Darwin Initiative Main Project Annual Report

Important note: *To be completed with reference to the Reporting Guidance Notes for Project Leaders: it is expected that this report will be about 10 pages in length, excluding annexes*

Submission Deadline: 30 April

Darwin Project Information

Project Reference	21-013
Project Title	Alternative livelihood opportunities for marine protected areas fisherwomen
Host Country/ies	Sierra-Leone, UK
Contract Holder Institution	University of Stirling (UoS)
Partner institutions	Fourth Bay College, University of Sierra Leone Institute of Marine Biology and Oceanography (IMBO), Njala University (NJU), Macalister Elliot and Partners Ltd. (MEP).
Darwin Grant Value	£247,264
Funder (DFID/Defra)	DFID
Start/end dates of project	1 Apr 2014 to 31 Mar 18
Reporting period (e.g., Apr 2015 – Mar 2016) and number (e.g., Annual Report 1, 2, 3)	Annual Report 2: 1 Apr 2015 to 31 Mar 2016
Project Leader name	Francis Murray
Project website/blog/Twitter	http://www.stir.ac.uk/aquaculture-mangrove-oyster/
Report author(s) and date	Francis Murray, Salieu Sankoh, Richard Wadsworth, William Leschen, James Green, Richard Quilliam, R. Kapindi, Amara Kalone, Nick Shell

Glossary of Terms and Abbreviations

BFPC	Bonthe Fisheries Processing Centre
CMA	Community Management Association
EJF	Environmental Justice Foundation (UK NGO)
GHI	Global Hunger Index (IFPRI)
HABS	Harmful Algal Blooms
IMBO	Institute of Marine Biology and Oceanography (Fourah Bay College, Freetown)
IRDP	Integrated Rural Development Program
LAR	Living Aquatic Resources
LMC	Local Management Committee (with oversight for CMAs)
Lumi	A weekly (usually Sunday) open-air food market
MFMR	Ministry of Fisheries and Marine Resources
MPA	Marine Protected Area
SSL	Sierra Leone Leones (Le: local currency)
TDS	Total Dissolved Solids
UoS	University of Stirling

Contents

1. Project Rationale

This 'Sherbro Oyster Project' project was established to support the work of the recently established Sherbro Marine Protected Area (MPA) by providing alternative livelihoods based on carefully managed extensive culture and value-added marketing of native mangrove oysters, in order to make it a financially viable income earning activity for local women whilst also protecting its sustainability for the future. A localised native oyster depletion and mangrove degradation problem was first 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).

Fig 1. Research locations in the Sherbro estuary; numbered red-flags indicate communities shortlisted for further in-depth assessment (see Table 1). Green flags indicate two weekly mainland retail and wholesale markets.

The primary research area and main target beneficiaries; female oyster gatherers and their households, are located in Bonthe District, Southern Province around the Sherbro River estuary. These women are responsible for most oyster harvesting, processing and marketing activity in the area. Most gathering and processing is undertaken by small satellite communities located around the oldest and largest settlements of Bonthe and York on Sherbro and York Islands (Fig 1). Oysters are steamed using mangrove wood for domestic consumption and local sales in Bonthe and York. Remoter communities must first steam then smoke-preserve their oyster (and fish) surpluses to retail or wholesale in one of two weekly mainland markets (*lumis*) with road connections; Yagoi on the Sherbro River to the south and Gbambatok to the north. In the absence of roads and motorised transport, most oyster-gathering, fishing and local transport is dependent on large numbers of small, 1-3man dug-out canoes. Market research on value-added fresh-live oyster sale options has also been conducted in and around Freetown, half a day's drive north of the MPA.

Further critical understanding of the development context has been gained following a first (post-Ebola) joint-mission to research areas in January 2016. A case for refinement of project objectives made in this report (Section 3.4) will be the subject of a separate logframe output and outcome change request with justifications presented in Sections 3.1, 3.4 and Annex 4:

2. Project Partnerships

The following project partners and affiliates collaborated on research activities during the projects first (post Ebola: Section 3) joint field-mission to Freetown and Bonthe District over 10 days in January 2016:

- Dr. Francis Murray and Mr William Leschen: aquaculture development specialists, UoS
- Dr Richard Quilliam: food borne pathogen analyses, UoS, UK
- Dr Saliue Sankoh: aquaculture and fisheries specialist, IMBO, UK
- Mr. Richard Kapindi: Community outreach & survey expert, IMBO, SL
- Dr Richard Wadsworth: environmental science specialist, Njala University, SL
- Mr James Green: Commercial oyster aquaculture specialist, Whitstable Oysters, UK
- Mr Edward (Amara) Kalone: IUU project officer, Environmental Justice Foundation, Bonthe, SL
- Fisheries support officer MFMR, Bonthe SL

Collaborators included local staff of the Ministry of Fisheries and the Environmental Justice Foundation (EJF) with an office in Bonthe. Building enduring working relations with these organisations is a key aspect of the projects exit-strategy. Plates 1a-f: show project partners collaborating on a range of research activities during the January mission.

Mr Kapindi (IMBO) and Mr Kalone (EFJ) are or will become permanently based in Bonthe to coordinate and support on-going project field-work. Dr Sankoh has also liased with Mr. Phil Gawne, Chairman of Isle of Man Govt. International Development Committee to provide additional financial support for the MPA co-management process through ISFMSL. This could potentially result in recruitment of a dedicated Fisheries Officer located Bonthe contingent on the World Bank continuing funding from August 2016. Dr Richard Quilliam a environmental ecologist from the University of Stirling, Joined the mission to analyse the risk of oyster contamination with human pathogenic bacteria of faecal origin.Mr James Green; proprietor of Whitstable Oysters a UK commercial oyster producer and retailer also joined the January Mission; provide technical advice on production and marketing issues. Mr Green who also coordinates the annual Whitstable Oyster Festival is highly committed to long-term post-project collaboration with local partners. At this stage of the project UK partner Macalister Elliot (with a minor budget) is yet to engage in activities as laid out in the proposal.

Ministerial re-shuffles complicate relation-building with Ministry of Fisheries and Marine Resources (MFMR) at national level. However, we have excellent connections at operational level through project partner Dr. Salieu Sankoh and his liaison with the West African Regional Fisheries Project, Sherbro MPA local and devolved Community Management Associations (CMAs). Face-to-face engagement between the project and other stakeholders also filled ‘inception-meeting’ gaps partially fulfilled through earlier Skype conferencing.

The research team were observers at a MPA Local Management Committee meeting in Bonthe attended by 19 persons, including 6 female oyster gatherers/ vendors and 13 fishermen (one member represents approximately 10 villages). The key concern for the male membership was the continued illegal use of illegal mono-filament gears (banned nationally in 2010) contributing to depletion of fish stocks. The females present indicated that women could manage production, harvesting and marketing of farmed oysters; men could assist with construction of racks. However, no concerns were expressed regarding over-exploitation of oyster stocks. This became a key topic for exploration during satellite community visits that were also poorly represented on the LMC. Generally the membership seemed frustrated with the lack of actionable outcomes from meetings to date.

Plates 1a-f: Clockwise from top left a&b: Project team members conducting focus group interviews with communities in the Sherbo MPA, c. Dr Richard Quilliam (UoS) conducting oyster bacterial contaminants analysis, EJF office Bonthe, d-e. Mr James Green (Whitstable Oysters), Mr Amara Kalone (EFJ), Mr Richard Kapindi (IMBO), Dr. Richard Wadsworth (NJU), Nick Shell (UoS) conducting water and sediments analysis near Bonthe. f. Dr Francis Murray (UoS) and Dr Saliue Sankoh (IMBO), Ministry of Fisheries & Marine Resources Freetown.

