STATUS REPORT

Pseudopentaceros richardsoni
Common names: Pelagic armourhead, Southern boarfish

2017
Updated 21November 2017

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1. Description of the fishery

1.1 Fishing fleets and fishing gear

In recent years the Korean trawl fishery was the only fishery targeting the pelagic armourhead in the SEAFO CA. It started in 2010 but due to the depletion of the pelagic armourhead stock, the fishery finished in 2014. During the period 2010-2013 two fishing vessels participated in the fishery, F/V Adventure and F/V Dongsan Ho.

Although primarily considered as a midwater trawl fishery, 94% of the tows recorded by onboard observers were classified as “Demersal”. Whether or not these trawls were bottom trawls remains uncertain, and this is an issue that still requires clarification.

At the SEAFO CA the F/V Adventure stern trawler operated with the following fishing gears (Table 1 and Figs. 1- 4 provide the specifications of the fishing gears):

- HAMPIDJAN NET is a bottom otter trawl with two-piece nets of 66 m in length. The head rope is 48 m long; ground rope is 50 m; the height, width and girth of the net are 5.5 m, 30 m and 100 m, respectively. The cod-end mesh size is 120 mm. The ground gear is 50 m in length and 903 kg in weight, and the float is 1,018 kg.
- MANUFACTURED NET is a four-piece net with a overall length of 66.9 m. The lengths of the head rope and ground rope are 59.0 m and 77.9 m, respectively. The height, width and girth of the net are 5.5 m, 200 m and 83 m, respectively. The cod-end mesh size is 120 mm. The ground is 77.9 m in length and the weight of the ground is 2,068 kg. The float is 913.200 kg with the floating rate of 44%.
- MIDWATER NET is 210 m long. The lengths of head rope and ground ropes are 93.6 m. The height and width of the net are 70.0 m and 240-260 m, respectively. The girth of the net is 816 m and the cod-end mesh size is 120 mm.

Table 1: Specifications of the fishing gears available at F/V Adventure.

Gear Specifications		HAMPIDJAN NET bottom trawl	MANUFACTURED NET bottom trawl	MIDWATER NET
Otter board	type	VRS-TYPE	VRS-TYPE	VRS-TYPE
	material	Steel	Steel	Steel
	size (mm)	2,300 x 4,030	2,750 x 4,900	1,854 x 3,818
	weight (kg)	3,930	4,320	2,000
	under water weight (kg)	2,619	2,473	1,145
Trawl Net	purpose	bottom fishing (figure1)	bottom fishing (figure2)	mid-water fishing (figure3)
	net length overall(m)	66	66.9	210.0
	head rope (m)	48	59.0	93.6
	ground rope (m)	50	77.9	93.6
	net height (m)	5.5	5.5	70
	net width (m)	30	200	240~260
	net girth (m)	100	83	816
	mesh size (mm)	120	120	120

At the SEAFO CA F/V Dongsan Ho, a stern trawler, operated with mid-water KITE trawl and the bottom trawl net PE Net. The mid-water KITE trawl (Fig. 4) includes ropes and has kites at the upper part and chains at the lower part . The height of the net's gate is approximately 50 m, and the total length is around 280 m. When net is settled, it sinks underwater and the sinking depth of the net is controlled by the wire ropes. The upper and lower parts of the bottom trawl net PE Net have attached plastic buoys and rubber balls respectively. As in the case of KITE gear the wire ropes control the sinking depth of the settled gear.

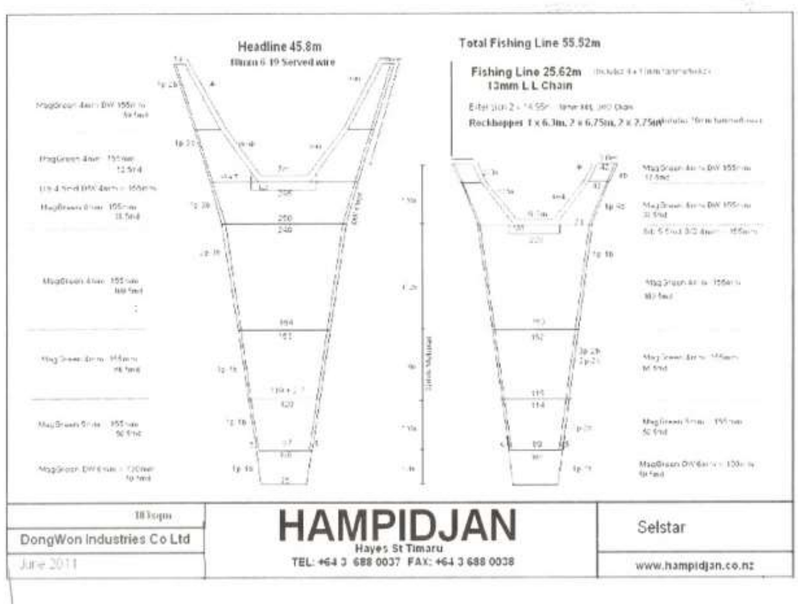


Figure 1: Diagram of HAMPIDJAN NET of F/V Adventure.

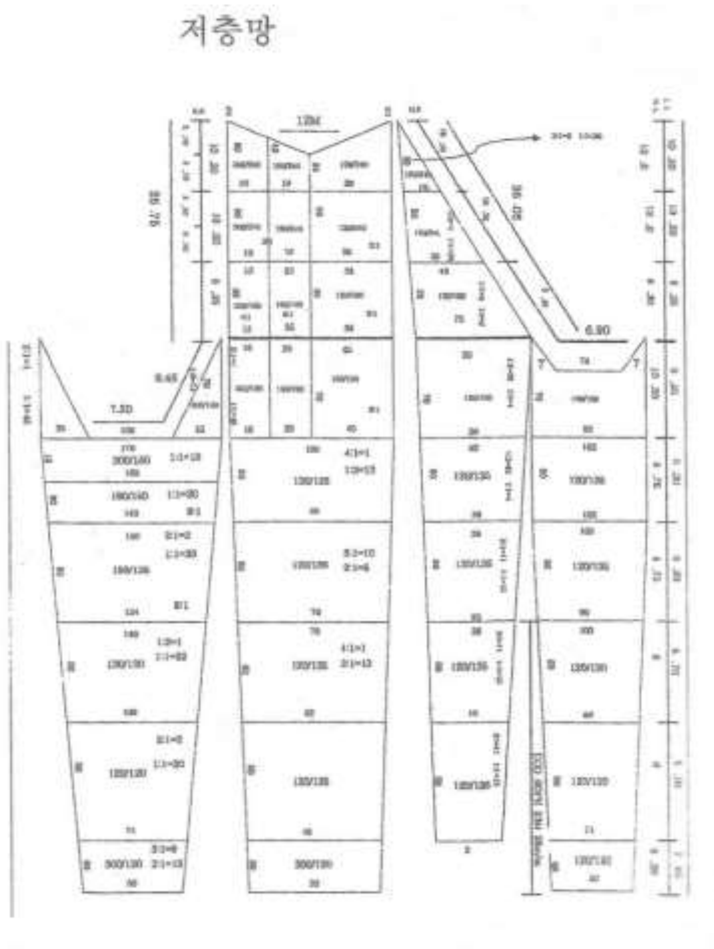


Figure 2: Drawing of the Custom Manufactured Bottom Trawl Net of F/V Adventure.

