Two sympatric, not externally discernible and heavily-exploited deep species with coastal migration during spawning season: Implications for sustainable stocks management of *Aphanopus carbo* and *A. intermedius* around Madeira

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ABSTRACT

Several artisanal fisheries target deep species. These stocks are highly sensitive to overfishing because of their slow growth and late maturation. This vulnerability is higher if species concentrate during spawning season in coastal areas, as occur with scabbardfish (*Aphanopus* spp.). We herein explore if two *Aphanopus* species (*A. carbo* and *A. intermedius*) that coexist show migration patterns to coastal areas during spawning. We analysed specimens of both species throughout 4 years (2014-2017) in a weekly basis and compare morphological parameters to the distance of the coast [coastal (< 12 nm) *vs*. offshore (> 12 nm)]. Both species showed coastal patterns of migration during the spawning season (October-December), with 65.90% of total specimens of *A. carbo* and 51.60% of *A. intermedius* being caught at < 12 nm during this season. Fishing events were also more numerous at < 12 nm to the coast during spawning season (46.6%) relative to non-spawning season (32.6%). A series of management measures, e.g. October-December season, were developed to preserve *Aphanopus* stocks in the NE Atlantic Ocean.

Keywords: Small-scale fisheries, deep sea, reproductive, *Aphanopus*, Atlantic Ocean.

INTRODUCTION

Overfishing persists in many developed and developing countries worldwide (Pauly and Zeller 2016; Zeller et al. 2017). The effects of overfishing are not identical around the globe and are particularly intense in areas with low primary productivity, without the possibility to harbor high biomass of demersal commercial stocks (McPherson and Gordoa 1996; Pikitch et al. 2004; Friedland et al. 2012). Nonetheless, overfishing is a global problem with social, economic and environmental consequences (Jackson et al. 2001; Rick and Erlandson 2009), especially on small-scale fisheries that are severely devastated mainly due to poor management practices, destructive fishing arts and full-access to stocks (Pauly 1997; Béné 2003). Most of commercial species targeted by small-scale fisheries (SSF) are coastal pelagic and demersal stocks (Batista et al. 2014; Diegues 2006). Although, several SSF have been focused on deep fishing grounds due to coastal stocks depletion (Pham et al. 2014) or in oceanic islands with a high accessibility to stocks due to the steep slopes and the lack of extensive platforms.

Most deep-sea fish species (living deeper than ~400-500 m; ICES 2007) possess life-history characteristics that define them as highly vulnerable to over-exploitation (Denney et al. 2002; Clark et al. 2010) and in need of protection (OSPAR 2000). Contrary to some deep-water fish species, *Aphanopus* spp. are a relatively fast-growing species (Morales-Nin and Sena-Carvalho 1996) living up to 14 (*A. carbo*) to 15 (*A. intermedius*) years around Madeiran waters (Delgado et al. 2013). Female specimens show a lower growth rate (K, 0.121- 0.153 years^{-1}) than males (0.143-0.166 years^{-}1) in both species (Delgado et al. 2013). Total fecundity estimates range from 73 to 373 oocytes g^{-1} female (Neves et al. 2009) and the potential rate of population increase (r^1) is 3.32 (Drazen and Haedrich 2012). According to these life history traits, it would be expected scabbardfishes to be less susceptible to fishing pressure than other deep species. However, they are vulnerable due to fishing being generally targeting spawning aggregations near Madeira, as occurs with the blue ling (*Molva dypterygia*) fisheries in all parts of the Northeast Atlantic (Large et al. 2010).

In the Northeast Atlantic, the bulk of deep-sea fisheries originated as artisanal fisheries, especially in zones where the continental shelf is narrow and deep water is near to land (e.g. in Madeira and Azores) (Gordon et al. 2003). The exhaustion of traditional fish stocks on continental shelves and the expansion of new technologies led to an enlargement of fisheries towards the deep sea in search of new fishing grounds and commercial opportunities (Piñeiro and Banón 2001; Morato et al. 2006). Currently, deep water fisheries are rather diverse and dominated by longline and trawl fisheries, both from artisanal fisheries and highly mechanized longline and trawl gear operating offshore in oceanic areas (Gordon et al. 2003; Large et al. 2003). Most of the studies on deep-water fisheries have been focused on the effects of trawling in extensive deep areas (Clark et al. 2015). Scarce information is available on fisheries from seamounts using other methods such as, longlines (Pham et al. 2014) that are considered to have a low impact on benthic communities, together with low by-catch and in-situ disturbances. In the NE Atlantic the longest well-known deep-water fisheries are the handline and longline fisheries off the Azores (e.g. the red seabream, *Pagellus bogarave*o, and alfonsinos, *Beryx* spp.), off Madeira and Portugal (targeting primarily black scabbardfish, *Aphanopus carbo*) and off Iceland, Norway and the Faroe Islands (targeting ling, *Molva molva*, and tusk, *Brosme brosme*) (Large et al. 2003).

