STATUS REPORT

Chaceon erytheiae

Common Name: Deep-sea red crab

FAO-ASFIS Code: YHI

2023

Updated: November 2023

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1. Description of the fishery

1.1 Description of fishing vessels and fishing gear

The SEAFO Deep-sea red crab fishery started in 2001 when a Spanish vessel first reported red crab catches of less than 1 tonne (Table 2). Since then the fishery has been accessed by Japanese, Namibian, Portuguese and Korean flagged vessels respectively. The depth range of the SEAFO Deep-sea red crab fishery has been recorded to be between 280 to 1150 meters. Specifications of the fishing vessels that were fishing Deep-sea red crab are outlined in Table 1.

Table 1: Vessel specifications for each year of fishing

Year	Vessel Name	Flag	Call Sign	IMO Code	Gear Type	Length
2005	KINPO MARU 58	JPN	JFXB		LL, Pot	62.6
2007	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2010	SEIRYO MARU NO1	JPN	JNNI	8617586	LL, Pot	37.06
2011	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2012	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2013	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2014	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2015	MERIDIAN NO8	KOR	DTBX5	9230646	LL, Pot	54.55
2017	NOORDBURG KALAPUSE	NAM	V5WO	7121736	LL, Pot	48.9
2017	SEIRYO MARU NO1	JPN	JNNI	8617586	LL, Pot	37.06
2018	CRAB QUEEN 1	NAM	V5XD	8909628	LL, Pot	49.61
2020	SEIRYO MARU NO1	JPN	JNNI	8617586	LL, Pot	37.06
2021	SEIRYO MARU NO1	JPN	JNNI	8617586	LL, Pot	37.06

* LL = Longline   * NAM = Namibia   * JPN = Japan
* KOR = Republic of Korea   * IMO = International Maritime Organisation

The Namibian, Korean and Japanese vessels' gear setup (design & set deployment) are very similar. Japanese beehive pots are used (Fig. 1). The beehive pots are conical metal frames covered in fishing net with an inlet shoot (trap entrance – Fig. 1) on the upper side of the structure and a catch retention bag on its underside. When settled on the seabed the upper side of the trap are roughly 50cm above the ground ensuring easy access to the entrance of the trap. The trap entrance leads to the kitchen area of the trap – which is sealed off by a plastic shoot that ensures all crabs end up in the bottom of the trap.

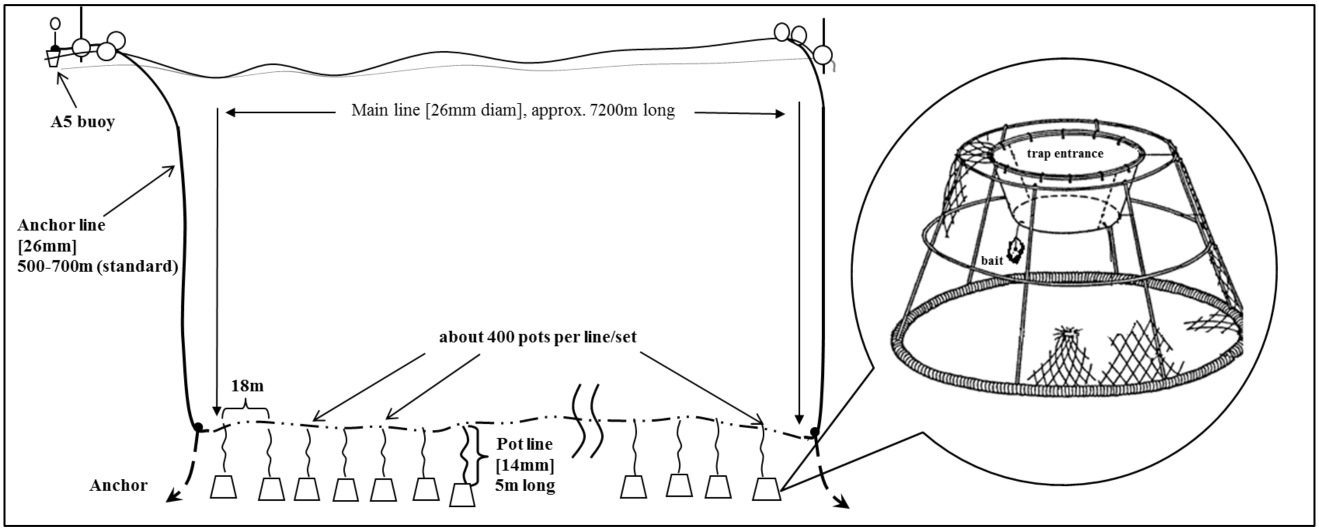

Figure 1: Deep-sea red crab fishing gear setup (set deployment and design) and illustration of a Japanese beehive pot (shown in enlarged form on the right).

One set or pot line consists of about 200-400 beehive pots, spaced roughly 18m apart, on a float line attached to two (start & end) anchors for keeping the gear in place on the seabed (Fig. 1). The start & end points of a set are clearly marked on the surface of the water with floats and one A5 buoy that denotes the start of a line. Under this setup (i.e. 400 pots at 18m intervals) one crab fishing line covers a distance of roughly 7.2km (3.9nm) on the sea floor and sea surface.

1.2 Spatial and temporal distribution of fishing

In the SEAFO Convention Area fishing for Deep-sea red crab is focussed mainly on *Chaceon erytheiae* on Valdivia Bank – a fairly extensive seamount that forms part of the Walvis Ridge. This seamount is located in Division B1 of the SEAFO Convention Area (CA) and has been the main fishing area of the deep-sea crab fishery since 2005. The spatial distribution of the catches aggregated to a 10 km^2 hexagonal area for each year can be seen in Figures 2 to 10. Fishing occurred over a depth range of 280-1150 meters.

The total number of sets made during each year can be seen in Table 2. No fishing was recorded during 2016 and 2019.

Table 2: The total number of sets for the period 2010 to 2021

2010	2011	2012	2013	2014	2015	2017	2018	2020	2021
181	133	129	103	107	73	145	177	38	27

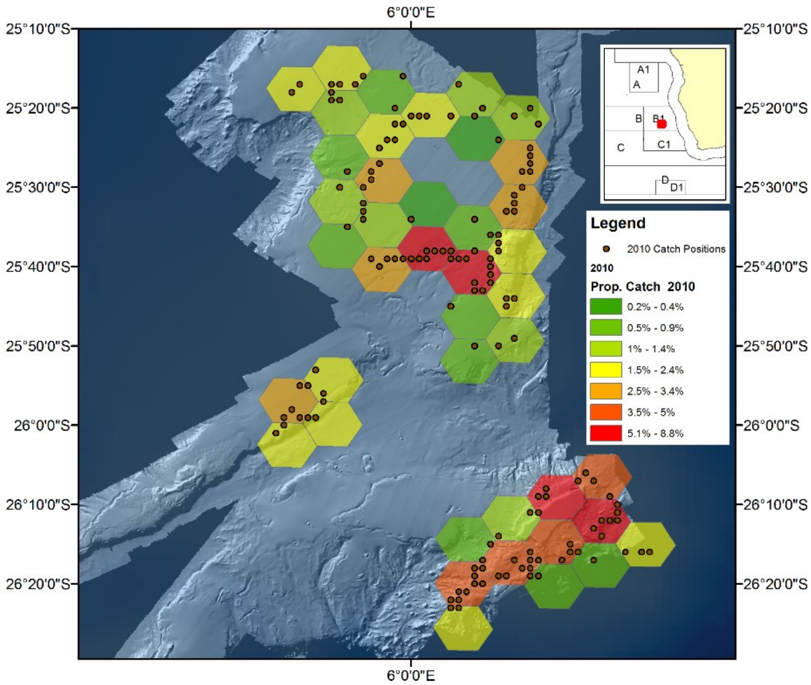

Figure 2: The spatial distribution of Deep-sea red crab during 2010 in SEAFO Division B1.

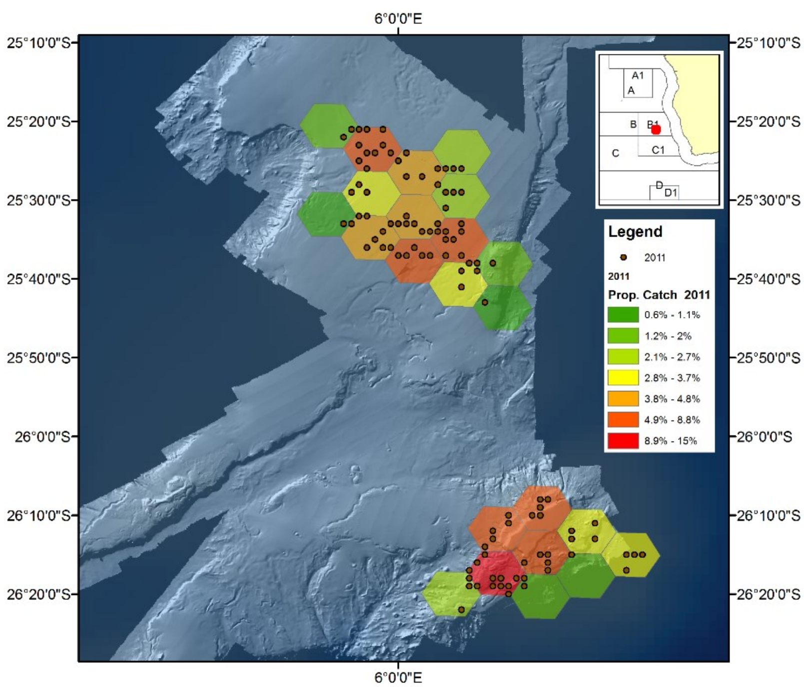

Figure 3: The spatial distribution of Deep-sea red crab during 2011 in SEAFO Division B1.

