ISSN: 1659-7141

SEYCHELLES FISHING AUTHORITY

TECHNICAL REPORT

Fishery Independent Indices for the Seychelles Lobster Resource

P. O. Box 449 - Fishing Port - Mahe - Seychelles
Phone: (248) 4670300 - Fax: (248) 4224508
Email: management@sfa.sc

SFA/R&D/074

Fishery Independent Indices for the Seychelles Lobster Resource

SFA Fisheries Research Section

August 2014

1. Introduction

The Seychelles artisanal spiny lobster fishery targets shallow water lobster stocks around the main granitic islands. The main species caught are *Panulirus penicillatus, P. longipes, P. versicolor* and *P. ornatus*. The most common harvest method involves snorkeling and skin diving. Scuba diving and baited bamboo traps are also used but to a much lesser extent. The snorkeling technique involves fishers operating at night using powerful handheld torches to stun the lobsters making them easier to be caught by hand. Fishers access the fishing grounds using small outboard vessels and an average fishing trip generally consists of three men fishing for approximately five hours.

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. Over the last 20 years the fishery has been characterized by a cyclical pattern of 3-5 consecutive open seasons marked by decreasing stock abundance and catch, followed by a period of closure during which stocks rebuild.

During the fishing season, fishers are issued with logbooks to collect information on the catch and effort. In addition, research technicians sample the landed catch whenever possible to collect weight and length measures. The information collected are analysed after each fishing season. The trend in the catch and effort, and size of lobsters is compared to the previous fishing season and a decision is taken on whether to open the next fishing season or not. After three or more consecutive open season a more comprehensive assessment of the fishery is undertaken looking at the historical trends of the fishery. These assessments rely on the use of fisheries-dependent information collected by fishers. Such information can often be inaccurate and in cases where fishers do not return their logbook several assumptions have to be made which can potentially influence our assessment of the resource. Therefore, it was necessary to introduce alternative methods to collect information on the resource that were not related to fishing activities during the open seasons.

In 2005, a monitoring programme called the Participatory Lobster Monitoring Programme (PLMP) was developed by the Seychelles Fishing Authority (SFA) in collaboration with lobster fishers. The main aim of the programme was to monitor the abundance of lobsters during the closed season and provide fisheries independent indices of the lobster stock. A total of 10 monitoring sites located along the northwest and western part of Mahé were selected for monitoring. In 2013, the PLMP was reviewed and an additional 10 sites along the western and southern part of Mahé were included in the survey bringing the total number of sites surveyed to 20. The PLMP surveys were carried out in 2005, 2006, 2010, 2013 and 2014.

The main aim of this report is to present analyses of the data collected during the PLMP surveys. It compares several stock indicators over the period and provides information on the status of the lobster stock. Moreover, this report provides several recommendations and advice to managers on whether the 2014/2015 fishing season should be opened or closed.

2. Study sites

In 2005, 10 sites were selected along the northwest and western part of Mahé in consultation with lobster fishers (Figure 1). The sites were chosen because they represented sites that were easily accessible to fishers and therefore subjected to higher fishing pressure during the fishing season. Moreover, these sites were areas where illegal fishing of lobsters was known to occur during the closed season. Therefore, assessments of lobster stock at such sites would represent a more conservative approach to the decision making process in comparison to if such assessments were done in areas where fishing pressure was low. In 2013, an additional 10 sites were selected to be included in the PLMP survey (Figure 1). The additional sites were chosen based on fisher interviews and from analysis of catch information from the fishery to identify the most important fishing sites. For simplicity, “PLMP sites” and “new PLMP sites” will be used to differentiate between these two groups of sites throughout the remainder of the report. By surveying these fixed sites over a period of time, it allows us to monitor changes in the relative abundance, size structure, fishing pressure and productive capacity of the lobster stock over time. The changes in the stock indicators can be interpreted to derive information about the status of the stock.

At each site, a single transect was established and the start and end position of each transect was recorded using a hand-held GPS. The transect differed in length, which is taken account of in the effort measure. Based on the most dominant biotope at each site, four of the sites were of carbonate reef biotope, whilst the other sixteen sites were of granite rock biotope.

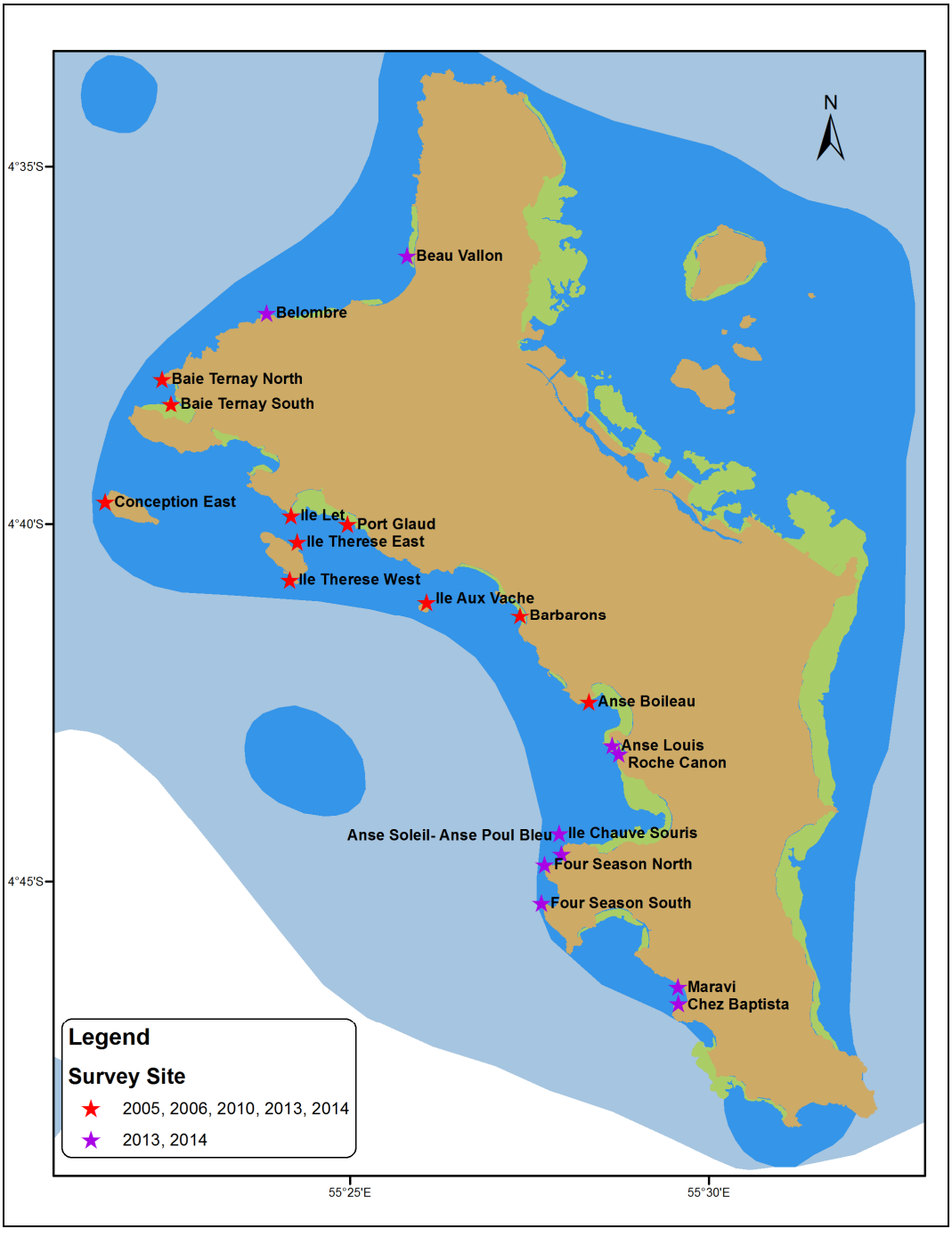

Figure 1. Map of Mahé showing locations of lobster survey sites. Red stars represent sites surveyed in 2005, 2006, 2010, 2013 and 2014. Purple stars represent sites surveyed in 2013 and 2014

3. Method

3.1 Survey Method

A total of five surveys were carried out between 2005 and 2014 (Table 1). The first survey took place in November 2005 following the closure of the fishery for two consecutive seasons. The second survey took place in late October 2006 after the 2005-2006 fishing season had been opened. The third survey was in November 2010 after the lobster fishery had been closed for 2 consecutive seasons. The forth survey was in November 2013 following the closure of the 2012-2013 fishing season. The last survey was in March 2014 following the closure of the 2013-2014 fishing season.

Table 1. Lobster survey summary: dates of survey period

Survey number	Survey period
1	8th - 12th November 2005
2	28th October - 1st November 2006
3	13th - 17th November 2010
4	11th – 20th November 2013
5	20th – 28th March 2014

A minimum of two sites were surveyed during each night of the survey period. At each site, two fishers surveyed each transect using snorkeling gear and torches to collect lobsters. The fishers were asked to collect all lobsters encountered, including berried females and immature individuals. A third fisherman operating a small skiff monitored the fishers and collected the lobsters caught. The fisher team collecting lobsters remained the same for the first three surveys, however, for the 2013 and 2014 survey a new group of fishers were chosen.

