Department for Environment Food & Rural Affairs

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	DPLUS001
Project Title	Bermuda Invasive Lionfish Initiative
Host Country/ies	Bermuda
Contract Holder Institution	Bermuda Aquarium Museum and Zoo
Partner institutions	Bermuda Institute of Ocean Sciences, Ocean Support Foundation, Bermuda Government Department of Environmental Protection, Dept. of Conservation Services
Darwin Grant Value	£169,897
Start/end dates of project	April 1, 2013 – March 31, 2015
Reporting period (eg Apr 2013 – Mar 2014) and number (eg Annual Report 1, 2, 3)	April 2013 – March 2014 Annual Report 1
Project Leader name	Dr. Gretchen Goodbody-Gringley
Project website	NA
Report author(s) and date	Dr. G. Goodbody-Gringley, Dr. J. Pitt, and C. Eddy, 29th April 2014.

1.   Project Rationale

Since 2004, invasive lionfish have successfully established populations throughout the Caribbean Sea, the Gulf of Mexico, the Western Atlantic, and the north coast of South America. Lionfish are now ubiquitous throughout these regions, having established themselves in a variety of marine habitats, consuming large quantities of small and juvenile fishes and reef invertebrates. Lionfish populations in the Atlantic have reached densities far exceeding those found in their native habitats, which will likely affect the biodiversity and community structure of reef fish communities and could impose significant ecosystem change. The Bermuda Invasive Lionfish Control Initiative aims to protect the biodiversity of reef systems around Bermuda through increased knowledge and management of the invasive lionfish population (see Map). This project is working to gather data on lionfish abundance and distribution that are critical for developing targeted removal plans. Additionally, a lionfish-specific trap is being developed for commercial fishers to facilitate large-scale, long-term removal of this species from deeper waters, thereby reducing the population and its impact. Furthermore, analysis of feeding ecology, reproductive ecology and recruitment rates will determine the impact of the population on the local environment and estimate levels of future lionfish recruitment, which will contribute to the management plan for long-term control of this invasive population.

Overall, the Bermuda Invasive Lionfish Control Initiative project will generate the tools and data required for the implementation of an on-going Bermuda Lionfish Control Plan being developed by the Bermuda Lionfish Taskforce. This plan will provide strategies for government and other stakeholder efforts to control the lionfish population at a level that will mitigate the long-term impact of this invasive species on native fish, reef communities, the island's economy and public health.

2.   Project Partnerships

Researchers from the Bermuda Institute of Ocean Sciences (BIOS), the Bermuda Zoological Society (BZS), the Bermuda Aquarium, Museum & Zoo (BAMZ), the Bermuda Department of Conservation Services (DCS), the Marine Resources Section of the Bermuda Government Department of Environmental Protection (DEP), the Ocean Support Foundation (OSF), and the University of Massachusetts Dartmouth are working together to gather key scientific data required for the development and implementation of an island-wide management plan of the invasive lionfish population in Bermuda. To our knowledge, this is the first time that such extensive collaboration between these organizations in Bermuda has ever occurred. Thus the gravity of this invasion and the initiation of the Bermuda Invasive Lionfish Initiative have served as a catalyst for communication and cooperation between the island's government departments, NGO's and research institutions. With key players from each organization participating in every aspect of the project development and execution, this work has created a network of scientists and conservationists that previously did not exist with such a clear focus. As in any large collaborative group, communication of progress and outcomes has been our main struggle. To tackle this challenge we arrange team meetings regularly where we exchange our ideas, progress, data, and challenges. Our last meeting was held on April 1, where we developed a cohesive plan for the next 6 months of work and agreed to provide summary reports to each other on the progress of each component of the research.

