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CPUE STANDARDISATION OF THE SOUTHERN INDIAN OCEAN ST. PAUL AND AMSTERDAM ROCK LOBSTER FISHERY



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Southern Fisheries Ecosystem Observation Program (2020) within the BIOPAC team of the Laboratory of Biology of Aquatic Organisms and Ecosystems.

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1. Abstract

This study reports on the analysis of long-term temporal trend in Catch Per Unit Effort (CPUE) for rock lobster caught in Saint Paul and Amsterdam (SPA) islands. CPUE standardization was performed using generalized linear models (GLM) fitted on catch and effort data for the period 1980-2019. Lognormal model was used to standardize the nominal CPUE using fishing year, fishing period, fishing area, and fishing year-area interactions as exploratory variables. For both islands a decline of standardised CPUE was observed at the beginning of the series followed by a relative stable trend with low variability until the recent years where an increase has been observed. The recent increase in both islands has been mainly driven by the offshore areas while a slight decline in the coastal area has been observed since 2016. These results suggest that the current stock level of the exploitable biomass of lobster in Saint Paul and Amsterdam have slightly increased in recent years.

2. Introduction

The commercial Catch Per Unit of Effort (CPUE) series of a resource is commonly employed as an index of population local abundance and integrated to the assessment of several exploited fish and invertebrate stocks. However, a number of factors besides density may influence the values of nominal CPUE including factors which affect catchability and availability. Standardisation procedures using General Linear Models (GLM) have been widely applied to commercial catch/effort data to produce reliable relative abundance index from nominal CPUE (e.g. Maunder & Punt, 2004; Tascheri et al., 2010, Brodziak & Walsh, 2013).

This document reports an application of a GLM standardization to rock lobster (*Jasus paulensis*) CPUE data from the French trap fishery in the Economic Exclusive Zone (EEZ) of Saint-Paul and Amsterdam (Figure 1) for the period 1980-2019.

3. Methodology

The fishery

SPA islands are part of the French Southern and Antarctic Territories (TAAF) and are located in the subtropical zone of the South Indian Ocean. Although the islands cover respectively a limited area of 8 and 58 km², the exclusive economic zone (EEZ) to which they belong covers 509 000 km² extending from 34° 30 'to 42 ° 00 South and 73° 12' at 81° 45 'East. Initially focused on the exploitation of fur seals (*Arctocephalus tropicalis*) and demersal fishes, these islands have

been exploited annually for rock lobsters since 1948. Management decisions taken by the TAAF are based on the scientific expertise of the Museum National d'Histoire Naturelle (MNHN). The fishery is managed by setting annual allowable catches (TAC) for the rock lobster¹ as well as technical prescriptions to control the fishing effort (e.g. fishing period, authorized fishing gear, mandatory fishing logbook, trap mesh size, legal size, control of discards) with the support of onboard fishing controllers on 100% of the fishing trips and landing controls. Recent TACs were shared between two fishing companies SAPMER and ARMAS PECHE which charter the fishing vessel.

The fishing fleet is composed of a single mother ship, currently the "Austral 2", owned by SAPMER, which targets and lands mainly rock lobster fished from 4 coastal (operating in depth inferior to approximately 50m) canots (doris) setting wooden traps in the kelp zone (coastal area) and 2 pilothouse fishing boats ("caseyeurs") in the deep area (operating in depth from approximately 50 to 350m) with line of 20 steel traps² (Figure 2). Rock lobsters are transhipped and weighted to the "Austral 2" where catches are proceeded on the on-board factory. Fishing takes place during the austral summer between end of November of the year N and May of the year N + 1 during which time the "Austral 2" makes two fishing trips of approximately the same duration (less than 2 months).

Data

An observation program of all fishing activity has been in operation since 1948 in SPA and all data have been integrated into the MNHN PECHEKER database since 1980 (Martin & Pruvost 2007). Onboard observers collect fine-scale data on catch (in weight), effort (in number of trap) and biometry of the target species (rock lobster) and on bycatch which are relatively small, few tons of octopus (*Octopus vulgaris*) representing less than 5% of the catch.

As detailed above, the fishery involves different types of small fishing vessels operating at different scales in different areas, therefore the ideal scale of analysis would be the fishing operation. However, since the rock lobsters are processed and weighted daily on the Austral during the transshipment operation, our preliminary approach uses data aggregated per day. Data per fishing operation, would allow us to explore the variability of the CPUE deeper, but would require assumptions on the distribution of the catches between boats and trap lines.

¹ TACs are also attributed to the main demersal fish exploited, cabot (*Polyprion oxygeneios*), rouffe antarctique (*Hyperoglyphe antarctica*) and saint-paul (*Latris lineata*).

² Soaking time for individual wooden pots is comprise between 30' to 2h30 while steel pots are soaked from 12h to 17h.

The daily data used in our approach includes total rock lobsters catches, number of traps, fishing area (coastal or deep), octopus CPUE and fishing trip.

Accounting for historic change in technical requirements

Although the characteristics of the fishery (gear, number of boats, fishing season, etc.) have changed little over the past 40 years, recent changes in technical requirements may have had an effect on nominal CPUE. The processing coefficients for the different products (rock lobster tail, whole rock lobster) have been readjusted every fishing trip since the 2014/2015 season, with an average value of 3.34, whereas it was previously set at 3 affecting the estimated gross weight (see Table 1 for summary of processing coefficients and Annex 1 for adjusted catch and CPUE series).

Standardisation model

Nominal CPUE

Arithmetic mean (Eq. 2) CPUE is calculated and used as the nominal nCPUE by island as the total catch for the year y divided by the total effort in year y :

$$CPUE_y = \frac{1}{n} \sum_1^n \frac{catch.adj_{i,y}}{effort_{i,y}} \quad (\text{Eq 2})$$

Where $catch.adj_{i,y}$ is the adjusted catch (in kg) for each fishing day i in year y ,

$effort_{i,y}$ is the number of traps for each fishing day i in year y , and,

n is the number of day fished in year y .

Standardised CPUE

Standardised CPUE is calculated from a GLM³ assuming a lognormal error distribution. Fishing year, fishing trip, fishing area and interaction between year and area were included in the GLM analyses as main explanatory variables. We also explored the effect of octopus predation on rock lobster catch rates using CPUE as a proxy of octopus densities, as reported in others studies (e.g. Briceno et al. 2016). Variables describing gear configuration have been excluded since fishing areas correspond strictly to the operation of two fleets (caseyeurs and canots) which operates different kind of traps. Furthermore, the same vessels, traps and fishing methods have been used throughout the time series at the same time of the year.

The GLM used to standardised CPUE is given by the following:

$$\ln(CPUE) = \mu + \alpha_{year} + \beta_{fishing\ trip} + \eta_{area} + \varphi_{CPUE\ octopus} + \gamma_{year*area} + \varepsilon \quad (\text{Eq. 3})$$

³ All analyses have been conducted using R (R Core Team 2018) and package ‘stat’ for GLM.