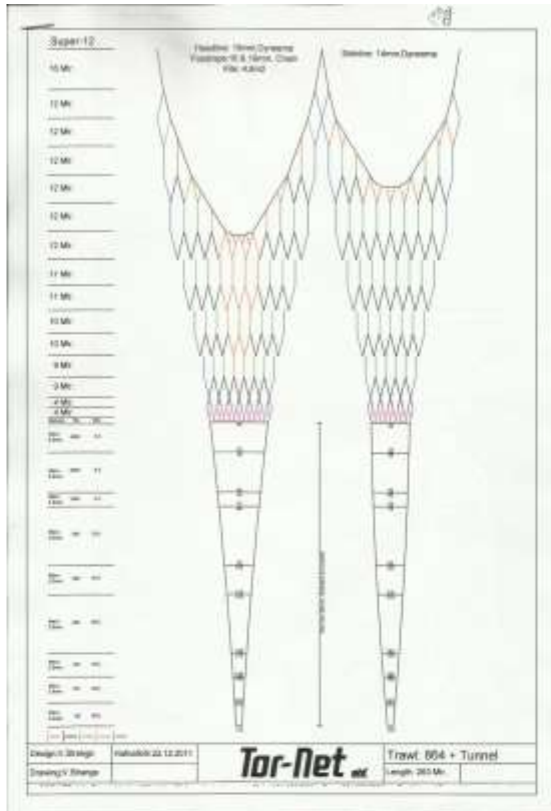


Figure 3: Drawing of mid-water trawl net of F/V Adventure.

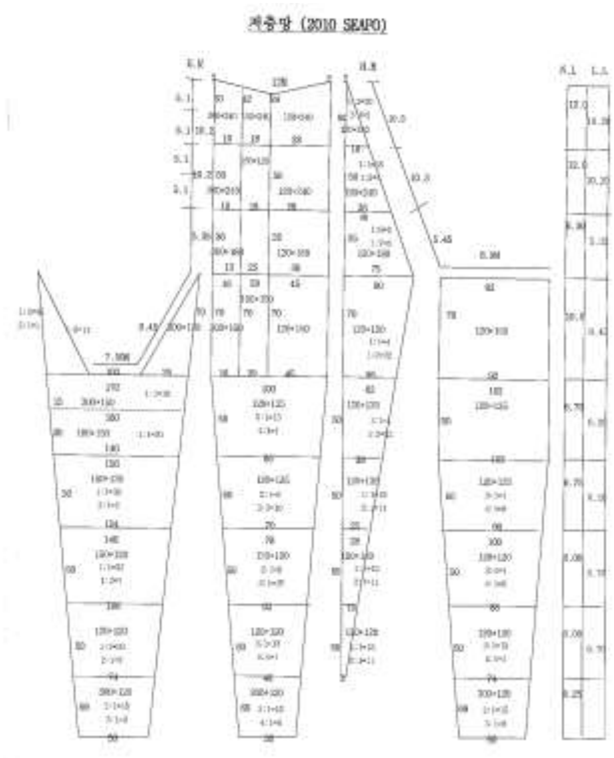
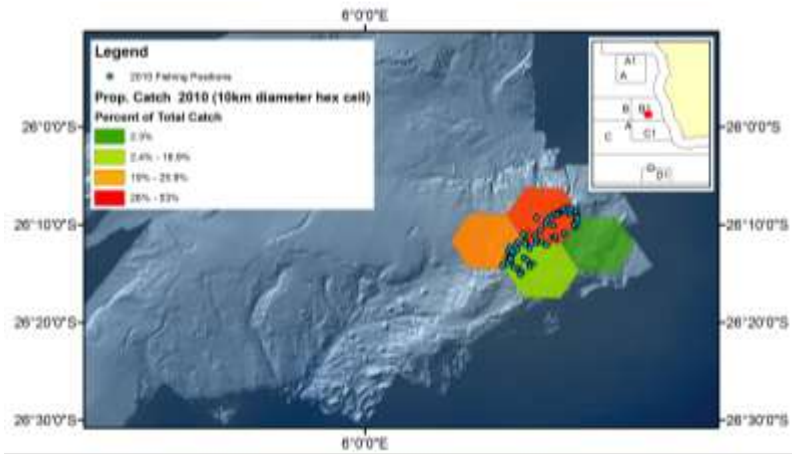


Figure 4: Drawing of mid-water KITE trawl of F/V Dongsan Ho.

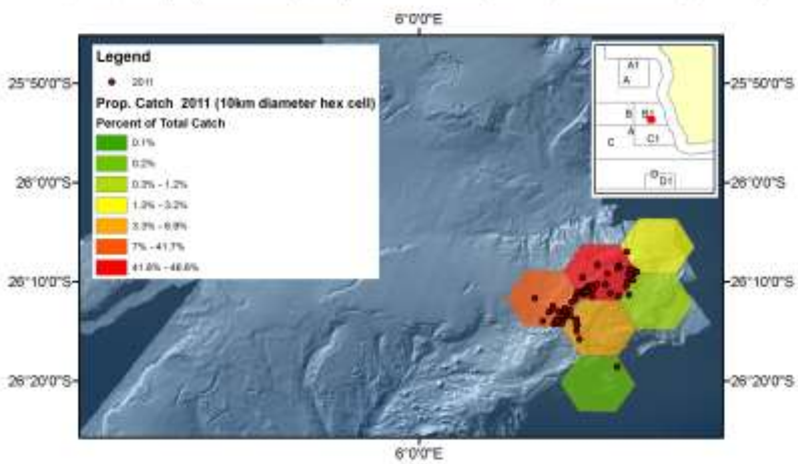
1.2 Spatial and temporal distribution of fishing

During the period 2010-2013 the Korean trawl fishery targeting pelagic armourhead took mainly place at the southern and northern parts of the Valdivia Bank, in Division B1 of the SEAFO CA (Figure 5). In addition, in 2013, a single haul was also conducted at North Walvis Ridge in Subdivision B1 (Table 1, Fig. 5, lower).