3.   Project Progress

3.1   Progress in carrying out project activities

In the initial year, surveys of lionfish and prey fishes have been conducted at a total of 47 out of the intended 100 sites, including 17 sites at 10m, 14 at 20m, ten at 30m, two at 45m, and four at 60m (1.1 & 3.1). The number of surveys in Year 1 was lower than originally expected due primarily to weather delays; however, we expect to complete all surveys by project end. Preliminary estimates suggest lionfish density increases with depth, ranging from 7 lionfish per hectare at 10m sites to 690 lionfish per hectare at 60m sites. These data are currently being analysed to generate a distribution map (1.4 & 1.5). No drop camera surveys have been completed to date (1.3), however, the camera system was purchased and surveys are

expected to occur in Q1-3 of Year 2. The data obtained will be used to develop a model of the Bermuda lionfish population and generate a distribution map that will highlight hotspots for targeted removal and management in the future. (2.1 & 2.2)

Underwater cameras were deployed on commercial lobster traps to gain insight into how lionfish interacted with the traps. Lobster traps with various structural modifications have been tested by fishers and Marine Resources staff using several different baiting strategies to assess lionfish catch and bycatch. "Shading" the traps with extra material to mimic a cave entrance did not significantly increase lionfish catch, and is thus an unnecessary expense that will not be trialled further. Traditional fish pot funnels produced greater bycatch, particularly of larger fishes, so all further testing will focus on funnels with a fixed opening. Artificial baits mimicking juvenile reef fish produced similar or greater catches of lionfish when compared to traditional baits, and generated less bycatch. Data indicate greater catches from certain 'hot spot' areas, reinforcing the importance of generating a good distribution map to facilitate targeted fishing. An additional 40 traps have been purchased in order to scale up the experiment in collaboration with fishers during the summer.

Juvenile fish surveys were conducted at all of the 47 sites surveyed for lionfish to compare to lionfish gut contents (3.1). A diversity of juvenile parrotfishes, wrasses, pufferfish, gobies and butterflyfishes were observed at the sites. These data are currently being analyzed, however, initial results indicate that the bluehead wrasse, *Thalassoma bifasciatum*, is the most abundant species across sites. Stomachs of 269 lionfish were removed and examined, and contained an average of 2.6 items per stomach made up of 51% fish, 36% shrimp, 9% lobster, 3% crab, and 0.5% octopus (3.2). A total of 238 samples (205 lionfish, 10 wahoo, and 23 dusky sharks) have been processed for stable isotope ratios and data are currently being processed (3.3), with data from other predators used to assess the significance of lionfish predation

In total, 251 lionfish have been dissected and examined for reproductive output of which 135 were identified as males and 95 as females (3.4). Females ranged from 180 to 375mm; males ranged from 208 to 461mm. Preliminary results suggest that 98.2% of females are mature individuals, where 12.5% were found to be actively spawning, 23.2% were capable of spawning, and 62.5% were developing eggs.

Although light traps have not yet been deployed as anticipated, traps have been purchased with deployment expected to occur in the next 6 months (3.5). Samples have been collected from over 200 fish for DNA analysis and reagents for analyses have been purchased. Extraction, sequencing and analysis are planned for Year 2 with completion anticipated by project end (3.6). Finally, otoliths from 240 lionfish have been collected, sectioned and prepared, and are currently being analysed for age (3.7). These data will be used in Year 2 to describe growth parameters and population demographics and develop a population dynamics model of lionfish in Bermuda (3.8 & 3.9).

3.2   Progress towards project outputs

We have made substantial progress towards the assessment of lionfish population density and distribution (Output 1); see section 3.1 for detailed numbers. It is anticipated that all surveys will be completed by project end, as well as repeated surveys to assess re-colonisation rates. Using the count data from the completed surveys we are currently calculating population demographics of the lionfish population to begin to generate a distribution map that will highlight hotspots for future targeted removal, with expected completion by project end.

Trap development (Output 2) has progressed to the point where two funnel designs and two baiting strategies will be tested in an expanded trial during the summer. Fisheries extension staff are in discussions with commercial fishers to determine how to efficiently incorporate these specific trapping protocols into the commercial fishery so that they will be cost-effective in the long term.