3.2 Data Collection

During each survey, the research team working with the fishers recorded the time taken to complete each transect, the wind speed, sea state, start time relative to high tide, current direction, moon phase, and water visibility. At the end of each survey, fishers were asked to rank

the fishing conditions using a 5-point scale from poor (1) to excellent (5). Fishers were also asked to count the number of lobsters sighted which they were unable to catch.

All lobsters collected were then transferred onto the research vessel where they were identified to species level, sexed, measured for carapace length (nearest 0.1mm) and weight using either a spring or an electronic balance. After processing, all lobsters were returned to the site where they were caught.

3.3 Data analysis

Since the weight of lobsters caught during the different surveys were measured at different levels of accuracy, the weights of the most common species of lobsters caught, namely, *P. penicillatus* and *P. longipes* were recalculated using length-weight relationships derived from sampling of the 2012/2013 fishing season (Table 2).

Table 2. Length-weight relationships derived for males and females *P. penicillatus* and *P.longipes*: where *W*= weight in grams and *L*= carapace length in millimetres.

Species	Sex	Length-Weight relationship
Panulirus penicillatus	M	$W=0.00335L^{2.68}$
Panulirus penicillatus	F	$W=0.00438\ L^{2.61}$
Panulirus longipes	M	$W=0.00768\ L^{2.52}$
Panulirus longipes	F	$W=0.00552\ L^{2.59}$

The catch per unit effort (CPUE) was calculated for each site during the survey period. Moreover, the CPUE was calculated for legal size lobsters caught (>75 mm carapace length). The CPUE was expressed as number of lobsters caught per man hour ($no \cdot menhour^{-1}$) and kilogram per man hour ($kg \cdot menhour^{-1}$), and was calculated as follows:

CPUE ($no \cdot menhour^{-1}$) = number of lobsters caught (fishing time in hours*number of men)

CPUE ($kg \cdot menhour^{-1}$) = total weight of lobsters caught/(fishing time in hours*number of men)

The CPUE between different survey periods (year) was compared using univariate analysis of variance (ANOVA). Assumptions of the ANOVA model were checked by examining the

residual plots for normality of error terms and homogeneity of variances. In addition, homogeneity of variances was checked by running the Bartlett test and the Fligner-Killeen test. A significance level of α=0.05 was used throughout the analysis.

The length frequency distributions of males and females of the different species of lobsters caught were compared between different survey periods using either parametric or non-parametric tests. Moreover, the length frequency distributions for all species grouped together were compared between surveys. One-way ANOVA tests were carried out when assumptions of the model were met. Where assumptions of the ANOVA models were not met, non-parametric Kruskal-Wallis rank sum tests were carried out. For significant ANOVA models, TukeyHSD multiple comparison tests were carried out to identify differences in size between years.

The reproductive capacity of the lobster stocks was compared between survey periods by examining the changes in the proportion of berried females and by looking at the proportion of berried females in relation to the total catch.

For comparative purposes the different stock indicators were derived for the “PLMP sites” and “new PLMP sites” respectively. Note that only the results for the “PLMP sites” are presented and discussed in this report.

4. Results

4.1 General findings

4.1.1 Total catch and catch by survey locations

A total of 86.99 kg of lobsters were caught during the first survey in 2005. Subsequently, in 2006, a total of 76.65 kg of lobsters were caught. In 2010, catches increased to similar levels as in 2005 at 85.20 kg. In contrast, in 2013 the total catch of lobsters dropped to 40.10 kg. Subsequently, in 2014 catches increased slightly to 59.02 kg (Figure 2).

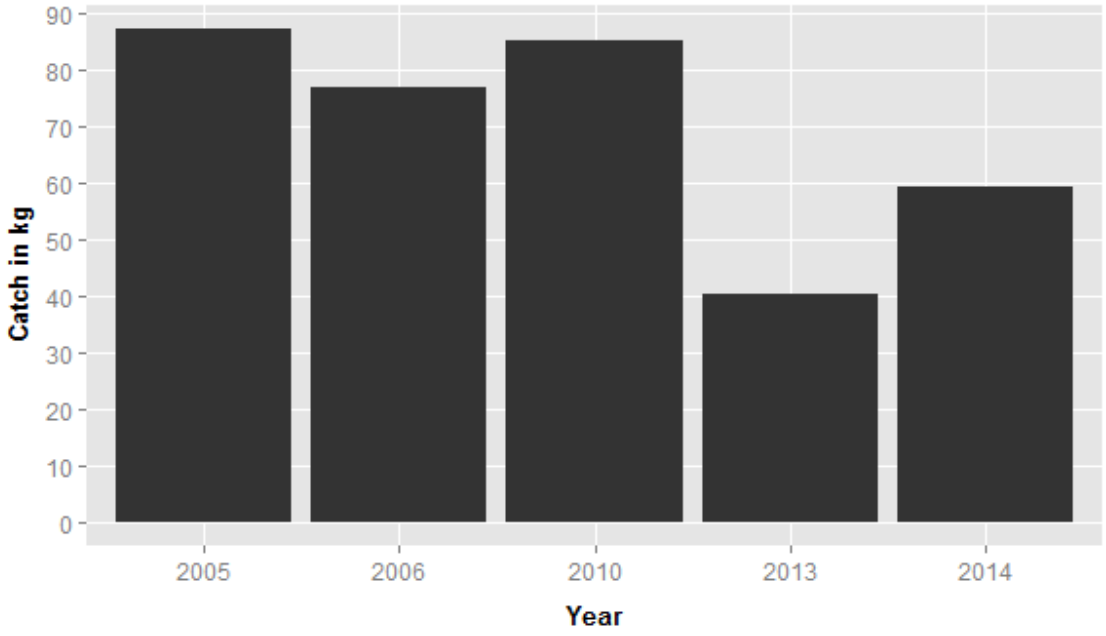

Figure 2. Total catch of lobsters in kilograms over the five survey periods

In terms of catch by location, overall over the last five surveys, Conception East recorded the highest catches of lobsters followed by Ile Therese East and Anse Boileau (Figure 3). In contrast, the lowest catches were recorded at Ile Aux Vache and Ile Therese East. During the 2005 and 2006 survey, the highest catch of lobsters was recorded at Conception East where 21% and 26% of the total catch was recorded respectively. In contrast, in 2010, catches at Conception East was amongst the lowest, comprising of only 2% of total catch. In 2010, the highest catches were recorded at Ile Therese West, Barbarons and Port Glaud comprising of 19%, 17% and 16% of the total catch respectively. In 2013, catches at all sites were lower compared to the 2010 survey with the exception of Conception East where there was an increase. In contrast, in 2014, catches at all sites surveyed increased compared to the previous year with the exception of Baie Ternay North and Ile Therese West where further decreases in catch were recorded.

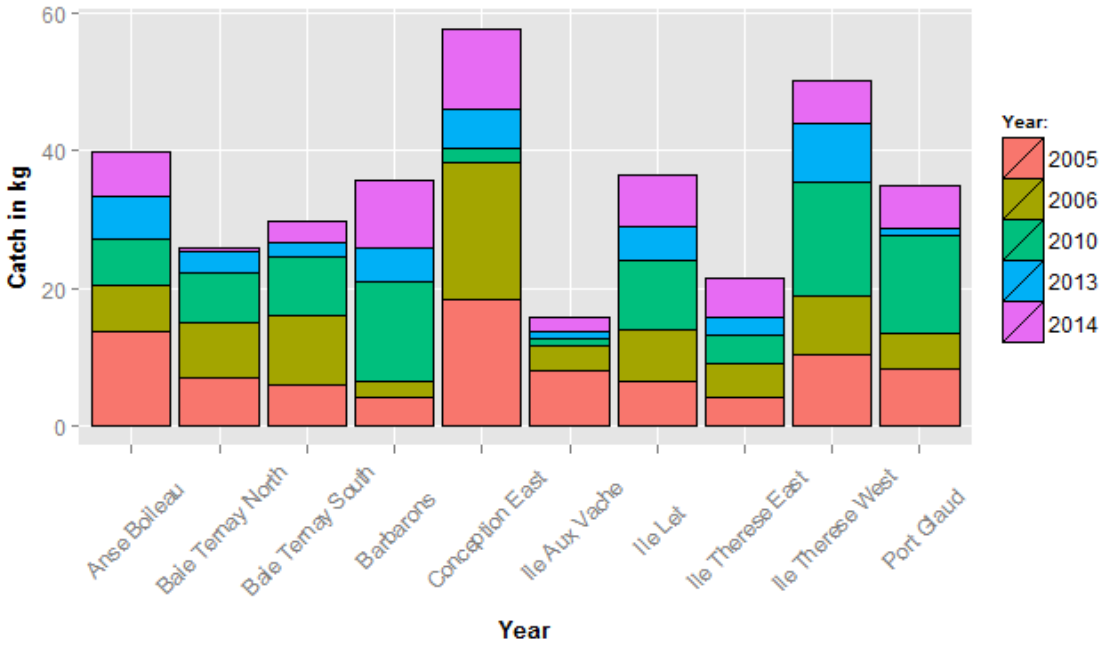

Figure 3. Total catch of lobsters in kilograms by fishing sites over the five survey periods

In terms of catch in numbers a total of 119 lobsters were caught in 2005 (Figure 4). Similarly, in 2006 a total of 116 lobsters were caught. In 2010, the total number of lobsters caught increased to 144. In contrast, in 2013 the catch in numbers dropped to 78 whilst in 2014 the numbers increased to 105 which is comparable to catches in 2005 and 2006.