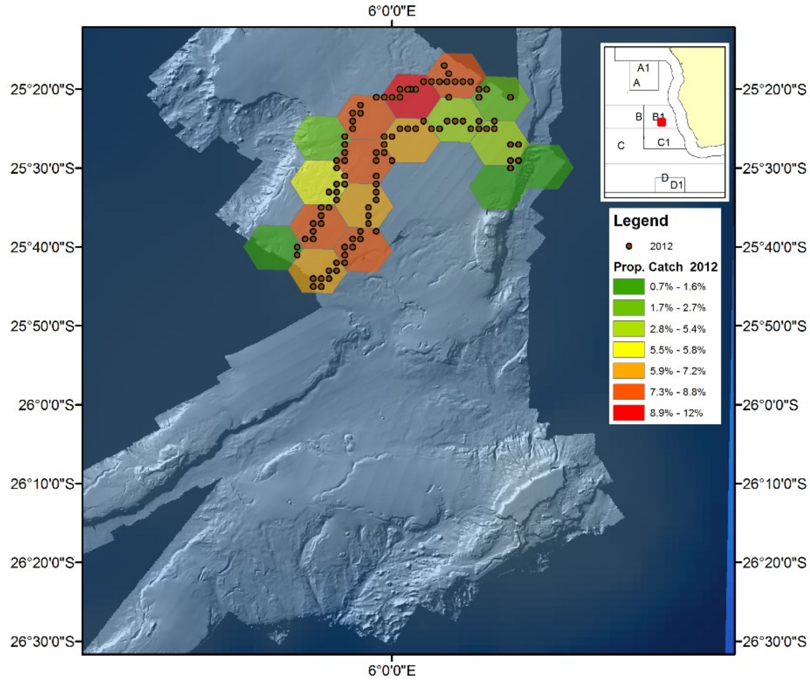

Figure 4: The spatial distribution of Deep-sea red crab during 2012 in SEAFO Division B1.

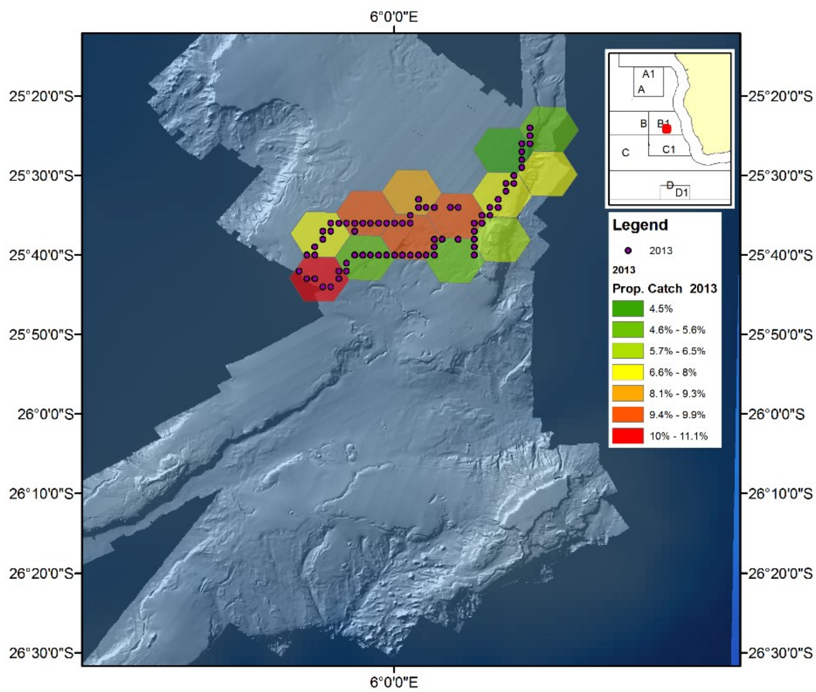

Figure 5: The spatial distribution of Deep-sea red crab during 2013 in SEAFO Division B1.

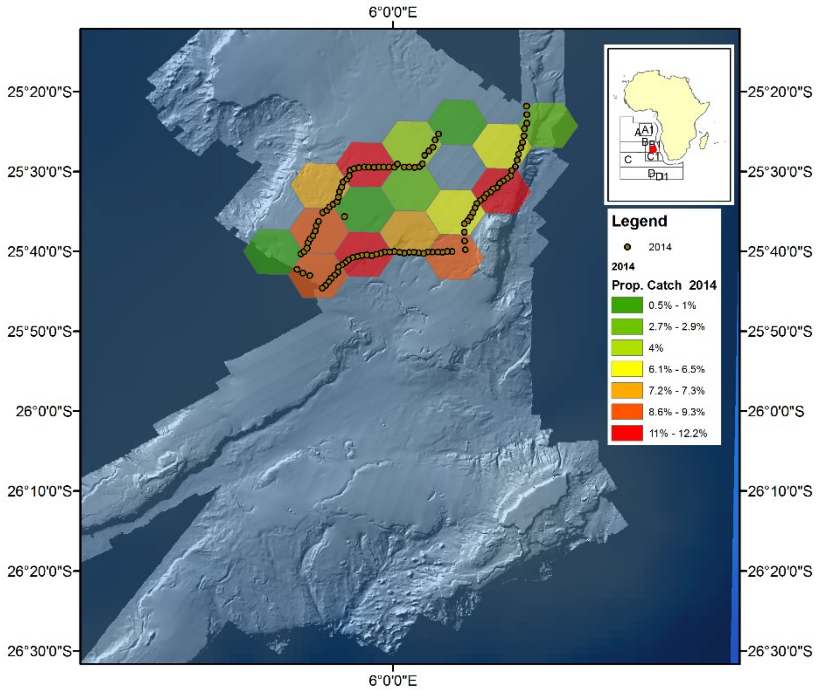

Figure 6: The spatial distribution of Deep-sea red crab during 2014 in SEAFO Division B1.

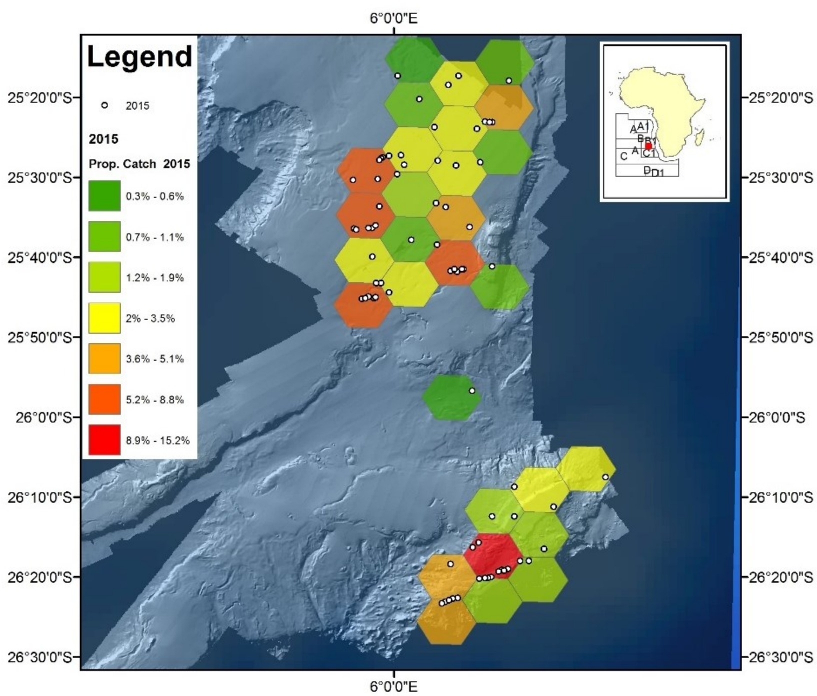

Figure 7: The spatial distribution of Deep-sea red crab during 2015 in SEAFO Division B1.

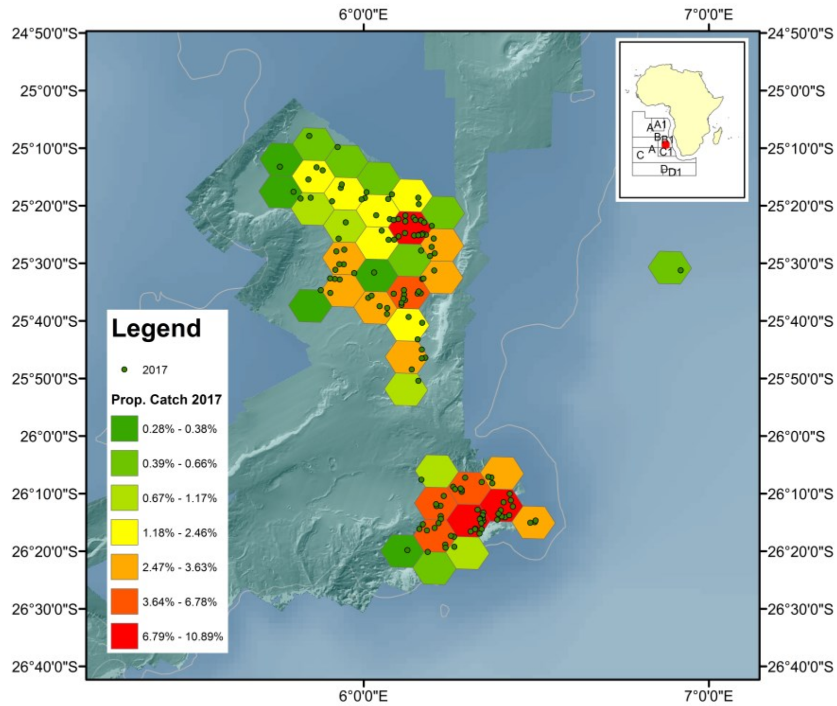

Figure 8: The spatial distribution of Deep-sea red crab during 2017 in SEAFO Division B1.

