processing (smoking) of at least 50% by project end.	2.1 Technical report on cost-benefit analysis (2018). 2.2 Report (2018) on household surveys in 2017 (baseline) and 2018 (monitoring). 2.3 Report (2018) on household surveys - 2017 (baseline) and 2018 (monitoring).	2.1 Sufficient demand exists or can be stimulated for value-added products in target markets (see Output 4). A 'do-no harm' ethos will also be adopted - acknowledging the potential risk of driving intensified resource extraction by linking local producers of low-value 'commodity-product' to regional markets under asymmetrical bargaining relations. Opportunities and constraints for transitioning from volumetric to weight-based measures/ packaging will also be explored.

			2.2 May provide greater opportunities for satellite communities with land access to Bonthe if/ where extended marketing is limited by female access to canoes and/ or safety characteristics. 2.3 Opportunity for verification of 2b and 2c is likely to be restricted to case-study documentation within remaining project duration (i.e. without no-cost extension).
3. Safety and seasonality of female oyster gathering opportunities increased through localised re-use of shell-waste for low-input-output culture enhancements on mud-banks	3.1 Harvests of 'mud-oysters' extended 2-3 weeks beyond the end of conventional harvests of inter-tidal oysters on mangrove roots.	3.1 Substantive yields are likely to be contingent on progressive build-up of oyster 'cultch' over successive years i.e. substantially beyond the current project life-cycle - during which it will only possible to verify initiation and preliminary	3.1 Stability of mud-banks permits progressive build-up of oyster-cultch on their surface. Banks with suitable tidal characteristics & access rights in proximity of communities. Note: Preliminary findings indicates negligible opportunity-cost for oyster shell-waste evidence by build-up of large shell-middens in many satellite communities
4. Demand for value-added products created through branding and promotion.	4.1 Logo(s) adopted and used by local stakeholders in marketing of value-added products and recognised by consumers 4.2 At least one branded product-line placed in at least one formal retail outlet increased by project end.	4.1 Opportunity for verification is likely to be restricted to case-study documentation within the remaining project duration. This will include testimonials from oyster vendors and retail outlets in target markets. 4.2 Retail and consumer testimonials and photographic evidence.	4.1 (i) Willingness of appropriate channels to engage in promotion; especially national and local radio, TV and press (ii) increase in commercial opportunity does not result in male displacement of females in marketing (this & other elite capture risk also underpin the need for development of an effective women's association that is inclusive of and empowers the target beneficiaries)

			4.2 Sufficient demand exists or can be stimulated and adequate food-safety standards can be assured (Note: there is currently no established market for any locally packaged oyster products).
5. Sherbro women's oyster gatherers association established based on mutually beneficial cooperation around processing and market interventions	5.1 Formation of Sherbro Women's Oyster Association - formalised post oyster festival (Jun 2017) - incorporating best-practice adaptive learning from the Ghana TWOA model. 5.2 At least 40 local women (from Bonthe & satellite communities) attend training on sustainable and profitable oyster production and marketing during Bonthe Oyster Festival. 5.3 Training manual on sustainable/ profitable oyster production and marketing utilised by Bonthe Municipal Authority Sherbro MPA, women's association, & local NGOs (e.g. Green Scenery).	5.1 Association constitution, membership and meeting activity documented. 5.2 &5.3 Post-training evaluation survey with target beneficiaries, training and extension staff.	5a. (i) Such association can increase the collective bargaining power of individual gathers to sell value-added products in local and regional markets. (ii) Women in satellite communities are not excluded due to remoteness or institutional capture by centralised interest-groups in Bonthe (iii) means to incentivise prudent harvesting practices can be devised in the absence of any real existing formal or social prohibition on damaging practices. 5b. Women from remote satellite communities are able to travel to Bonthe (efforts will be made to understand constraints and enable participation).
6. Research outputs documented & shared with target audiences.	6a. Journal article on project development outcomes submitted to peer-review journal & draft version uploaded to UoS open-access STORRE repository.	6.1 Journal confirmation email. 6.2 Conference confirmation email, online abstract or proceedings. 6.3 Policy meeting attendance register and signed-testimonials on utility of policy brief from local (MPA and municipal authorities) and national authorities.	6.1 Acceptance of abstract. 6.2 Adequate representation of female oyster gathers (within and around Bonthe) within the MPA institutional structure.
Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1) 1.1 Evaluate efficiency and adoptability of solar steam cooker designs for primary (steam) processing with/ by female oyster gatherers in Bonthe Town and satellite communities 1.2 Evaluate efficiency and adoptability of fuel efficient stove designs for primary (steam) and secondary (smoke) processing with/ by female oyster gatherers in Bonthe Town and satellite communities			