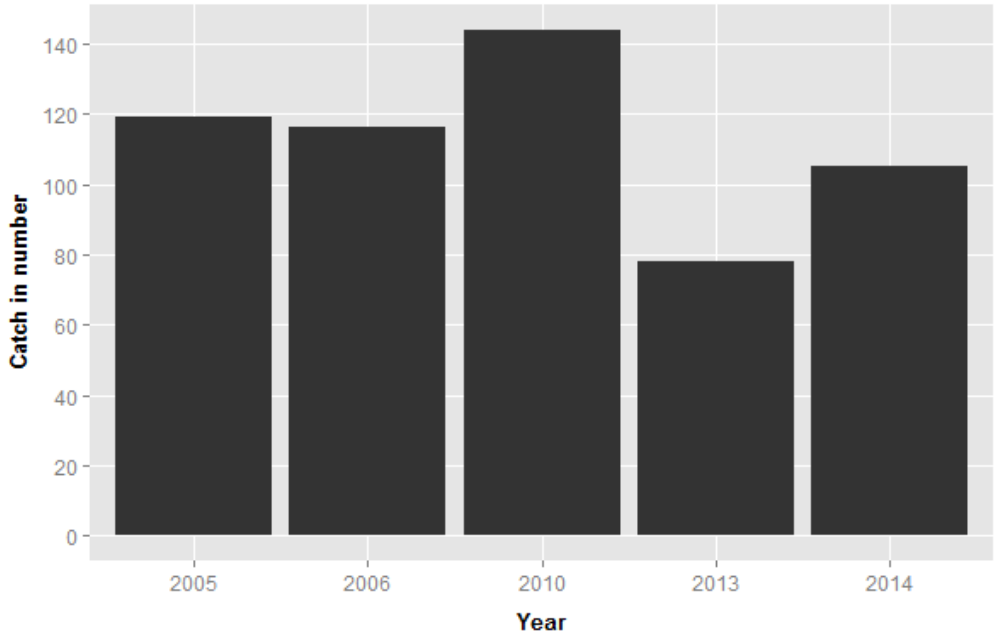

Figure 4. Total catch of lobsters in numbers by fishing sites over the five survey periods

The catch of lobsters in numbers by fishing location shows a similar pattern to the total catch in kg (Figure 5). The only difference is the increased importance in the catch in numbers of Ile Let compared to its equivalent catch in kg. Overall, over the five surveys, Conception East, Ile Therese West and Ile Let accounted for the highest catches whilst Ile Aux Vache recorded the lowest catches in numbers.

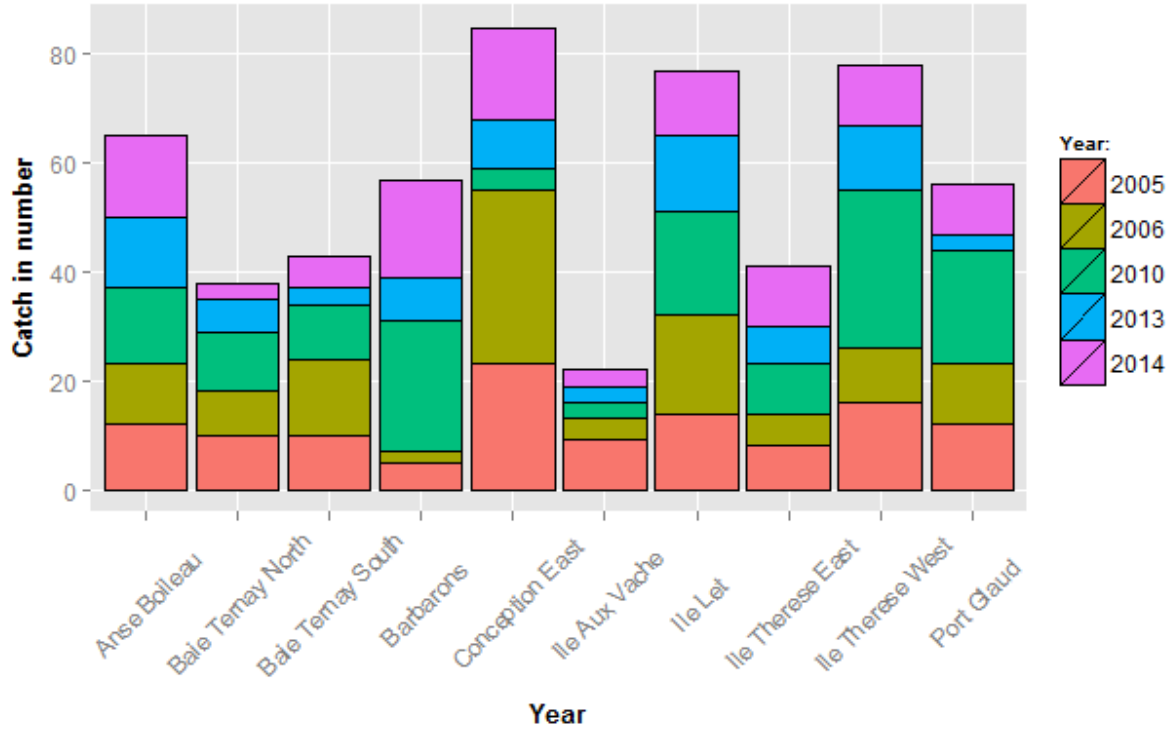

Figure 5. Total catch of lobsters in numbers by fishing sites over the five survey periods

4.1.2. Species composition in weight by location

During all five surveys *P. penicillatus* was the most dominant species caught accounting for 70% of the total catch in 2005, 57% in 2006, 56% in 2010, 50 % in 2013 and 68% in 2014 (Figure 6). The second most abundant species was *P. longipes* which comprised 22%, 25%, 36%, 40% and 23% of the total catch from 2005 to 2014 respectively. Amongst the rarest species caught, *P. versicolor* comprised of 8% to 18% of the total catch whilst only two *P. ornatus* were caught in 2010.

In 2005, at the majority of fishing sites *P. penicillatus* was the most abundant species with the exception of Ile let where *P. longipes* was the most abundant. In 2006, *P. versicolor* was the most abundant species caught at Baie Ternay North, whilst *P. longipes* was the most abundant species at Port Glaud, whilst at the other fishing sites *P. penicillatus* dominated the catch. In contrast, in 2010, *P. longipes* was the most abundant species at Ile Therese East, Ile Therese West, Conception East and Ile aux Vache. At Conception East and Ile Aux Vaches, *P. penicillatus* which was abundant in the catch in previous years was absent in the catch. In 2013, there was a decline in catches of *P. longipes* at the majority of the fishing sites compared to 2010 with the exception of Anse Boileau, Baie Ternay South and Conception East where slight increases were recorded. Similarly, catches of *P. penicillatus* followed the same pattern with slight increases at Conception East, Ile Aux Vaches and Ile Therese East. Moreover, in 2014, catches of *P. longipes* continued to decline at the majority of fishing sites with the exception of Barbarons, Ile Aux Vache and Port Glaud where catches increased slightly. Conversely, catches of *P. penicillatus* at the majority of fishing sites increased relative to 2013 with the exception of Baie Ternay North and Ile Therese West where declines were observed.

