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SEYCHELLES FISHING AUTHORITY

TECHNICAL REPORT

The Seychelles Spiny Lobster Fishery

Fishery and Stock Status: 2010-2013

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Fishery & Stock Status: 2010-2013

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Table of Contents

Table of Figures

1. Introduction

The Seychelles artisanal spiny lobster fishery targets shallow water lobster stocks around the main granitic islands. The main species caught are Homard Grosse Tete (*Panulirus penicillatus*), Homard Rouge (*P. longipes)*, Homard Vert (*P. versicolor*) and Porcellene (*P. ornatus*). The preferred habitats of these species are fringing carbonate reefs and granite reefs with many holes and overhangs in which they take shelter. The fishery takes place during the night. Fishing grounds are usually accessed using small outboard vessels. An average fishing trip generally consists of three men fishing for approximately five hours. The fishery uses a number of techniques for catching lobsters. The most popular technique involves snorkeling and skin diving. SCUBA and baited bamboo traps are also used but to a lesser extent. Fishing using snorkeling and SCUBA makes use of flashlight to stun lobsters which makes them easier to catch and remove from its shelter.

The Seychelles spiny lobster fishery is seasonal and licensed with a restriction on the number of licenses which are issued each year. The fishing season typically last 3 months and is restricted to the Northwest monsoon when weather conditions are calmer. Minimum size restrictions (75 mm carapace length for all species) are in place and retention of berried females is prohibited. Conditions of licenses specify that logbook and sales receipts must be kept and submitted to the Seychelles Fishing Authority (SFA). While the management measures in place provide a degree of input control, catches have not been managed through the use of output controls such as Total Allowable Catches (TACs). Since the start of the 2011/2012 fishing season, the SFA has introduced a compliance bond of SCR5,000 that fishers have to pay prior to the issuance of a license. The bond is refundable to the license holder provided that logbooks and sales records are fully completed and submitted by the due date.

Since SFA established a monitoring programme for this fishery in 1992 (Mees 1992), reports have been produced at the end of each season describing several aspects of the fishery, including research and management. In 2009, a more detailed report was produced that covered several consecutive open seasons (2005-2008) (Robinson et al. 2009). The main focus of the report was to analyse time-series and spatial patterns in stock indicators, and to undertake analytical stock assessments when data permit, to

provide more robust information on the status of the fishery and lobster stocks. This report follows the same format as the 2009 report. It presents analyses of fisheries-dependent data collected for the fishery over the period of 2010 to 2013. Over this period, the fishery was opened for 3 consecutive fishing seasons, namely the 2010/2011[1] (15th December 2012 to 14th March 2011), 2011/2012 (20th December 2011 to 20th March 2012) and 2012/2013 (1st December 2012 to 28th February 2013) seasons. Moreover, this report provides several recommendations and advice to managers on whether the 2013/2014 fishing season should be opened or closed.

2. Catch & Effort

2.1. Comparison with historical catch

The total catch for the 2010/2011 season was 2.40 t compared to 3.30 t for the 2011/2012 season and 2.11 t for the 2012/2013 season. The 2012/2013 season had the lowest catch of the recent 3-year period of open seasons (Figure 1). The total catch over the last 3 open seasons were below the historical mean catch of 4.38 t. In 2012/2013, the catch was 52% lower than the historical mean.

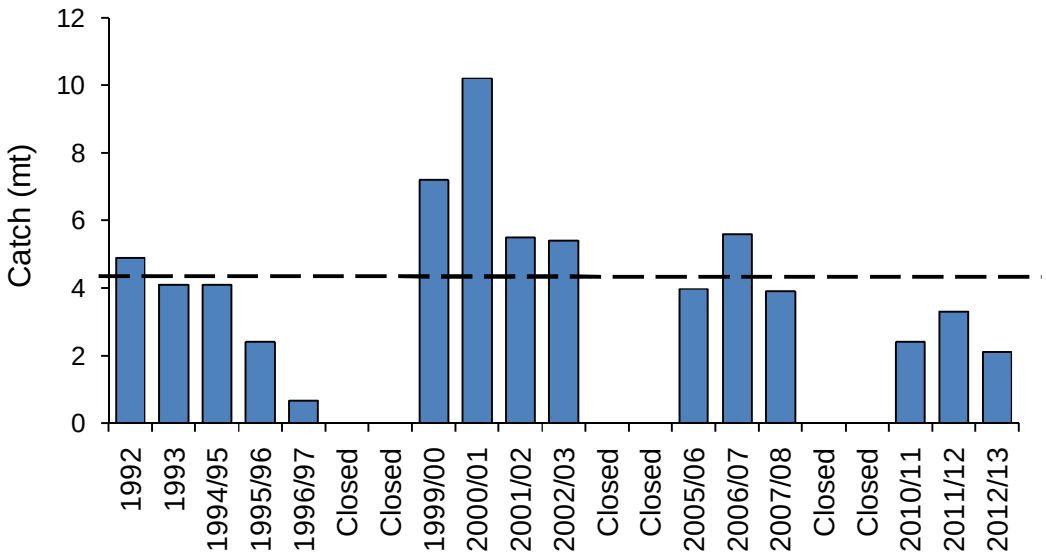


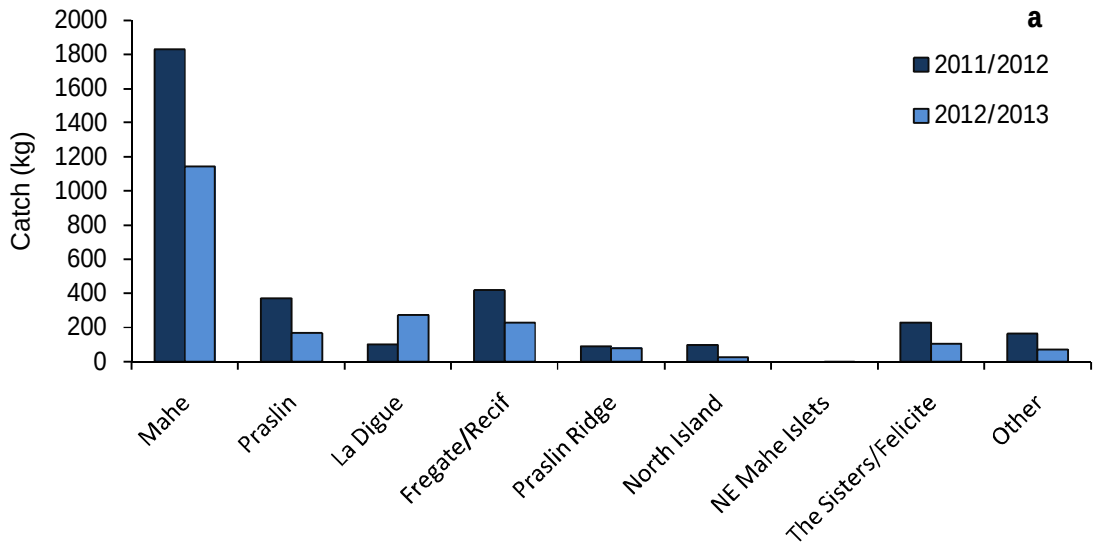
Figure 1. Historical seasonal catch (metric tonnes (t)) of spiny lobsters. Dashed line indicates mean seasonal catch since monitoring began in 1992.

[1] Due to poor data reporting from fishers during the 2010/2011 fishing seasons it was not possible to estimate some of the indicators for this season. Therefore, the 2010/2011 season was excluded in some of the analysis and comparisons were made only between the 2011/2012 and 2012/2013 fishing seasons

2.2. Catch and fishing effort by location

Mahé has remained the main fishing ground over the last 2 fishing seasons with catches reaching a peak of around 1.83 t in 2011/2012 compared to 1.14 t in 2012/2013 (Figure 2a). Catches from all major fishing grounds declined over the last 2 fishing seasons, except for La Digue where an increase of 171% in catches was observed in 2012/2013 compared to 2011/2012. Catches decreased by 37% on Mahé, 55% around Praslin, 45% around Fregate/Recif, 53% around The Sisters/Felicite and 79% around North Island.

