Darwin Plus:
Overseas Territories Environment and Climate Fund
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: extended from 30 April

Darwin Plus Project Information

Project Reference	20-001
Project Title	Managing the landscape-scale sustainability of Amazonian freshwater fisheries
Host Country/ies	Brazil
Contract Holder Institution	University of East Anglia (UEA)
Partner institutions	SDS/CEUC, ICMBio, UFAM, INPA, UFRN, ASPROC, AMARU, COLPESCA (all in Brazil)
Darwin Grant Value	£69,063.00 (claim for this period)
Start/end dates of project	1 July 2013 – 30 April 2016 extn to 30-9-16
Reporting period	Annual Report 3: March 2015 – April 2016
Project Leader name	*Prof Carlos Peres (UEA)*
Project website/Twitter	http://www.projetomediojurua.org https://twitter.com/pmj_mediojurua
Report author(s) and date	Prof Carlos Peres, Dr João Vitor Campos e Silva and Dr Joseph Hawes

1. Project Overview

Around one third of all vertebrate species worldwide are freshwater organisms. With rapidly increasing human populations, freshwater bodies and wetlands are rapidly becoming the most threatened ecosystems worldwide, particularly in the tropics. Lowland Amazonia supports the largest expanses of seasonally flooded forests, the largest and most valuable freshwater fishery, and the most species-rich fish fauna on Earth. Aquatic vertebrates (including fish, turtles and crocodilians) provide ~75% of the animal protein demands of rural Amazonians, who consume 369 – 800 g of fish person^{-1} day^{-1}, the highest per-capita fish protein intake recorded anywhere. Consequently, inland fisheries along major tributaries of the Amazon continue to be severely overexploited, particularly high-value large-bodied slow life-history species that are highly desirable by commercial extractivists. Yet basic life-history data and stock-recruitment relationships necessary to implement effective quantitative fisheries assessments and management are still lacking.

This Darwin Project aims to develop a spatially-explicit set of guidelines to inform landscape-scale fishery management protocols that can be applied to any major watershed across all lowland Amazonian countries. In particular, we have been using a network of 83 large oxbow lakes and 97 sandy fluvial beaches along the second-largest white-water tributary of the Amazon to (1) consolidate 'fishing agreements' to zone the spatial structure of commercial and subsistence fishing activities; (2) understand the relationship between spawning biomass and fish recruitment, and how these stock-recruitment relationships depend on baseline environmental variables such as lake size, productivity, and macrophyte cover; (3) understand the demographic importance of 'no-take' areas (i.e. strictly protected lakes and fluvial beaches) in maintaining a sustainable fishery and the spatial dynamics of commercial fishing boats; (4) resolve political conflicts between commercial and subsistence fisheries; and (5) assist government agencies in both developing exploitation management protocols for commercially valuable fish and *Podocnemis* turtle species and dealing with key human-wildlife conflicts in aquatic ecosystems.

This study has been conducted along a 492-km section of the Central Juruá basin within and around two contiguous sustainable-use forest reserves (Fig. 1). The Juruá River is the second-largest white-water tributary of the Amazonas River (Solimões), within the ~1.6 million km^2 State of Amazonas, Brazil. The area contains two main forest types: seasonally flooded (*várzea*) forests along the river channel and higher elevation (*terra-firme*) forests which are never exposed to the seasonal flood pulse; and unlike other major tributaries of the Amazon, these floodplain forests are relatively intact. The alternating wet and dry seasons and corresponding fluctuations in floodplain water-level are between January and June, and August and November, respectively.

The federally-managed Médio Juruá Extractive Reserve (RESEX Médio Juruá) was created in 1997. Situated on the left bank of the river (5º33'54"S, 67º42'47"W) this 253,227-hectare reserve is inhabited by nearly 2,000 people living across 13 well-established communities. The more sparsely populated state-managed 632,949 hectare Uacari Sustainable Development Reserve (RDS Uacari) (5º43'58"S, 67º46'53"W), which was created in 2005, is inhabited by some 1,200 people across 32 communities. Local livelihoods in both reserves are sustained primarily by floodplain and river channel fisheries, subsistence agriculture and non-timber forest products, such as oils, seeds and palm fruits. Although these two reserves have very different higher management structures, they represent a continuum of human population density and are virtually identical in their natural environments and the extractive livelihood patterns of local communities. We therefore decided to work with both of these reserves even though this involves a much larger area and doubling the amount of project bureaucracy and communication with environmental agencies.

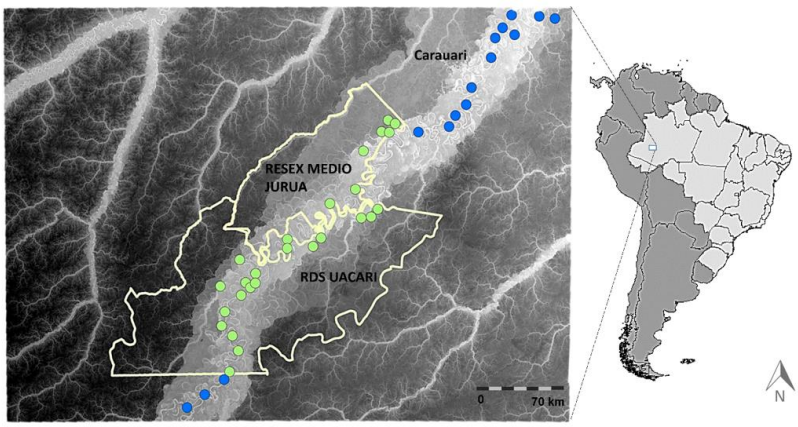

Figure 1. Core study area of Darwin Initiative Project 20-001 along the Juruá River of Western Brazilian Amazonia. Local communities engaged by the project, within and outside the two focal forest reserves, are indicated by green and blue circles, respectively.

2. Project Progress

In response to the last annual report review (AR2R) we recognised the need to prioritise activities during the third year for the timely completion of proposed outputs, by identifying the activities and outputs that will contribute most towards completion of the outcome and directing project resources towards them. We agreed that the implementation of the 'fishing accords' and the creation of management protocols that can be applied elsewhere represent our most important contributions and should be our top priority.

During the last year of our project we therefore applied a determined effort to finalise one of the most comprehensive fishing accords in the entire Brazilian Amazon (see details below). We conducted meetings involving all partners and leaderships and most fisherman to define the categories of lakes in every local community. This is fundamental for solving historical conflicts, which often threaten the personal safety of many fishermen.

In our most recent half-year report (HYR3) we responded to other feedback from AR2R relating to progress towards our planned outputs, in particular relating to complementary outputs that had been added to our original outputs during the course of the project. While accepting the concerns outlined in the review, we still maintain that these more ecological outputs represent valuable complementary information, strengthening our understanding of the project's more conservation-development aspects. Without detracting from our priorities identified above, progress was made towards a number of these outputs that demonstrate the cascading benefits of community conservation for non-target biodiversity and the wider ecosystem. For example, analyses were completed with important results for primary productivity dynamics in floodplains lakes, responses of waterbirds to fisheries managements, and collateral effects of fluvial beach protection.

Finally, during the last year, we worked on important communication outputs, such as the development of a project website, preparation of the management handbook to maximise local outreach of project results, and producing a project video documentary which will help win badly needed hearts and minds in Brazilian governmental agencies. We also worked extensively on developing our exit strategy, through supporting the creation of a local NGO for the long-term support and maintenance of training and management activities.

2.1 Progress in carrying out project activities

Output 1: Oxbow lake programme (protected vs unprotected lakes)

Fishing accords

During the last year, we applied a determined project effort to finalise one of the most comprehensive fishing agreements in the entire Brazilian Amazon. We conducted meetings involving all partners and leaderships and most fisherman to define the categories of lakes in every local community. This is fundamental for solving historical conflicts, which often threaten the personal safety of many fishermen.

