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).
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Funder (DFID/Defra)	DFID
Start/end dates of project	1 Apr 2014 to 31 Oct 18
Reporting period	Annual Report 3: 1 Apr 2016 to 31 Mar 2017
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

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Glossary of Terms and Abbreviations

CBD	The Convention on Biological Diversity (1992)
CMA	Community Management Association
DI	Darwin Initiative
dd-RAD	Double Digest Restriction-site Associated DNA marker analysis
EJF	Environmental Justice Foundation (UK NGO)
FT	Freetown
GHI	Global Hunger Index (IFPRI)
HH	Household
IMBO	Institute of Marine Biology and Oceanography (Fourah Bay College, Freetown)
(I)RDP	(Integrated) Rural Development Program
LMC	Local Management Committee (with oversight for CMAs)
Lumi	A weekly (usually Sunday) open-air food market
MDG	Millenium Development Goals
MFMR	Ministry of Fisheries and Marine Resources
MPA	Marine Protected Area
NJU	Njala University
PI	Principle Investigator
SDG	Sustainable Development Goals
SSL	Sierra Leone Leones (Le: local currency)
UoS	University of Stirling

1. Project Rationale

Sierra Leone is the 4th poorest country in the world according the IFPRI World Hunger Index. Many Sierra Leonean fisherwomen living in coastal mangrove areas are trapped in a downward spiral of environmental destruction and resource depletion. Because they are poor, lacking capital and alternative sources of income, they are compelled to harvest oysters in what has become an increasingly widespread and unregulated seasonal activity. It is a hard and dangerous life, injuries such as infected cuts from roots and shells are common. Mangrove trees are damaged by the harvesting 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. The government is making efforts to regulate the fishing effort of artisanal fishermen; from the start of 2014, only 11,000 boats, mostly dug-out canoes (on which female oyster gatherers also depend) were registered and licensed to fish throughout the country. Agricultural and other livelihood opportunities are few in the research area; most inhabitants depend on exploitation of primary (aquatic, and forest) resources. Alternative livelihoods also need to be found for families excluded from fishing. Most of the commercial fish species in Sierra Leone also depend on the mangroves as spawning and nursery areas.

This project aims to support the work of the Marine Protected Area 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 native oyster 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). Subsequent research indicates that the oyster population may be more resilient to the prevailing hand-gathering methods than first anticipated (see 2017-2018 annual report), thus greater emphasis is now being placed on sustainable mangrove management linked to incentivising prudent oyster harvest and processing practices.

The primary research area and main target beneficiaries, i.e. female oyster gatherers and their households, is located in Bonthe District, Southern Province around the Sherbro River estuary, an area which includes the district administrative centre, Bonthe Town on Sherbro Island (Figs 1a-c). Sherbro Island borders the Atlantic Ocean to the west, and is separated from the African mainland by the Sherbro River in the north and by 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 is Cape St Ann, and on the eastern end, is the chief port and commercial centre of Bonthe. Fig 1c shows the location of satellite-communities identified in mangrove stands around Bonthe town. This is effectively the larger target-population to which project results will be generalizable.

Figure 1a-c: Location of project area in the Sherbro estuary and Bonthe town. The lower map (Fig 1c) shows locations satellite mangrove communities around Bonthe town (red-flags are focal research communities (Satellite image source: Google Earth 2016).

Most oyster 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). In the absence of roads and motorised transport, oyster-gathering, fishing and most local transport is highly dependent on having access to small (1 to 3 person) dug-out canoes.

Oysters are steamed for domestic consumption and local retail in more populated areas to the south of the MPA, especially Bonthe (Pop. ~11,000) and York (Pop. ~500) towns, together constituting Bonthe Municipality. Remoter 'satellite' communities with poor access to these retail markets must first steam then smoke-preserve their oyster (and fish) surpluses to stockpile and sell in one of two weekly mainland wholesale markets (*lumis*) with motorable road connections; Yagoi on the Sherbro River to the south and Gbambatok to the north. A separate tier of female vendors then transport and market the smoked oysters in inland population centres including Bo and Kenema. Relatively low volumes appear to reach Freetown where preferential demand for steamed demands is met from adjacent mangrove fisheries.

As a euryhaline species the mangrove oyster (*Crassostrea tulipa*) targeted by artisanal fishers is phenotypically adapted to estuarine variability. In the Sherbro estuary, most oysters are harvested from mangrove roots where their inter-tidal position results in high periodic natural mortality linked to low surface water salinity during the rainy season. Thus most harvesting pressure appears to be on single year-class cohorts capable of rapid growth under nutrient rich, warm water conditions. Despite observed increases in gathering pressure, oyster populations still appear to rebound on an annual basis due to a combination of residual breeding pools e.g. sub-tidal 'mud' oysters are more resistant to hand harvesting, high fecundity and rapid growth Taxonomic similarities between morphotypes associated with different substrate types are being evaluated. Findings suggest that the most pressing environmental threat linked to the fishery is mangrove depletion resulting from imprudent oyster harvesting methods, especially root cutting and use of mangrove wood as fuel for oyster processing.

Consequently a revised Log-frame incorporating several major changes to the original planned intervention options has been developed following extended consultation with all project partners and the Darwin Initiative (Section 10). This includes a shift from resource intensive aquaculture and solar cold-chain options in favour of post-harvest interventions with greater economic justification for sustained adoption. The revised higher-level project impact statement (Annex 2a) is now as follows

'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)'

2. Project Partnerships

The following project partners and affiliates collaborated on research activities in around Bonthe during the current reporting year:

1. Dr Francis Murray: Aquaculture development specialist, UoS (PI)
2. Mr William Leschen: Aquaculture development specialist, UoS
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
6. Mr James Green: Commercial oyster aquaculture specialist, Whitstable Oysters, UK
7. Mr Edward (Amara) Kalone: IUU project officer, Environmental Justice Foundation, Bonthe, SL
8. Dr Richard Quilliam: food borne pathogen analyses, UoS, UK
9. Mr Nicholas Shell: Sustainable aquaculture MSc project-student UoS.

PIs of the three principle collaborating institutions (see above) participated in a joint field-mission to Bonthe District from 3rd – 11th June 2016 (following on from a similar mission in

January 2016). The party was also accompanied by Dr Richard Quilliam (UoS) and Mr James Green (Whitstable Oyster Company). Objectives of the mission were: to (i) review progress and support field skills training and supervisory support for embedded staff including UoS MSc student (Mr Nick Shell; Apr-Jul 2016), (ii) to implement further primary research around oyster production, hydrography, faecal contaminants and nutrients analysis and marketing and (iii) to review and revise intervention options with consortium members and local stakeholders. This included Bonthe Municipal Council Mayor; Mr Layemin 'Joe' Sandy. Mr Kapindi (IMBO) and Mr Kalone (EFJ) remained based in Bonthe to coordinate longitudinal production, marketing and water quality survey work.

3. Project progress

Previous research outcomes (Annual report 2015/16) demonstrated flaws in assumptions on which original log-frame outputs 1 '*Sustainable production and collective management systems'* & 2 *'Supply chain enhancement'* were predicated (Annex 1). Consequently, the revised Log-Frame (Annex 2a) has replaced the more resource intensive planned aquaculture and solar cold-chain options in-favour a range of (mainly) post-harvest interventions determined to have greater adoption potential under local resource and market-conditions. The original Output 3 *'Market promotion and value-addition & 4 Training and dissemination'* has also been revised in accordance with these changes. Following is a summary of the revised intervention changes (see Annex 2b):

(1) Fuel efficient cookers: for steaming & smoking oysters to reduce operational costs and dependence on mangrove fuel: The following options will be assessed (1.1) Solar cookers – for primary (steam) processing (1.2) Fuel efficient wood-stoves for steaming and secondary (smoke) processing and reduction in water activity (Annex 7: Box A7.1)

(2) Value-added through extension of product shelf-life: in addition to the above technologies, we will assess potential for Low-cost evaporative cooling **t**o extend supply catchment for daily marketing of more valuable steamed) oysters to the largest local market in Bonthe Municipality (also conferring direct food security benefits).

(3) Other value-added processing of smoked oysters (& possibly steamed if solar dried) (i) vacuum packing to extend niche value-added sales of branded product e.g. retail outlets in Freetown and inland cities. (ii) Ready meals - for value-added local sales in absence of cold-chain (also using vacuum packaging). A recipe competition will be central part of the first Bonthe Oyster Festival (BOF: see below)

(4) Re-use of shucked oyster shell waste for low input/output aquaculture: (i) bottom-culture thought transfer of shell-waste middens to adjacent mud banks. Note: whitewash production will not be considered as considerable amounts of mangrove wood is likely to be used in its production.

(5) Training & Institutional capacity building: On interventions above identified as having greatest potential (i) seek exchange around best-practice, training & institutional capacity building support from Gambia 'TRY' Women's oyster association[1]. (ii) Institutional capacity building in Bonthe around centralised processing activities linked to MPA objectives where possible. Bonthe & satellite community engagement will also be built through mutually beneficial branding & promotion.

(6) Branding & promotion: (i) development of Sherbro logo and promotional materials **(ii)** Bonthe Oyster festival June 17 (with support of James Green, Whitstable Oysters UK) **(iii)** Media promotional coverage including local station Radio Bontico.

[1] http://oceansymposium.com/wp-content/uploads/2016/06/TRY-Oyster-Women%E2%80%99s-Association.pdf

3.1 Progress in carrying out project Activities

Due to rainfall-linked salinity fluctuations in the Sherbro estuary, most oyster harvesting activity takes place from late Feb to Early Sept with May to July being peak months. Most field activities were timed around this cycle. Primary research outcomes for current year are summarised in Annexes 4 to 9.

These outputs contributed to improved problem-framing under-pinning the revised project design and the design of follow-on activities in the project M&E plan.

An additional 13 in-depth semi-structured interviews with oyster value-chain and institutional stakeholders in Bonthe and the Sherbro MPA were conducted during the June Mission. Results were transcribed and content thematically classified consistent with project research questions. A total of 30 such rich in-depth qualitative interviews have now been logged (6 institutional, 6 market and 18 with members of oyster communities in and around Bonthe). These interviews provided the basis for the preliminary analysis on mangrove impacts presented in Annex 4. Anonymised transcripts will be inventoried as a project output (Log-Frame Output 6).

Differential residual current (RC) patterns across the MPA have potential to influence: faecal contaminants concentration, mud-bank distribution primary productivity, oyster spat fall and condition index. To assess RC, hydrographic surveys were conducted at strategic locations of the estuary at different tidal states over a 12month period (Annex 7). Results can be used to predict the location of mud-banks supporting mud-oyster fisheries. This work is be conducted in conjunction with longitudinal primary productivity (PP) and oyster condition index analysis. PP levels in 'pilot' water samples collected from Bonthe waterfront were lower than anticipated emphasising the significance of residual currents to nutrient replacement rates (Annex 6).

In a second more systematic survey of oyster faecal contamination, Dr Richard Quilliam (UoS) confirmed unacceptable human health risks associated with consumption of fresh (un-steamed) oysters sampled in the Sherbro MPA (Annex 8). Although further research might have been directed at simple depuration options (e.g. solar depuration) market research indicated sufficient supplies of oysters are locally available adjacent to target-tourist beach markets near Freetown. Furthermore no contamination risk was detected in 'rock-oysters' in waters subject to full oceanic dilution near these beaches.

Samples of fresh and processed (steamed, smoked and sun-dried) mangrove oysters from Freetown and the Sherbro MPA were also subjected to proximate analysis (UoS) to determine impacts of processing on nutritional profiles (Annex 7). Results indicate a significant (21%) decrease in the crude protein levels of smoked compared to steamed oysters; being the two main commercial product forms.

A preliminary review of smoked oysters sales collected from Yagoi weekly wholesale market on the mainland (Annex 9) from Jun to Nov 2016, confirms the large catchment and primacy of this market. Female harvester-processors travel by launch from sites up to 75km distant at the northern mouth of the estuary. Prices rise significantly following the onset of the rains consistent with a reported decline in oyster condition index. Rising sales volumes recorded over the same period probably reflect a lack of discrimination between smoked oysters and cockles; the latter more likely to be collected in higher salinity waters at the northern mouth of the estuary.

The water quality analysis reported in the last annual report i.e. based on a single sample point at Bonthe Pier were extended over the same time period to give over a full year of data (data not shown). Attempts to extend the analysis to York Town and other satellite village sites were largely unsuccessful.

Mr. Nicholas Shell a UoS MSc student conducted project-related field work with these staff members between April to July 2017 contributing to submission of dissertation paper. '*Evaluating the role of mangrove oyster (Crassostrea tulipa) production and marketing on*

livelihoods of fisherwomen in the Sherbro River Delta, Sierra Leone; a mixed methods study'. The thesis has been uploaded to the project website.

3.2 Progress towards project Outputs

Progress against the revised project outputs are as follows and summarised in Annex 1:

Output 1. Secondary pressure on mangroves populations reduced through more fuel-efficient processing: Will be assessed as party of two MSc projects (i) coordinated by Dr Richard Wadsworth (Njala University) planned for 2018 using historic satellite imagery (Annex 10) combine with supervised land-use/ impact classification (ii) an empirical survey of mangrove exploitation practices associated with oyster harvesting and processing, including fuel efficiency assessments, planned for 2017 and coordinated by Dr Richard Quilliam (UoS). These survey's will be framed around preliminary research findings on mangrove exploitation patterns summarised in Annex 4.

Output 2. Profitability of female oyster gathering increased through testing and adoption of extended product 'shelf-life' and value added processing techniques: Interventions described in Section 3 to be evaluated with local stakeholders in next research period.

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: Will be assessed as part of an MSc project planned for 2017/18 coordinated by Dr Salieu Sankoh (IMBO). Hydrographic (Annex 5), primary productivity (Annex 6) and oyster condition index analysis will be used to assess the biotechnical feasibility of suitable sites.

Output 4. Demand for value-added products created through branding and promotion. Branding: A post-graduate intern with requisite marketing skills will be recruited to support evaluation of branded products through product placement exercises in target inland markets. A prototype logo has been developed (Section 12) and radio promotion initiated (Section 12).

Output 5. Sherbro women's oyster gatherers association established based on mutually beneficial cooperation around processing and market interventions: To be initiated in the next research period (see Sections 11 & 12).

Output 6. Research outputs documented & shared with target audiences: All interim project outputs to be uploaded on the project website and interim findings to be shared with primary stakeholders at first Bonthe Oyster Festival (May 2017)/

3.3 Progress towards the project Outcome

The revised project outcome is as follows: *'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'* (Annex 2a)

Associated revisions in development interventions were designed considering the following needs and risk analysis findings:

- Closer alignment with needs and capacities of the target female beneficiary group
- Reduction of unintended risks of increased resource extraction and elite-capture
- Reduction of pressure on mangroves assoc. with fuel use for primary (steaming) and secondary (smoking) oyster processing - potentially extending to reduction in use by males for smoking fish.
- Interventions accommodating very different resource & market constraints facing female gatherers in Bonthe Town and remoter satellite mangrove communities.

The efficacy of revised measurement indicators at will be assessed output and outcome level in the next research period. As the project is currently scheduled to end mid-way through a

seasonal production cycle in April 2018, a no-cost extension request has been submitted to the DI to extend the project to 31 Oct 2018.

3.4 Monitoring of assumptions

Critical monitoring of project assumptions lead to the major logical framework revisions comprehensively documented elsewhere in this report. Assumptions will continue to be monitored as part of the projects revised M&E strategy (Section 8).

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

Potential impacts of project interventions (Activities 1.1 and 1.2) on mangrove health with be assessed through empirical trials (e.g. of fuel efficiency; Activity 1a) combined with longitudinal survey of harvesting & processing effort in project villages (Activity 1.3) over the 2017 production season, validated against a survey of smoked oysters wholesale activity in Yagoi weekly market (Activity 1.4) number & origin of vendors, type and sales volumes). Longer term trends in coverage (Activity 1b) and population settlement (Activity 1.5) will be assessed though GIS analysis of satellite images (Annex 10). The stratified sample design presented in Table 1 (Section 7) will provide the basis for assessment of livelihood impacts on the primary stakeholder of female gatherer-processors.

Genetic (dd-RAD) mapping of oyster morphotypes associated with different inter and sub-tidal substrates will be used to verify the working hypothesis that sub-tidal mud-oysters which are more resistant to prevailing hand-gathering methods could represent resilient multi-year class breeding pools.

4. Contribution to the Global Goals for Sustainable Development (SDGs)

The projects revised objectives have potential to contribute to the following SDG's:

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

Goal 5. Achieve gender equality and empower all women and girls

Goal 10. Reduce inequality within and among countries

Goal 12. Ensure sustainable consumption and production patterns

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

The SDGs also emphasise improved monitoring, evaluation and accountability In this respect, the projects longitudinal mixed-methods social and environmental survey design is highly consistent with the SDGs target by 2020 to *"increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts."*[2]

As the MDGs were compromised by failure of aid-flows to materialise the SDGs have put sustainable, inclusive economic development at the core of the strategy in order to enhance the ability of countries to address social challenges largely through improving their own revenue generating capabilities. This objective is reflecting in the projects exit strategy around an economically empowered women's marketing association.

[2] https://advocacy.thp.org/2014/08/08/mdgs-to-sdgs/

5. Project support to the Conventions, Treaties or Agreements

Project objectives under the Convention on Biological Diversity (CBD) are highly consistent with national objectives underpinning establishment of the Sherbro MPA. The revised project logical-framework (Annex 2a) now places increased focus on mitigating mangrove destruction through promotion of more prudent oyster harvesting and processing practices. The project remains aligned to the conventions 3 main 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. Mitigation of the negative impacts of oyster production on the health of mangrove assemblages will also have wider benefits to ecosystem health.
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 2, Annex 2a) has also been designed to limit extraction pressure and secondary impacts on mangroves.
3. **Fair and equitable sharing of benefits arising from genetic resources**: exploratory analysis (Annual Report 2015/16) identified the most resource-poor dependents on the oyster fishery in remoter satellite communities lacking land-connections to Bonthe. This 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 lessons will be learned from other local development projects (Section 11). 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 is adopted to ensure there are no unintended negative impacts on these communities.

Despite repeated attempts by local partner Dr Sankoh it has not been possible to meet with the host country convention focal points in the last 12 months

6. Project support to poverty alleviation

Against a background of extreme poverty, it is noted that inhabitants of remoter satellite communities lacking land connections to Bonthe are amongst the neediest whilst also being the most difficult to reach. Consequently, processing and marketing development interventions will, as far as possible incorporate decentralised as well as centralised options (e.g. around branded packaging in Bonthe Town). This mix will be correlated with risks of 'elite-capture' assessed as partner of on-going stakeholder engagement and analysis. Direct benefits are not anticipated until the last 2 project years.

7. Project support to gender equality issues

The project explicitly targets female oyster gatherers and processors as the primary project beneficiaries. Female dominance in the profession is re-enforced by negative male attitudes of oyster gathering as 'a less serious' activity compared to fishing for example. However research has pointed to growing participation by some younger males in Bonthe Town; linked to their greater mobility in the use of dugout canoes for harvesting and lower entry costs compared to fishing requiring access to costly gears subject to theft. Further research effort will directed at assessing and quantifying this trend.

8. Monitoring and evaluation

The following research hypotheses, based analysis of qualitative data-transcripts with oyster gatherers in and around Bonthe (n = 18: Section 3.1) will be the basis for stratification of future primary stakeholder survey efforts (Annex 1) underpinning the projects M&E strategy.

Hypotheses 1: Gatherers with ready land-access or short canoe distances (up to 2-3km) have preferential access to more value-added markets for steamed oysters in Bonthe Municipality.

Hypotheses 2: Females oyster producers based in more exposed coastal locations (along the main estuary sea-channel) have lower mobility and autonomy in gathering decisions.

M&E survey efforts will be limited to eight communities in and around Bonthe Town classified according to these criteria (Table 1).

Table 1: Sample design for future stratification of community surveys based on (i) access to markets for steamed oysters (ii) female autonomy in gathering decisions linked to site exposure.