The total effort (number of trips) was similar over the past two fishing seasons. In 2011/2012 a total of 206 fishing trips were conducted compared to 208 fishing trips in 2012/2013. However, the total catch decreased by 36% in 2012/2013 compared to 2011/2012 catches. By location, effort increased slightly on Mahé and La Digue, whilst at the other locations, effort was stable or declined slightly over the last two fishing seasons (Figure 2b).



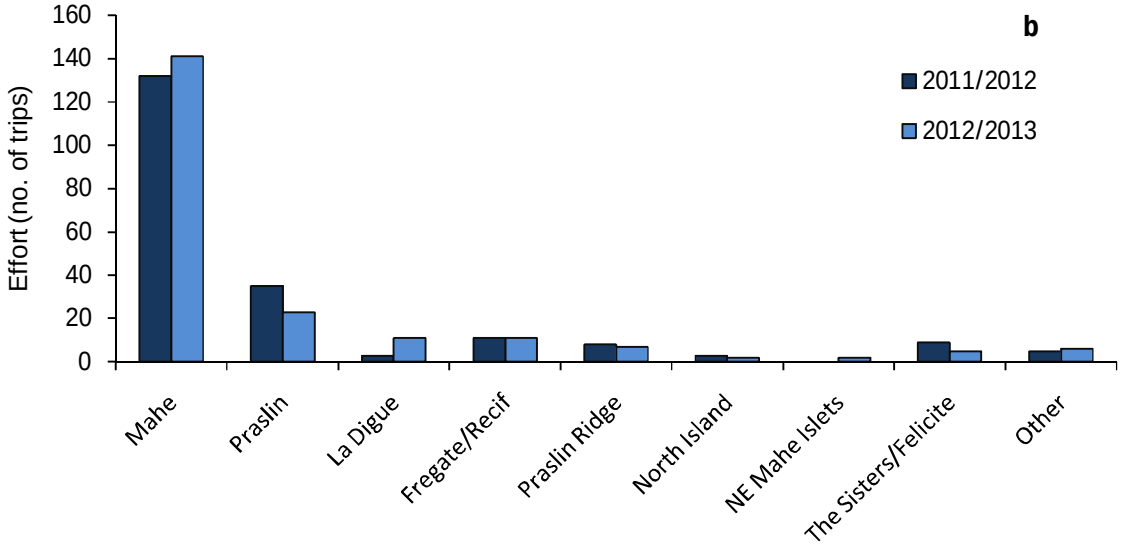


Figure 2. Catches (kg) (a) and fishing effort (no. of trips) (b) by major fishing location over the recent 3-year period of open seasons.

2.3. Catch against maximum sustainable yield (MSY)

MSY for the spiny lobster fishery was estimated by Bautil (1992) based on two approaches determined from a fisheries-independent survey. Firstly, estimates were based on mean densities at sites around Mahé, giving lower, conservative estimates (1.17 t), and secondly based on maximum densities at the same sites, giving high, less conservative estimates of MSY (4.7 t). Both rely on the assumption that standing stock biomass in 1991 equated to virgin biomass, which is probably not justified given the existence of a significant fishery prior to that year. Both Mahé estimates were extrapolated to provide MSY for the inner granitic island fishing grounds.

Catches from the Mahé and inner islands fishing grounds ('all sites') have not exceeded the high MSY estimates for that stratum over the last 3 seasons (Figure 3a). Similarly, using the more conservative estimates, catches from Mahé and the inner islands have not exceeded MSY, except for the case of the Mahé stratum where MSY was exceeded by more than 55% in the 2011/2012 season (Figure 3b). This is a stark contrast compared to the previous assessment in 2009 whereby catches from Mahé and the inner islands exceeded the conservative estimate of MSY in all 3 open season between 2005 and 2008. As there is considerable uncertainty in both approaches used to estimate MSY (Mees et al. 1998) such estimates should not be used as target or limit reference points for the fishery.

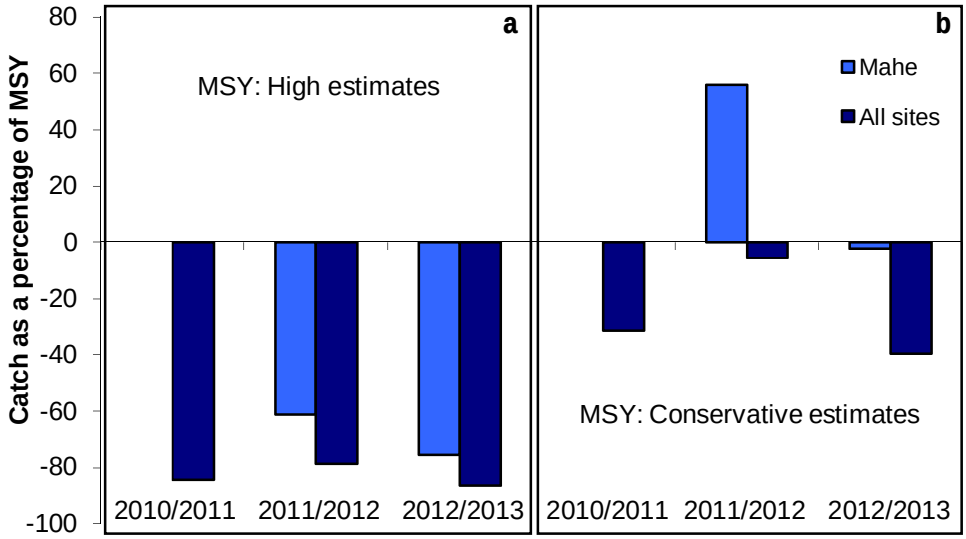


Figure 3. Catch by strata as a percentage of (a) high (Mahé MSY = 4.7 t; Inner island sites MSY = 15.5 t) and (b) conservative (Mahé MSY = 1.17 t; Inner island sites MSY = 3.5 t MSY) estimates over the recent 3-yr period of open seasons.

2.4. Species composition by location

Catches of the main target species over the last two open fishing seasons was dominated by *P. penicillatus*. A total of 2.35 t of *P. penicillatus* were caught during 2011/2012 compared to 1.37 t in 2012/2013. The second most dominant species in the catch was *P. longipes.* A total of 0.77 t of this species was caught in 2011/2012 compared to 0.71 t in 2012/2013.

By location, the catches from the important Mahé fishing location were dominated by *P. penicillatus* (Figure 4). Catches of this species decreased by 46% in 2012/2013 compared to 2011/2012. In contrast, *P. longipes* catches from Mahé was constant between the two seasons. On Praslin, catches were dominated by *P. longipes* for both fishing seasons. However, a decrease of 51% in the catch of this species was observed in 2012/2013 compared to 2011/2012. Similarly, catches of *P. penicillatus* on Praslin decreased by 62% between the two fishing seasons. In 2011/2012 catches at most of the other fishing sites were dominated by *P. penicillatus* except for catches from The Sisters/Felicite where *P. versicolor* was the most abundant species (Figure 4a). In 2012/2013 catches from La Digue and Praslin ridge was dominated by *P. longipes*, whilst at the "Other"

locations catches were dominated by *P. penicillatus* (Figure 4b). The observed changes in species composition may be the result from changes in gear use and depth targeted at fishing locations in addition to local changes in stock abundance.