Considerable effort has occurred toward increasing our understanding of lionfish ecology and their impact on reef communities (Output 3). See section 3.1 for details. Results and

implications of these data are currently being analysed with manuscripts and reports expected to be complete by project end.

All aspects of Output 4 are scheduled for Year 2. However, dissemination has occurred through participation in a Lionfish Workshop organized by JNCC, at which co-PI J. Pitt represented the DPLUS001 and presented information obtained thus far on lionfish trap development. Graduate student C. Eddy attended the Gulf and Caribbean Fisheries Institute (GCFI) meeting in 2013 and presented analyses of distribution and abundance patterns, and PI G. Goodbody-Gringley attended the EU *Life* Workshop hosted by Defra in March 2014. In Year 2, C. Eddy will attend GCFI and G. Goodbody-Gringley will attend the Benthic Ecology Meeting (BEM) to present project results. Additionally, manuscript and report preparation will occur in Year 2 in anticipation of project end.

3.3 Progress towards the project Purpose/Outcome

The overall purpose of this project is to gather data on lionfish abundance and distribution that are critical for developing targeted removal plans, and develop a lionfish-specific trap for commercial fishers to facilitate the large-scale, long-term removal of this species from deeper waters, thereby reducing the population and its impact. To that end we feel we have made significant strides in the first year, which are described in detail in sections 3.1 and 3.2 above. The data collected thus far indicate that our approaches will provide the information necessary to achieve the project's purpose; however, some analyses and dissemination will likely need to occur after the project end and trapping trials may also continue. Finally, our survey results indicate that continuous culling effort is needed to manage and control the population and thus this effort will need to be on going. To ensure that all project goals are met, we are seeking additional funding to extend our project.

3.4 Goal/ Impact: achievement of positive impact on biodiversity and poverty alleviation

The original goal of this project was to make a significant contribution to the long-term control of the invasive lionfish in Bermuda waters thereby reducing negative impacts on biodiversity. To achieve this goal, we are gathering critical data on abundance and distribution, reproductive and feeding ecology, and population genetics, all of which will contribute to development of a long-term control plan. These data are essential for proper development of management plans and thus our project is a fundamental component of long-term control. Furthermore, work on trapping lionfish has expanded the range of options available for continued removal.

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

Control of invasive species is activity K3.4 of the Bermuda Biodiversity Strategy and Action Plan and is included under guiding principle 7 of the Bermuda Environment Charter. Development of a commercial fishery for lionfish is an item in the Department of Environmental Protection's 15-year strategic plan for the sustainable use of Bermuda's marine resources. Defined project outputs, including a map of lionfish distribution with information on spatial and temporal variability, a lionfish-specific trap developed in collaboration with the local commercial fishing industry, and a population dynamics model, will provide tools and data required for the establishment of effective lionfish control strategies and will support on-going Bermuda Lionfish Control Plan activities. Reducing the impacts of invasive species also contributes to the conservation of marine habitats and their associated biodiversity, a common theme in the Bermuda Environment Charter and other Multilateral Environmental Agreements that Bermuda is party to, or working towards.

Project PI, G. Goodbody-Gringley, recently attended the EU *Life* Workshop, held in London and hosted by Defra. At this workshop she met with UK partners and began exchanging ideas for a future collaboration with other UKOT's to expand the work initiated with this project. Specifically, she will work with JNCC and OCTA, as well as representatives from the Cayman

Islands and the French outermost regions to develop an application for funding to implement a control strategy across EU overseas island territories.