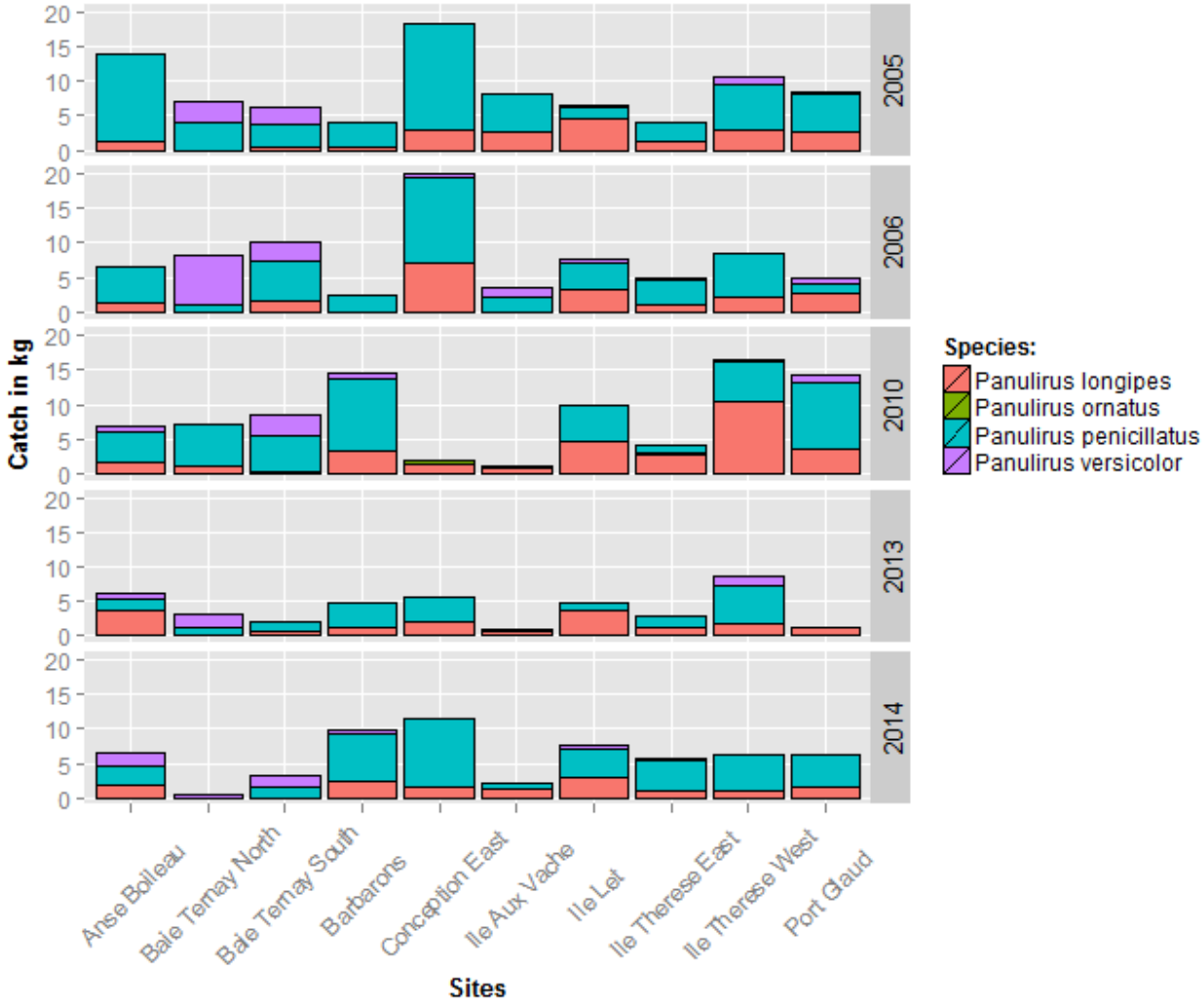

Figure 6. Species composition of spiny lobster catches by fishing sites over the five survey periods

4.2. Abundance indicators

4.2.1 Catch per unit effort all lobsters (kg·menhour^{-1})

The mean CPUE was 4.72 kg·menhour^{-1} in 2005. In contrast, in 2006, it declined to 3.90 kg·menhour^{-1}. Similarly, in 2010 the CPUE was 3.92 kg·menhour^{-1}. Conversely, the mean CPUE declined in 2013 to 2.85 kg·manhour^{-1}. In 2014, the mean CPUE increased slightly to 3.11 kg·menhour^{-1} (Figure 7). There were no significant differences between the CPUE of the different survey periods (ANOVA: *df* 4, 45, F= 1.80, P= 0.145).

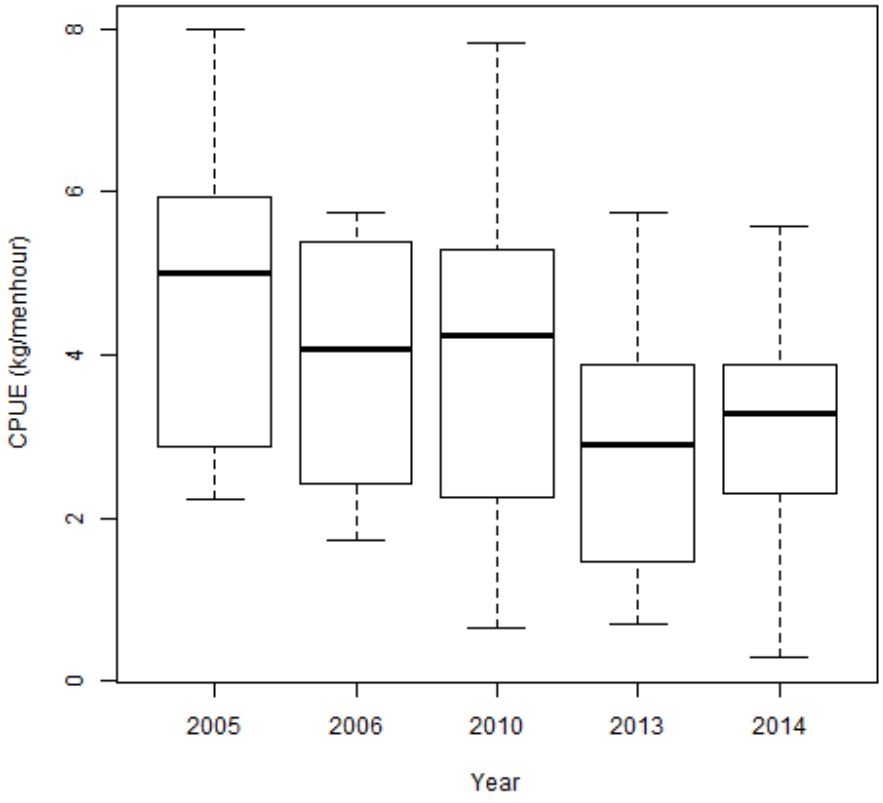

Figure 7. Box-and-whisker plots of CPUE (kg·menhour^{-1}) for all sites combined over the five survey period.

4.2.2. Catch per unit effort for legal lobster biomass (kg·menhour^{-1})

Overall, the mean CPUE of legal lobster biomass (> 7.5cm CL) shows a declining trend from 2005 to 2014 (Figure 8). The mean CPUE was at its highest in 2005 at 4.42 kg·menhour^{-1}. It declined to 3.41 kg·menhour^{-1} in 2006, 3.28 kg·menhour^{-1} in 2010 and 2.17 kg·manhour^{-1} in 2013. In 2014, the mean CPUE increased slightly to 2.51 kg·menhour^{-1}. There was a significant difference between the CPUE of the different survey periods (ANOVA: *df* 4, 45, F= 2.93, P= <0.05). The CPUE in 2013 was significantly lower than the CPUE in 2005[1].

[1] Tukey multiple comparisons test: 2005-2013 padj=0.025

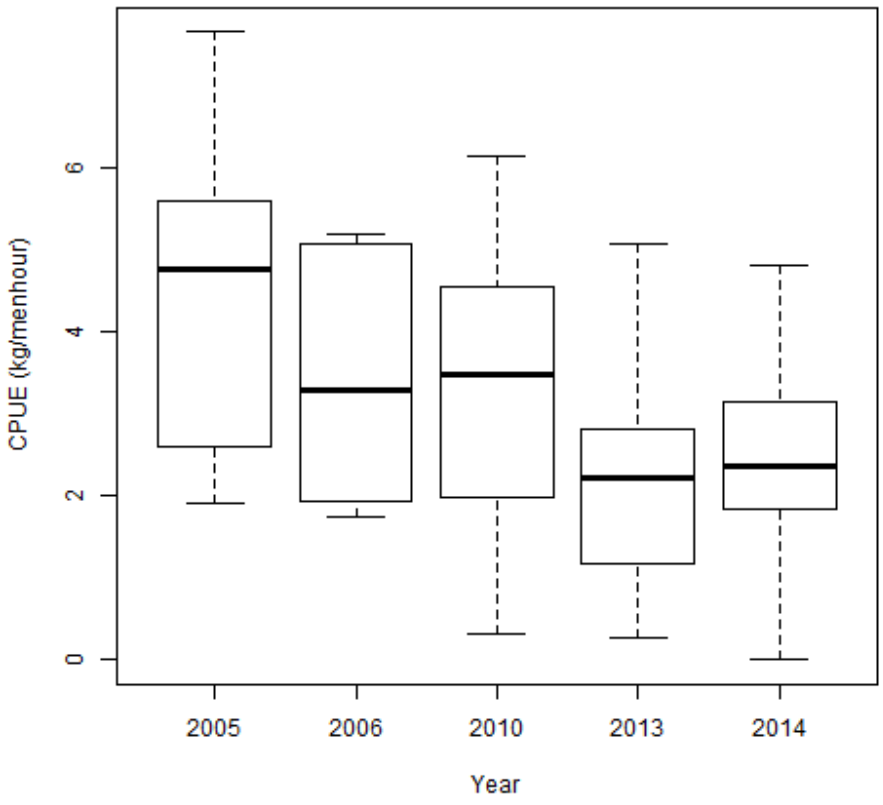

Figure 8. Box-and-whisker plots of CPUE (kg·menhour^{-1}) for legal lobster biomass for all sites combined over the five survey period.

4.2.3. Catch per unit effort all lobsters (no·menhour^{-1})

The mean CPUE for all lobsters caught in terms of no·menhour^{-1} was relatively stable over the five survey period (Figure 9). There was no significant differences between the CPUE for the five survey period (ANOVA: *df* 4, 45, F= 0.414, P= 0.79). In 2005, the mean CPUE was 6.39 no·menhour^{-1}. In 2006, it dropped slightly to 5.70 no·menhour^{-1}. In contrast, in 2010 it increased to 6.69 no·menhour^{-1}. The mean CPUE dropped to 5.53 no·menhour^{-1} in 2013. Similarly, in 2014 the mean CPUE was 5.50 no·menhour^{-1}.