SN	Village	Code	Market Access	Female Autonomy	GPS lat/long	Description
1	Gbembeehun	GHN	Low	Lower	7°37'9.56"N 12°30'11.11"W	Islet main channel
2	Bomblake	BBK	Low	Lower	7°34'35.60"N 12°29'54.10"W	Shero Island main channel
3	Keigbe	KGB	Med	Lower	7°31'5.56"N 12°28'33.80"W	Islet main channel
4	Tokpumbu	TPB	High	Higher	7°32'57.87"N 12°33'5.89"W	Shero Island coastal creek
3	Mosakai	BTB	High	Higher	7°32'45.58"N 12°32'49.68"W	Shero Island coastal creek
5	Gbongboma	GBM	High	Higher	7°31'21.80"N 12°31'50.81"W	Shero Island inland creek
6	Yankain	YKN	High	Higher	7°30'10.86"N 12°29'28.76"W	Sheltered Islet coast
7	York	YRK	High	Higher	7°32'34.98"N 12°27'47.73"W	York Island river mouth
8	Kingjimi	KJM	High	Higher	7°32'5.37"`N 12°30'15.99"W	Bonthe Town

9. Lessons learnt

Working in the remote and poorly developed Sherbro MPA requires careful contingency planning i.e. to deal with erratic electricity supplies, communications and lack all but the most basic supplies in Bonthe Town, the districts central administrative headquarters.

Assuring the quality of longitudinal research efforts out with joint field missions partner institution principle investigators (PIs) has been a challenge due to a lack of suitably trained personal embedded in the MPA over the longer term. Conditions are particularly challenging during the rainy season, also the low season for oyster gathering. In the coming year we will team MSc students from local and UK research partner institutions (IMBO and UoS) to conduct collaborative field-research over 2-3 months during the production season (May to July). We will also look to recruit a suitably qualified person to mentor local staff and coordinate research over a longer period including the 'off-season'.

10. Actions taken in response to previous reviews

The review of the last (2015/16) annual report raised no specific questions relating to the projects progress to date. However the following clarifications were requested regarding the (then) proposed significant change request (at impact, outcome and output level) to the DI:

'It would be helpful for the DI to understand how decisions for the anticipated change request will be made and how the process will be managed. The reviewer would encourage the project

to work closely with the DI to ensure that the outcome and outputs are achievable within the timeframe to project end and that the project's M&E is designed in such a way that indicators are SMART and capable of monitoring cross cutting issues, including poverty alleviation, gender or capacity building'.

Having determined that the fundamental precondition of natural resource scarcity for investment in aquaculture is not met under prevailing resource and market conditions; a dialogue was initiated by the UK PI with project partners and affiliates on how best to refocus the project more explicitly on oyster supply chain development. Discussion around the following themes: Fuel efficient cookers; Extending shelf-life, Value-added processing, Re-use of shell-waste Training & Institutional capacity building, resulted in the intervention shortlist presented in Annex 2b. This internal review initiated during June 2016 field mission (Section 2) included consultations with local stakeholders including the Mayor of Bonthe Municipality. The revised logical framework was finally submitted to the DI for review later in the year and the final version agreed in Feb 2017. In this second iterative phase emphasis was placed on refinement of SMART indicators consistent with the above recommendations, resulting in the log-frame presented in Annex 2a. All revisions were circulated and agreed by the project consortium.

11. Other comments on progress not covered elsewhere

Numerous development organisations have implemented projects in the research area over recent years. However, all on-going programs are humanitarian in nature e.g. a mother and child nutrition and health care and infectious diseases programs are being implemented by Plan International and the Red Cross. Signage in and around Bonthe points to several recently terminated rural development programs (RDPs), notably by local NGO 'Green Scenery' (www.**greenscenery**.org/). However, most of these organisations are head quartered in Freetown with little or no permanent presence in Bonthe District, most RDPs are limited to 1-3 year project cycles and outreach limited mainly to Bonthe and York towns and more accessible neighbouring settlements. Despite a post-civil policy-trend towards more decentralised governance (Box 1), the Mayor of Bonthe, Layemin 'Joe' Sandy has complained about the growing marginalisation of Bonthe, once second only to Freetown in terms of economic importance as a coastal trading centre. Many government offices, including health and education have relocated from the Island to the main land town of Mattru Jong. The Government sponsored fisheries is cited as an egregious example of mal-development. Intended to boost the district's fishing industry through provision of preservation, export-manufacturing and provision of youth employment '*the project structure is now eroding and its vision lost in the fog of neglect*'[3]

The challenge for this project then, is to support development of a representative local marketing cooperative; that is truly embedded within the local community. Further effort will be made to identify and engage local influencers, especially female around the revised project objectives.

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

Box 1: Local Governance. A total of 19 local councils in Sierra Leone are governed by the Local Government Act 2004, giving councils legislative, financial and administrative powers. Bonthe is one such council. Some 149 traditional chiefdom administrations operate alongside these councils, each headed by a paramount chief elected for life from a ruling family of the chiefdom. The Chieftaincy Act 2009 specifies the functions of a paramount chief including serving as an agent of development in the chiefdom.

The basic chiefdom administrative unit is the 'section', made up of a number of towns or villages headed by a section chief (aka subchief). The paramount chief, chiefdom speaker (deputy) and section chiefs form a political hierarchy along with town chiefs and village headmen. A chiefdom committee of sub-chiefs and chiefdom councillors presided over by the paramount chief serves as an executive body to the chiefdom. Bonthe district incorporates 11 such chiefdoms. Bonthe Town, the district headquarters is strategically positioned at the center of the district and was once an important economic hub. It is surrounded by the chiefdoms of Dema, Sittia, Nongoba-bullom, Bendu-cha and Kuamebai-Krin.

http://www.clgf.org.uk/default/assets/File/Country_profiles/Sierra_Leone.pdf

12. Sustainability and legacy

During the June 2016 mission, project aims were presented by project collaborators (Francis Murray and James Green) on Bonthe local station Radio Bontico (Section 13) during a weekly public service 'Council Hour' show. The show which deals with local development related activity was entirely dedicated to the project. It also included a Q&A session with the host and Bonthe Municipality communications officer. The 'Bonthe Oyster Festival' planned for 2016 was also publicised. Radio is recognised as the most effective means of mass communication in Sierra Leone, with over 76% of the population regularly listening to local radio[4]. The local effectiveness of this channel became apparent during subsequent visits to remoter satellite villages and mainland sites where community members evidenced clear familiarity with the project. Earlier ambiguities regarding the project objectives arising from word-of-mouth communication were also largely resolved. Ready access to (numerous) local radio stations also presents an opportunity brand-promotion which will be exploited in the projects value-added oyster marketing strategy.

Research findings indicate economic incentives are likely to be the most promising means for promoting mutually beneficial action around environmental and social-equity objectives in the absence of any effective formal or informal regulation of oyster gathering or processing practice. Accordingly, following log-frame revisions (Annex 2a), the project's exit strategy will centre on development of a women's oyster marketing (rather than production) cooperative. Post-project sustainability will be underpinned by collective economic benefits associated with development and promotion of value-added products carrying the Bonthe oyster brand and its associated marketing messages (Fig 2). Collective marketing opportunities for dried/ smoked oyster products in larger inland markets, backed by local promotion will also be explored.

In addition we will present project outputs including an audio-visual presentation chronicling the first (2017) Bonthe festival at UK oyster festivals and other events to solicit external sponsorship to support future Bonthe events. This will include the annual Whitstable Oyster Festival coordinated by project partner James Green.

The potential will also be explored to use the sale of carbon-credits to promote improved mangrove stewardship linked to prudent harvesting and processing methods reducing CO_2 emissions (this could also be used to re-enforce marketing messages). Examples of community based initiatives along with details of audit and brokerage processes/ options are available at the following link: http://www.planvivo.org/plan-vivo-certificates/.

[4] http://www.bbc.co.uk/mediaaction/where-we-work/africa/sierra-leone

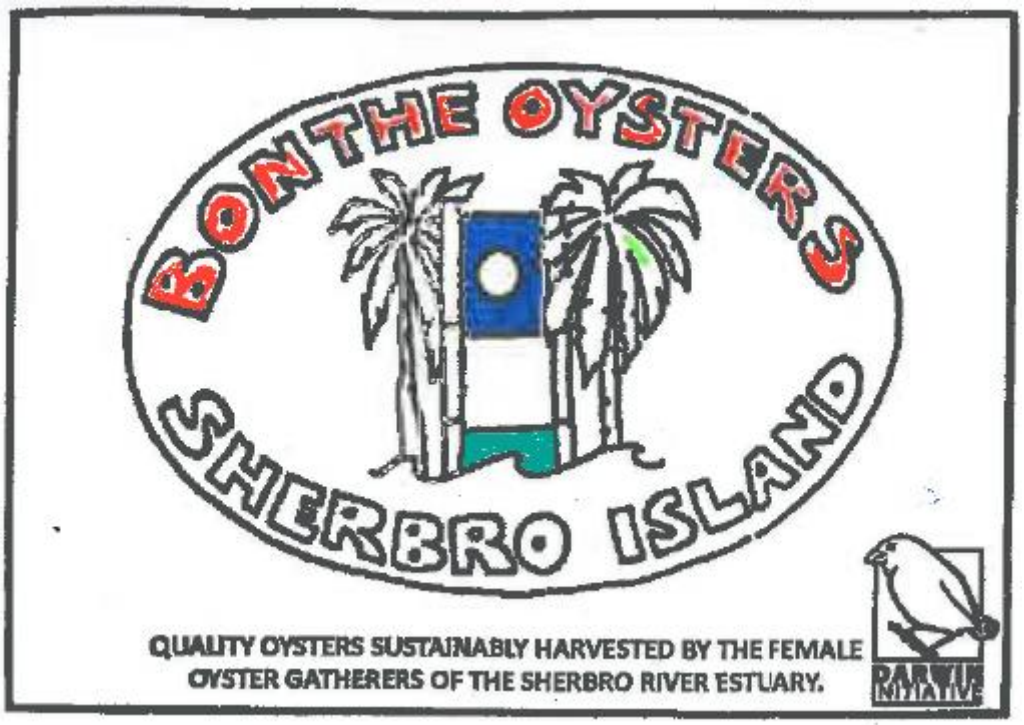


Fig 2 The pilot 'Bonthe Oyster' merchandising brand-logo, incorporating the DI logo (Courtesy of James Green, Whitstable Oysters).

13. Darwin identity

The project has been branded as the 'Bonthe Oyster Project' as part a marketing promotion strategy. The logo based on an iconic clock-tower on the water-front of Bonthe Town, has the Darwin Initiative logo embedded within it (Fig 2). Publicity materials for the forthcoming 'Bonthe Oyster Festival' including a poster and trade-journal article (The Grower: Annex 11) are similarly branded. All outputs on the project web-site and Facebook page carry the Darwin logo.

The Darwin Initiative was also publicised during Bonthe 'Council Hour' radio show hosted by local station 'Radio Bontico' (Section 12). The initiative was also introduced to staff and post-graduate students of the UoS Institute of Aquaculture during a project seminar given in January 2017 (Annex 11).

14. Project expenditure

Table 1: Project expenditure <u>during the reporting period</u> (1 April 2016 – 31 March 2017)

Project spend (indicative) since last annual report	2016/17 Grant (£)	2016/17 Total Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)	54,374.70	54,374.70	0	
Consultancy costs	40,682.24	40,682.24	0	
Overhead Costs	4,902.00	4,902.00	0	
Travel and subsistence	4,795.93	4795.93	0	
Operating Costs	182.37	182.37	0	
Capital items (see below)	642.36	642.36	0	
Others (see below)	0.38	0.38	0	
TOTAL	**105,579.98**	**105,579.98**		

Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2016-2017 (revised log-frame)

Project summary	Measurable Indicators	Progress and Achievements April 2014 - March 2015	Actions required/planned for next period
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).		Preliminary findings and stakeholder consultations indicate that incentives equitable sharing of costs and benefits will be best served through formation of a women's marketing association.	[redacted]
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.	Implementation to commence in next project period.	Key actions planned for next period; Action research on value-added interventions with local stakeholders Longitudinal (i) producer, market and (ii) GIS surveys to quantify contribution of oyster harvesting and processing practices on mangrove assemblages (these constitute two proposed UoS MSc student projects). Preparatory materials are presented in Annex4 and Annex 10. Indentification of locally embedded male and female influencers as first step formation of marketing assoc.
Output 1. Secondary pressure on mangroves populations reduced through more fuel-efficient processing	1a. 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. 1b. Contribution to reduction in mangrove clearance rates (over last decade) associated with fuel-efficiency gains and adoption quantified; normalised against historic trends in	Implementation to commence in next project period 1a. Secondary review of technologies in comparable development settings underway - resource inventory presented in Annex 2c 1b. Fuel efficiency experiments planned as part of UoS MSc student project.	

	coverage and population settlement trends.	
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.		Implementation to commence in next project period. Secondary review of technologies in comparable development settings underway
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		Implementation to commence in next project period. Secondary review of technologies in comparable development settings underway
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		Implementation to commence in next project period. This will constitute a proposed MSc project.
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 retail market		Ongoing activity; interim results presented in Annex 9
Activity 1.5 Trends in population settlement and mangrove coverage assessed using satellite images		Implementation to commence in next project period.
Output 2. Profitability of female oyster gathering increased through testing and adoption of extended product 'shelf-life' and value added processing techniques	2a. 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'. 2b. 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.	Implementation to commence in next project period. 2a. A post-graduate intern with requisite marketing skills will be recruited to support evaluation of branded products through product placement exercises in target inland markets.
Activity 2.1. Fuel-efficient pasteurisation options evaluated in conjunction with Output 1 activities		Implementation to commence in next project period. Secondary review of technologies in comparable development settings underway
Activity 2.2. Evaporative cooling and solar drying designs (for steamed oysters) evaluated with female oyster gatherers in Bonthe Town and satellite communities		Implementation to commence in next project period. Secondary review of technologies in comparable development settings underway

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		Implementation to commence in next project period. To be supported by same intern described above (Output 2) Resource inventory presented in Annex 2c
2.4 Value-added oyster ready-meal recipes developed based on locally available ingredients and potential market demand		A recipe competition open to contenders from the entire Bonthe District will be an integral part of the 'First Annual Bonthe Oyster Festival'. The event has already been publicised in a dedicated talk-show on local station Radio Bontico (Section 12)
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	3a. Harvests of 'mud-oysters' extended 2-3 weeks beyond the end of conventional harvests of inter-tidal oysters on mangrove roots.	Implementation to commence in next project period. To be the focus of a local (IMBO) student MSc project - project linked to hydrographic (Annex 5), primary productivity (Annex 6) and oyster condition index (CI) analysis.
Activity 3.1 Assess adoptability of enhanced mud-oyster fishery through placement of oyster-cultch on inter-tidal mud-banks with satellite communities		Implementation to commence in next project period. To be focus of local (IMBO) student MSc project (see above)
Output 4. Demand for value-added products created through branding and promotion	4a. Logo(s) adopted and used by local stakeholders in marketing of value-added products and recognised by consumers 4b. At least one branded product-line placed in at least one formal retail outlet increased by project end.	4a. Bonthe oyster logo has been developed (Section 11, Fig 2) along with publicity materials for the Bonthe Oyster Festival (Annex 11). 4b. Stakeholder engagement will be incorporated as part of Activity 2a (above)
Activity 4.1 'Sherbro' branding, logo, labelling options for value-added products developed and refined based on feed-back from local stakeholders		Logo will be evaluated as part of product placement research in next project period (see Output 2).
Activity 4.2 Demand for branded value-added products assessed through market survey and product placement with retail and food service outlets		To be evaluated in inland markets, including Bo, Kenema, Freetown and Gbambatok in next project period (see Output 2).
Output 5. Sherbro women's oyster gatherers association established based on mutually beneficial cooperation around processing and market interventions	5a. Formation of Sherbro Women's Oyster Association - formalised post Bonthe oyster festival (BOF Jun 2017) - incorporating best-practice adaptive learning from the Ghana TWOA model. 5b. At least 40 local women (from Bonthe & satellite communities) attend training on sustainable and	Implementation to commence in next project period 5b. Training (5b) to be embedded within two planned BOF events (see Activity 5.1).

	profitable oyster production and marketing during Bonthe Oyster Festival. 5c. 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 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 Ghana		Training on sanitary processing practices and review of prototype interventions to be incorporated in first BOF. Note: BOF date moved forward to May 2017 to fall out with the Muslim Ramadan Holy Month (26 May – 24 Jun). The 2nd 2018 BOF will be scheduled for late June (Ramadan 15 May – 14 Jun 2018).
5.2 Implement training of female oyster-gatherers on learning outcomes of outputs 1-4 as part of the BOF		Training on development interventions in second annual Bonthe Oyster Festival 2018.
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. 6b. Gender development learning-outcomes presented to an international audience in an oral session in at least one scientific conference. 6c. Policy brief developed and shared with local stakeholders.	6a Co-authored paper(s) to be drafted in 2018 pending development outcomes. A second paper based on dd-RAD sequencing of mangrove oyster morphotypes. Samples will be collected from the Sherbro MPA and Freetown regions for analysis by UoS partners. 6b Problem-framing paper abstract accepted for presentation in Iceland Seafood Congress, Sep 2017 (Annex 12). Paper outline presented in UoS seminar Jan 2017 (Annex 13). 6c Final project dissemination output scheduled for 2018
6.1 Policy workshop co-hosted with Bonthe Municipal Authority and Sherbro MPA		To be incorporated in second annual Bonthe Oyster Festival 2018
6.2 At least one scientific paper submitted to a peer-reviewed journal and presented at an international scientific conference		Submission of one or more draft papers scheduled for 2018 (see Output 6).

Annex 2a: Revised full- project logical framework (Feb 2017)

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. **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: **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	1a. 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. 1b. 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.	1a. 1a. End of project technical report on iterative demonstration trials with target beneficiaries and household baseline (2017) and monitoring survey outcomes (2018) - inc. photographic evidence. 1b. End of project technical report on survey (Activities 1.3, 1.4, 1.5) and associated modelling outcomes.	1a. 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 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. 1b. 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	2a. 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'. 2b. 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. 2c. As result of 2b - a concomitant decrease in fuel-use for secondary processing (smoking) of at least 50% by project end.	2a. Technical report on cost-benefit analysis (2018). 2b. Report (2018) on household surveys in 2017 (baseline) and 2018 (monitoring). 2c. Report (2018) on household surveys - 2017 (baseline) and 2018 (monitoring).	2a. 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. 2b. 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. 2c. 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	3a. Harvests of 'mud-oysters' extended 2-3 weeks beyond the end of conventional harvests of inter-tidal oysters on mangrove roots.	3a. 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	3a. 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

		harvesting based on photographic evidence.	large shell-middens in many satellite communities
4. Demand for value-added products created through branding and promotion	4a. Logo(s) adopted and used by local stakeholders in marketing of value-added products and recognised by consumers 4b. At least one branded product-line placed in at least one formal retail outlet increased by project end.	4a. 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. 4b. Retail and consumer testimonials and photographic evidence.	4a. (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) 4b. 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	5a. Formation of Sherbro Women's Oyster Association - formalised post oyster festival (Jun 2017) - incorporating best-practice adaptive learning from the Ghana TWOA model. 5b. At least 40 local women (from Bonthe & satellite communities) attend training on sustainable and profitable oyster production and marketing during Bonthe Oyster Festival. 5c. 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).	5a. Association constitution, membership and meeting activity documented 5b&5c. 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.	6a. Journal confirmation email. 6b. Conference confirmation email, online abstract or proceedings. 6c. Policy meeting attendance register and signed-testimonials on utility of policy brief	6b. Acceptance of abstract 6c. Adequate representation of female oyster gathers (within and around Bonthe) within the MPA institutional structure.

	6b. Gender development learning-outcomes presented to an international audience in an oral session in at least one scientific conference. 6c. Policy brief developed and shared with local stakeholders.	from local (MPA and municipal authorities) and national authorities.	