5. Project support to poverty alleviation

NA

6. Monitoring, evaluation and lessons

In order to monitor and evaluate our project progress we meet as a team on a regular basis, at a minimum of once a quarter (see supplemental document with meeting minutes). During these meetings we discuss what work has been done since our last meeting and what remains to be completed for each output activity. In cases where we have fallen behind in our original timeline we discuss how we can ensure the task will be completed by project end. We also share data at these meetings and discuss how and where to present data to the public and scientific community. We have set baseline milestones according to the timeline provided in the original proposal and strive to work together to meet these. Some of our main indicators are presentations to the public and at scientific meetings (see supplemental documents with conference abstracts). We also present updates on a quarterly basis to the Bermuda Lionfish Taskforce who monitor our progress. Indicators of success in year 2 will include completion of specific activities, presentations of results at conferences and publication of scientific articles.

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

NA

8. Other comments on progress not covered elsewhere

These topics have been discussed in the previous sections. However, our main difficulty has been in coordinating our dive team around fair weather windows. Going into year 2, the dive team is united in our expectations to complete all of the proposed surveys and have this as our top research priority.

9. Sustainability

Within the first quarter, receipt of Darwin Initiative support was featured in an article in the local newspaper. This article outlined our goals for the project as well as those of the Darwin Initiative. An exhibit was opened at a local museum (Bermuda Underwater Exploration Institute) featuring the lionfish invasion and highlighting the work by this project, which was visited by roughly 13,000 local and foreign visitors. Over 300 people have been trained to receive lionfish culling permits and several small groups of citizen scientists have initiated organized culling groups to aid in our efforts. A lionfish tournament was held in 2013 which was attended by >350 locals, exposing them to the lionfish issue. Another tournament will be held in July 2014 and we anticipate an even greater number of participants. One of the goals of these tournaments is to let people taste lionfish in order to promote a local fishery and increase demand for lionfish. Fishers catching lionfish are reporting good sales to both restaurants and local consumers. As we move into the second year of our project our exit strategy will aim to promote co-ordinated volunteer culling along with a commercial lionfish fishery featuring lionfish specific traps in order to ensure our efforts continue beyond project completion. Additionally, we are seeking funding for a full-time deep-reef culling program to control lionfish populations in key areas that are inaccessible to volunteer divers and unsuitable for trapping but where our research shows large numbers of lionfish reside. Development of a good distribution map will contribute the effectiveness of these efforts.

10.   Darwin Identity

To date, 5 presentations have been given related this work. G. Goodbody-Gringley gave a presentation to several UK ministers who came to visit BIOS, specifically highlighting the Darwin project and featuring Defra and Darwin Initiative logos on initial and closing slides. J. Pitt presented the plans for the trapping programme to other UK OTs at a JNCC sponsored workshop in the Cayman Islands and produced a poster on the preliminary results for the Gulf and Caribbean Fisheries Institute, while C. Eddy gave a presentation outlining survey results and feeding ecology at GCFI. All presentations and the poster featured the Defra and Darwin Initiative logos. Finally, a talk was given by J. Gleason to the Hamilton Rotary Club outlining the Darwin research project and featured the Darwin plus logo. Thus far, work undertaken with Darwin Initiative support has been recognised as a distinct project that fits within the goals established by the Bermuda Lionfish Taskforce. Within Bermuda, anyone involved in the lionfish issue or marine conservation is aware of the Darwin Initiative and specifically this project.

11.   Project Expenditure

Table 1   project expenditure <u>during the reporting period</u> (1 April 2013 – 31 March 2014)

Project spend since last annual report	2013/14 Grant (£)	2013/14 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)				Staff costs are significantly lower due to reallocation of the expenditures and one staff member donating their salary to the project. Darwin approved these changes.
Consultancy costs				
Overhead Costs				Overhead costs were reduced because the Bermuda Institute of Ocean Sciences facility was not used as much as was originally budgeted for.
Travel and subsistence				
Operating Costs				Operating costs were considerably lower than budgeted, as the Endurance Boat Captain was not able to be involved in the project.
Capital items (see below)				
Others (see below)				
TOTAL	**97058.09**	**89742.20**	**-7.5**	

All changes to the budget were approved by Darwin for the 2013-14 year and no line item surpassed the 10% threshold for over expenditure. The entire expenditure came in at 7.5% lower than budgeted for the first financial year of the project.

