



MAURITIUS RESEARCH COUNCIL

AN IMPROVED AND CONTINUOUS DATA COLLECTION SYSTEM FOR THE OCTOPUS FISHERY IN RODRIGUES FOR IMPROVED MANAGEMENT

Final Report

September 2012

MAURITIUS RESEARCH COUNCIL

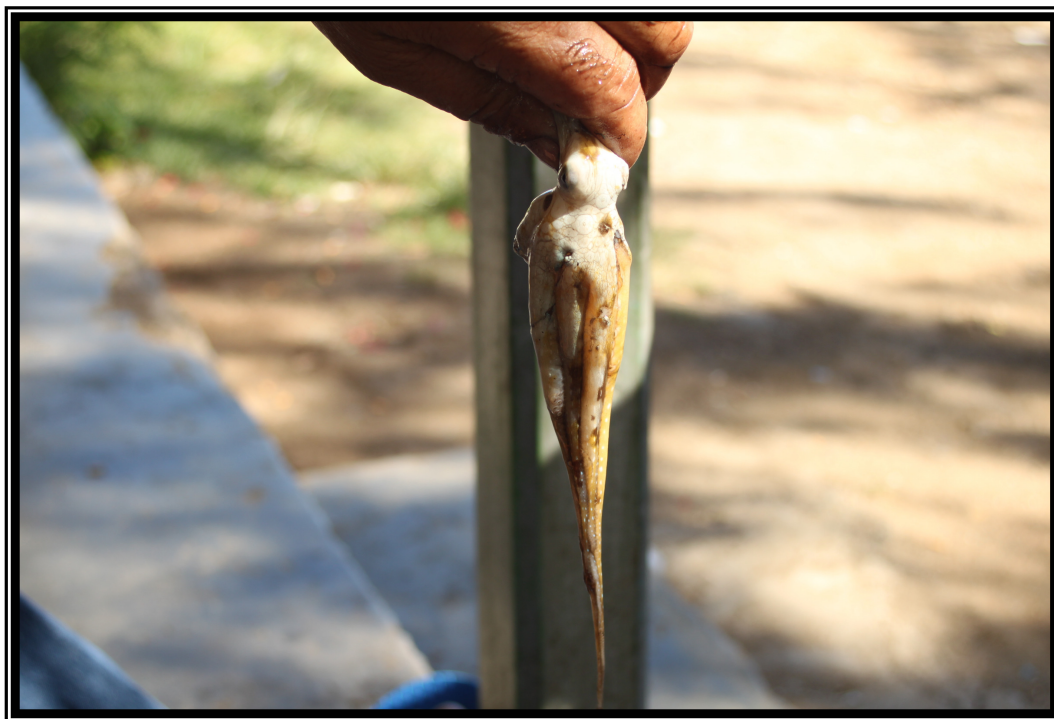
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An improved and continuous data collection system for the octopus fishery in Rodrigues for improved management



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September 2012



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Table of contents

Table of contents.....	2
Table of Tables.....	3
Table of Figures.....	3
Table of Pictures.....	5
Abbreviations and acronyms	6
Acknowledgments.....	6
Layman’s summary.....	7
Executive Summary.....	8
<u>Introduction</u>	<u>10</u>
<u>Context.....</u>	<u>12</u>
<u>Updating Shoals/SEMPA octopus database.....</u>	<u>13</u>
Rationale	13
Activities.....	13
Recruitment of data entry staff.....	13
Data entry training.....	14
Database clean-up	16
Accuracy validation	16
Outputs	17
SEMPA database.....	17
Shoals database	17
Combined databases	18
Proposed	18
Carried out	18
<u>Modelling several summer closure scenarios.....</u>	<u>19</u>
Rationale	19
Methodology	19
Activities.....	19
Outputs	21
Proposed	21
Carried out	21
<u>Refining winter closure period using the latest datasets.....</u>	<u>22</u>
Rationale	22
Methodology	22
Outputs	22
Proposed	22
Carried out	22
<u>Undertaking Octopus population dynamics study</u>	<u>24</u>
Rationale	24
Methodology	24
Outputs	24
Proposed	29
Carried out	29
<u>Evaluating the closure on the short term (weight distribution).....</u>	<u>30</u>
Rationale	30
Methodology	30

Outputs	30
Proposed	31
Carried out	32
<u>Evaluating the closure on the medium term (recruitment).....</u>	<u>33</u>
Rationale	33
Methodology	33
Outputs	33
Proposed	33
Carried out	33
<u>Discussion.....</u>	<u>37</u>
Modelling several summer closure scenarios.....	37
Refining winter closure period using the latest datasets.....	37
Evaluating the closure on the short term (weight distribution).....	37
Evaluating the closure on the medium term (recruitment).....	37
<u>Conclusions and recommendations.....</u>	<u>39</u>
<u>References.....</u>	<u>40</u>

Table of Tables

Table 1. Statistic of data collected and entered by the SEMPA scientific team and the data entered by the Shoals Rodrigues data imputers under MRC funding.

Table 2. Statistic of data collected and entered by the Shoals scientific team and the data entered by the Shoals Rodrigues data imputers under MRC funding.

Table 3. Statistic of all the data collected and entered by the Shoals and SEMPA scientific teams, and the data entered by the Shoals Rodrigues data imputers under MRC funding.

Table of Figures

Figure 1a. An example of SEMPA’s creole datasheet developed by Dr Rebecca Klaus and the SEMPA Scientific Officer, on which CROs inscribe their data

Figure 1b. An example of Shoals Rodrigues creole datasheet developed by Shoals Rodrigues field centre manager and Jim Anderson, on which observers inscribe their data.

Figure 2a. Microsoft Access Database front end in which the SEMPA and currently the MRC octopus fishery catch monitoring data is entered. This database is a variation of the Shoals Database below, modified by Dr Rebecca Klaus for use by the South East Marine

Protected Area. All data is currently entered into this database as it allows for additional datapoints to be saved.

Figure 2b. Microsoft Access Database front end in which the Shoals Rodrigues octopus fishery catch monitoring data was entered. This database was build with the courtesy of Mr J. Anderson under a ReCoMaP Programme Estimate funded project.

Figure 3. Results of the accuracy validation assessment

Figure 4. Based on the weight of octopus at recruitment in Rodrigues and work done by Sauer *et al*'s (2011) and growth equation was derived for the Rodrigues octopus.

Figure 5. Skewedness values for the weight frequency distributions of octopus assessed during the first 17 weeks of 2013 that sheds light on the proportion of larger octopus in the population to identify possible closure dates to maximise on returns.

Figure 6. Frequency distributions of female octopus weights from August 2008 to May 2013. The yellow boxes represent the range of the three highest values, and the red the highest value of the distribution. The peach coloured boxes occur in months during which data were not collected and consequently the highest three values from similar months have been placed to give a rough indication of what the distribution could look like.

Figure 7. Distribution of the 7 FLS around Rodrigues where Octopus fishery catch data are collected fortnightly during the spring tides.

Figure 8. Variation in mean male octopus weight over a consecutive six-month period following the reopening month of October in Rodrigues for the years 2010 to 2013

Figure 9. Variation in mean female octopus weight over a consecutive six-month period following the reopening month of October in Rodrigues for the years 2010 to 2013

Figure 10. Count of octopus weighing less than 350 grams during the first four months, comparing 2011, 2012 and 2013.

Figure 11. Frequency distribution of male and female octopus weights combined, caught in January at 10 landing stations, weighing less than 350g

Figure 12. Frequency distribution of male and female octopus weights combined, caught in February at 10 landing stations, weighing less than 350g

Figure 13. Frequency distribution of male and female octopus weights combined, caught in March at 10 landing stations, weighing less than 350g

Figure 14. Frequency distribution of male and female octopus weights combined, caught in April at 10 landing stations, weighing less than 350g

Table of Pictures

Plate 1. Brunette Raffin and Adrien Joseph entering data into on the MRC supported Octopus database.

Plate 2. Graviers team, Mrs Chrisna Botlar (65). Mrs Marie Therese Jolicoeur (50) *not on picture*

Plate 3. Port Sud Est team, left Mr Jean Nicolson Sam Yu (47) right Mrs Magdalena Sam Yu (26)

Plate 4. Tamarin team, left Mr Georges Gaspard (43) right Mr Jean Alex Prosper (48), SEMPA CRO

Plate 5. Dans Coco team, left Mr Cledio Momus (42) and middle Mr Jeantet Collet (52) SEMPA CROs

Plate 6. Baie du Nord team left Leng Meunier (60) and right Mrs Favinette Meunier (35)

Plate 7. Pointe Monier team left Mr Vening Meunier (56) and right Mr Wesley Collet (25)

Plate 8. Rivière Banane team Mr Stephan Cupidon (left) and Mrs Louisette Cupidon (right)

Abbreviations and acronyms

CPUE	Catch per Unit Effort
CRO	Community Resource Observer
FLS	Fish Landing Station
FPS	Fisheries Protection Service
FRTU	Fisheries Research and Training Unit
GPS	Global Positioning System
MRC	Mauritius Research Council
NEZS	North England Zoological Society
NGO	Non-Government Organisation
RRA	Rodrigues Regional Assembly
SEMPA	South East Marine Protected Area
TOR	Terms of Reference