At first, following a participatory approach, we built a document including the GPS points and management classes of more than 150 lakes. After that, we wrote a technical document, which was sent to Brazilian government. Last month (May 2016), the technical group from government conducted a public consultation in the town of Carauari. Hundreds of fisherman were in attendance for this event, to discuss and validate the fishing accord. Finally, the fishing accord was officially agreed upon, and should be formally published in an official government report by July 2016.

In the short-term (about three years) this accord will allow the large-scale recovery of *Arapaima* populations, as demonstrated by our monitoring results to date. Moreover, in the long-term this fishing accord will benefit more than 1,000 families of fishermen, providing food security for about 25,000 people, living in Carauari. This is extremely important, since these protected lakes will be established within the most overexploited parts of the region. Protecting fish stocks translates directly into ensuring food security for many families. Another pointing to highlight is the paradigm change which is now occurring in our study region. For many decades, 'conservation' was an unpopular word, associated by local communities with severe restrictions

and difficulties. Now, people are becoming more likely to link the idea of ‘conservation’ with opportunities, mainly due to the observed recoveries in fish populations.

Oxbow-lake productivity and ecosystem function

Our oxbow lake management program is revealing fascinating biological aspects, including a huge potential "win-win situation" resulting from fisheries management. We have now completed limnological lab analyses of physical, chemical and biological properties of lake water with seasonal controls (**Activity 1.1)** and we can show that both top-down and bottom-up processes drive the primary productivity of an oxbow lake. At first, we found that primary productivity is low during the wet season, probably because the high water level dilutes nutrient sources resulting in severe unavailability of some nutrients. At this time of year, the energetic input into the ecosystem is predominantly allochthonous. However, during the dry season, phytoplankton concentrations increased dramatically and the energetic source became primarily autochthonous (Fig. 2). This high primary productivity is very important for vertebrate populations when oxbow lakes become isolated from the main river channel.

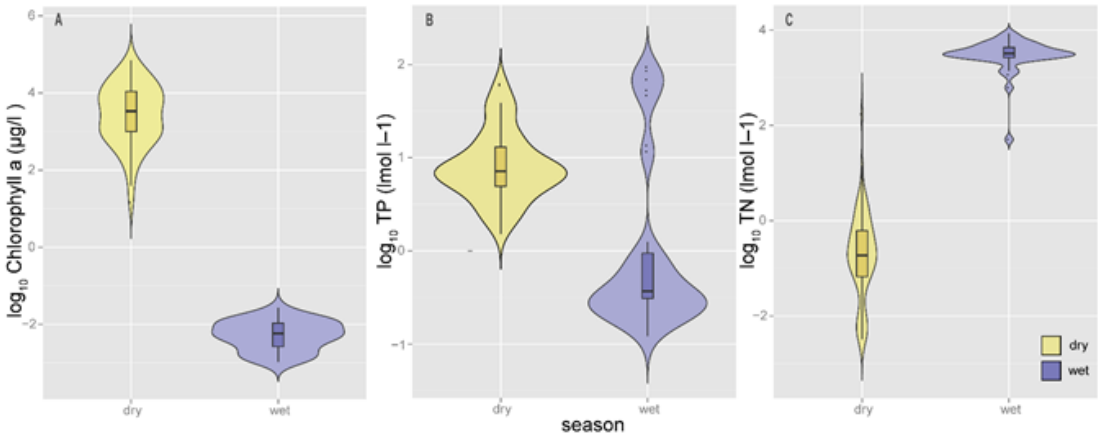

Figure 2. Primary productivity on oxbow lakes during the dry and wet season. A) phytoplankton biomass, B) phosphorus concentration and C) nitrogen concentration.

Using data from our completed household surveys (**Activity 1.2**) we have been able to explore the relationships between household CPUE and productivity (**Activity 1.3**). As expected, the bottom-up mechanism is mediated by phosphorus availability, which ensures a high biomass of phytoplankton. However, in addition to this, we found that the level of lake protection against commercial fishing boats can also regulate phytoplankton biomass. This is because unprotected lakes represent an experimental model where top predators become largely extirpated by overharvesting. Without top predators, smaller-bodied zooplanktivorous fish are more likely to increase in abundance, thereby reducing zooplankton biomass. As a result, because zooplankton feed on phytoplankton, we can then see a corresponding increase in phytoplankton biomass (Fig. 3). Phytoplankton is a key element determining detritivorous fish production, which represents almost 40% of the species (and a higher proportion of the consumed biomass) relied upon by local people for subsistence.

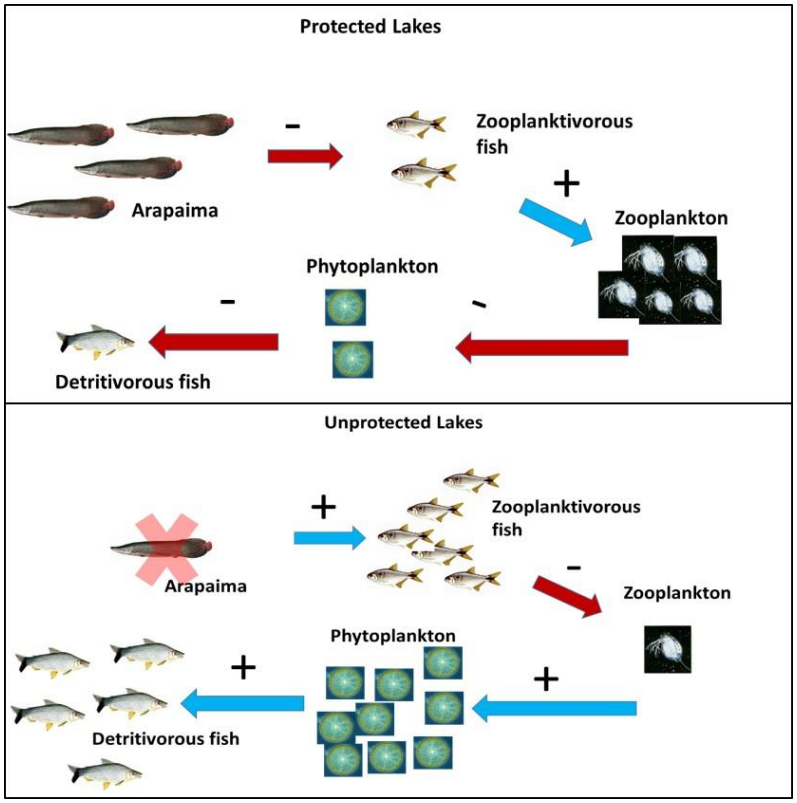

Figure 3. Example of trophic interaction in protected and unprotected lakes. Increasing *Arapaima* populations causes a decrease in the populations of zooplanktivorous and detritivorous fish. The absence of *Arapaima* allows an increase in certain other fish species due to predator absence and increasing primary productivity.

If a zoning approach is employed, this mechanism can ensure a "win-win" fisheries management strategy since protected lakes (as we have shown in the last report) produce a high biomass of high-value large-bodied fish species operating as apex predators (which can be harvested and sold to generate an important source of local revenue), while unprotected lakes can maintain a high biomass of smaller-bodied species that are important for direct local subsistence. Investigation of the relationship between household CPUE and patch/landscape-scale variables (**Activity 1.4**) are still ongoing.

To extend our examination of the functionality and ecosystem level consequences of lake protection status according to the fishing accords (**Activity 1.5**) we included an investigation of the effects of fisheries management on waterbird abundance in 31 lakes spread across the floodplain (previously listed as an additional output but more appropriately included here). We found that the population size of an apex predator species targeted in fisheries management has a strong negative influence on piscivorous waterbird guilds (Fig. 4). Others important variables were water transparency, depth, area, distance to river channel and macrophyte coverage. For non-piscivorous, fisheries management has no effect, and the important factors were only macrophyte coverage, area and landscape richness. These results are very interesting, highlighting a potential conflict between the fisheries management and waterbird conservation. Other mechanism are also possible, such as changes in fish behavior, but our findings help to improve understanding of the drivers of waterbird abundance in Amazonian floodplains.