In Madeira, exploited deep fish stocks are overwhelmingly dominated by two scabbardfish species, *Aphanopus carbo* Lowe, 1839 and *A. intermedius* Parin, 1983 that represent about half of the overall landings throughout the year (Delgado et al. 2013;

Hermida and Delgado 2016; Shon et al. 2016; Delgado et al. 2018). In 2017 combined landings of these two species were 2 162 tons representing a value of 7.6 M€ (Regional Fisheries Department, DRP). The local fishing methodology uses a drifting longline set above the bottom, targeting the depth range between 800 to 1,300 meters deep (Delgado 2018). This drifting longline is deployed to target the diel feeding migration to midwater made by these benthopelagic species in the water column (Parin 1986). These two sympatric species move to reproduction areas off Macaronesian archipelagos, i.e. Madeira and the Canary Islands, and the northwest coast of Africa (Figueiredo et al. 2003; Pajuelo et al. 2008; Perera et al. 2008; Farias et al. 2013). The spawning season of both *Aphanopus* species has been reported to take place from October to December (Figueiredo et al. 2003; Delgado et al. 2013), but no detailed studies on accurate geographic locations (areas and depth) where spawning occurs have been previously published. Prior information based on experimental fishing and empirical knowledge transmitted by fishermen indicated that, during the spawning season fish was more abundant and fisheries were more prone to occur close to the shore, reportedly the fishery "following" the fish in its inshore migration to spawn. These social aggregation behaviours, such as schooling or shoal spawning, are also typical of vulnerable species (Walters 2003; Sadovy and Domeier 2005). Migration of adult individuals has been also observed in a wide range of coastal species, from crustaceans to fish, but also in deep sea species, e.g. scabbardfish (*Aphanopus* spp) in Atlantic oceanic archipelagos, i.e. Madeira and the Canary Islands (Farias et al. 2013), and the blue ling in west and northwest of the British Isles (Large et al. 2010). Fisheries on blue ling, in some ICES Areas, have mostly targeted spawning aggregations, making this species vulnerable and susceptible to sequential depletion of spawning aggregations (ICES 2004, 2006, 2008). Thus, ICES advice for closed areas to protect spawning aggregations where appropriate (ICES 2004, 2006, 2008).

In the present study, an interannual database (2014-2017) of biological sampling, i.e. total length and maturity stage of both *Aphanopus* species (*A. carbo* and *A. intermedius*), was used to determine accurately the spatial and temporal distribution of the spawning areas off Madeira (NE Atlantic Ocean). It is expected that the area occupied by each scabbardfish (*A. carbo* and *A. intermedius*) is greater in non-spawning (January-September) than spawning (October-December) periods, due to migration relative to the coast (<12 nautical miles, nm) for the spawning season. Additionally, we hypothesize that the maturity stages are distributed differently in relation to the distance to from the coast (< 12 nm and > 12 nm) among seasons and within each season, due to spawning aggregations. Also, differences in fish size are expected between seasons due to the fishery targeting mainly aggregations of mature adults during the spawning season, thus larger individuals should be more susceptible to the fishery during this period. This hypothesis is also tested using information from logbooks of vessels that targeted both scabbardfishes all over the year, namely the geographic coordinates of the fishing events, grouped in coastal (< 12 nm) and offshore (> 12 nm). In spawning months, it is expected an increase in the proportion of fishing events is expected in areas < 12 nm from the coast. Additionally, we predict that the distribution of *Aphanopus* spp during the spawning season inside territorial waters is influenced by seabed topography, with spawning migratory movements towards coastal submarine canyons. The information obtained from these data analyses is pivotal to develop management strategies in order to preserve these commercially-important species for the NE Atlantic Ocean and specifically to the Madeiran artisanal fishery.

MATERIAL AND METHODS

Sampling data

Between October 2014 and December 2017, a total of 1 226 specimens of scabbardfish were sampled randomly every two weeks, from the commercial mid-water drifting longline fishery at the fishing port of Funchal, Madeira, north-eastern Atlantic (32°00′–33°30′N; 15°30′–18°00′W). *Aphanopus* species were identified based on morphological and meristic criteria following Biscoito et al. (2011). The data analyses were performed for whole sampled specimens.

From all specimens, individual total (TL, 0.1 cm) length and total weight (TW, 0.1 g) were recorded. Sex and maturity stages were assigned by macroscopic examination of the gonads based on a five-stage maturity scale: (I) immature, (II) developing, (III) pre-spawning, (IV) spawning (V) post-spawning (Gordo et al. 2000).

For further statistics, all data were organized in spawning season (October-December) and non-spawning season (January-September) (Figueiredo et al. 2003; Delgado et al. 2013). Two fishing areas, namely coastal (< 12 nm) and offshore (> 12 nm) were established using QGIS v3.0.

Geographic position information from 1 200 fisheries events (517 events registered at < 12 nm and 683 at > 12 nm) was obtained from electronic logbooks of each drifting longline vessel in the study period (2014-2017) (Regional Fisheries Department - DRP).