Acknowledgments

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Layman's summary

Octopus fishing is a key activity in Rodrigues involving some 539 fishers with permits, 730 without permits, 56 buyers, 37 handlers and 14 processors. Octopus fishing has been carried out for several generations and has resulted in over fishing and habitat damage leading to a steady collapse of the Rodrigues octopus stock. In 2012 the Rodrigues Regional Assembly in collaboration with NGOs and member of the private sector undertook the first island-wide closure co-financed by the Rodrigues Regional Assembly and the European Union under the Indian Ocean Commission's Smartfish programme. A scientific programme was set up to address a number of questions with regard to Rodrigues' first closure and to provide the necessary tools to improve the status of the octopus fishery. Shoals Rodrigues, a local marine NGO recruited two high school leavers to input outstanding octopus fishery catch data into a purpose made database under the supervision of a scientific officer who also ensured database integrity. The database contained information from 9,902 fisher surveys during which 39,321 octopuses were weighed and sexed. Once accuracy of the database was validated (96.6%), the full octopus weight dataset was inserted into a model based on *Octopus cyanea* growth equations to produce a number of summer closure scenarios from which policymakers could choose one best to meet local specification and needs. Models show that later closures in summer produce bigger gains over shorter durations. The data were rearranged by monthly increment using only female weight data to better understand migration periods to improve planning of winter closures. The data between August 2008 and April 2013 suggests females reach maturity in August and September, confirming the timing this is the ideal period for winter closures. Fourteen fishers previously employed as resource observers and trained in fisheries catch data collection were recruited to begin collecting data after reopening of the octopus fishery. The surveys involved interviewing 10 octopus fishers returning from fishing outings on 7 fish landing stations 6 times to assess their catch. The data imputers entered data collected by the resource observers into the database. These new data were used to assess the success of the closure in the short and medium term. Short-term result show massive increases in the minimum, mean and maximum size of octopus caught immediately after the reopening of the fishery confirming the positive effect of the 2-month closure. Medium term figures suggest good recruitment occurred in the months following the reopening which we attribute to more and larger females migrating out of the lagoon for spawning. Continued monitoring is necessary to assess the progress made in terms of management of the Rodrigues octopus stock following future closures.

Executive Summary

English

The Rodrigues octopus stock has been in steady decline for over two decades, reflected by annual octopus landings dropping from close to 800 tons in 1994 to just over 200 tons in 2011. This has had a negative effect on the financial status of the fisher community, which in turn is affecting the local economy. Seasonal closures of octopus fisheries have been pioneered in other countries in the region, most notably in Madagascar, with positive effects on their octopus stock as well as the quality of life of the fishers engaged in the trade. The Rodrigues Regional Assembly has opted for carrying out similar seasonal closures in a bid to rehabilitate the local octopus stock and improve the status of fishers and others involved in the octopus industry. The 2012 closure that took place in winter between the 13th of August and the 12th of October had a marked effect on the landings during that year, increasing by 188 tons compared to 2011. Similarly, octopus exports for the year 2012 increased by 106 tons injecting an additional MUR ~10.6 million into the local economy, bringing the recorded frozen octopus export figure up 185 tons I.E. MUR 18.5 million in revenue to Rodrigues' economy. The work reported here through the population dynamic study of *Octopus cyanea* by the Shoals Rodrigues team in collaboration with the Rodrigues Regional Assembly, reconverted octopus fishers and active octopus fishers has shown that the two-month winter closure was also a success from a biological point of view. The mean weight of female octopuses caught just after reopening of the fishery rose to 1,721 grams from 752 grams in 2011; similarly, mean male octopus weight increased from 742 to 1,730 grams. In the medium term, the number of juveniles assessed in the study, weighing less than 350 grams between January and April increased from 1,178 in 2012 to 1,707 in 2013; however, a break down of the individual months suggests this may be due to a poor sampling regime in 2012. Summer closure modelling work suggests that octopus double in weight regardless of age within a 5 to 6 week period and that their mean weight also increases from January to April. Consequently a closure at the beginning of the summer would protect the stock more than it would boost landings and conversely, a closure towards the end of summer would have the effect of boosting landings but would not be the best option for protecting new recruits and juveniles. Winter closure date/duration refining work suggests that female octopus weight peaks in late winter and that this should continue to be the preferred period for closures aimed at promoting the migration of females out of the lagoon for reproductive purposes; however, the data does not indicate whether the females are actually leaving the lagoon, therefore a study involving acoustic tagging of female octopuses during the winter period is recommended. In the meantime winter closures should be lengthened as much as reasonably possible, towards the end of the year, to increase the probability of octopus females migrating to lay and brood their eggs, incidentally this will significantly boost landings.

Le stock de poulpe Rodriguais a été en baisse constante depuis plus de deux décennies, se traduisant par des débarquements de poulpe annuelle étant tombée de près de 800 tonnes en 1994 à un peu plus de 200 tonnes en 2011. Cela a eu un effet négatif sur la situation financière de la communauté des pêcheurs, qui à son tour affecte l'économie locale. Les fermetures saisonnières de la pêche du poulpe ont été effectuées dans d'autres pays de la région, notamment à Madagascar, avec des effets positifs sur leur stock de poulpe ainsi que la qualité de vie des pêcheurs engagés dans l'industrie. L'Assemblée Régionale de Rodrigues a opté pour la réalisation de fermetures saisonnières similaires dans le but de réhabiliter le stock de poulpe local et améliorer la situation des pêcheurs et autres personnes impliquées dans l'industrie de la pieuvre. La fermeture de 2012 qui a eu lieu en hiver entre le 13 Août et le 12 Octobre a eu un effet marqué sur les prises de poulpes au cours de cette année, en hausse de 188 tonnes par rapport à 2011. De même, les exportations de poulpe pour l'année 2012 ont augmenté de 106 tonnes injectant environs MUR 10,6 millions supplémentaire dans l'économie locale, portant le chiffre à l'exportation de poulpe congelé jusqu'à 185 tonnes c'est-à-dire MUR 18,5 millions de recettes pour l'économie de Rodrigues. Le travail présenté ici à travers l'étude dynamique de population de l'*Octopus cyanea* par l'équipe de Shoals Rodrigues en collaboration avec l'Assemblée Régionale de Rodrigues, les pêcheurs de poulpes reconvertis et les pêcheurs de poulpes actifs ont montré que la fermeture hiver de deux mois a également été un succès sur le plan biologique. Le poids moyen de poulpe femelle capturé immédiatement après la réouverture de la pêche est monté jusqu'à 1,721 grammes de 752 grammes en 2011, de même, le poids moyen de poulpe males est passé de 742 à 1,730 grammes. A moyen terme, le nombre de juvéniles évalués dans l'étude, pesant moins de 350 grammes attrapés entre Janvier et Avril est passé de 1,178 en 2012 à 1,707 en 2013; toutefois, regardant les mois individuelles suggère cela peut être dû à un mauvais régime d'échantillonnage en 2012. Les travaux de modélisation de fermeture d'été suggèrent que les poulpes doublent de poids indépendamment de leur âge entre 5 et 6 semaines et que leur poids moyen augmente de Janvier à Avril. Par conséquent une fermeture en début d'été permettrait de protéger le stock plus de cela augmenterait les prises et, inversement, une fermeture à la fin de l'été aurait pour effet d'augmenter les prises mais ne serait pas la meilleure option pour protéger les nouvelles recrues et les juvéniles. Les travaux sur la variation de la date et durée de clôture d'hiver suggèrent que le poids moyen des poulpes femelles atteint son apogée en fin d'hiver et donc cela devrait continuer à être la période privilégiée pour les fermetures visant à promouvoir la migration des femmes sur le lagon à des fins de reproduction. Cependant, les données ne disent pas si les femelles effectivement quittent le lagon, donc une étude portant sur le marquage acoustique de poulpes femelles pendant la période d'hiver est recommandée. En attendant, la fermeture d'hiver devraient être allongées autant que raisonnablement possible, vers la fin de l'année, pour augmenter la probabilité que les poulpes femelles migrateurs puissent pondre et couvrir leurs œufs, d'ailleurs cela augmentera aussi considérablement le tonnage des prises.

Introduction

Isolated in the South Western Indian Ocean some 600km to the east north east of Mauritius, the semi-autonomous island state of Rodrigues (S19, E63) has historically relied on various fisheries within its shallow 240km² reef enclosed lagoon for food and employment. Several generations of fishers have exploited the lagoon both for finfish and for octopuses using a variety of gears notably hook/line, basket traps, seine nets, harpoons and metal spikes amongst others. The wide range ca. 1.8 m of our semidiurnal tides allows the pursuit of an important octopus fishery, predominantly performed by wading on to the reef and gleaning octopus individuals using metal spikes and/or harpoons, both by women (28.4%) and men (71.6%).

An increase in the number of fishers due to employment issues on the island has led to uncontrolled octopus fishing conditions resulting in damage to the octopus habitats and depletion of the octopus stock. Results of stock assessments carried out by the Fisheries Research and Training unit show a steady decline in total annual landings from 774 tons in 1994 to 269 in 2010. Results of the NGO Shoals Rodrigues long-term population dynamics studies show that over 80% of female octopus fished in 2008/2009 at two northern fish landing stations are below the age of first maturity suggesting severe recruitment over-fishing.

Concerns over the alarming figures have urged both NGO and local government to push for a seasonal closure of the octopus fishery similar to closures trialled in Madagascar by the NGO Blue Ventures. In Rodrigues the current closure concerns some 1,450 souls with varying reliance on the fishery. There are approximately 550 registered octopus fishers or “professionals” operating in the lagoon, and at least another 500 who do not have fisher permits but fish just as regularly. The remaining 400 people fish on a more casual basis for personal consumption

Information obtained from octopus catch data collected during previous octopus monitoring studies (financed by the DCP ReCoMaP) give the indication that a migration pulse occurs during the winter period although it is known that migration occurs throughout the year. During this period, mature brood stock female octopuses leave the lagoon to lay, brood and hatch their eggs, after which the female perishes. Armed with this information, the Rodrigues Regional Assembly (RRA) began work towards a two-month closure; the “Octopus Closed Season” regulation was drafted, and after minor modification, was accepted by the Executive council, Regional Assemble and National Assembly. The closure began on the 13th of August is scheduled to end on the 12th of October 2012.