Where μ is the intercept,

Fishing year is a factor with 39 levels associated with the years (i.e. the fishing years: 1980/1981 to 2019/2020),

Fishing trip is a factor with 2 levels associated with the fishing periods (M1: December to January-February and M2: February to March-April),

Fishing area is a factor with 2 levels associated with fishing areas around SPA (coastal <50m, deeper area >50m around the islands. The offshore bank area, 16 miles bank (situated about 16nm southeast of Saint-Paul) have been excluded from the analysis,

CPUE octopus is the proxy of octopus densities, and,

ε is the model residuals.

Forward selections based on AIC were used to determine the variables that contributed significantly ($p < 0.001^4$) to the deviance explained. In this document, the CPUE has been standardised on the year 1980, the first fishing trip and fishing area offshore bank for Saint Paul and coastal area for Amsterdam.

For this model, because of the fixed effect interaction of area with year (which implies changing spatio-temporal distribution patterns), an index of overall abundance needs to integrate the different trends in density in each area over the size of these areas. Accordingly, the standardised CPUE series is obtained from:

$$CPUE_y = \frac{[\sum_a e^{(\mu + \alpha_{year} + \beta_{fishing\ trip} + \eta_{area} + \varphi_{CPUE\ octopus} + \gamma_{year*area}) * A_a}]}{A_{total}} \quad (\text{Eq. 3})$$

Where A_a is the surface of the zone a (coastal and deep), and,

A_{total} is the total size of the fishing ground considered (the division by A_{total} is to keep the units and size of the standardised CPUE index comparable with those of the nCPUE). Table 2 provides the *fishing area* values for each fishing ground in SPA.

4. Results

The nominal CPUE time series shows a clear decrease at the beginning of the time series, following by a relatively stable period even though there were some oscillations and variability

⁴ Wald-tests.

between years and an increasing trend in the most recent years (Annex 1). Furthermore, the first fishing trip (November to January) appears to have a higher CPUE over the overall period as well as the offshore area especially in the last year (Annex 2, Annex 3). The octopus CPUE appears to be highly negatively correlated to rock lobster CPUE at Amsterdam while it had no significant effect in Saint-Paul (Annex 5).

All of the variables considered are highly significant ($p < 0.001$) and are supported by stepwise AIC selection procedure (Table , Table) and explained approximately 50% of the variance with a pseudo⁵ R^2 of 0.51 and 0.46 for Saint and Amsterdam respectively.

The Pearson residuals for the lognormal model show a reasonable distribution for the Amsterdam stock, whereas the distribution of the Saint Paul stock is slightly skewed toward the negative values (Annexes 5, 6).

Nominal and standardized CPUE (together with 95% C.I.) for rock lobster are presented by Islands in Table , Table 5 and Figure 3, 4. The nominal and standardised CPUE time-series are similar, but diverge notably in the last year.

Figure 4 and 5 shows the effects of the variables on CPUE included in the standardisation process. The first fishing trip appears to have a higher CPUE, which could indicate potential local depletion in fishing areas throughout the season. The offshore area shows higher CPUE at Saint Paul quite especially in the last year while the difference between coastal and offshore areas appears to be less pronounced at Amsterdam. The larger size of the lobsters present in the deep zone of Saint Paul explains this effect (Annex 7). Finally, the CPUE displays a negative linear relationship with octopus CPUE supporting that the capture of rock lobster using traps is affected by predation of octopus that occur inside fishing gear.

5. Discussion

From the preliminary analyses of this paper, the new GLM standardised CPUE series are put forward as a good index of abundance upon which to base future assessment of the population. For the two islands, the standardised CPUE indices show an initial decrease, followed by a relative stable trend over the years with an increase trend in the most recent years suggesting that the current adult stock size of lobster grows.

⁵ $R^2 = 1 - (\text{Deviance}_{\text{null_model}} / \text{Deviance}_{\text{selected_model}})$

6. Future work

Information from fine scale spatial distribution of fishing effort as well as gear setting, configuration and fishing masters are available since 2014 and should be integrated in the CPUE standardization. CPUE at the fishing operation level should be analysed considering for each fishing area as independent management unit. These data need to be analysed further to try to use them to estimate and account for the relative availability of the resource (i.e. lobster distribution) as well catchability (i.e. fishing power, fisher ability etc.).

Furthermore, environmental information should be integrated to explore notably the relation between rock lobster distribution and the benthic habitats. Also, the weather and sea conditions play also an important role in the spatial distribution of fishing effort especially in the coastal area where small “canots” operate.

7. References

- Briceño, F., León, R., Gardner, C., Hobday, A. J., André, J., Frusher, S. D., & Pecl, G. T. (2016). Spatial variation in mortality by in-pot predation in the Tasmanian rock lobster fishery. *Fisheries Oceanography*, 25, 6-18.
- Brodziak, J. & Walsh, W. A. (2013). Model selection and multimodel inference for standardizing catch rates of bycatch species: a case study of oceanic whitetip shark in the Hawaii-based longline fishery. *Canadian Journal of Fisheries and Aquatic Sciences*, 70, 1723-1740.
- Martin A. & Pruvost P. (2007). Pecheker, relational database for analysis and management of fisheries and related biological data from the French Southern Ocean fisheries monitoring scientific programs, Muséum National d'Histoire Naturelle.
- Maunder, M. N. & Punt A. E. (2004). Standardizing Catch and Effort Data: A Review of Recent Approaches. *Fisheries Research*, 70 (2-3),141-59.
- R Core Team. (2018). R: A language and environment for statistical computing (Version 3.5.1). [Computer software]. R Foundation for Statistical Computing.
- Tascheri, R., Saavedra-Nievas, C. & Roa-Ureta, R. (2010). Statistical models to standardize catch rates in the multi-species trawl fishery for Patagonian grenadier (*Macruronus magellanicus*) off southern Chilean. *Fisheries Research*, 105, 200-214.

8. Tables

Table 1: Conversion coefficients of the different rock lobster products in the SPA fishery.

Period	Product	Coefficient
2014/2015 – 2019/2020	whole cooked	1.10
	gross tail	3.37
	half lobster	1.18
1980/1981 – 2014/2015	whole cooked	1
	whole gross	1
	gross tail	3
	cooked tail	3

Table 2 : The size (km²) of each fishing area around Saint Paul and Amsterdam islands estimated from position of fishing operation from 2014/2015 to 2017/2018.

Island	Fishing area	Size (km²)
Saint Paul	Coastal area	14.2
Saint Paul	Deep area	215.5
Saint Paul	16 miles Bank	92.3
Amsterdam	Coastal area	24.2
Amsterdam	Deep area	90.6

Table 3: Summary table of the final model retained by forward selection based on AIC for Saint Paul standardised CPUE models using *fishing year*, *fishing trip*, *fishing area* as explanatory variables.