12.   OPTIONAL: Outstanding achievements of your project during the reporting period (300-400 words maximum). This section may be used for publicity purposes

I agree for the Darwin Secretariat to publish the content of this section (please leave this line in to indicate your agreement to use any material you provide here)

Since 2004, invasive lionfish have successfully established populations throughout the Caribbean Sea, the Gulf of Mexico, the Western Atlantic, and the north coast of South America. Lionfish are now ubiquitous throughout these regions, having established themselves in a variety of marine habitats, consuming large quantities of small and juvenile fishes and reef invertebrates. Lionfish populations in the Atlantic have reached densities far exceeding those found in their native habitats, which will likely affect the biodiversity and community structure of reef fish communities and could constitute significant ecosystem change. The Bermuda Invasive Lionfish Control Initiative aims to protect the biodiversity of reef systems around Bermuda through increased knowledge and management of the invasive lionfish population. Researchers from the Bermuda Institute of Ocean Sciences (BIOS), the Bermuda Aquarium, Museum & Zoo (BAMZ), the Marine Resources Section of the Bermuda Government Department of Environmental Protection (DEP), the Ocean Support Foundation (OSF), and the University of Massachusetts Dartmouth are working together to gather scientific data required for the development and implementation of an island-wide management plan of the invasive lionfish population in Bermuda. Thus far the research team has made substantial progress towards the assessment of lionfish population density and distribution around Bermuda, and has gathered key data on lionfish reproductive and feeding ecology that will increase our understanding of their impact on reef fish communities. Furthermore, a lionfish specific trap is currently in development and being tested for utility, which will promote establishment of a commercial fishery that can be an effective means of management in the long term. Overall, the Bermuda Invasive Lionfish Control Initiative is working to generate the tools and data required for the implementation of an on-going Bermuda Lionfish Control Plan. This plan will provide strategies for government and other stakeholder efforts to control the lionfish population at a level that will mitigate the long-term impact of this invasive species on native fishes, reef communities, the island's economy and public health.

Annex 1:   Report of progress and achievements against Logical Framework for Financial Year 2013-2014

Project summary	Measurable Indicators	Progress and Achievements April 2013 - March 2014	Actions required/planned for next period
Goal/Impact The goals of this project are to gather data on lionfish abundance and distribution, feeding ecology and population dynamics in order to contribute to the management plan being developed for the long-term control of this invasive population, and to develop a lionfish-specific trap for commercial fishers to facilitate large-scale, long-term removal of this species from deeper waters. The resulting strategy for targeted lionfish removals will reduce the local lionfish population and its negative impacts on biodiversity, coral reef health and the local economy.	We continue to gather critical data on abundance and distribution, reproductive and feeding ecology, and population genetics, as well as developing trapping technology. The data being gathered and the tools being developed are essential for development of a proper management plan for long-term control of lionfish in Bermuda.	███████████████████████
Purpose/Outcome This project will generate the tools and data to develop a strategy to mitigate the impact of invasive lionfish on the marine environment and the local community in Bermuda.	Lionfish population density mapped Population model produced. Risks to local marine communities evaluated. Lionfish-specific trap developed.	Work is progressing on all key deliverables. Products being developed are suitable for practical application. Interest in the community should foster uptake and a sustainable outcome.	Once data collection is complete and all samples are analysed, the density map and population model will be produced and the impact of lionfish on local reef populations can be evaluated. Traps will be trialled with more fishermen.
Output 1. Estimate of lionfish population size and initial map of distribution around Bermuda	*Population size estimated and distribution map created*	*Data collection is ongoing. An estimate of population size and a distribution map are useful products that will be developed from these surveys.*	
Activity 1.1 Survey 100 sites in 5 depth bands from the surface to 200 ft. depth. (Concurrently collect specimens for population biology studies.)		A total of 47 sites have been surveyed, including 17 at 10m, 14 at 20m, 10 at 30m, 2 at 45m, and 4 at 60m. Surveys will continue in year 2.	
Activity 1.2 Resurvey 50 previously sampled sites where fish were collected to assess re-colonisation rates.		To be carried out in year 2	
Activity 1.3 Conduct at least 28 drop camera surveys at depths between 100 and 200 ft, overlapping with 6 diver survey sites.		Equipment has been purchased. Surveys will be carried out in year 2	
Activity 1.4 Compile and analyse survey data by depth/habitat/season. Use GIS and interpolation algorithms to create a distribution map of lionfish density around Bermuda. Incorporate all data to describe spatial and temporal variability patterns.		Mapping software set up with preliminary data. Map to be developed at the end of year 2.	