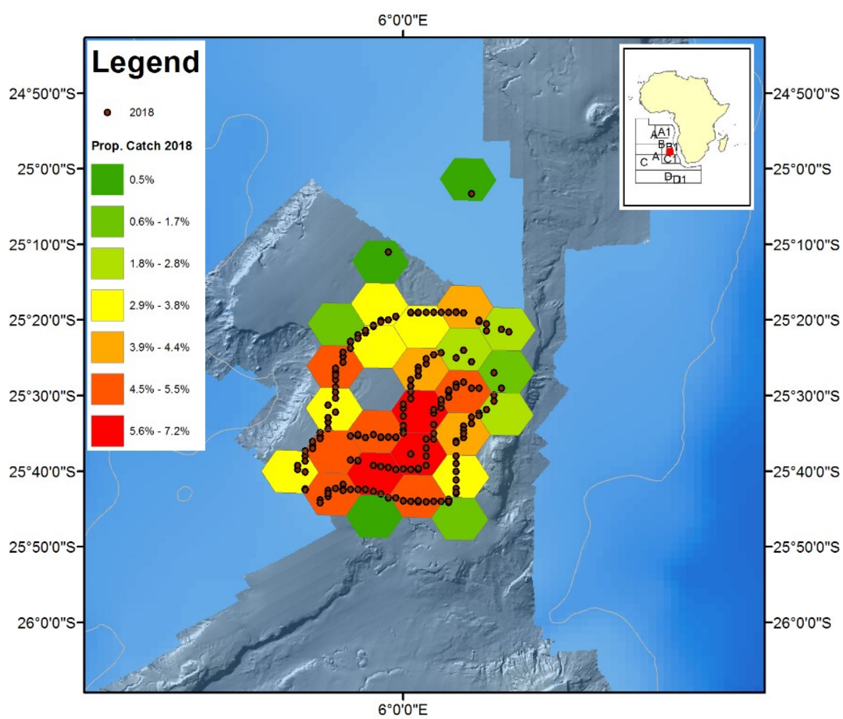

Figure 9: The spatial distribution of Deep-sea red crab during 2018 in SEAFO Division B1.

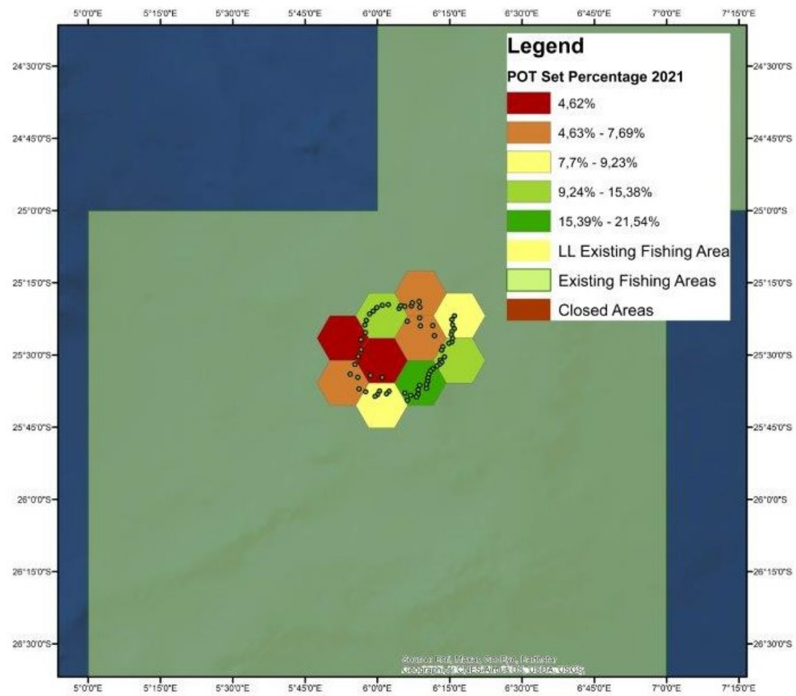

Figure 10: The spatial distribution of Deep-sea red crab during 2020 & 2021 in SEAFO Division B1. This catch position data shown here represents a single fishing trip that spanned the months of December 2020 and January 2021 – for this reason the data were presented on a single map (and not split into two separate maps – i.e. 2020 and 2021 maps).

1.3 Reported retained catches and discards

Reported landings (Table 3) comprise of catches made by Japanese, Namibian, Spanish, Portuguese and Korean-flagged vessels over the period 2001-2021. No fishing for Deep-sea red crab took place during 2022. From Table 3 the two main players in the SEAFO Deep-sea red crab fishery are Japan and Namibia, respectively, with Spanish and Portuguese vessels having only sporadically fished for Deep-sea red crab in the SEAFO CA over the period from 2003 to 2007. Spanish-flagged vessels actively fished for Deep-sea red crab in the SEAFO CA during 2003 and 2004, whereas Portuguese-flagged vessels only fished for Deep-sea red crab during 2007. The only reported catch outside SEAFO Division B1 was made by Portugal in SEAFO Division A1 during 2007.

Table 3: Catches (tonnes) of Deep-sea red crab (*Chaceon* spp. – considered to be mostly *Chaceon erytheiae*)

Flag State	**Japan**		**Rep of Korea**		**Namibia**		**Spain**		**Portugal**		**Research**	
Fishing method	**Pots**		**Pots**		**Pots**		**Pots**		**Pots**		**Bottom Trawl**	
Management Area	**B1**		**B1**		**B1**		**UNK**		**A**		**B1**	
Year	**Retain**	**Discard**	**Retain**	**Discard**	**Retain**	**Discard**	**Retain**	**Discard**	**Retain**	**Discard**	**Retain**	**TOTAL**
2001			-	-			<1					**<1**
2002			-	-								**0**
2003			-	-			5					**5**

2004			-	-			24					**24**
2005	253	0	-	-	54							**307**
2006	389		-	-								**389**
2007	770		-	-	3	0			35			**808**
2008	39		-	-								**39**
2009	196		-	-	-	-	-	-	-	-		**196**
2010	200	0	-	-			-	-				**200**
2011	-	-	-	-	175	0	-	-	-	-		**175**
2012	-	-	-	-	198	0	-	-	-	-		**198**
2013	-	-	-	-	196	0	-	-	-	-		**196**
2014	-	-	-	-	135	0	-	-	-	-		**135**
2015	-	-	104	0	-	-	-	-	-	-		**104**
2016	-	-	-	-	-	-	-	-	-	-		**0**
2017	140	0	-	-	7	0	-	-	-	-		**147**
2018	-	-	-	-	173	0	-	-	-	-		**173**
2019	-	-	-	-	-	-	-	-	-	-		**-**
2020	31	0	-	-	-	-	-	-	-	-		**31**
2021	20	0	-	-	-	-	-	-	-	-		**20**
2022	-	-	-	-	-	-	-	-	-	-	<1	**<1**
2023*	-	-	-	-	-	-	-	-	-	-	-	**-**
TOTAL	**2,038**	**0**	**104**	**0**	**941**	**0**	**29**	**0**	**35**	**0**	**0**	**3,147**

* Provisional (August 2023). - = No Fishing. Blank fields = No data available.

Annual catches in relation to TAC for Deep-sea red crab in SEAFO Division B1 and the remaining SEAFO CA are illustrated graphically in Figure 11.