Variable	DF	Residual Deviance	AIC
NULL		693.7	4083.8
Fishing_year	39	417.4	2690.6
Fishing_trip	1	383.5	2447.5
Fishing_area	1	366.9	2321.4
Fishing_area *			
Fishing_year	39	337.6	2156.8

Table 4 : Summary table of the final model retained by forward selection based on AIC for Amsterdam CPUE models using *fishing year*, *fishing trip*, *fishing area* as explanatory variables. Independent explanatory variables are listed in the order of acceptance to the model.

Variable	DF	Residual Deviance	AIC
NULL		674.9	3906.0
Fishing_year	39	423.1	2682.6
Fishing_trip	1	389.9	2480.4
Fishing_area	2	378.4	2389.7
CPUE octopus	1	377.5	2385.6
Fishing_area *			
Fishing_year	39	347.5	2300.2

Table 5 : Standardised CPUE and nominal CPUE (kg/trap) series for Saint Paul Island using the GLM model detailed in the text using *fishing year*, *fishing trip*, *fishing area* as explanatory variables.

Year	nCPUE	Standardised CPUE
1980	12,4	12,3
1981	12,4	11,9
1982	13,6	13,0
1983	13,7	13,8
1984	10,6	10,8
1985	8,1	8,7
1986	6,6	6,3
1987	6,0	6,2
1988	4,7	5,0
1989	6,2	5,8
1990	7,8	7,2
1991	6,8	6,6
1992	8,4	8,1
1993	5,9	5,8
1994	7,1	7,8
1995	5,5	6,9
1996	5,1	5,6
1997	5,7	5,6
1998	6,8	6,5
1999	6,8	6,5
2000	7,9	7,9
2001	11,3	10,6
2002	8,2	8,0
2003	9,6	9,2
2004	10,1	9,9
2005	10,0	10,3
2006	10,4	9,6
2007	13,6	14,6
2008	10,4	10,2
2009	12,5	12,1
2010	10,5	9,6
2011	7,4	5,9
2012	9,6	10,5
2013	8,2	10,0
2014	9,7	11,0
2015	9,6	10,8
2016	10,1	12,4
2017	11,6	12,1
2018	10,5	10,8
2019	12,0	14,2

Table 6 : Standardised CPUE and nominal CPUE (kg/trap) series for Amsterdam Island using the GLM model using *fishing year*, *fishing trip*, *fishing area* as explanatory variables.

Year	nCPUE	Standardised CPUE
1980	11,6	9,1
1981	13,1	12,1
1982	13,6	11,3
1983	10,6	9,2
1984	8,0	7,5
1985	7,6	6,6
1986	5,7	5,0
1987	4,4	3,8
1988	4,6	4,3
1989	5,2	3,9
1990	5,9	5,2
1991	6,9	5,0
1992	8,3	7,3
1993	5,0	4,5
1994	4,9	4,6
1995	4,3	4,1
1996	4,5	3,6
1997	6,2	4,7
1998	7,0	6,1
1999	7,1	6,4
2000	6,8	6,3
2001	12,2	11,4
2002	6,6	5,9
2003	7,4	6,3
2004	7,1	6,7
2005	5,9	5,3
2006	7,5	6,8
2007	8,4	7,5
2008	7,6	6,8
2009	10,0	10,6
2010	7,6	6,5
2011	5,3	4,7
2012	6,9	6,7
2013	5,9	5,9
2014	5,2	5,8
2015	6,3	6,9
2016	8,5	9,6
2017	8,6	11,2
2018	10,5	11,8
2019	11,1	12,7

9. Figures

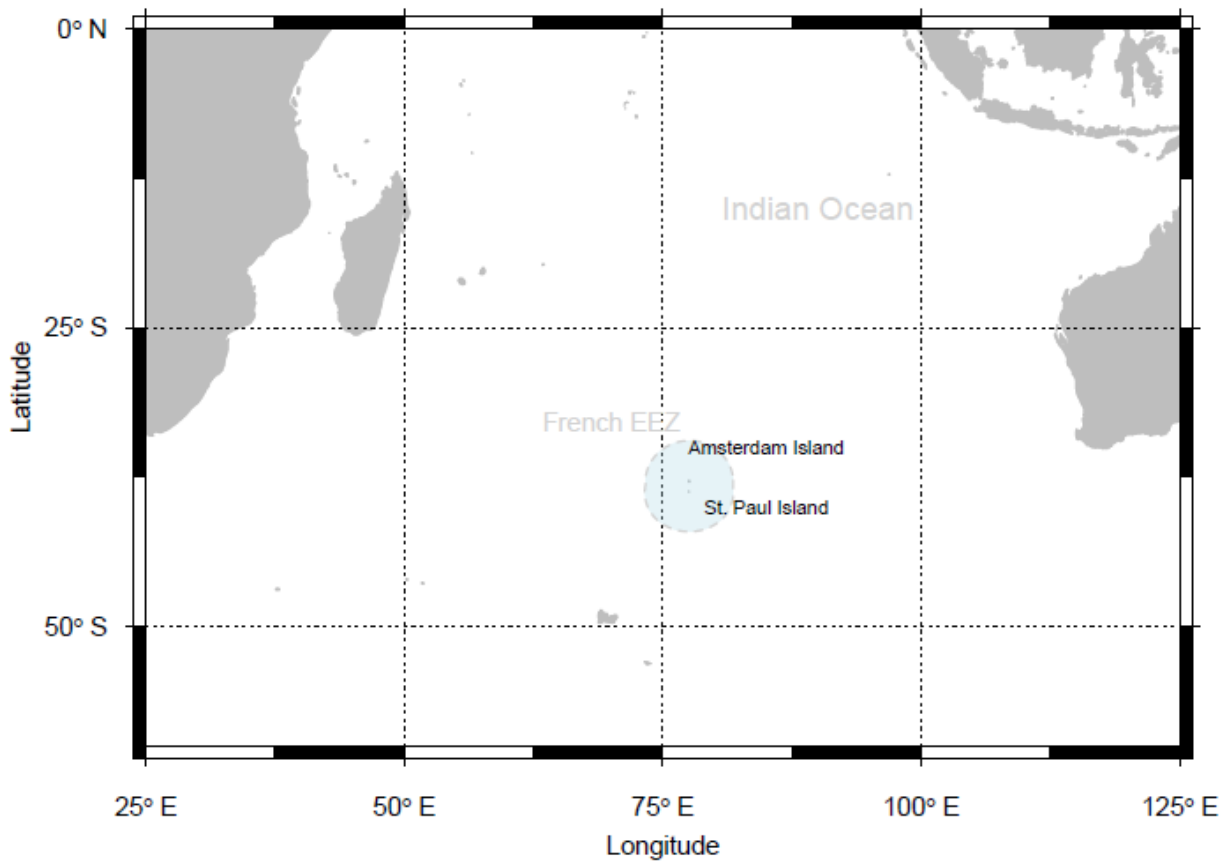


Figure 1: Location of St. Paul and Amsterdam within the French EEZ in the South Indian Ocean. The French EEZ is delineated by a grey dashed line.