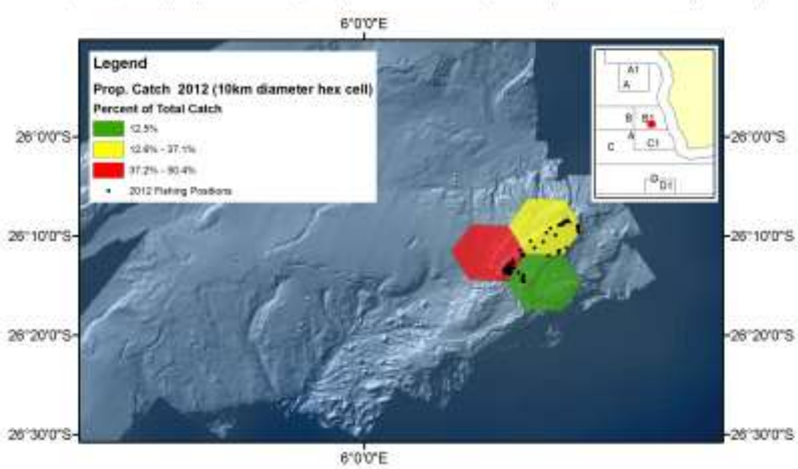
At the Valdivia Bank, the fishing grounds of the Korean fishery were primarily located in a small area of about 200 km^2.



Proportion Catch of pelagic armourhead (Peudopentaceros richardsoni) in 2011 (10km diameter hexagonal cells)



Proportion Catch of pelagic armourhead (Peudopentaceros richardsoni) in 2012 (10km diameter hexagonal cells)



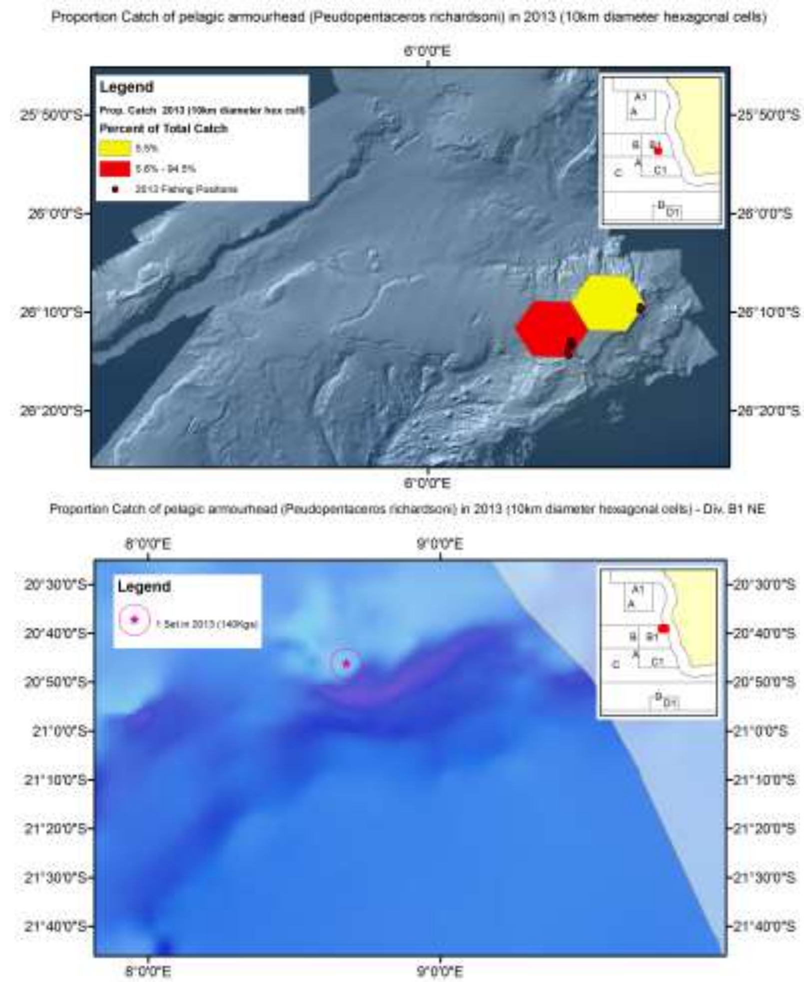


Figure 5: Spatial distribution of fishing positions and reported catches of pelagic armourhead (*P. richardsoni*) aggregated by 10km diameter hexagonal cells, 2010-2013. Lower map shows the single fishing position in the Northeastern seamount of B1 (Northeastern Walvis Ridge) reported in 2013. Data from observer reports submitted to SEAFO until Sept. 2014.

Table 1: Number of trawl hauls by year and SEAFO region (ref. Fig. 5).

Year	Valdivia Bank	North Walvis Ridge
2010	63	
2011	88	
2012	117	
2013	9	1

In 2017, only one vessel (trawler) from Namibia has conducted fishing activity in the SEAFO CA, targeting seamount species. Catches of pelagic armourhead took place in B1 and C0 (Fig. 6).