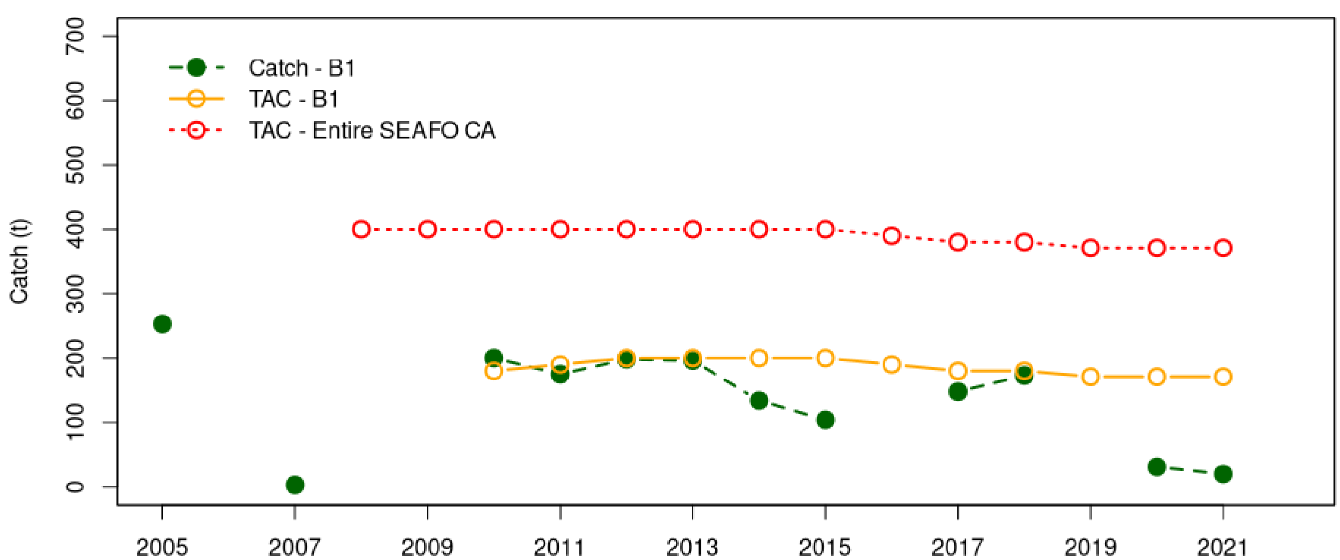

Figure 11: Annual catches in relation to TAC for Deep-sea red crab in SEAFO Division B1 and the remaining SEAFO CA. The only reported catch outside B1 is that made by Portugal in SEAFO Division A1 during 2007 (see Table 3 for clarity).

Being a pot fishery, the Deep-sea red crab fishery has an almost negligible bycatch impact. To date only 5kg of teleost (*Marine nei* and European sprat) fish discards have been recorded during 2010 from this fishery. As of 2010, however, minimal to moderate bycatches of king crabs have been recorded (see Section 5.3 for additional information).

1.4 Illegal, unreported and unregulated (IUU) catch

IUU fishing activity in the SEAFO CA has been reported to the Secretariat latest in 2012, but the extent of IUU fishing is unknown at present.

2. Stock distribution and identity

One species of Deep-sea red crab has been recorded in SEAFO Division B1, namely *Chaceon erytheiae* (López-Abellán *et al*. 2008) *and* is thus considered the target species of this fishery. Aside from the areas recorded in catch records the overall distribution of *Chaceon erytheiae* within the SEAFO CA is still unknown. Further encounter records documented through video footage during the 2015 FAO-Nansen VME survey in the SEAFO CA indicate that Deep-sea red crab are distributed across a major part of the Valdivia seamount range, as well as the Ewing and Vema seamounts (DOC/SC/22/2015).

3. Data available for assessments, life history parameters and other population information

3.1 Fisheries and surveys data

Fishery-dependent data exist only for more recent years (2010-2021) of the SEAFO Deep-sea red crab fishery (Fig. 12). During 2022 a small quantity of Deep-sea red crab (157 kg) was caught during a research bottom trawl survey in Division B1 – the results of which are still pending. Biological data from the fishery comprise gender-specific length-frequency, weight-at-length, female maturity and berry state data (Table 4).

Table 4: Sampling statistics from the Deep-sea red crab commercial fleet within the SEAFO CA (2010-2021). No fishing was recorded during 2016 and 2019.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2018**	**2020**	**2021**
Total number of sets	181	133	129	103	107	73	145	177	38	27
Total number of crabs sampled per set	30	30	30	30	100	136	100	100	100	100
Total number of crabs sampled	5430	3990	3600	3077	10654	32500	13500	17700	3800	2700

Very limited fisheries-independent data on Deep-sea red crabs exists for the SEAFO CA. A total of 479 Deep-sea red crabs were sampled during the 2008 Spanish-Namibia survey on Valdivia Bank. The data was collected over a depth range of 867-1660m. Additionally 127 Deep-sea red crab samples were collected on board the *RV Fridtjof Nansen* during the SEAFO VME mapping survey conducted at the start of 2015 (DOC/SC/22/2015).

3.2 Length data and frequency distribution

Available length-frequency data for crabs caught in the SEAFO CA over the period 2010-2021 are presented in Figure 12. Length-frequency data from all areas sampled in SEAFO Division B1 were pooled as no significant differences were detected between areas.

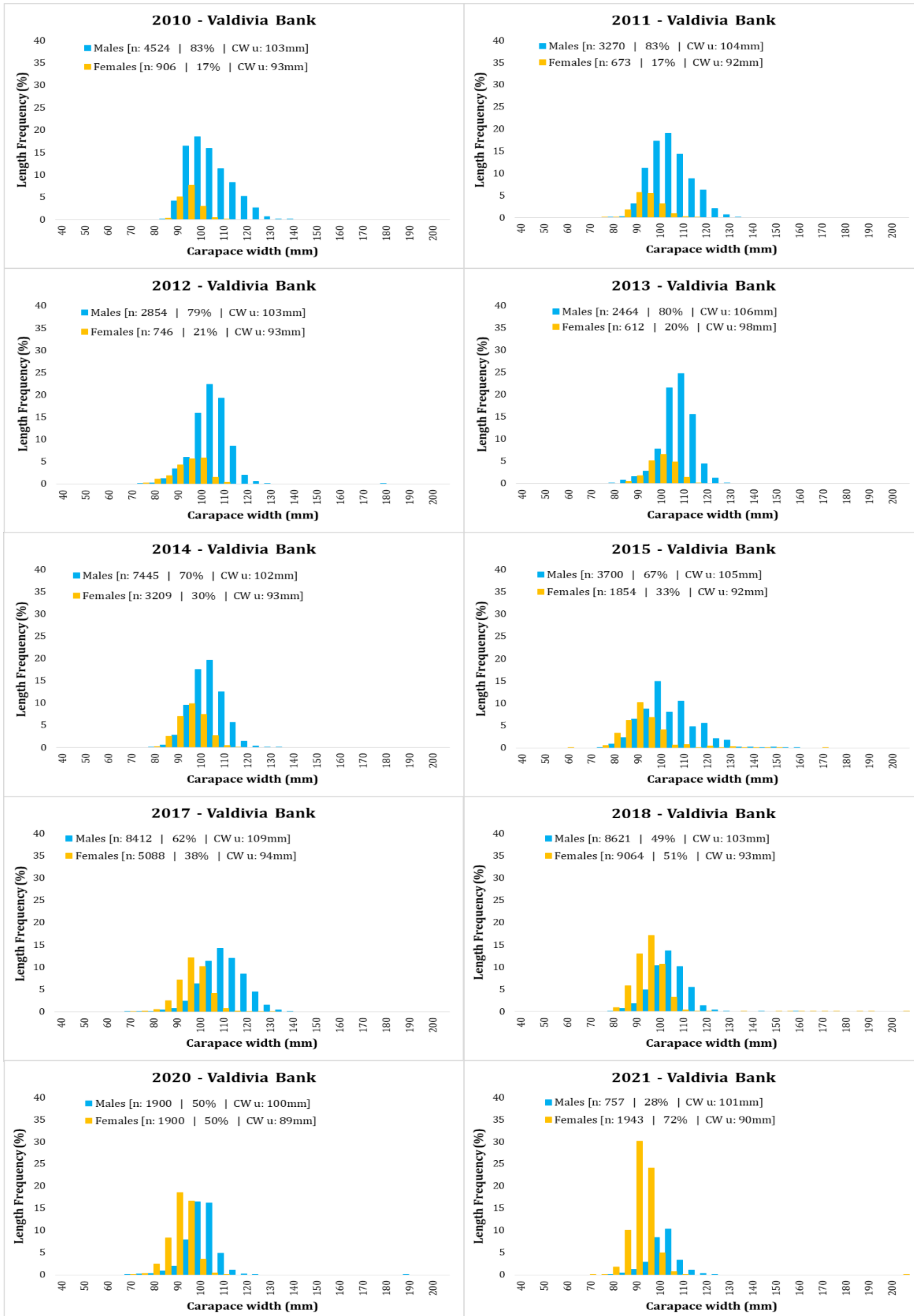

Figure 12: Carapace width frequencies (in percentages) of crabs sampled from commercial catches [2010-2015, 2017-2018 & 2020-2021]. Notes: “n” = sample size; “u” = mean carapace width.

For the period 2010-2021 there has been no significant changes in the female crab size distribution (Fig. 12). The male crab size distribution changed from a wider size distribution in 2010 and 2011, where larger male crabs were recorded, to a slightly narrowed size distribution in 2012 - 2014 of smaller crabs. During 2015 a lot more female crabs larger than 110mm were recorded than any preceding years since 2010 (Fig. 12). The male to female sex ratio of the crab commercial samples ranged from a maximum of 4:1 to around 2:1 in favour of male crabs – a well-known selectivity effect of the commercial traps used in this fishery.

Since the 2018 season, continuing into the 2020 and 2021 seasons, the biological dataset has revealed a peculiar trend in relation to the sex ratios of crabs sampled from the SEAFO commercial fleet (Fig. 12). Under normal circumstances male crabs generally dominate the commercial catch sex ratio (in terms of numbers) as a result of the well-known sexual dimorphism of crabs, and the retention bias of the fishing gear. Male crabs generally grow faster than female crabs and as a result attain greater sizes than similarly aged female crabs. Considering that the commercial traps have fixed mesh sizes, the traps generally retain more male than female crabs (as females, being smaller, easily fall out of the traps during the fishing process when traps are hauled from the seabed to the sea surface). For this reason commercial catches generally contain greater numbers of male crabs than females – which is clearly evident from the sex ratios of biological data recorded during former years, 2010-2017 (Fig. 12). This, however, changed in 2018 when the male to female sex ratios started to balance out and even reversed so that female crabs started to dominate the samples taken from commercial catches during the 2020 and 2021 fishing seasons (Fig. 12). This is a peculiar change in the commercial sex ratio as it was recorded by two vessels, i.e. *FV Crab Queen 1* and the *Seiryo Maru No. 1*, with the most pronounced sex ratio change recorded by the *Seiryo Maru No. 1* during January 2021 (Fig. 12). Further investigation into the latest sex ratio change is required to fully understand what the underlying cause for this anomaly could be.