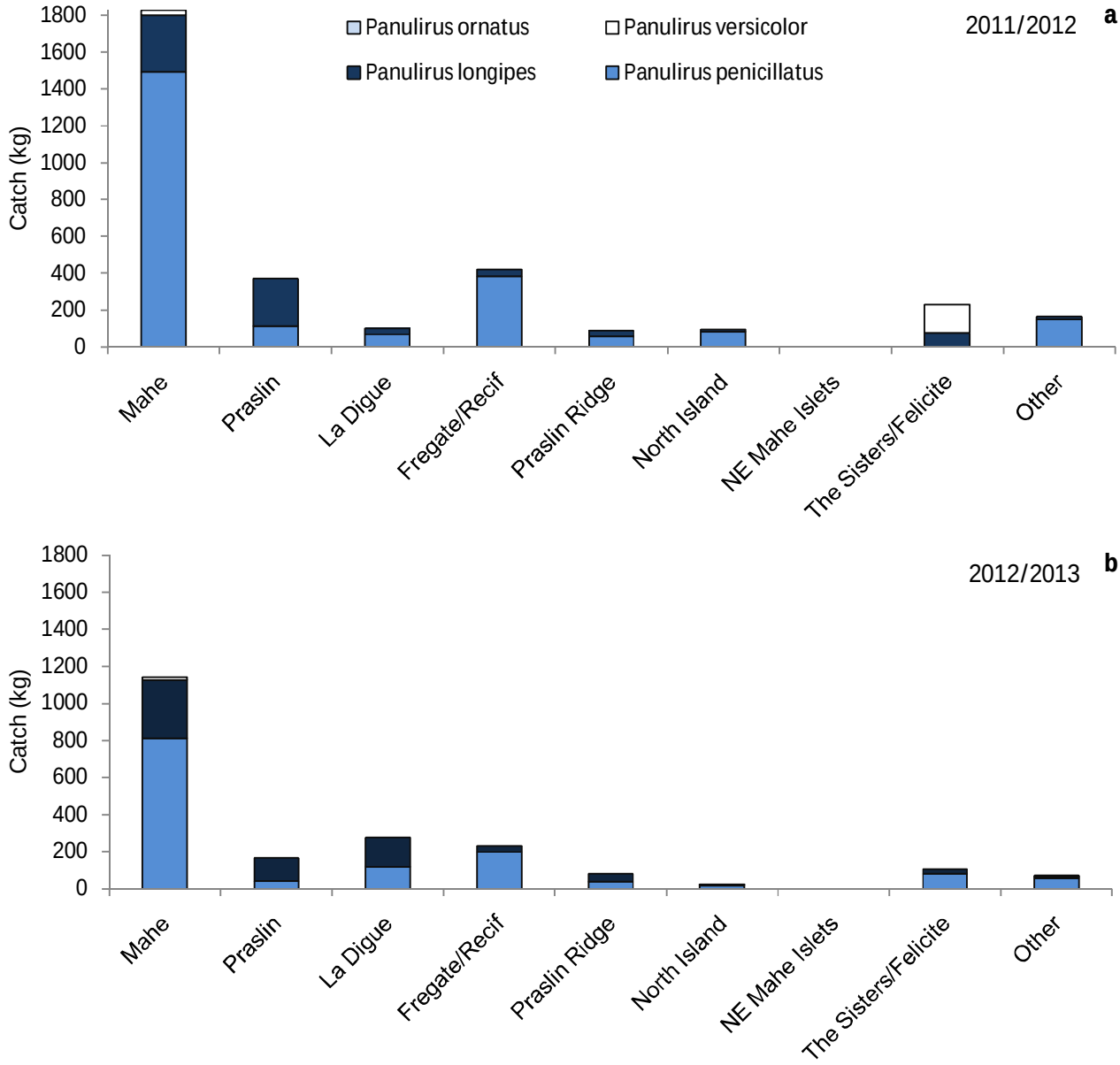


Figure 4. Species composition of spiny lobster catches from the main fishing locations during (a) 2011/2012 and (b) 2012/2013 fishing seasons.

3. Stock Indicators: Catch-Per-Unit Effort (CPUE)

3.1. Seasonal comparisons of CPUE by gear

For the snorkelling technique, there was a significant difference between the CPUE for the 2011/2012 and 2012/2013 fishing seasons. The statistical test* and box-and-whisker plots (Figure 5) indicated that CPUE was lower in the 2012/2013 season compared to the 2011/2012 season. The average snorkelling CPUE for the 2011/2012 season was 19.18 kg/trip compared to 11.88 kg/trip in 2012/2013. For traps, there was no significant difference in the CPUE between the two fishing seasons** (Figure 6). The average trap CPUE for the 2011/2012 season was 4.73 kg/trip compared to 4.61 kg/trip in 2012/2013.

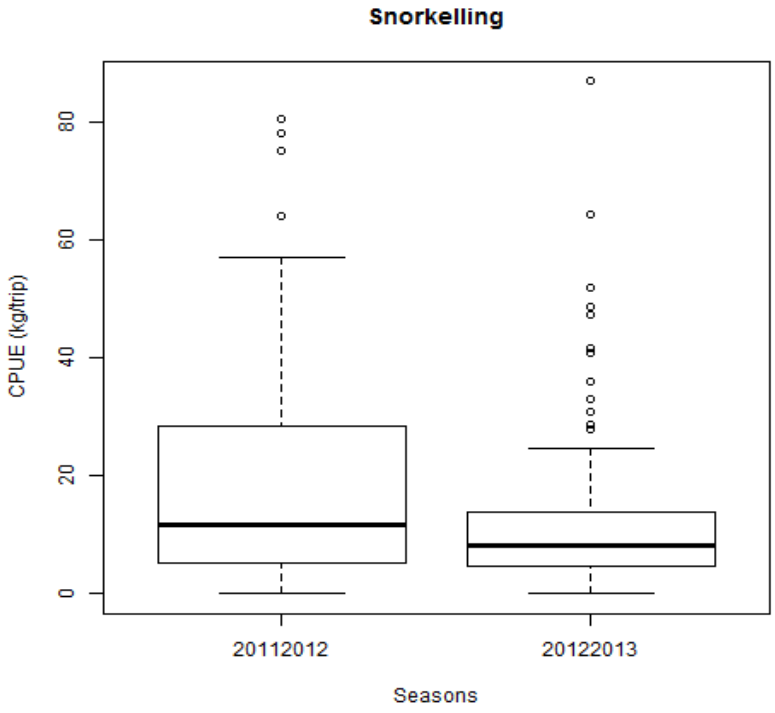


Figure 5. Box-and-whisker plots of CPUE for snorkelling gear (kg/trip) over the recent 2-yr period of open seasons. * Non-parametric Wilcoxon rank-sum Test: W=11100.5; p<0.005.