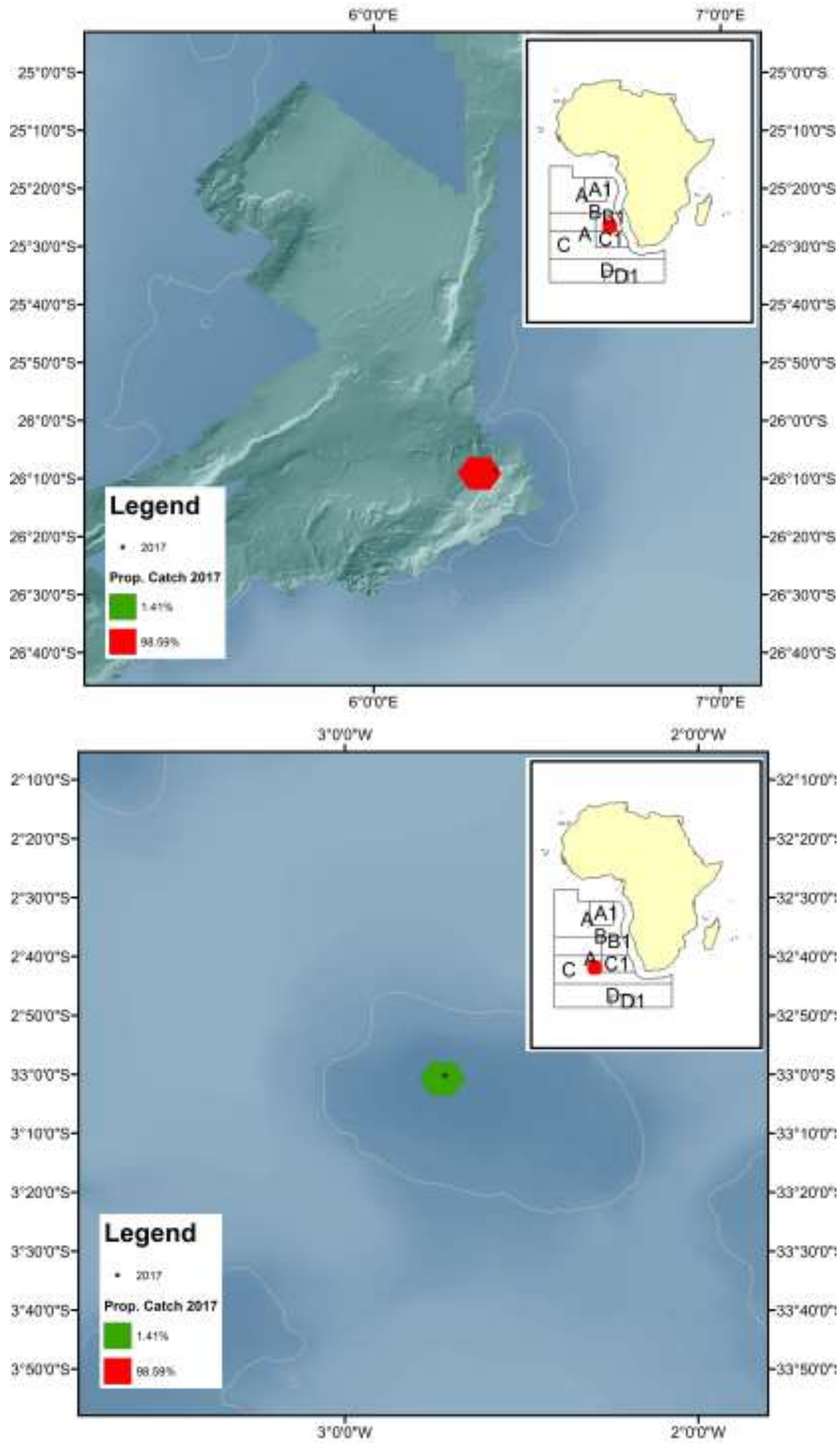


Figure 6: 2017 georeferenced fishing hauls and relative catches of pelagic Armourhead (*P. richardsoni*) aggregated by 10km diameter hexagonal cells. Upper map shows the single fishing position in B1 and the lower map the fishing position in C.

1.3 Reported retained catches and discards

Table 2 presents the annual catches and by-catches of pelagic Armourhead by country, fishing gear and SEAFO CA sub-divisions since 1976, At the early years the main fishing countries were:

- Russia operating with bottom trawls (late 1970s and 1993);
- Ukraine operating with bottom trawls (mid-1990s);
- Namibia and South Africa both operating with bottom trawls (mid-1990s);
- South Korea primarily operating with mid-water trawl (2010-2013).

The highest annual catches were recorded by Russia with 1,273 and 1,000 t in 1977 and 1993, respectively, and by Korea with 688 t in 2010. In 2017 the catches reported are derived from the Namibian trawler fishing hauls.

Table 2: Reported catches (tonnes) of pelagic armourhead *(Pseudopentaceros richardsoni*) from the SEAFO CA. Data reported by SEAFO CPs and other flag states reporting to SEAFO, and from FAO.

Nation	Namibia		Russia		Ukraine		Namibia	
Fishing method	Bottom trawl		Bottom trawl		Bottom trawl		Bottom trawl	
Management Area	B1		B1		UNK		C1	
Year	Retained	Discarded	Retained	Discarded	Retained	Discarded	Retained	Discarded
1976			108					
1977			1273					
1978			53					
1993			1000		435§			
1994								
1995	8				49			
1996	284				281			
1997	559				18			
1998	--							
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2013	--	--	--	--	--	--		
2014	--	--	--	--	--	--		
2015	--	--	--	--	--	--		

2016	--	--	--	--	--	--		
2017*	<1	0	--	--	--	--	<1	0

* Provisional (September 2017). -- = No Fishing. Blank fields = No Data Available.
UNK = Unknown. § = Values from FAO

1.4 IUU catch

IUU catches are unknown. Historically, fishing vessels have reported IUU fishing activity in the SEAFO CA to SEAFO secretariat. The reports may have been incomplete, and the extent of such activity and impacts on pelagic armourhead are unknown. In recent years no reports or other information indicating IUU fishing were received, so it is believed that IUU activity have stopped or become much reduced.

2. Stock distribution and identity

The pentacerotid *Pseudopentaceros richardsoni* (Smith 1844) is a southern circumglobal, benthopelagic species. The species inhabits the outer shelf and upper continental shelves, as well as, seamounts and underwater ridges (100-1000 m) between 0 and 1 000 m depth (Heemstra, 1986), e.g. Tristan de Cunha, on the Walvis Ridge and seamounts off South Africa (Southeast Atlantic); south of Madagascar (Western Indian Ocean) as well as in southern Australia, New Zealand and the Southeast Pacific.

In the SEAFO CA, the potential distribution area of the species and adjacent waters is shown in Figure 6. It is unlikely that the species is abundant south of about 40^{O}S, i.e. in Division D.

P. richardsoni populations particularly the adult exploited fraction, have patchy distributions Adult fraction tend to occur in a restricted depth *stratum* on the summit of seamounts and oceanic banks. The species recruit to the summit of the seamounts after approximately 4 years of pelagic life and thereafter aggregates.

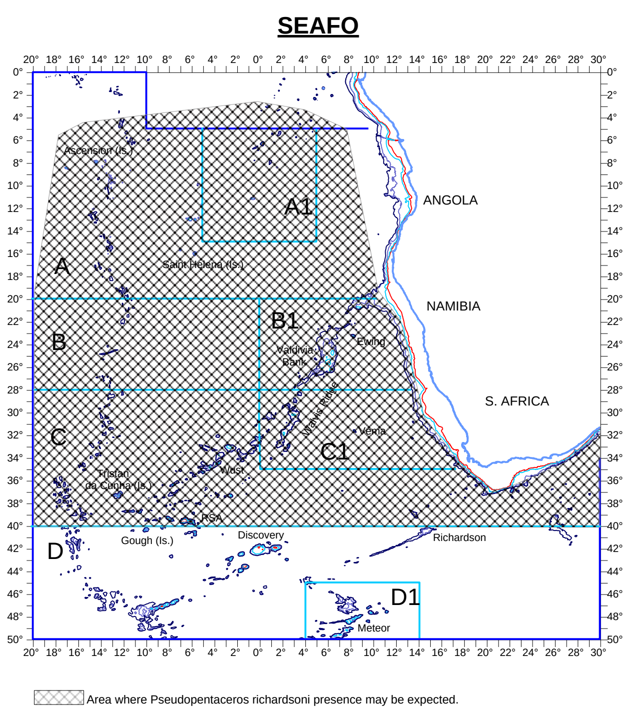

Figure 7: Potential geographical distribution of *P.richardsoni* in the SEAFO CA and adjacent waters (source: Species profile on the SEAFO website referring to several sources).

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

3.1 Fisheries and survey data

Geo-referenced data on catch and effort were available from haul-by-haul observer reports for the entire time-series of the Korean fishery (2010-2013), but logbook data were not available.