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 Ghana

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 2b: Intervention Review (F. Murray, S. Sankoh, R. Wadsworth, R. Quilliam, J Green - Sep 2016)

	Theme	Intervention	Potential	Comments
1	**Fuel efficient cookers**	**1.1 Solar steam cookers**	**High**	**Stage:** Primary steam processing oysters, villages Notes: Local (Freetown) availability of thermal solar units should be determined (before importing) & adapted locally for steaming purpose
		1.2 Fuel efficient wood-stoves	**High**	**Stage:** Secondary smoke processing oysters (& fish), villages Notes: Based on materials/ capacities within Bonthe District
2	**Extending shelf-life**	**2.1 Solar dryers**	**Med**	**Stage:** Drying steamed oysters (& fish), villages &/or Bonthe Town Notes: High challenges for decentralised operation
		2.2 Evaporative cooling	**High**	**Stage:** Steamed oysters, villages Notes: Pot-in-a-pot – Lunsar country pots (RW)
3	**Value-added processing**	**3.1 Vacuum packing**	**Med**	**Stage:** Smoked oysters villages &/or Bonthe Town • Notes: High food-safety risk (anaerobic bacteria) assoc. with vacuum packing exc. steamed oysters in absence of cold-chain • Electric-powered machines limited to Bonthe (foci for institutional capacity building – see below?)
		3.2 Ready meals	**Med**	**Stage:** Smoked oysters (in absence of cold-chain), villages &/or Bonthe Notes: Food safety assurance under ambient conditions may be beyond scope of this project?
4	**Re-use of shell-waste**	**4.1 Mud-bank culture substrate**	**Med**	**Stage:** Enhanced culture, villages Notes: Year on year laying may be required to demonstrate impact
		4.2 Whitewash production	**Low**	**Stage:** Value-added co-product, villages Notes: High risk of mangrove damage assoc. with processing
5	**Training & Institutional capacity building**	**5.1 Institutional capacity building – Sherbro Women's Prod Assoc.**	**High**	**Stage:** Centred in Bonthe (around centralised interventions)? Notes: Fostering collective action around shared provenance/ branding
		5.2 Gambia Tri-Oyster Festival Women's association exchange	**High**	**Stage:** Bonthe Oyster Festival Notes: Best practice knowledge exchange and training
6	**Branding & promotion**	**6.1 Develop Sherbro logo & promotional materials**	**High**	**Stage:** Pre. Bonthe Oyster Festival Notes: Separate for **Sherbro** Brand & **Bonthe** Festival (JG)
		6**.2 Bonthe Oyster festival June**	**High**	• Media: Radio Bontico support engaged - & Freetown? • Training & promotional videos

Annex 2c: Fuel efficient and value-added processing; resources & references

1. Solar steam cookers: To potentially eliminate dependence on mangrove fuel

Examples

http://solarcooking.wikia.com/wiki/Solar_Steamer
http://www.ebay.co.uk/gds/All-Solar-Ovens-are-Not-Created-Equal-5-Considerations-/10000000016505690/g.html

1.2 **Fuel efficient wood-stoves:** To reduce dependence on mangrove fuel

Examples:

https://www.sussex.ac.uk/webteam/gateway/file.php?name=the-next-generation-ideas-workshop-report.pdf&site=25

2. Value-added through extension of product shelf-life:

2.1 **Solar dryers (steamed & fresh oysters):** To reduce moisture content

http://www.fao.org/Wairdocs/X5434E/x5434e0f.htm FAO general shellfish Bangladesh
http://practicalaction.org/media/preview/10715 Practical Action Kenya
http://answers.practicalaction.org/our-resources/item/solar-dryers-in-kenya
http://nrgtechnologists.com/Solar_Dryer_Solution/nrg_solar_dryer.html
http://www.solare-bruecke.org/index.php?option=com_content&view=article&id=8&Itemid=8&lang=en
https://www.amazon.co.uk/s/?ie=UTF8&keywords=dehydrators&tag=mh0a9-21&index=aps&hvadid=2978590465&hvqmt=p&hvbmt=bp&hvdev=c&ref=pd_sl_17khn2u3g8_p Stacked food dehydrators
http://www.ebay.com/sch/i.html?_nkw=solar+dehydrator Solar hanging dehydrators Ebay
http://www.rainier.com/yurts/yurt-living/living-off-the-grid/solar-food-dehydrators/ Solar food dehydrators – hand made Italy

2.2 Low-cost evaporative cooling: To extend supply catchment for daily marketing of more valuable 1ry processed (steamed) oysters to Bonthe Town (& possibly more distant weekly markets e.g. Yagoi, Gbambatok)

Examples:

http://www.wikihow.com/Make-a-Pot-in-a-Pot-Refrigerator http://www.fao.org/climatechange/17850-0c63507f250b5a65147b7364492c4144d.pdf

3. Other value-added processing

3.1 Vacuum packing (smoked oysters & possibly steamed if solar dried?) - To extend niche value-added sales of branded product e.g. retail outlets in Freetown or regions.

Examples:

https://www.amazon.co.uk/s/?ie=UTF8&keywords=foodsaver+vacuum+sealer&tag=mh0a9-21&index=aps&hvadid=3170594485&hvqmt=p&hvbmt=bp&hvdev=c&ref=pd_sl_1ztpsdtq1v_p

Annex 3: Standard Measures

Table 1: Project Standard Output Measures

Code No.	Description	Gender of people	Nationality of people (if relevant)	Year 2 Total	Year 3 Total	Year 4 Total	Total to date	Total planned
2	Aquaculture MSc thesis	M & F	Vietnam/ USA Sierra Leone	1	2	2	1	5
3	Aquaculture Diploma	Male	Sierra Leone			1	0	1
4c	Post graduate field skills training	Male	Sierra Leone		1		0	1
6A	Training of local enumerators in survey methods	M & F	Sierra Leone	2	6	12	2	20
6A	Training on high potential post-harvest interventions extended to female gatherers during 2 Bonthe oyster festivals	M & F	Sierra Leone		40-50	40-50	0	80-100
9	Policy brief on intervention recommendations based on action research outcomes	M & F	Sierra Leone			1	0	1
11B	Papers submitted to peer reviewed journals	M & F	Sierra Leone, UK			1-2	0	1-2
12A	Excel database of abiotic, biotic, social mapping survey results - in Sherbro MPA	M & F	Sierra Leone, UK			1	0	1

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)
Evaluating the role etc[1]	MSc Thesis	Shel. N. TI	Male	Vietnamese/ American	Unpublished	Project website
[2] First Sherbro Oyster etc.	Trade assoc. Journal	Brown,J Murray,F Green,J	Female	UK	The Grower (ASSG)	http://assg.org.uk/the-grower/4532754744 *(Annex 11)
[3] *Oysters, mangroves, Ebola etc*	Power point present	Murray,F	Male	UK	Unpublished	Project website *(Annex 13)

[1] 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).
[2] Brown, J., Murray, F., Green, J. Mar-Apr 2017 *First Sherbro Oyster Festival* -'The Grower' Assoc. Scottish Shellfish Growers. No. 20: Photo news. http://assg.org.uk/the-grower/4532754744
Murray, F. 2017 *Oysters, mangroves & Ebola! Development problem-framing in a data-deficient environment;* A Darwin Initiative research project in Sierra Leone. Presentation given at the University of Stirling, 18 Jan 2017 (Unpublished)

Annexes 4 - 13: Supplementary materials evidencing of project achievement

Annex 4: Impacts of mangrove oyster (*C. tulipa*) production on mangrove biodiversity in the Sherbro Marine Protected Area (MPA), Sierra Leone (F. Murray).

4.1 Background: Prior research (annual report 2015/17) indicated that despite intensifying harvesting pressure, mangrove oyster populations appear relatively resilient to the normative hand-gathering methods in the MPA. Further effort is required to determine impacts of the industry on mangrove assemblages and associated biodiversity.

Three genera of mangrove species are found on the Atlantic coast of W. Africa; *Rhizophora, Laguncularia*, and *Avecennia spp.* (biodiversity here tends to be lower than in Asian mangrove forests). Species are frequently differentiated as red, white, and black mangroves on account of the colour of their wood (Saenger, 1995). Two *Rhizophora* morphotypes; one red (and relatively easy to split) and one white and *Avecennia* spp.; known as black mangrove have been identified in the Sherbro MPA (Thomas Lebbie; Pers. Comm. in Boardman 2017; the *Laguncularia* genus is reported to be rare).

Impacts can be direct; contingent on when and how oysters are harvested from mangrove roots or indirect through extraction of mangrove trees to use as fuel-wood for oyster processing. The following is a synthesis of qualitative research findings contributing to refined problem-framing assessment which will underpin implementation systematic impact survey in the second phase of mixed-methods survey design in 2017 and 2018. Objectives are summarised in the revised log-frame (Annex 2a)

Based on knowledge of seasonal and spatial variability in oyster gathering practice and effort, the following three approaches will used to estimate and triangulate associated mangrove extraction pressure.

1. (i) harvesting methods (root scraping or cutting) and (ii) mangrove-tree fuel-requirements for primary and secondary processing (steaming and smoking).

2. Volumes of steamed and smoked oysters sold at key market bottle-necks (Bonthe daily and Yagoi weekly markets for steamed and smoked oysters respectively.

3. Supervised classification of historic satellite imagery linked to knowledge of resource extraction patterns.

4.2 Primary determinants of aquatic resource extraction pressure

Oysters: Whilst some fishing rules including a ban on mono-filament nets linked to a canoe registration scheme are codified under MPA statues, as yet there appears to be little systematic enforcement of the rules, or capacity to do so. This deficit is more marked with respect to mangrove oysters. With no formal or informal codification of rights in national or MPA statutes,

customary norms and reciprocal expectations, mangrove oysters are an almost entirely open-access resource. Thus individual gatherers are effectively free to collect oysters where, when and how they wish.

Mangroves: Access to mangroves for fuel wood is determined in-part by informal restrictions on 'out-sider' harvesting adjacent to individual communities underpinned by residence-rights granted by local government; Bonthe Municipality in the case of Bonthe and York Towns and Paramount Chieftaincies in the case of satellite communities. Residents pay a nominal annual poll-tax to these authorities.

Market regulation: Marketing of these primary resources; mangroves, oysters and fish is also lightly regulated (for example a prescription on formal Sunday trading implemented during the Ebola crisis continues to be implemented such that the Yagoi weekly market has permanently shifted to a Monday). Furthermore currently there is little market segmentation beyond fresh/steamed and smoked fish and oysters or associated consumer quality demands.

This combination of *open-access*, *free-market* and *surplus resource* (under current population levels) characteristics means extraction pressure on primary aquatic resources is primarily determined in by three interlinked factors

i. **Labour and capital endowments:** household or individual labour (i.e. physical ability to harvest, process and market) and capital (i.e. canoe) endowments.
ii. **Production and market geography:** The geographic location of gatherer communities in relation to oyster resources and markets for steamed and smoked oysters
iii. **Seasonal environmental conditions:** The influence of tides and seasonal environmental/ weather conditions on biological cycles and gathering effort - and the relative risk of accidents associated with more or less exposed gathering sites.

The role of these factors in shaping oyster harvesting patterns and thereby mangrove and livelihood impacts is evaluated in the following sections.

These factors will also provide the basis for a stratified sample design for further longitudinal surveys of oyster harvesting and processing effort.

4.3 Gender and mobility: As the primary dependents on the oyster resource the above determinants have particular implications female gathering effort contingent on their mobility characteristics. In the absence of codified rights (see above), oyster access and gathering effort is determined primarily by two types of endowment (1) canoe ownership and (2) physical

attributes linked to gender - and the seasonal interactions of these factors with environmental conditions, other household income generating and marketing opportunities.
Most females share access to canoes owned by male family members who prioritise their use for fishing at night or on spring high-tides during the dry i.e. oyster-gathering season. Serendipitously, neap low-tides are favoured for oyster gathering. Despite their lower amplitude neap-tides are slower to turn than springs thus providing a longer window of gathering opportunity. Furthermore trailing roots can be lifted to expose lower-lying submerged oysters. Early morning tides can also enable same-day processing and are generally safer compared to low-tides nearer nightfall.

Some females do own their own canoes, often smaller '1 or 2' man craft. Others rent canoes from male owners on a daily basis; for between Le 5,000 to 10,000 for a 2 or 3 man boats[5]. These ownership patterns also reflect the fact that fishing is a year round activity whilst oyster gathering is highly seasonal.

Female canoe mobility is typically limited to a 3-4km radius around their home-base. In addition to individual physical attributes, range is contingent on (i) canoe-size; 1-man boats being most restricted in range as well as capacity and (ii) site-specific safety conditions; female gathering autonomy and effort appears to be highly correlated with the prevalence of fatal canoe accidents. Such risk is greater for communities sited along more exposed sea channels compared to those located along narrower, sheltered tributaries within mangrove stands.

Risk is elevated when canoes are fully-loaded; two fatal drownings of females in 2016 (from satellite villages along the main sea-channel to the north of Bonthe) were associated with carriage of freshwater supplies in windy conditions. Although knowledge of these accidents was widespread; restrictions appear relatively localised to affected and neighbouring communities (3 of 9 communities in the current study). An NGO worker described 'oyster-fever' contributing to a prevailing belief that jettisoning any surplus oyster load in rough conditions is more likely to unbalance a boat and increase than decrease likelihood of accident.

Following the above fatalities, women in the affected communities were limited to oyster gathering only when male family members were also available to crew. This tended to limit both the range and frequency of gathering trips. The duration of restrictions, which appeared to be mutually agreed, requires further clarification. However a long-standing prohibition was observed in one project community in a more exposed location underscored by the absence of any female canoe ownership.

[5] Prevailing exchange rate = $1 : Le 7700

Male participation in oyster harvesting: Prevailing male attitudes towards oyster gathering as a 'less serious activity' i.e. compared to fishing clearly contribute to conserving its persistence as female dominated livelihood activity. However, we found some evidence of growing male participation linked to economic incentives and lower capital entry requirements compared to fishing (i.e. for fishing gears). Greater paddling range also mean males are able to access remoter gathering sites beyond the access of most females. For example, one young male gatherer and other male friends regularly paddled over 7km to and from Bonthe on the same day across the main channel to remoter and less-exploited oyster beds on the mainland shore. This trend will be further evaluated in the coming season, noting that accident-induced joint male-female activity (see above) should also be differentiated from other examples of cooperative gathering with male family members which may increase harvesting range and effort.

4.3 Estimation of oyster CPUE: The previous discussion also highlights key factors that should be considered in assessment of oyster catch per unit effort (CPUE) under local conditions. CPUE measured as oyster yield/person hour/ per canoe unit-size requires knowledge of the following factors relating to effort (1&2) and yield (3):

1. Size and oyster holding capacity of canoe number/ gender of persons crewing canoe
2. Total person-hours in combined travel and harvesting
3. Oyster condition factor (CI) Here measured as ratio of dried meat to internal shell volume; as volume rather than weight of shells is the primary determinant of canoe load-capacity. Gatherers report that processed oyster yields (i.e. CI) are highly correlated with seasonal salinity levels. This, together with increased natural mortality, determines the end of the oyster season with the onset of the rainy season; typically in July-August.

Limiting or fixed factors: Most gatherers place more priority on maximising returns to capital (i.e. canoes) above labour inputs. Thus during the early dry-season when oyster densities are lower; travel distance and crew size may be increased to ensure a full-load can be harvested over a fixed 2hr low-neap-tide window. At the same time gatherers must also coordinate harvesting effort to optimise expense and effort involved in processing which is in-turn contingent on geographically determined marketing opportunities. Gatherers based in or within a short walking distance of Bonthe Town, the largest local population centre maximise profits by limiting processing to primary processing and 'hawking' steamed oysters to local consumers.

Given the high perishability of steamed oysters, this market is only accessible to those within a relatively narrow radius of Bonthe able to process, travel and market oysters on the same day. Gatherers based in or very close to Bonthe may also incorporate gathering on the same day.

However**,** oysters can be kept alive by keeping them submerged in sea-water for several days post-harvest such that gathering can be decoupled from this time-table to some degree i.e. processing might be initiated only when sufficient oysters have been harvested to fill a commercial processing vessel and/ or sufficient quantity to merit a journey to Bonthe.

Consequently processing vessel capacity or canoe size may be first limiting factors under different conditions. Alternatively they may be strategically correlated, such that given favourable tides and market proximity during the peak-harvesting season, a gatherer has potential to fill their craft and complete primary processing of steamed oysters in a single day. This is less of an issue for remoter communities who must also smoke and stockpile their oysters for sale at weekly wholesale markets e.g. Yagoi.

Seasonal effort patterns: Low oyster condition factor and more inclement weather result in negligible oyster gathering activity between August-September to December. Effort then starts to increases progressively from late January-February onwards. Combined journey & harvesting times also decrease from up to 5hrs during the early 'lean season' to 3-4 hrs in the main season (Feb-Mar onwards). Gathering opportunities then become more localised and increased CPUE also correlates with increased processing frequency.

4.4 Oyster harvesting practice and mangrove impacts: Female gathering activity (observed in January and June 2016 revealed to dominant harvesting patterns correlated with seasonal CPUE factors:

(i) Gatherers are more likely to selectively scrape larger inter-tidal oysters ('shooters' or surviving multi-year class?) off exposed mangrove roots using 'cutlasses' early in the salinity-determined annual growth cycle.

(ii) Later in the season gatherers cut whole roots loaded with more mature oysters. Safety issues are also an incentive for 'cutting' as oysters easily cause cuts such that gatherers wish to avoid any unnecessary contact. Hanging roots are also likely to be cut where gatherers in their canoes are exposed to strong currents.

During the peak harvesting season (May-July) female gatherers are likely to return with full canoe loads of oysters (mostly on roots) enabling simple estimates of effort based on yield estimated for different canoe sizes (Table A4.1).

Table A4.1 Average yield per full canoe load as cups of steamed oysters

Canoe size/ season	Lean season (Jan-Feb)	Main season (Apr-Jul)	Early rainy season (Jul-Aug)
1-man		15	8-10
2-man	25	22-30	8-10
3-man		30	8-10

Note: seasonal timing are subject to inter-annual variability in rainfall patterns.
Male gatherers tend to be capable of harvesting oysters over a much larger geographic range and in more exposed conditions than females. Where root cutting occurs, males appear more likely to scrape and discard the roots whilst in their boats to maximise carrying-capacity over longer boat journeys. Women are more likely to undertake all processing back in their villages; steaming oysters 'on the root'.

The extent of damage caused by selective removal of oysters resulting in removal of the root surface layer remains un-determined. Despite some evidence of some social approbation against more extreme root-cutting, this appears more effective in shaping behaviour around fuel-wood than oyster extraction. For example respondents described informal prescriptions on harvesting the fringing mangroves that afford their settlements storm protection. Conversely we were advised that requesting an oyster-gatherer to stop cutting-roots 'would only result in an abusive response!'

4.5 Other anthropogenic pressures on mangrove populations?

Mangroves are primarily harvested for use in (i) construction and (ii) as a fuel-wood for domestic as well as seafood (fish, shellfish and oyster) processing.

Construction: Buildings in satellite communities are of wood and mud construction as is most new construction in the periphery of Bonthe and York Towns. As yet we know little of these construction practices and demands for mangrove wood relative to other substitutes.

Fuel-wood: Amongst satellite communities' wood is the primary, or only source of energy for domestic cooking and processing of seafood harvests. Primary processing (steaming) of oysters facilitates shucking, whilst secondary processing (smoking) of oysters, fish and other seafoods (crabs and shellfish) extends storage-life enabling periodic sales on local markets. Exploitation and sale of fuel-wood is primarily limited by the effort required to extract it, being highly labour intensive with only hand tools to harvest and un-motorised canoes to transport it. As the economic costs of entry to the sector are so low and physical demands high, commercial extraction is mainly practiced by younger males lacking resources to invest in fishing gears. Some males combine fishing and commercial mangrove harvesting as a secondary activity. Female involvement tends to be more localised; for example in one instance offering 'farm-gate' sales to buyers visiting their village to purchase processed oysters.
One such 25yr old interviewee paddled mangrove wood extracted close to his home, 2-3km to sell at the central (Heddle Road) market in Bonthe twice per week, 'resting in between'. A full-load in his 2 man canoe retailed for around Le 40,000. All sales are by approximated weight

and volume; the smallest lots consisting of four split logs <1m in length and weighing 8.7-10.5kg retailed for Le 1,000 per bundle in June 2016. The largest lots observed retailed for Le 5,000.