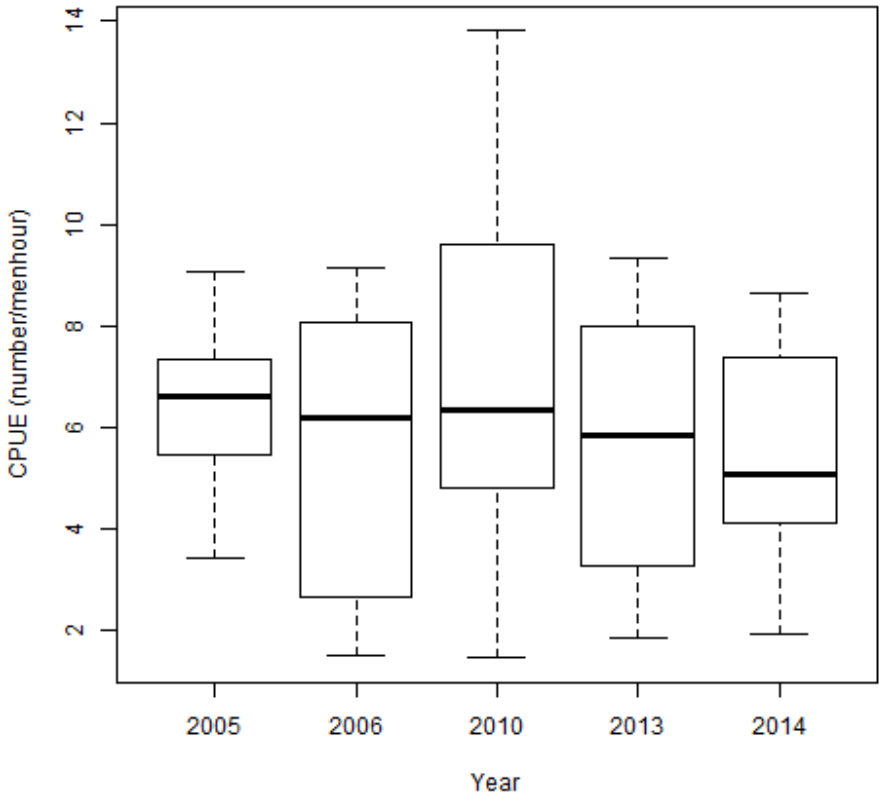

Figure 9. Box-and-whisker plots of CPUE (no·manhour^{-1}) for all sites combined over the five survey period.

4.2.4 Catch per unit effort for legal lobsters (no·menhour^{-1})

Similarly to the CPUE trends of legal sized biomass (> 7.5cm CL), the CPUE for legal sized lobsters in no·menhour^{-1} shows a declining trend over the five survey period. Between 2005 and 2006 the mean CPUE dropped from a high of 5.42 no·menhour^{-1} to 4.19 no·menhour^{-1}. Similarly, between 2010 and 2013 the mean CPUE declined from 4.23 no·menhour^{-1} to 2.77 no·menhour^{-1}. In 2010, the mean CPUE increased slightly to 2.99 no·menhour^{-1}. There was a significant decline in CPUE over time (ANOVA: *df* 4, 45, F= 3.534, P= 0.013). The CPUE in 2013 and 2014 were significantly lower than the CPUE during the initial survey in 2005[2].

[2] Tukey multiple comparisons test: 2005-2013 padj=0.016, 2005-2014 padj=0.033

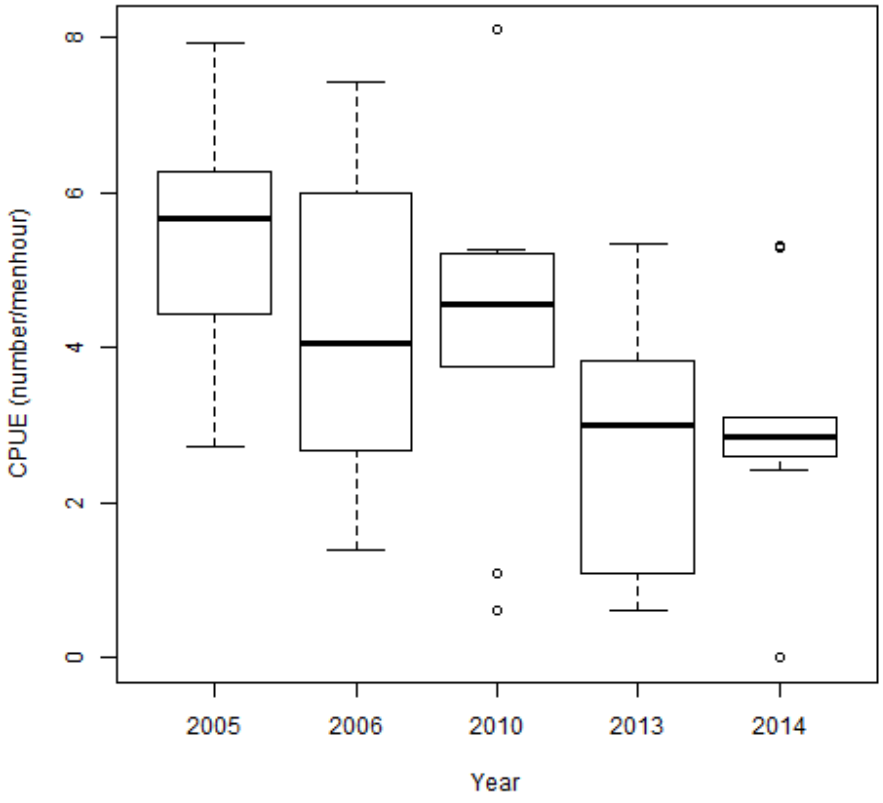

Figure 10. Box-and-whisker plots of CPUE (no·menhour^{-1}) for legal sized lobsters for all sites combined over the five survey period.

4.3 Productivity indicators

4.3.1 Proportion of berried females

During the first three lobster surveys in 2005, 2006 and 2010, the proportions of egg-bearing females were higher compared to non egg-bearing females. In 2005, 56% of females were berried. This proportion decreased to 53% in 2006, however in 2010, the proportion of berried females increased to 58% (Figure 10). In contrast, in 2013 and 2014, the proportions of egg-bearing females were lower compared to non egg-bearing females. In 2013, the proportion of berried females dropped to 38% whilst in 2014 the proportion increased to 48%. Moreover, the proportion of berried females in the total catch shows a decreasing trend from 2005 to 2013. In 2005, 34% of the total catch comprised of berried females, whilst in 2006 and 2010 the

proportion dropped to 30% and 29% respectively. In 2013, the proportion of berried females dropped to 19% of the total catch. However, in 2014, the proportion increased to 27%.

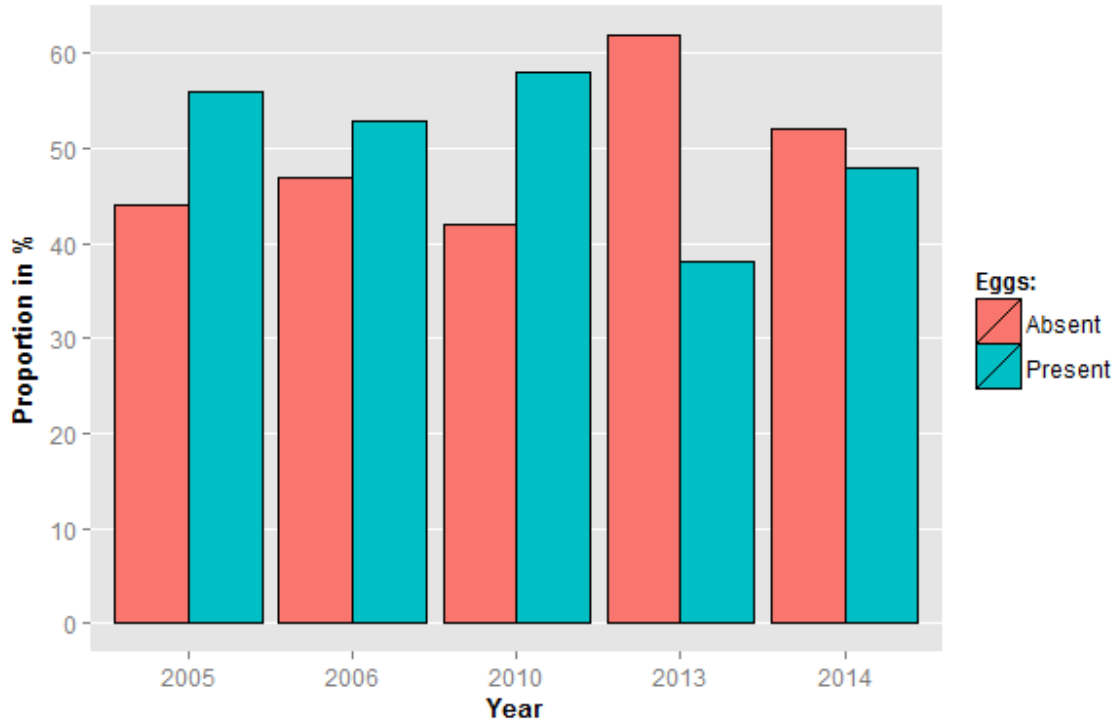

Figure 10. Proportions of egg-bearing and non egg-bearing female lobsters over the five survey period

4.4. Demographic indicators

4.4.1 Sample sizes and sex ratios

A total of 562 spiny lobsters were measured and sexed over the last five surveys (Table 3). In 2005, 2006 and 2014, *P. penicillatus* was the most abundant species caught. However, in 2010 and 2013, *P. longipes* was the most common species caught. Overall, the sex ratio of females was 1.22 indicating a slight dominance of females in the total samples. Moreover, throughout the different survey periods females of the different species were more dominant in the total catch. This pattern in the sex ratio differs from that of samples taken during the fishing season where males dominate the catch. This is primarily due to the fact that during the fishing season there is a restriction on the catch of berried females whilst during the surveys there were no such restrictions.