During this time, the 1,450 fishers have been redirected to various remunerated work coordinated by the Commission for fisheries and Marine Parks, but organised by a number of departments namely Forestry Department, Department of Agriculture, Fisheries Protection Service, South East Marine Protected Area, Environment. The payment of these fishers is being co-financed by Smartfish, via three NGOs namely: Shoals Rodrigues, The Mauritius Wildlife Foundation (MWF) and the Rodrigues Council of Social Services (RCSS). All work carried out by the fishers is oriented towards improvement of the environment.

There are growing expectations that the closure will lead to miraculous catches on reopening and while we are confident there will be a an increase in the mean size of octopuses, the fact of the matter is if there are many more people going fishing on reopening there may be little or no benefits seen by the population. To address this, robust scientific surveys are required to ascertain the success of the closure in the short term. In the medium term we also expect to see an increase in recruitment of juveniles to the lagoon in the coming summer. This also requires rigorous monitoring to confirm, hence the need to setup an island-wide monitoring programme.

Context

Low level of education, lack of readily available work and lack of water available for agriculture has led generations of less educated Rodriguans to fish in the lagoon. Octopus fishing has long been a socio-economically important activity offering work and a source of protein to over one thousand souls. However, catches have been dropping significantly over the last two decades, as have export figures due to decades of unregulated fishing. The steady decline of the local octopus stock is a result of recruitment over-fishing where individuals are caught before the age at which they can reproduce. Enforcement of and compliance to laws and regulations are both tenuous.

Temporary octopus fishery closures in other African countries aimed at rehabilitating declining octopus stocks have been met with considerable success, so with the support of the Indian Ocean Commission's ReCoMaP programme in 2009-2011 the idea of a seasonal closure in Rodrigues was suggested to the previous RRA administration and while an island wide sensitisation campaign was carried out in all Rodriguan schools, the administration however did not manage to implement the first closure. In 2012, the IOC approached the present administration again, this time under the Smartfish programme, thereby reviving the idea of a closure. By mid-2012 the Seasonal Octopus Closure Regulations had been drafted, approved by the Executive Council, passed as a motion in the Rodrigues Regional Assembly and then in the National Assembly of the Republic of Mauritius, where they were approved. During this period a vast campaign of consultation and sensitisation was carried out around the island. Between the 13th of August and 12th of October 2012, Rodrigues saw its first island-wide seasonal closure, with some 1,400 octopus fishers, buyers and processors involved in remunerated ecosystem services type alternative work.

The primary aim of the closure was to allow female octopus to increase their sizes and reach maturity, migrate out of the lagoon and reproduce, thereby boosting the stock. Scientific monitoring of the resource before and after the closure was the logical and scientific way to assess of the success of this endeavour. Octopus fishery catch data collected by the SEMPA prior to the closure had accumulated and required entry into a purpose built Access database. Octopus fishery catch data entered into the Shoals Rodrigues Access database required considerable maintenance. These databases, once updated and validated would therefore allow: 1) A short-term assessment of the closure i.e. changes in landings; 2) A medium term assessment of the closure i.e. changes in recruitment during the following summer; 3) Modelling of summer closure scenarios i.e. landings; and 4) Refining of winter closures.

Shoals Rodrigues, a local marine NGO proposed this work due to its extensive experience in octopus fishery catch data collection, and its capacity to undertake such scientific studies. The current document is the final report for the contract awarded and details the activities Shoals Rodrigues was responsible for.

Updating Shoals/SEMPA octopus database

Rationale

Due to a lack of appropriate staff, seven months worth of octopus catch data generated by the SEMPA fishery monitoring programme, recorded by 43 Community Resource Observers (CROs) at 8 Fish Landing Stations (FLS) along the South East Marine Protected Area (SEMPA) between August 2011 and February 2012 lay un-entered. Similarly, Shoals Rodrigues has been employing 10 fishers to collect similar data at 5 FLS around the island and while this raw data has been entered into an Access database, however the latter has not been maintained and no analyses had yet been done. These data were critical in understanding octopus population dynamics in the Rodrigues lagoon, in particular during the winter period when short seasonal closures can protect migrating brood stock promoting a recovery of the local octopus stock and during summer when a greater majority of individuals are in the growth phase and an additional short seasonal closure could boost stock biomass.

Activities

Recruitment of data entry staff

Two Rodriguan school leavers namely Adrien Joseph (19) and Brunette Raffin (17) were recruited by Shoals Rodrigues staff on the 26th on the 31st of October 2012 respectively, to enter SEMPA and Shoals data under the Smarfish project. Both had sufficient technical and computer skills to understand the basic workings of a Microsoft Access Database System front end.



Plate 1. Brunette Raffin and Adrien Joseph entering data into on the MRC supported Octopus database.

On the 1st of November 2012, the Shoals Rodrigues Scientific Officer met with the two trainees to explain in more detail the rationale behind the octopus data collection by Shoals Rodrigues and SEMPA, notably the rapid decline of the fishery, the resulting closure. He then presented and explained the two different datasheets used by SEMPA and Shoals (Figure 1a and 1b) and data they contain. One at a time the Shoals then SEMPA Microsoft Access databases explained to the trainees. This included the various input features of the two front ends (Figure 2a and 2b) where data would be entered and the tables where already entered data could be checked for errors and corrected. Data entry was demonstrated on both databases. The datasheets were organised for effective data entry I.E. in order of collection date. All the old SEMPA data were entered into the SEMPA database, and all the old Shoals data were entered into the Shoals database under the supervision of the technical and scientific officer.

Figure 1a (left) An example of SEMPA's creole datasheet developed by Dr Rebecca Klaus and the SEMPA Scientific Officer, on which CROs inscribe their data, **Figure 1b** (right), An example of Shoals Rodrigues creole datasheet developed by Shoals Rodrigues field centre manager and Jim Anderson, on which observers inscribe their data.

Formulaire SEMPA pou met donn   ourite

Date: 10/1/2013 Divan: Napa divan Kuran: Napa Kouran
 Debarcader: Pointe Monier Lapli: Napa Lapli
 Nom CRD 1: COLLET Wesley Leciel: Solay Survey ID: 1467
 Nom CRD 2: MEUNIER Vening Vag: Laglas **Clik Ici**

Enan carte pesser? Oui
 Ti servi enn bato? Oui
 Bato la ti enan moter? Non
 Ki ti servi pu lapess? Zegwi
 Ki ler li ti kit la kote? 4:00
 Ler linn retourne la kote? 8:31

Clik Ici Pu Nuvo Pesser Trip ID: 3967

Poid (g)	Sex:
328	Male
993	Femelle
1168	Male
1007	Femelle
1242	Male
925	Femelle
672	Femelle
632	Male

Endroit	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5
Ile aux fou	V-13				

	Lundi	Mardi	Mecredi	Jeudi	Vendredi	Samedi	Dimanche
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Record: 7 of 7

Friday, January 11, 2013 11:07 AM

Record: 1 of 1

Figure 2a. (above) Microsoft Access Database front end in which the SEMPA and currently the MRC octopus fishery catch monitoring data is entered. This database is a variation of the Shoals Database below, modified by Dr Rebecca Klaus for use by the South East Marine Protected Area. All data is currently entered into this database as it allows for additional datapoints to be saved.

Data Entry Form for Shoals Rodrigues Octopus Fisheries Survey

Landing Site: Data Record: Sampling Day ID: (AutoNumber)
 Date: **Finish Data Entry**

D  part du Port: Arriv   le Port:
 M  thode: En Bateau? (O/N): N Moteur? (O/N): N

Endroit: Trip ID Number: (AutoNumber)

Poids (g)	Sex

	Lundi	Mardi	Mecredi	Jeudi	Vendredi	Samedi	Dimanche
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Add Record

Record: 1 of 1

Friday, January 11, 2013 11:36 AM

Record: 1 of 1

Figure 2b. (above) Microsoft Access Database front end in which the Shoals Rodrigues octopus fishery catch monitoring data was entered. This database was build with the courtesy of Mr J. Anderson under a ReCoMaP Programme Estimate funded project.

Database clean-up

As with all large datasets, input invariably results in the introduction of errors. Consequently, once the data had been entered the SEMPA and Shoals database was examined for entry inconsistencies. These consisted, in no particular order of importance, of wrong observer names, data collections dates, fish landing station names, fisher entry and exit times, anomalous octopus weights and missing entries including Trip Ids, Octopus Ids, BAC Ids, site names, grid codes. Fishing area names were homogenised for consistency. All obviously apparent inconsistencies were removed using the hardcopy datasheets. The finalised databases were backed up on a number of different computers for safety. Hardcopies of the data are presently stored in order of Survey ID numbers in a filing cabinet at Shoals Rodrigues Field Centre at Pointe Monier.

Accuracy validation

To assess data entry accuracy, a validation exercise was performed on the database using 50 randomly selected octopus survey datasheets. The accuracy of each selected fisher survey datasheet was assessed into two sections; the first including 10 survey variables (Day, month, weather, FLS, permit, gear, time in, time out, boat, area) and the second octopus weight and sex data. The paper data were compared against the corresponding entry in the database, using unique survey and trip identification numbers, and points were deducted from a predefined total for entry mistakes made.