1.3 Longitudinal baseline quantitative survey of harvesting and processing effort/ practices and livelihood contribution to female oyster gatherers in satellite Sherbro Island communities over peak production months and mangrove impacts modelled
1.4 Validate production estimates of smoked oysters from Activity 1.3 through assessment of smoked oyster sales at Yagoi lumi - a 'bottle-neck' mainland weekly retail market
1.5 Trends in population settlement and mangrove coverage assessed using satellite images
2.1 Fuel-efficient pasteurisation options evaluated in conjunction with Output 1 activities
2.2 Evaporative cooling and solar drying designs (for steamed oysters) evaluated with female oyster gatherers in Bonthe Town and satellite communities
2.3 Vacuum packing options designs (for smoked oysters alone and in ready meals) evaluated with female oyster gatherers in Bonthe Town and satellite communities
2.4 Value-added oyster ready-meal recipes developed based on locally available ingredients and potential market demand
3.1 Assess adoptability of enhanced mud-oyster fishery through placement of oyster-cultch on inter-tidal mud-banks with satellite communities
4.1 'Sherbro' branding, logo, labelling options for value-added products developed and refined based on feed-back from local stakeholders
4.2 Demand for branded value-added products assessed through market survey and product placement with retail and food service outlets
5.1 Plan and implement the first 'Bonthe Oyster Festival (BOF) ' in June 2017 with collaboration of local and international stakeholders (inc. representatives of the successful Try Women's Oyster Association (TWOA) in The Gambia.
5.2 Implement training of female oyster-gatherers on learning outcomes of outputs 1-4 as part of the BOF
5.3 Support institutional capacity building of female oyster gatherers within the Sherbro MPA centred on collective processing and marketing activities and sustainable production practices - based on adaptive learning from the TWOA model
5.4 Assess genotypic differentiation of oyster phenotypes associated with different substrates through DNA marker analysis
6.1 Policy workshop co-hosted with Bonthe Municipal Authority and Sherbro MPA
6.2 At least one scientific paper submitted to a peer-reviewed journal and presented at an international scientific conference

Annex A2: Report of Progress and Achievements Against Final Project Logframe for the Life of the Project

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Impact: Improved wellbeing of local communities and reduced pressure on mangrove populations resulting from improved sustainability of mangrove-oyster harvesting and processing practices and value-added marketing in the Sherbro Marine Protected Area (Bonthe District, Sierra Leone).		
Outcome: Environmentally sustainable mangrove-oyster harvesting and value-added processing and marketing options for female gatherers evaluated and rolled out in the Sherbro Marine Protected Area (Bonthe District, Sierra Leone). Prudent harvesting and fuel-efficient processing also reduces pressure on mangrove populations with associated biodiversity gains.	(i) Income from oyster processing and marketing activity of at least 30 female gatherers in 8 communities increased by at least 10% by end of project. (ii) Rate of mangrove degradation (and associated botanical and invertebrate diversity) relative to overall oyster-gathering livelihood dependency, reduced by at least 8% across 8 study sites as a result of improved oyster (and potentially fish) harvesting, processing and collective marketing practices by end of project.	Detailed comments on project outcomes and outputs are given in Section 3 of the main report.
Output 1: Secondary pressure on mangroves populations reduced through more fuel-efficient processing	1.1 Most promising technologies evaluated with stakeholders in satellite communities increase fuel-efficiency of primary and secondary processing by at least 50% and 10% respectively by project end. 1.2 Contribution to reduction in mangrove clearance rates (over last	1.1 Primary steam-processing trials with local stakeholders compared conventional smaller (domestic-pots) and larger (folded metal) troughs with an improved high-volume troughs developed by the project (&rolled out as prizes in the 2018 Bonthe Oyster Festival). Results indicated fuel-efficiency gains of up to 35% and 77% per cup of steamed oysters from 'up-scaled' project troughs compared to the local folded-troughs and domestic pots respectively. Results also indicate scale-economies achievable through collective processing effort by neighbouring women (Annex B3.4).