Data analysis

Descriptive statistics were performed and the existence of statistically significant differences between the mean TL between seasons was tested through analysis of variance (ANOVA) with a 0.05 significance level for both species (*A. carbo* and *A. intermedius*) (Sokal and Rohlf 1995).

1. Distance from the coast (< 12 nm and > 12 nm) as a predictor of spawning

1.1. Distribution of scabbardfish relative to the coast (<12 nm and > 12 nm) as a function of spawning season

The existence of differences between areas by season (spawning *vs*. non-spawning) was tested using Mann-Whitney statistic test ($p<0.001$) for both *Aphanopus* species. In order to infer the proportion of individuals closer or further to the coast according to the season a Pearson χ^2 ($p<0.001$) was performed.

1.2. Distribution of maturity stages of scabbardfish relative to the coast (<12 nm and > 12 nm) as a function of spawning season

The distribution of maturity stages (five stages: I-V) in relation to the distance from the coast (<12 nm and > 12 nm) among seasons and within each season was performed using a Pearson χ^2 ($p<0.05$) test. For this analysis, only 78 fishing events with sampled specimens were used.

2. Distribution of fishing events as a function of spawning season

The distribution of fishing events of scabbardfish in relation to distance from the coast (<12 nm and > 12 nm) was analysed per month and per season for the studied period.

A yearly analysis was also performed in order to determine whether the distribution of fishing events follows a trend throughout the years. Both analyses were carried out using the Pearson´s Chi-square statistics ($p<0.001$).

3. Distribution of fishing events as a function of sea bottom topography

The distribution of fishing events of *Aphanopus* spp in relation to sea bottom topography (canyons *vs*. slopes) was analysed during the spawning season inside territorial waters (<12 nm) for the study period.

The fishing events during the spawning season were plotted dividing the territorial waters in compartments of 10x10 km and a density map showing the mean density values in each compartment, covering a search radius of 10 km of the study area was generated using Kernel Density Estimation (KDE) approach (Wolters 2012). Additionally, the distribution of fishing between slopes and platforms was analysed using an Analysis of Variance (ANOVA) ($p<0.001$).

All statistical analyses were performed using SPSS v. 24.0 (IBM Corp., Armonk, NY) and all spatial analyses executed applying QGIS v3.0.

RESULTS

A total of 1 068 *Aphanopus carbo* (99.6 – 147.8 cm TL; mean size of 120.0 ± 6.5 cm TL) and 158 *A. intermedius* (104.0 – 147.5 cm TL; mean size of 127.7 ± 9.3 cm TL) were sampled (Table 1). Significant differences were found in the mean length between spawning (n = 349, 120.5 ± 6.7) and non-spawning season (n = 719, 119.6 ± 6.5) for *A. carbo* ($F = 4.273$, $p < 0.05$), with larger individuals being more common during the spawning season, while such differences were not found for *A. intermedius* among seasons (spawning season: n = 62, 127.1 ± 10.0; non-spawning season: n = 96, 128.0 ± 8.9) ($F = 0.307$; $p > 0.05$) (Table 1).

The analysis of the distribution of fishing events considered the geographic location of the fishing events of scabbardfish occurring from 2014 to 2017 in the Exclusive Economic Area of Madeira (ZEE) encompassing a total of 7 228 fishing events.

1. Distance from the coast (< 12 nm and > 12 nm) as a predictor of spawning

1.1. Distribution of scabbardfish relative to the coast (<12 nm and > 12 nm) as a function of spawning season

Aphanopus carbo and *A. intermedius* showed similar patterns in terms of distribution relative to < and > 12 nm during spawning season. Significant differences were found when comparing the number of specimens of *A. carbo* (Mann-Whitney test: U = 85 358.00, $p < 0.001$) and *A. intermedius* (Mann-Whitney test: U = 1 812.00, $p < 0.001$) caught at distances < and > than 12 nm from the coast among seasons (Figure 1).

In the case of *A. carbo* during spawning season 65.90% of total specimens were caught at < 12 nm, while during the non-spawning season the reverse was observed with 66.10% of total specimens being caught > 12 nm off Madeira ($\chi^2 = 97.264$, $p < 0.001$) (Figure 2). The same pattern was also observed for *A. intermedius* with more individuals being caught at < 12 nm from the coast (51.60%) during spawning season and > 12 nm from the coast during the non-spawning season (87.50%) ($\chi^2 = 28.682$, $p< 0.001$) (Figure 2).

1.2. Distribution of maturity stages of scabbardfish relative to the coast (< 12 nm and > 12 nm) as a function of spawning season

The distribution of maturity stages of *A. carbo* differed between < 12 nm and > 12 nm from the coast during the spawning season ($\chi^2 = 22.158$, $p<0.05$). Maturity stage IV was more commonly found (62.30%) closer to the coast (< 12 nm) than all other maturity stages. The same pattern was found for *A. intermedius*, however less pronounced with 54.20% of specimens at stage IV being found < 12 nm from the coast ($\chi^2 = 9.825$, $p<0.05$).