3. Project Progress

On 7 November 2015 the WHO finally declared an end to the Ebola outbreak in Sierra Leone which had severely disrupted our planned year 1 and 2 activities (resulting in Darwin granting the project a 12 months no-cost project extension to 31 mar 2018). A joint mission of local and UK partners was immediately arranged from 16-24 Jan 2016 to conduct joint-planning and situation/ needs analyses and to further develop relationships, awareness-raising and 'social license' with local stakeholders. Building on previous contacts, meetings were held with the following stakeholders during the January mission (See Appendix 4 for further details):

Secondary

- Deputy Minister of Fisheries and Marine Resources, Freetown
- Staff of the 'Institutional Support for Fisheries Management in Sierra Leone' project (ISFMSL) at IMBO.
- Mr Layemin Joe Sandi, Mayor of Bonthe (met with Mayor and staff before and after field work to brief/ de-brief on mission findings)

Primary

- Survey of live oyster vending on 4 beaches & steamed oysters in 1 retail market of Freetown
- Meeting of the local management committee (LMC) of the Sherbro MPA - representing community management associations (CMA)
- Individual and focus groups meetings with female oyster gatherers and fishermen in 9 communities within the Sherbro MPA
- 1 sub-chief of a traditional Paramount Chieftaincy.

Although no Ebola cases were recorded in Bonthe or surrounding islands the outbreak clearly further isolated these already remote communities from both national and international (development) support. Project progress, mainly linked to the January joint-mission is summarised against logframe outputs below (and Annex 1). More detailed accounts and images of activity outputs are presented in Annexes 4 to 9.

3.1 Progress in carrying out project activities

Output 1

Activity1.1 Multi-stage sample design for selection of 6-8 intervention communities according to social and environmental criteria (e.g. harvesting mangrove oysters along salinity and primary productivity gradients)

In the absence of reliable sample frame data[1], community selection was based on purposive sampling along a salinity gradient along the Sherbro River from Yagoi and the main delta sea channel to its southern mouth at Mania. A total of 9 of 15 communities previously short-listed using this approach in 2015 were selected for further in-depth assessment during the current mission (Fig 1a and Table 1). Exclusions included communities (i) in areas of lower seasonal salinity upstream and oyster ab abundance on the Sherbro River; delineated by the occurrence of flood-irrigated rice cultivation on river banks (ii) nearer the delta mouth requiring extended journey times by boat from the project base in Bonthe (Fig 1).

[1] The first national census since 2004 was in enumerated Dec 2015; at time of writing only preliminary results were available: see Annex 9.

Table 1: Community names and locations (see Fig 1.)

SN	Village	Code	Location	GPS N	GPS W
1	Gbembeehun	GHN	Islet coast, creek mouth	7°37'9.56"N	12°30'11.11"W
2	Bomblake	BBK	Shero Island coast	7°34'35.60"N	12°29'54.10"W
3	Bontibai	BTB	Shero Island coastal creek	7°32'38.35"N	12°30'51.74"W
4	Gbongboma	GBM	Shero Island inland creek	7°31'21.80"N	12°31'50.81"W
5	Yankain	YKN	Islet coast	7°30'10.86"N	12°29'28.76"W
6	Keigbe	KGB	Islet coast	7°31'5.56"N	12°28'33.80"W
7	York	YRK	York Island river mouth	7°32'34.98"N	12°27'47.73"W
8	Momaya	MMY	Sherbo River	7°32'1.64"N	12°23'9.88"W
9	Kingjimi	KJM	Bonthe Town	7°32'5.37"N	12°30'15.99"W

'Satellite' fishing communities can be differentiated by (i) their distance to and primary means of access (land-connection or canoe) to Bonthe Municipality (Fig 4.2), the main MPA population/ service centre and market for freshly steamed oysters (ii) age and size of settlement; communities on smaller islets with no *in-situ* access to well water or agriculture tend to be smaller, more transient and dependent on harvesting living aquatic resources (Annex 4). The largest fishing communities (50 households or more) are located along the landward side of Sherbro Island, with many smaller communities (4-20 households) distributed between and (especially) in the mangrove interior west of Bonthe. For reasons of safety, women tend to have better access to oysters in more sheltered mangrove areas out with the main sea-channel.

Results highlight limitations of the sampling approach, development of which was constrained by the Ebola crisis and lack of appropriate secondary frame-data. An *ex-post* sample frame (Fig 4.2) based on supervised satellite image classification and field-survey, will be further refined through (i) estimation of community-size based on hut counts, (ii) cross-referencing the origins of steamed and smoked oyster vendors at retail and wholesale markets (through longitudinal surveys) (iii) results of the Dec 2015 national population and housing census when/ if data becomes available as suitable resolution[2]**.**

Table 2 lists 22 communities recorded selling smoked oysters (and clams) at Yagoi. This excludes four of our sample satellite communities (GHN, BTB and KJM) who preferentially retail steamed oysters to consumers in Bonthe. As well as steamed oysters, one community (YKN) indirectly sends smoked oysters to Yagoi through female gatherer-assemblers in nearby Bonthe. However Table 2 is representative of the majority of remoter communities who must undertake secondary smoking to preserve their oysters for sale in mainland markets i.e. Yagoi or secondary markets in Gbambatok and Matru (Fig 3). The most distant communities, Cheppu at the west end of Sherbro Island are 78km by boat to Yagoi. Survey outcomes from our sample communities will be validated against a random selection of communities identified as supplying these markets, both directly and indirectly in future work-phases. Fig 4 shows how these sites and our 9 sample communities are positioned within the wider settlement context of the MPA.

Analysis of preliminary census data (Annex 9) shows the population of Bonthe District (3,468 km^2) has risen by 55% since 2004, to 200,730 in 2015 (in 1,011 villages and towns) and is projected to rise to over 318,000 by 2050 (Fig 2). Most growth has been in villages, presumably linked to fishing opportunities with the population of Bonthe town remaining relatively static; population density now stands at 58 persons/ km^2 compared to a national average of 99. A heavily skewed gender balance with 94 males per 100 females in 2004 i.e. shortly after the civil war, has begun to rebalance with the ratio now standing at 98.

[2] Provisional results indicate Sierra Leone's population has grown by 2.1 million persons (from 4,976,871 during the last census in 2004 to 7,075,241 in 2015). Females account for 50.9% of the population and the southern region (Inc. Bonthe District) is the least populous with 1,438,572 people. http://www.sierra-leone.org/Census/ssl_final_results.pdf - See Annex9

Sampling-designs for future bio-physical assessments (water quality, primary productivity and bacterial food-safety: Annexes 6 & 7) will also be integrated in this design and analysis stratified on key ecosystem and community livelihood characteristics in order to enhance the generalizability of findings and specificity of intervention recommendations.