During the investigation of selected SEAFO seamounts in Jan-Feb 2015 by the RV Dr Fridtjof Nansen, pelagic armourhead were recorded in trawl catches and videos, and attempts were made to record aggregations of these species by acoustics. Small aggregations were observed in videos on a summit knolls in Wüst, and a single aggregation in Valdivia Middle. Scattered individuals occurred on the upper slope of Vema. The main former fishing area Valdivia Bank appeared impoverished with only scattered individuals and no acoustic recordings.

3.2 Length data and length frequency distributions

In 2014 the SC reviewed length data collected by observers on Korean fishing vessels. The number of individuals measured was considered insufficient to derive reliable length compositions of the catches. As a consequence, the length frequency distributions and length statistics (e.g. ranges and mean lengths) presented in 2013 or earlier SC reports were considered invalid. However, if sufficient length data were available, cohort analyses to perceived stock status based on length could be adopted.

The number hauls versus the number of fishes measured at each fishing haul are presented in Figure 7 and Table 3. Although most trawl tows have been sampled the number of individual measured per haul was clearly insufficient. This number has even decreased in the latter years

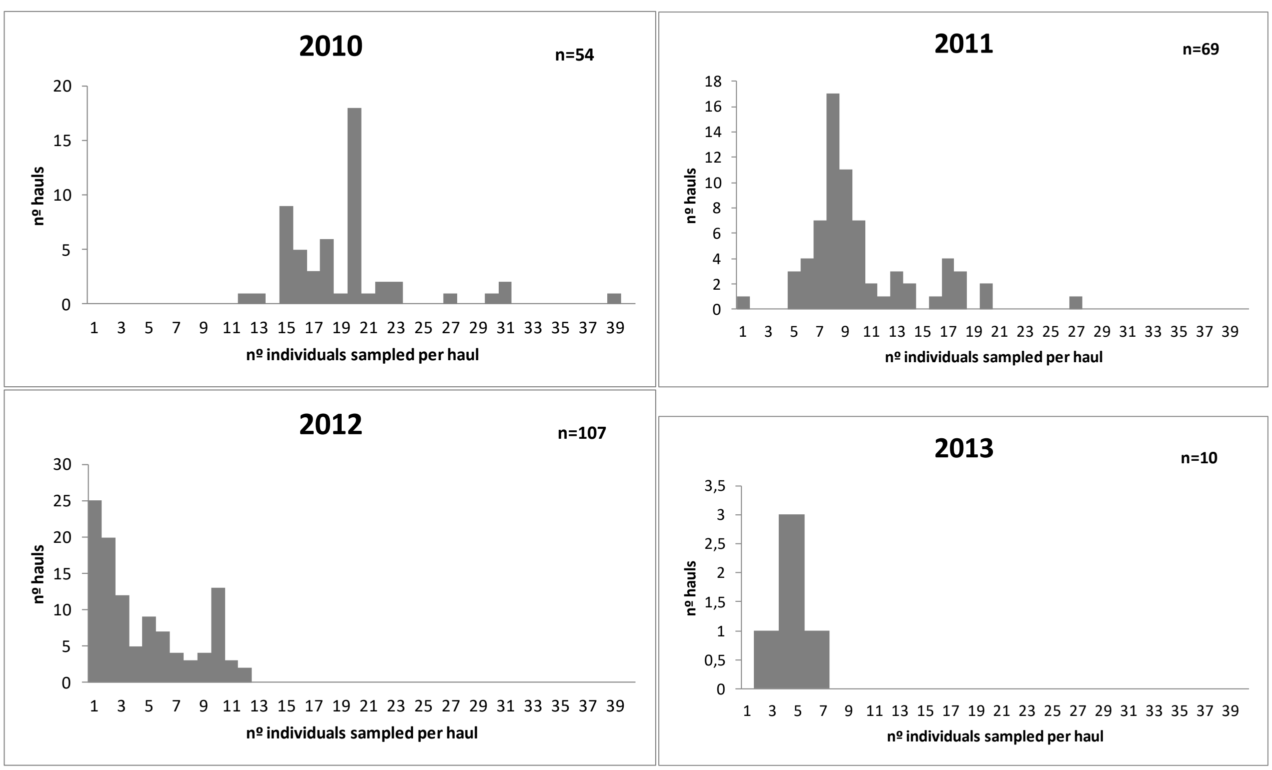

Figure 8: Frequency distributions of sample sizes for individual trawl tows, 2010-2013 in the Valdivia Bank trawl fishery for pelagic armourhead. The source is observer reports submitted to SEAFO until September 2014. n- number of tows sampled by observers.

Table 3: Total number of trawl tows sampled per year, annual mean, minimum, maximum number of fishes measured per trawl tow. The mean number of individuals measured per tonne is presented in the last column. (Data presented are official data submitted to SEAFO till Sept. 2014).

Year	No. of trawl tows sampled	Mean ind. sampled/tow	Min. ind. sampled/tow	Max. ind. sampled/tow	Mean ind. sampled/tonne
2010	54	19.3	12	39	0.03
2011	69	10.1	1	27	0.09
2012	107	4.5	1	12	0.03
2013	10	4.5	2	7	0.35

3.3 *Length-weight relationships*

The weight-length relationship of pelagic armourhead (for the two sexes combined) derived from observed data collected between 2010–2012 was: W=.016 L3.048 (r2 =.96).

3.4 *Age data and growth parameters*

There is no available information for SEAFO CA.

3.5 *Reproductive parameters*

For the period 2010 – 2012, the number of fishes by maturity stage and month are shown in Table 4. High proportions of pre-spawning and spawning stages were observed (Fig. 8). Although for the period 2010-2012 fishing activity in SEAFO CA has been restricted to May and June, data suggest that spawning is likely to occur after May, probably before September. If this is the case at the SEAFO CA the spawning period is different from that in the Southwest Indian Ocean, admitted to occur between October and December (López-Abellán et al. 2007).

Table 4: Annual number of fish by maturity stage of Pelagic Armourhead (*Pseudopentaceros richardsoni*) in the SEAFO CA for 2010-2012. Source: observer samples from Korean fishery.

Year	Month \ Maturity stage	Immature	Developing	Pre-spawning	Spawning	Spent
2010	Sep	0	504	159	0	0
	Oct	0	437	107	0	0
	Nov	0	84	26	0	0
2011	Jan	14	78	27	0	0
	Sep	59	75	4	0	0
	Oct	30	26	13	0	0
	Nov	0	16	27	2	0
2012	May	0	0	38	96	0
	Jun	0	0	69	352	0

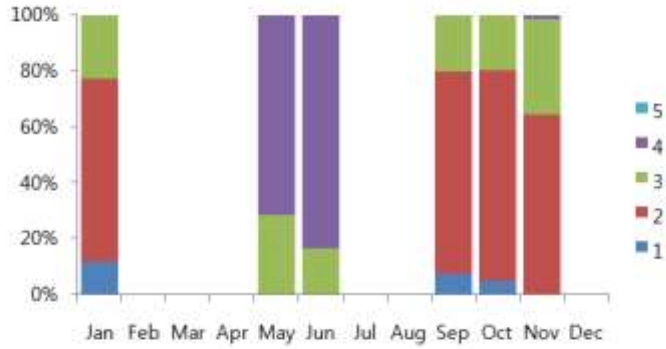

Figure 8: Pelagic Armourhead (*Pseudopentaceros richardsoni*) in the SEAFO CA for 2010-2012 - Proportion of specimens by maturity stage by month (1: immature, 2: developing, 3: pre-spawning, 4: spawning and 5: spent).