Commercial extraction appears to be limited to a short-radius around demand in population centres, especially Bonthe (for reasons indicated above). At a micro-scale extraction appears to be concentrated within short-carrying distances to canoe loading points. The commercial market also favours larger split-logs over smaller 'sticks'.

Differences in the relative ease and cost of transport of different fuel types e.g. bush and mangrove wood is likely to be one factor determining retail price and substitutability. Fuel efficiency is a second; locals differentiate between just two mangrove types, red and white. Red is considered to burn longer and hotter than white mangrove. This corresponds with 3 dominant mangrove species in the MPA and W. Africa. Non-mangrove 'bush' trees are favoured for charcoal production; demand for which remains to be quantified.

Alternative energy sources?: Better-off inhabitants, mainly in Bonthe have access to petrol generators. Bonthe, York and some larger communities have also had solar street-lighting installed through development interventions, though life throughout the MPA mainly follows natural day and night cycles. Further insight into the use of petroleum fuels (e.g. paraffin) for domestic energy requirements is required.

Agriculture?: very little remains of traditional export-orientated commercial agriculture sectors (e.g. palm kernel, piassava) practiced on York and Sherbro Islands during the colonial period. Highly limited availability of inputs (quality germplasm, agro-chemicals and mechanised plant) restricts today's production to small-subsistence vegetable/ fruit plots around settlements, rice-paddy around interior freshwater swamps and along inland river banks on the margin of mangrove areas and a limited oil-palm stands. Shifting '*swidden*' (slash and burn) is still common, but in bushland (i.e. non-mangrove areas. Thus impacts of agriculture on mangrove clearance appear relatively limited.

Aquaculture: Pilot trials using mangrove wood to construction oyster racks – indicated a very short (3-4 month) life expectancy for cut mangroves submerged in seawater. Preliminary findings on the use of 'red and white' mangroves for commercial oyster and seafood processing was reviewed in the last annual report.

Demography & mangrove extraction pressure: Limited livelihood opportunities in the two main island population centres of the MPA Bonthe and York Towns have stifled their population growth (saline-intrusion is actually reducing the population on York Island). Instead most growth appears to be through settlement of small 'satellite communities in fringing mangroves along

interior coasts to extract primary resources e.g. fishing, oyster and mangrove products. Settlement on smaller islets is limited by access to freshwater which needs to be canoed in. Settlement and resource management patterns are also complicated by the movement of transient populations exploiting seasonal or longer-term fishing opportunities.

4.6: Survey topics: This assessment will underpin the design of longitudinal survey around the three areas specified in Section 4.1 i.e.

(1) Harvesting methods and fuel requirements of different mangrove species for processing steaming and smoking oysters.
(2) Assessment of volumes of steamed and smoked oysters sold in Bonthe and Yagoi markets
(3) supervised classification of historic satellite imagery to determine localised impacts of oyster gathering and processing on mangrove forests (see Annex 10).

Survey 1 may also address - cooking-specific fuel requirements linked to local food consumption preferences (e.g. longer boiling of smoked v steamed oysters)
Survey 2 (longitudinal) will assess ratios of fresh to processed sales of seafoods and their geographic and seasonal production patterns

References:

Boardmam, E.,Sankoh S., Carboni S., Leschen L., Wadsworth R., Murray, F. 2017 Factors influencing the access to improved livelihoods of oyster harvesters in the sherbro river estuary, sierra leone; a mixed methods study. MSc dissertation, University of Stirling, Unpublished.

Saenger, P., 1995. *The mangrove vegetation of the Atlantic Coast of Africa: a review,* s.l.: Southern Cross University: School of Environment, Science and Engineering Papers.

Annex 5: Sherbro MPA Hydrographic survey of Sherbro MPA residual current patterns (F. Murray, T. Telfer, N. Schell)

5.1 Introduction: The main purpose of this survey effort was to assess residual current patterns (direction and speed) across full (high to low water) tidal cycles.

Residual current patterns can also be expected to be a predictive determinant of the following factors associated with other work-streams:

i. Spat-fall distribution patterns
ii. Food-safety risk associated with dispersion of human faecal materials
iii. Oyster growth potential and condition index associated distribution/ replacement of nutrients under-pinning primary productivity.
iv. Distribution of mud-banks as substrates for 'mud-oysters'

Simple hydrographic surveys were conducted at more and less exposed locations along the main sea channel separating Sherbro Island from the mainland.

5.2 Methods: Current velocity and direction were collected by mapping the GPS coordinates of 3 near-neutrally buoyant floats with low wind resistance at approximately 10 minute intervals over approximately one hour. Multiple transects were initiated at the same origin for each of the 6 sites indicated in Fig A5.1 and Table A5.1. As far as possible, in each case transects were initiated at the same four tidal points; mid ebb and mid flood, high and low slack water on the same and/ or concurrent days within a tidal cycle (tides around Bonthe are semi-diurnal with a maximal spring-tide range of 1.6m). Resource limitations precluded a factorial design incorporating matched neap and spring phases. Sites encompassed a range of more and less sheltered/ exposed locations along the main sea channel separating Sherbro Island from the mainland. Depth measurements were also collected at the transect start middle and end points using a weighted line.

5.3 Analysis: Using MS Excel and following the method of Asmah et al (2015) current speed and direction data were used to calculate net residual current (speed and distance) between individual, start and end points of each transect and a net value across all transects (i.e. tidal points) measured at each site. Transects were also visualised for each site in a (i) track plot; with each transects distance and direction plotted from a unified origin (ii) a residual current plot, with each successive transect plotted from the end-point of the last; the distance between the start and end points of the first and last transit being indicative of the sites net residual current across tides.

5.4 Results and discussion: Mean current speeds of individual transects ranged from 0.95/ 0.96m/s at the Bonthe and York sites to 0.18/ 0.21m/s at the York and Mania-shore sites.

However, interim results indicate higher inter-tidal residual current in more exposed N-S sea channel sites on the inland side of Sherbro Island i.e. Yankain, Bomblake and the Mania-channel, whilst lower currents were observed in sites adjacent to Bonthe and York Towns. The greater depositional nature of such lower currents is also consistent with the presence mud-banks supporting important 'mud-oyster' fisheries in both these locations. The flat at the York site is particularly extensive, located as it is at the mouth of the Jong River and the confluence of three currents i.e. from the river and the N & S arms of the Sherbro Channel. This is reflected by a markedly cruciform tidal plot (Fig A5.3a), whilst a more bidirectional inter-tidal pattern was observed at the Bomblake and Yankain sites (based on 4&3 transects respectively).

5.5 Future direction:

- Complete mapping of any of the four tidal points outstanding for existing sites
- Undertake full mapping of an additional more-sheltered mangrove channel/ creek with abundant oyster yields (Bontibai Creek immediately N of Bonthe).
- Harmonise the collection of periodic Chlorophyll-a sample and mud/ mangrove oyster condition index measurements at the same sites
- Collect other key water quality parameters (temperature, salinity, Secchi depth - & DO) from the same sites when any other samples are collected.

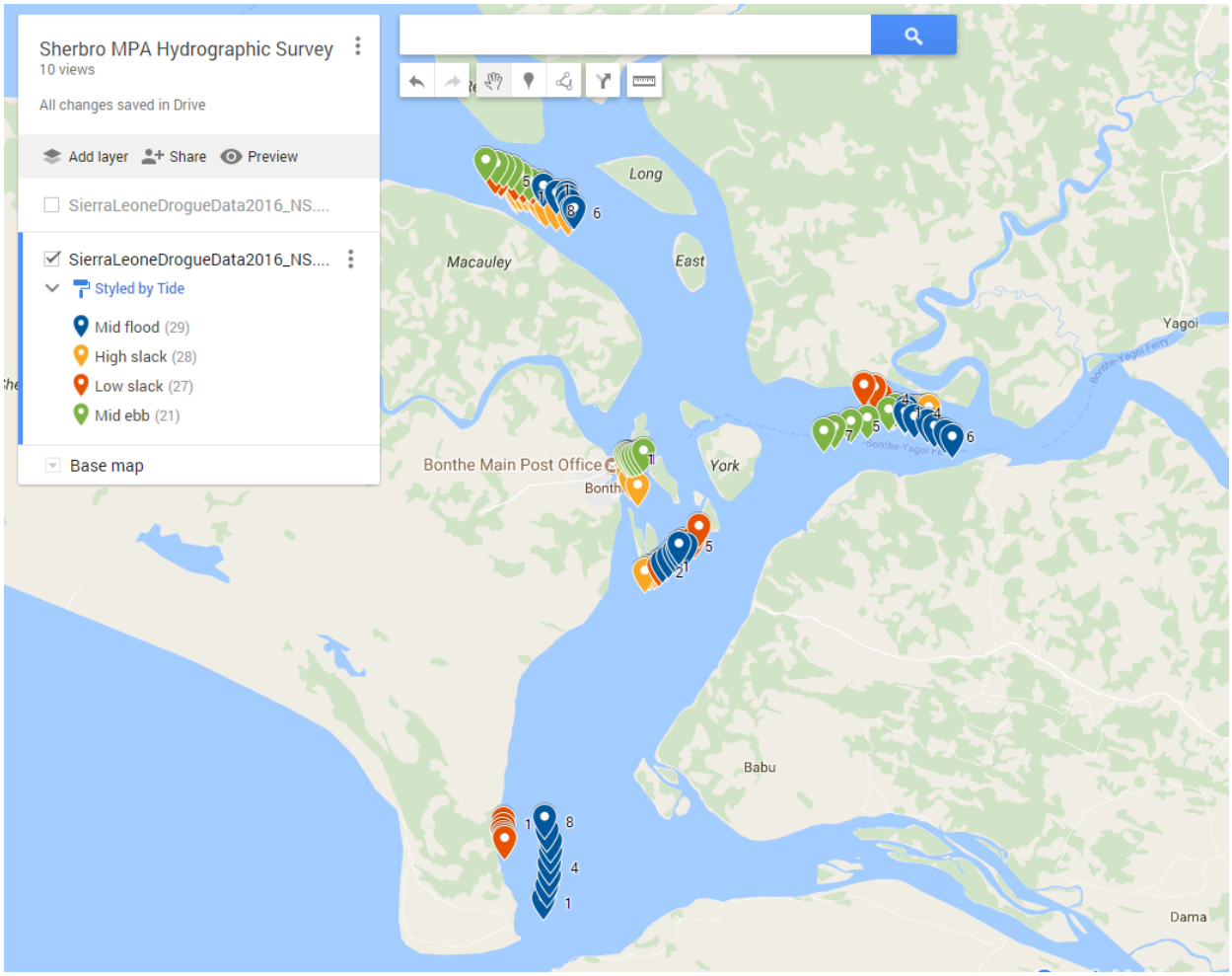


Fig A5.1: Location of hydrographic transects at different tidal states

Table A5.1: Summary of residual speed & distance analysis from 6 Sites

Site	Tide	No Marks	Mean speed (m/s)	Mean Direction (degrees)	Residual Distance (m)	Residual Speed (m/s)	Net Residual Distance (m)[1]	Residual current direction (°)
Mania - channel	Mid flood	8	0.62	90	2573	0.84	-	-
Mania - shore	Low slack	6	0.21	279	592	0.13	-	-
Yankain	Low slack	7	0.50	43	1783	0.49	[2042]	295 °
	Mid flood	7	0.31	56	776	0.26		
	High slack	7	0.37	174	564	0.19		
Bonthe	High slack	5	0.96	271	1519	0.63	[973]	-
	Mid ebb	7	0.18	186	580	0.20		
York Island	Low slack	7	0.35	136	1142	0.32	855	283 °
	Mid flood	7	0.52	320	1777	0.59		
	High slack	7	0.34	110	1146	0.38		
	Mid ebb	7	0.95	222	2455	0.82		
Bomblake	Low slack	7	0.43	154	1562	0.42	1011	27 °
	Mid flood	7	0.38	315	1248	0.40		
	High slack	10	0.37	278	804	0.26		
	Mid ebb	7	0.50	178	1750	0.58		

[1] Figures in square brackets [ ] are based on partial coverage of tidal cycles (<4)

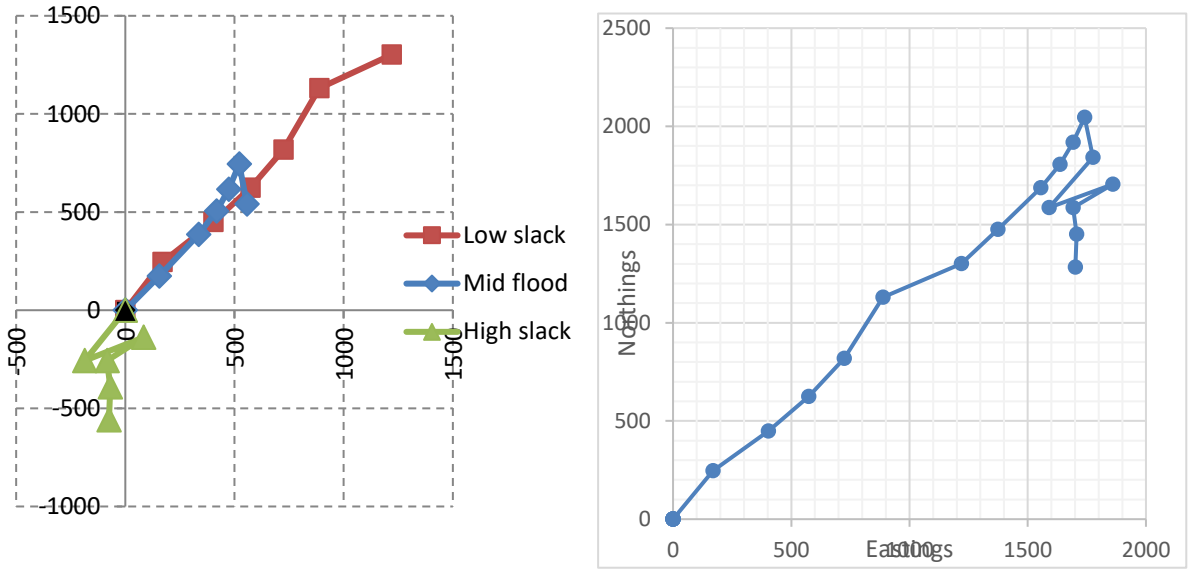


Fig A5.2a&c: Track plot (a) and residual current plots, Yankain site (centre channel)

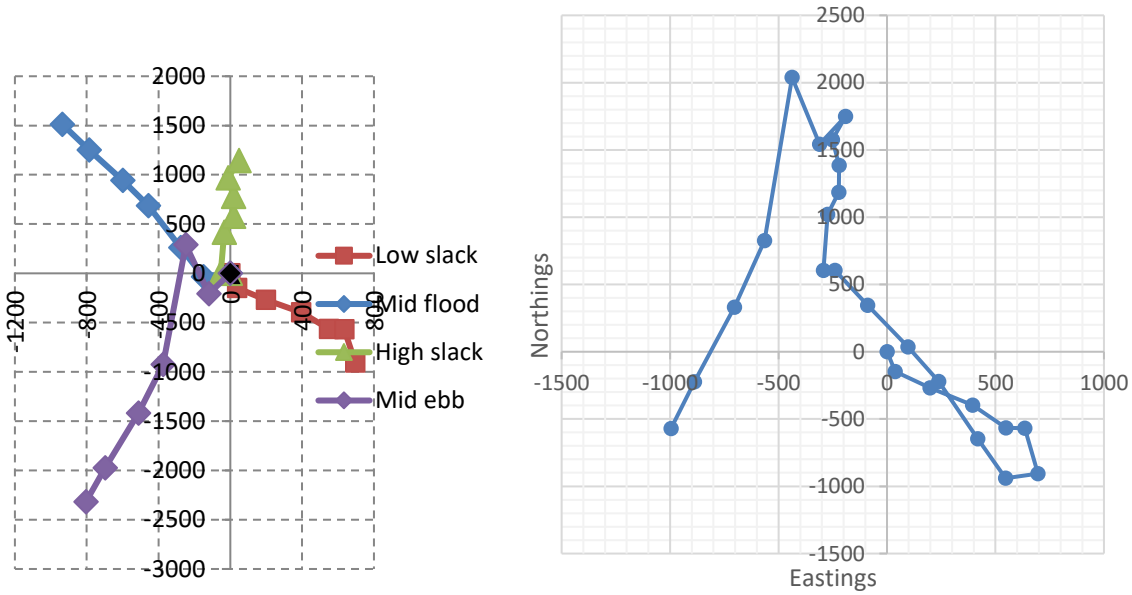


Fig A5.3a&c: Track plot (a) and residual current plots, York site (confluence 3 currents)

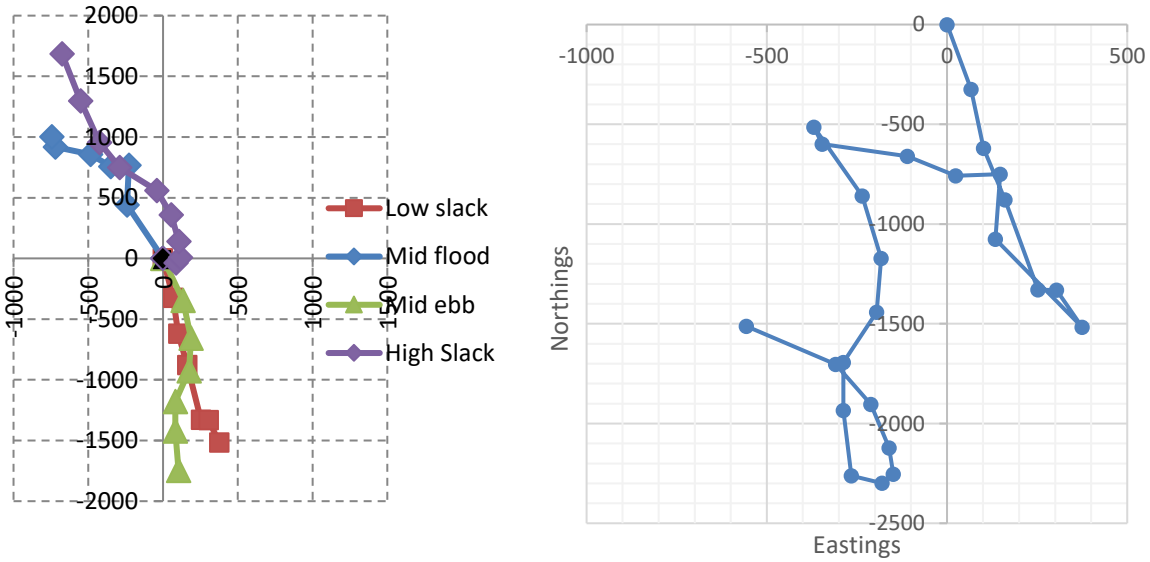


Fig A5.4a&c: Track plot (a) and residual current plots, Bomblake site (near shore)

Reference: Asmah, R., Karkari, A., Falconer, L, Telfer, T., Ross, L. 2015 Cage Aquaculture in the Lake Volta, Ghana: Guidelines for a sustainable future. CSIR Water Research Institute, Ghana and University of Stirling. UK. 112pp. http://www.aqua.stir.ac.uk/GISAP/Ghana

Annex 6: Sherbro MPA primary productivity (chlorophyll-a) analysis (F. Murray)

Table A6.1 Preliminary Chlorophyll-a sampling results - Bonthe Pier 11 Jun 16, 07:30AM

Sample	Reps	ABS (750)	[Chlorophyll-a] ug/l	Mean [Chlorophyll-a] ug/l	SD [Chlorophyll-a] ug/l	Secchi/ water (cm)	Temp °C	pH	TDS (uS)	Salinity (ppt)
1 7:30AM High Water	1	0.012	2.78	3.03	0.39	44/ 144	29	7.4	397	29
	2	0.02	3.33							
	3	0.005	3.40							
	4	0.0019	2.63							
2 9:20AM Low Slack	1	0.02	2.48	2.58	0.09	41/ 44	30	7.4	344	30
	2	0.015	2.63							
	3	0.008	2.63							

Fig A6.1 Proposed sampling sites for longitudinal chlorophyll-a &oyster condition index analysis (Note: green flags indicate 5 proposed sample sites)

Table A6.2 Characteristics of 5 proposed longitudinal sampling-sites (See Fig A6.1)

Site	Latitude	Longitude	Name	Description
1	7°33'11.60"N	12°32'4.01"W	Gbongboma Creek	Tertiary mangrove channel
2	7°33'27.11"N	12°30'58.93"W	Bontibai Channel	Secondary mangrove channel
3	7°31'7.28"N	12°29'20.65"W	Mbendu Mud bank	In front of Bonthe town and source of mud-oysters samples for condition index analysis
4	7°30'18.29"N	12°29'17.25"W	Yainkain main Channel	Primary mangrove Channel - and source of mangrove oysters for condition index analysis
5	7°31'30.45"N	12°29'59.23"W	Bonthe Pier	In front of council guest-house (earlier samples collected from here)

Annex 7: Nutritional profile of fresh and processed mangrove oysters (F. Murray)

Introduction: This study aimed to assess the effects of the main forms of processing (steaming and smoking) together with ambient (sun) drying on gross nutritional profiles of the resulting products. The study focused exclusively on the mangrove (*C. tulip*a) morphotype as the main marketed form. Samples were collected from commercial gatherer-processors in June 2016, i.e. during the peak harvesting season. All processing with exception of sun-drying was also conducted by the same processors according to normal commercial practice.