Table 3. Size frequency sample sizes by species for the four surveys

Year	Species	M	F	Total	Sex ratio (Male/Female)
2005	*Panulirus longipes*	18	22	40	1: 1.22
	Panulirus penicillatus	23	45	68	1: 1.96
	Panulirus versicolor	5	6	11	1: 1.20
2006	*Panulirus longipes*	21	26	47	1: 1.24
	Panulirus penicillatus	23	30	53	1: 1.30
	Panulirus versicolor	6	10	16	1: 1.67
2010	*Panulirus longipes*	32	42	74	1: 1.31
	Panulirus ornatus	1	1	2	1: 1.00
	Panulirus penicillatus	27	23	50	1: 0.85
	Panulirus versicolor	11	7	18	1: 0.64
2013	*Panulirus longipes*	22	26	48	1: 1.18
	Panulirus penicillatus	11	13	24	1: 1.18
	Panulirus versicolor	6		6	1: 0
2014	*Panulirus longipes*	15	20	35	1: 1.33
	Panulirus penicillatus	25	23	48	1: 0.92
	Panulirus versicolor	7	15	22	1: 2.14
	Grand total	253	309	562	1: 1.22

4.4.2 Size frequency distributions

The relative size frequency distributions of male and female *P. penicillatus* sampled during the five surveys are shown in Figure 11. During all five surveys, the majority of lobsters caught were above the legal size limit of 7.5 cm CL. The frequency distribution of females shows a similar pattern over time. In 2005, females ranged in size between 7.02 cm to 12.41 cm. The average size was 9.47 cm. Similarly, in 2006 the average size of females was 9.62 cm, ranging from a size of 7.53 cm to 11.9 cm. In 2013, a higher number of lobsters caught were below the legal size limit. Females ranged in size from 6.44 cm to 10.75 cm with an average size of 8.77 cm. In 2014, the average size increased to 9.93 cm and females caught ranged in size from 4.77 cm to 12.62 cm.

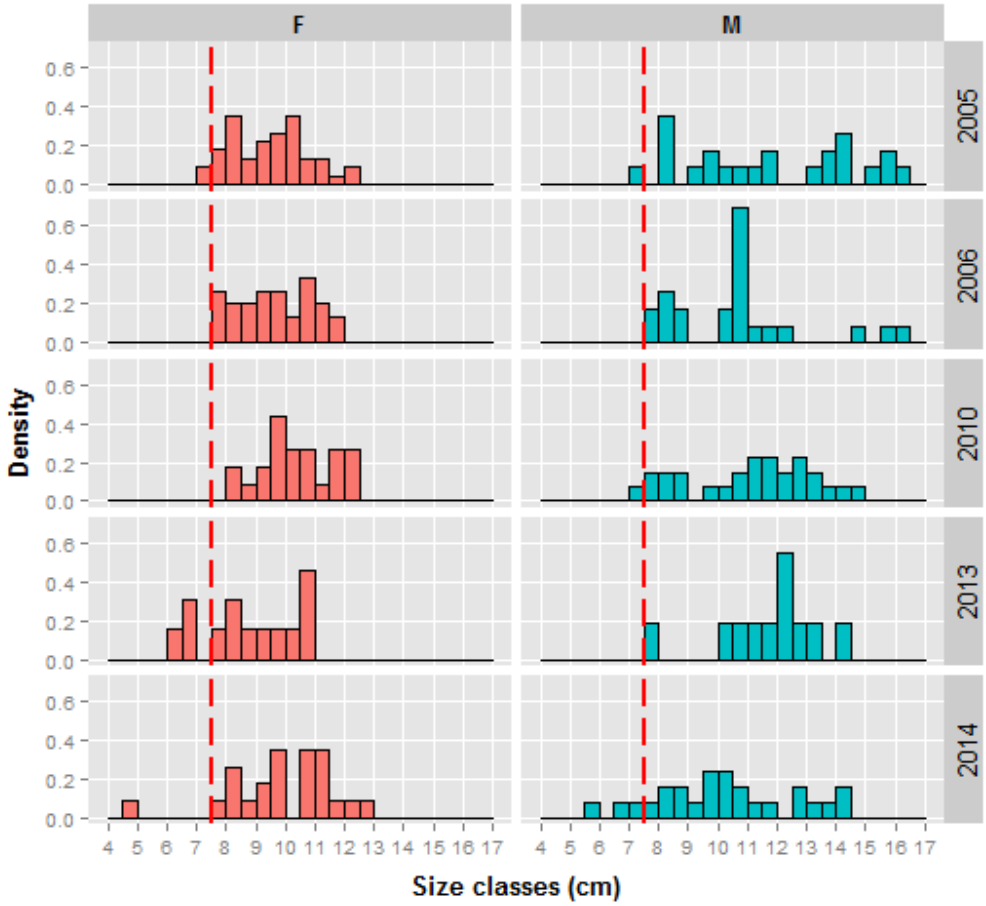

Figure 11. Size frequency distributions of male and female *P. penicillatus* over the five survey period

The mean size of female *P. penicillatus* was significantly different between the different survey periods (ANOVA: *df* 4, 129, F= 2.964, P= <0.05). Female *P. penicillatus* caught in 2013 was significantly smaller compared to female lobsters caught in 2010[3] (Figure 12a). The mean size of females *P. penicillatus* caught in 2010 was 10.32 cm compared to 8.77 cm in 2013.

[3] Tukey multiple comparisons test: 2010-2013 padj=0.016

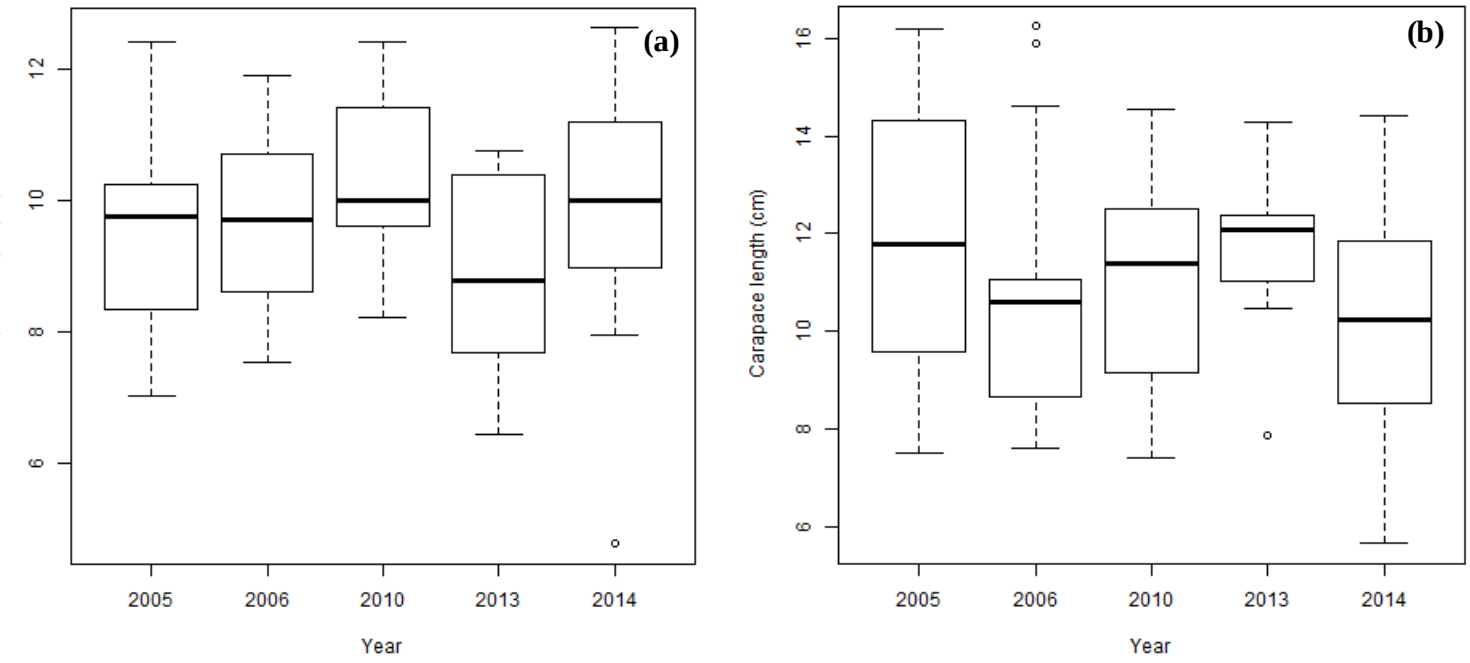

Figure 12. *P. penicillatus* sizes across surveys: (a) Box-and-whisker plot of female sizes (cm, CL), and (b) box-and-whisker plot of male sizes (cm, CL)

Similarly to females, the majority male *P. penicillatus* caught during all five surveys were larger that the legal size of 7.5 cm CL (Fig. 11). In 2005 and 2006, males ranged in size from 7.49 cm to 16.2 cm and 7.60 cm to 16.25cm respectively. In contrast, in 2010, 2013 and 2014, large males above 15 cm were absent from the catch. In 2010, males ranged in size from 7.40 cm to 14.55 cm. Similarly, in 2013, males ranged in size from 7.88 cm to 14.29 cm. In 2014, a few smaller lobsters (<7.5 cm) were caught and lobsters caught were between 5.66 cm to 14.42 cm.

