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Original Article

Harvesting juveniles of blackspot sea bream (*Pagellus bogaraveo*) in the Azores (Northeast Atlantic): biological implications, management, and life cycle considerations

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Blackspot sea bream (*Pagellus bogaraveo*) is the most important economical resource of Azorean fisheries. Juveniles (age 0 and 1) were detected along island coastlines in nursery grounds that sheltered individuals of up to 13 cm (fork length). Juveniles occurred in coastal areas in all seasons, but higher catch per unit efforts occurred during summer. Larger individuals tended to be caught on the shelves and slopes of the islands and seamounts by the demersal, mixed hook, and line fisheries. Juveniles were exclusively found at inshore areas, while spawners were distributed over offshore areas (islands shelf/slope and seamounts), suggesting an inter-connected cycle of recruitment in coastal areas and ontogenetic migration of juveniles from inshore to offshore areas, while eggs and larvae drift in the opposite direction. Juveniles were found to be targeted by three types of fisheries, amounting to cumulative annual catches of ~36 t. Shore angling was the most important fishing method, followed by bait fishing for tuna and the coastal pelagic live-bait fishery. Fishery managers have enforced several measures to protect juveniles, although our results indicate that effective interdiction of juvenile catch would provide a long-term increase of 15 and 8% in spawning-stock biomass and catch, respectively, as well as ~13% increase in the value of landings. Although this measure could improve the protection of a species in an advanced state of overexploitation, our results showed that a decrease in fishing effort would be necessary to achieve sustainability of the stock.

Keywords: essential habitat, live-bait fishery, ontogenetic habitat shift, recreational fishing, recruitment.

Introduction

Blackspot sea bream (*Pagellus bogaraveo*) is found in the Northeast Atlantic, from the south of Norway to Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1932). Hareide and Garnes (2001) reported the occurrence of this species along the Mid-Atlantic Ridge (north and south of the Azores). This species presents complex biological dynamics in the face of slow growth, sequential hermaphrodism, and discontinuous essential habitat including coastal areas of the islands and seamounts (Krug, 1990, 1998; ICES, 2012). It is considered a deep-water species and, since the stock structure is unknown, three management units have been adopted for assessment purposes in the Northeast Atlantic (ICES, 2007, 2010a). Stocks have been depleted in northern areas of the European Shelf (Bay of Biscay, ICES Divisions VIIIa, b, c; Lorance, 2011) and are overexploited in the Strait of Gibraltar (south of ICES Division IXa; ICES, 2012).

The availability and market demand for blackspot sea bream seem to drive the dynamics of the multi-specific demersal, mixed hook, and line fishery in the Azores. Blackspot sea bream is the main target species owing to its high selling price (Pinho, 2003), and ranks first in terms of total landed value in the region (Menezes *et al.*, 2006; ICES, 2010a). The current state of the stock is uncertain, although recent trends of the abundance suggest to be fully or even overexploited (ICES, 2012). As a consequence, several technical measures to limit catch and fishing effort have been implemented in recent years (ICES, 2008, 2010a, 2012). However, there are shortcomings in the assessment and management of this resource due to lack of knowledge of the spatial dynamics of the species.

In the Azores, ICES Division Xa2, the blackspot sea bream is considered a stock unit based on genetic and tagging studies (ICES, 2010a); however, the population may have a meta-population structure owing to its discrete spatial distribution around islands and at seamounts separated by areas of deep water where the species does not occur. Migrations and recruitment processes have been thought to connect subpopulations of the different islands and seamounts (Silva and Menezes, 1996; Pinho, 2003).

The location of spawning areas, egg and larval distribution, abundance and transport, as well as adult migration routes and timing are poorly known. The ontogeny of younger life stages of this species has only been described from aquaculture experiments (Peleteiro *et al.*, 1994, 1997). In the Azores, some information about spawning is available from the spring, demersal longline survey. Information on the distribution and abundance of juveniles is also available from the Azorean tuna live-bait fishery and from recreational shore angling (Pinho *et al.*, 1995; Diogo, 2007; Diogo and Pereira, 2014). The young of the year (age 0) tend to shelter at inshore areas, forming dense schools and using these areas as nurseries (Santos *et al.*, 1995; Lorance, 2011). Understanding the dynamics associated with juveniles may give greater insight into the spatial dynamics of the population as a whole.