1	24 / 212	HTTHTT	15/2	SP	1	3 / 2	HTT HTT	2/2	SP
2	47 / 105			SP	2	25 / 222	HT HT	5/5	SP
3	63 / 469	HT HT	2/2	SP	3	49 / 12	HT HT	8/8	SP
4	82 / 614	HT HTT	2/2	SP	4	64 / 479	HT HT	5/5	SP
5	98 / 743	HT HT	3/3	SP	5	83 / 626	HT HT	4/4	SP
6	117 / 929	HT HT	5/5	SP	6	99 / 749	HT HT	5/5	SP
7	147 / 1174	HT HT	9/9	SP	7	118 / 941	HT HT	2/2	SP
8	173 / 1404	HT HT	3/3	SP	8	148 / 1185	HT HTT	9/9	SP CVS
9	202 / 1674	HT HT	8/8	SP	9	174 / 1414	HT HT	5/5	SP
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11	239 / 2024	HT HT	1/1	SP	11	222 / 1861	HT HT	3/3	SP
12	266 / 2270	HT HTT	4/4	SP	12	240 / 2029	HT HT	1/1	SP
13	289 / 2487	HT HT	4/4	SP	13	267 / 2280	HT HT	2/2	SP
14	321 / 2779	HT HT	3/3	SP	14	290 / 2497	HT HT	3/3	SP
15	362 / 3110	HT HT	5/5	SP	15	322 / 2789	HT HT	1/1	SP
16	388 / 3363	HT HTT	7/7	SP	16	363 / 3120	HT HT	5/5	SP
17	420 / 3675	HT HT	1/1	SP	17	389 / 3372	HT HT	2/2	SP
18	444 / 3909	HT HTT	5/5	SP	18	421 / 3685	HT HT	2/2	SP
19	469 / 4146	HT HT	15/15	SP	19	446 / 3919	HT HTT	3/3	SP
20	492 / 4355	HT HT	2/2	SP	20	491 / 4158	HT HT	8/8	SP
21	526 / 4698	HT HT	2/2	SP	21	493 / 4365	HT HT	13/13	SP
22	570 / 5130	HT HTT	4/4	CB	22	529 / 4708	HT HT	3/3	SP
23	602 / 5381	HT HT	2/2	CB	23	571 / 5140	HT HT	2/2	CB
24	635 / 5701	HT HTT	2/2	CB	24	603 / 5391	HT HTT	10/10	CB
25	651 / 5858	HT HT	6/6	AJ	25	636 / 5711	HT HTT	4/4	AJ

Figure 3. Results of the accuracy validation assessment

All noted errors were corrected. Percentages were calculated for individual surveys and averaged across the 50 random surveys. On average, the first section scored 95.2% and the second 98%, placing the data within the 95% confidence limit thus suggesting the data is of sufficient quality to undertake rigorous scientific analyses and to base decisions.

Outputs

SEMPA database

Between the 1st of November and 10th December 2012, 311 CRO surveys were entered into the database bringing the total CRO surveys to 435 for the entire SEMPA survey period. The surveys entered by the data imputers for SEMPA include 2,134 surveys with individual fishers operating within the SEMPA area adding up to a total of 3,239 fishers surveyed during the entire SEMPA octopus catch monitoring period. The weights and sexes of 7,672 octopuses were entered into the database bringing the total number of octopus weighed and sexed up to 10,177. See Table 1 below for these figures in tabular form.

SEMPA	Data previously entered	Data entered under MRC/Smartfish	All data entered
CRO survey days	124	311	435
Fishers surveyed	1,105	2,134	3,239
Octopus weighed and sexed	2,505	7,672	10,177

Table 1. Statistic of data collected and entered by the SEMPA scientific team and the data entered by the Shoals Rodrigues data imputers under MRC/Smartfish funding.

Shoals database

Up until the first seasonal octopus closure in Rodrigues, the Shoals Rodrigues association had weighed and sexed 23,963 octopuses, caught by 5,374 fishers during 582 surveys since 10th of August 2010. As from the reopening of the Octopus fishery on the 12th of October 2012, data was collected at 7 FLS by a team of 14 observers and SEMPA Community Resource Observers. As of the 22nd of January 2013, 5,181 octopuses caught by 1,289 fishers, were weighed, sexed and recorded during 123 surveys. As of the 10th of December 2012, the two octopus data entry staff had entered all these new data into a Microsoft Access Database. See Table 2 for these figures.

SHOALS	Data previously entered	Data entered under MRC/Smartfish
Observer survey days	582	123
Fishers surveyed	5,374	1,289
Octopus weighed and sexed	23,963	5,181

Table 2. Statistic of data collected and entered by the Shoals scientific team and the data entered by the Shoals Rodrigues data imputers under MRC/Smartfish funding.

Combined databases

To date a total of 39,321 octopuses caught by 9,902 fishers have been weighed and sexed and these data collected during 1,140 surveys entered into 2 Microsoft Access Databases. See Table 3 below for these figures in tabular form.

	SEMPA	SHOALS	COMBINED
Observer survey days	435	705	1,140
Fishers surveyed	3,239	6,663	9,902
Octopi weighed and sexed	10,177	29,144	39,321

Table 3. Statistic of all the data collected and entered by the Shoals and SEMPA scientific teams, and the data entered by the Shoals Rodrigues data imputers under MRC/Smartfish funding.

Proposed

A computer literate school leaver assisted by a fisher will enter the outstanding SEMPA octopus catch data into the Octopus Microsoft Access Database under the supervision of the Shoals Rodrigues Technical officer. A scientific officer will ensure the integrity of both Access databases for future analyses.

Carried out

Due to the lack of a suitably educated and motivated fisher in the vicinity of the Shoals Rodrigues centre, two school leavers were recruited to carry out the data entry. Data entry was completed under the supervision of the Shoals Rodrigues technical officer. The scientific officer verified the datasets, and carried out accuracy assessments on the data. The two databases currently contain the most up-to-date and complete datasets of octopus fishery catch data in Rodrigues.

NB: The Shoals Rodrigues database is complete and has been archived, the SEMPA database continues to receive new data via the Mauritius Research Council (MRC) funded octopus-monitoring project.

Modelling several summer closure scenarios

Rationale

The Rodrigues octopus fishery is currently undergoing its first temporary seasonal closure. The latter aims to rehabilitate the declining octopus stock by allowing females to migrate out of the lagoon and boost recruitment rates over the following summer. While this closure will also allow octopuses remaining in the lagoon to increase in size, this closure was not specifically designed for short-term biomass increase. A second temporary seasonal closure implemented during the summer months may, however, increase the overall stock biomass, which in turn would boost octopus landings and consequently fisher income.

The ideal timing of such a closure and its estimated effects are presently unknown, however, work on the life characteristics of *Octopus cyanea* has been published and thus growth rates for this species are well understood. Using published growth rates, the weight distribution and monthly FLS landings of *Octopus cyanea* in Rodrigues at different times of the year from the databases obtained from Activity 1, the effects of various closure scenarios, in terms of biomass increase, landings and financial return can be modelled. The merits of the various models will be assessed and policy makers will have the right information to make the best possible decision as the timing and duration of a summer closure.

Methodology

1. Find and review academic documentation on the growth characteristics of *Octopus cyanea*, assessing the merits of lab experiment growth parameters versus fisheries data extrapolations to identify the ideal growth equation to apply to the local octopus weight data
2. Prepare a growth model in Microsoft Excel
3. Extract and combine octopus weight data for all octopus sexes by catch date from the Shoals Rodrigues and SEMPA octopus databases
4. Organise the Shoals Rodrigues and SEMPA datasets by week as from January and apply the growth model to distributions for four months in weekly increments.
5. Reiterate the growth model for subsequent weeks until and April as far as good data permits
6. Prepare and submit a policy brief to the Fisheries Commission

Activities

Three papers were found on the growth of *Octopus cyanea*, notably by Wells and Well (1970), Van Heukelem (1973) and Sauer *et al* (2011). The 1970 paper describes the growth characteristics of 4 juvenile Hawaiian *Octopus cyanea* held in captivity as from 12 days after their settlement for 6 a period of months. The 1973 paper describes the growth characteristics of 29 octopuses the smallest weighting 67 grams, in captivity and fed *ad libitum*. The 2011 study derived the growth rate of *Octopus cyanea* from catch data collected by the NGO Shoals Rodrigues in 2004 and 2009. All studies confirm the exponential growth of *Octopus cyanea* however the exact parameters varied slightly.

The latest paper by Sauer was used as there is known intra-specific variability of growth parameters within the *Octopus cyanea* species, however the growth equation used in the literature needed to be modified to accommodate for smaller recruitment weights identified during the data collection phase. As such the weight at supposed recruitment was 85.967g in Sauer *et al*'s (2011) equation however in the present study the lowest recorded weight of octopus caught in the entire dataset was 15g. Since this low weight considerably affected the weight towards the end of the life of the modelled octopus the growth rate was also adjusted to reach the weight at 12 months suggested by Sauer *et al* (2011). The final equation used to model the data can be seen on the graph below.