There was no significant differences between the mean length of male *P. penicillatus* between the different survey periods (ANOVA: *df* 4, 104, F= 1.723, P= >0.05). The mean size of males was 11.86 cm in 2005, 10.67 cm in 2006, 11.03 cm in 2010, 11.66 cm in 2013 and 10.25 cm in 2014 (Fig. 12b).

The relative size frequency distributions of male and female *P. longipes* sampled during the five surveys are shown in Figure 13. In contrast to the frequency distribution of female *P. penicillatus*, a large majority of female *P. longipes* caught during the five surveys were below the legal size of 7.5 cm CL. From 2005 to 2014, the relative proportion of females above 7.5 cm

decreased whilst the proportion of females below 7.5 cm increased. In 2005, females ranged in size from 5.77 cm to 8.59 cm with a mode at around 7.75 cm. Similarly, in 2006, female ranged in size from 5.40 cm to 8.75 cm with a mode at 7.8 cm. In contrast in 2010, the mode had shifted to a lower size of 6.80 cm. Similarly, in 2013, the mode decreased to 5.75 cm and the majority of lobsters ranged in size from 4.04 cm to 8.32 cm. In 2014, lobsters rand in size from 5.51cm to 11.73 cm.

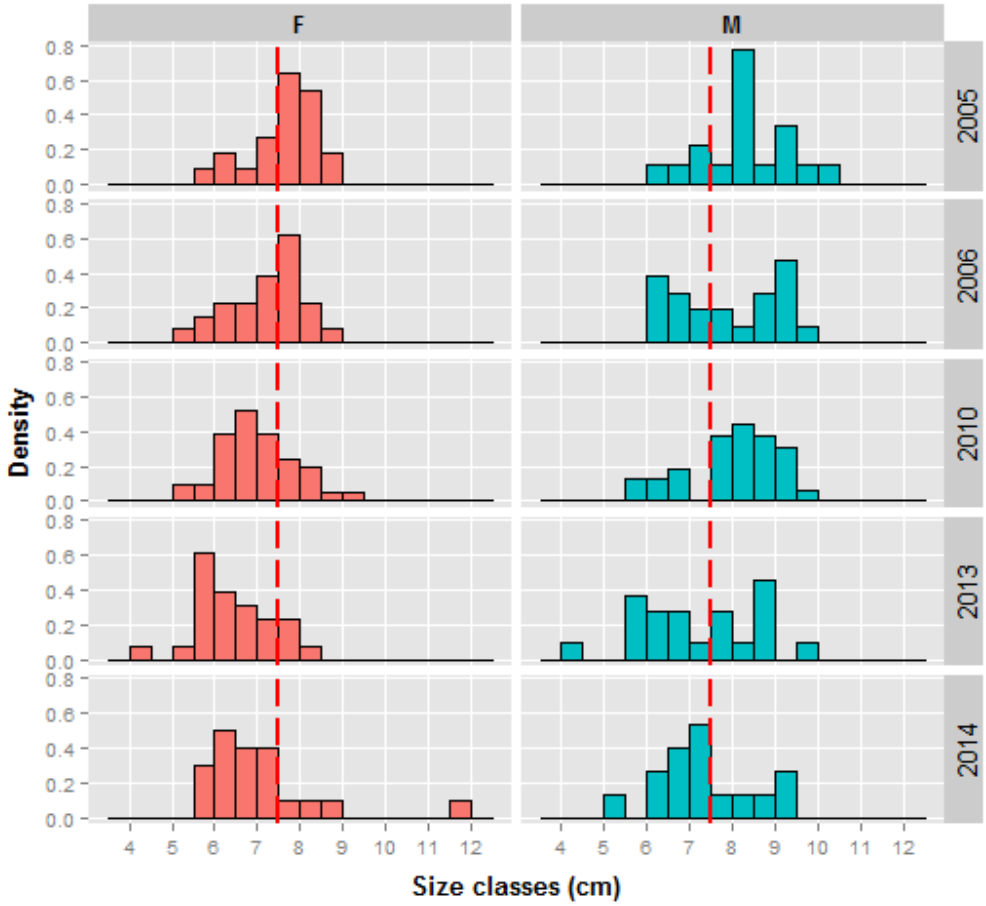

Figure 13. Size frequency distributions of male and female *P. longipes* over the five survey period

A gradual decline can be observed in the mean size of female *P. longipes* from 2005 to 2013 (Figure 14a). The mean size decreased from 7.58 cm in 2005 to 7.17 cm in 2006. Furthermore, the mean size decreased to 6.98 cm in 2010 and 6.42 cm in 2013. In 2014, the mean size increased to 7.10 cm. A significant difference was observed in the mean size of females caught during the different surveys (ANOVA: *df* 4, 128, F= 4.354, P= <0.01). Females caught in 2013 were significantly smaller than females caught in 2005[4].

[4] Tukey multiple comparisons test: 2005-2013 padj=<0.001

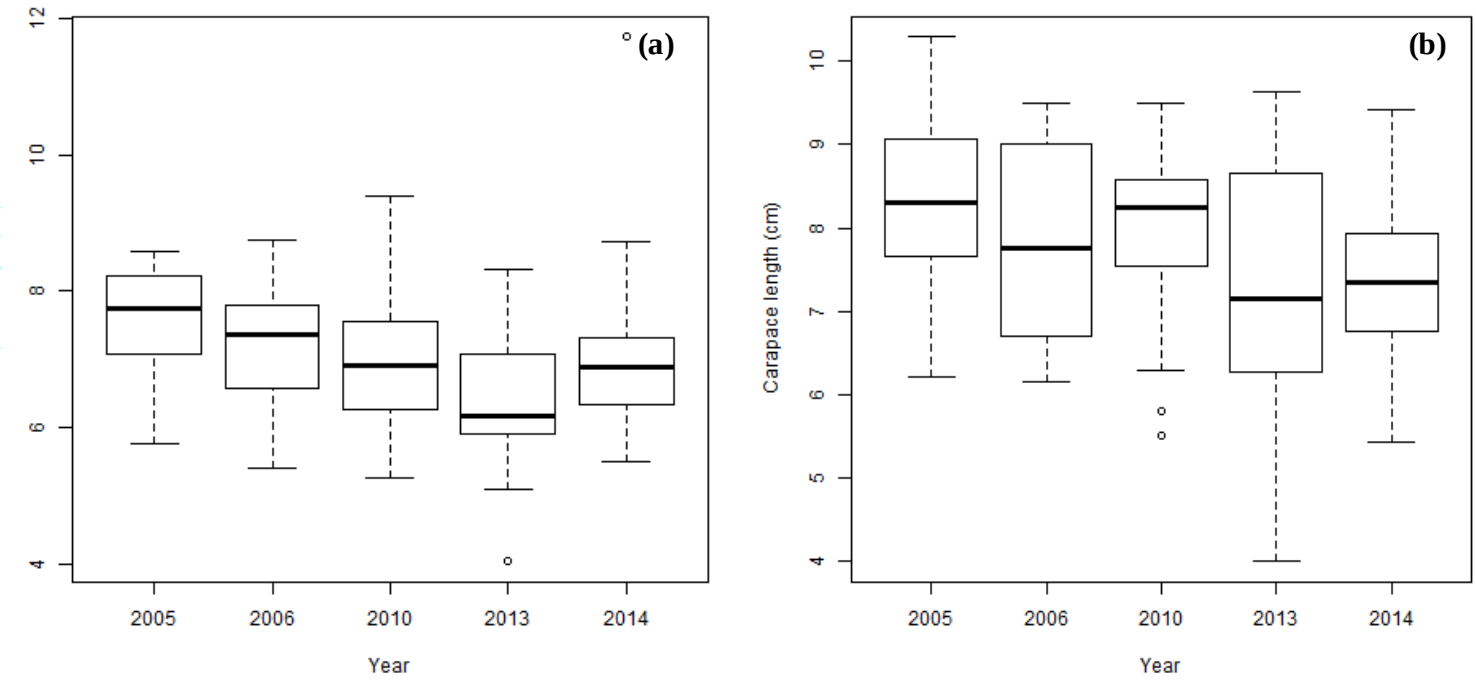

Figure 14. *P. longipes* sizes across surveys: (a) Box-and-whisker plot of female sizes (cm, CL), and (b) box-and-whisker plot of male sizes (cm, CL)

For male *P. longipes*, from 2005 to 2010, the relative proportion of lobsters above 7.5 cm was more than lobsters below 7.5 cm. However, in 2013 this proportion was about equal whilst in 2014 the proportion of lobsters below 7.5 cm was higher than lobsters above 7.5 cm. In 2005, males ranged in size from 6.22 cm to 10.29 cm with a single mode at around 8.25 cm. In contrast, in 2006, the sizes displayed a binomial distribution with a mode at around 6.25 cm and 8.75 cm. In 2010, lobsters caught were between 5.50 cm and 9.50 cm with a mode at 8.25 cm. In 2013, a similar binomial pattern as in 2006 can be observed. Lobsters ranged in size from 4.00 cm to 9.64 cm with modes at around 5.75 cm and 8.75 cm. In 2014, the majority of males caught were below 7.5 cm. The sizes of lobsters caught ranged in size from 5.44 cm to 9.43 cm.