	decade) associated with fuel-efficiency gains and adoption quantified; normalised against historic trends in coverage and population settlement trends.	Feedback from women issued with 'bespoke' metal steaming troughs to trial (in daily-use) pointed to severe corrosion problems (Annex B3.3, Fig B3.3.7) reducing operational life to as little as 4 months. More appropriate vessels crafted from locally available steel barrels (used in palm oil production), with purpose-built covers were found to offer a more optimal combination of improved fuel-efficiency and durability (Figs B3.3.2 & B3.3.9). 1.2. Direct quantification of effects on clearance rates was not feasible due to delayed implementation of activity 1.1 (associated with the log-frame revision) and inadequate resolution/ time-series of satellite imagery (Annex B3.1). However production surveys in 38 communities indicate considerable potential for reduction of mangrove fuel consumption for steaming & processing, Compared to domestic-pots, homemade 'folded' and 'up-scaled' project troughs gave average reductions of 46% and 77% in fuel-wood consumption respectively. Survey estimates indicate total fuel consumption of 728 - 1,140t by the 38 communities over peak oyster harvesting months from Mar to June 2017. Steaming and smoking respectively accounting for 49% and 51% of this total. (Annex B3.3).
Activity 1.1 Evaluate efficiency and adoptability of solar steam cooker designs for primary (steam) processing with/ by female oyster gatherers in Bonthe Town and satellite communities.		1.1 A review of solar-powered steaming technology (Rossi, MSc Thesis 2017) indicated such systems do not reliably generate sufficient heat to guarantee safe pasteurization of oysters i.e. as conventional steaming methods were found to do in a separate project microbiological study (Annex B4.1). However during surveys we found evidence of existing 'light-touch' smoking practices highly calibrated to extend female gatherers access to local retail markets for fresh-steamed oysters. This adaptive learning was incorporated in evolution of value-added smoked oyster retail marketing options with female gatherers (Output 2).
Activity 1.2. Evaluate efficiency and adoptability of fuel-efficient stove designs for primary (steam) and secondary (smoke) processing with/ by female oyster gatherers in Bonthe Town and satellite communities.		1.2 See comments against 1.2 above.
Activity 1.3 Longitudinal baseline quantitative survey of harvesting and processing effort/ practices and livelihood contribution to female oyster gatherers in satellite Sherbro Island communities over peak production months and mangrove impacts modelled.		1.3 Daily processing records were kept by 52 female oyster gatherers in nine focal project communities during peak harvesting (March-June 2017). Further production estimates were collected from gatherers in an additional 29 'satellite' communities using recall surveys. Based on responses from 35 communities (with most reliable record keeping) we extrapolated total production of 194-307mt of steamed oyster and 25-38mt of smoked oysters over this period. This 28-29% net transformation rate for

		smoked oysters compares with a 73% recovery rate (i.e. 27% moisture loss) calculated in our experimental margin analysis (Annex B4.3). Most of this difference was accounted for by the ability of survey communities around Bonthe and York Towns to retail steamed oysters. However, satellite communities were found to retain a relatively small proportion (8-14%) of their (steamed) oysters for direct household consumption i.e. most harvesting and processing activity is targeted at production of smoked oysters for the wholesale market also incurring significantly greater mangrove fuel consumption by these women than those close to Bonthe or York.
Activity 1.4: Validate production estimates of smoked oysters from Activity 1.3 through assessment of smoked oyster sales at *Yagoi lumi* - a 'bottle-neck' mainland weekly wholesale market.		1.4 Longitudinal data on smoked oyster (& substitute cockle) volume and provenance collected by project-trained enumerators May-June 2017 (peak oyster season) and Aug-Sept 2018 (low oyster season). Under-reporting associated with 'black' Sunday sales (when trading is officially banned) precluded accurate sales estimates. However, the dominance of this single market was underscored by the regular presence of smoked oysters and cockles harvested by communities as far as 70km from Yagoi.
Activity 5: Trends in population settlement and mangrove coverage assessed using satellite images.		GIS analysis was precluded by unavailability of longitudinal time-series of satellite imagery at appropriate resolution (Annex B3.1). However analysis of historic satellite imagery and census data (2004 & 2015) pointed to a rapidly growing population in micro-dispersed satellite mangrove communities alongside a static population in Bonthe and York Towns. These trends reflect the growing reliance on primary aquatic resource extraction and lack of alternative livelihood opportunities (Annex B1.2)
Output 2: Profitability of female oyster gathering increased through testing and adoption of extended product 'shelf-life' and value added processing techniques.	2.a. Cost-benefit analysis indicates an increased net margin for value-added products of at least 7% on retail of 'loose' smoked oysters 'by the cup'. 2.b. Volume and/ or number of women currently capable of selling steamed oysters to the market in Bonthe increased by at least 10% by project end. 2.c. As result of 2b - a concomitant decrease in fuel-use for secondary	2.a. Cost-benefit-analysis indicated a net margin of 108% gained through the retail of value-added oyster snacks in branded packages (sold in the mainland mining town of Moriba Town) compared to existing pattern of marketing of smoked oysters loose by the cup at nearer wholesale markets. 2.b. & 2.c. A review of evaporative cooling technologies (e.g. clay 'pot in a pot') as an alternative to (previously discounted) solar-refrigeration option was carried out (Boardman, MSc thesis, UoS 2017). This revealed that such systems can only reduce ambient temperature by 8^{o}C under optimal conditions. High humidity and year-round average temperatures of 26-29^{o}C in Bonthe precluded this as viable option for seafood preservation. However, survey findings revealed a zone of highly-calibrated 'light-touch' smoking (with much reduced fuel requirements) practiced by some