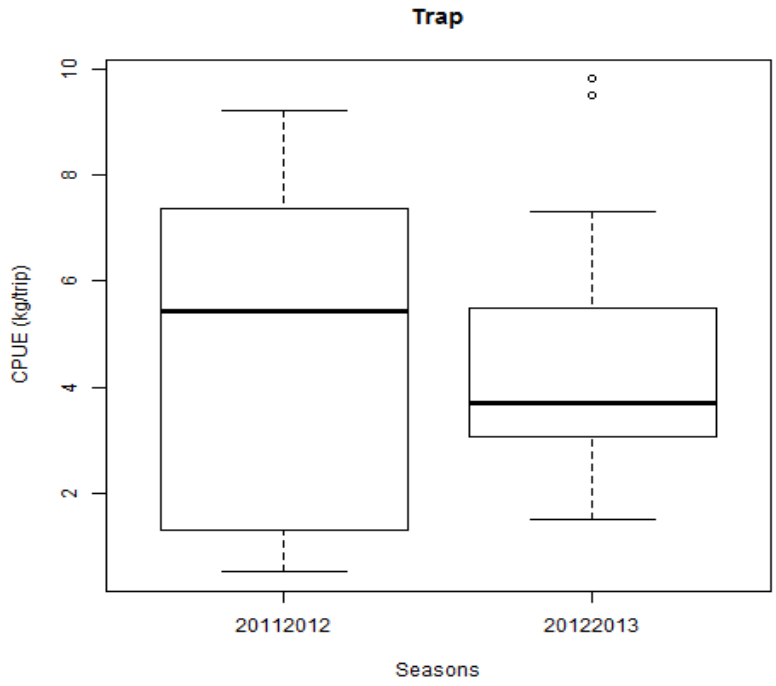


Figure 6. Box-and-whisker plots of CPUE for trap gear (kg/trip) over the recent 2-yr period of open seasons.** Non-parametric Wilcoxon rank-sum Test: W=78; p>0.05

3.2. Changes in CPUE by location

Comparison of CPUE between the 2012/2013 and 2011/2012 fishing seasons showed a marked decline at all locations except at the Praslin ridge where there was a slight increase in CPUE[2] (Figure 7). The most impacted locations were North Island and "Other" areas where declines of 61% and 63% in CPUE were observed respectively. These two sites consist of a number of small fishing grounds. Consequently, the lobster resources at these sites are vulnerable to overexploitation even at low levels of fishing effort. At the major fishing grounds of Mahé, Praslin and Fregate/Recife, declines of 41%, 31% and 45% were observed respectively.

[2] Note: Change in CPUE was calculated as the 2012/2013 CPUE minus the 2011/2012 CPUE at locations except NE Mahe Islets where no fishing was reported in 2011/2012. The NE Mahe Islets was excluded from this analysis.

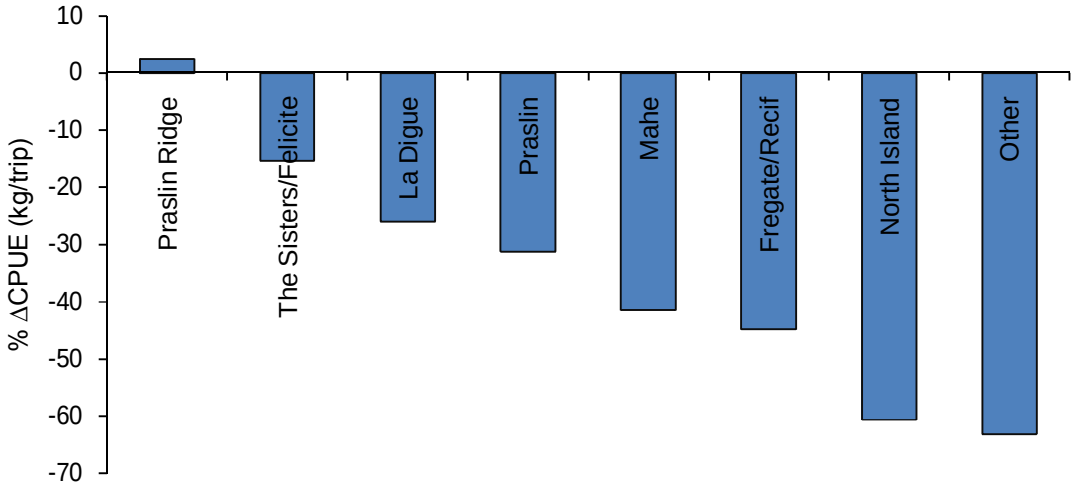


Figure 7. Percent change(Δ) in CPUE (kg/trip; all gears) between the 2011/2012 and 2012/2013 seasons for the major fishing locations.

3.3. Comparison with historical CPUE

The mean seasonal CPUE for the 2011/2012 season (16.04 kg/trip) was slightly lower than the historical mean of 17.48 kg/trip (Figure 8). However, in the last fishing season (2012/2013), the mean CPUE had declined to 10.14 kg/trip. For the 2012/2013 season, mean CPUE (all gears combined) was at its lowest level since the historical low of 11.68 kg/trip in the 2002/2003 season.

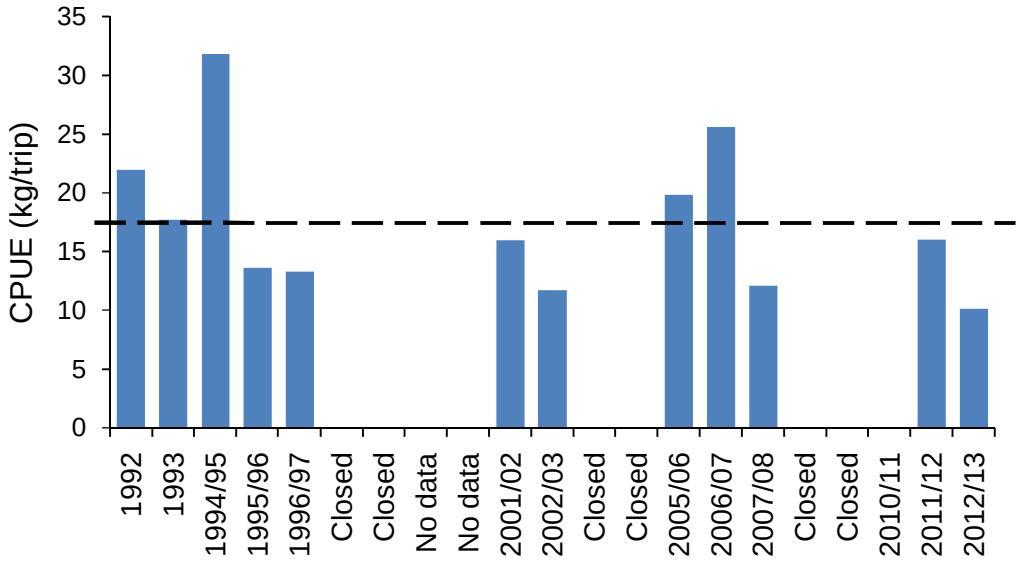


Figure 8. Seasonal mean CPUE (kg/trip) for open seasons of the lobster fishery between 1992 and 2008. Dashed line indicates the historical mean CPUE (17.48 kg/trip). Data were unavailable to calculate CPUE for 3 open seasons (no data). CPUE for 2010/11 was not calculated due to underreporting.

4. Stock Indicators: Size structure

4.1. Sample sizes

A total of 5815 spiny lobsters were measured and sexed over the 3-year period (Table 1). Despite the fact that sampling effort was similar over the 3-year period, a decrease in the sample sizes was observed over the period. The species composition of samples largely reflected that of the catch. A total of 2367 lobsters were sampled during the 2010/2011 season compared to 1958 sampled during 2011/2012 season and 1490 sampled during the 2012/2013 season. Males dominated females in most of the samples taken. This bias towards males is largely due to the management measures in place for the fishery, where berried females are supposed to be discarded.

Over the last 3 seasons, sample sizes were large enough to conduct a preliminary demographic stock assessment to estimate the fishing mortality rates (F) (See section5).