Similarly to the mean size of females *P. longipes*, mean sizes of males decreased from 2005 to 2006 (Figure 14b). In 2005, the mean size was 8.26 cm, whilst in 2006 it was 7.84 cm. In 2010, the mean size increased slightly to 8.00 cm. However, in 2013, the mean size decreased to 7.20 cm. In 2014, the mean size increased slightly to 7.43 cm. There was a significantly difference in

the mean size of males between the different surveys (ANOVA: *df* 4, 103, F= 2.712, P= <0.05). Similarly to females, male lobsters caught in 2013 were significantly smaller than lobsters caught in 2005[5].

When the size data of all males and females of the different species were grouped by year, an overall decline can be observed in the mean size between the different surveys. The mean size was 9.31 cm in 2005 compared to 8.76 cm in 2006. In 2010, the mean size decreased to 8.56 cm. Similarly, in 2013, the mean size had decreased to 7.79 cm (Figure 9). However, in 2014, the mean size increased slightly to 7.88 cm. There was a significant difference in the mean size of lobsters between the five surveys (ANOVA: *df* 4, 557, F= 5.72, P= <0.001). The mean size of lobsters caught in 2010, 2013 and 2014 were significantly smaller than lobsters caught in 2005[6].

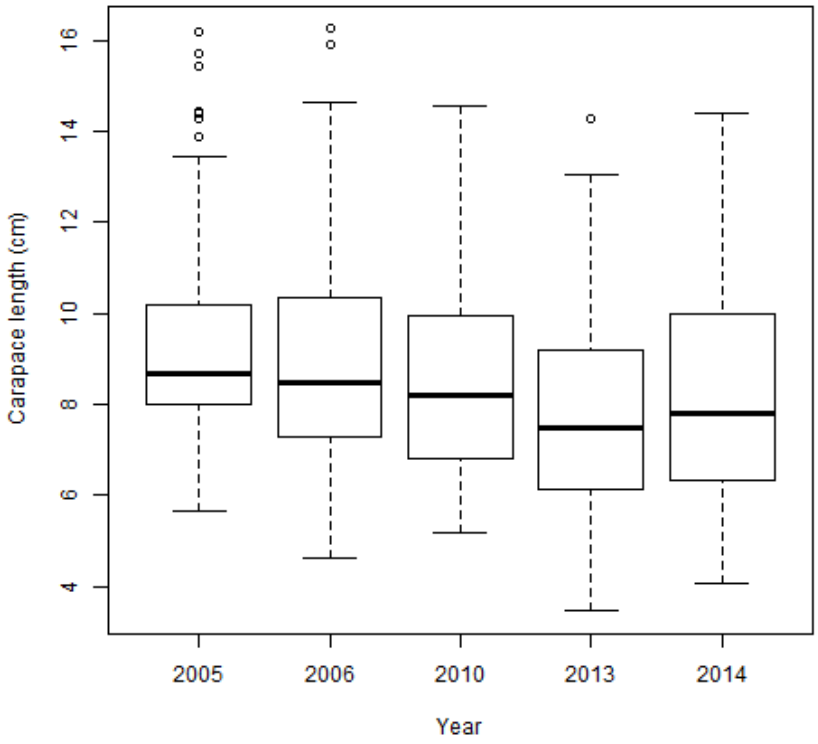

Figure 15. Box-and-whisker plot of sizes (cm, CL) of all lobsters grouped together. For the five survey period.

[5] Tukey multiple comparisons test: 2005-2013 padj= <0.05
[6] Tukey multiple comparisons test: 2005-2010 padj= <0.05, 2005-2013 padj= <0.001, 2005-2014 padj= <0.01

5. Discussion

Results from the fisheries independent surveys showed that there were no significant changes in the relative abundance for all lobsters caught between the different surveys. Although changes in abundance were not statistically significant, declines in the CPUE (kg·manhour^{-1}) was observed between surveys carried out in 2006 and 2013 whilst the CPUE in terms of no·manhour^{-1} remained stable over time. In contrast, there were significant changes in the relative abundance of legal size (> 7.5cm CL) lobsters caught between the different surveys. Marked decreases in the CPUE were observed between the first survey carried out in 2005 and surveys carried out in 2013 and 2014. This indicates a decrease in the relative abundance of legal size lobsters in recent years. Such a decrease can possibly be attributed to the fishing pressure considering that the fishery has remained opened for the last four years from 2010 to 2014. It is clear that the 9 month closure period between the opened seasoned has not been sufficient to allow stock to recover. Therefore, a longer closed season should be implemented to allow stocks to recover to appropriate levels.

A shift in the most abundant species caught (in terms of numbers) was observed over the five surveys. In 2005, 2006 and 2014, *P. penicillatus* was the most common, whilst in 2010 and 2013, *P. longipes* was the most common species. This shift in the most abundant species differs from the patterns from the fishery. During the fishing season, *P. penicillatus* is the species that dominate the catch. A possible explanation for the shift in the dominant species caught might be due to the effects of fishing conditions on the catchability of the two species which have slightly different habitat preference. *P. penicillatus* occurs mostly in shallow water of reefs and in the surf zone around rocks (Mees 1989). During poor fishing conditions such as low tide and rough seas such habitat might be inaccessible to fishers, therefore, catches of *P. penicillatus* might drop. In contrast, *P. longipes* can be found mostly under coral heads and in slightly deeper areas where the slope is more abrupt (Mees 1989). Such habitats might still be accessible to fishers even in poor fishing conditions resulting in higher catches of such species. A more detailed analysis looking at the effects of different factors that influence the fishing conditions (tide, sea state, moon phase) on the catch rate of the different species, will help improve our understanding on this issue.

The productivity indicators indicate that there has been a decrease in the proportion of egg-bearing females in 2013 compared to previous surveys in 2005, 2006 and 2010. In 2014, the proportion of berried females has improved. Declines in the proportion of berried females can

potentially have negative impacts on future recruitment levels. Future studies should focus on the monitoring of post larval settlement of lobsters to have a better understanding of the level of recruitment. Changes in recruitment will have a direct impact on the future abundance of lobsters.

An overall decline was observed in the size classes of lobsters (all species combined) over the four different surveys. Lobsters caught in 2010, 2013 and 2014 were significantly smaller than lobsters caught in 2005. Moreover, declines in the average size of females *P. penicillatus* and *P. longipes* and males *P. longipes* were observed, especially in 2013. Declines in the average size can possibly be attributed to the removal of larger individuals from the population or it can be attributed to increases in the number of smaller individuals in the catch. Clear shifts can be observed in the length frequency distributions of *P. longipes*. The proportion of large females (> 7.5 cm CL) has decreased from 2005 to 2014 whilst the proportion of smaller (< 7.5 cm CL) individuals has increased. Moreover, for males, increases in the proportion of smaller individuals can be observed. The decrease in the proportion of large individuals is a cause for concern. The declines can be due to increased fishing pressure. However, the increase in the proportion of smaller individuals is encouraging as over time the smaller individuals will grow larger and reach sizes where they will be able to be exploited in the fishery. However, the stock should be allowed sufficient time to recover.

Data collected during the surveys has allowed us to derive key fisheries independent indices that help us to monitor the abundance and recovery of lobster stocks. Such surveys should be carried out annually in order to monitor temporal changes in the indices derived. The buildup of a long term dataset could potentially allow us to derive standardized index of abundance for the lobster resource. Fisheries independent sources of information are essential in the 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.

6. Recommendations

It is recommended that:

- the lobster fishery remains closed for a period of 1 year (2014 to 2015) 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 size regulations.

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

7. References

Govinden, R. and Hollanda, S. (2013). The Seychelles Lobster Fishery, Fishery & Stock Status: 2010-2013. SFA Technical Report (SFA/R&D/070).

Mees, C. C. (1989). The lobster fishery – Data collection. SFA.

Robinson, J., Dorizo, J. and Assan, C. (2009). The Seychelles Lobster Fishery, Fishery & Stock Status: 2005-2008. SFA Technical Report (SFA/R&D/067).