EXECUTIVE COUNCIL

PUBLIC

Title:	Post Doc Scientist 2-year Position D. gahi (Loligo) in DoNR – Fisheries
Paper Number:	160/18
Date:	26 September 2018
Responsible Director:	Director Natural Resources
Report Author:	Senior Fisheries Scientist
Portfolio Holder:	MLA Barkman
Reason for paper:	This paper is submitted to Executive Council: For policy decision (including budgetary policy)
Publication:	Yes
Previous papers:	167/15
List of Documents:	Project Proposal and Job Description of the new Post

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1. Recommendations

Honourable Members are recommended to:

a) Agree to create a Post Doc Scientist Post that will fill important knowledge gaps for the stock assessment and management of the *D. gahi (Loligo)* fishery

2. Additional Budgetary Implications

	2019/2020	**2020/2021**
Operating Budget	£36,042	£36,042

Note that this Post Doc Position will be fully funded by a local fishing company and therefore there are no financial requirements from FIG

3. Executive Summary

3.1 The Research Project associated with this Post Doc Position will aim to reveal how the life histories of *Loligo* squid populations from the north and south sub-areas of the 'Loligo box' differ. Current stock assessment models use data to the north and south of the latitude 52°S to separate two stocks of *D. gahi*.

3.2 This can be achieved using (but not limited to):

a/ Elemental analysis of the statolith microstructure (Links already established with the British Geological Survey in Nottingham and the Natural History Museum in London)

b/ Genetic analysis

4. Background and Links to Islands Plan and Directorate Business Plan/s

4.1 The Falkland calamari fishery is one of the most important resources in Falkland Islands waters, and is a complicated fishery to manage. As these squid have an approximately annual lifecycle, and therefore lack multiple year-groups, there are no successive year groups to buffer against periods of poor recruitment. In addition, this species has a complex population structure, a weak stock-recruitment relationship and a high inter-annual variability in abundance, making it difficult to apply the stock assessment techniques developed for longer-lived (and more predictable) traditional finfish stocks.

4.2 The effects of extrinsic factors such as temperature can often have a profound effect on stock size, distribution, timing of recruitment and size-at-maturity. Therefore, research focused on understanding the interaction between the environment and the population dynamics of *Doryteuthis gahi* is crucial to improving our ability to manage this stock sustainably.

4.3 Since a spatially and temporally confined fishery with an effort-regulated management regime was introduced in 1986 (summarised by Arkhipkin et al. 2008), there has been much progress in our understanding of the ecology of this important commercial species. Early research revolved around the identification of distinct spawning cohorts. Analysis of catch per unit effort (CPUE) seemed to show that in some years up to four cohorts were present within the 'Loligo box', in the northern and southern fishing areas (Agnew et al. 1998). Squid to the north and south of the 'Loligo box' were initially considered as separate cohorts due to their significant difference in size.

4.4 Though there is considerable geographic diversity in size-at-maturity, genetic studies within the FICZ have failed to detect any genetic differences between squid from different geographic regions (Carvalho and Pitcher 1989; Shaw et al. 2004). With the advancement of genetic techniques it may be possible to provide critical information on if there are (if any) genetic differences between squid found to the north and south of 52°S.

4.5 With no genetic differences evident at present, it has been suggested that differences in food availability and/or temperature are responsible for the significant disparity in size between squid found in the north and south. It may be that these squid are derived from different shallow-water spawning sites and that environmental conditions in one

spawning area have resulted in accelerated growth during early life when growth is exponential. Understanding why and how these two groups are different is important for the definition of management units. At present, modified DeLury depletion models are calculated separately for north and south sub-areas of the 'Loligo box', dissecting the fishing zone into two at latitude 52°S (Winter 2017).

4.6 The best way to determine why there are differences between these two groups of squid is to determine their migratory routes. As squid are vulnerable for tagging, an alternative method is the elemental analysis of calcified structures of marine organisms, which simply requires in-season sample collection from the commercial fishery. Statoliths are 'black boxes' that record the conditions an individual has experienced throughout its lifetime, with daily precision (Arkhipkin 2005). For example, strontium (Sr) has been suggested to have a negative relationship with temperature; at higher water temperatures less Sr is incorporated into the statolith.