Table 1. Size frequency sample sizes by species for the last 3 open season

Season	Species	U	F	M	Total
2010/2011	*P. penicillatus*	14	702	915	1631
	P. longipeds	4	205	495	704
	P. versicolor	0	13	19	32
2011/2012	*P. penicillatus*	1	619	798	1418
	P. longipeds	1	173	348	522
	P. versicolor	0	5	12	17
	P. ornatus	0	0	1	1
2012/2013	*P. penicillatus*	0	335	488	823
	P. longipeds	0	284	365	649
	P. versicolor	0	8	10	18
Grand total		20	2344	3451	5815

Note: U=undetermined sex; M=males, F=females

4.2. Size-frequency distribution: P. penicillatus

Over the last 3 seasons, the fishery targeted female *P. penicillatus* in the range of 6.0 to 15.25 cm CL (Figure 9). However, a large female measuring 19.6 cm CL was caught in 2012/2013. The size frequency distribution of females displayed similar patterns over the

3-year period. However, the number of lobsters in each length class decreased progressively over the period. The average size of females sampled for all 3 seasons was almost similar with 9.28 cm CL for 2010/2011, 9.29 cm CL for 2011/2012 and 9.51 cm CL for 2012/2013. Clear modes could be identified for all 3 seasons. The modes for female *P. penicillatus* were 9.20, 8.90 and 10.10 cm CL for the 2010/2011, 2011/2012 and 2012/2013 season respectively. The trend in the mode shows a decrease between the 2010/2011 and 2011/2012 seasons; however it increased for the 2012/2013 season.

The size frequency distribution of male *P. penicillatus* displays a different pattern from that of females. The fishery targeted males in the range of 6.75 to 17.25 cm CL (Figure 9). The relative strength of the larger size classes (above 13.25 cm CL) decreased gradually over the 3-year period. In contrast the relative strength of the smaller size classes was similar between the 2010/2011 and 2011/2012 seasons, however, it had decreased by the end of the 2012/2013 season. The average size of males sampled showed little variations over the period, with 11.72 cm CL for 2010/2011, 11.42 cm CL for 2011/2012 and 11.81 cm CL for the 2012/2013. In contrast, the mode decreased between the 2010/2011 and 2011/2012 season from 13.60 cm CL to 9.20 cm CL. The mode increased slightly to10 cm CL for the 2012/2013 season. The minimum size class of both male and female lobsters sampled showed that lobsters are being caught below the legal size which is 7.5 cm CL.

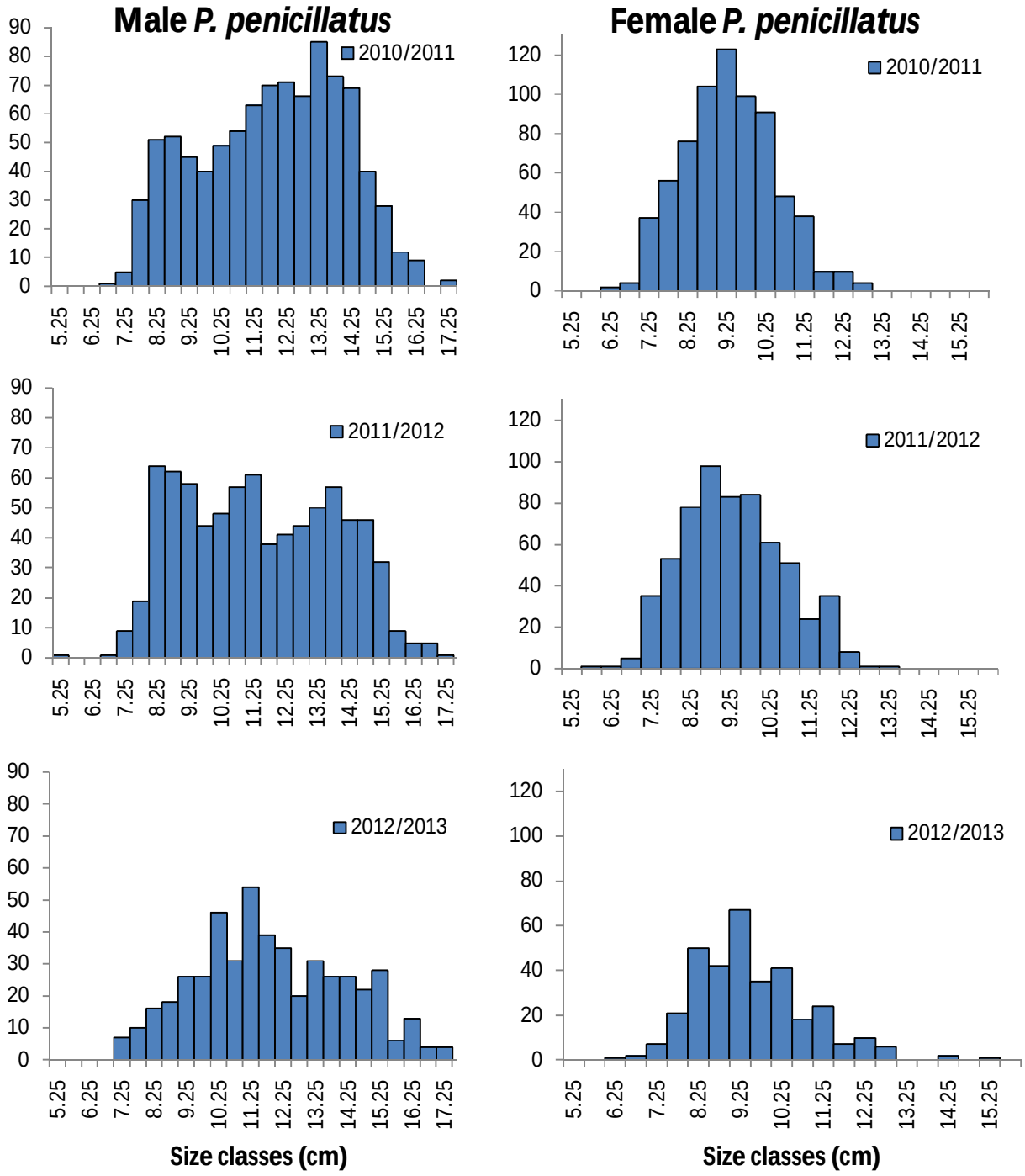
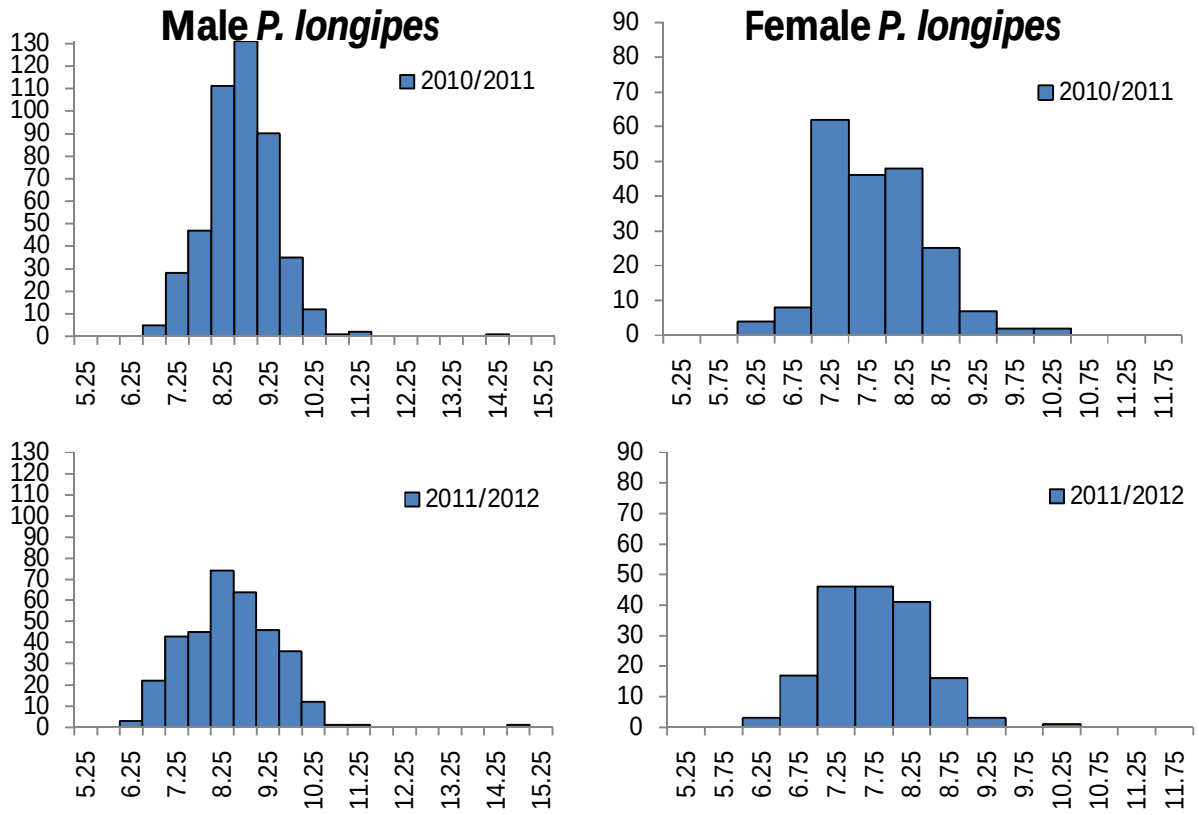