Table 2: Locations of female vendors Sherbro MPA selling smoked oysters at Yagoi weekly market (Note: names in bold are project sample communities)

SN	Community	SN	Community
1	Barki	12	Mosembo
2	Bendu	13	Mossally
3	**Bomblake**	14	Msemea
4	Chako	15	Mutty
5	Cheppu	16	Porbatoke
6	Delkin	17	Sale
7	Gbanema	18	Seway
8	Gbangsie	19	Sulay
9	Mbokie	20	Suway
10	Molebeh	21	Tome
11	**Momaya**	22	Yele

(Note: Communities near the sea mouths harvest and smoke other more stenohaline shellfish species including clams to retail, often together with oysters. Data: Nick Schell)

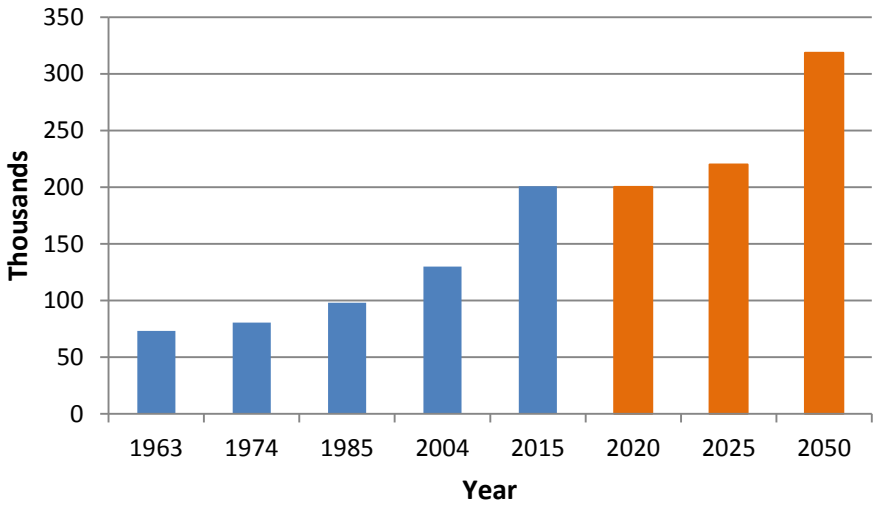

Fig 2: Bonthe District population trends 1963-2015 (in blue: Source: 2015 Housing & Population Census (preliminary) & extrapolated to 2050 (in orange: Source: extrapolated from a national UN -WPP 2015 Revision - See Annex 9)

Fig 3. Origins of vendors (green flags) marketing smoked oyster & clams at Yagoi weekly market (red flags also show secondary markets at Gbambatok & Matru: Map Nick Shell)

Fig 4. Sample frame of communities within the main mangrove areas of the Sherbro MPA based on supervised classification of Google Earth satellite images and field survey (red flags = project sample communities, yellow pins = other mangrove communities, ? = supervised classification only).

Future work required:

- Further supervised classification and ground-truthing of time-series satellite (Google Earth) images for improved understanding of oyster gathering effort and dependency in the wider Sherbro MPA and generalizability of in-depth research outcomes in project communities. Further integrated with marketing results (Activity 3.1) and census results when published).

Activity 1.2 Baseline livelihood surveys & selection of target-households:

Semi-structured focus group and individual key informant interviews: were conducted in each of the nine communities described above in order to assess:

- Community characteristics (demography, settlement pattern wealth profiles & indicators).
- Levels of dependency and effort (by gender, age, wealth, household and community) on oyster gathering activity (seasonally and historically) and linkage with other household livelihood activities (inc. fishing, mangrove harvesting, agriculture)
- Gender roles in seasonal production, processing and marketing
- *De jure* and *de facto* access rights (the former linked to over-lapping legal and traditional tribal property rights systems; the latter most closely linked to gender mobility differences and access to canoes)
- Linked resource dependency; especially re. impacts on mangroves linked to oyster harvesting practices and use for post-harvest processing (steaming and smoking)
- Market geography linked to processing options & demand-supply driven price trends
- Sanitation facilities and practices linked human pathogen contaminant risk in oysters – linked to live-whole value-added marketing options
- Stakeholder attitudes towards enhanced oyster culture options

Main Findings: Survey results are described in Annex 4 and key points summarised below

- A typology of gathering communities was developed based on well-being indicators (roofing materials, canoe-ownership, secondary education levels), oyster resource access and market geography indicators.
- Households on smaller satellite communities on resource limited islets appear poorer and most dependent on oyster gathering, though they are also likely to be more transient.
- Oysters are currently managed as open access resources, predominantly by female gathers within a limited radius, typically within 2-3km of their homes.
- Most gathering is of single year-class inter-tidal oysters exposed on mangrove roots with most gathering occurring from Jan-Aug and peak months May-Jul linked to salinity conditions.
- Canoe access is the main *de-facto* access determinant of gathering effort. Though few women own their own canoes, tidal optima for gathering is highly complementary with alternating canoe use for male fishing activity. Women will share, borrow or lease boats from extended family members and neighbours.
- In more exposed locations females (gathering) are more likely to partner with male family members (paddling) also potentially extending their range.
- Although considered a female activity, some unemployed male youth in Bonthe were found to be exploiting remoter longer range gathering sites. *Further research is required to determine the significance of this trend.*
- Harvesting is either by selective removal of larger oysters or indiscriminate cutting of entire roots. Indiscriminate cutting may be more common during the peak season.
- Women are almost entirely responsible for steaming, shucking and smoking oysters at their homes.
- Bulk commercial steam and smoke processing of oysters using mangrove wood as fuel typically follows 2-3 days of continuous harvesting, with one harvest around low tide per day and most activity around neap tides.
- Participation in a local management committee (LMC) with CMA oversight responsibility revealed some progress on canoe licencing and registration but frustration over lack of enforcement of a ban on mono-filament gill-nets. Oyster gathering communities within our sample were poorly represented. CMA focus is primarily on regulation of unsustainable fishing practices. *Further exploration is required of how CMAs can support mutually reinforcing co-management of oyster resources with effective participation of the primary female dependents*.

Outputs:

- Validation and further refinement of conclusions from initial reconnaissance surveys.
- Transcripts of 14 semi-structured individual, key informant and focus group interviews.

Future work required:

- Longitudinal survey work in sample sites to assess seasonal oyster gathering and processing patterns, female and household dependency on the activity and the adverse contribution of oyster gathering and processing activity on mangrove health.
- Understanding whether oyster distribution patterns are predominantly driven by harvesting or abiotic and biotic factors is highly challenging under field conditions. One approach will be to classify and map harvesting effort and associated mangrove impacts against a community typology based on household and canoe numbers (and estimates of active gatherers), gendered mobility conditions and market geography (other research needs highlighted in italics above).

Activity 1.3 Development of oyster artificial-substrate culture & depuration options.

A trial oyster culture rack has been established to the east of Bonthe Town according to the specification of Mr James Green an experienced UK commercial oyster cultivator (Annex 8). An 'appropriate technology' ethos underpinned the design, one early raft-option (see last annual report) being over-reliant on what are by local standards costly imported materials likely to be scavenged for alternative uses. The rack option was designed around locally available materials; mangrove wood, rope/ string from the local market and waste oyster shells spaced at intervals on suspended strings as spat collectors (cultch). Collectors were placed in September and October 2015. The design is also simple to construct and repair. Cultch was also laid on a nearby inter-tidal mud bank in a second trial. Yield outcomes to be assessed in June 2016 will contribute to a cost-benefit analysis.

As conditions on the rack approximate inter-tidal conditions on mangrove roots, the trial will also allow us to assess oyster recruitment and growth performance in conjunction with water quality assessments at an adjacent sample site, discussed below:

Water Quality: Five parameters salinity, Secchi depth, total dissolved solids (TDS), temperature and pH were measured by local partner Amara Kalone (EJF) from Bonthe Town pier at high and low tide on a daily basis from Nov 2015 (Annex 7).