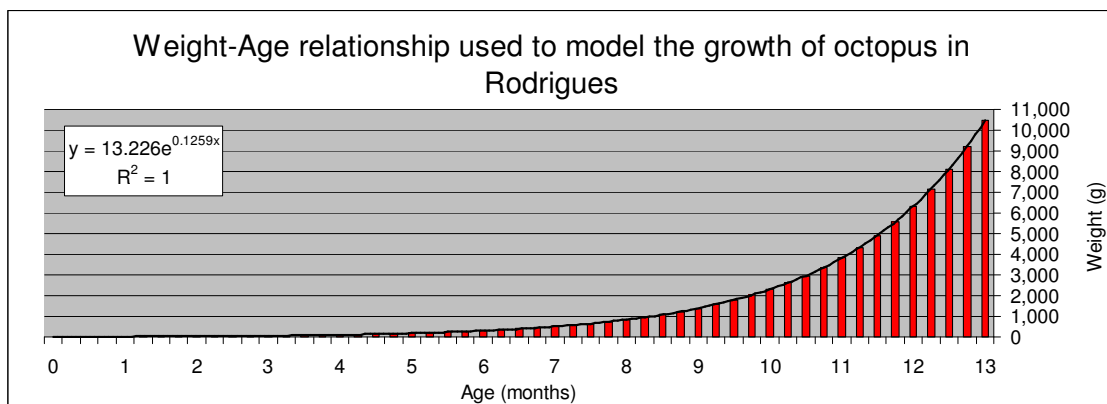


Figure 4. Based on the weight of octopus at recruitment in Rodrigues and work done by Sauer *et al*'s (2011) and growth equation was derived for the Rodrigues octopus.

Data were exported from the Shoals Rodrigues and SEMPA Access databases to Excel and merged, all sexes combined. Weight data were organised into 17 groups in seven-day increments from the 1st of January to the 31st of April 2013 and the growth model applied to the dataset. According to the equation, octopuses double their weight every 5 to 6 weeks. This implied that the more right skewed the distribution the favourable a closure would be. The datasets were analysed in SPSS 14.0 and the kurtosis of the distributions calculated. The trendline, illustrated in the graph below suggests a decreasing positive skewedness suggesting an increase in the proportion of larger octopus individuals later in the year.

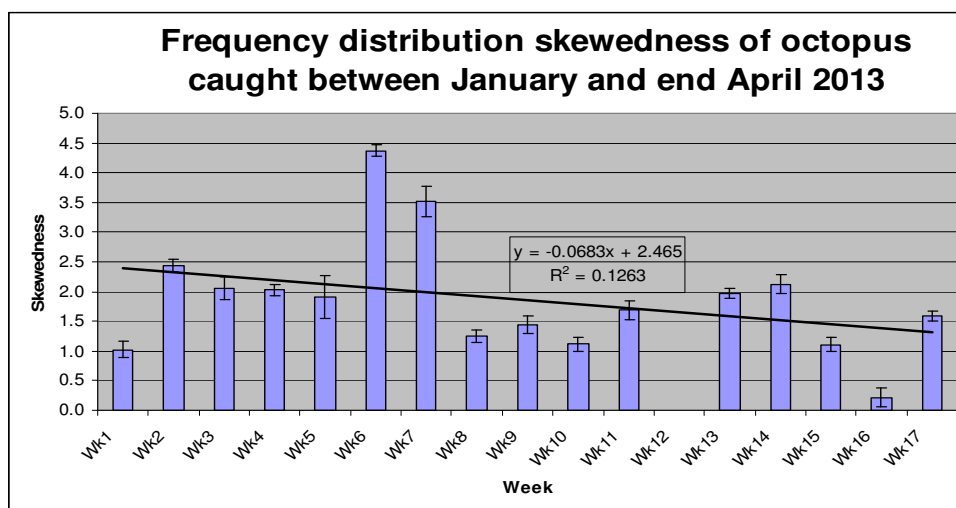


Figure 5. Skewedness values for the weight frequency distributions of octopus assessed during the first 17 weeks of 2013 that sheds light on the proportion of larger octopus in the population to identify possible closure dates to maximise on returns.

This would suggest that the later in the summer the larger the effect of the closure on landings. A caveat however is the variability in the skewedness and the low fit of the trendline that mean caution should be taken.

Outputs

Better understanding of the population dynamics in summer to plan future summer closures of the octopus fishery in Rodrigues.

Proposed

Once entered into their respective Microsoft Access databases, the Shoals Rodrigues and SEMPA datasets will be merged. Summer data will be extracted from the database, split into weekly increments and inserted into an Excel spreadsheet. The latter will be used to simulate a variety of summer closures, reflecting different starting dates and durations, from which policy makers can select the most cost beneficial closure.

Carried out

SEMPA and Shoals datasets were combined and sorted by month instead of by week. Since the RRA opted against a summer closure in 2012, this information will be used to plan the 2013 summer closure of the octopus fishery.

Refining winter closure period using the latest datasets

Rationale

The Rodrigues octopus fishery underwent its first temporary seasonal closure in 2012. The latter aimed to begin rehabilitating the declining octopus stock by allowing more females to increase in size, migrate out of the lagoon, lay and brood their eggs to boost recruitment rates or juvenile octopuses over the following summer. If the short and medium term effects of the first closure were not entirely positive yet another winter closure was proposed, the start dates and duration of the following winter closure would need refining to improve the outputs.

Methodology

The female weight dataset was extracted from the merged Shoals and SEMPA octopus database, and organised by month. Frequency distributions were calculated for each month spanning August 2008 to May 2013. Changes in peak female weight were used to improve the timing and duration of future winter closures by identifying the time of year during which weights increase to maturity level then drop as it is assumed they are migrating out of the lagoon.

Outputs

Analyses of the weight distributions shows that in general, throughout the dataset, female octopus weights tend to peak in August, September and October, and this is in line with the recommendations of Sauer *et al.* (2011), although in May 2011 and February 2012 there were peaks in female octopus weights. Note the cleanliness 2008 and 2009 data is attributed to the fact these data were collected by Shoals Rodrigues staff from only 2 monitoring stations in the north notably Pointe Monier and Baie du Nord. In 2010 data were also collected on 3 additional stations (Rivière Banane, Port Sud Est and Gravières) by fishers trained by Shoals Rodrigues staff, with the financial support of ReCoMaP. In addition to the data collected at these 5 stations, in 2011/2012, data were collected from another 8 stations by teams of Community Resource Observers (CROs) in the SEMPA fisheries catch monitoring programme, financially supported by the UNDP/GEF/RRA. Note these CROs were trained by the scientific officer of SEMPA, previously the Science Coordinator of Shoals Rodrigues. The addition of new landing stations around the island and the limited academic abilities of the data collectors are believed to be the reason the noisy data in 2011, 2012 and 2013. This could either indicate the need for more training or within stock variance.

Proposed

- Refined start date of the winter migratory closure
- Refined winter closure duration

Carried out

Data was extracted, merged and analysed as planned and though the latest datasets were very noisy (see figure 6 below), elevated number of larger females were generally noted in August, September and October supporting the need to carry out closures

during these months of the year. Compared to the 2012 closure that took place in from mid-August to mid-October, the results of the present study therefore suggest that a lengthening of the closure would be favourable, with start date as from the beginning of August all the way to the end of October.

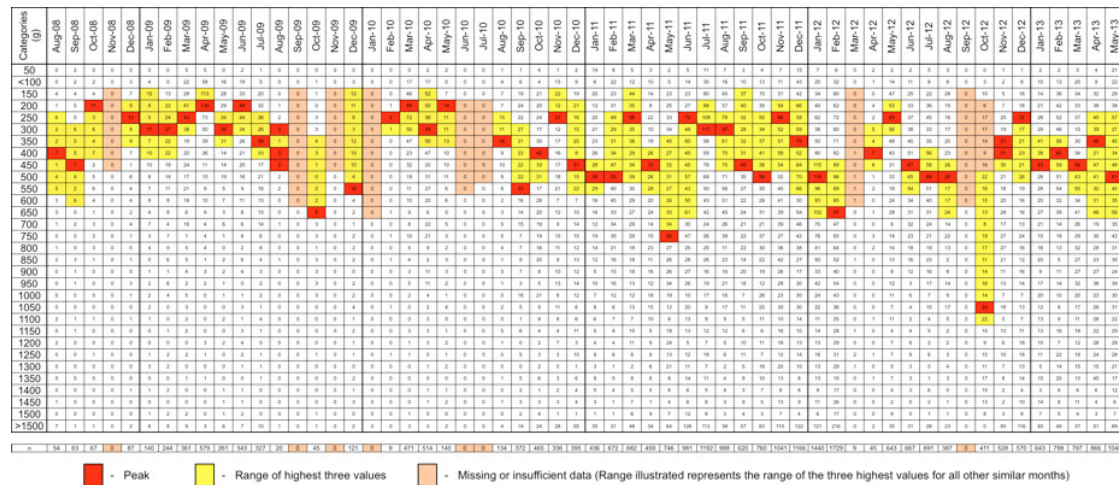


Figure 6. Frequency distributions of female octopus weights from August 2008 to May 2013. The yellow boxes represent the range of the three highest values, and the red the highest value of the distribution. The peach coloured boxes occur in months during which data were not collected and consequently the highest three values from similar months have been placed to give a rough indication of what the distribution could look like.

Undertaking Octopus population dynamics study

Rationale

It was expected that a two-month closure will have three main effects on the Rodrigues octopus stock. Firstly, an increase in the standing biomass of all octopus individuals remaining in the lagoon during the closure. Secondly, an increase in the number and size of brood stock females migrating out of the lagoon during and immediately after the closure. And thirdly, an increase in recruitment during the follow summer months leading to an increase in the abundance of juvenile individuals. To quantify the effects and determine the success of the current closure, an octopus fishery catch monitoring programme was necessary in the short to medium term. With the necessary experience in octopus monitoring Shoals Rodrigues and SEMPA personnel had already trained up fishers and Community Resource Observers to carry out the data collection in several coastal villages around the island. The necessary equipment, scales, datasheet templates had already been acquired or prepared via past funding from ReCoMaP and SEMPA.