3.3 Length-weight relationships

Length-weight relationship derived from catches on Valdivia Bank reveal the gender-specific growth disparity (Fig. 13). Male crabs grow at a faster rate than females and thus attain much larger sizes than female crabs. This species attribute, however, is not unique to *Chaceon erytheiae* and has been recorded for other crab species in the *Chaceon* genus (Le Roux 1997). Data from the 2008 survey show a much more coherent length-weight relation for both male and female crabs (Fig. 14).

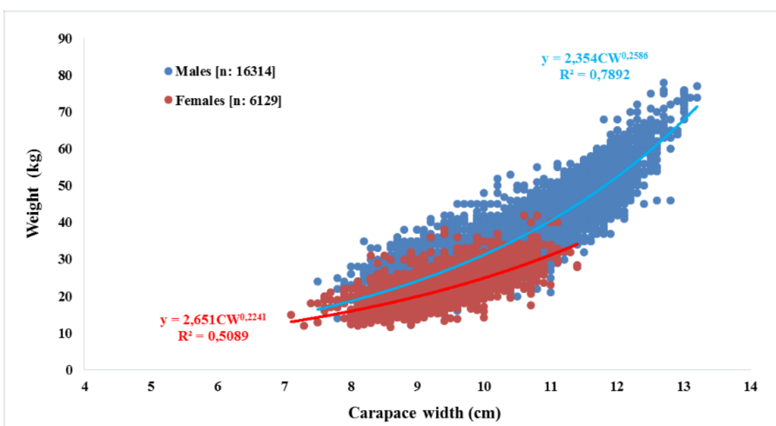

Figure 13: Length-at-weight data for *Chaceon erytheiae* as recorded from catches on Valdivia Bank (2008-2015). Red text show female length-weight relationship, blue text show male length-weight relationship.

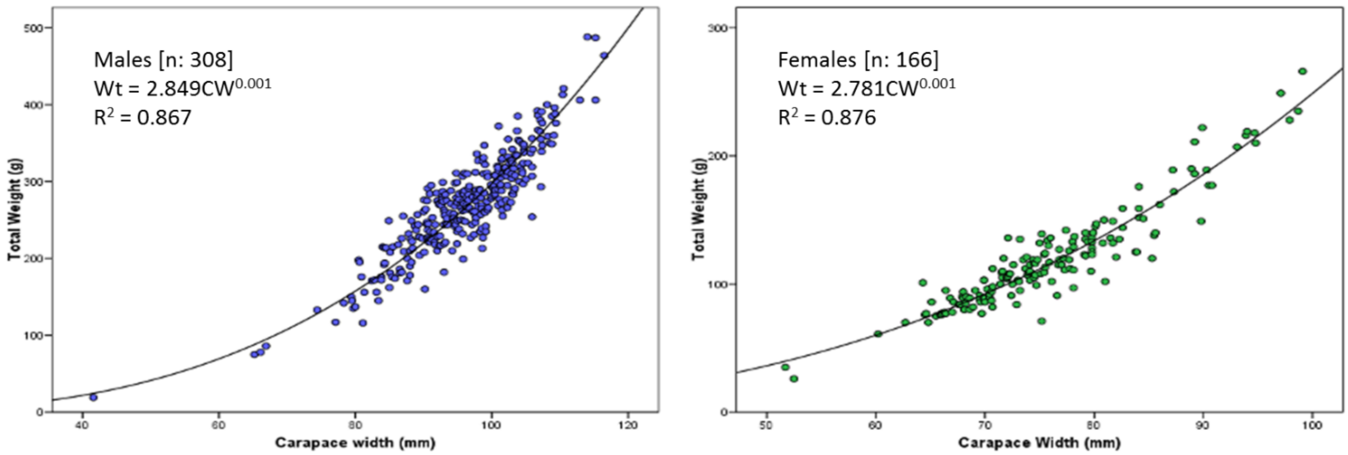

Figure 14: Length-at-weight data for *Chaceon erytheiae* as recorded from the 2008 Spain-Namibia survey (López-Abellán *et al*. 2008).

3.4 Age data and growth parameters

No information exists on the age and growth attributes of *Chaceon erytheiae*.

3.5 Reproductive parameters

Very limited reproductive data exist for *Chaceon erytheiae* from commercial samples. This dataset constitute female maturity and berry data collected during 2011-2015 & 2020-2021 in Division B1 – which (after cleaning) totalled 7,699 records (Table 5).

Table 5: The sexual maturity data for the SEAFO CA recorded in Division B1 (source: SEAFO Database).

Vessel ID	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2021**
CRAB QUEEN 1	626	568	534	2119			
MERIDIAN NO8					8		
SEIRYO MARU NO1						1900	1943

Some anomalies were observed in the sexual maturity data set that require further investigation and validation before a proper analysis can be conducted. Thus, at this point in time, the mating and spawning seasons for *C. erytheiae* within the SEAFO CA are still unknown.

3.6 Natural mortality

No natural mortality data exist for *Chaceon erytheiae*.

3.7 Feeding and trophic relationships (including species interaction)

No data exist for *Chaceon erytheiae*.

3.8 Tagging and migration

No data on migration exist for *Chaceon erytheiae* in the SEAFO CA.

4. Stock assessment status

4.1 Available abundance indices and estimates of biomass

Currently the only data available for the assessment for *C. erytheiae* abundance within the SEAFO CA are the catch and effort data from which a limited catch-per-unit effort (CPUE) series can be constructed.

4.2 Data used

The available SEAFO data (2005-2021) for purposes of considering possible assessment strategies are presented in Table 6.

Table 6: Description of the entire Deep-sea red crab database highlighting important datasets

Year	Flag State	Data Type - Source	Brief Description [NB Data Groups only]
2005	JPN	Catch Data – Observer Report	Set-by-Set data (vessel ID, set-haul positions & dates), Depth, Catch, Effort - (157 records).
2007	NAM	Catch Data –Observer Report	Set-by-Set data (vessel ID, set-haul positions & dates), Depth, Catch, Effort - (10 records - sets).
2010	JPN	Catch & Biological Data – Observer Report	Set data (vessel ID, set-haul positions & dates), Depth, Length, Weight, Catch, Effort - (Catch: 181 records, Biological: 5430 records).
2011	NAM	Catch & Biol. Data – Observer Report	Set-by-Set data (vessel ID, set-haul positions & dates), Depth, Length, Weight, Catch, Effort - (Catch: 133 records, Biological: 3990 records).
2012	NAM	Catch & Biol. Data – Obs. Report & Captain's Logbook [log sheet data]	Set-by-Set data (vessel ID, set-haul positions & dates), Depth, Length, Weight, Catch, Effort - (Catch: 129 records, Biological: 3600 records).
2013	NAM	Catch Data – Captain's Logbook [log sheet data]	Set-by-Set data (vessel ID, set-haul positions & dates), Depth, Catch, Effort - (Catch: 103 records, Biological: 3090 records).
2014	NAM	Catch Data – Captain's Logbook [log sheet data]	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 107 records, Biological: 10660 records)
2015	KOR	Catch Data – Fishing Logbook data	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 73 records, Biological: 5554 records)
2017	JPN & NAM	Catch Data – Fishing Logbook data	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 142 records, Biological: 5554 records)
2018	NAM	Catch Data – Fishing Logbook data& Biological Data (not from Observer Report)	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 177 records, Biological: 17700 records)
2020	JPN	Catch Data – Fishing Logbook data & Biological Data	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 38 records, Biological: 3800 records)

2021	JPN	Catch Data – Fishing Logbook data & Biological Data	Set-by-Set data (vessel ID, set-haul positions and dates), Depth, Length, Weight, Catch, Effort – (Catch: 27 records, Biological: 2700 records)

4.3 Methods used

CPUE Standardization:
As part of the annual updating of the Deep-sea red crab abundance index another attempt was made during 2021 at standardizing the CPUE index. Following the outcomes of the 2015 assessment that revealed "SoakTime" as an unreliable factor for consideration in the CPUE standardization, "SoakTime" was again omitted from the 2021 standardization of the annual CPUE from the SEAFO Deep-sea red crab fishery. Table 7 outlines the number of sets used in the CPUE standardization.

Table 7: Number of sets per year for which catch and effort data are available for the CPUE standardization. No fishing was recorded during 2016 and 2019.

2005	**2007**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2018**	**2020**	**2021**
157	10	181	133	129	103	107	73	142	177	38	27

The records from 2007 were excluded from the analysis as they were derived from an area not exploited in the remaining years, constituting only 10 sets, and were not comparable to datasets from the rest of the data series. In addition to this the 7 sets from a Namibian vessel that conducted some very uncharacteristic crab fishing operations during 2017 were also removed from the analysis as the data from this vessel was severely disparate (both in terms of total set number and catch) from all of the remaining data in the SEAFO database.