The adjustment of the maturity ogive to the reproductive data indicates 44.1 cm FL as size of first maturity (Fig. 9).

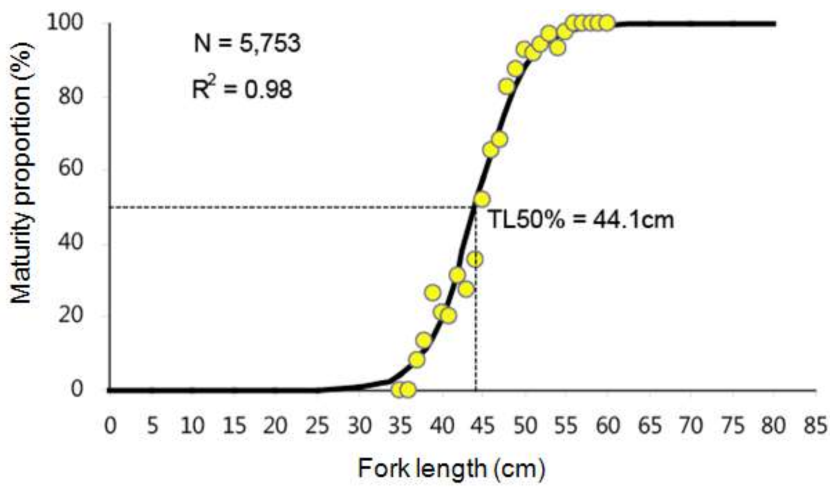

Figure 9: Pelagic armourhead (*Pseudopentaceros richardsoni*) - Valdivia Bank (SEAFO CA Subdivision B1). Proportion mature specimens *versus* fork length in cm

3.6 Natural mortality

Empirical natural mortality for pelagic armourhead were estimated using different methods (Tab. 6). For some methods the species growth parameter estimates (K=0.27 $year^{-1}$; L_{inf}=65.1 cm; and t_0=-0.34 year-1) derived for the Southwest Indian Ocean (López-Abellán et al. 2008a) and for Valdivia Bank during the Spanish-Namibian research survey (López-Abellán et al. 2008b) were used. In the Southwest Indian Ocean the maximum observed age of the species was 14 years.

Table 6: Empirical natural mortality estimates determined using the Fishmethods R package.

Method	M

Pauly (1980) - Length Equation	0.457
Hoenig (1983) - Joint Equation	0.316
Hoenig (1983) - Fish Equation	**0.300**
Alverson and Carney (1975)	0.253
Roff (1984)	0.417
Gunderson and Dygert (1988)	0.089

The estimate M=0.3 calculated using the Hoenig´s method was considered the most adequate for the species and it was therefore adopted for the subsequent analyses.

3.7 Feeding and trophic relationships (including species interaction)

There is no available information for SEAFO CA

3.8 Tagging and migration

There is no available information SEAFO CA

4. Stock assessment status

The specific spatial distribution of the adult fraction of *P. richardsoni* population favours the use of catch per unit of effort (CPUE) data as indicator of biomass and support the analysis of CPUE temporal trends. Furthermore, given the fact that data time series available begins at the start of fishery local depletion model was used as a tool to evaluate the status of the population.

Depletion estimators are widely used to estimate population abundance (Seber, 2002; Hilborn and Walters, 1992). These estimators assume a simple linear relationship between CPUE and cumulative effort (DeLury, 1947) or cumulative catch (Leslie and Davis, 1939). Procedures and discussions to evaluate stock status using depletion models are available in the Scientific Committee reports (SEAFO SC Report 2012 (Pages 21-23); SEAFO SC Report 2013 (Pages 17-18)).

As data available suggest that prior to 2010 the stock was unexploited, the Gulland (1971) method was adopted to estimate maximum sustainable yield (MSY)

4.1 Data used

Catch and effort data per fishing haul were available for the whole fishery time series. The fishing hauls considered in the analysis were restricted to those in which the total catch of *P. richardsoni* represented more than 80% of the total catch of *P. richardsoni* plus *Beryx splendens*. This criterion was adopted because catches of these two species are highly negatively correlated, i.e., when one of these two species occurs in the haul the other does not occur, as it can be seen for 2010 data (Fig. 11).

For each haul the estimate of CPUE of *P. richardsoni* corresponded to the ratio of total catch of the species by the haul duration.

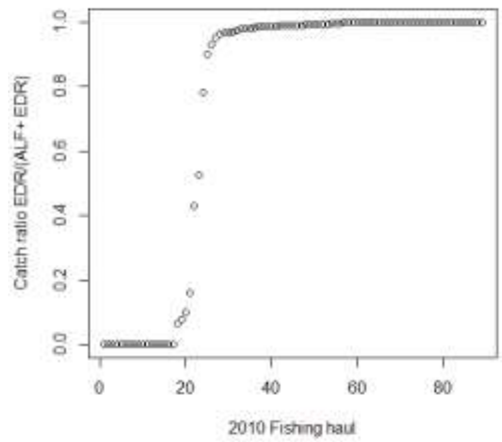

Figure 10: Korean trawl fishery - 2010 estimates of ratio of total catch *Pseudopentaceros richardsoni* by the total catch of *Pseudopentaceros richardsoni* and *Beryx splendens* by haul.

4.2 Methods used

The depletion model was adjusted to the whole data set available for the Korean trawl fishery (2014 was the last year with fishery data available). This model assumes that no recruitment and emigration/immigration to the fishing area occur during a particular season of fishing. So, under these assumptions, catch rates will decline with continued fishing until all the fish have been removed.

The model is adjusted by fitting a linear regression model to CPUE and the corresponding temporal cumulative catches. The total biomass available at the beginning of the season is estimated as the total catch that corresponds to local extinction, i.e. point that intersects the x-axis.

The uncertainties on parameter estimates were determined by bootstrapping; a total of 2000 bootstrap samples were derived from the input data and confidence interval of each parameter using the bootstrap estimates were derived accordingly. MSY estimate was determined based on the estimate of the initial biomass value derived from the depletion model and following the Gulland approach as MSY = 0.5*B*M, where B is unexploited (virgin) biomass and M the estimate of instantaneous natural mortality rate.