	processing (smoking) of at least 50% by project end.	satellite communities up to 7km from Bonthe. This extends shelf-just long enough to allow processing on one day and retail, still as steamed-oysters on the next. Based on this combination of consumer acceptance and fuel efficiency, we also evaluated this light-touch processing as part of the 2018 product placement trials (Annex B5.2). This extended shelf-life to only 2-3 days (compared to 2 weeks – 3 months for conventionally smoked oysters). However, provisional findings indicate market demand is sufficiently high to limit risk of financial loss to vendors (consumers were also advised to consume products on the day of purchase).
Activity 2.1: Fuel-efficient pasteurisation options evaluated in conjunction with Output 1 activities.		2.1 See comments against 1.1 above.
Activity 2.2: Evaporative cooling and solar drying designs (for steamed oysters) evaluated with female oyster gatherers in Bonthe Town and satellite communities.		2.2. See comments against 1.1 and 2.b above (lack of clay deposits in Sherbro mangrove area was also cited as limitation for local production of clay pot-in-pot refrigeration).
Activity 2.3: Vacuum packing options designs (for smoked oysters alone and in ready meals) evaluated with female oyster gatherers in Bonthe Town and satellite communities.		2.3. Vacuum packing and electric sealers were supplied to and evaluated by target beneficiaries in 2017. However, Restricted access to reliable electricity supply (especially for communities further from Bonthe) limits the adoptability of the technology by beneficiaries post-project. Safety concerns re. anaerobic pathogens such as botulism in sealed packets intended for long-term storage also make vacuum sealing unsuitable for oyster marketing.
Activity 2.4: Value-added oyster ready-meal recipes developed based on locally available ingredients and potential market demand.		2.4) A recipe competition open to contenders from the entire Bonthe District was an integral part of both Annual Bonthe Oyster Festivals in 2017 and 2018. The events were also publicised in a dedicated talk-show on local station Radio Bontico to encourage wider participation and stakeholder engagement.
Output 3: Safety and seasonality of female oyster gathering opportunities increased through localised re-use of shell-waste for low-input-output culture enhancements on mud-banks	3.a. Harvests of 'mud-oysters' extended 2-3 weeks beyond the end of conventional harvests of inter-tidal oysters on mangrove roots.	3.a) Culture enhancement trials were initiated in June 2018 at two mud banks already accessed for harvesting by communities in Bonthe. Substantive yields can be expected after successive years of cultch build-up, and interim monitoring of spat collection and oyster mortality at transects in 10 communities with mud bank access commenced from August 2018 (Annex B2.5, figs B2.5A-C). Results from UoS Msc thesis (Boardman, 2017), however, revealed higher condition index (CI) (meat yield) for mud oysters than for mangrove oysters in salinity conditions below 20ppt (between July and January) (annex B4.3). This correlates with survey results in 38 communities showing reduced harvesting efforts during this