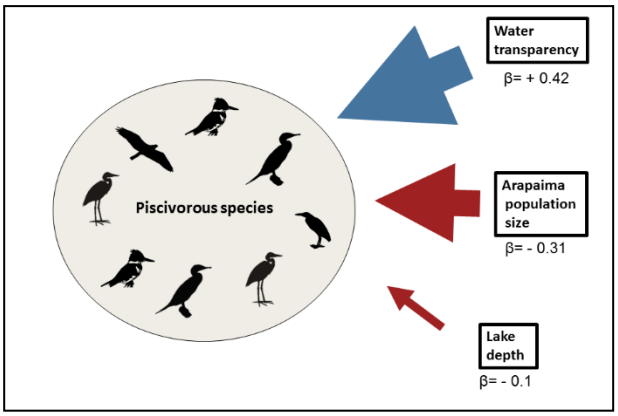

Figure 4. Schematic figures showing the effect size of the three significant variables on the total abundance of piscivorous (fish-eating) fish. Red and blue arrows represent a negative and positive effect, respectively. Arrow size indicates the magnitude of the effect size.

Activity 1.6

The illustrations and contents for a handbook of freshwater resource management techniques (**Activity 1.7**) is in the final stages of completion. The video documentary to accompany the handbook is also currently being completed. Filming for this video, including footage of both *Arapaima* management and freshwater turtle beach protection, was conducted last field season (August-October 2015) by a professional Brazilian filmmaker. Editing and production of this documentary will be completed by July 2016.

Output 2: Freshwater turtles programme (protected vs unprotected fluvial beaches)

Conservation benefits of beach protection

Our results are now fully revealing the impressive effects of beach protection, which justifies the future implementation of similar programs along other major Amazonian rivers. We have now recorded data demonstrating that the illegal traffic of turtles is very strong in our study region. More than 12,000 individuals are currently sold each year in the nearest towns, so the protection of nesting sites is clearly critical to ensure the conservation of these stocks. In addition to monitoring the abundance and reproductive output of *Podocnemis* females during the breeding season (**Activity 2.3**), we have also monitored the effect of beach protection for non-target taxa. Beyond turtle conservation, our results clearly show that beach protection is important for the conservation of several other taxonomic groups (Fig. 5). Many of these groups are also very important for the regional economy and local food security, such as large catfish (high commercial value), aquatic megafauna (high cultural value), migrant birds (high subsistence value with eggs being harvested and consumed locally).

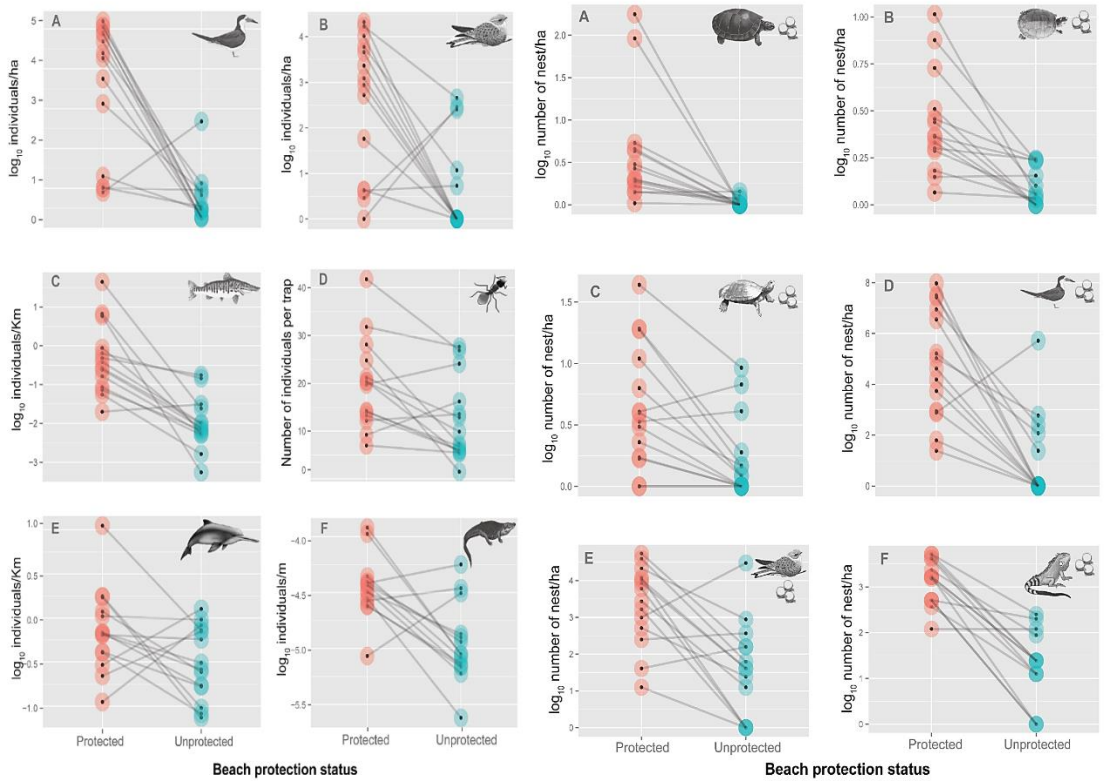

Figure 5. Effects of beach protection for freshwater turtles and other taxonomic groups

Even though large portions of suitable *Podocnemis* habitat are covered by of sustainable-use protected areas in Amazonia, the protected area strategy could be insufficient to ensure their conservation, due to high rates of hunting and egg harvest across rural communities within extractive reserves. Besides, illegal commerce in small cities within protected areas can place substantial pressure on turtle populations. For example, in Carauari – a small town in lowland Amazonia – the profit generated from the ten largest illegal turtle traders is around US$57,000 per year, with the majority of harvested individuals sourced from protected areas (PMJ, unpublished data). In fact, our findings support the idea that sustainable-use reserves cannot guarantee the successful freshwater turtle reproduction, since the nest raiding is around 99% on unprotected beaches within protected areas. Breathtakingly, our CBC approach reduced poaching to around 2.1% of the unprotected beach baseline.

Notably, the ecological benefits of beach protection are particularly impressive compared to the low cost of implementation. This CBC scheme currently costs the Brazilian government and partners about US$106.40 per beach-guard/month, paid as a monthly basic food basket throughout the six months of the dry season. This means that each turtle hatchling released cost just US$0.03 over the last five years. There is a heated discussion about the most appropriate mechanism of payments for biodiversity conservation in developing countries (Ferro and Kiss, 2002). Here, we suggest a mixed approach, with the costs supported by government and local communities, because we understand that rural communities cannot carry the heavy burden of conservation of biodiversity alone, once biodiversity maintenance is considered a global objective (Ferraro, 2000). Moreover, there is a clear dissatisfaction with current rewards, and beach-guards are increasingly vocal in their claims for a basic salary. We argue that CBC programmes should strive to generate enough income to ensure their continuation in the long term. To become less independent on government rewards, the programme itself could potentially start management schemes, as already occurs in the study region with *Arapaima* management

Socio-economics of beach protection

Fluvial beach protection is clearly a very important conservation programme. However, our results are showing that the social dimension of this programme is currently very unsatisfactory, as local monitors (whose valiant efforts are often belittled and publicly challenged) do not receive any payment for their valuable services. They spend six months per year protecting their local beach while local government and partners only provide a 'bare-bones' amount of food per month. As a result they currently live below the poverty line, with very few income opportunities. Our project is working to reverse this situation, by implementing a hatchling management initiative. Brazilian laws in this respect are very restrictive, and for now, we can only explore this possibility through a research programme. However, at the same time, we are playing a key role in a central-government discussion about possible changes to these laws, which may allow the future establishment of a full hatchling management programme.