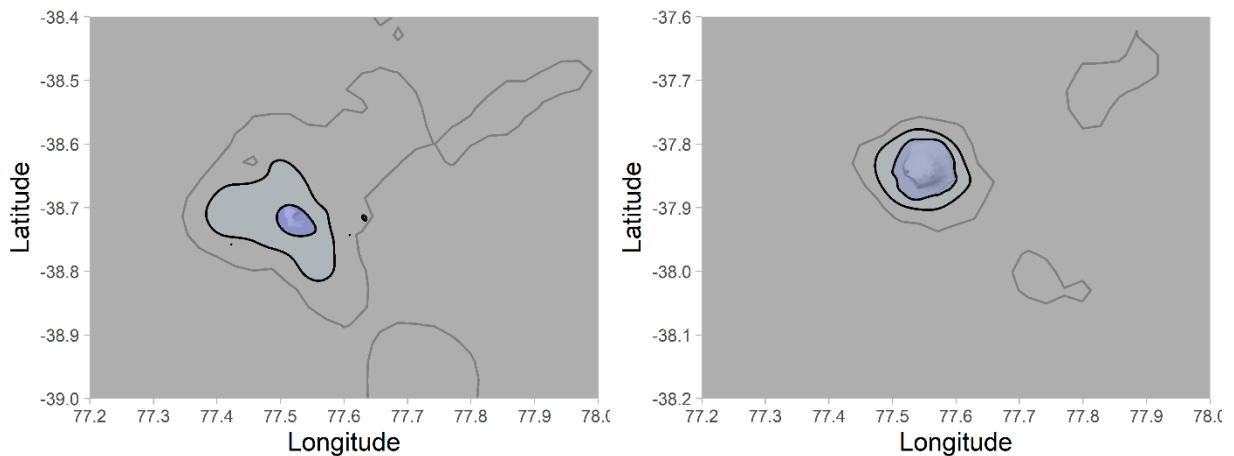


Figure 2: Location of fishing area around St. Paul and Amsterdam islands. Coastal and deep fishing area are represented in blue and light blue respectively.

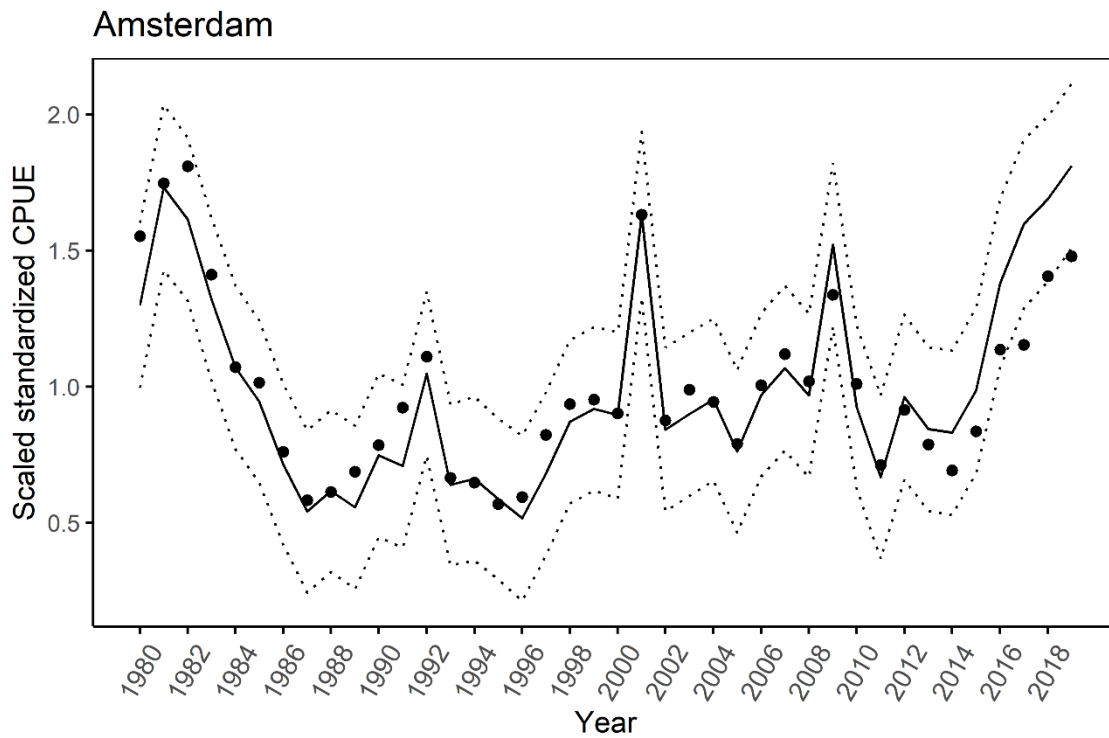


Figure 3 : Comparative plot of the nominal CPUE (black dots) and GLM standardised CPUE series (black line) for Amsterdam Island with 95th confidence interval (dashed lines).