Methodology

Shoals Rodrigues and SEMPA personnel worked in collaboration with a team of pre-trained fishers and Community Resource Observers at 7 Fish Landing Stations around the island, see map below. Each pair of data collectors will collect octopus data from 10 fishers or 2 at each landing station for a total of 6 days per month or 3 days per spring tide during which octopus fishers are active. Data collected will include: Weather state, fisher time out and time back, gear used, transport type, days fished during the week, as well as the sex and weight of every octopus caught by each fisher. The data sheets will be collected and managed by the Shoals Rodrigues technical officer. The data will be input into the database by an HSC school leaver assisted by a fisher under the supervision of a technical officer and the database maintained by a scientific officer.

Outputs

New enumerators and data collection

Prior to reopening of the octopus fishery 7 pairs of fishers previously trained for octopus enumeration were contacted. Shoals Rodrigues staff explained to them the project and the need to restart monitoring at 7 FLS instead of the previous five. On the 13th of October 2012, the 7 teams began collecting octopus fishery catch data at their respective FLSs around the island; see Figure 3 below for a distribution of these stations followed by photographs of the seven enumerator teams. Shoals Rodrigues technical officer Sydney Perrine has had the responsibility of supervising work carried out at the 7 FLS.

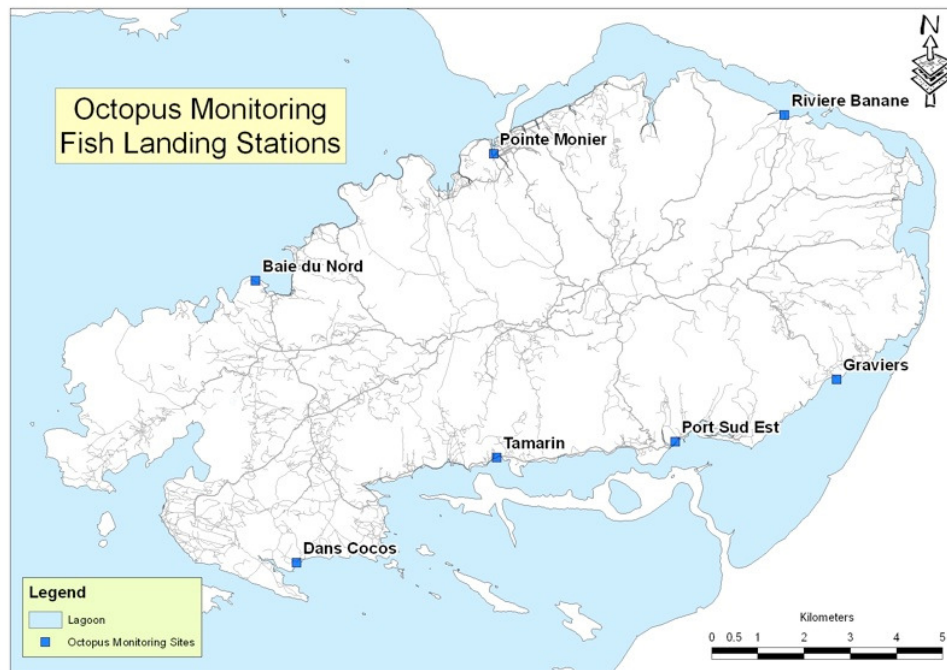


Figure 7. Distribution of the 7 FLS around Rodrigues where Octopus fishery catch data are collected fortnightly during the spring tides.



Plate 2. Graviers team, Mrs Chrisna Botlar (65). Mrs Marie Therese Jolicoeur (50) *not on picture*



Plate 3.Port Sud Est team, left Mr Jean Nicolson Sam Yu (47) right Mrs Magdalena Sam Yu (26)



Plate 4.Tamarin team, left Mr Georges Gaspard (43) right Mr Jean Alex Prosper (48), SEMPA CROs



Plate 5.Dans Coco team, left Mr Cledio Momus (42) and middle Mr Jeantet Collet (52) SEMPA CROs



Plate 6.Baie du Nord team left Leng Meunier (60) and right Mrs Favinette Meunier (35)



Plate 7.Pointe Monier team left Mr Vening Meunier (56) and right Mr Wesley Collet (25)



Plate 8. Rivière Banane team Mr Stephan Cupidon (left) and Mrs Louissette Cupidon (right)

Proposed

Shoals Rodrigues and SEMPA personnel will work in collaboration with a team of pre-trained fishers at 7 Fish Landing Stations around the island, see map below. Each pair of data collectors will collect octopus data from 10 fishers or 2 at each landing station for a total of 6 days per month or 3 days per spring tide during which octopus fishers are active. Data collected will include: Weather state, fisher time out and time back, gear used, transport type, days fished during the week, as well as the sex and weight of every octopus caught by each fisher. The data sheets will be collected and managed by the Shoals Rodrigues technical officer. The data will be input into the database by an HSC school leaver assisted by a fisher under the supervision of a technical officer and the database maintained by a scientific officer.

Carried out

CROs from the FLSs of Tamarin and Dans Cocos had previously received training from the SEMPA scientific Officer in 2011 and therefore had considerable experience in collecting octopus catch data. On the other 5 FLS, the data recorders had also already received training from the Shoals Rodrigues scientific coordinator and other staff members in 2010, but these observers however were used to an obsolete octopus datasheet and were therefore trained to collect additional data notably weather and grid codes where the fishing took place.

All 7 FLS were in possession of survey equipment, notably digital scales weighing to the nearest gram up to 5 kg. One FLS needed a new scale replaced since it stopped working. Batteries and stationary were distributed to the 7 FLS to ensure the observers had all the equipment necessary to carry out surveys.

At the end of each spring tide survey, the supervisor visits the 7 FLS to distribute and recover blank and filled datasheets respectively. Feedback from the enumerators and data entry staff is shared to improve the data collection input stages. This is also the time when the enumerators sign a receipt to receive their wages.

Lastly, the FLS supervisor carries out random spot-checks at all 7 FLS to ensure the enumerators are actually collecting real data from the fishers, as it became known during previous surveys that certain data collectors did not turn up at FLS to collect data yet they had data for those days. Random stop checks were found to be an effective deterrent.

Octopus data was collected at all 7 FLSs between the 13th of October 2012 and the 30th of April and entered into the SEMPA Access database by school leaver Adrien Joseph, and verified by a scientific Officer.

Evaluating the closure on the short term (weight distribution)

Rationale

The Rodriguan octopus fishery has been in rapid decline for several years and the current temporary closure while not specifically designed to increase biomass in the short-term, should nevertheless have a positive effect on the weight of octopus individuals remaining the lagoon during the closure. This increase in biomass while less important in rehabilitating the stock can serve as important promoting factor to convince octopus fishers of the merits of short temporary closures. An important aim of this study will therefore be to determine the short-term success of the current closure that is, the increase in mean size of individual octopuses as well as a shift in weight distribution towards heavier octopuses. The results will also give an indication of the drop-off of benefits of the closure over time and may help in determining better closure durations.

Methodology

Weight data were extracted from the database and compared with octopus weight distributions of the previous two years, effectively comparing protected and unprotected octopus stocks. These comparisons were done for six months following reopening of the fishery to assess the short-term benefits and duration of the positive effects of the two-month closure on both males and females.

Outputs

Between 2010 and 2012, mean male octopus weights measured from October to March hovered rather stably between 682 and 940 g suggesting that while the resource is heavily fished, on average males exceed threshold maturity levels twofold during the winter season. Nonetheless, after the 2012 closure, figures more than doubled reaching a peak of 1,730 g on average, immediately after the fishery was reopened. This remained above the previous two years average for a month and a half before returning to normality.

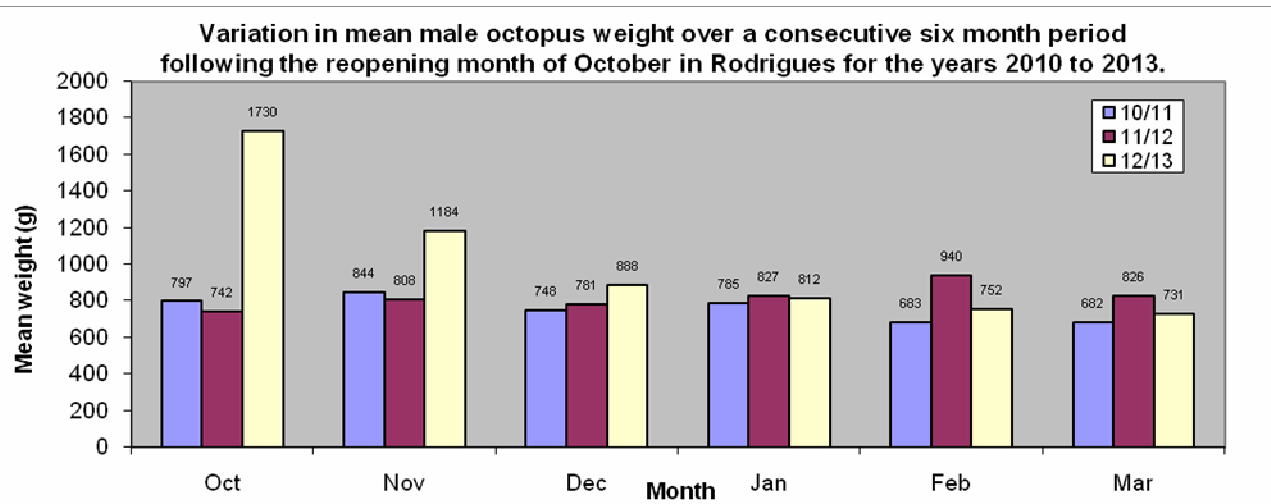


Figure 8. Variation in mean male octopus weight over a consecutive six-month period following the reopening month of October in Rodrigues for the years 2010 to 2013.