Last year, we captured some 500 hatchlings, with two communities rearing the hatchlings in nurseries inside small oxbow lakes (**Activity 2.4**). They provided the hatchlings with natural foods, and we expect them to be able to sell the hatchlings in the third year, when they reach approx. 5 kg in weight. The entire process is under the supervision of our UFAM partner Dr Paulo Andrade, who recently completed his PhD, and has extensive research experience in turtle conservation and cost-benefit analysis of hatchling management. In collaboration with UFAM (Projeto Pé-de-Pincha), we have successfully recorded biometric data from >12,000 hatchlings over the course of this project, tracked 4 adult females using GPS/VHF transmitters, and tagged >1,000 post-quarantine hatchlings (**Activities 2.4, 2.5**). Analyses of these data are currently being completed by Dr Andrade, whose technical background has greatly strengthened our activities towards this programme, which would represent an important step towards ensuring the economic sustainability of beach management, while providing financial support to improve the quality of life of key players. This initiative is entirely unique and will help us and policymakers understand the full consequences of strictly protecting key egg-laying habitats both within and outside multiple-use Amazonian forest reserves.

Output 3: Arapaima stock assessment and management programme

Arapaima management

Our initial presentation and subsequent training workshops (**Activity 3.1**) had already been completed. We have continued to expand the number of protected oxbow lakes and trained local fishermen to conduct annual counts of adult Arapaima (**Activities 3.2, 3.4**), especially in areas outside the reserves. We have previously demonstrated the impressive recovery rates for Arapaima populations within protected lakes, which we feel shows the value of this pioneer scheme for Amazonia. We have now mapped (**Activity 3.3**) and helped to establish protection for a total of 17 ox-bow lakes (including 3 additional lakes inside the reserves and 15 lakes outside the reserves; Fig. 6). We therefore have a total of 32 large oxbow lakes currently being protected and monitored (Fig. 7), and which will be included in our final stock assessments (**Activity 3.5**) to be presented in our final report.

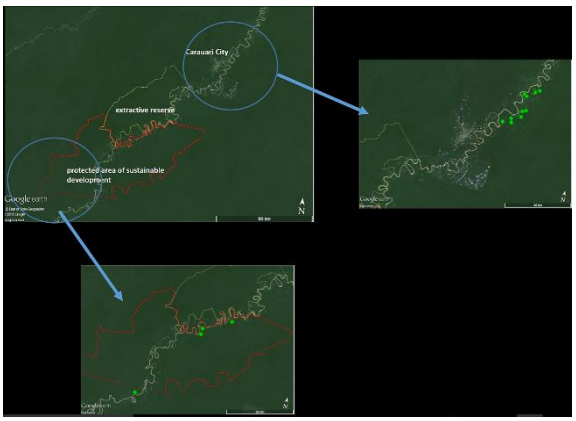

Figure 6. Distribution of protected lakes within and outside reserves along the Rio Juruá.

Using information produced through our work to date, we wrote an experimental proposal to start *Arapaima* management outside the study Protected Areas. This proposal is currently being examined by IBAMA, the Brazilian government environmental office. We proposed an offtake quota of 35 individuals per lake, which represent less than 3% of the total individuals counted last year. We expect to be in a position to conduct the first *Arapaima* management outside the PAs in September 2016. This will be the most important practical result from our project, enforcing the importance of community-based conservation, even outside Protected Areas.

We have also made a significant advance in this area of the project, in helping to establish a new grassroots NGO called Associação Baixo Juruá (ABJ). This initiative, introduced in close partnership with local communities, represents an important tool to advance the training and empowerment of local associations and will significantly strengthen our exit strategy and help to support recently project-trained local people in long-term management of their fish stocks. We are currently working with the leaders of the new association to complete the necessary bureaucratic process and to better define their scope. ABJ will eventually assume full responsibility for development and conservation schemes in those communities located downriver of Carauari, outside the boundaries of the two reserves where we have been working. Since its creation, we have worked in collaboration with ABJ to establish lake protection and Arapaima counts in 15 lakes outside the reserves. Through our support, local communities have gradually become more empowered as ABJ moves towards eventual self-sufficiency. This process will be greatly assisted by the already agreed co-operation of existing associations (ASPROC and AMARU) from communities inside the reserves, which will similarly assume responsibility for the continuity of project activities inside the reserves. As part of our exit strategy, during the next two dry seasons (2016 and 2017), in cooperation with local associations, we will strengthen this management approach, developing the role of our social capital and institutions involved. Harvested fish will be sold at a local market, and the income earned will benefit about 20 families.

Figure 7. Participation in Arapaima community management, including the monitoring of offtake harvested to generate financial revenue that supports the continued conservation of fish stocks.

***Arapaima gigas* ecology**

In response to comments in the review of our AR2, we have now included research activities on Arapaima fish ecology under this output (now recognised more appropriately as Activities), as recommended.

We have had some very interesting results from our Arapaima telemetry work (**Activity 3.6**), confirming the long distances that Arapaima can travel into the flooded forest during the wet season. One of our focal Arapaima was recorded to have travelled more than 30 km, where it was killed by a fisherman outside the reserves (Fig. 8). At first, this finding was very sad, however, it also provides a very important message in better understanding how Arapaima movement ecology affects the efficiency Arapaima management. Using this example, we are able to illustrate to local people that, during the wet (high-water) season, fish resources cannot be monopolised. Several valued fish species can migrate up and down the river, colonising over-exploited environments, thereby providing food for families from different communities, including people outside the protected areas. In this way the protected lakes can be seen to have wider benefits for subsistence households far from management sites.

Figure 8. Results of Arapaima telemetry, showing unprecedented movement of one individual over 30 km.

Our preliminary results also show that, at the onset of the dry season after six months in the flooded forest, four individuals returned to the same lakes where they were initially caught. With these results we confirmed a high level of site fidelity for protected lakes, which provides a strong justification to local communities to introduce or continue protection because, during the dry season (when oxbow lakes become more discrete geographic features, fish stocks can be monopolised and harvested for financial returns.

We continued our mark-recapture programme (**Activity 3.7**) during the latest field season, focussing on tagging juvenile Arapaima in non-protected lakes. We successfully tagged a further 30 individuals, to complement our tagging in protected lakes in the previous year. During this season's annual harvest (based an agreed sustainable offtake quota), we also recovered four individuals which had each returned to the same lake location where they had been tagged previously. This supports findings from our telemetry study that there exists a high site fidelity for protected lakes.

We continued our DNA and scale sampling (**Activity 3.8**) during the latest field season, focussing on sampling juvenile Arapaima in unprotected lakes. We collected a further 79 tissue

samples of different individuals, to complement our collections from protected lakes in the previous year and expand the spatial coverage of our sampling. All DNA samples have been deposited with our project partner at the Genetics Lab at UFAM, where they are being examined for fine-scale genetic divergence using DNA microsatellite analysis.

Output 4: Conflicts resolution management

Our project has been working hard to solve some treacherous conflicts between local communities and professional fisherman. During our last field campaign we helped to solve two historical conflicts around two lakes inside the reserves. The situation in each case was complex due to threats of violence and our role as an intermediary was valuable in helping the various parties reach an understanding. We have been able to show that it is possible to form a partnership between local communities and professional fisherman from nearby towns. From this point on, these two lakes will now be protected under a new (and yet untested) model involving both professional fisherman and local fishermen. We are now focussed on working with local communities and organisations to formulate a set of lasting rules for the management of these lakes, and to act as a template for similar cases in the future.

The educational booklet will also cover superficially the issue of subsistence vs commercial fisheries, and we continue to talk to local communities and our partners about this type of conflict resolution.

A global review of conflicts between often lethal freshwater predators and fishermen, including a case study incorporating the results of interviews from our study site (**Activity 4.3**), was successfully completed as part of an undergraduate degree dissertation at UEA (by Patrick Cook) during this reporting period. This is clearly a thorny issue in our study area, as Black Caimans continue to take the lives of both adults and children (**Activity 4.2**), followed by retaliation measures that typically result in the death of the 'problem animal'. We have successfully mapped the distribution of Giant Otters and Black Caimans (**Activity 4.1**) and mapped all water bodies (**Activity 4.4**) are conducting the spatio-temporal overlap with fisherman (**Activity 4.5**) that plays a large part in the perceived conflict.