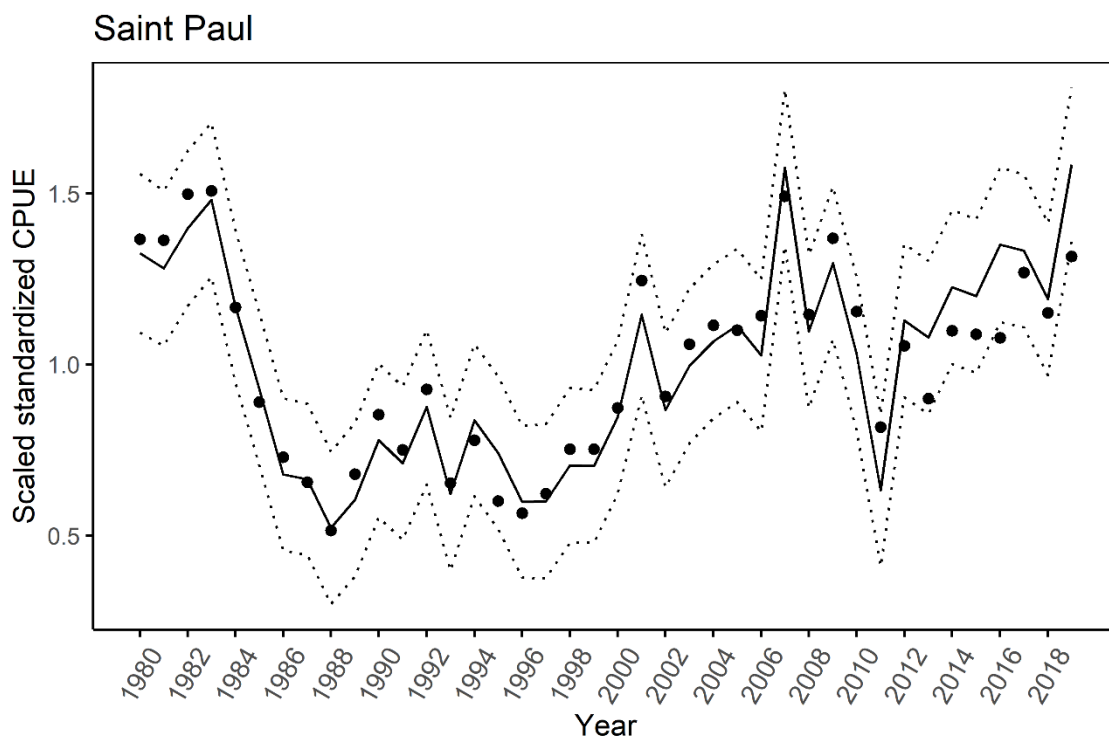


Figure 4 : Comparative plot of the nominal CPUE (black dots) and GLM standardised CPUE series (black line) for Saint Paul Island with 95th confidence interval (dashed lines).

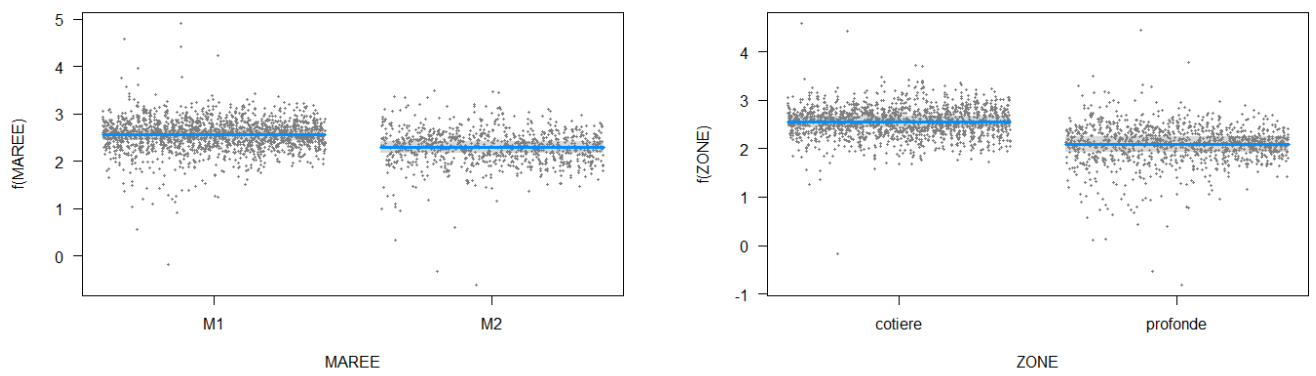


Figure 4 : Partial plot (residuals) of main categorical effect on the CPUE for Saint Paul Island with 95th confidence interval (grey area).

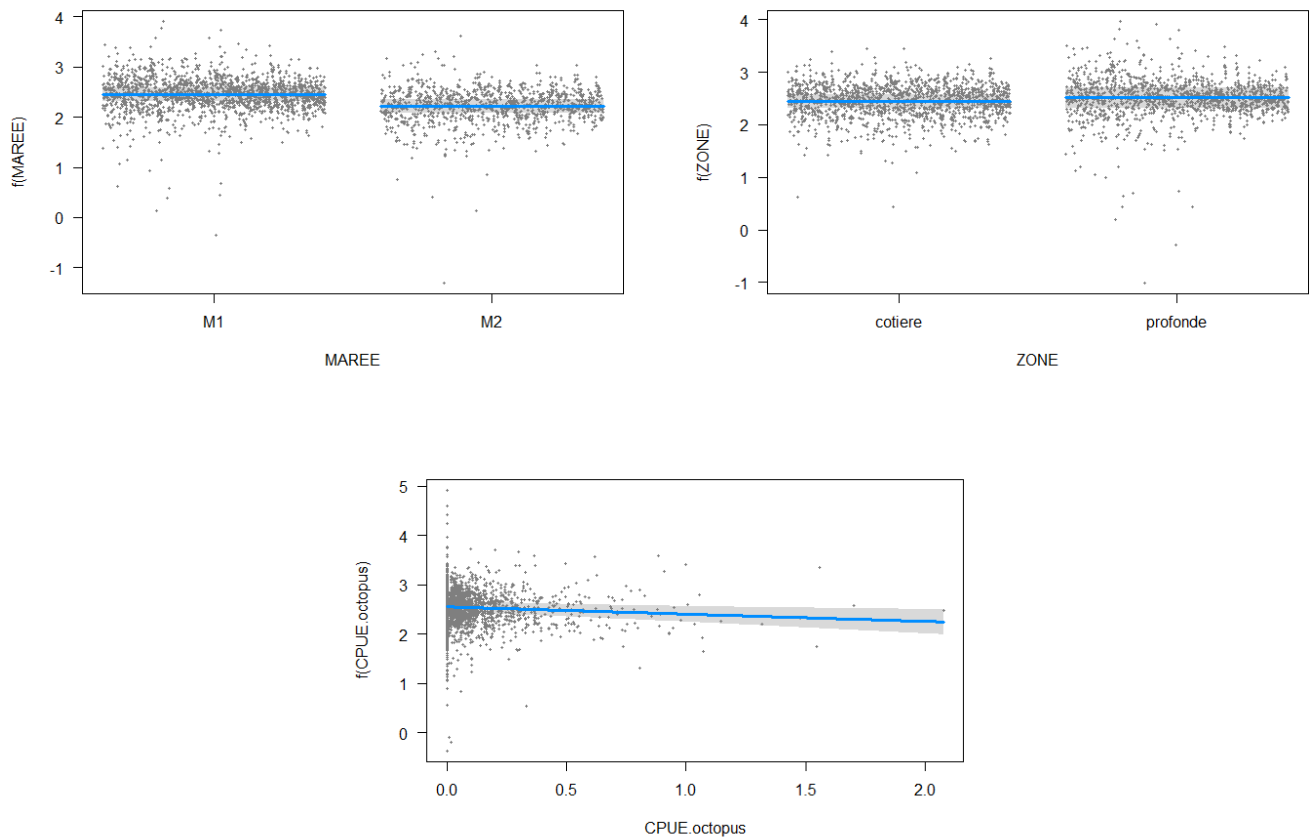
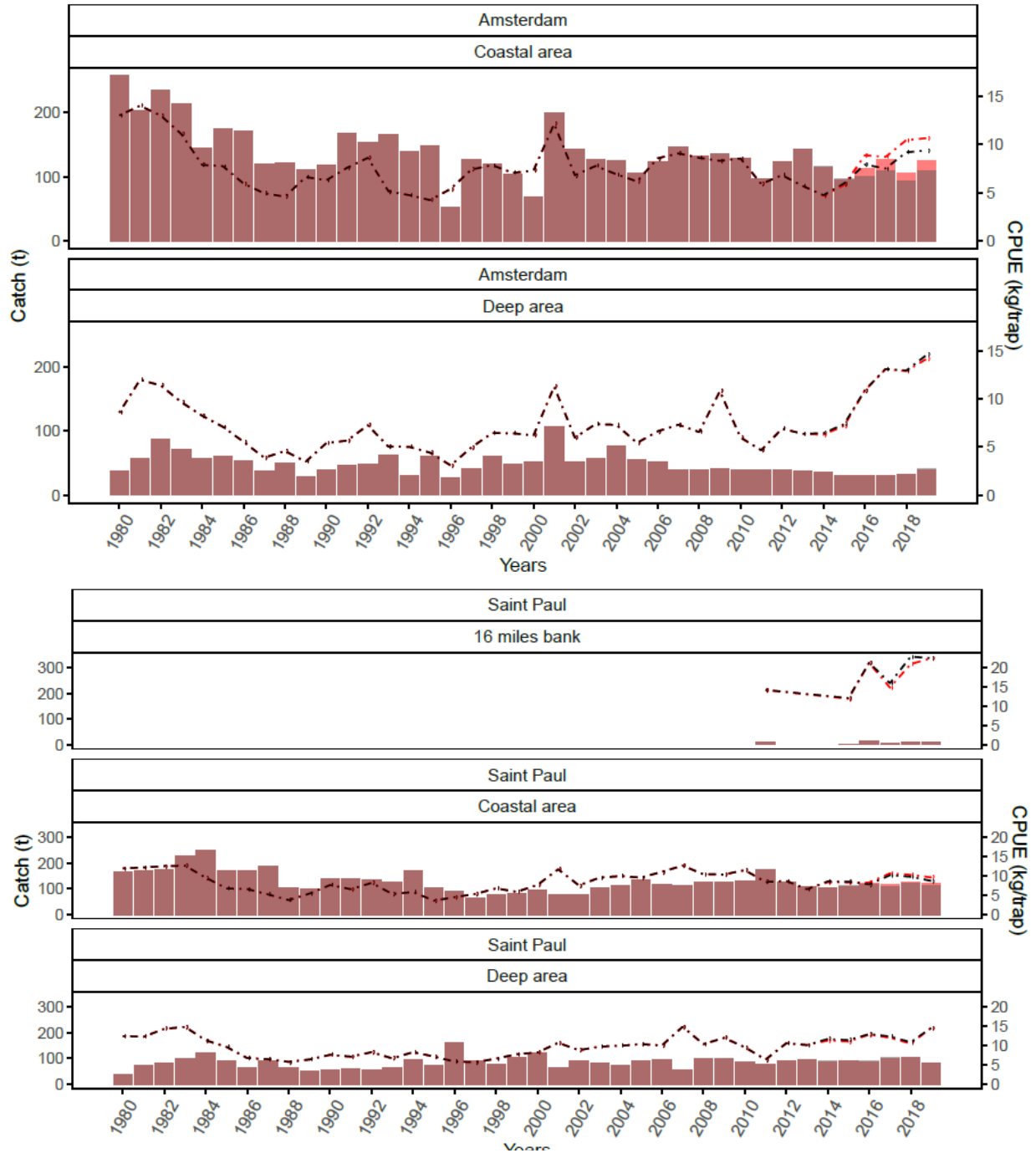