Trends are highly correlated with seasonal rainfall patterns and to a lesser extent tidal states. Salinity ranged from a brackish 5ppt in Nov to a full oceanic 35ppt in April. Temperature ranged from 25 to 34 ^{o}C over the same period and pH from 7.4 to 8.4. Secchi readings a crude indicator of primary productivity rose during the rainy season (readings were temporarily interrupted thereafter). How these factors interact to influence oyster growth, reproduction and survival requires further research. For example although survival is clearly correlated with salinity conditions in time and space, this may also influence availability and quality of the oysters main phytoplankton food source[3]. Although mangrove (rock) oysters also appear to thrive in full oceanic salinity, reproduction and spat-fall, triggered by the onset of rains may be more restricted to lower salinity conditions within the delta.

Depuration options and microbial contaminants analysis: Public health risks associated with consumption of filter-feeding shellfish are widely recognised (for which reason globally, currently only 13 countries are licenced to import fresh shellfish into the EU). Risks include contamination with human bacterial and viral pathogens, algal toxins and heavy metals.

[3] Bainbridge (1963) describes phytoplankton species composition in gut contents of the phytophagous clupeid *E. dorsalis* with a similar seasonal diet and occurrence as mangrove oysters. Bainbridge, V. 1963 The food, feeding habits and distribution of the Bonga *Ethmalosa Dorsalis* Oceanic Lab. Edinburgh. http://icesjms.oxfordjournals.org/content/28/2/270.full.pdf

Harmful algal blooms (HABs) are often linked to availability of nitrates and (especially) phosphates from anthropogenic sources e.g. agricultural run-off, or naturally occurring e.g. in coastal upwelling's. Although HABs have been recorded in S. Africa but no examples of their occurrence were found in the tropical W. Africa (further research still required). Risk of inorganic pollution also appears low (the Sierra Rutile mining concession has a barge trans-shipment dock at Nitti on the 'Northern Channel': Fig 1) whilst there is little or no industry on the Sherbro River). The greatest risk therefore appears associated with organic faecal pollutants from the micro-dispersed nature of settlement in the Sherbro MPA (Fig 3.). Using portable culture equipment, tissue samples from juvenile oysters collected from the mud and rack trials (see above) and 3 other Sherbro estuary sites were analysed for *E. coli* as an indicator of faecal contamination (Dr Richard Quilliam, UoS, Annex 6). Preliminary results indicate that some (mangrove) oyster harvesting areas are contaminated by extremely high levels of faecal pollution; oysters could therefore be contaminated by human pathogens such as rotavirus, *Vibrio* spp., norovirus, *Cryptosporidium* & *Giardia.* Some concentrations were so high that shellfish harvesting for human consumption would be prohibited as 'beyond-depuration!' under an EU risk classification system. This clearly presents a significant challenge for value-added live oyster sales on Freetown Beaches, though depuration efficiency may also be very different compared to temperate conditions.

Outputs

- Oyster culture trials and longitudinal water quality recording established for improved understand of reproduction, growth and survival and culture/ wild harvest cost-benefit.
- Preliminary assessment of human pathogen risk in live oyster tissue from faecal contamination.

Future work required:

- Preliminary bacteriology findings will validated in a more systematic, replicated survey during the peak harvest season (June 2016). This will also compare Sherbro samples with local oysters currently supplying tourist beaches to the south of Freetown.
- Depuration options (including simple solar methods) will be evaluated on oysters across a spatial range of faecal contamination risk (determined in the above survey).
- Residual currents will be measured at strategic locations within the estuary using GPS mapping of boat launched drogues around high and low tides. The resulting tidal ellipse plots will contribute to our understanding of dispersal patterns for (i) faecal contaminants, (ii) oyster-spat and (iii) nutrients underpinning primary productivity and oyster carrying capacity. Linked to this, we will also attempt to measure oyster phytoplankton clearance rates (this is likely to challenging under field conditions).

Output 2

Activity 2.1 Procurement and adaptation of solar powered freezers

Survey findings highlight the challenges for reliable cold-chain operation in this setting. Annex 4 documents a number of failed or struggling cold chain interventions at different scales in the research area. The examples highlight the need for adequate maintenance training and support and spares-inventories as integral parts of any sustainable initiative. Drs Sankoh (IMBO) and Wadsworth (NJU) had previously reviewed solar powered freezer technological options appropriate to field conditions in Sierra Leone and obtained quotes for a series of different product options in country.

Fixed installation of freezers in Bonthe could also increase the range and capacity of outlying communities around to sell value-added steamed oysters (see Activity 3.1) to the retail market in Bonthe[4]. This would bring benefits both for local food security and reduction of pressure on mangroves through reduction of secondary smoke-processing requirements.

Future work required:

[4] Imported frozen marine clupeids are sold by female 'hawkers' in Freetown, defrosting as they go.

- Next steps will be contingent on positioning cold-chain needs within the evolving value-addition strategies described above and in Section 3.4. Evaluation of options will incorporate cost-benefit analysis, a 'do-no-harm' ethos linked to primary food security and complementarities with alternative 'non cold-chain' dependent preservation strategies e.g. brine pasteurisation, solar drying, vacuum-packing, use of preservative ingredients in ready-meals etc.

Output 3

Activity 3.1 Analysis of markets for oyster-based products and their substitutes

In January 2016 the research team jointly conducted further marketing interviews with female vendors of locally harvested steamed oysters in Freetown (Pamuronkoh market in Calaba Town and a vendor of fresh oysters on a tourist beach in Freetown. Female oyster harvesters in each of the nine communities in Bonthe were questioned about their marketing and associated processing practices (Annex 4).

- The choice between primary processing (steaming) and secondary (smoking) processing is mainly contingent on market geography. Given ability to process and access retail markets on the same day the clear preference is to steam only.
- Remoter communities must stockpile smoke-preserved oysters to sell at static weekly mainland markets with good river/sea road connections. Preserved (smoked) oysters are sold at weekly markets Preliminary findings indicate negligible wholesale discounting indicative of strong local demand relative to supply (further monitoring over the peak harvesting season (May-Jul) is required).
- The Short 'shelf-life' and high demand for fresh oysters (and other fresh sea foods) means that most product is retailed ('hawked') by mobile vendors along roadsides and door to-door within 24hrs of processing.
- These observations and a margin analysis of smoking and steaming losses (Annex 5) confirm that in local markets (i.e. Bonthe District), and in the absence of a functioning cold-chain smoking is primarily a preservation rather than a value-addition strategy.
- Both steamed and smoked oysters are sold volumetrically, by the heaped 'cup' or tin (around 400mls/cup); steamed oysters retailed for Le 1,000/cup in Bonthe and Le 3,000 in Freetown (all locally sourced in each case) and smoked oysters for Le 2,000-2,500 in Yagoi and up to Le 6,000 in Freetown.
- Little evidence of any supply chain specialisation was observed in Bonthe District; most females are responsible for their own gathering, processing and marketing. Further mapping of regional wholesale supply chain components for smoked oysters is required i.e. beyond the two primary mainland weekly markets.

Future Work Required:

- Longitudinal survey of smoked oyster sales in weekly mainland markets (especially Yagoi which appears to be the most accessible primary outlet). To include collection of volumes, prices, vendor origins and numbers, product mix, retail-wholesale patterns and discounting, value-added marketing (e.g. fried oysters and bread), consumer characteristics and origins.
- This will also permit an assessment of micro-dispersed seasonal harvesting effort over much of the MPA. Though more challenging due to the mobile nature of vending, further attempts will also be made to quantify steamed oyster marketing in Bonthe.