Activity 1.5 Estimate total lionfish population in Bermuda waters.		To be carried out once data are complete at the end of year 2
Output 2. Lionfish-specific trap to control species proliferation	*Suitable trap design identified.*	*Several modifications and deployment protocols have been trialled. An expanded experimental fishery will test the practicality of a reduced number of modifications and baiting strategies in collaboration with commercial fishers.*
Activity 2.1 Attach time-lapse video cameras to modified lobster traps and deploy in conjunction with the lobster fishery.		Preliminary work done. Work continuing into year 2.
Activity 2.2 Monitor video of modified traps to determine utility in long-term control.		Preliminary work done. Work continuing into year 2.
Output 3. Assessment of present impact and model of potential future impacts	*Inputs to population estimated and included in population model. Lionfish predation patterns identified.*	*Data collection is ongoing. A population model is a useful product that will be developed from these activities. Identifying lionfish predation patterns is key to evaluating the impacts on prey species and the wider marine environment, and thus is vital for any cost-benefit analysis of options to control this invasive species.*
Activity 3.1 Conduct prey fish surveys (in conjunction with lionfish surveys) at 100 sites in 5 depth bands from the surface to 200 ft. depth.		A total of 47 sites have been surveyed, including 17 at 10m, 14 at 20m, 10 at 30m, 2 at 45m, and 4 at 60m. Surveys will continue in year 2.
Activity 3.2 Identify and analyse gut contents of each fish collected, and compare to relevant prey fish surveys to determine feeding rates and selectivity.		264 prey surveys have been conducted at all study sites. Many samples have been collected. Gut contents of 269 fish examined. Sample collection and analysis will continue into year 2
Activity 3.3 Analyse stable isotopes in collected specimens to determine trophic level and feeding habitats of lionfish.		A total of 205 samples have been processed and will be compared to stable isotope ratios of other reef predators
Activity 3.4 Weigh and section gonads of collected specimens to estimate maturity, fecundity, reproductive seasonality and reproductive capacity.		251 lionfish have been dissected and examined for reproductive output.
Activity 3.5 Deploy light traps for larval collections and estimate recruitment rates.		Traps purchased. Deployment planned for Q1-2 in year 2.
Activity 3.6 Use DNA microsatellites from small specimens and analyse for potential recruitment patterns.		>200 samples collected. Supplies purchased. Analyses will be run during Q3 of year 2.
Activity 3.7 Utilise otolith microchemistry signatures from small specimens to detect the rate of larval input from distant populations.		Low numbers of small specimens collected in year 1 and the difficulties associated with rolling over funds into year 2 meant that funds for this analysis were reallocated to stable isotope analysis. If adequate samples are collected in year 2, efforts will be made to acquire replacement funds for microchemistry analysis.
Activity 3.8 Using collected samples, describe growth parameters and demographics of local lionfish population using standard fisheries biology and otolith ageing techniques.		Ongoing