The following variables from each record were considered in the model:

Year	-	A 12-month period – explanatory variable (covariate).
SEASON	-	The seasonal cycle – explanatory variable (covariate).
Vessel ID	-	Identification code for a participating vessel – explanatory variable (covariate).
Zone	-	Identification code for a fishing area – explanatory variable (covariate).Co-ordinates where categorized into three smaller fishing zones reflecting the fishing records within Division B1.
Depth	-	Fishing depth – explanatory variable (covariate). Depth was categorized into 50 metre intervals covering the entire range of depths recorded by the fishery.
Pots	-	The number of baited pots used per set during fishing operations – explanatory variable (co-variate).
CPUE	-	Catch/number of pots – response variable.

4.4 Results

Results from the CPUE standardization are presented below to illustrate some of the more important outputs and methods applied.

The maximum set of model parameters offered to the stepwise selection procedure was:

$$\text{CPUE} = \beta_0 + \beta_1\ \text{Year} + \beta_2\ \text{Vessel ID} + \beta_3\ \text{Depth} + \beta_4\ \text{Zone} + \beta_5\ \text{Season} + \beta_6\ \text{Pots} + \varepsilon$$

A stepwise backward model selection procedure was deployed in selecting the covariates, to the model. The model with lowest Akaike value (AIC - Akaike Information Criterion) was selected as the best model, since it has a better predictive power. The best model (outlined below) was then used for further analysis.

$$CPUE = \beta_0 + \beta_1 \text{ Year} + \beta_2 \text{ Depth} + \beta_3 \text{ Zone} + \beta_4 \text{ Season} + \varepsilon$$

Table 8 presents the estimates of the coefficients, standard error and *t* values for different variables selected in the best model. The four model covariates year, depth, zone and season all had highly significant p-values and as such indicated strong predictive effects on the Deep-sea red crab catch rates (CPUE).

Table 8: ANOVA results for the CPUE model

Covariates	Df	Deviance	Residual Df	Residual Deviance	Pr(>Chi)
NULL			1262	1546.83	
Year	10	713.11	1252	833.72	< 2.2e-16 ***
Depth	17	30.79	1235	771.34	1.481e-14 ***
Zone	2	7.00	1233	755.13	1.316e-06 ***
as.factor(SEASON)	3	7.85	1230	736.44	7.668e-07 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Model diagnostics of the best model were assessed. This involved checking for normality of the residuals and the spread of the residuals across the fitted values. A total of 82 outliers were removed (out of a total of 1198 data points – i.e. outliers removed equates to 6.8% of entire dataset) on the basis of residual skewness and

Cook’s Distance disparity. After the removal of the outliers diagnostic plots revealed improve distributions thus indicating that model assumptions were not violated. QQplots of the residuals indicated that the model residuals were well within the excepted limits for data skewness (Fig. 15). Plots of the residuals versus fitted values indicated evenly distributed data points, no overridingly skewed patterns in the plot (Fig. 15). Therefore there is no evidence of non-constant error variance in the residual plot and independence assumption also appeared reasonable.

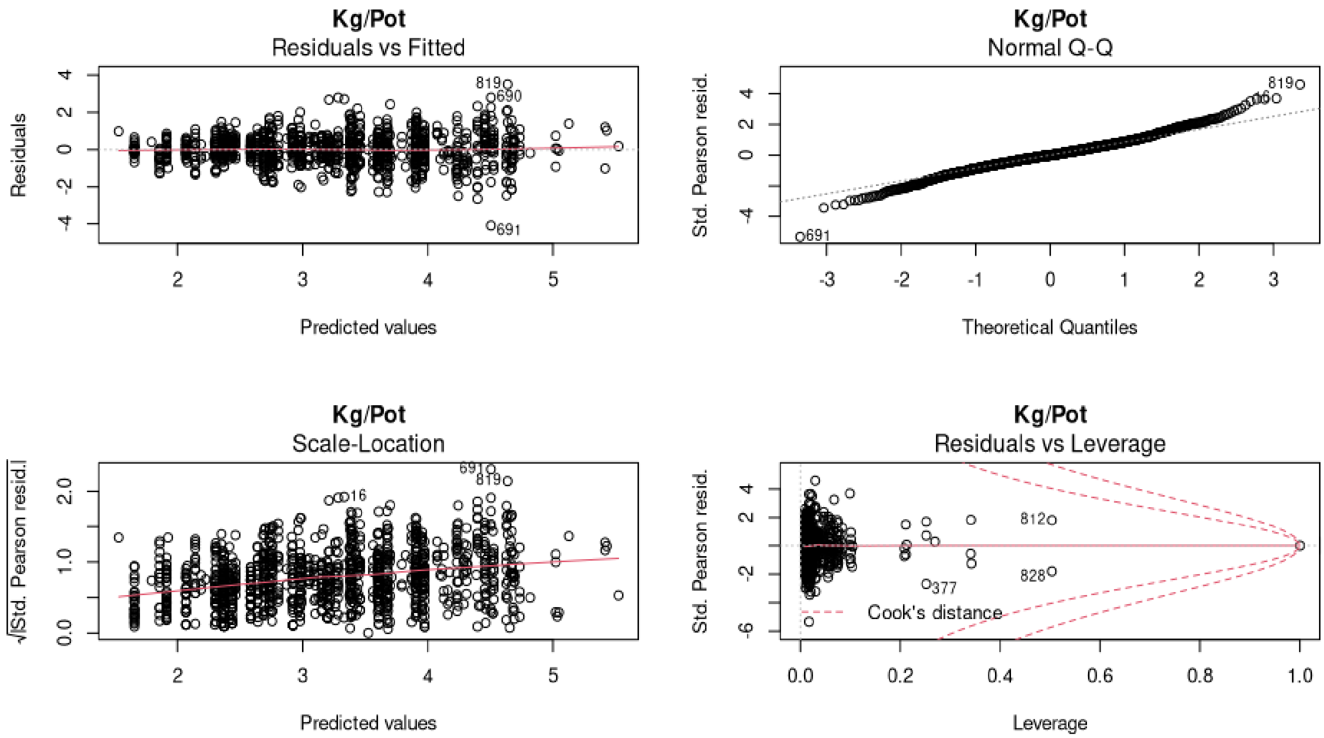

Figure 15: QQ and Studentized Residual Plots of the best fit model for retained catch CPUE (kg/pot).

Results from the standardized CPUE exercise suggest that the CPUE has fluctuated during the period 2005 to 2015. However, the confidence margins are fairly wide for the main part of the CPUE series (especially for 2013 and 2015 – Fig. 16), which indicates that the CPUE for these years (i.e. 2005, 2013 & 2015) are more comparable to each other than the CPUEs for the rest of the time series (Fig. 16). Furthermore, with the exception of 2010 - 2017 the CPUEs for the last two years of the data series were very close to zero (0.08 and 0.05 Kg/Pot, respectively) (Fig. 16).

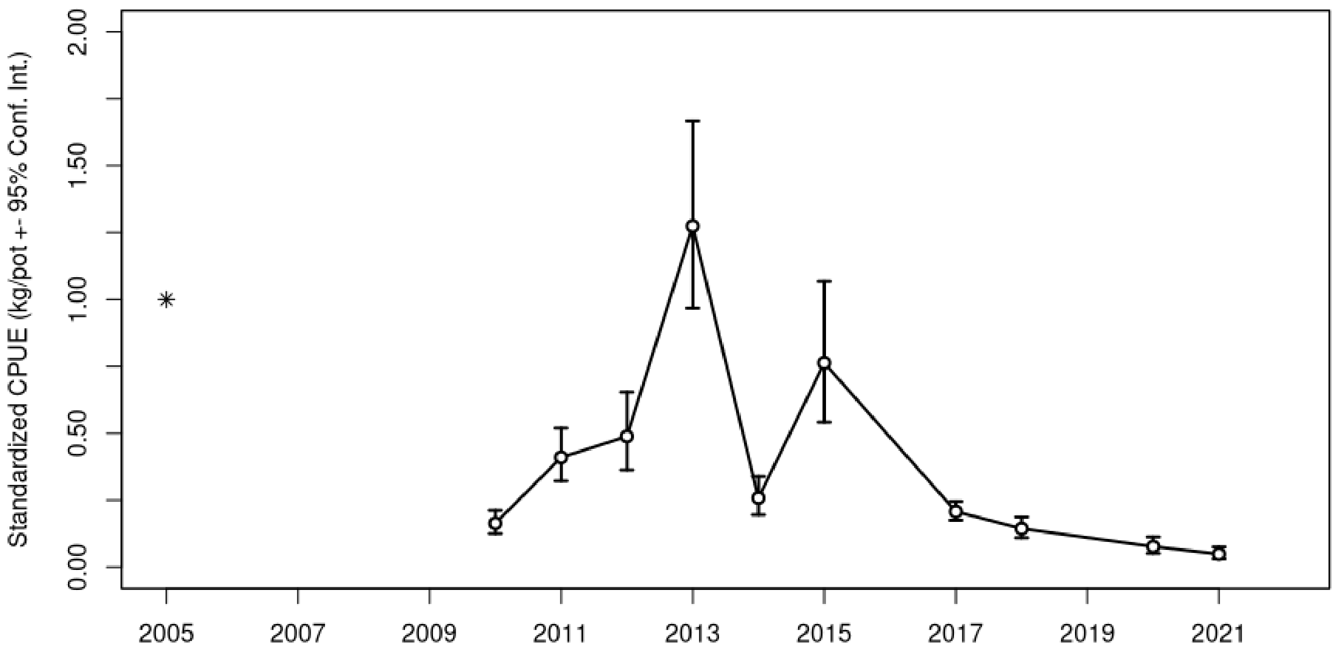

Figure 16: Trends in catch CPUE indexes for catches per pot – with soak time as a categorical variable (factor) not included in the model. Standardized Index (black line) with the 95% Confidence Intervals (whiskers).