Output 4

Activity 4.1 Establishment of project web-site

The project website (http://www.stir.ac.uk/aquaculture-mangrove-oyster/) continues to be developed and populated with content as the project proceeds. The in-depth progress summary

embodied in this report will be posted here and a link circulated on the 'SARNISSA' African Aquaculture network website (www.**sarnissa**.org/) coordinated by Mr William Leschen (also responsible for our project website). Social media (Facebook and Twitter) sites will also be developed now that interim results are available and monitored using Google analytics etc.

3.2 Progress towards project outputs

A review of our initial problem-framing following exploratory field research indicates that there is likely to be little economic incentive for oyster aquaculture (Output 1a) under current resource conditions in the Sherbro MPA (Section 3.4). This may change if resource extraction pressure on oysters and (especially) mangroves increases due to increasing population growth (extraction methods appear less likely to intensify) and (if) more males move to oyster gathering as fish stocks decline.

Whilst further effort will directed at evaluating these trends, we propose to adopt a more explicit supply-chain development focus looking for opportunities to redeploy resources earmarked for this output around our existing post-harvest intervention strategies i.e. depuration, cold-chain logistics and value-added sales of fresh oysters to tourists and ready meals. Options in these areas are elaborated in Sections 3.1, 3.4 and Annex 4, and will be the subject of on-going stakeholder consultations. Projects around the most promising interventions will offered to two UoS MSc students partnered with local counterparts in 2017.

3.3 Progress towards the project Outcome

No project interventions are underway as yet. We propose to revise the existing project outcome as follows consistent with the arguments presented in Section 3.4:

From: *'Incomes of oyster-fisherwomen in at least 40 households of the Sherbro MPA increased by 45% pa and abundance/ mean-size of adjacent wild-oyster populations increased by at-least 18% over base-line levels'*

To: '*Incomes of oyster-fisherwomen in at least 40 households of the Sherbro MPA increased by 20% pa and consumption of mangroves for primary and secondary oyster processing decreased by at-least 15% over base-line levels'.*

3.4 Monitoring of assumptions

In ecological 'r/K' selection theory (MacArthur and Wilson, 1967, Ito 1980, Parry 1981[5]) 'r' selected species mature quickly, have short generation and gestation times, are highly fecund and have the ability to disperse offspring widely with little parental investment. This is a common strategy in unstable or unpredictable environments where ability to reproduce quickly is more critical than investment in quality of off-spring. Thus 'r-selected' species are natural opportunists, contrasting with k-selected 'equilibrium' species more evolved to compete with other species. Such adaptations are or of less value in environments such as estuaries with their highly variable spatial and temporal salinity profiles. Consistent with this view oysters and other bivalves including cockles and clams can adjust spat production and generation times in response to environmental pressure. Known as 'mangrove', 'rock' or 'mud' oysters the euryhaline *Crasostrea tulipa* is phenotypically adapted to such estuarine variability. In the Sherbro estuary most oysters are mainly harvested from mangrove roots where their inter-tidal position also results in high periodic natural mortality linked to low surface water salinity during the rainy season. Thus most harvesting pressure is on single year-class cohorts capable of rapid growth under nutrient rich, warm-water conditions. Sub-tidal mud (and rock) oysters are more resistant to the dominant method of hand gathering oysters exposed during low tides; furthermore due to gendered mobility restrictions (Annex 4), most oyster gathering effort is concentrated within a short radius of fishing settlements. Thus, despite increasing artisanal

[5] Ito, Y. 1980 Comparative Ecology, Cambridge University Press. NY. Pp 38-46

6hg6MacArthur, R.H., Wilson E.O. 1967 The theory of island biogeography. Princeton University Press.

Parry, G.D. 1981 The meanings of r- and K-selection. Oecologia 48, 2, 260-264

gathering effort, oyster populations on available substrates still appear to be rebound on an annual basis due to this combination of residual breeding pools, high fecundity and rapid growth; reaching minimum harvestable size in as little as 4-5 months post spat-fall. These findings have the following implications for planned project interventions:

- The fundamental precondition of natural resource scarcity for investment in aquaculture is not currently met. Thus even if the bio-technical potential of oyster can be demonstrated (Annex 8[6]) there is likely to be little economic incentive for its adoption under the prevailing resource and market conditions described below and in Annex 4.
- Rather, the most serious imminent threat to future well-being of the oyster fishery is pressure mangrove populations, directly through imprudent oyster harvesting methods, especially root cutting and extraction of mangrove wood as a fuel for cooking and processing (steaming and/ or smoking oysters and fish) and other secondary uses e.g. construction.
- Thus protecting mangroves will ensure sustainability of the more resilient oyster fishery and other aquatic biodiversity. Improved understanding is needed of the relative importance of the aforementioned pressures, seasonal interactions and underlying behavioural motivations of resource dependents. Mitigation strategies should be one element of a more integrated value-chain approach.
- Oysters are currently exploited as an open-access resource by micro-dispersed communities with little or no effective external regulation. They also an important primary source of seasonal food security for these communities, many of whom lack alternative agricultural food-production options.
- Thus under free-market conditions, interventions that support up-scaling of commoditised steamed and smoked oyster transfers to regional and national markets, risk escalating unsustainable mangrove extraction and damage and potentially negative food-security impacts on a growing population of vulnerable local resource dependents[7].
- Primary project interventions should therefore be on post-harvest supply-chain up-grading with emphasis on niche value-addition. The project is evaluating two such options; sale of (i) live fresh oysters, to tourists and expatriates visiting beaches around Freetown (Fig 4.4) (iii) steamed and or smoked oysters as ingredients of ready-meals through beach-bars, cold chain retail outlets in Freetown and other regional centres.
- Future research is needed to improve understanding of and promotion of market potential for such value-added goods. Any deployment of solar cold-chain infrastructure must also be compatible with these objectives.
- At the production level, mangrove damage mitigation steps could include awareness-raising around poor oyster harvesting practice, more fuel efficient processing. Strategically located and timed no-take zones might augment spat-fall in depleted areas, though enforcement would be a challenge. Knowledge of residual currents is first required to understand natural planktonic dispersal patterns.
- Efforts will be made to engage and involve MPA-CMAs in these activities.

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

The project is nearing the end of its exploratory phase, thus it is still too early to demonstrate biodiversity and poverty impacts. However, the improved understanding of critical risks and assumptions (Section 3.4) gained during this early effort provides the basis for refinement of

[6] A grey-literature report by Kamara and McNeil describes results of trials using a range of oyster culture methods in estuaries around Freetown in 1976. Although the research was successful in elucidating bio-technical constraints, there was no consideration of socio-economic development and marketing contexts and no record of adoption. The report has been scanned and uploaded on the project website.
[7] Sierra Leone ranked 4th in the world on IFPRI's Global Hunger Index (GHI) in 2015; 4 indicators are: calorific intake, child wasting, stunting & mortality https://www.ifpri.org/topic/global-hunger-index

project objectives and activities consistent with more achievable and sustainable development outcomes.