Sample Design: Samples of different mangrove oyster (*C. tulipa*) product forms; smoked, steamed, ambient-dried and fresh were collected from two production sites (Fig A7.2); one in the Sherbro MPA (7.50302, -12.49149, UTM WGS84) and River No 2 beach south of Freetown (8.33399, -13.19799 UTM WGS84). Steaming and smoking of the Sherbro MPA samples was carried out local female processors as part of larger batch according to normative practices i.e. steaming (for around 20 mins) in a large covered steel trough and smoked (for another 40mins) on a cane rack over an open fire using *Rhizophora spp.* ('red') mangrove as fuel. 'Dried' oysters samples were spread on silver foil and sun-dried (by researchers) at ambient day-time temperatures of around 30^{o}C over 3 days. 'Fresh' samples were shucked and stored directly from the shell. The samples were chilled (-5^{o}C) and then frozen (to -20^{o}C) within 3 days of collection or processing.

Analysis: Proximate analysis was undertaken at the University of Stirling. Samples of 8-12 individual oysters were prepared as pooled homogenates (Table A6.1) and 3 replicates analysed per sample. Crude lipid content was determined gravimetrically after Soxhlet lipid extraction (Tecator Soxtec system 2050 Auto Extraction apparatus). Crude protein was measured by determining (Kjeldahl) nitrogen content (N x 6.25) using an automated FOSS 2300 Kjeltec analyser, Warrington UK. Moisture content was determined by oven drying samples at 110^{o}C for 16hrs and ash content through incineration of samples in a muffle furnace set at 600oC.

Results & discussion: Negligible difference was observed between the same product forms collected from different locations (Table A7.2). Crude protein levels were highest in the steamed samples (57% DM) and lowest in the smoked oysters (46% DM). Lipid levels were also highest in the steamed oysters (13% DM) and lowest in the sun-dried samples (3% DM; with lipids in smoked oysters constituting 9% DM). These results (Fig A7.1) indicate higher nutritional value is the retained in steamed compared to smoked oysters; the two dominant product forms available to consumers.

Moisture levels averaged from 72% - 84% for steamed and fresh oysters respectively and 35% for dried and smoked oysters. Although normally wholesaled with 1-4 weeks post-processing, smoked oysters were reported to be stored for up to 2-3 months by consumers, if sufficiently well processed. Although low moisture levels are indicative of lower spoilage risk this more accurately measured by water activity levels (aW: Box A7.1).

Further assessment is required to evaluate potential qualitative differences in fatty-acid and amino-acid profiles. Contingent on the processing method smoked foods may also become contaminated with carcinogenic polycyclic aromatic hydrocarbons and coal tar dyes (Frits & Soós 1980)

References: Fritz W, Soós K. 1980 Smoked food and cancer. Bibl Nutr Dieta. (29):57-64.

Box A7.1 Water activity (aW): is defined as 'the partial water vapour pressure (PVP) in a substance divided by the standard state partial vapor pressure of water'. In food scient the 'standard state' is usually defined as the PVP of pure water at the same temperature (whereby distilled water has PVP of 1). Higher aW substances tend to support more microbial activity. aW also increases with temperature except in some products with crystalline sugar or salt.
Bacteria typically require aW of at least 0.91 and fungi (i.e. for fermentation) at least 0.7. Water also migrates from areas of high to low aW i.e. 'smoked' oysters with low aW may spoil rapidly if exposed to humid air.

Reference: Rockland, L.B.; Beuchat, L.R. 1987.*Water Activity:Theory and Applications to Food* (2nd ed.). New York: Marcel Dekker

Table A7.1: Proximate analysis of fresh and processed oysters collected from the Sherbro MPA and a beach near Freetown.

Product Form	Sample Location	Sample Date	N (pooled oysters)	Moisture %	Ash %	% Crude Protein [1]	Lipids % [1]
Smoked	Sherbro MPA (Yankain)	09-Jun-16	12	35.4	7.1	46.3	9.1
Steamed			12	71.6	8.8	53.9	13.8
		08-Jun-16	12	72.7	12.6	63.4	13.0
Dried [2]	Freetown (River No 2 Beach)	06-Jun-16	12	35.0	14.5	54.8	3.1
			12	34.2	10.9	50.8	2.9
Fresh	Sherbro MPA (Yankain – near Bonthe Town)	08-Jun-16	8	87.0	16.4	57.4	13.6
			8	84.9	23.6	37.6	12.6
			8	83.2	42.0	53.9	13.1
			8	86.5	48.8	58.7	9.5
	Freetown (River No 2 Beach)	12-Jun-16	12	80.3	10.6	61.1	2.0
			12	82.6	11.5	38.8	1.8
			12	80.7	9.1	65.1	2.2
			12	85.8	10.7	54.7	2.2

Notes: [1] As % of dry matter [2] dried under ambient sunlight over 48hrs

Table A7.2 Summary of oyster proximate analysis results (mean and standard deviation)

Product Form/ Location	Moisture (%)	SD	Ash (%DM)	SD	Proteins (%DM)	SD	Lipids (%DM)	SD
Smoked, Sherbro MPA	35.4		7.1		46.3		9.1	
Steamed, Sherbro MPA	72.1		10.7		58.7		13.4	
Dried, River No 2	34.6	0.5	12.7	2.5	52.8	2.8	3.0	0.1
Fresh, Sherbro MPA	85.4	1.7	32.7	15.2	51.9	9.8	12.2	1.8
Fresh, River No 2	82.3	2.5	10.5	1.0	54.9	11.6	2.0	0.2

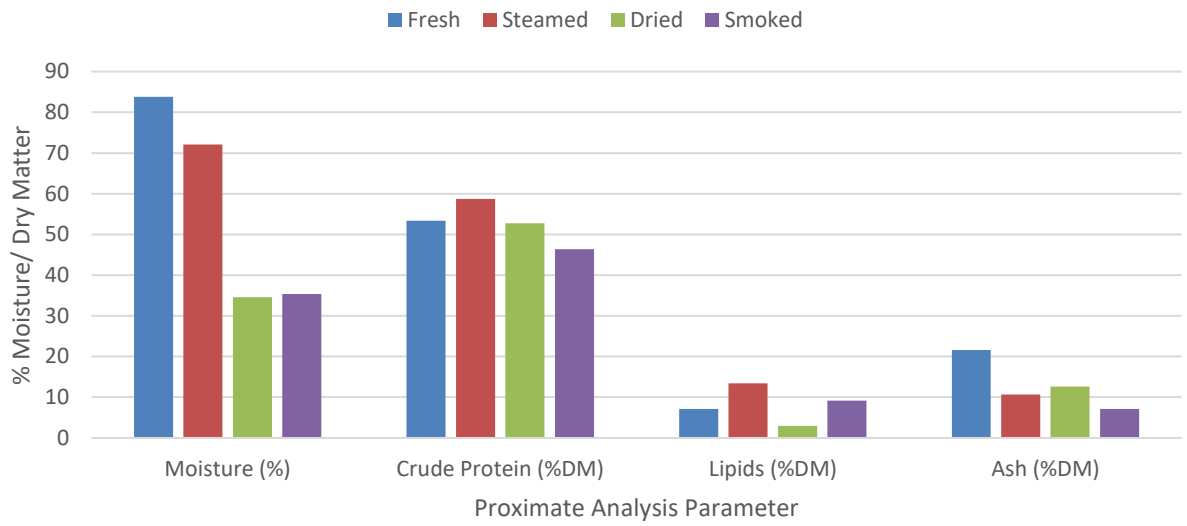


Fig A7.1: Summary of proximate analysis results by oyster product form

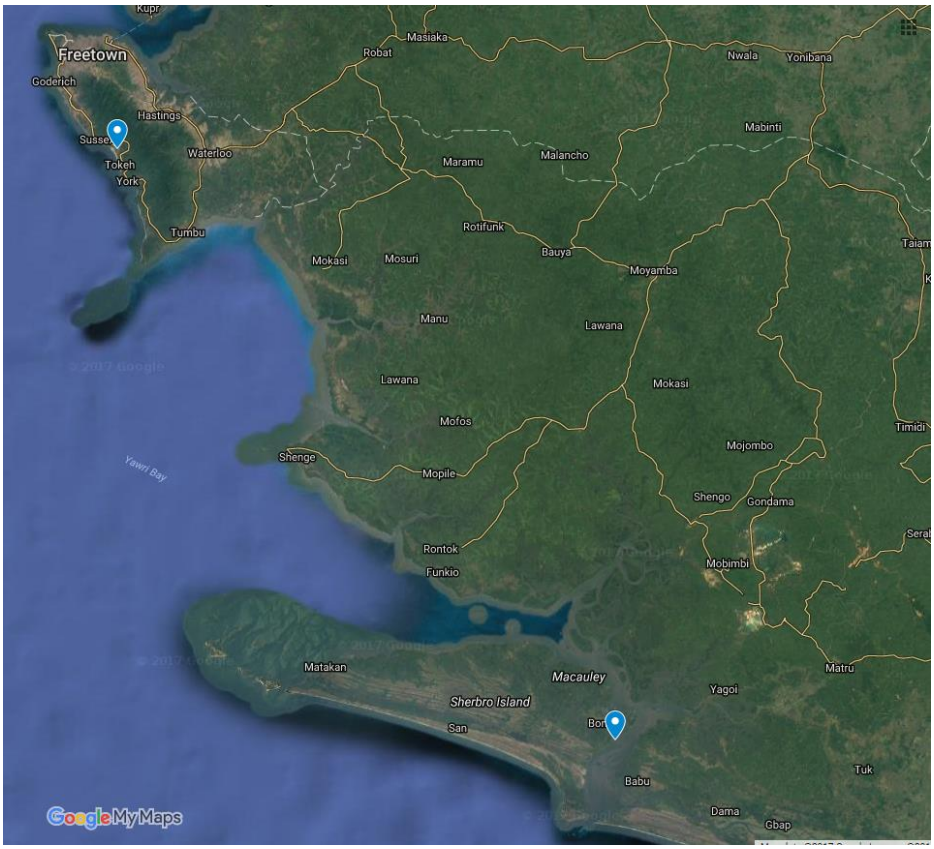


Fig A7.2. Location of mangrove oyster sample sites (River No 2 to north and Sherbro MPA to south).

Annex 8: Assessment of faecal contamination in mangrove oyster flesh (Dr R. Quilliam).

A8.1 Background to shellfish regulatory monitoring in the EU

In Europe, shellfish beds are assigned a classification grade under EC/854/2004 based upon *E. coli* concentrations within shellfish flesh (Table A8.1). Subsequently, the classification grade assigned to an individual shellfish bed impacts not only consumers, but also the shellfish industry, as it dictates the level of post-harvest treatment required for shellfish products at each classification grading, and could promote either a change in management practice or a temporary closure of the harvesting area. Previous research has shown that environmental factors such as seasonality, tidal state & rainfall events, and position on the bed may alter concentrations of *E. coli* detected within shellfish tissues and hence affect the classification assigned to a harvesting area (Clements et al., 2014). Subsequently, the classification assigned to each shellfish harvesting area has substantial economic implications for both the local and wider shellfish industry

Table A8.1: Current regulatory classification according to EC 854/2004

Shellfish bed classification	*E. coli* concentration (100 g^{-1} flesh)	Management requirements
A	< 230	Can be harvested for direct human consumption
B	230 - 4,600	Can be sold for human consumption: (i) after purification in an approved plant, or (ii) after re-laying in an approved Class A re-laying area, or (iii) after an EC-approved heat treatment process.
C	4,600 – 46,000	Can be sold for human consumption only after re-laying for at least two months in an approved re-laying area followed, where necessary, by treatment in a purification centre, or after an EC-approved heat treatment process.

A8.2 Sampling and processing mangrove oysters (Bonthe)

Clusters of oysters were collected from the boat by carefully cutting them from mangrove tree roots or the strings of the artificial oyster rack. Oyster samples were stored in sterile plastic zip-lock bags and kept out of the sun whilst being transferred back to the lab for further processing. Individual oysters were opened aseptically and the flesh and extra-cellular fluid combined in a sterile container (each sample of ca. 5 g was obtained from approximately ten individual animals); an additional 20 ml of sterile phosphate buffered saline (PBS) was added to each sample to allow homogenisation. Samples were homogenised for 60 seconds at 10,000 rev min^{-1} using a Bamix® blender (Seal Rock Enterprises Ltd., Bishop's Stortford, UK), and 100 µl of homogenate streaked out onto MLGA media to quantify *E. coli* concentrations (diagnostically blue or blue-green colonies). All plates were inverted and incubated at 37 °C and Colony Forming Units (CFU) were enumerated after a 24 h incubation period.

Table A8.2: First sampling (20 January 2016) of the oyster rack at Bonthe

Location on wrack	Fresh weight (g)	*E. coli* (CFU 100 g^{-1})
September inside	4.78	2,092
September outside	3.50	57, 142
October inside	4.45	nd
October outside	3.36	nd

nd, not detected

Table A8.3: Sampling oysters in the estuary (20 Jan 2016)

Site	Coordinates	Fresh weight (g)	*E. coli* (CFU 100 g^{-1})
2 (mud oysters)		2.95	nd
3		8.50	nd
4		3.58	419,000
5		7.15	28, 000
7		10.35	4,831
8		4.60	13,043

nd, not detected

Results from the first day's harvesting were variable (Tables A8.2 and A8.3). Only one replicate was taken from each sampling site or location on the rack and so it is unclear whether these data are an accurate representation of the true levels of *E. coli* contaminations. However, *E. coli* was used as a faecal indicator organism (FIO), and this data suggests that some of these oyster harvesting areas are contaminated by extremely high levels of faecal pollution. Although FIOs are not an indicator pathogens, the presence of faecal pollution strongly suggests that these oysters could be contaminated by human pathogens such as rotavirus, *Vibrio* spp., norovirus, *Cryptosporidium & Giardia*. Using the EU regulatory classifications for this sub-tropical shellfish harvesting site is not practically useful; however, it is clear that faecal pollution levels are so high in these areas that shellfish harvesting for human consumption wouldn't be allowed under the EU Directive, and the harvesting areas wouldn't even receive a classification.

On the second day samples were taken to understand spatial heterogeneity of *E. coli* contamination in oysters growing in the rack: strings laid in both September and in October were sampled by harvesting oysters growing at the top and the bottom of the external and internal strings. In addition, oyster samples were collected from three other sites in the estuary. Samples were processed as above, however, a variable temperature profile, due to a loss of power, throughout the incubation period meant that *E. coli* on these plates could not be quantified with any certainty the next day. There was however, blue *E. coli* colonies on all of the plates although as they were not growing as discrete colonies they could not be accurately enumerated.

A8.3 Second field mission (June 2016)

The aim of this field mission was collect data on spatial patterns of *E. coli* contamination of raw oysters, particularly with reference to distance from areas of human population in the villages of Sherbro Island. Specifically, we tested the working hypothesis that human faecal deposition associated with the villages would result in higher levels of contamination in oysters growing nearer the villages (which would also be the preferential harvesting areas in terms of distance to travel and the associated energy expenditure). Live oysters were collected as described above, with three or four replicates per sample. Each replicate comprised a composite sample of between 4-10 individual animals that were homogenised together and quantified as a single replicate.

In addition to the above sampling survey, oysters from the tourist beaches of the Freetown area were also sampled for *E. coli* to determine the public health risks of eating raw oysters in Sierra Leone. Locally shucked and unshucked mangrove oysters bought from a beach restaurant were tested, in addition to locally harvested rock oysters. Mangrove oysters from River No. 2 that were meant for raw consumption were generally clear of *E. coli* contamination (Table A8.4) although some of these oysters did have high levels of faecal contamination. Mangrove oysters from Tokeh beach were consistently contaminated with faecal pollution, whilst rock oysters collected several hundred meters away were less contaminated (Table A8.4), presumably due to higher rates of dilution from their substrate being in the ocean. In general, oysters destined for the tourist trade on these two Freetown beaches had lower levels of faecal contamination than mangrove oysters harvested from around Sherbro Island (Table A8.5).

Table A8.4: **Oysters from Freetown tourist beaches (5th June 2016)**

Site	Mean weight of individual oyster (g)	*E. coli* per oyster	*E. coli* (CFU 100 g^{-1})
River No 2			
Mangrove shucked	4.7	nd*	nd
Mangrove shucked	3.6	nd	nd
Mangrove shucked	3.8	nd	nd
Mangrove shucked	4.1	375	9109
Mangrove in shell	6.3	nd	nd
Mangrove in shell	4.6	nd	nd
Mangrove in shell	5.3	nd	nd
Mangrove in shell	5.9	83	1404
Tokeh			
Mangrove in shell	3.5	125	3571
Mangrove in shell	2.3	100	4274
Mangrove in shell	4.6	1300	28384
Rock oyster in shell	5.4	nd	nd
Rock oyster in shell	5.9	nd	nd
Rock oyster in shell	6.3	125	1976
Rock oyster in shell	7.4	250	3363

*nd, not detected

Table A8.5: Spatial sampling of mangrove oysters near harvesting villages of Sherbro Island (9th June 2016)

Coordinates	Sample	Replicate	Mean weight of individual oyster (g)	*E. coli* per oyster	*E.coli* (CFU 100 g^{-1})
	Gbembeehun far from village				
	1	a	2.9	10714	371287
	2	b	2.7	7750	282847
	3	c	2.2	4125	184701
	4	d	3.2	4107	128348
	Gbembeehun near to village				
	5	a	3.9	2500	63830
	6	b	2.4	800	33613
	7	c	4.2	450	10817
	8	d	2.8	1375	48529
	Bomplake far from village				
	9	a	4.2	nd*	nd
	10	b	2.0	4000	204380
	11	c	1.5	333	22472
	12	d	2.2	1292	59615
	Bomplake near to village				
	13	a	4.2	150	3571
	14	b	1.4	214	15000
	15	c	1.2	nd	nd
	16	d	0.7	25	3846
	Opposite York island				
	17	a	3.5	nd	nd
	18	b	5.9	938	15890
	19	c	3.0	600	20134
	Yankain South (right side)				
	20	a	3.3	nd	nd
	21	b	2.6	100	3817
	22	c	2.7	nd	nd
	Yankain North (left side)				
	26	a	2.5	500	20325
	27	b	2.5	100	4065
	28	c	2.1	150	7212
	Far away from Yankain				
	32	a	3.3	5813	177481
	33	b	2.5	1125	45000
	34	c	2.3	4300	185345
	Keigbe far from village				
	23	a	3.6	50	1381
	24	b	6.4	500	7853
	25	c	6.8	167	2463

Coordinates	Sample	Replicate	Mean weight of individual oyster (g)	*E. coli* per oyster	*E.coli* (CFU 100 g^{-1})
	Keigbe near to village				
	29	a	1.6	nd	nd
	30	b	1.8	50	2841
	31	c	2.7	nd	nd
	Bontibai village west				
	38	a	4.7	1563	33422
	39	b	4.3	1688	39017
	40	c	4.6	1875	40541
	Bontibai from opposite shore				
	41	a	6.8	2938	43199
	42	b	4.8	18750	392670
	43	c	5.5	5563	101598

*nd, not detected

Mangrove oysters harvested from around the villages of Sherbro Island consistently contained faecal contamination (Table A8.5). Although some replicates were clear of E. coli (e.g. near to the village of Keigbe) this was not consistent among all of the replicates, and may have been due to very low weights of initial oyster flesh. We tested the hypothesis that faecal contamination would be lower in oysters growing further away from the villages compared to those growing very close the village. Our rationale for this was the high levels of open defecation that is common on the beaches (Figure A8.1) of these villages where sanitation systems are either very basic or non-existent.