During spawning season, mature and post spawning individuals (stages IV and V, respectively) of *A. carbo* were more common at < 12 nm from the coast with 68.00% and 70.60% respectively ($\chi^2 = 7.843$, $p<0.05$). While during non-spawning season there isn't a clear distinction on the distribution of maturity stages ($\chi^2 = 1.273$, $p=0.736$) nonetheless all other stages were more abundant at > 12 nm from the coast (Figure 3).

A. intermedius follows the same trend regarding the distribution of maturity stages according to the season with individuals at maturity stage IV and V being more common at < 12 nm from the coast (59.10% and 52.00% respectively) during spawning season, however differences were not statistically significant ($\chi^2 = 1.347$, $p=0.718$). Also, during non-spawning season there is not clear distinction on the distribution of maturity stages ($\chi^2 = 5.058$, $p<0.168$), nonetheless, all other stages are more abundant at > 12 nm from the coast (Figure 3).

2. Distribution of fishing events as a function of spawning season

The number of fishing events follows the same trend along the year during the studied period (2014-2017). This trend was characterized by a higher number of fishing events in fishing grounds > 12 nm, from January to September, and an increase in fishing events at < 12 nm from the coast during the last quarter of the year (Figure 4).

Overall, the proportion of fishing events occurring at < 12 nm increased from 32.6% in non-spawning season to 46.6% in spawning season. Monthly fishing events showed a clear pattern along the year (χ^2 = 229.628, p < 0.001), with an increase in the proportion of events in areas < 12 nm from the coast in spawning season (χ^2 = 114.851, p < 0.001) (Figure 4).

The observed trend is consistently found in each study year and was more pronounced in 2014 with 53.9% of fishing events occurring closer to the coast (< 12 nm) from October to December (χ^2 = 158.816, p < 0.001). Even though, the trend was less pronounced in the following years, the differences in proportion of fishing events that occurred closer to the coast in these months were statistically significant each year (2015: χ^2 = 83.275, p < 0.001; 2016: χ^2 = 116.450, p < 0.001; 2017: χ^2 = 113.359, p < 0.001) (Figure 4).

3. Distribution of fishing events as a function of sea bottom topography

According to the KDE map (Figure 5) the distribution of fishing events of *Aphanopus* spp showed different spatial cluster patterns. As expected, the major proportion of fishing events during the spawning season, inside territorial waters, occurred in canyons and adjacent slopes (F=26.283; p<0.001).

DISCUSSION

The reproductive biology of commercial-interest species is of utmost importance to develop integrative management actions focused on the conservation of stocks. In the present study, migrations to areas < 12 nm from the coast, were observed in both *Aphanopus* species (*A. carbo* and *A. intermedius*) throughout the spawning season. This pattern was more pronounced in *A. carbo* relative to *A. intermedius* off Madeira, and mature stages IV and V were the ones that overwhelmingly dominated this migration pattern to shallower areas. This migration of mature adults towards areas near the coast, specially between October and December, occurs simultaneously with a noticeable increase of the proportion of fishing events inside the ZEE (< 12 nm), making them more susceptible to drifting longline fishery.

There are three main aggregation areas off Madeira, where fishing events occurs during spawning. Most likely, these areas correspond to areas with environmental and sea bottom topography that favour reproduction as these areas roughly correspond to canyons where there are conspicuous folds in the bathymetry towards the coast and its nearby steep slopes. These represent very closed geological formations with the dimension of extensive canyons, probably protected from strong currents and where high densities of spawning individuals aggregate facilitating high probability of successful external fertilization. The three main aggregations areas identified (Figure 5) are the fishing grounds Lobos and Ribeira Brava, at the south coast of Madeira and Porto do Moniz-Seixal at the north coast. The fishing grounds are located at an average distance of 2 to 4 nm offshore although the same depths are found over a wider range of 3 to 6 nm offshore. The results obtained herein confirmed all initial hypotheses, i.e. a spawning migratory movement towards coastal submarine canyons of Madeira as confirmed through individual gonad analysis. A high concentration of reproductive individuals was found as expected, in spawning areas at < 12 nm from the coast.