Figure 9. Size frequency distributions of male and female *P. penicillatus* over the last 3 open seasons

4.3. Size-frequency distribution: P. longipes

The size frequency distribution for male and female *P. longipes* showed similar patterns for all three seasons. Females targeted were between 6.25 and 11.25 cm CL (Figure 10). Similarly, the majority of males targeted were between 6.25 and 11.75 cm CL with a few lobsters over 14.25 cm CL sampled. For females, a single mode at around 7 cm CL was observed over the 3-years. Moreover, the relative strength of the dominant size classes increased by the end of the 2012/2013 season. For males, the mode was between 8.5 and 9.0 cm CL over the 3-year period. The relative strength of the dominant size classes decreased between the 2010/2011 and 2011/2012 season. However, it increased slightly in 2012/2013. Similarly to *P. penicillatus*, the minimum size class of both male and female lobsters sampled showed that lobsters are being caught below the legal size.



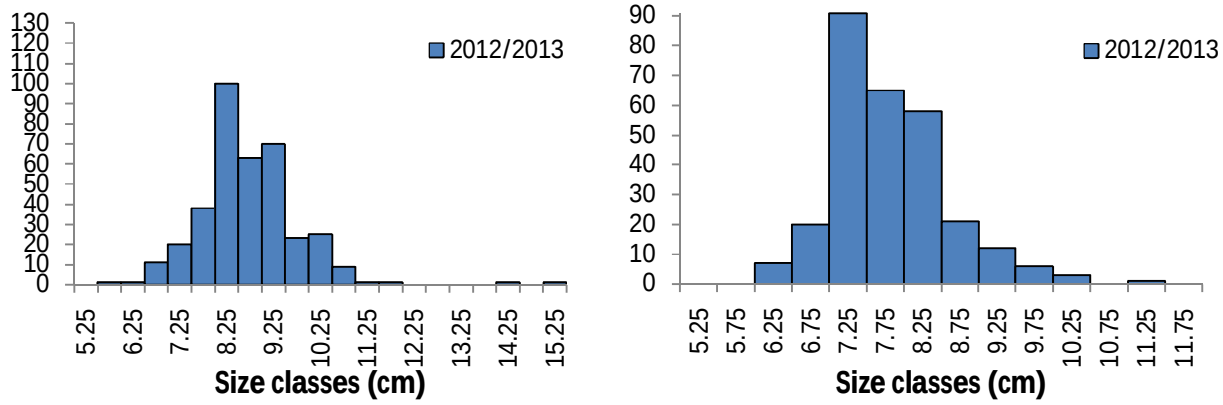


Figure 103. Size frequency distributions of male and female *P. longipes* over the last 3 open seasons.

4.4. Seasonal differences in size: P. penicillatus

There was no significant difference between the sizes of female *P. penicillatus* over the three seasons (Figure 11a)[3]. In contrast, there was a significant difference in the sizesof males between the 3 seasons (Figure 11b)[4]. Males did not differ in size between the 2010/2011 and 2012/2013 season but were significantly larger than lobsters caught during the 2011/2012 fishing season[5].

4.5. Seasonal differences in size: P. longipes

The statistical analysis for female *P. Longipes* showed that there was no significant difference between the sizes over the last 3 open season (Figure 12a)[6]. In contrast, for males, there was a significant difference in size among open seasons during the same period (Figure 12b)[7]. Males did not differ in size between the 2010/2011 and 2012/2013 season. However, males caught during these two season were significantly larger than those caught during the 2011/2012 season[8].

[3]Non-parametric Kruskal-Wallis Test: Chi-squared = 3.4; p>0.05
[4]Non-parametric Kruskal-Wallis Test: Chi-squared = 10.5; p<0.05
[5] Multiple comparison test after Kruskal-Wallis Test: 2010/2011=2012/2013>2011/2012
[6]Non-parametric Kruskal-Wallis Test: Chi-squared = 1.9; p>0.05
[7]Non-parametric Kruskal-Wallis Test: Chi-squared = 14.0; p<0.05
[8]Multiple comparison test after Kruskal-Wallis Test: 2010/2011=2012/2013>2011/2012

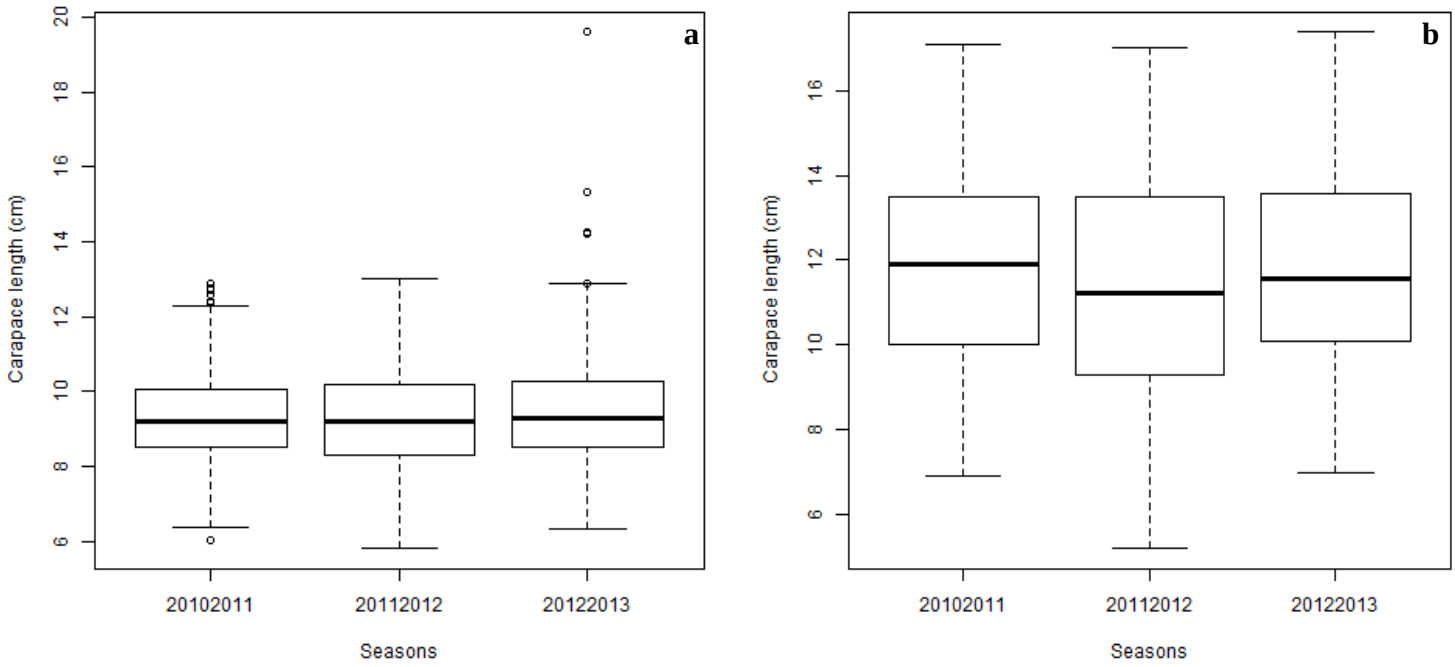


Figure 11. *P. penicillatus* sizes across seasons: Box-and-whisker plot showing variations in the size of (a) female (cm, CL), and (b) males (cm, CL) caught in the fishery among the last three open seasons.