4.7 Recently, elemental analysis has been undertaken on *D. gahi* to confirm the migration patterns of the spring and autumn spawning cohorts (Jones et al. 2018). Since publication of this paper, new analytical techniques have been developed in this field that allow high-resolution 2D mapping of elemental concentrations within the statolith. This 2D mapping has never been attempted on a squid statolith before and would be an exciting addition to this project.

5. Options and Reasons for Recommending Relevant Option

5.1 Previous experience to undertake research projects in the Fisheries Department revealed that the best and most effective way to complete the Project will be to have a dedicated scientist with existing knowledge and experience in working with cephalopods in general and Falkland calamari in particular as a part of his/her research Thesis such as PhD. In this case, little time will be spent on learning new methods and techniques, and most of the time spent on collection and interpretation the data and results.

5.2 The position will be to undertake post-doctoral research in *Doryteuthis gahi* – a two year contract of mentored research by an individual holding a doctoral degree for the purpose of acquiring additional professional skills to pursue a career in academia. Research is predominantly focused on how the life histories of D. gahi squid populations to the north and south of 52°S differ, but the post-doctoral scientist will also have a managerial role as a supervisor of a PhD Interns within the Department in the same species and would be expected to partake in departmental research cruises. Job accountabilities, person specification and description of research project are in Appendices 1 and 2

6. Resource Implications

6.1 Financial Implications

6.1.1 None – this PhD studentship can be fully funded by a local fishing company. There is an agreement in the form of signed MOU between the local fishing company and DoNR – Fisheries confirming that the fishing company will pay for the full two years, and describing what the post will do.

6.1.2 Table 1: Costs per annum for two-year post-doc position (Marine Ecology, *Doryteuthis gahi*) based on current FIG pay grades (2018/19) based in the Falkland Islands Fisheries Department – Natural Resources.

	Costs Per Annum	
	Salary (Grade D1, Step 1)	£30,203
	RPC	£819
	OPC	£2,020
	Travel	£3, 000
	Total	**£36,042**

6.2 Human Resource Implications

6.2.1 The new Post should be advertised and undergo the normal recruitment process. Additionally, there will be a requirement on the Senior Fisheries Scientist's time as a result of the supervision of the Post Doc Scientist. Supervision will be conducted outside of the main responsibilities and will be manageable within existing resources without impacting their ability to achieve their wider strategic objectives.

6.2.2 Although the proposed post has not been formally evaluated for pay grading, the proposed D1 Grade is comparable to other Scientist roles within the Fisheries Department.

6.2.3 If approved there is no provision within the current Government Housing Stock to accommodate the postholder and therefore they would need to obtain accommodation from the private sector as per the arrangements that are in place for the PHD Interns.

6.3 Other Resource Implications

FIG will provide an office and lab space for the post holder.

7. Legal Implications

7.1 None

8. Environmental & Sustainability Implications

8.1 Successful completion of this research project by Post Doc post holder will substantially contribute to the current stock assessment modelling of squid populations and therefore further enhance management and sustainability of this fishery.

9. Significant Risks

9.1 No significant risks can be foreseen with this particular project as the resource is fully domestic with samples available from every region and any time of the year.

10. Consultation

10.1 Several consultations were conducted with the fishing company to organise the structure and aims of the research project.

11. Communication

11.1 Information on the project progress will be summarised every 6 months and communicated to Loligo Producers Group and other stakeholders in the Loligo fishery.

Post-doc Research Proposal

Understanding the patterns of recruitment and migration in a commercial loliginid squid population (Doryteuthis gahi)

Research Duration: 2 years **Commencing: February 2019**

The Falkland calamari fishery is one of the most important resources in Falkland Islands waters, and is a complicated fishery to manage. As these squid have an approximately annual lifecycle, and therefore lack multiple year-groups, there are no successive year groups to buffer against periods of poor recruitment. In addition, this species has a complex population structure, a weak stock-recruitment relationship and a high inter-annual variability in abundance, making it difficult to apply the stock assessment techniques developed for longer-lived (and more predictable) traditional finfish stocks. The effects of extrinsic factors such as temperature can often have a profound effect on stock size, distribution, timing of recruitment and size-at-maturity. Therefore, research focused on understanding the interaction between the environment and the population dynamics of *Doryteuthis gahi* is crucial to improving our ability to manage this stock sustainably.