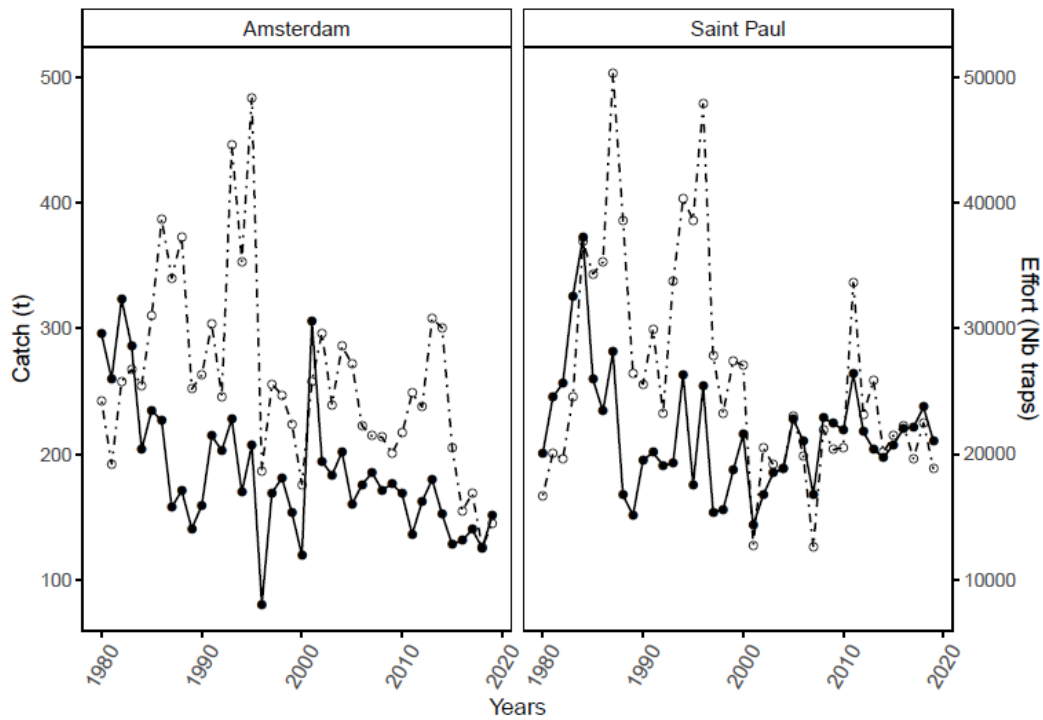
Figure 5 : Partial plot (residuals) of main categorical effect on the CPUE for Amsterdam Island with 95th confidence interval (grey area).