Migratory patterns are only fully known for small number of commercial fish species, mainly small-pelagics (e.g. Bishop and Eiler 2018) or highly migratory species, e.g. swordfish (Shimose et al. 2012). Different migratory patterns have been observed, with pathways to offshore environments (e.g. Rose 1993), and movements to coast, even including beach spawning (Martin and Swiderski 2001). However, most of the previously published information is focused on highly vagrant species, e.g. pelagic sharks (Gore et al. 2008; Weng et al. 2008; Jorgensen et al. 2010). Hence, information on migration patterns may be crucial for stocks conservation in order to be exploited in a sustainable manner, since migration involve large concentrations of individuals in small areas during a short period of time. Several conservation figures, e.g. Key Biodiversity Areas (KBAs), have recently included congregators species to identify areas where a significant portion of a global population aggregates on a regular basis (Eken et al. 2004). In fisheries context, these areas need to be preserved from fishing activities during the aggregation period of the targeted species, e.g. spawning season. We herein studied two demersal deep-water species (*Aphanopus carbo* and *A. intermedius*) that show coastal migration to an oceanic archipelago (Madeira) during spawning season. During this period, both species are subjected to an intense fishing by a specialized artisanal fleet that only targets these species using drifting longline. The two *Aphanopus* species show an Atlantic geographic distribution, with scarce suitable sites for their spawning migration. They concentrate mostly in the archipelago of Madeira and a small area close to the Canary Islands (Farias et al. 2013). The inherent characteristics of both species, i.e. coastal spawning aggregation, and the particularities of the geographic region, with a limited number of potential coastal areas for their migration behaviour. According to the hypothetical migratory cycle of the black scabbardfish proposed by Farias et al. (2013), eggs, larvae, and possibly juveniles migrate to the northernmost Atlantic areas, i.e. from south of Iceland and Faroe Islands to the west of the British Isles where they remain for some years to feed and grow. Then, they move south to the area off mainland Portugal, for a few more years before migrating further south to the spawning grounds (Farias et al. 2013) around Madeira and the Canary Islands, and the northwest coast of Africa (Figueiredo et al. 2003; Pajuelo et al. 2008; Perera et al. 2008; Farias et al. 2013).An integrative management is necessary to preserve *Aphanopus* stocks in the Macaronesian region, especially those on the proximity of Madeira. A battery of measures is of utmost importance, based on fishing effort and quota management. Based on the present results and information from Farias et al (2013) and Delgado et. al. (2018) a series of measures are recommended to preserve stocks of *Aphanopus* spp. at sustainable levels: (i) season period from mid-October to mid-December (2 months), which corresponds approximately to the reproductive peak of both targeted species (*A. carbo* and *A. intermedius*), and (ii) this season period spatially comprises the coastal area of Madeira, from shore to 12 nautical miles offshore, where the aggregations of spawning individuals is evident during the spawning season. The former management measures are pivotal due to the high fragility of both *Aphanopus* stocks, considering their particularities, i.e. two sympatric and no-externally discernible species (*A. carbo* and *A. intermedius*), slow-growth deep species and coastal migration during spawning season. But above all, heavily exploited stocks throughout several decades in the study area with catches all year round, being closer to the coast during spawning season since they follow *Aphanophus* aggregations. Moreover, *Aphanopus* fishery is currently full-access in Madeira, with no restrictions on fishing effort, i.e. nº of hooks, nº of fishing days, nor areas with fishing limitations.

The black scabbard fish is an important regional resource, fished in the North-eastern Atlantic in the ICES and CECAF areas by different fleets with different methodologies and in different phases of its life cycle. However, there are clear indications that this resource makes a clockwise migration in the NE Atlantic with the more clearly confirmed spawning area being located off Madeira (ICES 2018). Thus, the application of technical measures to protect from fishing the aggregations of fish during its active spawning period (when they are more vulnerable to fishery) is of outmost importance not only locally but at a trans-Atlantic regional level, especially for deep-water species. Being *Aphanopus* spp. one of the faster growing deep-water species in the NE Atlantic, the implementation of the above-mentioned management actions may support the hypothesis that deep-water stocks can recover from overexploitation. Hence, the management measures we propose herein are therefore important with its impact transcending the area and the Madeira fishery.

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Figures

Fig. 1. Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (A) and non-spawning (B) seasons according to the distance from the coast (<12 and >12 nautical miles).

Fig. 2. Proportion of individuals (%) in spawning and non-spawning according to the distance from the coast (<12 and >12 nautical miles) for *Aphanopus carbo* and *Aphanopus intermedius*.

Fig. 3. Proportion of each maturity stage (2, developing; 3, pre-spawning; 4, spawning; 5, post-spawning) in spawning and non-spawning (bars) according to the distance from the coast (<12 and >12 nautical miles) for (A) *Aphanopus carbo* and (B) *Aphanopus intermedius*.

Fig. 4. Proportion of fishing events (%) along the year and according to the distance from the coast (<12 and >12 nautical miles) for both *Aphanopus* species during the study period: (A) 2014, (B) 2015, (C) 2016, (D) 2017.

Fig. 5. Kernel Density Estimation (KDE) plot showing the mean density values of the fishing events during the spawning season per compartment of 10x10 km generated for the study area and for the period 2014-2017. Low: [1-10]; Medium: [11-20]; High: [21-30]; and Very High: >31 fishing events.

Table 1 – Number of individuals (n) per sampling period (SS: spawning season; NoSS: Non-spawning season), total length (TL, cm) range, and mean total length and respective standard deviation of *Aphanopus carbo* and *Aphanopus intermedius* sampled in Madeira.