Since a spatially and temporally confined fishery with an effort-regulated management regime was introduced in 1986 (summarised by Arkhipkin *et al.* 2008), there has been much progress in our understanding of the ecology of this important commercial species. Early research revolved around the identification of distinct spawning cohorts. Analysis of catch per unit effort (CPUE) seemed to show that in some years up to four cohorts were present within the 'Loligo box', in the two northern and southern fishing areas (Agnew *et al.* 1998). Squid to the north and south of the 'Loligo box' were initially considered as separate cohorts due to their significant difference in size. Though there is considerable geographic heterogeneity in size-at-maturity, genetic studies within the FICZ have failed to detect any genetic differences between squid from different geographic regions (Carvalho and Pitcher 1989; Shaw *et al.* 2004). However, only 6 microsatellite loci were used during this study (out of thousands of possible loci). With the advancement of genetic techniques it is now possible to determine the entire mitochondrial genome sequence (as in Jiang *et al.* 2018), which may provide critical information on the genetic differences there are (if any) between squid found to the north and south of 52°S.

With no genetic differences evident at present, it has been suggested that differences in food availability and/or temperature are responsible for the significant disparity in size between squid found in the north and south. It may be that these squid are derived from different shallow-water spawning sites and that environmental conditions in one spawning area have resulted in accelerated growth during early life when growth is exponential. Understanding why and how these two groups are different is important for the definition of management units. At present, modified DeLury depletion models are calculated separately for north and south sub-areas of the 'Loligo box', dissecting the fishing zone into two at latitude 52°S (Winter 2017).

The best way to determine why there are differences between these two groups of squid is to determine their migratory routes. Often this is accomplished by tagging, however loliginid squid such as *Doryteuthis gahi* are often too fragile for an external tag to be fitted, and retrieval rates

are very low. An alternative method is the elemental analysis of calcified structures of marine organisms, which simply requires in-season sample collection from the commercial fishery. Statoliths are calcified structures found within the cephalic cartilage of a squid, responsible for the detection of linear and angular acceleration and functioning in a similar way to our inner ear. Each day material is laid down around the statolith, resulting in daily growth rings which can be read through a microscope to obtain the total post-hatching age of a squid in days. When material is deposited around the statolith, elements are also incorporated into the statolith microstructure. Daily uptakes of certain elements are thought to reflect the environmental conditions in the squid's surroundings at the time of incorporation. Statoliths can therefore be considered as 'black boxes', recording the conditions an individual has experienced throughout its lifetime, with daily precision (Arkhipkin 2005). For example, strontium (Sr) has been suggested to have a negative relationship with temperature; at higher water temperatures less Sr is incorporated into the statolith.

Recently, elemental analysis has been undertaken on *D. gahi* to confirm the ontogenetic migration patterns of the spring and autumn spawning cohorts (Jones *et al.* 2018). Both cohorts had distinct elemental compositions that were consistent between years (Figure. 1). The elemental concentrations found at each stage of a squid's ontogeny were found to coincide with our current understanding of where the squid migrate. The same methodology can be applied to squid from the northern and southerly regions of the 'Loligo box', using high-resolution elemental chronologies to assess their migratory patterns and to determine whether it is likely that that have come from a similar spawning site or not (natal origins). Since the most recent elemental paper, exciting new analytical techniques have been developed in this field that allows high-resolution 2D mapping of elemental concentrations within the statolith (Figure. 2). This 2D mapping has never been attempted on a squid statolith before and would be an exciting addition to this project.