		same period due to unfavourable yields. In addition to low-input culture enhancements, extension of the conventional harvesting season may therefore be achieved through changes in planned resource management (i.e. harvesting mangrove and mud oysters respectively when salinity levels & CI are most favourable for larger yield).
Activity 3.1: Assess adoptability of enhanced mud-oyster fishery through placement of oyster-cultch on inter-tidal mud-banks with satellite communities.		See comments against 3.a above & main report Section 3.1
Output 4: Demand for value-added products created through branding and promotion.	4.a. Logo(s) adopted and used by local stakeholders in marketing of value-added products and recognised by consumers 4.b. At least one branded product-line placed in at least one formal retail outlet increased by project end.	4.a) Bonthe oyster logo was developed (Annex B6.1, figure B6.1.2) along with publicity materials for the Bonthe Oyster Festival (Annexes B6.1). Logos were also used in two product development and placement trial in 2018 (see Annex B5.2, fig. B5.2.15, Annex B6.2). 4.b) Results from product placement and marketing surveys (2017&2018) indicated prohibitive barriers to entry for branded packaged oysters in formal retail outlets. Chief concerns for retailers included reliability of supply and quality assurance mechanisms (Annex B5.2), meaning increased capacity building and coordination of female harvesters beyond the 3 communities involved is needed to meet these fundamental requirements. However, opportunities for sales at roadside junctions indicate the best entry-point for future market penetration of packaged oyster products. Low barriers to entry, rapid sales and visible impact of branded attire used in the placement trial indicate favourable market conditions for the quick sale of perishable food items along busy thoroughfares. These findings also mirror the experience of the now well-established Try Women's Oyster Association (TWOA) in the Gambia.
Activity 4.1: Sherbro' branding, logo, labelling options for value-added products developed and refined based on feed-back from local stakeholders.		4.1: Feedback from female oyster gathers leading the 2018 product placement trial and consumer surveys indicated key characteristics for improved branding and labelling. For producers, procurement of smaller pre-branded packaging will enable increased margins (through reduced product volumes) and maintain brand integrity. For consumers, consistent product volumes and labelling information detailing tractability (contact numbers) and ingredients (i.e. spices) used in processing are also valued product attributes (see Annex B5.2).

Activity 4.2: Demand for branded value-added products assessed through market survey and product placement with retail and food service outlets.		4.2: See comments against 4.b above and main report Section 3.1.
Output 5: Sherbro women's oyster gatherers association established based on mutually beneficial cooperation around processing and market interventions**.**	5.1 Formation of Sherbro Women's Oyster Association - formalised post oyster festival (Jun 2017) - incorporating best-practice adaptive learning from The Gambia's TWOA model. 5.2 At least 40 local women (from Bonthe & satellite communities) attend training on sustainable and profitable oyster production and marketing during Bonthe Oyster Festival.	5.1. Three women's oyster associations including membership of 65 active female harvesters in 3 target communities was achieved in 2018. Formation was based on existing indigenous microfinance institutions found to have best entry points for formalised oyster processing and marketing activities. Institutional analysis of 37 local microfinance institutions found 9 female-headed groups (av. 77% female membership) with frameworks most amenable to oyster processing & marketing activities. Micro-dispersal range of members, regular meetings and use of generated funds for petty trading activities in all 9 groups indicate best-practices and characteristics of enduring self-governing institutions relevant for target beneficiaries in satellite communities. The 3 target groups are highly representative of active female harvesters (65), with already imbedded microfinance institutions. Association constitutions and meeting activity was documented (annex 1.3), with further constitutional provisions for operational rules inclusive of formal cooperation in oyster processing and marketing activities. 5.2. Four (weekly) training exercises with 65 female harvesters from Aug-Sep 2018 was conducted by UoS RA J. Hoepfl in three respective communities. Training encompassed principles of value-added marketing strategies, adaptable packaging, labelling and food hygiene methods and dissemination of 2017 market surveys (revealed consumer preferences and valued product attributes in processed oysters). Training exercises concluded with 3 groups leading successful product development and placement in September and December 2018 trials, with marketing strategies & entry points adapted from learning of experience of TWOA in the Gambia (Annex B5.2 & B6.2).
Activity 5.1: Plan and implement the first 'Bonthe Oyster Festival (BOF) ' in June 2017 with collaboration of local and international stakeholders (inc. representatives of the successful Try		Two Bonthe Oyster Festivals (2017 and 2018) were was successfully implemented in participation with Bonthe Municipal Council (Annex 6). The festivals were also aligned with the projects product development, branding and policy dissemination objectives. External policy-makers, regulatory and development practitioners invited to participate in the 2018 event (Annex B6.1). Logistical issues precluded participation the Gambian Try Assoc. representative. Project associate James