10. Annexes

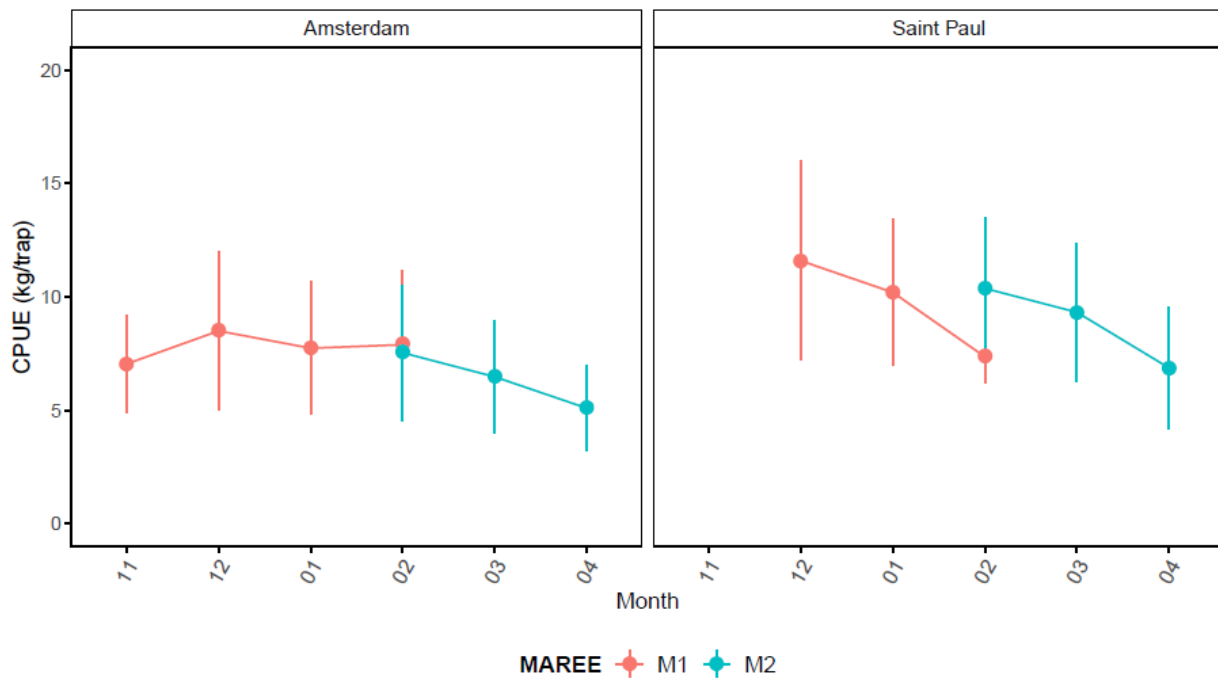
Annex 1: Time-series of catch (t, in black) and adjusted catch (in red), CPUE (kg/trap, black dotted line) and adjusted CPUE (red dotted line) for the St. Paul and Amsterdam rock lobster.



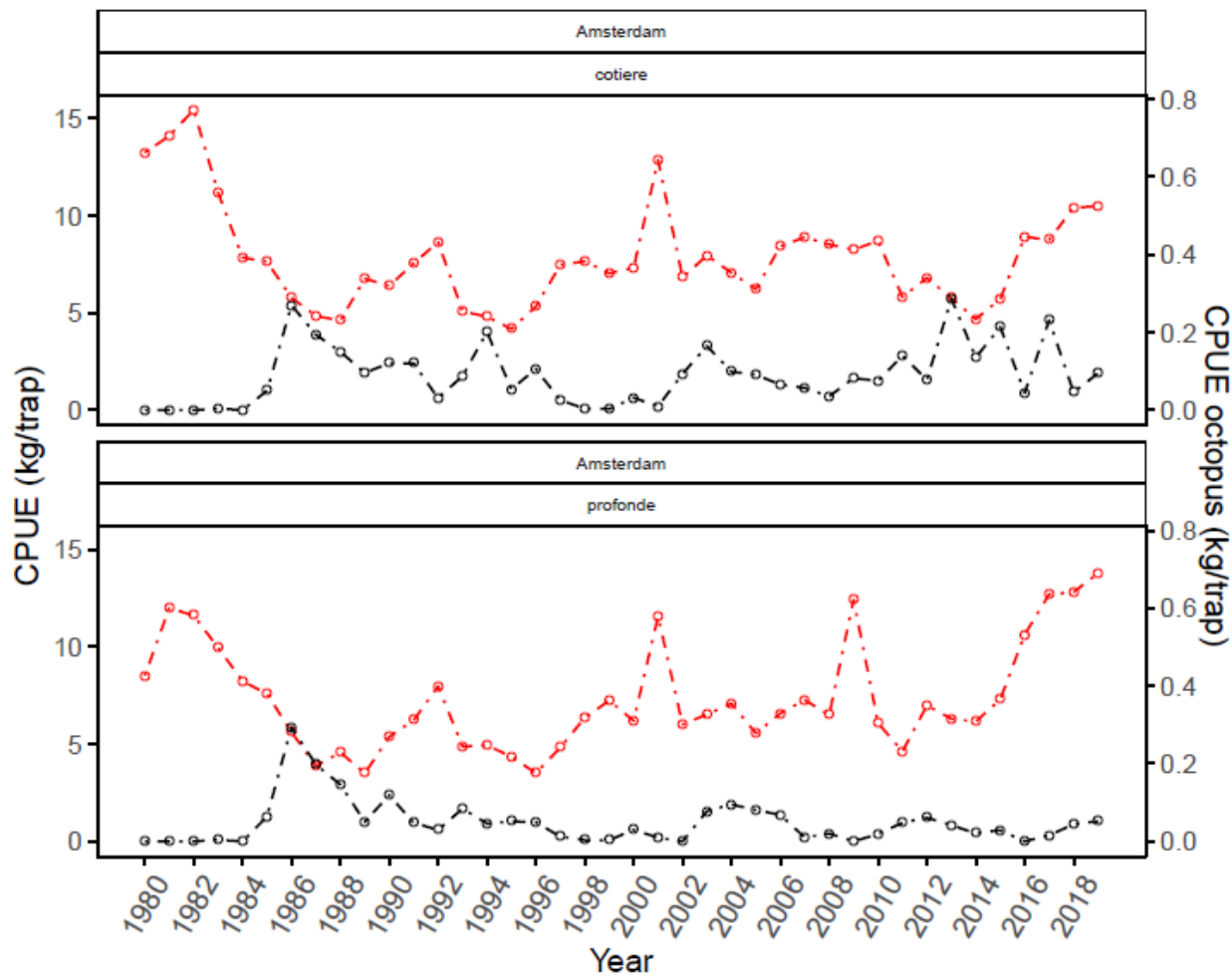
Annex 2: Time-series of fishing effort (Number of traps, dashed line) and Catch (t, solid line) for the St. Paul and Amsterdam rock lobster.