Output 5: Empirical and modelling tests of management protocols

Analyses are ongoing but we have already presented early results at national and international conservation conferences to disseminate our findings amongst the research community. Oral presentations were well received at the Environment and Development Convention (Convención Internacional sobre Medio Ambiente y Desarrollo) in Cuba (July 2015; http://www.cubaambiente.com), the Association for Tropical Biology & Conservation (ATBC) meeting in Honolulu, Hawaii (July 2015; http://www.atbc2015.org/), and the Brazilian Mammalogy Congress (Congresso Brasileiro de Mastozoologia) in João Pessoa, Brazil (Sept 2015; http://www.8cbmz.com.br/site/capa). An additional talk about this Darwin Project has also been given at Oregon State University, USA. We are also discussing with project partner Dr Taal Levi (Oregon State University) about the spatial modelling work on the optimal allocation of protected lakes across a landscape-scale harvesting mosaic. This modelling work requires the full set of data on Arapaima dispersal, and spatial behaviour of commercial boats, but we are committed to see this work through to completion either before or after the project end date.

Understanding past declines in fish abundances is crucial to avoid similar declines in the future. During this reporting period we conducted over 5,000 household interviews within 25 local communities with experienced fishermen to help us understand the institutional characteristics that promote successful local management in our study area (**Activity 5.4**). These results will be compared with existing data from various sites across the Brazilian Amazon to understand the causes of any differences. For example, we have already learnt that management plans frequently collapse when government cannot provide enough financial support or human resources. However, if communities are empowered (as through our project activities) then social and economic resilience can be strengthened and management is more likely to persist. An analysis and evaluation of the role of protected areas in the welfare of traditional Amazonian communities, focussed on the results of household and community interviews, was also successfully completed as an MSc thesis by a Brazilian student at Aarhus University during this reporting period.

Output 6: Understand the co-benefits of community management for biodiversity conservation

Here we present project activities that were inappropriately listed in previous reports as additional outputs.

Activity 6.1: Seasonal movement of terrestrial vertebrates

No further fieldwork was conducted during this period and the focus is now on manuscript preparation based on a large amount of camera-trapping data.

Activity 6.2: Wildlife depletion envelopes

No further fieldwork was conducted during this period and the focus is now on data analysis and manuscript preparation.

Activity 6.3: Wattled curassow ecology

Fieldwork was fully completed during this reporting period, with the conclusion of the telemetry activity. The focus now is on data analyses and manuscript preparation as part of a Brazilian PhD thesis by Gabriel Leite (co-supervised by Prof CA Peres and Dr Izeni Farias).

Activity 6.4: Conservation programme of lowland paca and other nocturnal mammals

Considering the concerns in the review, we have opted to shift our attention away from this additional output, which we will hopefully pursue as an independent project in the future. This will help us to prioritise on finalising activities for our core outputs.

Activity 6.5: Tambaqui management programme

Considering the concerns in the review (AR2R) and the practical difficulties we experienced in our attempts during the last dry season, we have opted to shift our attention away from this additional output. This will help us to prioritise on finalising activities for our core outputs.

2.2 Project support to environmental and/or climate outcomes in the UKOT's

This project has clearly boosted general belief that 'win-win' integrated conservation-development strategies can be developed in a number of UKOT in the tropics. Using creative co-design initiatives such as those presented here, we believe project results can be extended to other countries grappling with critical issues of biological resource management.

2.3 Progress towards project outputs

Output 1:	Design, local empowerment, consolidation and expansion of the landscape scale spatial management system concerning a large network of oxbow lakes		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 1.1 Background research leading to the development of a spatially explicit management protocol of community-based freshwater fisheries management	None before project	Data collection of artisanal and commercial fish landing data was completed. Detailed analyses of the large amount of fisheries exploitation data are nearing completion.	Dataset
Indicator 1.2 Data from limnological sampling of 83 spatially-explicit oxbow lakes during both the wet and the dry seasons.	None before project	Limnological lab analyses of physical, chemical and biological properties of lake water, with seasonal controls, have been completed.	dataset

Indicator 1.3 Technical training Workshop deployed to both artisanal and commercial fishermen of the central Rio Juruá region; Technical training Workshop with key stakeholders including the Fishermen Cooperative, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio)	None before project	No further training workshops were conducted during this reporting period, but during our long field work campaign last year, several sampling protocols were reinforced including our data quality control measures. To address the query from the last review, we have previously conducted three training workshops over the course of the entire project, with an attendance around 50 people per workshop which was highly biased towards local community leaders.	Photographs and document from Fishing Cooperative
Indicator 1.4 Deliberations of negotiated settlement between commercial and artisanal fishermen thereby subsidizing a legal agreement ratified by the Fishermen Cooperatives of Carauarí	None before project	During the last year we have completed efforts to formalise an official fishing agreement.	Official document to be attached in the next (final) report
Indicator 1.5 Preparation of the *Handbook of Community-Based Freshwater Fisheries Management Techniques*	None before project	The illustrations and contents for a handbook of freshwater resource management techniques is in the final stages of completion. The video documentary to accompany the handbook is also currently being completed. Filming for this video, including footage of both *Arapaima* management and freshwater turtle beach protection, was conducted last field season (August-October 2015) by a professional Brazilian filmmaker. Editing and production of this documentary will be completed by July 2016.	Images, dataset, Illustrated Handbook and video documentary

Indicator 1.6 Dissemination of the *Handbook* to all institutions involved in resource management, particularly concerning fisheries	None before project	Dissemination of the materials mentioned above will be conducted as soon as they are finally completed.	Number of local communities receiving handbook
Output 2:	Design, local empowerment, consolidation and expansion of the spatial management system addressing freshwater turtles and ovipositing sites on fluvial sandy beaches		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 2.1 Training Workshop on turtle management to local stakeholders, namely the residents of RDS Uacari and RESEX Medio Jurua	None before the project	Three conducted now	Photographs
Indicator 2.2 Discussions with Reserve Management Council on spatial zoning of all dry-season sandy beaches	None before the project	Five major discussions conducted now	Document from stakeholders to be attached to the next report
Indicator 2.3 Number of fluvial sand beaches protected along a 492-km section of the Rio Juruá	14 beaches poorly protected before the project into protected areas	14 beaches protected now + potential (not yet implemented) outside protected area	Document from stakeholders to be attached to the next report
Indicator 2.4 Counts and electronic tagging of live turtle hatchlings dug from nests, quarantined, and released.	None before the project	>1000 now	Dataset
Indicator 2.5 Large-scale movements of adult *Podocnemis* turtles over a 24-month period.	None tracked before the project	4 adult females tracked now	Dataset
Output 3:	Design, local empowerment, and expansion of the management system addressing *Arapaima* fisheries in both oxbow lakes and the river channel (including *Arapaima* ecology)		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 3.1 Initial presentation of subproject and training workshop to local artisanal fishermen from 35 local communities on	None	1 x presentation + 1 training workshop, attended by over 40 project participants from local communities.	photographs