Women's Oyster Association (TWOA) in Ghana.		Green, Director of The Whitstable Oyster Company (WoC) has committed funds to stage 5 more annual events which will continue to support the projects development objectives post-project.
Activity 5.2: Implement training of female oyster-gatherers on learning outcomes of outputs 1-4 as part of the BOF.		See comments against 5.2 above and main report Section 3.1
Activity 5.3: Support institutional capacity building of female oyster gatherers within the Sherbro MPA centred on collective processing and marketing activities and sustainable production practices - based on adaptive learning from the TWOA model.		See comments against 5.1 & 5.2 above and main report Section 3.1
Activity 5.4: Assess genotypic differentiation of oyster phenotypes associated with different substrates through DNA marker analysis.		Analysis of samples by UoS indicated that the two predominant mangrove and mud oyster phenotypes present in the Sherbro MPA are highly likely to be the same *Crassostrea. Tulipa* species, while rock oysters sampled from a beach near Freetown appear to be a different, as yet unconfirmed species (Annex B3.2). These findings highlight the role of sub-tidal mud oysters (refractory to prevailing hand gathering methods) as resilient multi-year class breeding pools. Findings underpinned policy recommendations for sustainable management of the oyster fishery within the Sherbro MPA framework (main report Section 3.1).
Output 6: Research outputs documented & shared with target audiences.	6a. Journal article on project development outcomes submitted to peer-review journal & draft version uploaded to UoS open-access STORRE repository.	6a) Two peer-review articles (for submission to inter-disciplinary Journals; Maritime Studies & Ambio) are in draft form (Annex B3.2 & B7.4).Three other project publications include two trade press articles (in The Grower; Annex B7.1 and Fish Farmer; Annex B7.2) and the Sunday Times Magazine (Annex B7.3). All outputs summarised in Annex 4.
Activity 6.1: Policy workshop co-hosted with Bonthe Municipal Authority and Sherbro MPA.		Policy recommendations summarised in Section 3.1 of the main report were delivered to key stakeholders (policy, regulatory, development NGO and academic research as part of the second Bonthe Oyster Festival (Annex B6.1 & Section 2 of the main report).

Activity 6.2: At least one scientific paper submitted to a peer-reviewed journal and presented at an international scientific conference.		Following a colloquium at the University of Stirling (2017) scientific findings were communicated through presentations at two international conferences (the Bangor Oyster Symposium 2017 and the Icelandic Seafood Symposium, Reykjavik 2017). A co-authored paper based on the presentation shown in Annex B7.4) is being prepared for submission to an inter-disciplinary peer-reviewed journal (Maritime Studies, Springer). A second paper (Annex B3.3) reporting findings of our oyster genotype analyses work and fisheries management implications is also in draft for submission to Ambio.

Annex A3: Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1	Number of (i) students from the UKOTs; and (ii) other students to receive training (including PhD, masters and other training and receiving a qualification or certificate)	4 MSc projects; (i) 1 IMBO (UKOT) student (ii) 3 UoS (UK) students
2	Number of (i) people in UKOTs; and (ii) other people receiving other forms of long-term (>1yr) training not leading to formal qualification	4 MSc awarded; (i) 1 IMBO (UKOT) student (ii) 3 UoS (UK) students
3a	Number of (i) people in UKOTs; and (ii) other people receiving other forms of short-term education/training (i.e. not categories 1-5 above)	(i) 65 women trained on hygiene best practice in (a) oyster processing and storage. (b) branded packaging and marketing
3b	Number of training weeks (i) in UKOTs; (ii) outside UKOTs not leading to formal qualification	(ii) 52 women trained in longitudinal oyster production recording keeping.7 production data enumerators trained in 6 villages. 3 marketing enumerators trained in weekly wholesale markets.
4	Number of types of training materials produced. Were these materials made available for use by UKOTs?	Branding logo's stamps, sealing materials etc. left with beneficiaries.
5	Number of UKOT citizens who have increased capacity to manage natural resources as a result of the project	65 female oyster-gatherers belonging to 3 mico-finance groups targeted by the project.
Research Measures		
9	Number of species/habitat management plans/ strategies (or action plans) produced for/by Governments, public authorities or other implementing agencies in the UKOTs	1: Recommendations for incorporation of oyster fisheries management in MPA statutes (Annexes B3.1 & B3.2).
10	Number of formal documents produced to assist work in UKOTs related to species identification, classification and recording.	1: Oyster genotype analysis (Annex B3.2)
11a	Number of papers published or accepted for publication in peer reviewed journals written by (i) UKOT authors; and (ii) other authors	NA (2 co-authored papers in draft)
11b	Number of papers published or accepted for publication elsewhere written by (i) UKOT authors; and (ii) other authors	(i) 4 co-authored MSc project reports (ii) 4 magazine & trade-journal articles.
12b	Number of computer-based databases enhanced (containing species/genetic	DNA analysis of 3 oyster phenotypes completed (Summary in Annex B3.2)