Blackspot sea bream stocks can easily be overexploited, as shown by the Bay of Biscay stock collapse in the 1980s (Lorance, 2011). This case was a wake-up call for scientists and fisheries managers to the vulnerability of the species related with the life history traits (protandrous hermaphroditism and late maturity). In the Azores, management of this species dates back to 1998, when an annual quota of 1116 t was established, with no special concern for the fate of juveniles. A minimum landing size of 25 cm TL was only introduced in 2006, but this regime made exceptions for shore angling and live-bait catches, by special request. In 2007, the recreational fishing legislation was reviewed and a bag limit of 7.5 kg d^{-1} was imposed for all fish smaller than 40 cm TL. In 2009, the Azorean Government increased the minimum landing size to 30 cm TL and simultaneously banned shore angling for this species and restricted catches of juvenile blackspot sea bream for live bait. However, the tuna observers programme has continued to report catches of juveniles for tuna bait. As the stock was perceived to be overexploited, the TAC was gradually reduced from 1116 t in 1998 to 904 t in 2014 (EC Regulation of the council no. 1262/2012).

This paper aims to summarize the available information about juvenile blackspot sea bream from the Azores, mapping their habitat, as well as describing and estimating catches. Based on this information, the population dynamics of the species is discussed. The pertinence of current management, including recently implemented measures, is also examined.

Material and methods

Spatial distribution of the species

Three population variables were mapped using GIS (Geographic Information System, ArcMap, version 9.1): (i) area with a probability of occurrence of blackspot sea bream in the ecosystem, (ii) distribution of the spawning stock, and (iii) distribution of juveniles (here defined as individuals of age groups 0 and 1). Suitable habitat was assumed to correspond to all seabeds shallower than 700 m within the Azores Exclusive Economic Zone, as suggested by Menezes *et al.* (2006). The distribution of the spawning population was based on the distribution of spawning individuals from spring, bottom longline surveys. The distribution of the spawning stock was defined based on the presence of individuals in spawning and post-spawning stages, maturity stages III and IV (Krug, 1990). Moreover, the proportions of mature and immature individuals were estimated by depth strata, from the spring bottom longline survey for the period 1995–2010. Length composition by depth was used assuming a knife edge on length of first maturity of 30 cm (FL) (ICES, 2012). Details of the Azorean longline survey design can be found in Pinho (2003), Menezes *et al.* (2006), and ICES (2010b).

The distribution of juveniles was defined based on sampling of the live-bait fishery from tuna vessels, data collected by the Regional Fisheries Observer Program (POPA; www.popaobserver.org), and complemented by historical data from the tuna logbooks or personal captain books compiled by the Department Oceanography and Fisheries at the University of the Azores (DOP/UAç).

Catches of juvenile blackspot sea bream

Different datasets and protocols were used to estimate the catch of juveniles from the three main fisheries that exploited them over the period 1998–2010: the recreational shore angling, the tuna live-bait fishery, and the coastal pelagic live-bait fishery.

Recreational shore angling fishery

A roving creel survey method was conducted from October 2004 to September 2005 in Faial and Pico islands. Surveys, over a total of 193 sampling days, were designed to cover all coastal strata and were carried out during 8 d in Faial and 10 d in Pico each month. Additional factors considered were day type (week day/weekend) and time of day (morning/afternoon). The sampling design was defined to cover each spatial unit with two replicates per month randomly selected for each combination of the temporal strata (more details of the sampling design and catch estimation can be found in Diogo and Pereira, 2014).

The catch of juvenile blackspot sea bream by the recreational shore angling fishery in these islands was estimated to be 1.6 t $year^{-1}$ (0.05 kg per capita) in 2004 and 2005 (Diogo and Pereira, 2014). To estimate the total catch in the Azores, this value was raised to the total Azorean human population, assuming that blackspot sea bream are distributed randomly around the Azores and that a similar proportion of the populace practices shore angling everywhere. Time-series of annual abundance indices of juveniles from the spring, demersal longline survey were used to estimate historical catches between 1998 and 2010. The abundance index was the stratified estimation of the abundance of individuals with a fork length $\leq$22 cm, corresponding to the mean length at age 2 (ICES, 2012). The survey time-series was then lagged 1 year to match-up the year-0 and year-1 individuals. Using 2005 as a reference year, the catch from shore angling in each year (y_x) was estimated as the product of the catch in 2005 by the ratio of the abundance index in that year (y_x) to the abundance index in 2005.

Tuna live-bait fishery

Bait fishing targeting blackspot sea bream is similar for all pole-and-line fisheries and fish are usually caught with lift- and handled nets on board small fishing boats. The live bait are kept in water tanks and used later to capture tuna. The tuna live-bait fishery has two components: the bait boats and the general fishing fleet. The first is a targeted fishery for tunas using pole-and-line gear. Since 1998, this fishery has been monitored through the POPA program, which oversees the activity of at least 50% of the fleet during the Azorean tuna season (May–October) (Pereira, 2005). Under this initiative, live bait is identified to species level, biological sampling is performed and catch composition of the bait is recorded (Feio *et al.*, 2005). The remaining component, the general fishing fleet, corresponds to the Azorean, demersal, mixed hook, and line fleet that occasionally and opportunistically targets tunas, particularly the skipjack tuna (*Katsuwonus pelamis*), during summertime. This component of the fleet was not sampled.