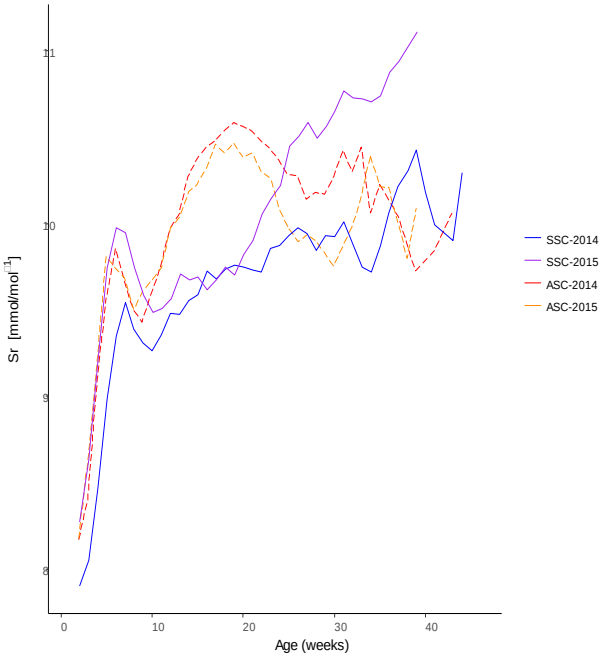

Figure 1: Elemental concentrations of strontium (Sr) for each week of a squid's post-hatching life for the spring spawning cohort (SSC) and autumn spawning cohort (ASC) in two consecutive years.

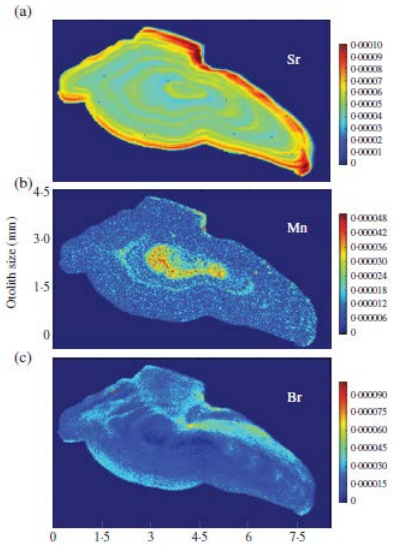

Figure 2: 2D-maps of the elemental concentrations within a cod otolith, from Limburg and Elfman 2017.

Research Aim: to determine how the life histories of squid populations from the north and south sub-areas of the 'Loligo box' differ

This can be achieved using (but not limited to):

1.) Elemental analysis of the statolith microstructure (Links already established with the British Geological Survey in Nottingham and the Natural History Museum in London)
2.) Genetic analysis

Annual costs for this proposed research are outlined in Table 1, with the post-doc running for two years. The data obtained from this investigation will help resolve the stock structure of this species, with the aim of refining management to ensure long and sustainable exploitation.

Table 1: Costs per annum for two-year post-doc position (Marine Ecology, *Doryteuthis gahi*) based on current FIG pay grades (2017/18) based in the Falkland Islands fisheries department – Natural Resources.

	Costs Per Annum
Salary (Grade D, Step 1)	£30,203
RPC	£819
OPC	£2,020
Travel/Conference Attendance	£3, 000
Total	**£36,042**

Reference

Agnew, D. J., Nolan, C. P., and Des Clers, S. (1998). On the problem of identifying and assessing populations of Falkland Island squid *Loligo gahi*. *South African Journal of Marine Science* **20:** 59-66.

Arkhipkin, A. I. (2005). Statoliths as 'black boxes' (life recorders) in squid. *Marine and Freshwater Research* **56:** 573-583.

Arkhipkin, A. I., Middleton, D. A., and Barton, J. (2008). Management and conservation of a short-lived fishery resource: *Loligo gahi* around the Falkland Islands. *American Fisheries Society* **49:** 1243.

Carvalho, G. R., and Pitcher, T. J. (1989). Biochemical genetic studies on the Patagonian squid *Loligo gahi* D'Orbigny. II. Population structure in Falkland waters using isozymes, morphometrics and life history data. *Journal of Experimental Marine Biology and Ecology* **126:** 243-258.

Jiang, L., Kang, L., Wu, C., Chen, M., and Lü, Z. (2018). A comprehensive description and evolutionary analysis of 9 Loliginidae mitochondrial genomes. *Hydrobiologia* **808:** 115-124.

Jones, J. B., Arkhipkin, A. I., Marriott, A. L., and Pierce, G. J. (2018) Using statolith elemental signatures to confirm ontogenetic migrations of the squid *Doryteuthis gahi* around the Falkland Islands (Southwest Atlantic). *Chemical Geology* **481:** 85-94.

Shaw, P. W., Arkhipkin, A. I., Adcock, G. J., Burnett, W. J., Carvalho, G. R., Scherbich, J. N., and Villegas, P. A. (2004). DNA markers indicate that distinct spawning cohorts and aggregations of Patagonian squid, *Loligo gahi*, do not represent genetically discrete subpopulations. *Marine Biology* **144:** 961-970.