Species	Year	Sampling periods	n	TL range (cm)	Mean TL (cm)
Aphanopus carbo	2014	SS	94	99.6 - 132.8	119.4±7.2
	2015	NoSS	315	103.0 - 144.5	118.9 ± 6.5
		SS	98	104.2 - 143.8	120.2 ± 7.5
	2016	NoSS	176	104.2 - 138.8	121.0 ± 6.7
		SS	19	106.8 - 128.0	119.2 ± 5.4
	2017	NoSS	228	103.7 - 147.8	119.6 ± 6.1
		SS	138	103.6 - 137.6	121.7 ± 5.6
Aphanopus intermedius	2014	SS	14	106.3 - 145.0	130.0 ± 12.3
	2015	NoSS	46	104.0 - 142.6	126.3 ± 9.7
		SS	11	114.0 - 138.8	126.3 ± 9.1
	2016	NoSS	12	114.7 - 144.1	128.2 ± 9.7
	2017	NoSS	38	112.9 - 147.1	130.0 ± 7.1
		SS	37	109.5 - 147.5	126.3 ± 9.4

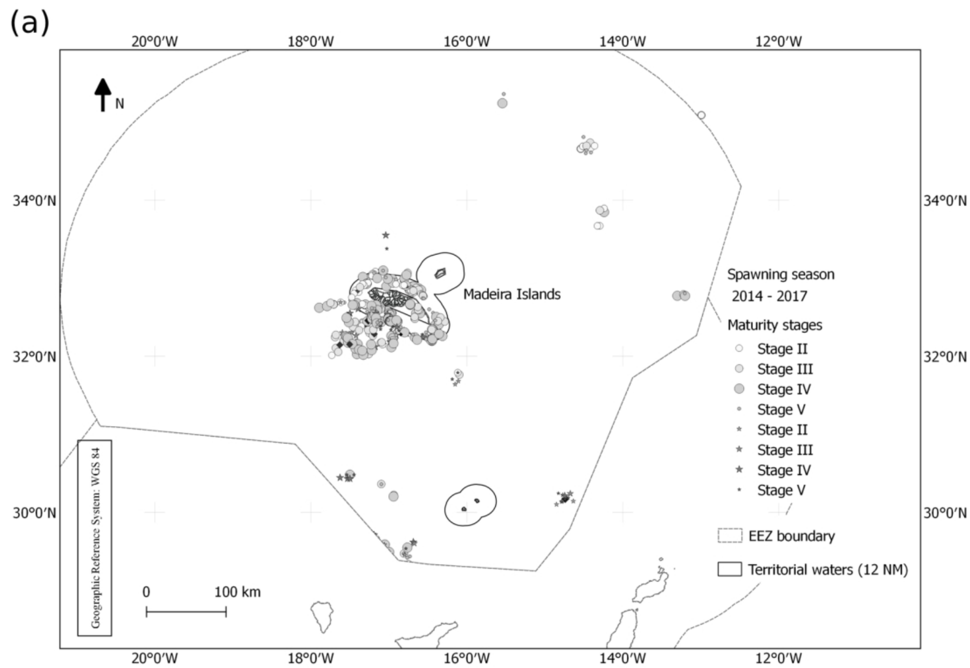
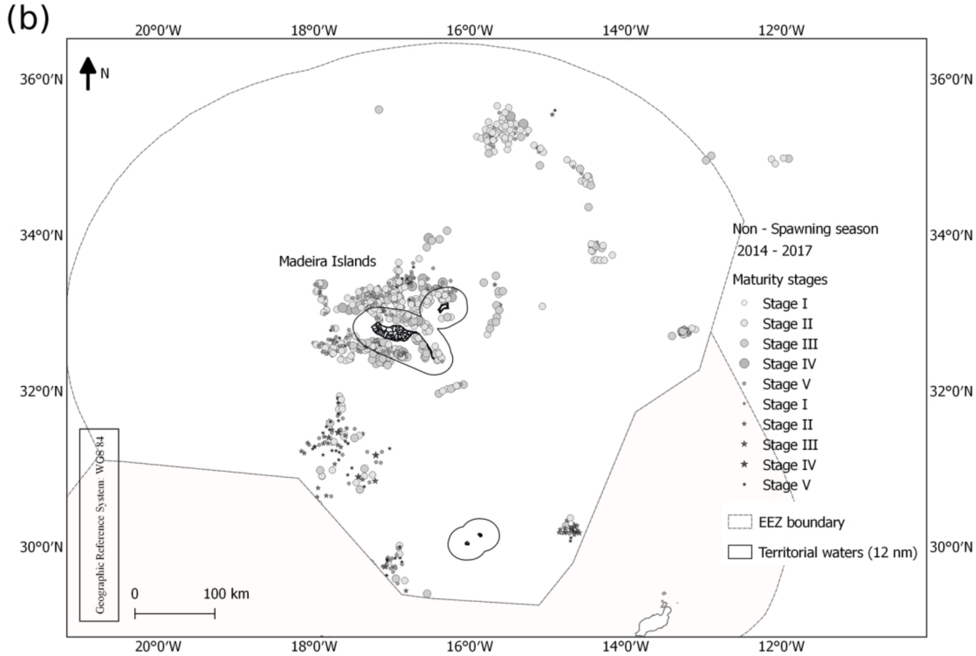


Fig. 1. Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (A) and non-spawning (B) seasons according to the distance from the coast (<12 and >12 nautical miles).