Code	Description	Totals (plus additional detail as required)
	information). Were these databases made available for use by UKOTs?	
13a	Number of species reference collections established. Were these collections handed over to UKOTs?	See above
13b	Number of species reference collections enhanced. Were these collections handed over to UKOTs?	See above
Dissemination Measures		
14a	Number of conferences/seminars/workshops/stakeholder meetings organised to present/disseminate findings from UKOT's Darwin project work	As part of 2 'Oyster Festivals' held in Bonthe Town, Sherbro Island 2017 and 2019 2 International conferences (Icelandic Seafood Symposium 2018, Bangor Oyster Symposium 2017) 1 Colloquium (UoS 2018)
14b	Number of conferences/seminars/ workshops/stakeholder meetings attended at which findings from the Darwin Plus project work will be presented/ disseminated	Post-project: 3rd Bonthe Festival scheduled for June 2019.
Physical Measures		
20	Estimated value (£s) of physical assets handed over to UKOT(s)	£ 985.82
21	Number of permanent educational/training/research facilities or organisation established in UKOTs	NA
22	Number of permanent field plots established in UKOTs	NA
23	Value of resources raised from other sources (e.g., in addition to Darwin funding) for project work	£21,100 during project lifecycle £28,500 committed post-project

Annex A4: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. weblink, contact address, annex etc)
Msc. Thesis[16]	Shell, N, T. (2016)	Vietnam / USA	UK	M	Unpublished	https://www.stir.ac.uk/about/faculties-and-services/natural-sciences/aquaculture/research/aquaculture-research-projects/the-darwin-sherbro-oyster-project/
Msc. Thesis[17]	Boardman, E. (2017)	USA	UK	F	Unpublished	
Msc. Thesis[18]	Rossi, E.H. (2017)	USA	UK	F	Unpublished	
Magazine Article[19]	Brown, Murray & Green (2017)	UK		M	Association of Scottish Shellfish Growers.	http://assg.org.uk/the-grower/4532754744
Magazine Article[20]	Murray, F., Green, J. Brown, J	UK	UK	M	ISSUU	https://issuu.com/fishfarmermagazine/docs/fish_farmer_may_2017
News Article[21]	Hodges, M. (2018)	UK	UK	M	The Sunday Times	https://www.thetimes.co.uk/article/from-whitstable-to-west-africa-how-kents-oyster-farmers-are-taking-their-shucking-expertise-to-sierra-leone-7xskrp55g
Msc. Thesis[22]	Kamara, A. (2019)	Sierra Leone	Sierra Leone	M	Unpublished	Summary report in Annex B2.5.

[16] Schell, N. T. 2016 '*Evaluating the role of mangrove oyster (Crassostrea tulipia) production and marketing on livelihoods of fisherwomen in the Sherbro River Delta, Sierra Leone; a mixed methods study*'. MSc Thesis, University of Stirling (Unpublished).
[17] Boardman, E. 2017. 'Factors Influencing the Improved Livelihoods of Oyster Harvesters in the Sherbro River Estuary, Sierra Leone: A Mixed Methods Study'. Msc. Thesis. University of Stirling (Unpublished).
[18] Rossi, E.H. 2017. 'The Environmental Impacts of Oyster Harvesting Upon Mangrove Swamps: Sherbro Island Estuary, Sierra leone'. Msc. Thesis. University of Stirling (unpublished.
[19] Brown, J., Murray, F., Green, J. Mar-Apr 2017 *First Sherbro Oyster Festival* -'The Grower' Assoc. Scottish Shellfish Growers. No. 20: Photo news.
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Annex A5: Darwin Contacts

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