Similarly to males, between 2010 and 2012, mean female octopus weights measured from October to March hovered between 602 and 852 g suggesting the resource is susceptible to recruitment over-fishing such that a greatly reduced number of females are reaching maturity. After the 2012 closure, figures more than doubled, peaking at 1,721 g on average and remained above the previous 2 years' average for two and a half months before returning to previous years' levels.

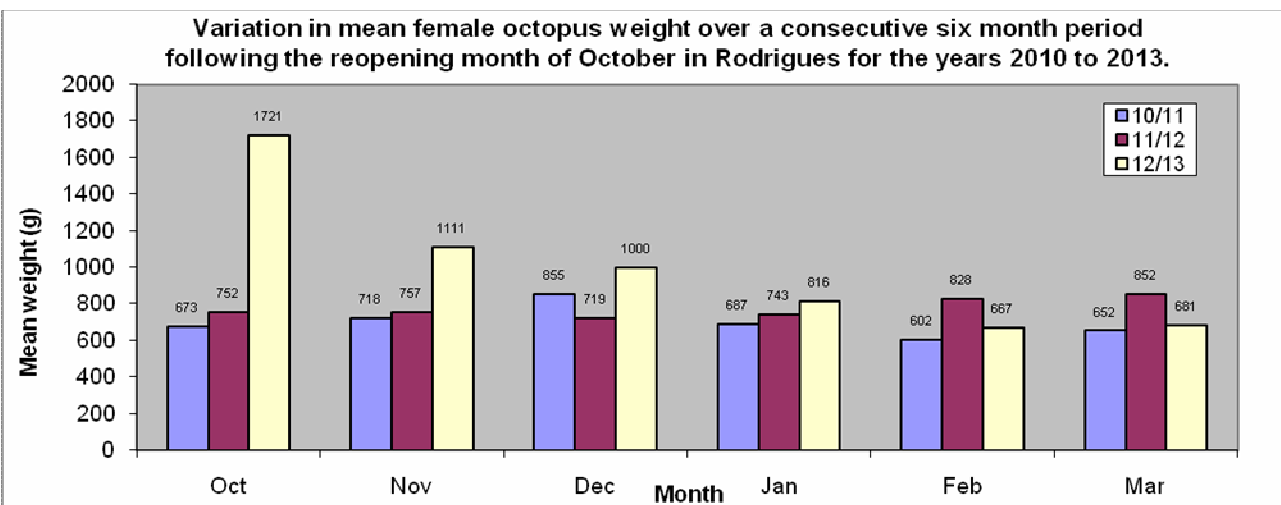


Figure 9. Variation in mean female octopus weight over a consecutive six-month period following the reopening month of October in Rodrigues for the years 2010 to 2013

Proposed

Evaluate the closure on the short term (weight distribution)

Carried out

Data collected between 2010 and 2013 were entered into the database, extracted, combined and analysed to assess the short-term effect of the 2012 closure. Information stemming from the results was used to support future closure and source funding for the 2013 closure.

Evaluating the closure on the medium term (recruitment)

Rationale

The Rodriguan octopus fishery has been in rapid decline for several years. As such, the current temporary winter closure was specifically designed to allow more female octopi to migrate out of the lagoon to lay and brood their eggs, thereby increasing the number of juvenile octopus recruiting to the lagoon during the summer months of 2013. This will be a direct contribution in rehabilitating the stock. Results will also serve as an important promoting factor to convince octopus fishers of the merits of short temporary winter closures. The primary aim of this study will therefore be to determine the medium-term success of the current winter closure that is, the increase in abundance of juvenile octopuses within the distribution.

Methodology

Weight data was be extracted from the database and compared with octopus weight distributions of juveniles caught during the previous years' surveys, effectively comparing protected and unprotected octopus stocks. These comparisons were done month-by-month to assess changes in the numbers of juvenile octopus recruiting into the lagoon.

Outputs

Data collected between 2010 and 2013 were entered into the database, extracted, combined and analysed to assess the medium-term effect of the 2012 closure.

Proposed

Evaluate the closure on the medium term (recruitment) by assessing the number of juvenile octopus weighed during the summer months when recruitment is through to occur.

Carried out

Combining the number of all octopuses weighed at less than 350 grams in 2011, 2012 and 2013, one can see that in 2013, 1,707 juveniles were weighed, more than in 2011 and 2012. See figure 10 below.

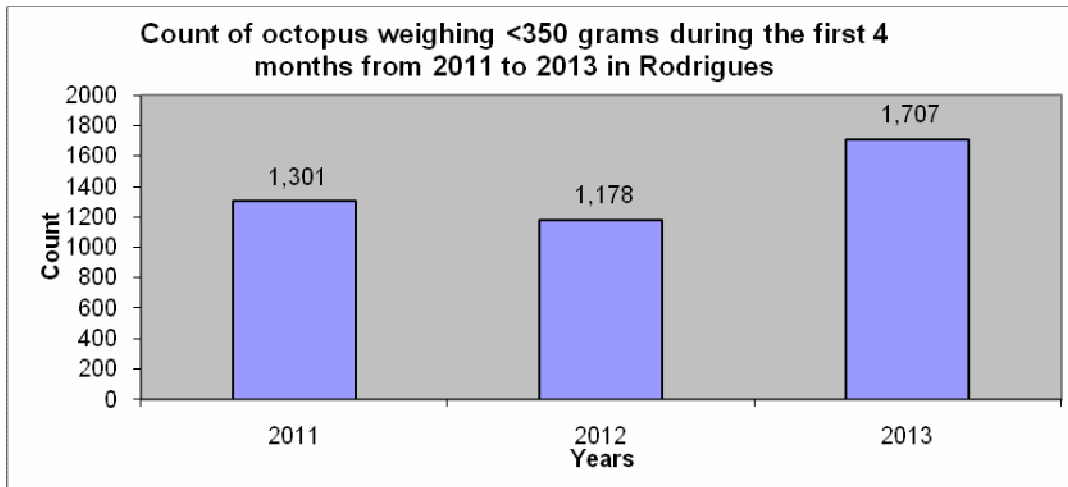


Figure 10. Count of octopus weighing less than 350 grams during the first four months, comparing 2011, 2012 and 2013.

Comparing the frequency distributions of juvenile octopus caught in January in 2011, 2012 and 2013, see Figure 11 below, the 2012 batch was the highest of the 3 years and that the 2013 batch higher than that of 2011.

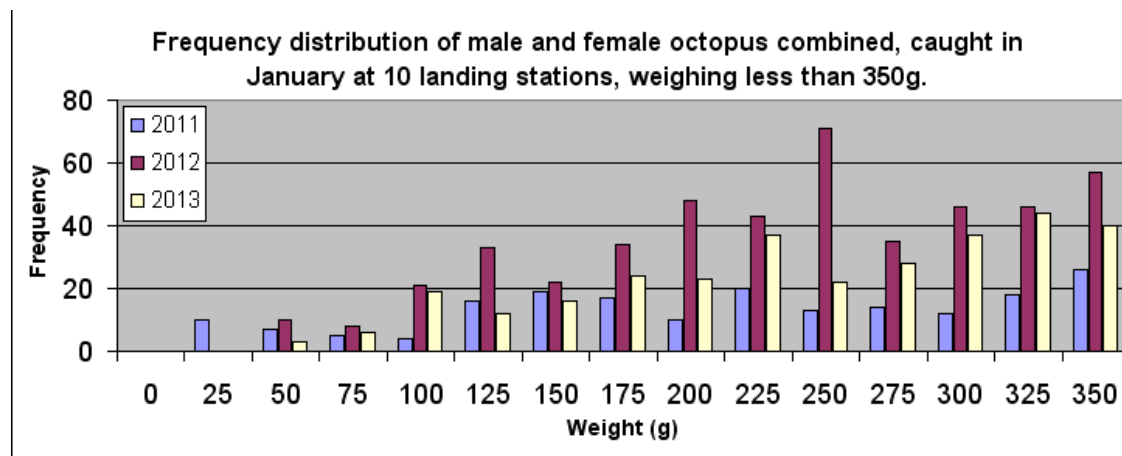


Figure 11. Frequency distribution of male and female octopus weights combined, caught in January at 10 landing stations, weighing less than 350g,

Comparing the frequency distributions of juvenile octopus caught in February 2011, 2012 and 2013, see Figure 12 below, suggest again that the 2012 batch had more juveniles than all other years and that the 2013 batch had more juveniles than that of 2011.