149x106mm (300 x 300 DPI)



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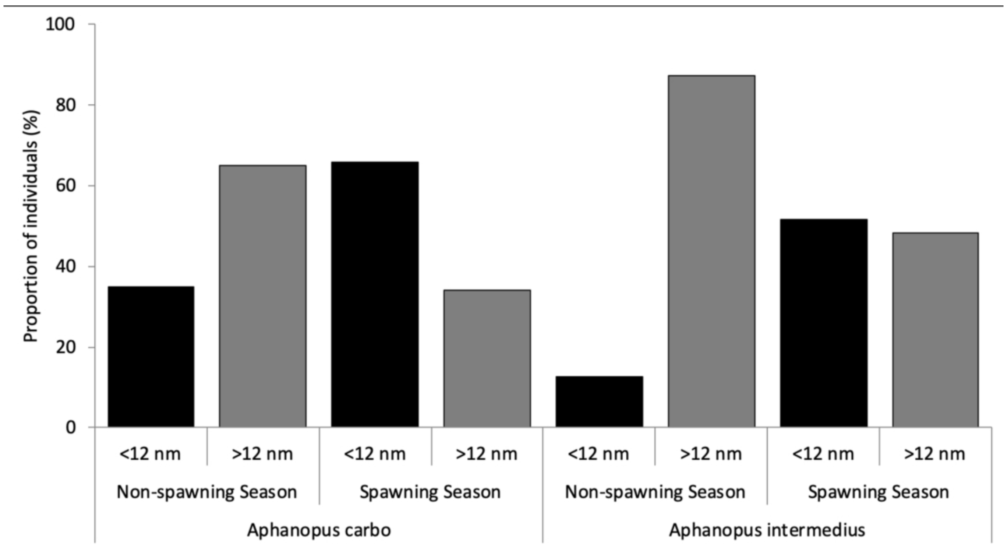

Fig. 2. Proportion of individuals (%) in spawning and non-spawning according to the distance from the coast (<12 and >12 nautical miles) for *Aphanopus carbo* and *Aphanopus intermedius*.

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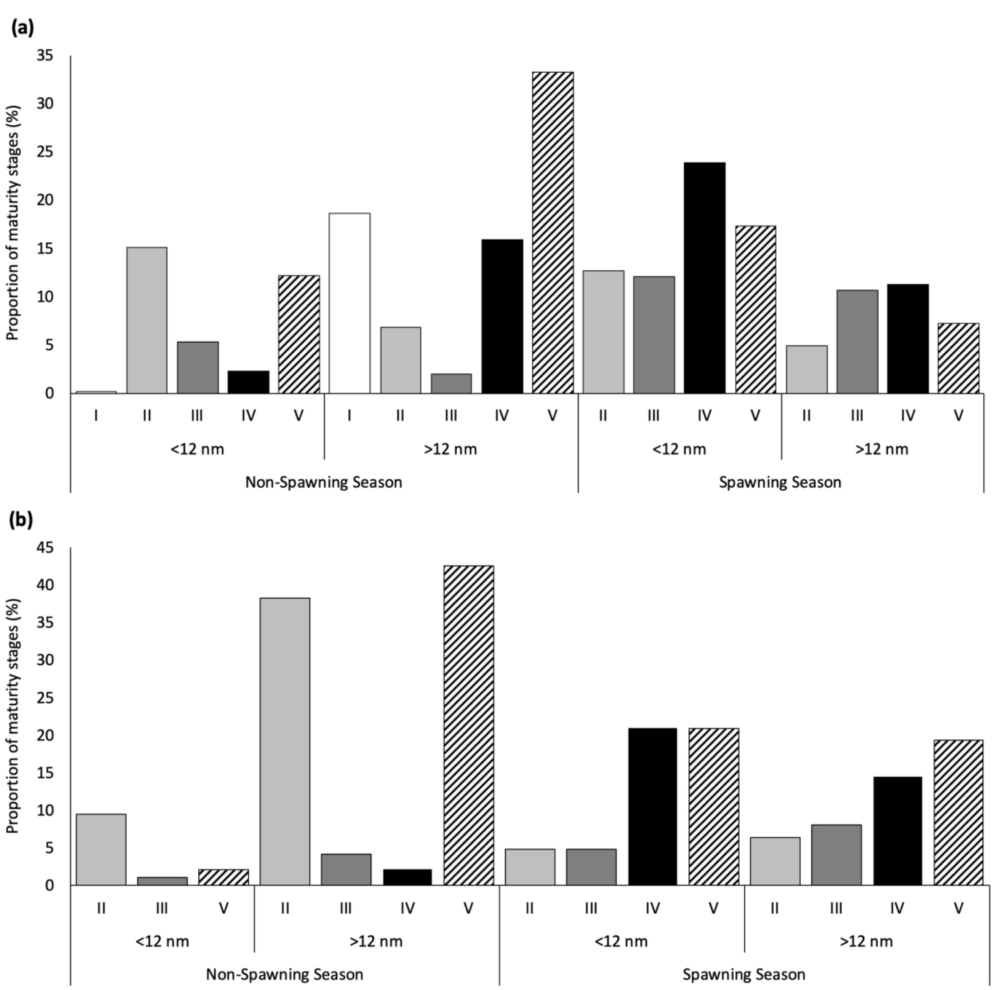