4.3 Results

The CPUE time-series showed a big decline from 2010 to 2011 follow by a stability at low levels in 2011, 2012, and 2013 (Fig. 11). In 2014 there was no fishery, hence no data on CPUE.

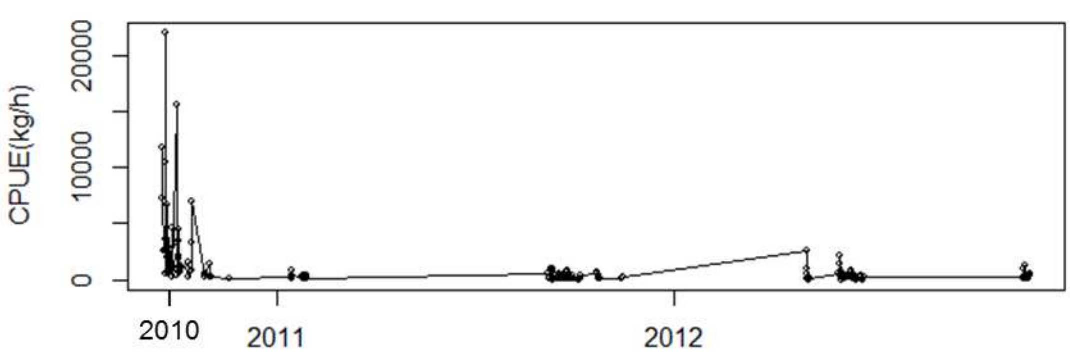

Figure 11: Time-series of catch per unit of effort (CPUE, kg/trawl hour), i.e. set-by-set data, for pelagic armourhead from 2010 to 2013. Source: observer reports submitted to SEAFO.

Figure 12 presents the CPUE against cumulative catch and the adjusted regression lines for 2010 and 2011. The 2010 biomass estimate at the beginning of the fishing season (851 t) was considered a proxy of the unexploited biomass. Table 6 shows estimates of the biomass at the beginning of the fishing seasons in 2010 and 2011, as well as the 25% and 75% percentiles.

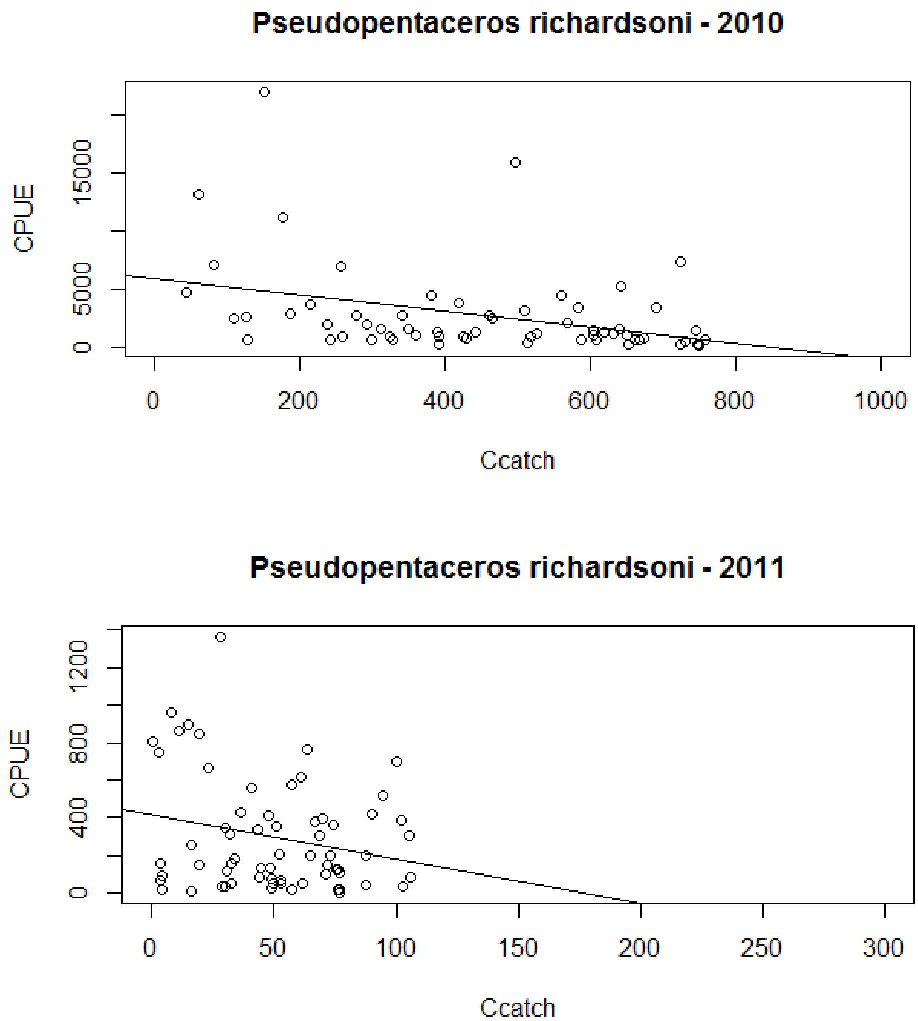

Figure 12: The CPUE against cumulative catch (Ccatch, tonne) of *Pseudopentaceros richardsoni* and the adjusted regression lines for 2010 and 2011. Note the different scales on the CPUE axes.

Table 6: Summary statistics of the biomass (t) at the beginning of the fishing season derived from 2000 bootstrap re-sampling estimates.

Year	25 Percentile	Estimate	75 Percentile
2010	751	851	1096
2011	137	176	229

Applying the Gulland method, and assuming a virgin biomass of 851t and 0.3 for M, the estimate of MSY is 128 t.

4.4 Discussion

The catches of P. richardsoni were derived from a directed fishery on Valdivia Bank held in a very small area, where the adults concentrated. Such species spatial distribution pattern make it highly vulnerable to overfishing.

The biomass index derived from onboard observer data Korean fishery targeting pelagic armourhead show a strong decrease (in 2011 the CPUE was approximately 16% of that in 2010). After 2011 the values of CPUE remained stable but very low levels.

The depletion model run adjusted for the year 2010 showed a significant negative regression slope and the regression explained near 40% of the variance.

Similar perception of the stock development could be depicted from the analysis of CPUE time series and from depletion model. No valid size or age distributions allowing evaluation of trends in size-age structure of the stock through time, as well as, no recruitment indexes were available. However, under the assumption of a 4-year recruitment age, it was expected that until 2015 the entries in the population mainly come from year classes born prior to 2010, i.e. before the fishery started.

The current perception of the stock fished primarily on the Valdivia Bank is that it is reduced to a low level.

The 2010-2013 fishery for armourhead was mainly conducted on the Valdivia Bank. A single catch was, however, also reported from a seamount in the northeastern corner of B1. The true distribution of the species in the SEAFO CA is probably wider, but the areas of suitable character and depth, i.e. shallower than 600m and north of 40°N, are few and widely dispersed (Figure 13). Fisheries expanding into other areas also have to be closely monitored and regulated (Ch 4.7).