Figure A8.1: fresh human faeces a common sight on the of Sherbro Island village beaches

However, there was no clear spatial correlation between the location of oysters and their corresponding levels of faecal contamination. This may be due to residual currents quickly moving contaminated water away from areas of poor sanitation and concentrating faecal pollution in specific areas. Furthermore, there is no consistent pattern of larger oysters having higher levels of faecal contamination, and therefore size is probably not an indicator of greater food availability due to higher rates of faecal pollution.

The local people of Sherbro Island never eat raw oysters, but always steam them first. Considering the high concentrations of faecal contamination in these oysters we tested how efficient this process was at destroying E. coli. Two out of three replicate samples had undetectable levels of E. coli contamination (Table A8.6), although one replicate was contaminated with E. coli. It is difficult to know at this stage whether this was due to inefficient sterilisation during the steaming process, or more likely, post-processing contamination from handling the oysters (i.e. contaminated fingers or bowls).

Table A8.6: *E. coli* contamination of freshly steamed mangrove oysters from Bontibai (10th June 2016)

Coordinates	Sample	Site	Mean weight of individual oyster (g)	*E. coli* per oyster	*E.coli* (CFU 100 g^{-1})
	35	Bontibai Steamed	3.6	nd*	nd
	36	Bontibai Steamed	3.9	63	1603
	37	Bontibai Steamed	2.5	nd	nd

*nd, not detected

Reference:

Clements K, Quilliam RS, Jones DL, Wilson J, Malham SK. (2015) Spatial and temporal heterogeneity of bacteria across an intertidal shellfish bed: implications for regulatory monitoring of faecal indicator organisms. Science of the Total Environment 506–507, 1-9

Annex 9: Preliminary analysis of longitudinal harvesting and marketing survey, Bonthe and Yagoi Jun- Nov 2016 (R. Wadsworth, F Murray)

Dr Richard Wadsworth (Department of Biological Sciences, Njala University. Tel: 079 675004 e-mail: Richard.wadsworth1960@gmail.com)

Introduction

Longitudinal harvesting data in and around Bonthe Town during over the high (Jun-Jul 2016) and low (Aug-Nov 2016) oyster seasons was collected by embedded project staff (Amara Kalone and Richard Kapindi). Data on wholesale smoked oyster volumes and prices at Yagoi weekly market (on the mainland) was collected by two locally recruited enumerators.

Harvesting effort by fisherfolk in and around Bonthe Town

Data was collected mainly from gatherers (mainly female) in Bonthe town and occasionally from outlying settlements. Collection was opportunistic and sporadic and not based on a structured sample-design.

The distribution of effort by fisherfolk is extremely skewed one fisherwomen (Jeneba Jong) is recorded 30 times (representing 14% of the total recorded fishing effort) while more than half the fisherfolk (59%) were recorded only once (Table 2) and represent 27% of the total fishing effort.

Table A9.2: Effort by fisherfolk

Harvester	Observations in the database
Jeneba Kong	30
Satta Baun	9
Jokiatu John	8
Seinya Charley	8
Bobor Charley	5
Kaidi Duada	5
Sorgoi Koroma	5
recorded 2-4 times	***87***
recorded once	***58***

Harvesting effort by location – for smoked oysters wholesaled in Yagoi weekly market

The cluster of sites in and around Bonthe are the most recorded in the database (Table A9.3) with a total of 2262 cups harvested, this is followed by Delkan (910 cups) and Chappo (792 cups) together these represent 42% of all cups harvested.

No differentiation was made (i) between smoked and steamed oysters; though the latter are most likely to be harvested and in the proximity of and retailed directly to consumers in Bonthe Town or (ii) between oysters and cockles; the latter being the dominant off-season crop around more northerly sites near the estuary mouth, including Delkan and Chapo. Although a Ebola-crisis ban on Sunday trading remains in place, interviews suggest informal wholesale transactions of oysters are common. These transactions are undertaken by (many) traders arriving on the day prior to the official market day i.e. each Monday.

Table A9.3 Effort by location

Location	Cups harvested	Location	Cups harvested
Baimba	71	Moisokie	102
Barkie	280	Mokendeh	300
Bissawoi	38	Molebie creek	36
Bolloh	28	Mosokie creek	20
Bonthe	**12**	Moyeama	25
Bonthe King Jimmy	**381**	Musalley	189
Bonthe new site	**662**	Mutty	458
Bonthe-Bye	**1177**	Nyangai	128
Bonti-bye creek	**30**	Opposite King Jimmy	289
Chappo	792	Pebehun creek	319
Delkan	910	Penbihun	23
Gbamina	417	Pokia	305
Gbomgboma creek	150	Potopot	30
Gbongboma	131	Sieh	395
Gboning	309	Siway	243
Mbotie	88	Tissana	330
Moboni	40	Yealeh	449
Moi yeama	185	Moisokie	102

Harvesting effort by month

Table 1, indicates the total catch, average price per cup and number of observations as recorded in the database. A peak of activity in August is not consistent with intuition.

Table A9.1: Harvesting effort by month (inc. smoked oysters and cockles)

Month	cups harvested	average price (Le)	Observations
Jun	196	1,000	6
Jul	260	1,000	10
Aug	4,706	1,373	90
Sept	1,727	1,665	17
Oct	1,568	1,368	37
Nov	885	1,037	54

Conclusions

Results to a large-degree reflect intensity of data collection effort which together with a lack of discrimination between oysters and cockles, limits ability to make generalizable conclusions with any confidence. However some indicative findings are apparent.

A progressive increase in the price of oysters is apparent over the transition from high (Jun-Jul) to low season (Aug – Nov) consistent with other anecdotal of declining oyster gathering effort and supply linked to declining salinity and oyster condition factor. The peak in cups harvested between Aug-Sep may also reflect an increase in cockle harvests from outlying sites. Smoked oysters and cockles appear to be close substitutes, though oysters appear to command marginally higher prices due their larger mean size and negative perceptions linked to presence of gritty-sand in poorly depurated cockles.

Annex 10: Resources for GIS assessment of oyster harvesting and processing impacts on mangrove forests (R. Wadsworth)

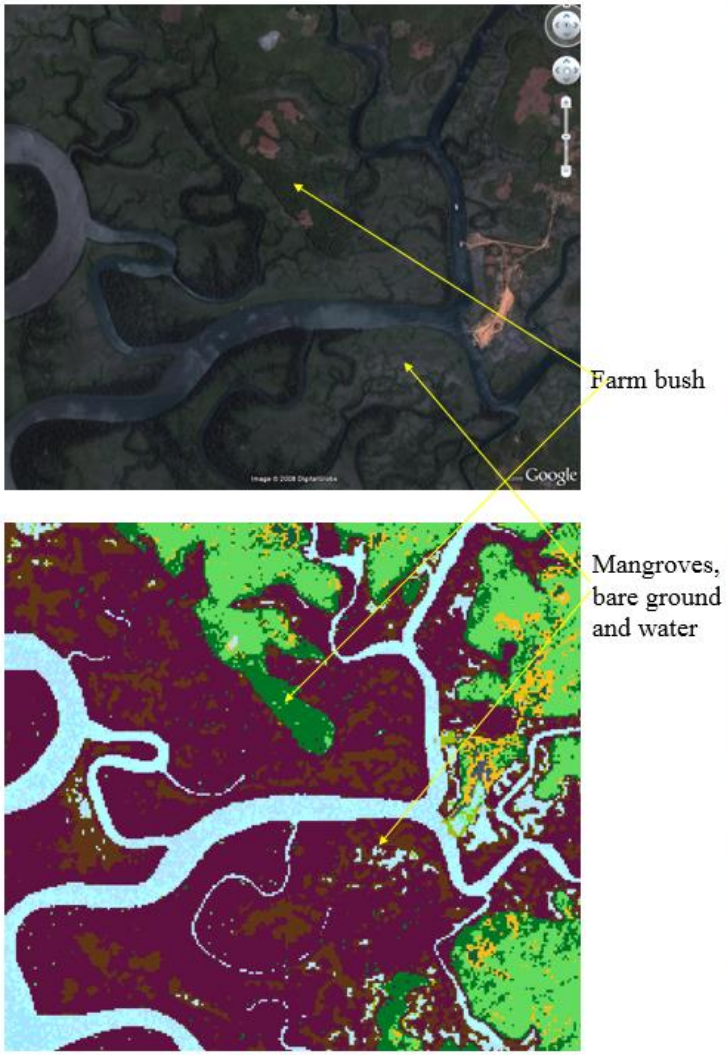


Figure 1a & 1b Google Earth image (top) and classified Landsat image (bottom)

Figure 2 High resolution imagery of mangrove forests (Google Earth)

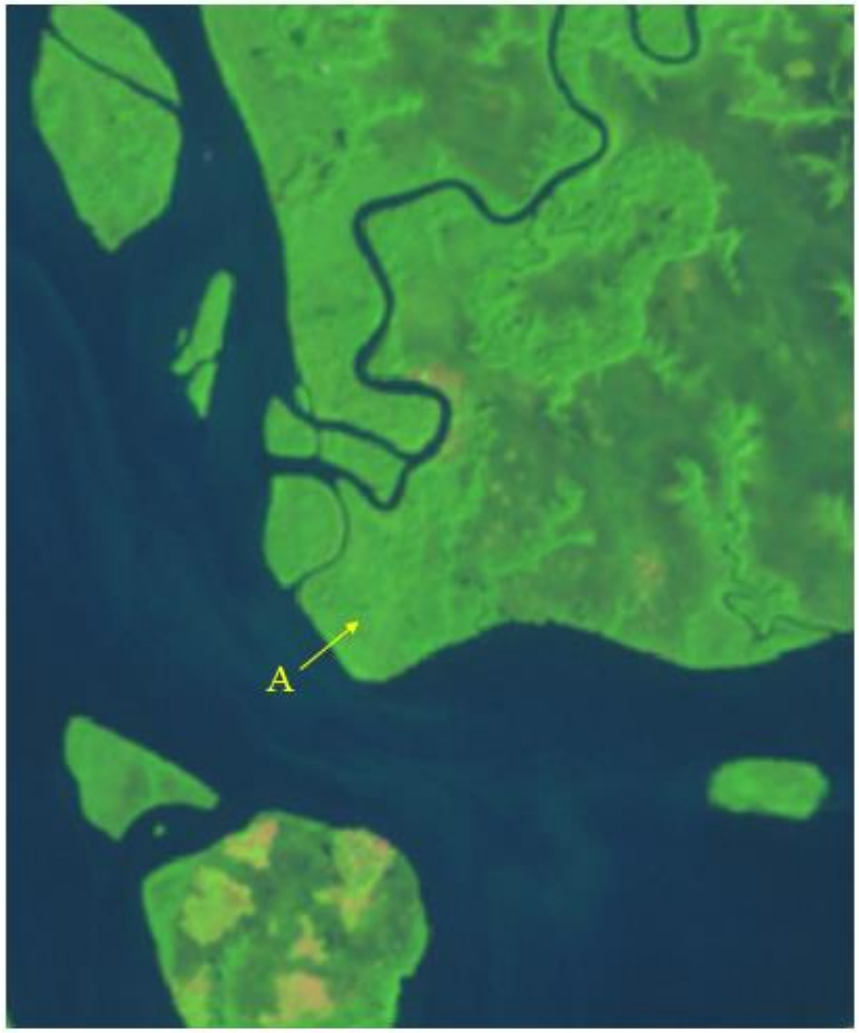


Figure 3 Medium resolution imagery of mangrove forests (Note that using these wavelengths the tall and mid-sized mangroves are not distinguished at point A (compared to the high resolution image in Figure 3a).

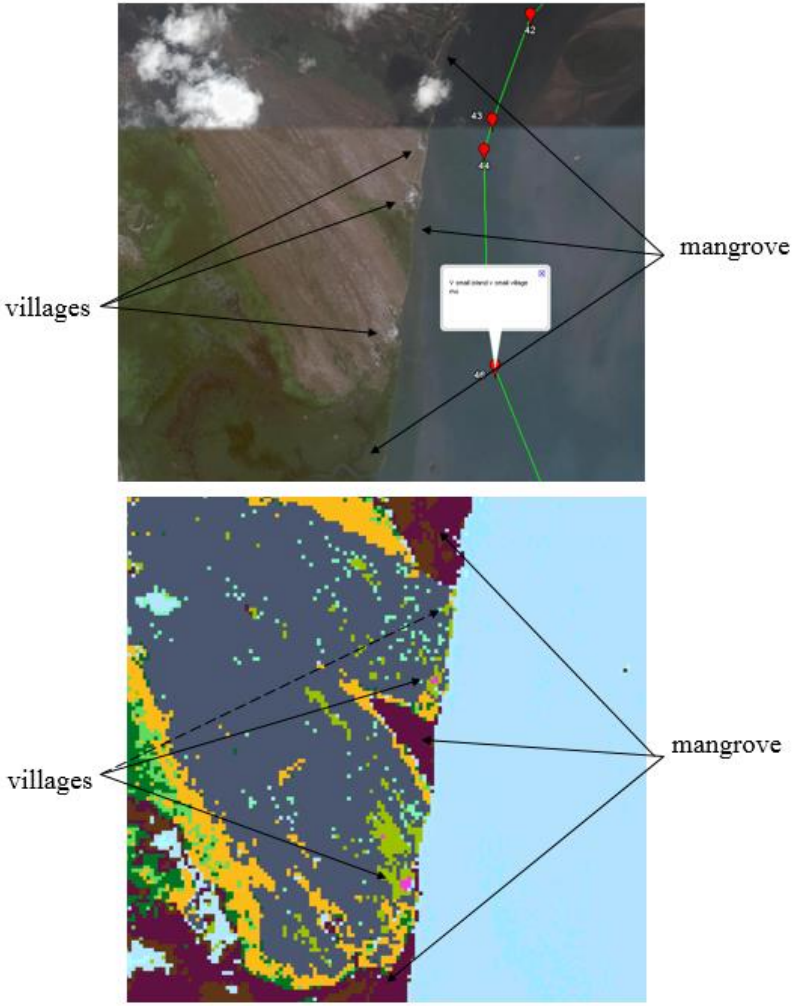


Figure 4a&b Identification of villages

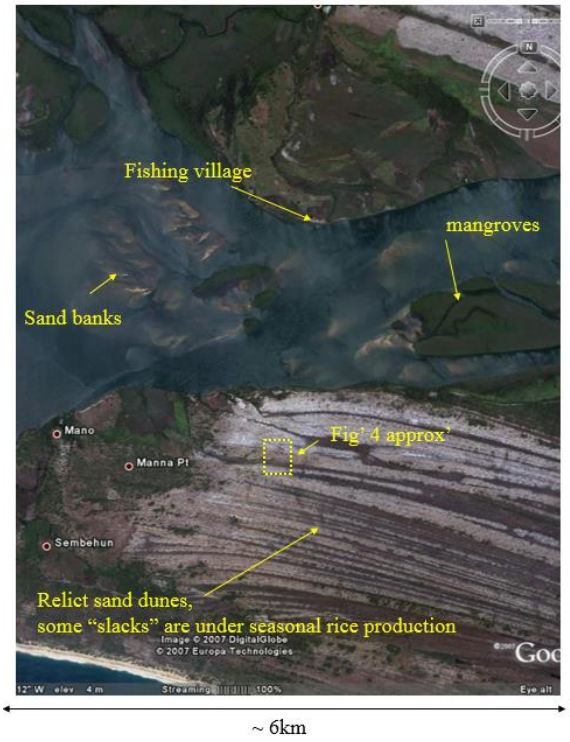


Figure 5a High resolution imagery of coastal savannah (Google Earth)

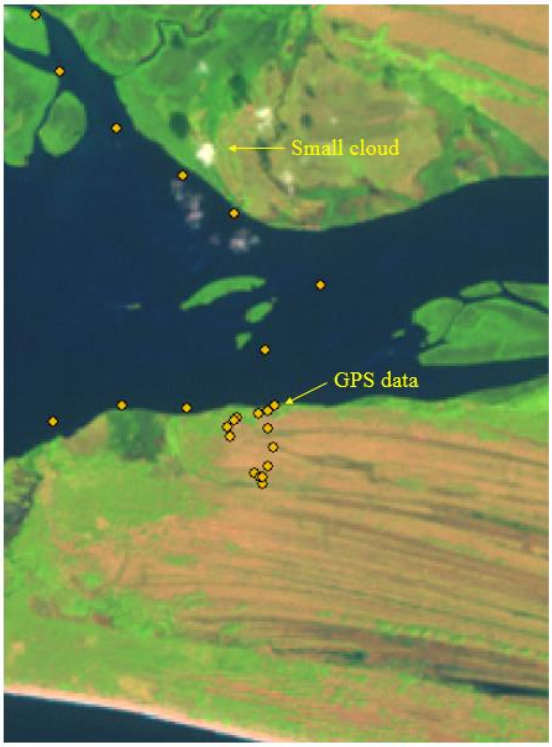


Figure 5b Medium resolution imagery of coastal savannah (False colour Landsat ETM+ image)

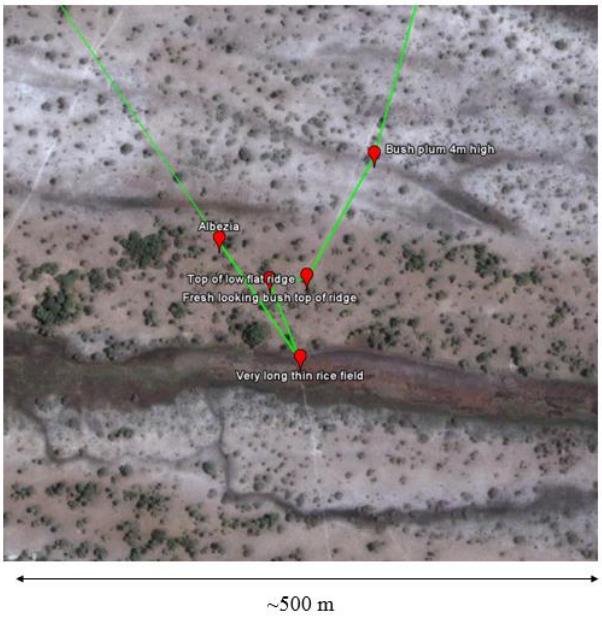


Figure 6a High resolution imagery of "dune and slack" (Google Earth)

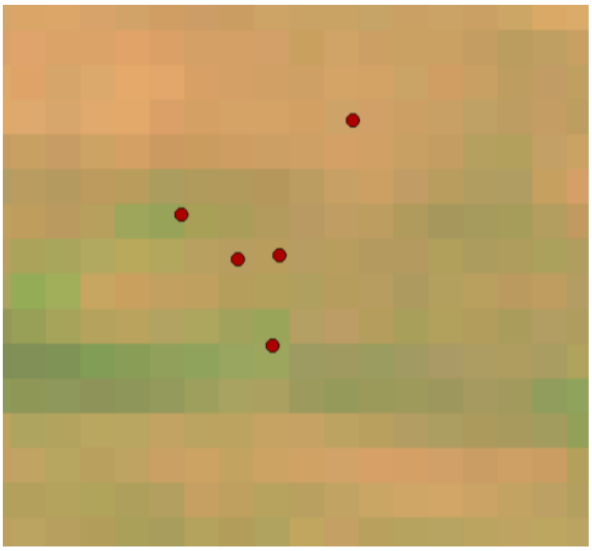


Figure 6b Medium resolution imagery of "dune and slack" (False colour Landsat ETM+ imagery. Area corresponding to that in Figure 6a

Annex 11: First Bonthe Oyster Festival

Brown, J., Murray, F., Green, J. Mar-Apr 2017 ***First Sherbro Oyster Festival*** -'The Grower' Assoc. Scottish Shellfish Growers. No. 20: Photo news. http://assg.org.uk/the-grower/4532754744

As part of the Darwin Initiative project entitled "Alternative Livelihood Opportunities for Marine Protected Areas Fisherwomen "an oyster festival is planned for June this year. The project is based in the Sherbro River Estuary, a marine protected area (MPA) in Southern Province, Sierra Leone and seeks to offer alternative sustainable income earning opportunities for local women in mangrove oyster cultivation and sales. At first it was thought that the local oyster *Crassostrea tulipa* was a depleted stock but has been found to be recruiting prodigiously and grows very fast in the local conditions.