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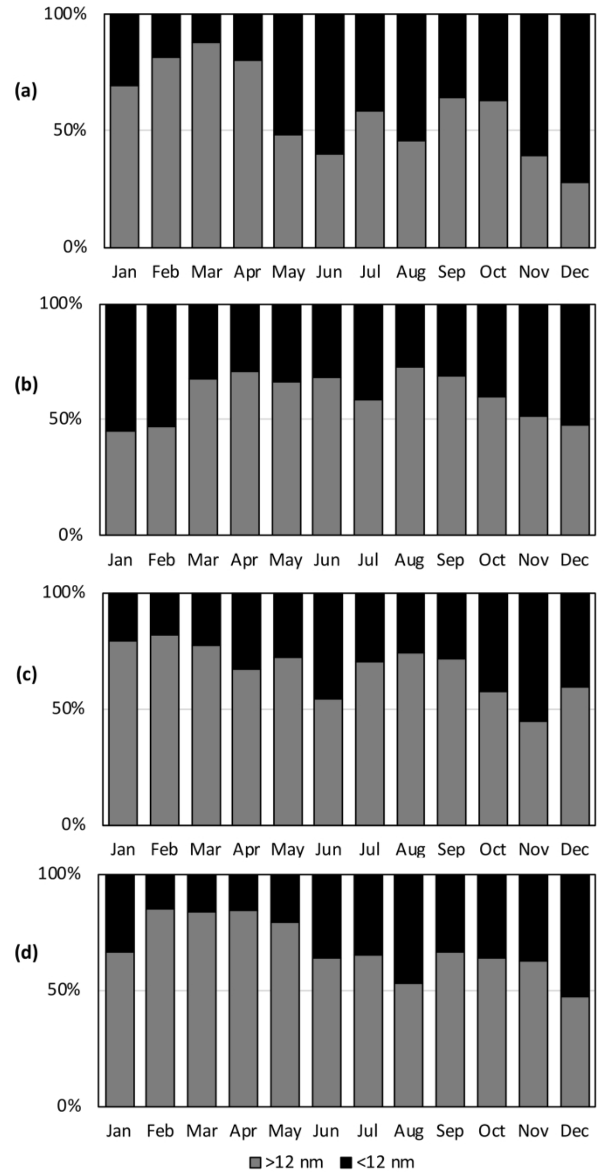

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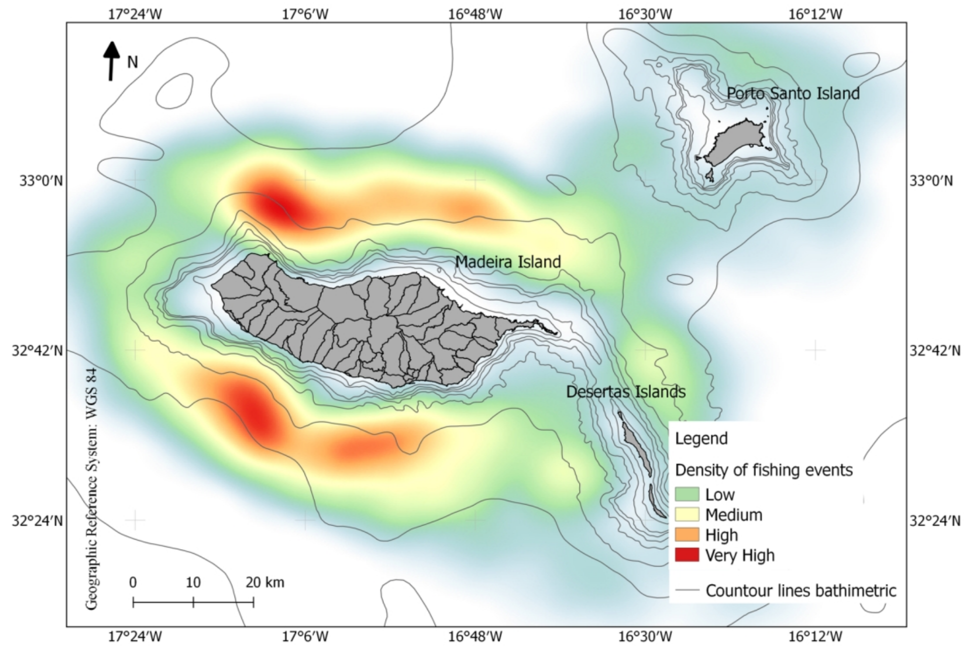

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149x106mm (300 x 300 DPI)