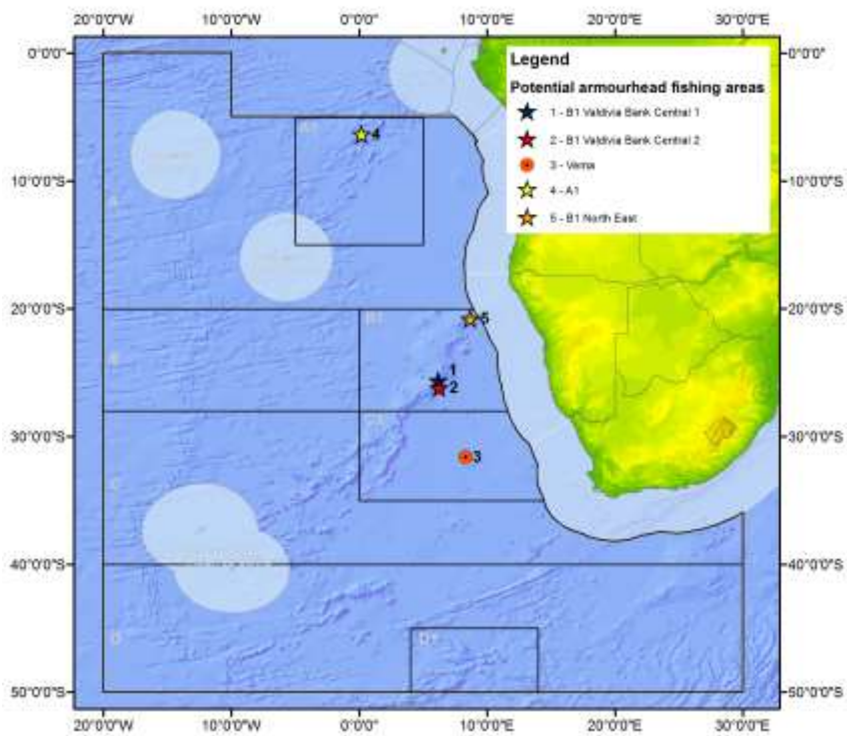

Figure 13: Bathymetry of the SEAFO CA and locations with bottom depths of 600m or less.

There is no information on recruitment, and it is not known whether the concentrations of the species constitute a self-sustaining population or are sustained by immigration/influx of larvae and juveniles from other areas. Furthermore, it is unknown if the 2013 biomass estimate on Valdivia Bank was above or below a level at which recruitment is impaired.

In recent years, i.e. 2014 onwards, there is no further information that allows to perceive the status of the adult population in Valvidia Bank.

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5. Incidental mortality and by-catch of fish and invertebrates

5.1 Incidental mortality (seabirds, mammals and turtles)

There are no reports of incidental bycatches of birds, mammals and turtles in the armourhead fishery.

5.2 Fish by-catch

Observer reports document that by-catch species in the pelagic armourhead fishery on Valdivia Bank were blackbelly rosefish, imperial blackfish, oilfish, Cape bonnetmouth, and silver scabbardfish. Among these alfonsino, blackbelly rosefish, imperial blackfish, and oilfish were the most abundant species (Table 7).

Minor catches of Japanese mackerel (*Scomber japonicas*) (50 t in 2010)**,** Cape horse mackerel (*Trachurus capensis*), and the longspine bellowfish (*Notopogon xenosoma*) were also recorded in the Korean observer reports, but it is uncertain whether these species occurred in the armourhead fishery. The identification of the latter species is also uncertain.

Table 7: By-catch from Pelagic Armourhead / southern boarfish (*Pseudopentaceros richardsoni*) fishery.

	2010	**2011**	**2012**	**2013**
Species (FAO code)	**B1**	**B1**	**B1**	**B1**
BRF	161	42	35	4
HDV	24	35	24	<1
OIL	5	13	7	<1
EMM	11	2	<1	0
GEM	0	0	<1	0
SVS	30	15	2	0

BRF: Blackbelly rosefish (*Helicolenus mouchezi*); HDV: Imperial blackfish (*Schedophilus ovalis*); OIL: Oilfish (*Ruvettus pretiosus*) ; EMM: Cape bonnetmooth (*Emmelichthys nitidus*) and PRP: Roudi escolar (*Promethichthys prometheus*)??, SVS: silver scabbardfish (*Lepidotus caudatus*).

5.3 VME indicator incidental catch

For the Korean armourhead fishery on Valdivia Bank observers recorded 0.4 kg of VME indicator species in 2013 and less than 1 kg in previous years of the 2010-2013. Catches never exceeded the agreed SEAFO threshold levels.

5.4 *Incidental and bycatch mitigation methods*

There are no technical mitigation measures implemented for the armourhead fishery.

5.5 *Lost and abandoned gear*

There were no reported lost and abandoned gear resulting from the armourhead fishery

5.6 *Ecosystem implications and effects*

There is no formal evaluation available for this fishery.

6. Biological reference points and harvest control rules

Apart from the provisional estimate of MSY=128 t (Ch. 4.4), no reference points have been estimated and found to be valid. The main reason is the shortage of basic data to carry out assessments.

In 2014 SC recommended that a harvest control rule be implemented and suggested as a candidate HCR the following:

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

Where 'Slope' = average slope of the Biomass Indicator (CPUE) in the recent 5 years
and ;
λu :TAC control coefficient if slope > 0 (Stock seems to be growing) : λu=1
λd :TAC control coefficient if slope < 0 (Stock seems to be decreasing) : λd=2

The TAC generated by this HCR is constrained to ± 5% of the TAC in the preceding year.

7. Current conservation measures and management advice.

Considering that the TACs set for pelagic armourhead under CM 32/16 is reviewed every two years, and that the last review was done in 2016, no update or review of the TAC was conducted for 2017.

The TAC advised in 2014 was derived using the average of the catches in 2011 and 2012. This is a simplistic approach not based on stock assessments or stock trend indices, hence the resulting TAC advice will be uncertain. Currently, due to the interruption of the fishery, the recommended and accepted HCR cannot be applied, nor the average of recent catches as in 2014. Due to the lack of recent fishery data there is even greater uncertainty than in 2014.

Prior to the interruption of the fishery, the catch per unit of effort had declined to a low level. The survey in 2015 did not detect concentrations of armourhead in the previous fishing area at that time. It was expressed that the absence of a fishery has provided a potential for recovery.

Due to the uncertainties explained above, SC members expressed different views on the TAC advice for 2017-2018 for the SEAFO CA. The agreed advice is a TAC of 135 tonnes. This level is slightly lower than that derived in 2014, hence possibly more precautionary. It must be emphasized that the state of the stock is unknown.

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