Arapaima census techniques			
Indicator 3.2 Training workshop extension to key stakeholders outside the two protected areas (Fishermen Cooperative, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio)	None	Two workshops attended by ~40 participants from 35 communities, and including representatives of local cooperative associations.	Photographs and document with signatures to be attached to the next report
Indicator 3.3 Total number of protected oxbow lakes negotiated with commercial fishermen cooperative under mutually-agreed "fishing accords".	Five inside the reserves None outside the reserves	We have negotiated and implemented protection of three additional lakes inside the reserves, and 15 new lakes outside the reserves.	Legally sanctioned "Fishing Accord"
Indicator 3.4 Time-series from at least 26 lakes beginning to show population recovery trends by the end of Project Year 3.	None	We have a huge dataset with arapaima counts in 87 lakes, since 2012.	Dataset
Output 4:	Design and establishment of a conflict-resolution management plan considering large vertebrates perceived to be "problem species" including key apex predators (e.g. *Pteronura* and *Melanosuchus*)		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 4.1 Development and preparation of educational booklet with the goal of reducing conflicts between subsistence/commercial fishermen and *Pteronura* and *Melanosuchus*	None	Not yet completed	
Indicator 4.2 Dissemination of a "problem-species" illustrated educational booklet to all Jurua communities.	None	Not yet completed	
Indicator 4.3 Population estimates combined intensive field surveys and	None	We conducted interviews at more than 40 communities	Dataset and dissertation work by Patrick Cook (UEA)

information from interviews at 40 communities on the spatial distribution of occupancy records of *Pteronura and Melanosuchus*			
Indicator 4.4 Illustrated talks at seven venues bringing together representatives of ~40 local communities of RESEX Medio Jurua and RDS Uacari	None	We provided explanations about wildlife conflicts at 18 communities	photographs
Output 5:	Empirical and theoretical test of management protocols and expansion into other river basins of Brazilian Amazonia and other Amazonian countries		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 5.1 Analytical approaches to data integration including productivity-based stock recruitment models; spatial modelling showing the importance of no-take areas under a source-sink population framework; an analysis of the socioeconomic benefits of no-take areas accrued to local communities.	None	This is a key project Indicator; but has been delayed to the post-project phase of data analysis and writing.	Still not available
Indicator 5.2 Distribution of the *Fisheries Handbook* to all relevant institutions and government agencies involved in the management of freshwater fisheries in Brazilian, Bolivian, Colombian and Peruvian Amazonia	None	This Handbook is in the final stages of preparation. Printing and distribution costs will be shared with state management agencies of Amazonas	Drafts (in preparation)
Indicator 5.3 Final Workshop held in Manaus to a target audience of natural resource management agencies, particularly government and nongovernment organizations responsible for fisheries management	None	This will be funded by the state government of Amazonas and therefore postponed to 2017	

Indicator 5.4 Presentations of project results at the Latin American Wildlife Management Congress, Association for Tropical Biology & Conservation meeting, and Society for Conservation Biology.	None	• Silva et al. 2015 Latin American Wildlife Management Congress, Havana, Cuba. • Silva et al. 2015 ATBC, Hawai'i, USA. • Hawes et al. 2016 ATBC, Montpellier, France.	
Output 6:	Understand the co-benefits of community management for biodiversity conservation		
	Baseline	Change recorded by 2016	Source of evidence
Seasonal movement of terrestrial vertebrates	None	Large sampling effort in both floodplains and upland forest	Dataset and MSc dissertation by Hugo Costa (MPEG)
Terrestrial wildlife depletion envelopes near local communities	None	Large sampling effort and strong evidence of wildlife depletion	Dataset and PhD thesis by Mark Abrahams (UEA)
Wattled curassow ecology	None	Generation of data on the population ecology and distribution	Dataset and PhD thesis by Gabriel Leite (INPA)
Conservation programme of lowland paca and other nocturnal mammals	None	We have been working on a monitoring protocol development, but this activity is now on hold.	Dataset
Tambaqui management programme	None	This activity was not satisfactory due the huge difficulties in capturing sufficient numbers of tambaqui	None

2.4 Progress towards the project outcome

Outcome:	Understand the spatial dynamics of productivity and exploitation of aquatic vertebrates — including fish, turtles and caimans — along the Rio Juruá, a major tributary of the Amazon river, and create a spatially-explicit set of management guidelines to protect the landscape-scale sustainability of inland fisheries that can be feasibly enforced by local resource users. This will be based on community-based "fishing agreements" over an access-rights zoning system defining a spatio-temporal harvesting mosaic of commercial and subsistence fisheries including no-take areas (i.e. subsistence-only and strictly protected oxbow lakes). This will lead to measurable protein-acquisition benefits to small-scale artisanal fishermen resulting from population recovery of harvest-sensitive stocks.		
	Baseline	Change by 2016	Source of evidence
Indicator 0.1 Annual counts of adult pirarucu (*Arapaima gigas*) fish in 83 oxbow lakes under varying categories of protection status, as per 'fishing agreements' between local communities and	Arapaima counting at 23 lakes since 2008.	After 2012, arapaima counts have taken place at an unprecedented 87 floodplain lakes (within an outside protected areas)	Dataset, PhD thesis of João Vitor Campos-Silva (UFRN; April 2016)

commercial fishermen.			
Indicator 0.2 A range of research and management activities centred on breeding sites where ovipositing female turtles (*Podocnemis expansa* and *Podocnemis unifilis)* converge. A total of ~28 protected and unprotected sandy beaches along the Juruá River will be monitored.	Participatory monitoring at 12 beaches inside protected areas.	14 beaches monitored and robust analysis to clarify the broad community-wide ecological effects of beach protection	Dataset, PhD thesis of João Vitor Campos-Silva (UFRN; April 2016)
Indicator 0.3 Limnological measurements conducted at 83 oxbow lakes along a ~492-km section of the Juruá River.	None	83 comprehensively sampled lakes	Dataset, PhD thesis of João Vitor Campos-Silva (UFRN; April 2016)
Indicator 0.4 CPUE data from offtakes of all aquatic sources of animal protein recorded on a weekly basis over 24 months at ~420 households from 35 local communities along a ~492-km section of the Juruá River	None	A large sampling effort at ~35 communities	Dataset
Indicator 0.5 GPS monitoring of the movements of a fleet of commercial fishing boats over at least a 1-year period, following authorization from the Fishermen Cooperative of Carauarí and Eirunepé; and Monitoring of fish landings from fishing boats at the local markets of these urban centres.	None	We had a decisive problem with deploying GPS trackers in fishing boats (under the consent of the fisherman), so we used another methodology to estimate the landscape use by fishermen.	Dataset
Indicator 0.6 Spatial modelling of oxbow-lake fish productivity under varying degrees of protection from commercial fishing and connectivity to the main river channel.	None	This outcome is still being developed in collaboration with Dr Taal Levi (Oregon State Univ)	

We believe that over 85% of the original project objectives have already been achieved, although the project grew considerably in both scale and scope in Years 1 and 2 to take advantage of critically available opportunities that were entirely relevant to meeting project objectives. We estimate that these additional activities account for ~40% of all project achievements so far in terms of local to regional real-world impact, datasets generated, and worthy tangible outcomes such as implementation of floodplain fisheries management across disenfranchised communities outside formal protected areas. This project has therefore been excellent value in going beyond what we had promised and achieving way more than what we originally set out to do (by a factor of ~1.25). These expected and additional achievements can be demonstrated and substantiated; and we would like to be selected for an in situ post-project evaluation and technical audit, if at all possible.

2.5 Monitoring of risks

The central risk faced by the project since its first inception was the level of approachability and receptiveness from local communities, who are the life & blood of everything we have been able to achieve in the Médio Juruá region. We are pleased to report however that our local working relationships are stronger than ever before, and on this count we have passed with flying colours. We have in fact laid the foundation for other ventures both in this region and elsewhere in Central-Western Amazonia to leverage community-based resource management programmes. The only overarching "risk" faced by any such venture is the political climate at the highest spheres of power towards all things environmental. This issue was featured in a paper we published last year as a result of our experience with this project (Campos-Silva et al. 2015. Policy reversals do not bode well for conservation in Brazilian Amazonia. Brazilian Journal of Nature Conservation).

3. Project Stakeholders/Partners

A notable feature of this project is the strong and welcoming working relationship with the institutions involved in the management of natural resources in the project area. This partnership has been built by utilising the lengthy field experience of our staff in the area, and collaborative ties with certain individuals that now go back as far as 7 years. As the project has been designed considering the demands of the partners, it was relatively easy to build a strong partnership considering both bottom-up demands and top-down constraints. Next, we describe our partners as following:

A- SDS/CEUC – Secretaria do Meio Ambiente e Desenvolvimento Sustentável do Amazonas e Centro Estadual de Unidades de Conservação (http://www.sds.am.gov.br/)

This state institution is based in the state capital (Manaus) and is responsible for the bewildering task of managing a large number of state-level protected areas across the State of Amazonas. This partnership is strategic and fundamental to the project objectives, because SDS/CEUC hopes to be able to roll out the applied knowledge generated by our project to other sustainable use forest reserves within Amazonas. All project activities undergo a technical evaluation by this partner, who is given ample freedom to discuss the proposals and objectives. In addition to legal support to work within their jurisdiction, SDS/CEUC also helps with the logistics of the project as it occasionally provides small boats for field activities.

B- ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade (http://www.icmbio.gov.br/portal/)

This federal government institution is responsible for managing the federal protected area where we work (RESEX Médio Juruá). We also have a strong relationship with this partner which participates in the project in a similar way to SDS/CEUC. All project activities are sent to and analysed by this partner. This will also become a strategic partner as the project advances because, with ICMBio's oversight, it will be possible to eventually scale up and apply the management models that can be achieved with this project to other protected areas in the other eight states of Brazilian Amazonia, other than the state of Amazonas.

C- UFAM – Universidade Federal do Amazonas (http://www.ufam.edu.br/)

The Universidade Federal do Amazonas is the oldest in Brazil. It is an important partner of the Project because project members based therein are responsible for the freshwater turtle ecology & management component of the project. Through *Projeto Pé de Pincha* (http://pedepincha.com.br/) UFAM has been studying the ecology and management of freshwater turtles for 15 years, and this project has enabled these activities to be extended to the Juruá. They will contribute knowledge on the seasonal movements, foraging ecology, and management of freshwater turtles, as proposed by our project. These activities are intimately linked to zoning and protection of fluvial beaches along the Juruá during the critical egg-laying season of two large-bodies species of *Podocnemis* turtles.

D- INPA- Instituto Nacional de Pesquisas do Amazonas (https://www.inpa.gov.br/)

INPA is the largest tropical ecology research institute in the world and has extensive research experience in Amazonia (although most of the activities are concentrated around Manaus in the Central Brazilian Amazon). INPA has been providing the laboratory structure for all limnological analysis.

E- UFRN – Universidade Federal do Rio Grande do Norte (http://www.ufrn.br/)

UFRN has recently excelled in Brazil in the area of ecology. As a counterpart, UFRN provides a Brazilian doctoral scholarship to a core project member (João Vitor Campos e Silva**)**. His dissertation involves the management of aquatic resources of the Juruá floodplains and the field and lab work are being funded by this project.

F- ASPROC – Associação dos Produtores Rurais de Carauari (http://www.asproc.org.br/)

ASPROC is the strongest local partner of the project, and operates as a spokesperson for local natural resource users because it is a grassroots, community-based organization which was borne out of local demands following the emancipation of former rubber tappers from powerful rubber landlords and local trade monopolies and middlemen. ASPROC is co-leading several programs of natural resource management, which are guided by a constant dialogue with project members. This partner strongly supports work on the ecology and management of the iconic *Arapaima* fish, and helps us build a close relationship with community leaders. The *Arapaima* ecology and management program has become a key cornerstone of the project, and is intimately related to the oxbow lake ecology and management components of the project.

G- AMARU – Associação dos Moradores da Reserva de Desonvolvimento Sustentável Uacari (http://amaru.org.br/)

Similarly to ASPROC, AMARU co-organizes the practice of resource management in rural communities where our project has been implemented. This is also a key local partnership for the implementation of our activities. AMARU is closely in touch with local communities, and constantly helps us think about the demands and needs of the local population, so we can build our goals based on two important, but often diametrically opposite challenges in modern conservation science and practice: biodiversity conservation and improving the standards of living of traditional populations.

H- COLPESCA – Colônia de Pesca de Carauari (Cooperative/Sindicate of Fishermen of Carauarí)

The township of Carauari operates as a convergence point for a fleet of over 800 variable-sized fishing boats that largely trades chilled fish with a few wholesale buyers, which export large amounts of fish to large urban markets such as Manaus (2 million people). This partner is vital to the success of our work, and it was an enormous political challenge to initially earn their trust and then encourage them to collaborate with our project, likely due to suspicion and resentment of outside researchers who may be mistrusted for blowing the proverbial whistle on commercial fishing activities. There is a large historical conflict in the Juruá, where COLPESCA fishermen often violate property rights and transgress community boundaries of oxbow lakes located in protected areas in order to plunder fish stocks. Our project is opening the doors for a more formal dialogue and through our project COLPESCA commercial scale fishermen are presently working with local subsistence fishermen living within the project reserves.

We intend to support and develop a fisheries protocol that avoids or minimises stakeholder conflicts, promotes the population recovery of harvest-sensitive fish stocks, and allows the wide acceptance of a large-scale spatial mosaic of locally-enforced fishing activities and fishing

rights, whereby the land(water)scape stock renewal and source-sink dynamics can compensate for depletion effects induced by varying deployment and selectivity of fishing practices. This is crucial because fish has now become the largest earner of monetary revenues in the Carauari municipal county, and commercial fishermen, who are themselves destitute and oppressed by powerful merchants up the trade chain, cannot be entirely excluded from the basin-wide spatial equation of fishery management. They also represent an important electorate, thereby harnessing support from local politicians.

4. Monitoring and evaluation

We monitor all activities of our project according to our success in data collection and progress towards outputs, each semester. We are in constant contact with full-time field workers from local partners and communities to monitor ongoing data collection and conservation management. We have also conducted an additional evaluation of our overall progress at the beginning and end of each major dry-season field campaign, which is the critical time of year for this project. This evaluation is made incorporating feedback from our partner organisations and local communities.

Thinking beyond the project, we have also adopted a strategy to enhance and support the autonomous long-term monitoring by local stakeholders of their success in community-based conservation and management schemes:

• Monitoring Arapaima populations - Each year, Arapaima counts are now conducted at ~80 lakes by experienced fishermen from local communities supported by a technician from one of our local partner organisations. Monitoring the Arapaima population is a critical step in setting sustainable harvest quotas, but also allows local communities to directly gauge the benefits and impact of their lake protection efforts.

• Monitoring turtle nesting - Data from 14 strictly protected fluvial beaches are collected each year by local monitors, who record information on the number of nests, number of hatchlings emerged, and mortality rates. Again, these data are passed on to local management bodies (which have been strengthened by the project) but also local communities to see for themselves the direct impact of their conservation action.

In both cases, our local partners promote an annual discussion about the information collected in a large meeting. This way, all stakeholders can analyse the management tendency and make relevant adaptive decisions.

Both Arapaima and nesting turtles are key species in our aquatic resource management programme. Fishing Accords were tested in Brazil around 30 years ago, but their success was often questionable and elusive. Arapaima was the "wind of change" for this model, because this large-bodied, low-fecundity fish has become the very justification for lake protection. More fish means more purchase power to enhance household income and local services, so the protection make sense and directly results in tangible benefits. Something similar occurs with the turtles, due their high cultural value. We have an unprecedented body of data to show how effective protection of resource stocks results in direct local to regional scale benefits.

With this in mind, our project has strengthened the monitoring protocol of both Arapaima populations and turtle egg-laying. This provides us with a means to measure the success of our project. It also works well as an exit strategy, because this monitoring scheme was developed in close collaboration between ourselves, UFAM, the Brazilian Government, and local associations which were frail prior to the project. We would like to highlight that this monitoring has now become entirely independent of Darwin financial support, so local associations will be able to continue monitoring these key species even after the conclusion of our project.

5. Lessons learnt

Lessons learnt: prioritising project outputs

We found the review of our last annual report to be extremely useful in helping us identify where we may have strayed away from our original project outputs. While we still consider

some of our additional project activities to be valuable complementary contributions towards our main project outcome, those were achieved at minimal additional effort by maximising the existing project infrastructure and personnel. We were however able to identify certain aspects that could be dropped or postponed to allow us to focus more effectively on our key original outputs. For example, we have now discontinued activities towards paca conservation and tambaqui management, as admittedly the scope of the project expanded considerably particularly during Year 2 to take advantage of a number of relevant applied research opportunities.