Activity 3.9 Develop population dynamics model for lionfish in Bermuda.		Planned for Q4 of year 2
Output 4. Dissemination and application of results	*Results incorporated into Bermuda Lionfish Control Plan. At least two scientific papers published. Sharing of knowledge with other UKOTs through GCFI and UKOT conservation forum. Local public outreach document developed.*	*Most dissemination and application activities will take place towards the end of year 2. The modes and activities planned should enable us to reach all stakeholders and interested parties.*
Activity 4.1 Compile and analyse all data. Look for value-adding opportunities.		Planned for Q4 of year 2
Activity 4.2 Use data to suggest optimal times, locations and frequencies for fishing and culling activities and set targets for removals.		Planned for Q4 of year 2
Activity 4.3 Present results to the Bermuda Lionfish Control Taskforce for incorporation into the Bermuda Lionfish Control Plan. Meet with stakeholders to discuss how results can assist in implementation of control activities.		Ongoing
Activity 4.4 Publish results in scientific literature. Share results at conferences, especially with other UK OTs.		Preliminary results presented at the GCFI meeting in 2013. Attendance planned at 2 conferences in 2014/2015.
Activity 4.5 Assist stakeholders with the development of outreach activities and communication materials.		Ongoing

Annex 2 Project's full current logframe

	Activity	No of Months	Year 1				Year 2			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Output 1	**Estimates of species abundance and distribution**	**24**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
1.1	Survey 100 sites in 5 depth bands from the surface to 200 ft. depth. (Concurrently collect specimens for population biology studies.)	15	X	X	X	X	X	X		
1.2	Resurvey 50 previously sampled sites where fish were collected to assess re-colonisation rates.	6						X	X	
1.3	Conduct at least 28 drop camera surveys at depths between 100 and 200 ft, overlapping with 6 diver survey sites.	9					X	X	X	
1.4	Compile and analyse survey data by depth/habitat/season. Use GIS and interpolation algorithms to create a distribution map of lionfish density around Bermuda. Incorporate all data to describe spatial and temporal variability patterns.	9						X	X	X
1.5	Estimate total lionfish population in Bermuda waters.	1								X
Output 2	**Lionfish-specific trap to control species proliferation**	**12**			**X**	**X**	**X**	**X**	**X**	**X**
2.1	Attach time-lapse video cameras to modified lobster traps and deploy in conjunction with the lobster fishery.	4+8			X	X	X	X	X	X
2.2	Monitor video of modified traps to determine utility in long-term control and write report on findings.	4+4			X	X			X	X
Output 3	**Assessment of present impact and model of potential future impacts**	**24**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
3.1	Conduct prey fish surveys (in conjunction with lionfish surveys) at 100 sites in 5 depth bands from the surface to 200 ft. depth.	15	X	X	X	X	X	X		
3.2	Identify and analyse gut contents of each fish collected, and compare to relevant prey fish surveys to determine feeding rates and selectivity.	18	X	X	X	X	X	X		
3.3	Analyse stable isotopes in collected specimens to	18	X	X	X	X	X	X		

	determine trophic level and feeding habitats of lionfish.									
3.4	Weigh and section gonads of collected specimens to estimate maturity, fecundity, reproductive seasonality and reproductive capacity.	18	X	X	X	X	X	X		
3.5	Deploy light traps for larval collections. Process samples and estimate recruitment rates.	8+6	X	X	X		X	X		
3.6	Use DNA microsatellites from small specimens and analyse for potential recruitment patterns.	3					X	X	X	
3.7	Utilise otolith microchemistry signatures from small specimens to detect the rate of larval input from distant populations.	3					X	X		
3.8	Using collected samples, describe growth parameters and demographics of local lionfish population using standard fisheries biology and otolith ageing techniques.	18	X	X	X	X	X	X	X	
3.9	Develop population dynamics model for lionfish in Bermuda.	6							X	X
Output 4	**Dissemination and application of results**	**15**				**X**	**X**	**X**	**X**	**X**
4.1	Compile and analyse all data. Look for value-adding opportunities.	15				X	X	X	X	X
4.2	Use data to suggest optimal times, locations and frequencies for fishing and culling activities and set targets for removals.	6							X	X
4.3	Present results to the Bermuda Lionfish Control Taskforce for incorporation into the Bermuda Lionfish Control Plan. Meet with stakeholders to discuss how results can assist in implementation of control activities.	1								X
4.4	Publish results in scientific literature. Share results at conferences, especially with other UK OTs.	9						X	X	X
4.5	Assist stakeholders with outreach and communication.	9						X	X	X