One of the partners in this project which is led by Dr Francis Murray of the Institute of Aquaculture, University of Stirling with Dr Salieu Sankoh, is James Green of the Whitstable Oyster Company (who has coincidentally provided an article for this issue—see page 13). His experience with the Whitstable Oyster Festival is being transferred to Sierra Leone where it is hoped added value can be provided in the oyster market with selling smoked oysters that have a better shelf life in the local conditions. We hope to bring more information on this project in a future issue of The Grower.

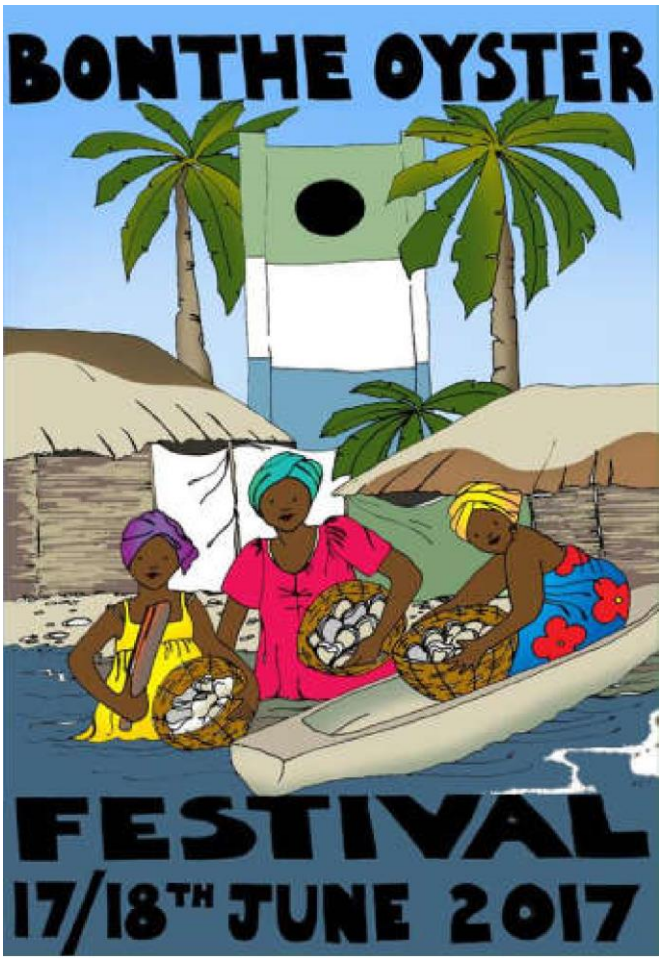


Fig 9.1 Festival graphic art (contributed by Mr James Green Whitstable Oyster Company)

Note: Festival subsequently rescheduled to 13th May to fall out with Ramadan.

Annex 12: Presentation abstract (accepted) - Iceland Seafood Summit - Sep 2017 (F. Murray)

Oysters, mangroves & Ebola! Problem-framing in a data-deficient development context in Sierra Leone

The 'Sherbro Oyster Project' (http://www.darwininitiative.org.uk/project/21013/) was established to support the recently established Sherbro Marine Protected Area, Sierra Leone through development of alternative livelihoods based on extensive culture and value-added marketing of native mangrove oysters for local women. Sierra Leone, the world's fourth poorest country (IFPRI World-Food-Hunger-Index) retains a skewed gender-ratio following a brutal civil-war. This, rising population and lack of formal employment has increased female dependence on oyster-gathering, processing and marketing as a seasonal livelihood option. Exploitation of this open-access resource depends on gendered-mobility attributes and shared access to canoes with males prioritising fishing and transport uses. After delays due to the Ebola-crisis, taking a 'do-no-harm' ethos the research-team collated evidence to challenge a native oyster depletion problem and market interventions on which the project was predicated. This study details a responsive inter-disciplinary problem-(re)framing approach with lessons for data-deficient and production-oriented aquaculture development interventions with a history of failure across sub-Saharan Africa.

Annex 13: 'Oysters, Mangroves & Ebola' Seminar presented by F. Murray; UoS 18 Jan 2017

Sherbro Oyster Project Objectives

'Alternative livelihood opportunities for marine protected areas fisherwomen' 2014-2018

- Darwin/ DFID funded small-scale project (£247,000)
- Project Partners:
  1. University of Stirling, UK **(UoS)**
  2. Institute Marine Biology & Oceanography, Fourah Bay College, Freetown **(IMBO)**
  3. Njala University, Sierra Leone **(NIU)**
  4. Environmental Justice Foundation, UK/Sierra Leone **(EJF)**
  5. Whitstable Oyster Company, Kent, UK **(WOC)**
  6. **Ministry of Fisheries** (through IMBO & West Africa Regional Fisheries Program)

Project Objectives

- Provide sustainable alternative livelihoods for local fisherwomen (& their households) based on extensive culture & value-added marketing of native mangrove oysters
- Support sustainable development of recently established Sherbro Marine Protected Area (MPA)
- Problem Framing?
  - ***Localised native oyster depletion & mangrove degradation problem identified during earlier (2006/7) Darwin project - combined with growing dependency on this fishery***

Planned Interventions

Oyster Production

- Evalulate bio-technical and economic feasibility of extensive culture options with target groups

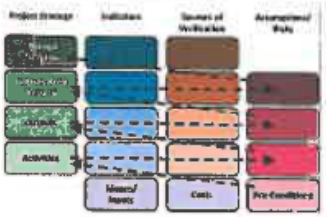
Post harvest (for value-added marketing)

- Test solar cold-chain transport options for transport of live oyster to tourist beaches around Freetown
- Ready-meal recipe competition for sales to beach bars/ urban outlets

UN - Convention on Biodiversity (CBD)

- Reduce pressure on wild oysters populations (& mangroves)
- Equitable sharing of genetic resources: re-enforcement of MPA institutions

Methodological Approach



- Log-frame planning project design:
  - 'Assumptions column!' – flexibility to adapt
  - Shift from blue-print/ GANT type planning in development programs
- 'Sequential- exploratory mixed methods' (Carswell 2015) – exploratory qualitative phase followed by more systematic quantitative methods
  - For data deficient situations – here for refined problem framing
  - Findings used to build successive quantitative phase(s)

Exploratory Questions?

What is the potential for environmentally sustainable & poverty-focussed oyster culture/ enhancements?

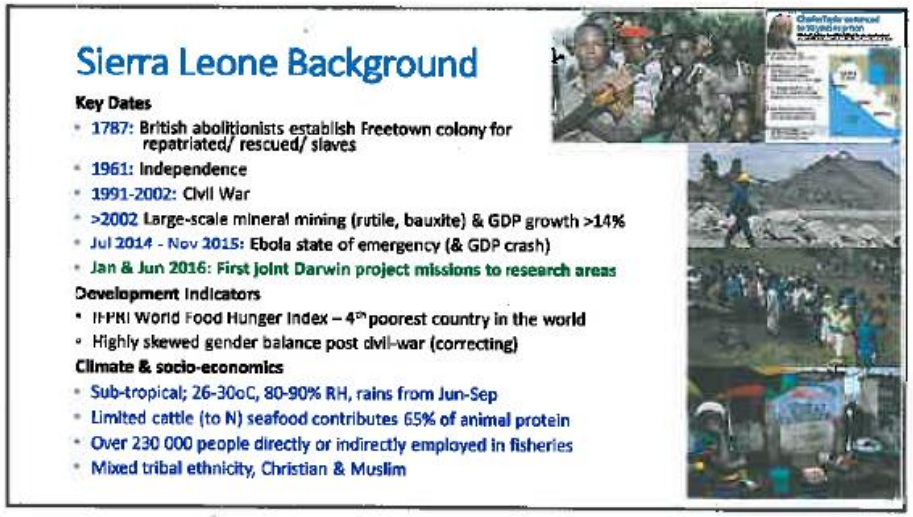
1. What is the existing demand for oyster products, where, form, value-add?
2. What are the logistical constraints to supplying this demand?
3. How do governance & regulatory systems shape access rights?, open access v common property or co-management, & market failures?
4. What risks do production & market interventions pose to the environment and livelihoods of marginal dependents? - 'do no harm' medical ethos
5. How will interventions be affected by/ adapted to wider demographic and economic transitions? (trends v static picture)?
6. Other aligned work in this and/ or similar contexts; data gaps/ validation?

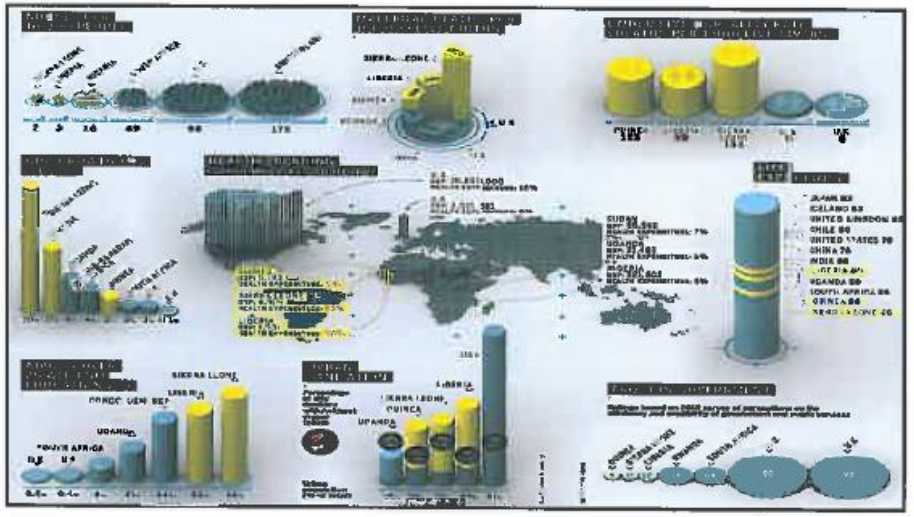
Interdisciplinary Project Team

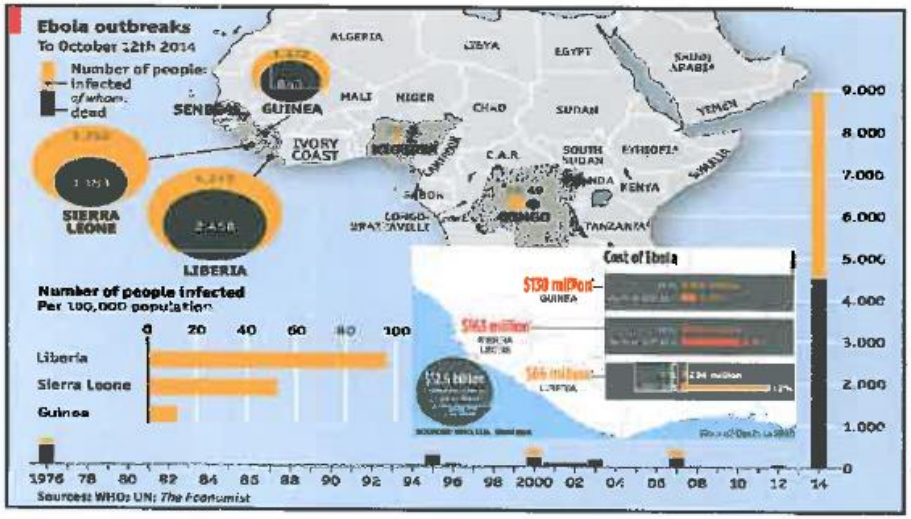
- Saliue Sankoh (IMBO)
- Richard Kapindi (IMBO)
- Richard Wadsworth (NJU)
- James Green (Whitstable Oysters)
- Mr Amara Kalone (EJF)
- Will Leschen (UoS)
- Nick Shell (UoS)
- Richard Quilliam (UoS)
- Francis Murray (UoS)
- Trevor Telfer (UoS)

First Steps?

- Assess recent national & regional development trends (secondary data)
- Assemble sample frames (generalisability)
- Characterise variability around key environmental & socio-economic concerns
  - Establish typologies or classification systems
  - In-dependent variables for comparative assessments
  - Research-output 'recommendation domains'
- Stakeholder engagement; familiarisation with/ refine aims


Sierra Leone Background
Key Dates
1787: British abolitionists establish Freetown colony for repatriated/ rescued/ slaves
1961: Independence
1991-2002: Civil War
>2002 Large-scale mineral mining (rutile, bauxite) & GDP growth >14%
Jul 2014 - Nov 2015: Ebola state of emergency (& GDP crash)
Jan & Jun 2016: First joint Darwin project missions to research areas
Development Indicators
IFPRI World Food Hunger Index – 4th poorest country in the world
Highly skewed gender balance post civil-war (correcting)
Climate & socio-economics
Sub-tropical; 26-30oC, 80-90% RH, rains from Jun-Sep
Limited cattle (to N) seafood contributes 65% of animal protein
Over 230 000 people directly or indirectly employed in fisheries
Mixed tribal ethnicity, Christian & Muslim

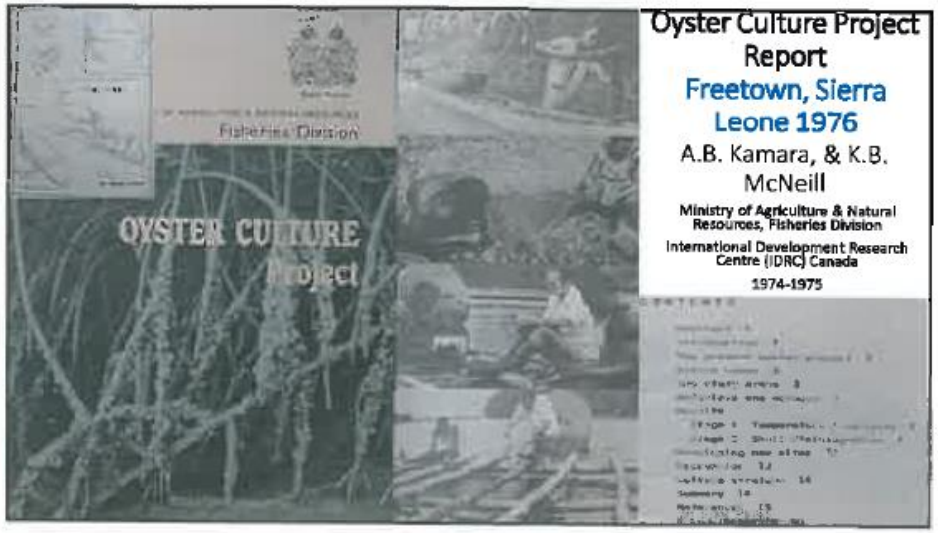



Ebola outbreaks
To October 12th 2014
Number of people:
infected
of whom:
dead
SIERRA LEONE
LIBERIA
GUINEA
Number of people infected
Per 100,000 population
Liberia
Sierra Leone
Guinea
Cost of Ebola
$130 million
GUINEA
$163 million
$806 million
Sources: WHO; UN; The Economist


Ebola in Sierra Leone (by District)
GUINEA
LIBERIA

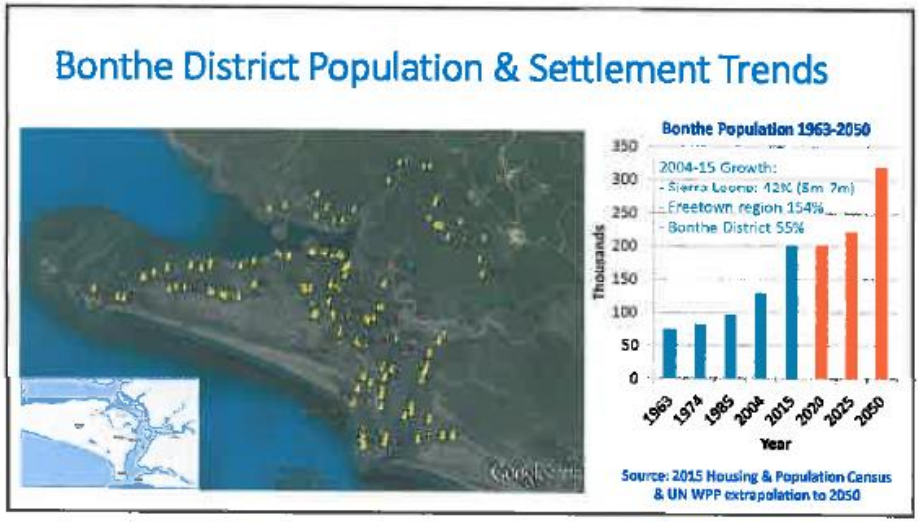
Oysters & livelihoods

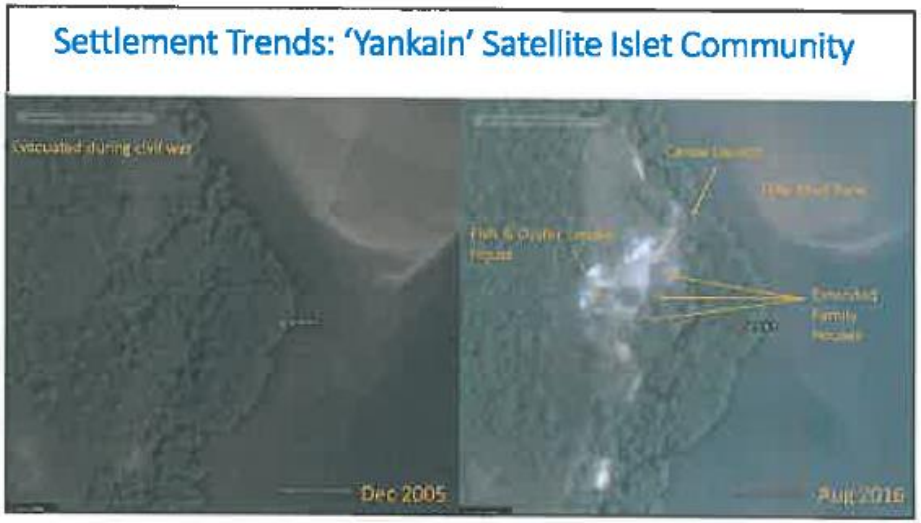
- Data-scarcity
- Pre-war: mainly low-level subsistence activity – female gathering
- Post-war: increasing commercialisation; female gathering & processing; artisanal production & local sales