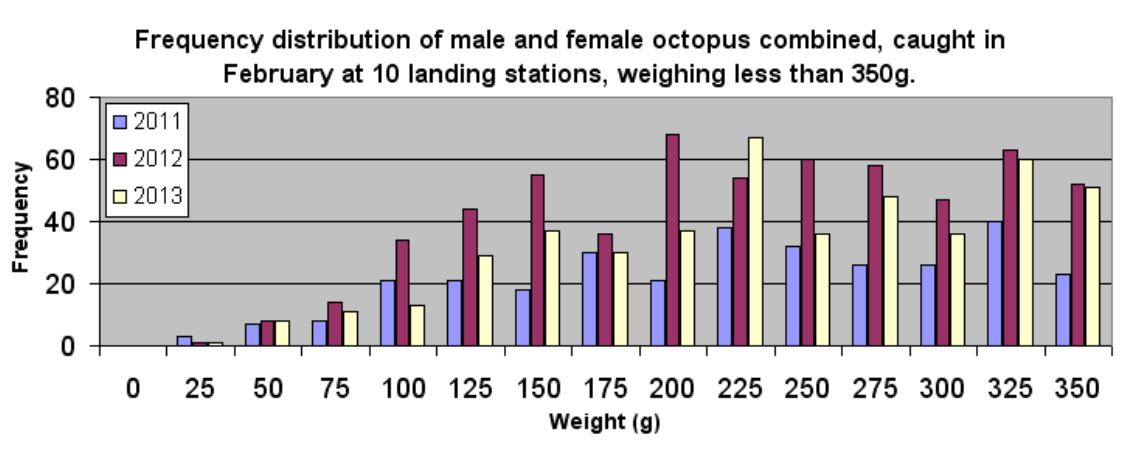


Figure 12. Frequency distribution of male and female octopus weights combined, caught in February at 10 landing stations, weighing less than 350g,

Comparing the frequency distributions of octopus caught in March 2011, 2012 and 2013, see figure 13 below, the number of juvenile octopus weighed were approximately equal in 2011 and 2013. Note the low number of octopus caught in March 2012 resulted in the quasi-absence in the graph.

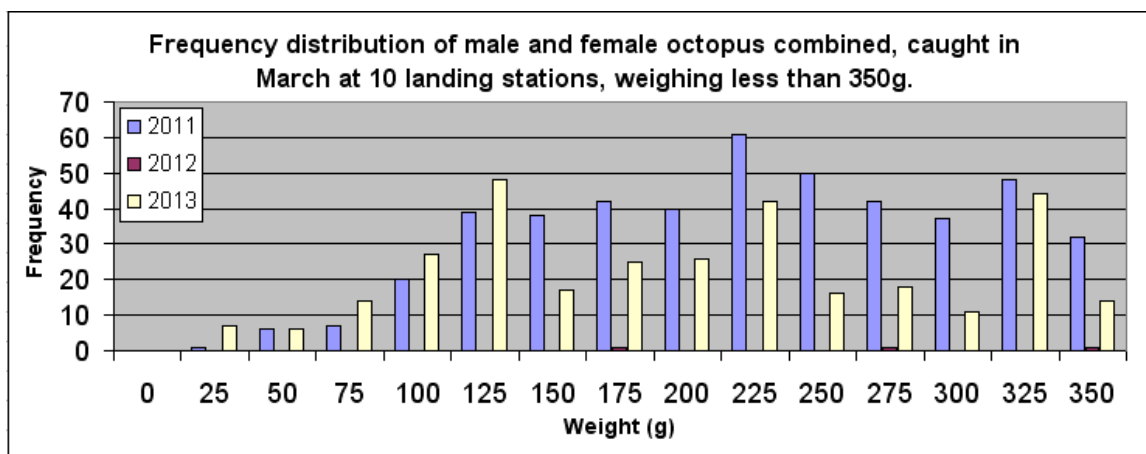


Figure 13. Frequency distribution of male and female octopus weights combined, caught in March at 10 landing stations, weighing less than 350g,

Comparing the frequency distributions of octopus caught in April 2011, 2012 and 2013, see figure 14 below, the number of juvenile octopus weighed in 2013 is higher than in 2011. Note again April 2012 resulted in the quasi-absence in the graph.

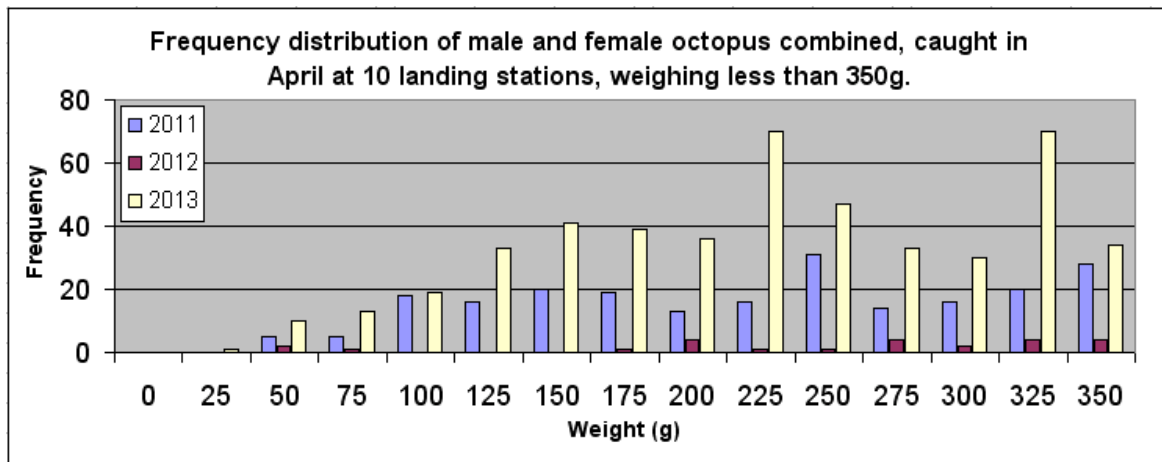


Figure 14. Frequency distribution of male and female octopus weights combined caught in April at 10 landing stations, weighing less than 350g.

Discussion

Modelling several summer closure scenarios

The modelling work with the weight data revealed that octopuses double their weight every 5 to 6 weeks regardless of age. This has implication in deciding when best to temporarily close the fishery in summer as the larger the octopus the bigger the return will be. Since the data suggest that mean octopus weight and the proportion of larger individuals in cohorts increase later in the summer, a closure aiming to increase landings in the short term would be more suitably placed as late as possible in summer; however, if the main aim of the closure is to protect recent recruits and the smallest juveniles, then closure would be better placed as soon as the biggest peak in recruitment is recorded. This however is difficult to assess as the results of the present study have shown.

The decision of when the summer closure will be carried out is likely to be largely a political one, as fisher will expect big landings after the closure. However, for the best of the octopus stock, a closure aiming to protect the new recruits and small juveniles is more appropriate if the priority is rehabilitation of the stock.

Refining winter closure period using the latest datasets

The results of the 2012 winter closure were very promising with massive increases in octopus sizes that dropped off after approximately two months suggesting the dates of the closure were well chosen for that year in what concerns landings; however the main aim of the winter closure in the case of Rodrigues being rehabilitation, the dates must be chosen to increase the probability of closing the fishery in time for migration, which is difficultly planned without a study that investigates actual migration rather than the size of females, and this has also been indicated in Sauer et al's (2011) study. The 2012 closure did show that females reached sizes at which they were certainly sexually mature, however this does not imply that they will necessarily migrate out of the lagoon to lay and brood.

Evaluating the closure on the short term (weight distribution)

As previously said, the first winter closure was a success in terms of short-term returns. This was verified by the landings statistics generated by the Fisheries Research and Training Unit (FRTU) for the year 2012, which were 188 tons greater than in 2011. However the mean weight of 1,730g and 1,721g for males and females respectively immediately after reopening is considerably lower the maximum known size of the species in the region (the largest octopus recorded in the present study was 10kg for both male and female) Accordingly, a longer closure would allow the octopuses to reach far greater weights. A later closure may also have a positive effect on the stock, however the impact of leaving the closure until later may lead to the removal of too many large individuals that in turn may prevent the closure from reaching its intended purpose.

Evaluating the closure on the medium term (recruitment)

While the number of juveniles weighed during the first 4 months of 2013 combined by year suggests that in 2013 more juveniles were present in the Rodrigues lagoon,

breaking down the data by month revealed that inadequate monitoring during the early months of 2012 may mislead us in believing that recruitment of juveniles was highest among the three years during which data were collected. However, the drop in mean weight of both male and female octopus in January, February and March 2013 may point towards an increase in the number of smaller sized individual.

Note that several reports of large numbers of 1-inch long recruits were noted in late December 2012 and early January 2013, clinging onto night divers' equipment off-lagoon and on macroalgae inside the lagoon; however such small octopuses are not caught by fisher and are therefore not assessed in the present study, furthermore, these tiny octopuses would only reach catchable sizes several months later. As such, further monitoring may reveal the presence and growth of this cohort.

Conclusions and recommendations

The present study suggests that in the short term, in terms of landings, the 2012 winter closure was a clear success; as such additional closures are recommended to boost landings thereby contributing to bettering the financial status of octopus fishers and traders, while contributing to boosting the economy as a result of increased exports.

In the medium term, I.E. in terms of recruitment, the study suggests that there was an increase in the number of juveniles present in the lagoon between the months of January to April 2013; however it is difficult to link this directly with the closure as there have been past episodes of high recruitment most notably in 2003. As such a further monitoring is deemed necessary to determine whether recruitment continues to at the same level as in 2013 or if it increases further thereby increasing the confidence that it is the effect of the closure rather than a confounding factor such as elevated water temperatures of superabundance of food.

The summer modelling exercise has shed light on one aspect of *Octopus cyanea*'s growth in notably its ability to double in size every 5 to 6 months. This is relevant in deciding when to carry out a closure of the fishery since an earlier closure will protect new recruits and juveniles but have a lesser effect on landings, whereas a closure carried out in the later months of summer will lead to increased landings as the octopus will be far larger. It would perhaps be wiser to plan a closure in the middle of summer to both protect juveniles whilst also resulting in better landing that if the closure was in the beginning of summer.

The winter closure date refining exercise suggests that a closure carried out between months of mid-August and mid-October had a considerable effect on landings, and these are likely to increase further were future winter closures to last longer. A longer closure would also increase the probability that the closure and migration overlap. It is however recommended to carry out a study on the migration of mature female octopus by acoustic tagging to better ascertain the winter migration phase.

References

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