4. Project support to the Conventions (CBD, CMS and/or CITES)

Project objectives are also highly consistent with national CBD objectives underpinning establishment of the Sherbro MPA. No contact has been made with the local CBD focal point as yet; this is being prioritised by local PI Dr. Sankoh and will be an agenda item on future joint-missions. The project aims and progress to date and summarised above are consistent with the 3 main Conventions on Biological Diversity goals as follows:

1. **Conservation of biological diversity**: In the short to medium term and under prevailing environmental, market and artisanal gathering practices; oyster populations appear relatively resilient to over-exploitation. The project will focus greater attention on the negative impacts of gathering and processing practices on the health of mangrove assemblages which underpins wider ecosystem health (Section 3.4).
2. **Sustainable use of its components:** The economic rationale for investment in aquaculture appears questionable under prevailing resource conditions (further assessment is underway). The proposed shift of emphasis toward post-harvest supply chain interventions (Section 3.4, Annex 4) especially value-added product options, will also be designed to limit extraction pressure and secondary impacts on mangroves.
3. **Fair and equitable sharing of benefits arising from genetic resources**: exploratory analysis (Annex 4) has identified the most resource-poor dependents on the oyster fishery in remoter satellite communities lacking land-connections to Bonthe. These same reasons and their greater population transience make such communities a challenging intervention target. Risks of centralising post-harvest options (in Bonthe for example) are well recognised and attempts will be made to mitigate them learning from other local development projects. Nevertheless poverty levels are universally high and interventions may be merited even if the poorest of the poor are difficult to reach. Any interventions must still consider food-security implications for these most vulnerable and a ‘do-no harm’ ethos has also been described above.

5. Project support to poverty alleviation

Although too early to demonstrate impact, the project aims to achieve direct impacts on livelihoods through value-added production and supply chain interventions (described above). Female oyster gatherers in and around Bonthe Town and their households are the direct target beneficiaries. Interventions will also be designed to limit extraction pressure on mangrove populations bringing indirect benefits to a wider range of resource dependents.

6. Project support to Gender equity issues

The project is highly gender focussed with female oysters gatherers (and their households) being the primary target beneficiaries. Preliminary research has increased understanding of female access rights, both formal and informal to oyster resources and markets for steamed and smoked product forms. As oysters in the Sherbro MPA essentially remain an open-access resource, female access is highly dependent on mobility characteristics linked to canoe ownership and sharing arrangements with males, geographic safety factors and competition for oyster beds in more populous areas. Although females are responsible for most gathering and almost all processing and marketing (with little evidence of supply-chain specialisation) early findings suggest male participation and competition may increase as fishing yields decline.

7. Monitoring and evaluation

M&E planning will be further developed consistent with the refined intervention-foci elaborated in Section 3.4. Following several exploratory missions we are now commissioning longitudinal surveys to understand seasonal variability in the dependency of gathering communities/ households on oyster (& mangrove) harvesting and marketing. Findings will also constitute a baseline for monitoring project interventions.

8. Lessons learnt

Even by developing country standards, the research area is a particularly poor and remote area. Even in Bonthe Town access to electricity and all but basic supplies is highly limited. Thus extremely careful contingency planning is required for any 'kit-intensive' activities. For example oyster bacteriology work (Annex 6) was delayed for two days due to contamination of a vessel used to transport distilled water from Freetown (IMBO).

Learning around development failures and best-practice was gained from other established development organisations active in and around Bonthe. These lessons are contributing to refinement of our own intervention strategy (Annexe 4) e.g. challenges around cold-chain maintenance and repair and centralisation of cooperative production interventions.

9. Actions taken in response to previous reviews

Steps taken to address actions recommended by the reviewer of last year's annual report are as follows:

1 Review M&E plan to ensure indicators are achievable and ensure that all indicators and targets are achievable given the likely change in focus of beneficiaries and stakeholders on the ground post Ebola.
   - See Section 3.4 regarding proposed steps to deal with variances in risks and assumptions.

2 Demonstrate how the project will effectively communicate with beneficiaries, given low literacy levels in some project sites.
   - The aims and progress of the 'Sherbro Oyster Project' will be presented in a weekly local radio (Radio Bontico) public service hour. Radio and 3g SMS appear to be the most reliable means of reaching outlying stakeholders (Annex 4). With support of James Green (Whitstable Oysters), local government & radio.
   - We have started consultation and planning for a 'Bonthe (or Sherbro) Oyster Festival' in June 2017. In addition to culture events, activities will include judging of value-added oyster recipes, branding and promotion and show-casing of value-addition options (e.g. vacuum packing, solar cold-chain etc.).

3 Ensure the trade aspect of the project is considered in the M&E review. Given that the market is likely to change as a result of the Ebola outbreak, the project should not become over ambitious.
   - The project is highly value-chain orientated. Further analysis was a key focus of the January joint mission based on which intervention refinements are proposed in Section 3.4. On-going analysis has been constrained by lack of relevant local capacity (tragically our local marketing specialist, Ms Zainab Sankoh who led our initial surveys, summarised in the first annual report passed-away during the Ebola crisis). A UoS MSc student will collaborate of longitudinal market analysis in Bonthe District during field work planned for May to June 2016.

4 Define 'low-income' women and explain targeting criteria

- Considerable effort has been directed toward sample-frame refinement (see Activity 1.1 above) and further livelihoods analysis and validation during the current mission. Communities have been differentiated according to fisheries and female oyster gathering dependence based on market geography, resource endowments and access, in turn heavily contingent on canoe ownership and sharing arrangements (Annex 4).

10. Other comments on progress not covered elsewhere

Project design is being refined consistent with the revised assumption and risk assessment in Section 3.4. Sample-design/ frame improvements (Section 3.1; Activity 1.1) will also improve specificity and generalizability of project recommendation outcomes.

One well-established locally embedded development NGO 'Green Scenery' (www.**greenscenery**.org/) was found to be particularly active in the research area (Annex 4). Further engagement will be sought as part of our exit-strategy; with a view to understanding how project findings might be incorporated within the NGO's integrated rural development programming (IRDP).

11. Sustainability and legacy

Regrettably a planned stakeholder inception meeting was not possible due to the Ebola crisis. Activities during the January mission have started to fill this gap (including meetings with national and local governance bodies, but further promotional effort is required. Content of this summary report will be one means of increased outreach locally and internationally. Planning for a Bonthe Oyster Festival 2017 is also underway with participation of local government and radio (Section 3.1).

12. Darwin Identity

The project will be branded as the 'Bonthe Oyster Project' (or Sherbro tbc, & associated logo to be developed) as part of our marketing promotion strategy (Sections 3.1 & 11). The Darwin logo will be embedded in this branding and our social media outreach strategy (Section 3.1; Output 4).

13. Project Expenditure

Table 1 Project expenditure during the reporting period (1 April 2015 – 31 March 2016)

Project spend (indicative) since last annual report	2015/16 Grant (£)	2015/16 Total Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items (see below)				
Others (see below)				

TOTAL				

The variance of 24.1% with the budgeted figure (a 14.1% underspend above the 10% threshold) is due to extended implementation delays caused by the Ebola Crisis. This pushed most field activity during this year into the last quarter of the reporting period, and planned capital expenditure (100% variance) on interventions into 2015/16 (to be discussed with Darwin).

14. Outstanding achievements of your project during the reporting period

I agree for the Darwin Secretariat to publish the content of this section:

Although planned development interventions are still to be initiated, the project's exploratory phase provides useful lessons around inter-disciplinary problem-framing for sustainable development in a data-deficient context. A short article will be drafted for the Darwin Newsletter summarising these findings.

Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2014-2015

Project summary	Measurable Indicators	Progress and Achievements April 2014 - March 2015	Actions required/planned for next period
Impact: *Environmentally sustainable and pro-poor livelihood opportunities created in Sierra Leone through enablement of community-managed, mangrove-based oyster culture systems with value-added marketing attributes**.*** Proposed change (see Sections 3.3 and 3.4) *Environmentally sustainable and pro-poor livelihood opportunities created in Sierra Leone through enhanced processing and value-added marketing of mangrove oysters.*		Results of a scoping visit (Jan 16) indicate that oysters populations in the Sherbro delta appear more resilient to artisanal gathering than earlier thought. Rather the main biodiversity concern appears linked to impacts of imprudent harvesting and processing practices (steaming and smoking of oysters & fish catches) on the health of mangrove populations. Naturally high recruitment and growth of single-year class cohorts on mangrove roots means aquaculture interventions are unlikely to be profitable under current circumstances.	Longitudinal community and market surveys are being developed to better characterise oyster gathering & effort, livelihood dependency and environmental impacts. Project focus on post-harvest value-addition strategies, depuration, cold-chain logistics etc. will be expanded consistent with the reduced focus on aquaculture.
Outcome: Incomes of oyster-fisherwomen in at least 40 households of the Sherbro MPA increased by 45% pa and abundance/ mean-size of adjacent wild-oyster populations increased by at-least 18% over base-line levels. Proposed change (see Sections 3.3 and 3.4) *Incomes of oyster-fisherwomen in at least 40 households of the Sherbro MPA increased by 20% pa and consumption of mangroves for primary and secondary oyster processing decreased by at-least*	Indicator 1. Annual income of oyster-fisherwomen increased by at least 45% above baseline levels through oyster culture Indicator 2. Contribution of wild-oyster culture to annual income of target-beneficiaries decreased by 50% during first culture cycle and 100% by the second cycle Indicator 3. Adjacent abundance and mean shell-size of wild-oyster populations increased by 18% (along with stable or increased cover of associated mangrove assemblages)	Indicators to be reframed consistent with the proposed impact and outcome level revisions. The new, more supply chain orientated project outcome will also see greater focus on linkage/ design of interventions to reduce mangrove extraction pressure. This to be the subject of a formal project change request.	9 of 16 shortlisted communities selected for in-depth focus representative of a range of oyster production, marketing and dependency conditions across the Sherbro MPA.

15% over base-line levels.			
Output 1. Sustainable production and collective management systems (WP2)	Indicator 1. Technical and economic efficiency of alternative culture systems for at least two mangrove-oyster species (annual yield > 20kg/m2 substrate area) Indicator 2. Spatial mapping and field surveys of wild oyster and mangrove assemblage abundance/ diversity indicating specified improvement above baseline levels Indicator 3. LMC and/ or community area-management and collective production activity agreements formalised and documented)	Indicators to be reframed consistent with the proposed impact and outcome level revisions (see above).	
Activity 1.1. Multi-stage sample-design for selection of 6-8 intervention-communities according to social & environmental criteria (e.g. harvesting mangrove oysters along salinity and primary-productivity gradients).		*Ex-post* sample frame developed based on supervised classification of satellite images (Google Earth) and marketing surveys. This has improved understanding of the representativeness of selected communities to the wider MPA.	
Activity 1.2. Environmental, rapid rural appraisal (RRA) and household livelihood surveys for selection of target-households and establishment of intervention baselines.		Exploratory survey work has characterised key interacting resource use threats to mangrove help. Further understanding to gained through systematic longitudinal survey of households in project communities.	
Activity 1.3. Development of initial oyster artificial-substrate based culture-technology and depuration options.		Pilot suspended rack and bottom culture systems installed in Bonthe for cost-benefit and growth/ survival assessments.	
Activity 1.4. LMC and/or community agreements brokered on collective-production activities and extractive-restrictions in adjacent mangrove oyster-nursery areas.		Meetings held with the Bonthe Muncipal Council and the Local Management Committee of the Sherbro MPA in Bonthe. Next substantive collaboration steps contingent on refinement of interventions and effective representation of target beneficiaries in satellite fishing communities.	
Activity 1.5. Initial training of 40 wild-oyster harvesters on oyster-spat collection and culture techniques		To be reframed consistent with the proposed impact and outcome level revisions (see above).	
Activity 1.6. Adaptation of artificial-substrate based oyster culture techniques (e.g. post, tray, raft, long-line) through two full iterative phases of action research.		To be reframed consistent with the proposed impact and outcome level revisions (see above).	
Output 2. Supply chain enhancement (WP3)	Indicator 1: Solar-freezer systems procured, adapted, maintained and	Technologies (and costs) appropriate to ground conditions in Sierra Leone reviewed in year 1. Key operation and maintenance challenges learned from	

	operated by target-community-groups Indicator 2: Supply-chain systems operate effectively under seasonal conditions most associated with demand for value-added oyster products	other development projects in Bonthe will help shape our intervention design.
Activity 2.1. Procurement and adaptation of solar powered freezers for transport of oysters from the Sherbro MPA to free town under variable seasonal conditions		Notes produced on prices and operation of solar freezers in Sierra Leone (Annual Report No1). Procurement pending further market and needs analysis. Fixed installations in Bonthe could provide an opportunity for local value-added marketing of steamed (v smoked oysters) with further food security and mangrove extraction off-setting benefits. Focus to be expanded to other 'appropriate technology' means of extending product life e.g. brine pasteurisation, solar drying, preservative ingredients in ready meals, vacuum packing.
Activity 2.2. Training staff/ beneficiaries in operation and maintenance of freezer plant		No progress to date
Activity 2.3. Seasonal testing of freezer systems & cold-chain implementation		No progress to date
Output 3. Market promotion and value-addition (WP 4)	Indicator 1: Sales inventories of producer-groups and buyers increased Freetown compared to baseline levels Indicator 2: Project and media reports of outcomes of the oyster recipe competitions documented	No progress to date
Activity 3.1. Analysis of markets for premium oyster-based products (and their substitutes) in Freetown and other regional markets		Further market survey work in Freetown and Bonthe District and a processing loss margin analysis confirms steamed oysters to be more profitable than smoked oysters in local retail markets but 24hr' shelf-life' constrains market access (further seasonal survey work required).
Activity 3.2. Staging of regional and national oyster recipe competitions		Planning underway to host a Bonthe/ Sherbro Oyster Festival in June 2017 – to stage the regional competition and promote locally branded value-added products.
Activity 3.3. Development and testing of value-added oyster ready meals with super-markets, restaurants and beach-bars in Freetown		Potential local filler ingredients with low primary food-security opportunity cost and preservative qualities identified during January survey (further assessment required).
Activity 3.4. Evaluation of wider international demand & market-based certification potentials & statutory recommendations for MPA policy-makers		No progress to date

Output 4. Training and dissemination	Indicator 1: Documentation of curricula and attendance at 2 Farmer Field Schools (FFS) and final project workshop Indicator 2: Relevant decision-makers as identified by stakeholder analysis rate usefulness of policy briefs on a five point scale. Indicator 3: At least 2 peer-reviewed primary research papers made available in open access format.	Findings summarised in this report will contribute to a peer-reviewed co-authored paper around mixed-methods problem-framing for sustainable development.
Activity 4.1. Establishment of project web-site (with links to partner web-sites and the regional SARNISSA research network		Website operational and being updated http://www.stir.ac.uk/aquaculture-mangrove-oyster/
Activity 4.2. Extension to neighbouring communities through 2 'Farmer Field-Schools' (in each case for separate female and male groups).		No progress to date
Activity 4.3. Regional best-practice/ policy workshop (inviting participants from comparable initiatives in Benin, The Gambia, local EJF project, MPA representatives)		No progress to date
Activity 4.4. Project reports & publications (x2) on environmental social and economic sustainability outcomes in international peer-reviewed journals		See output level comment above