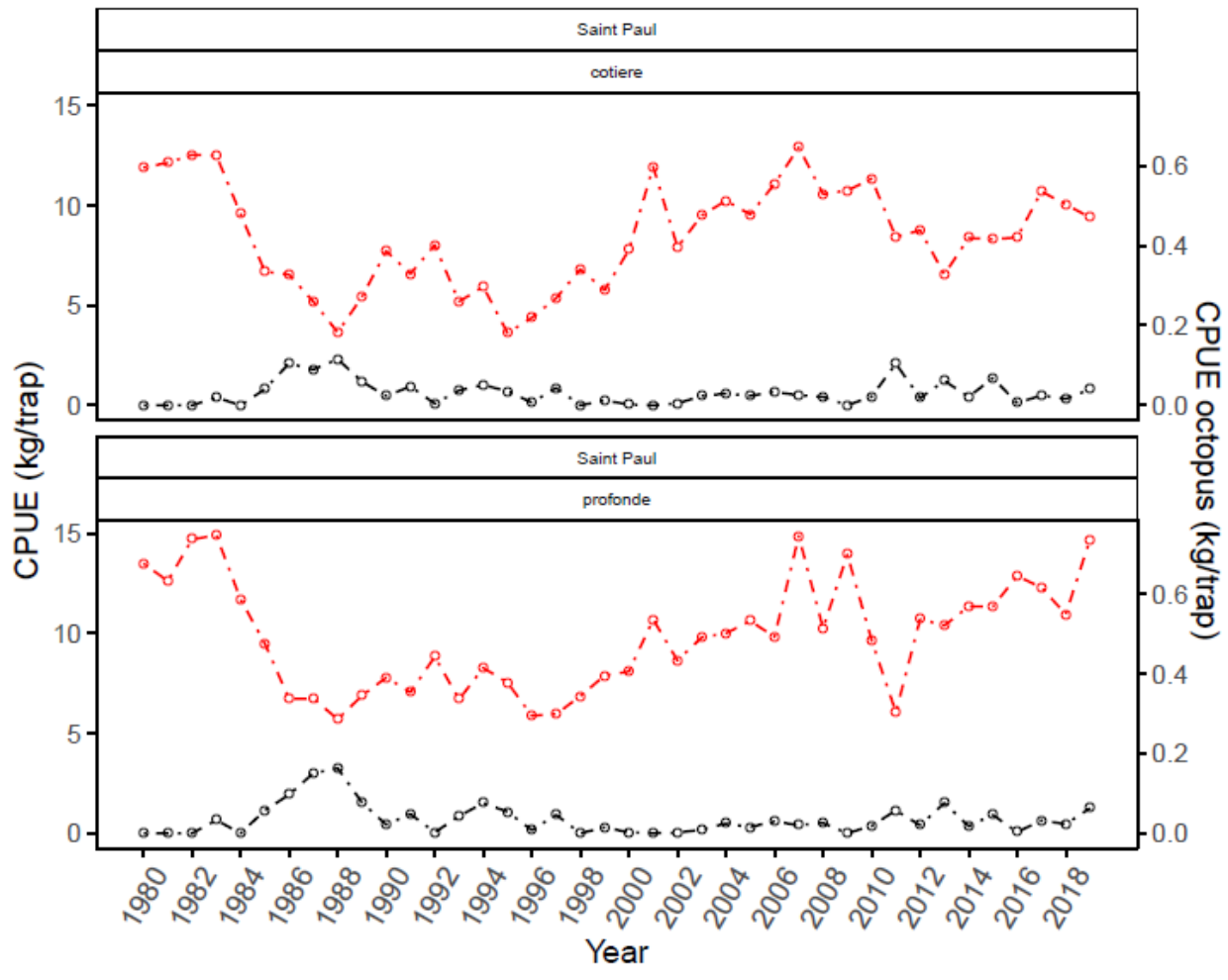


Annex 3: Mean CPUE (kg/trap) by month and fishing trip for the St. Paul and Amsterdam rock lobster. Standard deviations are represented by vertical lines.

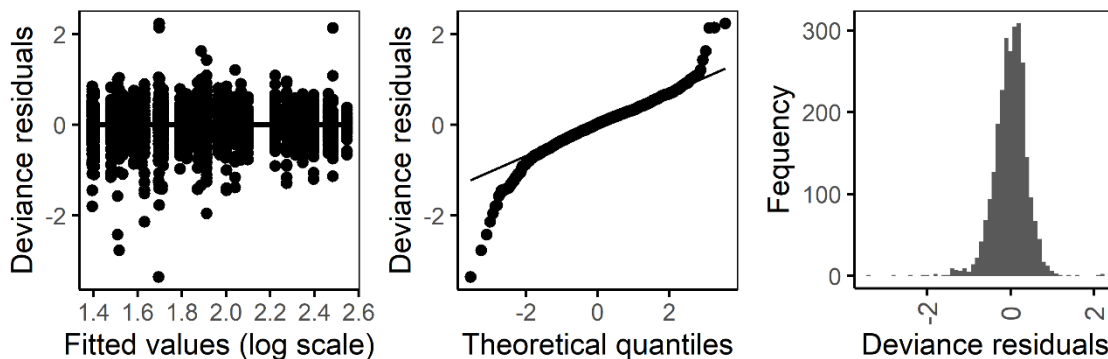


Annex 4: Time-series of rock lobster CPUE (kg/trap left axis, in red) and octopus CPUE (kg/trap right axis, in black) in St. Paul and Amsterdam.

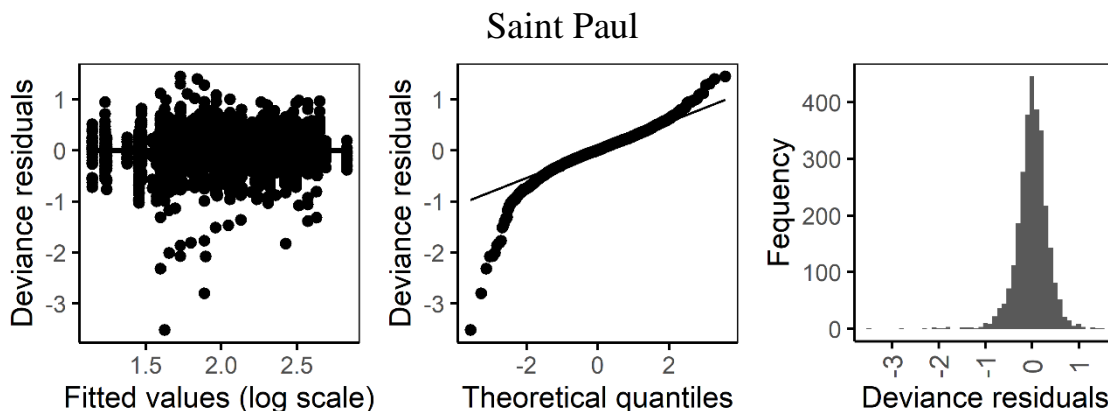




Annex 5: Residual plots for Amsterdam CPUE regression analyses using *fishing year*, *fishing trip*, *fishing area* as explanatory variables.



Annex 6: Residual plots for Saint Paul CPUE regression analyses using *fishing year*, *fishing trip*, *fishing area* as explanatory variables.



Annex 7: Length frequency distribution (Cephalothoracic Length LC in cm) of rock lobsters according to sex and fishing areas in Saint Paul and Amsterdam during the last 3 seasons 2017/2018 to 2019/2020.