Annex 3 Standard Measures

Table 1   **Project Standard Output Measures**

Code No.	Description	Year 1 Total	Year 2 Total	Year 3 Total	Year 4 Total	Total to date	Number planned for reporting period	Total planned during the project
Established codes								
1A & 1B	C. Eddy to submit a PhD thesis and expected to attain PhD qualification				1		0	1
4A&B	Undergraduate intern field training, 6 wks	2	2				2	4
6A&B	Technical dive training, 2 wks	2	1				2	3
7	Information Brochure Permitting course presentation Enhanced OSF website Scientific posters	1 1 1 2	 1				1 1 1 2	1 1 1 3
8	48 weeks	24	24				24	48
9	Lionfish management plan produced		1				0	1
11A&B	3-5 peer reviewed papers submitted and published	0		3-5			0	3-5
12A&B	Contribution to creation of the Lionfish Taskforce website Enhancement of OSF website	0 1	1				0 1	1 1
14A&B	BLCI project end conference organized Attendance at GCFI 2013, JNCC 2013, EU Life Workshop 2014; GCFI 2014; BEM 2015	0 3	1 2				0 3	1 5
15A&B	Press releases, Royal Gazette	3	2				2	5
17A&B	Lionfish training courses enhanced and	1					1	1

	extended							
	Volunteer Culling Association established		1				1	1
20	Value of Physical Assets: Dive Gear Fisheries Gear	GBP 7,367.82 13,581.22					20,949.04	20,949.04
21	Technical Deepwater Culling Dive Team to be established	0	1				0	1
New - Project specific measures								

Table 2   **Publications**

Type (eg journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (eg contact address, website)	Cost £
Press Release	Lionfish tamers. Owain Johnston-Barnes. May 31, 2013	Royal Gazette, Hamilton, BDA	http://www.royalgazette.com/article/20130531/NEWS/705309881	0
Published Abstract	Eddy et al. Preliminary analysis of lionfish (*Pteroi volitans* and *P. miles*) populations in Bermuda. (2013)	GCFI, Marathon, FL, USA	http://www.gcfi.org/Conferences/66th/Book_of_Abs_Eng/GCFI_Book_of_Abstracts_English/index.html	0
Published Abstract	Pitt, J and Trott, T. Invasive lionfish: Biology, ecology and control strategies. (2013)	GCFI, Marathon, FL, USA	http://www.gcfi.org/Conferences/66th/Book_of_Abs_Eng/GCFI_Book_of_Abstracts_English/index.html	0
Press Release	Lionfish: Controlling the Predator. Department of Environmental Protection. March 6, 2014	Royal Gazette, Hamilton, BDA	http://www.royalgazette.com/article/20140306/FEATURES02/140309821	0
Press Release	More resources needed for lionfish battle. Owain Johnston-Barnes. March 20, 2014	Royal Gazette, Hamilton, BDA	http://www.royalgazette.com/article/20140320/NEWS07/140329937	0

Annex 4 Onwards – supplementary material (optional but encouraged as evidence of project achievement)

Attached documents:

Supplementary Document 1. Map of Bermuda indicating selected sample sites intended for survey at 10m (green), 20m (blue), 30m (red), 45m (yellow) and 60m (white) depths.

Supplementary Document 2. Meeting notes

Supplementary Document 3. GCFI extended conference abstract, C. Eddy et al.

Supplementary Document 4. GCFI extended conference abstract Pitt & Trott

Checklist for submission

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Is the report less than 10MB? If so, please email to Darwin-Projects@ltsi.co.uk putting the project number in the Subject line.	Yes
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