Annex 2: Project's full current logframe

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Goal. Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources.			
Outcome. Incomes of oyster-fisherwomen in at least 40 households of the Sherbro MPA increased by 45% pa and abundance/ mean-size of adjacent wild-oyster populations increased by at-least 18% over base-line levels.	Indicator 1. Annual income of oyster-fisherwomen increased by at least 45% above baseline levels through oyster culture Indicator 2. Contribution of wild-oyster culture to annual income of target-beneficiaries decreased by 50% during first culture cycle and 100% by the second cycle Indicator 3. Adjacent abundance and mean shell-size of wild-oyster populations increased by 18% (along with stable or increased cover of associated mangrove assemblages)	Project reports & peer reviewed publications (at least 2) Local media coverage of project initiatives	Containment of the Ebola outbreak will allow local and international project partners full access to project field sites. Sustained & sufficient demand will be exist for value-added ready-meals by consumers in Freetown
Outputs: **1. Sustainable production and collective management systems (WP2)**	1a. Technical and economic efficiency of alternative culture systems for at least two mangrove-oyster species (annual yield > 20kg/m2 substrate area) 1b. Spatial mapping and field surveys of wild oyster and mangrove assemblage abundance/ diversity indicating specified improvement above baseline levels 1.c LMC and/ or community area-management and collective production activity agreements	1a.Technical efficiency report 1b. Biodiversity report (inc. site maps) 1c. Livelihoods report and documentation of management agreements	Enhanced oyster culture and negotiated formal/ informal access rights can reduce fishing effort on wild oysters around culture areas.

	formalised and documented		
2. Supply chain enhancement (WP3)	2a Solar-freezer systems procured, adapted, maintained and operated by target-community-groups 2b Supply-chain systems operate effectively under seasonal conditions most associated with demand for value-added oyster products	2a. Procurement inventory and training/ operation reports 2b. Supply-chain enhancement 'action-research' report(s)	
3. Market promotion and value-addition (WP 4)	3a Sales inventories of producer-groups and buyers increased in Freetown compared to baseline levels 3b Project and media reports of outcomes of the oyster recipe competitions documented	3a. Market report inc. testimonials of producer groups, supermarket and food service-sector stakeholders 3b. Coverage by local media and project website	Market demand for value-added oyster products is not significantly depressed by the Ebola outbreak over the project duration.
4. Training and dissemination (WP1)	4a. Documentation of curricula and attendance at 2 Farmer Field Schools (FFS) and final project workshop 4b. Relevant decision-makers as identified by stakeholder analysis rate usefulness of policy briefs on a five point scale. 4c. At least 2 peer-reviewed primary research papers made available in open access format.	4a. Training manual, FFS and workshop reports. 4b. Policy brief evaluation report 4c. Papers submitted to appropriate peer-reviewed scientific journals	
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) Activity 1.1 Multi-stage sample-design for selection of 6-8 intervention-communities according to social & environmental criteria (e.g. harvesting mangrove oysters along salinity and primary-productivity gradients) Activity 1.2 Environmental, rapid rural appraisal (RRA) and household livelihood surveys for selection of target-households and establishment of			

intervention baselines.

Activity 1.3 Development of initial oyster artificial-substrate based culture-technology and depuration options

Activity 1.4 LMC and/or community agreements brokered on collective-production activities and extractive-restrictions in adjacent mangrove oyster-nursery areas

Activity 1.5 Initial training of 40 wild-oyster harvesters on oyster-spat collection and culture techniques

Activity 1.6 Adaptation of artificial-substrate based oyster culture techniques (e.g. post, tray, raft, long-line) through two full iterative phases of action research

Activity 2.1. Procurement and adaptation of solar powered freezers for transport of oysters from the Sherbro MPA to free town under variable seasonal conditions

Activity 2.2. Training staff/ beneficiaries in operation and maintenance of freezer plant

Activity 2.3. Seasonal testing of freezer systems & cold-chain implementation

Activity 3.1. Analysis of markets for premium oyster-based products (and their substitutes) in Freetown and other regional markets

Activity 3.2. Staging of regional and national oyster recipe competitions

Activity 3.3. Development and testing of value-added oyster ready meals with super-markets, restaurants and beach-bars in Freetown

Activity 3.4. Evaluation of wider international demand & market-based certification potentials & statutory recommendations for MPA policy-makers

Activity 4.1. Establishment of project web-site (with links to partner web-sites and the regional Sarnissa research network

Activity 4.2. Extension to neighbouring communities through 2 ‘Farmer Field-Schools’ (in each case for separate female and male groups).

Activity 4.3. Regional best-practice/ policy workshop (inviting participants from comparable initiatives in Benin, The Gambia, local EJF project, MPA representatives)

Activity 4.4. Project reports & publications (x2) on environmental social and economic sustainability outcomes in international peer-reviewed journals

Annex 3: Standard Measures

Table 1 Project Standard Output Measures

Code No.	Description	Gender of people (if relevant)	Nationality of people (if relevant)	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the
2	Aquaculture MSc student dissertations	M &/or F	TBC	0	1	1-2	0	2-3
6A	Initial training of 40 wild-oyster harvesters on oyster-spat collection and culture techniques	Mainly F	Sierra Leone	3	0	0	0	3
6B	Weeks training on spat collection (above)	Mainly F	Sierra Leone	2	0	0	0	2
6A	Training staff/ beneficiaries in operation and maintenance of freezer plant	M &/or F	Sierra Leone	0	10	10	0	20 (tbc)
6B	Weeks training on freezer plant (above)	M &/or F	Sierra Leone	0	1-2	1-2	0	2-4
6A	Extension to neighbouring communities through 2 'Farmer Field-Schools' (in each case for separate female and male groups)	M & F	Sierra Leone	0	0	40-50	0	40-50 tbc
7	Freezer plant operation training manual FFS training manual	M & F	Sierra Leone, UK	0	1	1	0	2
9	Policy brief on intervention recommendations based on action research outcomes	M &/or F	Sierra Leone UK	0	0	1	0	1
11B	Number of papers to be submitted to peer reviewed journals	M & F	Sierra Leone, UK	0	0	1-2	0	1-2
12A	Excel database of abiotic, biotic and social mapping survey results - for research areas in Sherbro MPA	M &/or F	Sierra Leone, UK	0	0	1	0	1
14A	Regional best-practice/ policy workshop (inviting participants from comparable initiatives in e.g. Benin, The Gambia, local EJF project, MPA	M &/or F	Sierra Leone	0	0	1	0	1

	representatives)							
14B	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	M &/or F	Internatio nal – TBC	0	1	1-2	0	2-3
20	Estimated value (£'s) of physical assets (freezer & culture system equipment, to be handed over to host country(ies)	NA	Sierra Leone	0			0	
23	In-kind funding (£'s) through UoS MSc student participation	M &/or F	UK (UoS)	0	1000-2000	1000-2000	0	2000-4000
23	West African Regional Fisheries Project (Contribution in kind)	NA	Sierra Leone	5000	5000	5000	5000	5000

Table 2 Publications

Title	**Type** (e.g. journals, manual, CDs)	**Detail** (authors, year)	**Gender of Lead Author**	**Nationality of Lead Author**	**Publishers** (name, city)	**Available from** (e.g.website link or publisher)

- There have been no project publications as yet

Checklist for submission

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