Lessons learnt: logistical difficulties

Over the course of the project we have also learnt to cope more effectively with the difficulties posed by working in a remote region of Western Brazilian Amazonia. For example, we are now much more capable of coping with logistical difficulties in the town of Carauari, including lack of basic facilities like a cash withdrawal machine, and budgeting for travel expenses and field costs. We now take project cash by plane from Manaus and we have been able to pay for some basic subsistence & operational expenses (e.g. food and fuel) with a credit card. We have also made many friends in the local business community during the course of the project whom have made a number of obstacles easier to be overcome. In fact, the project has built considerable socio-political capital not just with local authorities, but business and societal leaders, which will make any exit strategy more effective.

Lessons learnt: health and safety

While the nature of fieldwork in the Western Brazilian Amazon will always be relatively hazardous, we have taken every effort to learn from past experiences and make our fieldwork as safe as possible for all project members and local field assistants. We reviewed our procedure for events such as venomous snake bites in remote areas, and in discussion with local partners agree that in the case of the accident with our field assistant we acted in the most effective way possible. The most important thing in this scenario is to get the patient to hospital in a speedy but safe manner. We are delighted to report that, as a result of this action, our field assistant made a complete recovery with no permanent damage, and he is back to full functionality. However, because of the potential seriousness of such events we are determined to minimise the risk of any future events of a similar nature. To this end we are sure to inform all project members and field assistants of the risks and best practise to avoid/minimise danger. In a similar nature, we now take additional care when piloting boats in fast-flowing streams. As a result of our experience last year we now avoid travelling on these streams at dusk and ensure that life jackets are always available.

Lessons learnt: responses of local communities to conservation initiatives

We learnt that to do well in the implementation of a program we need to understand the paradigm of local communities. In general, local people are anxious to improve their quality of life, and we are not referring to access to technology, but essential services such as primary schooling, basic sanitation and medical care which are typically lacking in all low-governance societies. If conservation projects can provide some opportunity to improve local livelihoods, we can more easily gain the hearts and minds of thousands of people as dedicated allies of surveillance and management of forest and floodplain resources.

6. Actions taken in response to previous reviews (if applicable)

In the feedback on our last annual report (Ref. 20-001 AR2R) we noted concerns over issues that were considered to potentially threaten the completion of the original outcomes. One of these issues was our progress towards planned outputs. We accept that our additional outputs (now corrected to be recognised as activities) were not agreed in advance with Darwin (LTSI) but we considered their inclusion to be highly complementary to our original outputs at minimal additional effort. We can confirm that all additional activities took advantage of the existing project infrastructure and in no way compromised the attention devoted to our original project aims.

While we agree that poverty alleviation is a primary goal of our Darwin Project we see this as working hand-in-hand with biodiversity conservation. The feedback suggests that baseline information was not the purpose of this project but we remain resolute in thinking that the collection of such data, and training local people — in biodiversity monitoring and natural resource management techniques — is central to the success of conservation-development projects and the long-term viability of initiatives to alleviate poverty. Although this remains contentious in the Integrated Conservation-Development Programs (ICDPs) literature, we make no apologies for conducting a sustainable development project, while if anything erring on the side of biodiversity conservation. Indeed, the Darwin Initiative strategy in deciding future funding priorities should take note of that.

For example, background ecological data on the movement patterns of adult/juvenile Arapaima fish are of central importance to evaluating the success and implications of any sustainable harvest. Training local people to work on the population ecology and migration behaviour of valuable resources also helps strengthen understanding of what a sustainable harvest really means and relates closely to our work on resolving conflicts between local semi-subsistence communities and competing stakeholders.

As another example, an output monitoring waterbird populations may at first glance seem incongruous but it clearly helps to demonstrate the cascading benefits of lake protection (with the primary aim of enhancing community-based fishery management) for other taxonomic groups. We have therefore considered it more appropriate to include this work under Activity 1.5, in reference to the ecosystem level consequences of lake protection. We feel that clearly showing such 'win-win' situations can be hugely beneficial for our local partner organisations in securing future funding and political support after the conclusion of this Darwin project on 30 Sept 2016 (as formally agreed with DEFRA and LTSI).

We accept, however, that we needed to prioritise and improve progress on our original outputs. We have therefore opted to discontinue our work towards some of our additional activities (e.g. nocturnal floodplain forest mammal and tambaqui activities, see below for details) to help prioritise our efforts towards our original core outputs. Other additional activities (e.g. ecology of the endemic wattled currasow (*Crax globulosa*); terrestrial vertebrate camera trapping) were largely activities led by Brazilian and British PhD students who have now completed fieldwork and are now focussed on data analyses and manuscript preparation. As such, these are no longer at any risk of diverting attention from progress towards our original outputs and overall project outcome. From August-November 2014, we conducted a sustained field work campaign during the dry season in our study region and we have advanced a great deal on the execution of important practical outputs (see below).

In addition, we have worked on important communication outputs, such as the development of a project website, preparation of the management handbook to maximise local outreach of project results, and producing a project video documentary which will help win badly needed hearts and minds in Brazilian governmental agencies. We have also worked extensively on developing our exit strategy, through supporting the creation of a local NGO for the long-term support and maintenance of training and management activities.

7. Other comments on progress not covered elsewhere

Nothing further to add here, and we reserve additional comments to our Final Report (agreed deadline 31 Dec 2016).

8. Sustainability

Due to the large geographic expanse and insufficient institutional governance and human resources, it is impossible to contemplate conservation in the Amazon without the inclusion of rural peoples as key components of this process. Community-based management (CBM) can be a powerful tool to promote conservation. The Brazilian government has attempted to implement some initiatives using a CBM framework, but these approaches are at best patchy

and poorly monitored. Our staff has a strong and amiable relationship with different spheres of the Brazilian government. With a good proposal in hand we would be able to convince local and state governments to implement our guidelines in several other areas.

We are using a mixed approach between environmental predictors and traditional ecological knowledge (TEK), so it is completely feasible and economically realistic to replicate project lessons in other areas. In addition to completing our research and outreach program over the next two years, one of the principal actions will be to distribute the Handbook of Freshwater Fisheries Management Techniques for all government departments, and present the guidelines in all important Brazilian conservation meetings. Above all, however, we expect that there will be spontaneous grassroots initiatives to follow through with similar guidelines as the success story of fishery management spreads well beyond our study area. In fact, there is a huge demand from local tribal and non-tribal communities right across the Amazon to sustainably manage natural resources. Yet there is a dearth of research targeting many resource populations, and few technical extension programs to support local communities and spread the lessons. It is our hope that this project goes some ways to bridge this gap, particularly along the major meandering tributaries of the Amazon.

9. Darwin Identity

The Darwin Initiative logo has been used on all our project materials, including presentations to reserve management bodies, regional stakeholders, local communities and international scientific conferences. Darwin Initiative is recognised as the major support for Projeto Médio Juruá (PMJ), which is the name used locally for our project since its establishment in 2007 through the support of an earlier Darwin Initiative project (Ref: 16001).

Both federal and state government agencies and our collaborating institutions from Brazil are now very familiar with Darwin Initiative and the support it has provided for our long-term research activities in the region.

Since the last annual report we have built a website and started a twitter account to publicise our Darwin Project online. We plan to expand our use of both of these tools and to continue updating them with new material, even after the formal end of the project. We also plan to make more of our outputs available online, including a selection of videos on our newly created YouTube channel.

10. Project Expenditure

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

Project spend (indicative) in this financial year	2015/16 D+ Grant (£)	2015/16 Total actual D+ Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				For a number of reasons, detailed in an explanation to LTSI, field costs including local wages, fuel, food supplies, internal airfares, and costs of hiring diesel-powered boats, were more expensive than anticipated. This excludes additional costs such as replacing durable equipment loss incurred when one of our boats accidentally capsized in 2015 (reported in HYR3, and email to LTSI). This has not been helped by the rising local costs of fuel/food and airfares at Carauari, Amazonas (arguably the most expensive anywhere in Brazil), and fluctuating exchange rate. We believe, however, that overall we have been able to cover all project expenses at no additional costs, and achieve more than we originally projected at the beginning of the project.
Capital items	0.00	0.00		
Others (Please specify)				
TOTAL				**69,063.00**