4.5 Discussion

In light of new catch and effort data received from the Deep-sea red crab fishery in 2015 another run on the standardization of crab CPUE series was conducted in 2015. In contrast to the CPUE standardization of 2014, soak time was not considered as a predictive variable or covariate in the GLM implemented during 2015. The reason for this were twofold: - firstly, the soak times recorded for the 2015 crab fishing operations were far in excess of those calculated for years prior to 2015; and secondly, there doesn't seem to be any correlation between the viability of bait and catch rates in the crab fishery that would necessitate the inclusion of soak time as a predictive variable in the CPUE standardization. For these reasons the CPUE calculated in 2015 for the crab fishery is referenced as "Kg/Pot" and not "Kg/Pot.Hour" as was the case in 2014. The CPUE standardization revealed that, although the data series is very short, there were no severe changes in the CPUE trend since 2010 and that it is well within range of the 2005 CPUE.

In 2014 an exploratory Length Cohort Analysis (LCA) was conducted, and was found to be inconclusive but nevertheless indicated that the SEAFO Deep-sea red crab resource is not in any risk of over-exploitation. This exploratory exercise has not been repeated since 2014.

SC discussed in 2014 the possibility of applying the harvest control rule and it was decided that the Greenland Halibut harvest control rule used in NAFO may be the most appropriate option for Deep-sea red crab. This was adopted by the Commission in 2014.

In 2014 approximately 50% of the TAC was caught. The reason for this is unknown to the SC. At this point in time there are no indications why the TACs for SEAFO Division B1 were not landed fully in 2014, 2015, 2017, 2020 and 2021 (Fig. 11).

4.6 Conclusion

The biological data series obtained from the SEAFO Deep-sea red crab fishery, although temporally limited, is of relatively good quality. Nevertheless, important data such as growth parameter for the *C. erytheiae* stock, which will enhance the cohort analyses of the resource, was not available for the SEAFO CA and emphasis needs to be given in collecting this data for future assessments.

4.7 Biological reference points and harvest control rules

At this point in time it should be noted that no biological reference points exist for this stock in the SEAFO CA.

However, it is worthwhile to note that the *C. erytheiae* stock, based on the grounds of it being a long-lived and relatively stable stock, is a good candidate for an empirical Harvest Control Rule (HCR) similar to that applied to the Greenland halibut stock by the North Atlantic Fisheries Organization (NAFO). This is a simple HCR that merely considers that slope of an abundance index such as the CPUE and applies a catch limit to future years based in the current year's TAC. The concept is as follows:

$$TAC_{y+1} = \begin{cases} TAC_y \times (1 + \lambda_u \times slope) & if \quad slope \geq 0 \quad \textbf{...rule 1} \\ TAC_y \times (1 + \lambda_d \times slope) & if \quad slope < 0 \quad \textbf{...rule 2} \end{cases}$$

Slope: average slope of the Biomass Indicator (CPUE, Survey) in recent 5 years.

- λ_u :TAC control coefficient if slope >= 0 (Stock seems to be growing) : $\lambda_u = 1$
- λ_d :TAC control coefficient if slope < 0 (Stock seems to be decreasing) : $\lambda_d = 2$
- TAC generated by the HCR is constrained to ± 5% of the TAC in the preceding year.

For the interim this is considered to be a fairly good starting point, given the current status of the *C. erytheiae* resource, until such time that additional data are available for more advance stock assessment approaches.

5. Incidental mortality and bycatch of fish and invertebrates

5.1 Incidental mortality (seabirds, mammals and turtles)

No incidental catches of seabirds, mammals and turtles have been recorded from the Deep-sea red crab fishery to date.

5.2 Fish bycatch

Incidental and bycatch records from the Deep-sea red crab fishery indicate that only one species is currently impacted by this fishery.

Table 6: Incidental (bycatch) catch from the Deep-sea red crab fishery (kg).

	2009	2010	2011	2012
Species	**-**	**B1**	**-**	**-**
***MZZ**		5.23		

*** Marine Nei fishes (*Osteichthyes*)**

5.3 Invertebrate bycatch including VME taxa

Very limited bycatches of invertebrate and VME taxa have been reported from the SEAFO Deep-sea red crab fishery. To date roughly 1343kg of King crab (*Lithodes ferox* – KCA) bycatches been recorded from the Deep-sea red crab fishery in Division B1 (Fig. 17 & 18). All these bycatches were made during 2015 only.

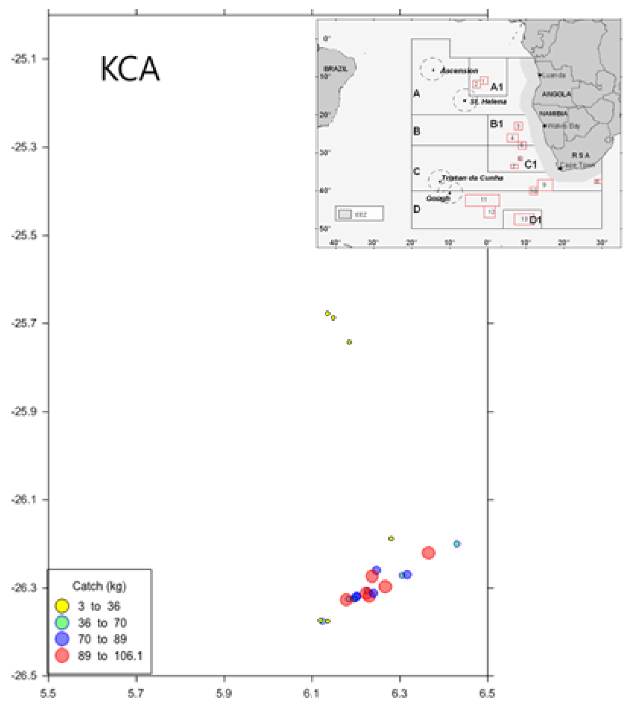

Figure 17: Spatial reference of King crab (*Lithodes ferox*) bycatches recorded from the Deep-sea red crab fishery in SEAFO Division B1 during 2015.

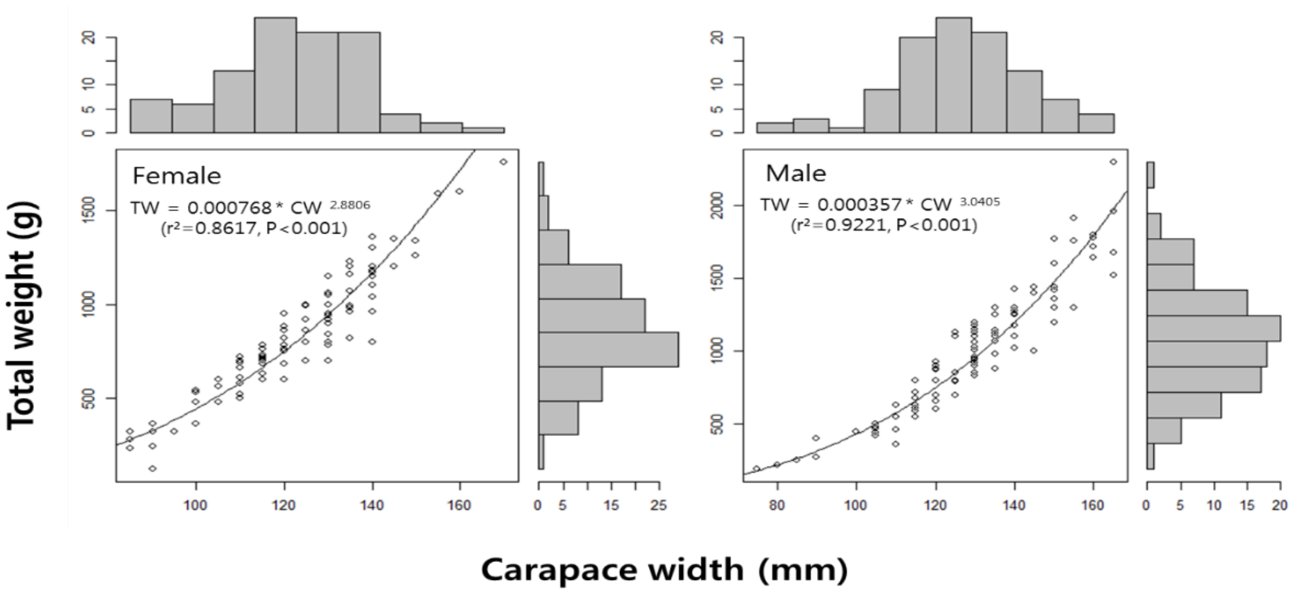

Figure 18: Sample statistics of King crab bycatches recorded by the Deep-sea red crab fishery in SEAFO Division B1 during 2015.