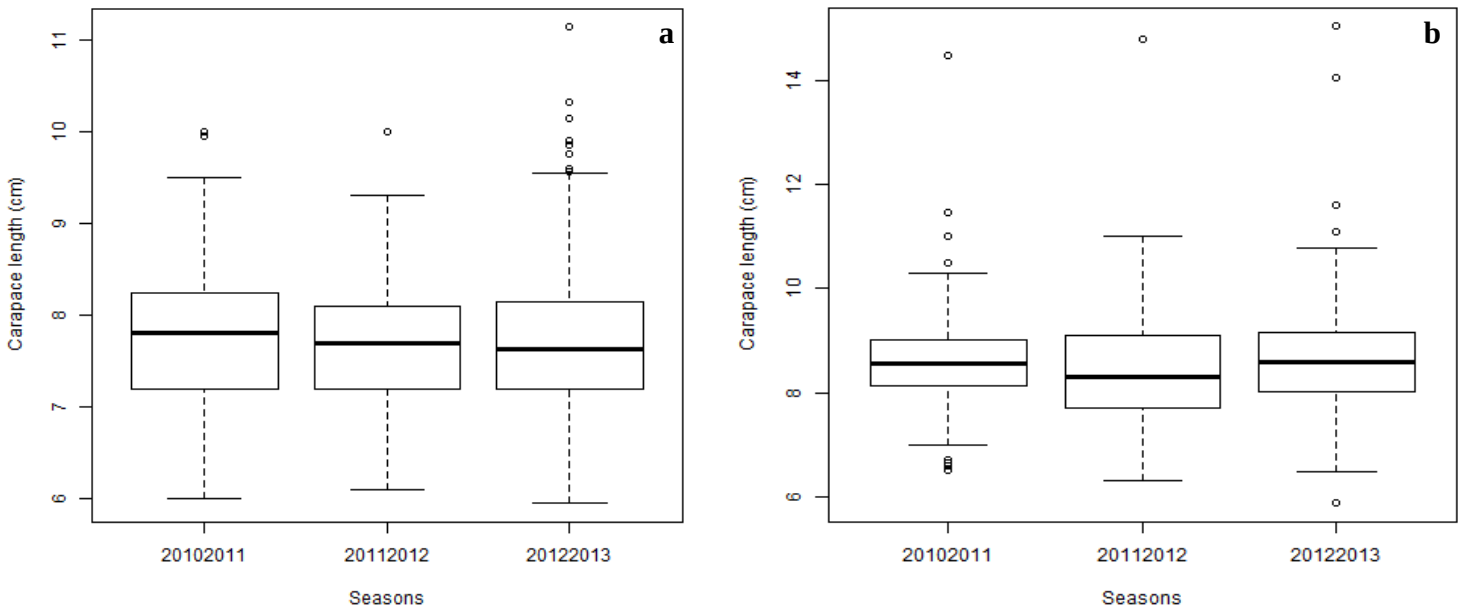


Figure 12. *P. longipes* sizes across seasons: (a) Box-and-whisker plot of female sizes (cm, CL), and (b) box-and-whisker plot of male sizes (cm, CL).

5. Stock Indicators: Fishing mortality

Over the last 3 seasons, sample sizes were large enough to conduct a preliminary demographic stock assessment to estimate fishing mortality (F). Fishing mortality was estimated only for male P. *penicillatus*, as this species is the most dominant in the catch and because all males above the minimum size limit are kept (as opposed to females for which berried individuals are released). The growth parameters used in this analysis was sourced from published studies undertaken in other locales at similar latitudes to the Seychelles. The growth coefficient K used was based on an average of 3 estimates from Munro (1988), Arellano (1988) and Hearn and Murillo (2008), where K= 0.23. The L_∞ value used was estimated from the average size of the 5 largest lobsters sampled in 2012/2013, where L_∞ = 17.07 cm.

A decline in the fishing mortality was observed between the 2010/2011 and 2011/2012 fishing seasons. In contrast, the fishing mortality was stable between the 2011/2012 and 2012/2013 seasons (Figure 13). The fishing mortality was highest during the first open season (2010/2011) at 0.28 compared to 0.21 in 2011/2012 and 0.20 in 2012/2013.

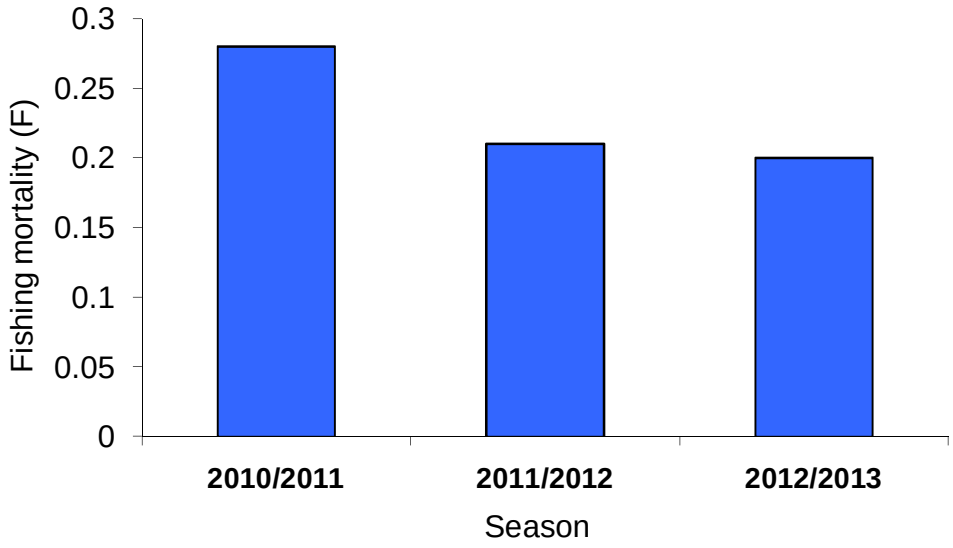


Figure 13. Fishing mortality (F) of males P. *penicillatus* over the last 3 open season

Fishing mortality in 2010/2011 (green line) exceeded the lower limit reference point (black line) set to maintain the spawning stock biomass above 30% of unfished levels (Figure 14). In contrast, the fishing mortality in 2011/2012 and 2012/2013 was below the reference point.