Winter, A. (2016). Falkland calamari stock assessment, second season 2017. *Technical Document, Falkland Islands Fisheries Department* 28pp.

Job Title:	Post-Doctoral Research Scientist *D. gahi* (Loligo)		
Department:	Natural Resources (Fisheries)	**Section:**	Scientific
Reports to:	Senior Fisheries Scientist		
Grade:	**D (suggested - to be evaluated)**	**Job Code:**	

Job Purpose

The position will be to undertake post-doctoral research in *Doryteuthis gahi* – a two year period of mentored research by an individual holding a doctoral degree. Research is predominantly focused on how the life histories of *D. gahi* squid populations to the north and south of 52°S differ, but the post-doctoral scientist will also have a managerial role as a supervisor of a PhD Interns within the Department and would be expected to partake in research cruises. Given that research is the primary purpose of the role, the chosen individual would be expected to contribute to the given academic field within the fisheries department and on an international level, through science communication and through the publication of scientific material in peer reviewed journals.

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Main Accountabilities

- Organise and implement the programme of research and investigation to deliver the research project: Understanding the patterns of recruitment and migration in a commercial loliginid squid population (*Doryteuthis gahi*) (see separate full project document).
- Plan procedures for sample collection for scientific fisheries observers. Organise and partake in any additional research cruises necessary to ensure an appropriate dataset is available for analysis (this requires close work with the Observer Coordinator and FIFD fisheries observers).
- Deliver scientific findings in appropriate formats, including technical reports and peer-reviewed scientific papers.
- Undertake a supervisory role for PhD Interns in the Department, providing general advice and comments as requested.
- Undertake specific analyses including trace elemental, stable isotope and genetic analysis that may require travel abroad as specialist equipment cannot be sourced in the Falkland Islands).
- Actively liaise and engage with colleagues, stakeholders, the fishing industry and external experts to ensure regular information exchange. Most particularly, ensuring that any useful material applicable to the management of the fishery itself is shared with the Loligo stock assessment scientist.
- Share project progress with the Loligo Producers Group and other stockholders in the Loligo fishery every 6 months.
- Attend relevant internal and external meetings related to *D. gahi*.

The job description is not an exclusive or exhaustive definition of your duties. You shall undertake such additional or other duties as may reasonably be required by FIG commensurate with your role and grade.

Additional Information:			
The Falkland Islands Fisheries Department has been managing a very successful fishery for 27 years and is hailed as one of the best managed in the world. FIFD conducts fisheries and marine ecological studies as well as assessing all of the exploited stocks with in the Falkland Islands Conservation Zones.			
Person Specification:	Post-Doctoral Research Scientist (*D. gahi*)		
Criteria	**Essential**	**Desirable**	**Assessment Method**
Education and Training:			
PhD degree specialising in Cephalopod Biology or related subject (candidates awaiting viva considered)	✓		A/I/R
Knowledge, Skills and Experience:			
At least 2 years of work experience in a field of marine biology	✓		A/I
Understanding of the ecology of cephalopods, particularly Loligo squid	✓		A
Sea-going experience in excess of 100 days		✓	A/I
Knowledge of Falkland fisheries and ecosystem		✓	A/I
Substantial level of computer literacy and experience of managing databases (in MS Access) skills in statistical analysis and statistical programmes (e.g. R), with an ability to analyse and manage large datasets.	✓		A/I
Experience in the preparation and reading of statoliths	✓		A/I
Proven ability to plan and execute scientific studies	✓		A/I
Excellent communication skills in English with strong interpersonal and networking skills. Ability to convey biological findings to a variety of audiences, including industry, international scientists, and the general public	✓		A/I
Ability to produce scientific papers suitable for publication in peer-reviewed journals	✓		A/I
Proven ability to lead work programmes, with strong skills in project management		✓	A/I

Experience of managing other individuals	✓		A/I
Personal Attributes:			
Be approachable and able to communicate advice to other colleagues. Confident and diplomatic	✓		I
Ability to work independently, as well as collaboratively as part of a team with the ability to enthuse, inspire and motivate others	✓		I
Ability to manage time where there are multiple demands, planning and prioritising own work load	✓		R/I
Resourceful and Flexible	✓		R/I

Method of assessment:

A - Application Form I - Selection Interview R - Reference