Incidental bycatches of VME indicator species have been minimal, and to date no bycatches exceeding the encounter thresholds have been recorded from the SEAFO Deep-sea red crab fishery.

5.4 Incidental mortality and bycatch mitigation methods

There currently exist no incidental and bycatch mitigation measures for the Deep-sea red crab fishery in the SEAFO CA.

5.5 Lost and abandoned gear

Two incidences of lost gear was report during 2017 for a new fishing vessel (*MFV Noordburg Kalapuse*– Call Sign: V5WO). The two incidents were report on 20 & 22 February 2017, the locations where the gear was lost are indicated in Figure 19 and a description of the lost gear lost is outlined below:

Gear Type: Crab pots, search grabber, 4 line anchors, 12 weight bars and 20 floats.
Quantity: 6 pots lost offline and 608 pots lost attached to the line. Search grabber, 4 anchor lines and 12 weight bars. Twenty floats attached to the lost line.

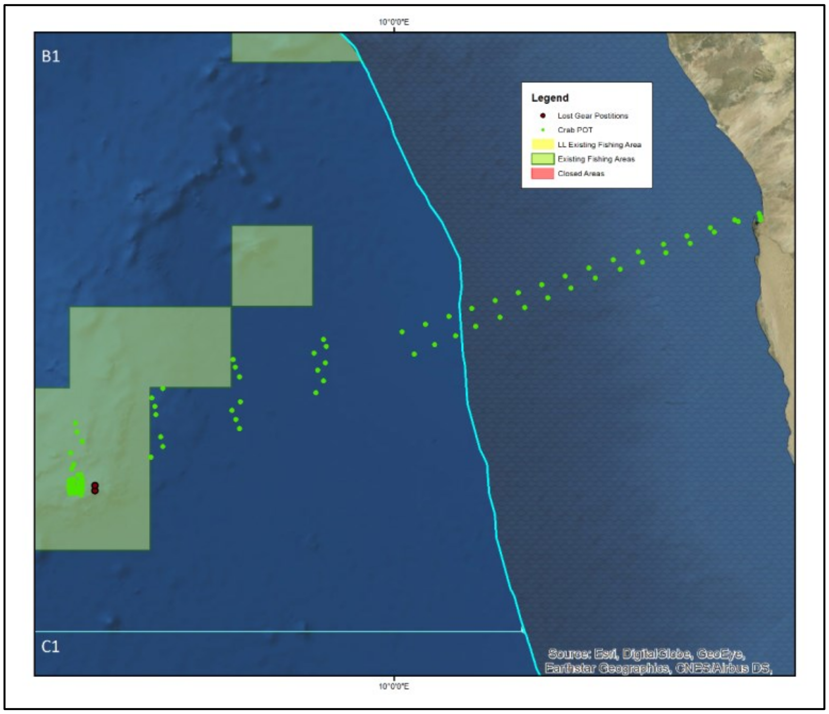

Figure 19: Positions of crab fishing gear lost by the MFV Noordburg Kalapuse 20 and 22 February 2017.

5.6 Ecosystem implications and effects

The SEAFO Deep-sea red crab fishery has very limited to no negative ecosystem impacts in terms of it temporal and spatial context.

6. Current conservation measures and management advice

6.1 Current conservation measures

The current conservation measures in use can be seen in Table 7 below.

Table 7: Conservation Measures that are applicable to the Deep-sea red crab fishery in the SEAFO CA.

Conservation Measure 04/06	Conservation of sharks caught in association with fisheries managed by SEAFO.
Conservation Measure 14/09	Reduce sea turtle mortality in SEAFO fishing operations.
Conservation Measure 25/12	Reducing incidental bycatch of seabirds in the SEAFO Convention Area.
Conservation Measure 30/15	On the Management of Vulnerable Deepwater Habitats and Ecosystems in the SEAFO Convention Area
Conservation Measure CM-TAC-01 (2023)	On Total Allowable Catches and related conditions for Patagonian toothfish, Deep-sea red crab, Alfonsino, Orange Roughy and Pelagic Armourhead for 2024 in the SEAFO Convention Area.

6.2 Management advice

Fishing activities in 2021 provided the required catch and effort data to update the CPUE series (which formed the basis for the application of the HCR as adopted by the Commission in 2015). The SC applied the HCR based on CPUE trend illustrated in Figure 20.

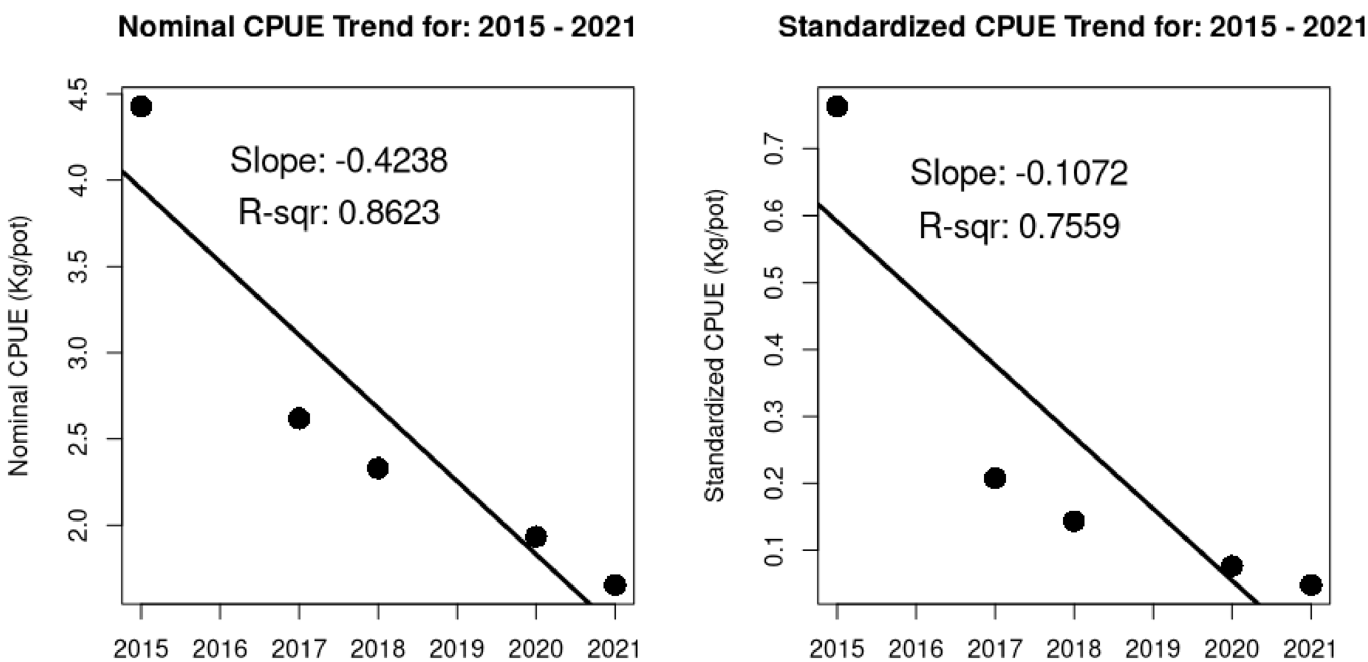

Figure 20: Comparison of the regression lines fitted to both the nominal and standardised CPUEs (2015-2021) for use in the Harvest Control Rule.

Considering that no catches were recorded outside Division B1 the 2024 & 2025 TAC recommendations are only applied to Division B1.

$$TAC_{2024} = TAC_{2021} * (1 + (2 * \text{slope}))$$

$$TAC_{2024} = 171 \text{ tonnes} * (1 + (2 * -0.4238))$$

$$TAC_{2024} = 26 \text{ tonnes}$$

The SC agreed to adopt the best estimate of the slope which is -0.4238. Under this scenario the HCR stipulates the use of “Rule 2” for setting the TAC.

The difference between the 2022-2023 and proposed 2024 TAC is greater than the 5% limit stipulated by the HCR. **SC therefore recommends a TAC for 2024 and 2025 be set at 162 tonnes for Division B1, and 200 tonnes for the remainder of the SEAFO CA.**

Significant crab fisheries have been conducted in B1 since 2005, and at the start of the CPUE series (2013) the fishery was well established. This is thus not a new fishery where a strong decline in the CPUE might be expected. The perception in 2017 of a stable fishery with no significant negative trend was based on a CPUE series for the years 2010-2017 (but with 2016 missing). For the shorter but more reliable series from 2013-

2018, the slope is negative and the CPUE level in 2018 is only about 50% of that in 2013. This suggests a fast-declining abundance, i.e. a result in stark contrast to the perception last year. In addition, significant changes in the sex composition were observed during the time-series, with a decline in the proportion of males, and the larger individuals. The decline in CPUE and the sex composition/size composition change are worrying signs and creates uncertainty that requires cautious action.

The HCR was designed during a period when the crab fishery was perceived as relatively stable or varying without trend. It was not designed to handle a situation of strong and steady decline in CPUE as suggested by the 2013-2021 CPUE series. Using the HCR and the "Rule 2" produces a TAC = 26 t. However, the TAC becomes 162 t when applying the 5% restriction on changes between consecutive years.

7. References

Le Roux L. 1997 – Stock assessment and population dynamics of the Deep-sea red crab *Chaceon maritae* (Brachyura, Geryonidae) off the Namibian Coast. M.Sc. thesis, University of Iceland, Department of Biology. 88 pp.

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