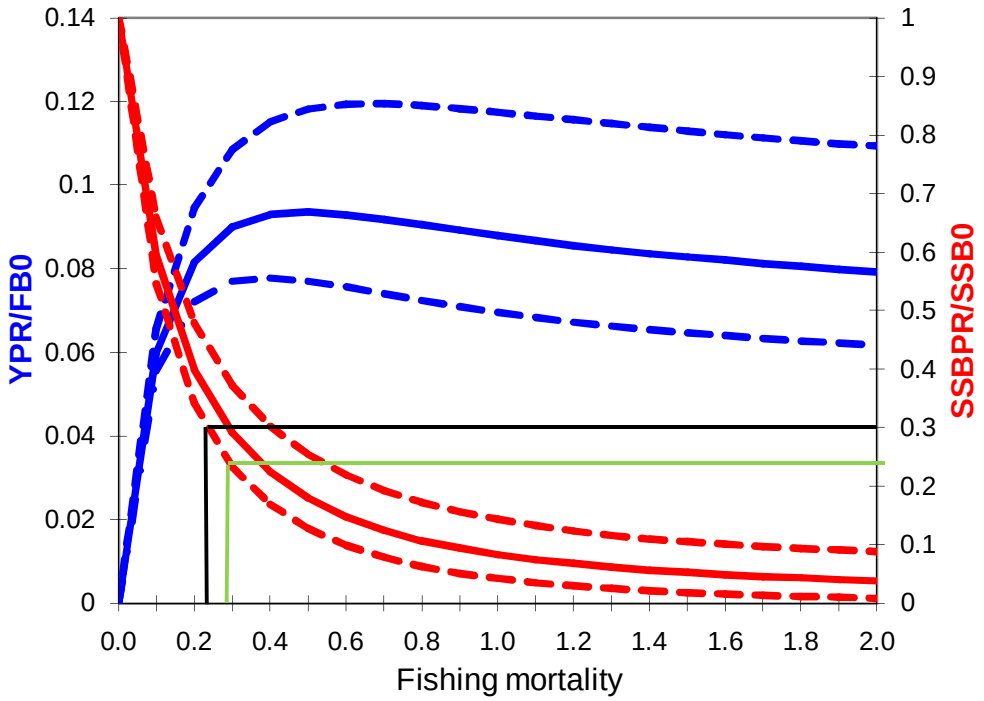


Figure 14. Relative yield per recruit (unbroken blue line) and spawning stock biomass (unbroken red line) against fishing mortality. Green line indicates the fishing mortality in 2010/2011. Black line indicates the fishing mortality which maintains the spawning stock biomass above 30% of unfished levels. Dashed lines represent confidence intervals.

Caution should be taken when interpreting the results from this analysis as the fishing mortality varied depending on the growth parameters used. There is a need to carry out studies to establish the appropriate growth parameters of lobster in Seychelles. Such information will improve our accuracy for this analysis.

6. Discussion

A wide range of indicators were used in this assessment of the spiny lobster stocks around the main granitic islands of Seychelles. The fishing effort remained stable over the last two fishing seasons; however, the total catch decreased over the period. Moreover, declines in overall CPUE were observed at the majority of the fishing grounds. The decrease in overall CPUE was mostly driven by a decrease in CPUE of the snorkeling fishing technique. The mean size of male lobsters was slightly lower during the 2011/2012 compared to the 2010/2011 and 2012/2013 fishing season. The observed decline in the relative strength of the larger and the dominant size classes over the three fishing seasons is a great point of concern, particularly since a decline in the fishing mortality was observed. Combined, the two indicators suggest that the stocks were overfished during the recent period, leading to declines in biomass. It is strongly recommended that the fishery is closed for a period of 1-2 years to allow recovery of the stock.

The lobster fishery is relatively well regulated compared to most other artisanal fisheries in Seychelles, and limited access combined with seasonal restrictions has provided a degree of management control. Detailed assessments of stock indicators after each fishing season should continue to be used to inform managers on the decision to open/close the fishery and to establish appropriate levels of fishing effort (number of licenses). Moreover, fisheries-independent surveys should be carried out during the closed seasons to assess the recovery of lobster stocks. The Participatory Lobster Monitoring Programme (PLMP) established in 2005 should be extended and carried out during this closed season to monitor changes in abundance of lobsters. The information collected and subsequent assessment should inform managers whether the fishery should be open for the 2014/2015 season.

Uncertainties relating to previous estimates of biomass and MSY (Bautil 1992) highlight the need for improved resource management information, including biomass, stock size composition and growth parameter information. Biomass estimates can be provided from fisheries-independent (i.e. UVC) surveys (expensive data to collect) or production models

(more cost effective). In the latter case, however, it is important to collect accurate data on effort in the fishery. To try and achieve this objective, before the last fishing season (2012/2013) was opened; extensive efforts were made to improve data collection from the fishery. The logbook was redesigned to make it simpler for fishers to fill. Moreover, fishers were explained how to properly fill the logbooks so that accurate data are collected. We have noticed an improvement in the quality of the data collected from a number of fishers; however, we still need to work with some of the fishers that are not filing their logbook properly.

To provide a more reliable index of abundance of lobsters, attempts should be made to standardize the CPUE data from the fishery. However, the issue of illegal fishing during the closed and opened season by non-licensed fishermen could potentially make it difficult to use standardized CPUE as a reliable index of resource abundance. This is because the magnitude of illegal fishing is unknown thus making it impossible to be factored into our assessments. There is a serious need to increase monitoring and surveillance efforts in future in order to curb illegal fishing activities. A proposal by fishers to introduce identification tags to identify lobsters that they catch is currently being considered. Such an introduction will allow lobsters caught by licensed fishers to be easily identified. Moreover, a publicity campaign should be undertaken to encourage customers to purchase only lobsters that have been caught and tagged by licensed fishers.

Resource management information for the lobster fishery should continue to be obtained using participatory approaches. Such approaches would strengthen the potential for co-management of the fishery. Improved management of the fishery will ensure that lobster stocks are fished at sustainable levels whilst protecting the resource for future generations.

7. Recommendations

It is recommended that:

- the lobster fishery is closed for a period of 1-2 years to allow recovery of the stock;

- the Monitoring, Control and Surveillance section carry out more spot-checks at fishing and landing sites during both the closed and open season. This will help with the reduction of illegal fishing and in the implementation of the management regulations;

- fisheries independent surveys are carried out during the closed seasons to assess the recovery of lobster stocks in order to inform managers on the decision to open/close the fishery;

- fishers be continually trained on how to fill the logbooks properly before the commencement of fishing;

8. Assessment Summary Table

Fishery Indicators:2010-2013 open season period

Indicator	2010/2011 Season	2011/2012 Season	2012/2013 Season	Comments
1. Catch (compared to long-term average)	**2.40 t**	**3.30 t**	**2.11 t**	Catches were lower compared to the long-term average (4.38 t) for all 3 seasons
2. Effort (compared to previous season)		**Unknown**	**0.9% increase**	Effort (no. of fishing trips) was stable over the last two open seasons. 206 trips recorded in 2011/2012 compared to 208 trips in 2012/2013
2. CPUE (all gears compared to long term average)	**Unknown**	**8.2% decrease**	**42% decrease**	Long-term mean = 17.48 kg/trip. CPUE declined over the period at all fishing locations except one.
2. CPUE snorkelling (compared to previous season)		**Unknown**	**38% decrease**	Declined significantly between the 2011/2012 and 2012/2013 season
3. CPUE traps (compared to previous season)		**Unknown**	**2.5% decrease**	Declined slightly between the 2011/2012 and 2012/2013 season. However, the decline was not statistically significant
4. Mean size (seasonal comparisons): *P. penicillatus*				Males decreased in size between 2010/2011 and 2011/2012. However, between 2011/2012 and 2012/2013 the size of lobsters increased. There were no significant differences in female sizes
5. Mean size (seasonal comparisons): *P. longipes*				Males decreased in size between 2010/2011 and 2011/2012. However, between 2011/2012 and 2012/2013 the size of lobsters increased There were no significant differences in female sizes

Key		Indicator shows negative trend or comparison		Indicator shows positive trend or comparison		Indicator shows a stable trend

***Stock Status*:** 2013

Stock sizes	Fishing pressure	Comments
		Bmsy & Bcurrent unknown. Indicators suggest stocks were overfished over the period. Catches declined and CPUE declined at the majority of fishing grounds

Key		Stock estimates or indicators show that the stock is overfished or overfishing is occurring		Uncertainty in the assessment or indicator.		Stock estimates or indicators show that the stock is not overfished and overfishing is not occurring

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