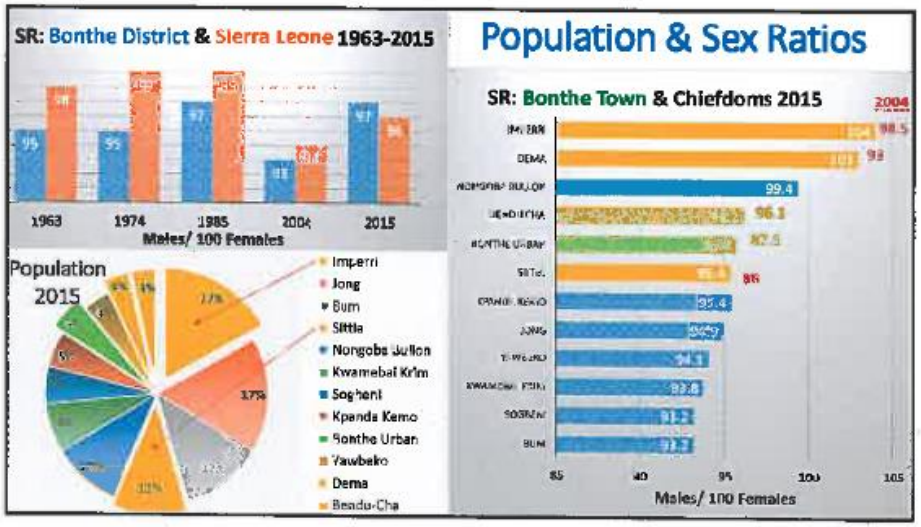


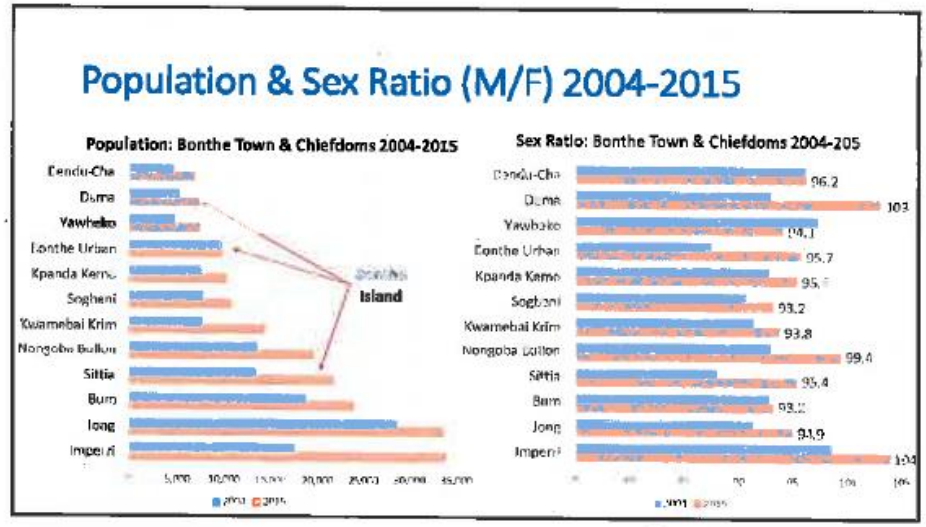
Sample Frames

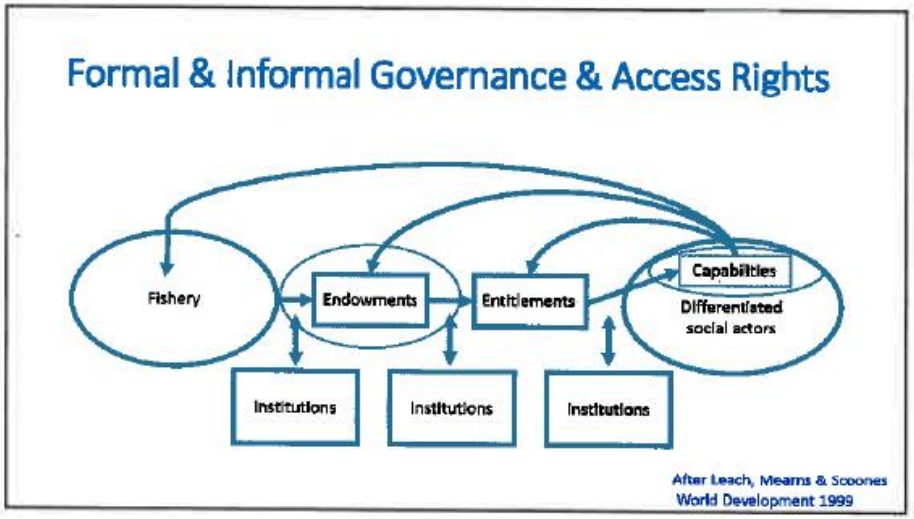
- The population to which we wish to generalise research findings?
- Non-probabilistic v probabilistic approaches?
- Post-war national census 2004 & Dec 2015 (limited as yet)
- Other options
  - Disaggregate data from local/ district government offices
  - Localised data from other development projects
  - Satellite imagery (Google Earth etc.) – supervised classification
  - Project 'census' at limited scale e.g. small communities
- Bias & validation?


Bonthe District Population & Settlement Trends
Bonthe Population 1963-2050
2004-15 Growth:
- Sierra Leone: 42% (8m 7m)
- Freetown region 154%
- Bonthe District 55%
Thousands
350
300
250
200
150
100
50
0
1963
1974
1985
2004
2015
2020
2025
2050
Year
Source: 2015 Housing & Population Census
& UN WPP extrapolation to 2050


Settlement Trends: 'Yankain' Satellite Islet Community
Evacuated during civil war
Dec 2005
Aug 2016


SR: Bonthe District & Sierra Leone 1963-2015
1963
1974
1985
2004
2015
Males/ 100 Females
Population 2015
Imperri
Jong
Bum
Sittia
Nongoba Bullon
Kwamebai Krim
Sogbeni
Kpanda Kemo
Bonthe Urban
Yawbeko
Dema
Bendu-Cha
Population & Sex Ratios
SR: Bonthe Town & Chiefdoms 2015
2004
99.4
96.1
85
85
90
95
100
105
Males/ 100 Females


Population & Sex Ratio (M/F) 2004-2015
Population: Bonthe Town & Chiefdoms 2004-2015
Bendu-Cha
Dema
Yawbeko
Bonthe Urban
Kpanda Kemo
Sogbeni
Kwamebai Krim
Nongoba Bullon
Sittia
Bum
Jong
Imperri
Island
Sex Ratio: Bonthe Town & Chiefdoms 2004-205
96.2
103
95.7
93.2
93.8
99.4
95.4
93.9


Formal & Informal Governance & Access Rights
Fishery
Endowments
Entitlements
Capabilities
Differentiated social actors
Institutions
Institutions
Institutions
After Leach, Mearns & Scoones
World Development 1999


WE'RE GOING TO NEED A BIGGER BOAT!

Fishing canoes Bonthe & Sierra Leone, 1981 (FAO 1986)

Year 1981		Bonthe	Sierra Leone	Bonthe % SL Total
Canoe Type	1-3 men	2,517	5,026	50.1
	3-5 men	237	1,326	17.9
	Ghana-Type	12	284	4.2
	Other	0	100	0
Total Sierra Leone		2,766	7,074	39.1
Outboard Engines		9	677	-
Motorization %		0.3	9.6	1.3

Year	SL Change YoY %
1974	-
1975	3.8
1976	-0.8
1977	6.3
1978	1.3
1979	1.1
1980	1.5
1981	1.1

Mangrove Oyster Taxonomy

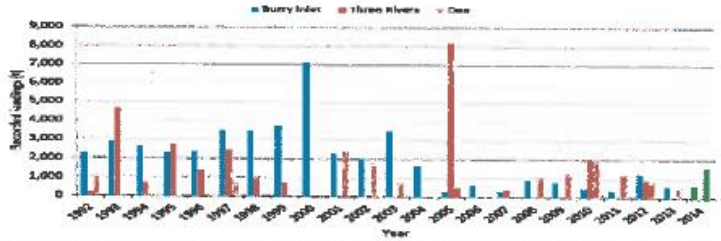
- *Crassostrea tulipa* (defunct *C. gasar* synonym)
- Locally differentiated by morphotype assoc. with substrate-type: 'mangrove', 'mud' or 'rock oyster' in inter and subtidal locations
- Sub-tidal rock oysters designated *C. denticulata* (Kamara & McNeil 76)
- Phenotypic variation continuous across estuaries (?) and this taxonomic differentiation remains unaccepted (WoRMS 2016)

World Register of Marine Species:
http://www.marinespecies.org/aphia.php?p=taxdetails&id=819170

Log-frame Assumptions

- ***Localised native oyster depletion & mangrove degradation problem?***
- Chance favours the prepared mind! – Louis Pasteur

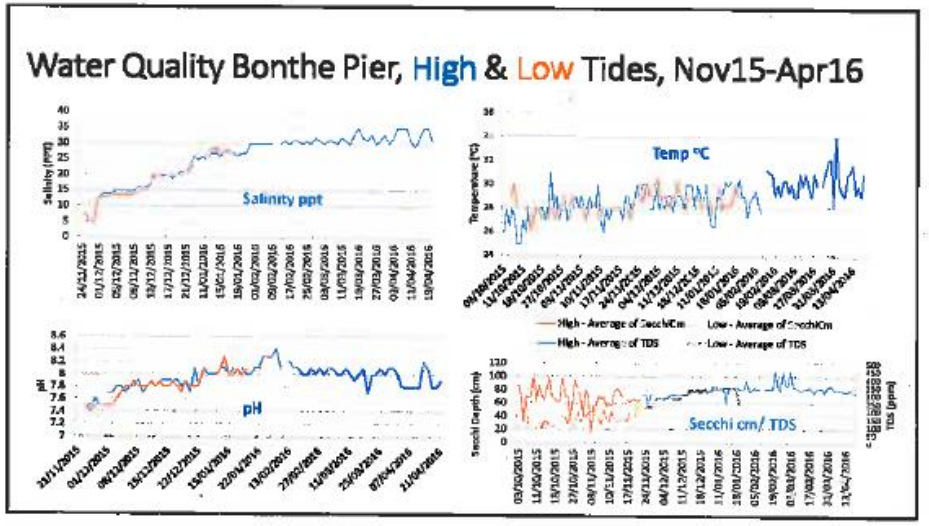
Total cockle landings (tonnes) Burry Inlet, 3-Rivers 1992-2014, Dee Estuary 1992-2011



Murray, Tarrant 2015 A social and economic impact assessment of cockle mortality in the Burry Inlet and Three Rivers cockle fisheries, South Wales UK. Seafish Project Code: SEA-1109

'r/k' selection theory (MacArthur & Wilson 1967)

- r-selected spp. as opportunists (cockles, clams, tilapia... mangrove oysters?)
  - Highly fecund & fast maturation (*C. tulipa* 4-5 months to min harvest size)
  - Wide dispersal with minimal parental investment
- Common in unstable/ unpredictable environments
- e.g. euryhaline spp. in estuaries with highly variable temperature & salinity profiles
- k-selected spp. more evolved to compete with other spp. in more stable environments (marine oysters.... *C. gigas?*)
- Genotypic v phenotypic variation in mangrove, rock and mud morphotypes & UN- Convention on Biodiversity (CBD)?



Water quality data collection implemented by James Green (Whitstable Oyster Company) and Amara Kalone (Bonthe Town)

Project-design implications?

- Most effort on single year class inter-tidal oysters on mangrove roots – due to substrate abundance and accessibility
- Limited harvest of rock (negligible substrate) & mud-oysters on tidal mud-flats (assoc. with extended seasonality)
- High natural mortality of mangrove oysters v sub-tidal/ halocline mud (& rock?) oysters following onset of rains (Jul-Aug – 'white shells')
- Mud oysters as multi-year class breeding pool?
- Aquaculture options? Resource scarcity condition not met re. competition with hand gathered harvest

Trial Suspended 'Rack' Culture Bonthe Town

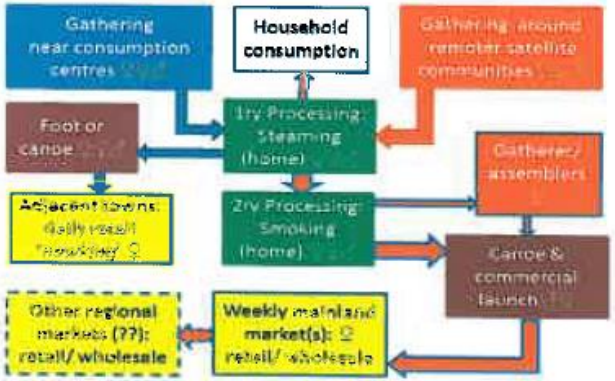
- Local materials: mangrove wood, string & oyster cultch
- 3 days construction 3.5x12m
- Sub & intertidal levels
- 40 strings of spat collectors/ level (15 shells/ string)
- Placed in Sept & Oct 2015
- Yield equivalent to 3-4 days wild harvesting @ peak season!

Trial 'Mud' Oyster Bottom Culture

- Oyster cultch placed as spat collector on inter-tidal mud bank near Bonthe Town
- Oysters shells have value as construction material – but low opportunity-cost in remote villages due to transport costs
- Low input-output enhancement option?
- Post harvest value added marketing options.....?

Culture trials implemented by James Green (Whitstable Oyster Company) and Amara Kalone (Bonthe Town)

Oyster Marketing & Gender Roles Bonthe




Secondary Processing – smoking


Retail – Bonthe (steamed) & Yagoi (smoked)


Yagoi weekly market (*lumi*) supply catchment for smoked oysters & other shellfish


Regional markets – preservation & cold-chain?
SIERRA LEONE
GUINEA
LIBERIA

Value-added Strategies - [1] Live oysters Freetown?
Human Pathogen Contamination?
Assay of Faecal Indicator Organisms

- *E. coli* as indicator of rotavirus, *Vibrio* spp., norovirus, *Cryptosporidium* & *Giardia etc.*
- EU shell-fish beds classified re *E. coli* concentrations 100 g^{-1} shellfish flesh (EC/854/2004):
  - (A) <230 = direct consumption
  - (B) <4,600 = relay in A, depurate, heat-treat
  - (C) <46,000 relay >2mnths & depurate or heat-treat
- Jan 2006 sampling in Sherbro Delta
  - Rack oysters, water front Bonthe Town (n=4)
    - Seeded Oct 2015 – no detection; Seeded Sep 2016 – 2,092 & 57,142 CFU 100 g^{-1}
  - 'Mud' oysters, Bonthe Town channel (n=6)
    - No detection to 419,000 CFU 100 g^{-1} (mean 87,345, SD 185,461)
- Beyond (EU) classification (BC)!
- Follow-up assays in Jun 2016 Sherbro Delta & Freetown beaches
  - Confirmed elevated levels in mangrove oysters collected around satellite communities near Bonthe
  - No detection in (i) steamed oysters or (ii) 'rock' oysters collected from beaches south of Freetown
- Development implications? – depuration options, local provision of rock oysters

Faecal contaminants analysis implemented by Dr Richard Quilliam (University of Stirling)

Value-added - [2] Whole-fresh, Steamed, Smoked?

- Three yield scenarios assessed
  - Weight – re. putative use of weighing scales
  - Unit-price – for whole-fresh v steamed & smoked comparison
  - Volume – current marketing model 'by the cup'

Weight yield

- Decanted meat = 18.5% whole weight (n=7, mean 3.1g, SEM 1.2g)
- Steamed meat = 8.5% whole weight (n=75, mean 1.7g, SEM 2.3g)
- Smoked meat = 35-46% steamed meat (n=75, mean 0.8, SEM 1.7g)
- Smoked 54-65% loss on steamed for circa 50% value-added!

Value-added - [2] Whole-fresh, Steamed, Smoked?

Average price

- Whole fresh oyster (cleaned) = Freetown: Le 30,000/ dozen
- Steamed meat (mean 162 meats/cup) = Bonthe: Le 1,000 per cup, Freetown: Le 3,000
- Smoked meat (mean 2015 meats/cup = Yagoi Le 2,000 per cup, Freetown: Le: 5,000?

Unit Price [& % whole-fresh mark-up on steamed or smoked]:

Whole-fresh = Le 2,500,
Steamed = Le 6.2 [406%]
Smoked = Le 9.3 [270%]

Prevailing exchange rate = 8,000 Le: £ and 6,000 Le: $

Value-added - [2] Whole-fresh, Steamed, Smoked?

Volumetric yield - meats per cup (400mls)

- Steamed = 162, Smoked = 215
- Volumetric loss = 27%
- Smoking corrected price/cup gross: Le 1,459
- Smoking corrected price/cup net fuel costs (7% RP) = Le, 369
- Additional labour in gathering and smoking 20% more oysters; break even at best – consistent *inter-alia* with preference to sell steamed
- Reduction of fuel needs & costs through fuel efficient stoves?

Value added [3] preservation and branding

Value added [3] preservation and branding

MPA Development & Governance

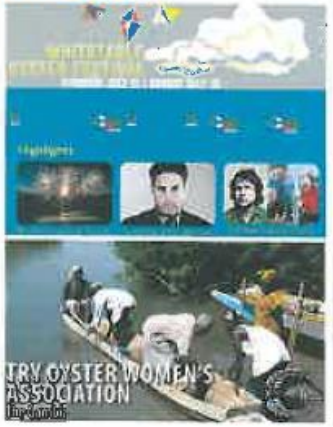
Sherbro Marine Protected Area

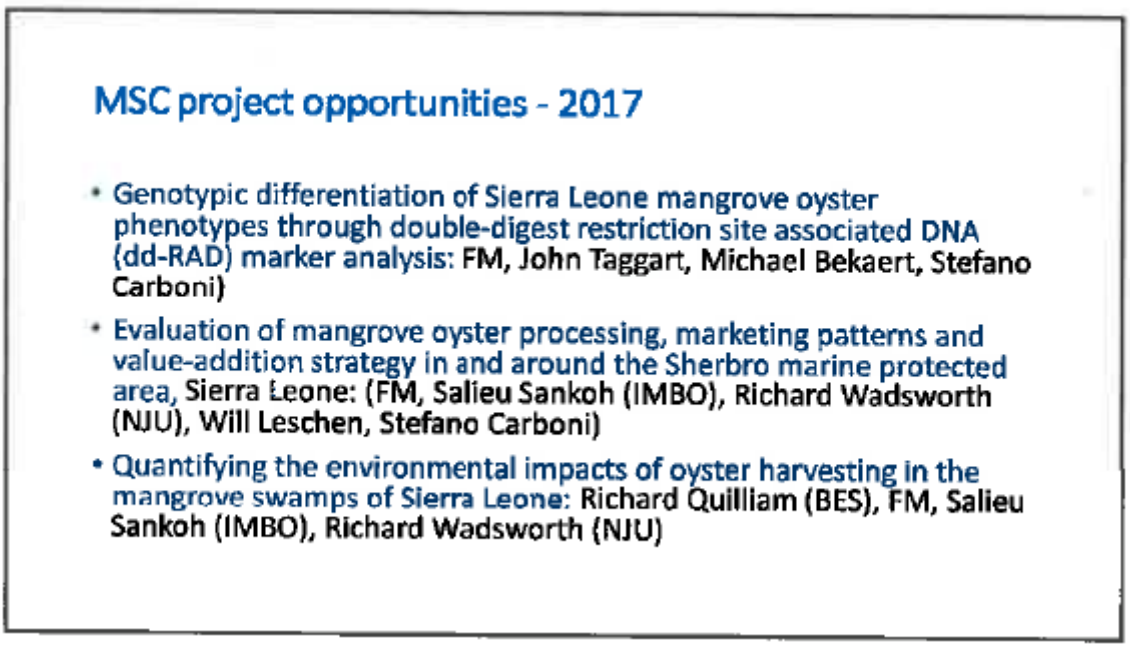
- One of 4 recently established MPAs around major river estua
  - Scarcies, Sierra Leone, Yawry & Sherbro Rivers
- Management structures and by-laws drafted
- Canoe license scheme & ban on mono-filament fishing nets
- Community based surveillance to reduce IUU
- Co-management association (CMA
- World Bank (WARFP) & EU project support (EJF)
- Bonthe Fisheries Complex
- Limited progress to date – mangroves & oysters??
- Decentralised options (CF GreenSpace programs)

Other secondary Stakeholder Engagement?

First Sherbro Oyster Festival – June 2017

- Best-practice training based on project findings
- Oyster recipe competition
- Culture & local arts
- Radio Bontico & local council promotion
- Building/ learning from:
  - **Whitstable Oyster Festival** – James Green
  - **Tri-Oyster Festival Gambia** - (Rhode Island University, USA - shared experience)





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	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.	