Annual blackspot sea bream catches from the tuna live-bait fishery were estimated in two steps: (i) estimation of the total catches from the bait-boat fleet by raising the catches from the sampled vessels to the total number of bait boats, and (ii) raising these estimates to the total landings of skipjack tuna (assuming that the general fishing fleet used the same amount of juvenile blackspot sea bream as bait per unit of landed skipjack tuna.

Live bait for the pole-and-line coastal pelagic fishery

This fishery targets pelagic species occurring in coastal areas (e.g. *Seriola rivoliana*, *Sphyraena viridensis*, *Pomatomus saltatrix*) using pole-and-line gear. To estimate the total catch of blackspot sea bream from these fisheries, three datasets were used: (i) landings reports from Azorean auction markets for the period 1998–2010 (Lotaçor, 2010); (ii) live-bait composition data from POPA for the period 1998–2010; and (iii) mean weight of live-bait catches from logbook data for the period 2006–2010.

Landings data from Lotaçor (2010) were used to identify which coastal pelagic species landings had been made by pole-and-line by analysing the species composition of the landings according to vessel and year. Two steps were used to identify landings produced by pole-and-line: (i) seeking fishing trips where the weight of coastal pelagic species (e.g. *S. rivoliana*, *Sphyraena viridensis*, *P. saltatrix*) was higher than the weight of all other landed species, and (ii) eliminating fishing trips including species that were highly indicative of other gears (e.g. gillnets gears that captured parrot fish simultaneously with coastal pelagic fish). These two steps provided an estimate of the total number of coastal, pelagic, pole-and-line fishing trips per year.

Logbook data were used to estimate the average, total live-bait catch (species combined) per trip for the coastal pelagic, pole-and-line fishery. Seventy-six logbook records of catch of live bait for this fishery were found. Since the skippers of these boats did not report the catch of live bait by species, and the live-bait fishing method is very similar to that of the tuna fleet, the species composition observed in the catch of live bait for the latter, in coastal areas (0–50 m depth), was used. The average quantity of blackspot sea bream caught for bait, per trip, was estimated for the study period and then scaled-up to the total annual number of trips (landings) to estimate the total annual catch of blackspot sea bream.

Catches from all three fisheries were summed to estimate the total, juvenile blackspot sea bream catch per year.

Abundance of juvenile blackspot sea bream by month and habitat

To analyse seasonal variations in juvenile blackspot sea bream throughout the year, data from the recreational shore angling fishery around Faial and Pico (2004–2005) were used. An index of abundance of juveniles was obtained by combining information from interviews and biological sampling of the catch. Only the fishing periods using appropriate hook size and bait for catching blackspot sea bream were considered. Short fishing operations of <30 min were not considered, as suggested by Hoenig *et al.* (1997) and Pollock *et al.* (1997). The coastal habitat was classified into five main categories: boulders, rock, cliffs, harbours, and sandy beaches. The mean catch per unit effort (cpue), estimated by dividing the catch of juvenile blackspot sea bream by the fishing time spent by recreational angler, was calculated for each of the five habitat categories. Furthermore, the length composition, by month, was computed from the biological sampling records.

Yield per recruit

A yield-per-recruit (YPR) model was used to simulate the long-term effects of a ban on juvenile fishing. A steady-state population structure and the corresponding fishing mortality vector were first reconstructed by non-corrected pseudo-cohort analysis of the mean catch-at-age for the period 1995–2010. This estimate corresponds to the current situation of the fishery.

The mean catch-at-age data used on the pseudo-cohort analyses were adopted from ICES (2012). Calculations were carried out with age-at-recruitment set at 1-year old (combining age groups 0 and 1) and a plus-group at age 14. Catch data at age 1 include the average catch of juveniles estimated by this study. The mean weight-at-age data were adopted from ICES (2012). Maturity and sex ratio at age data from Krug (1998), estimated for the year 1991, were used. The proportion of mature females at each age was estimated by the product of maturity and sex-ratio values. Average price per kilogramme by age was calculated as the mean price per commercial category (juveniles, pre-adults, and adults) observed during the last 5 years of the catch time-series (Table 1). The rate of natural mortality was set at 0.2. A terminal *F*-value of 0.5 was used.

Long-term projections, due to changes in fishing mortality, were then performed using the recruitment and fishing patterns estimated from the pseudo-cohort. Simulations were made by changing the fishing mortality from 0 to 1.8 times the fishing vector estimated from the pseudo-cohort. These simulations were performed for the two cases: including and excluding the catches of juveniles at age group 1.

Results

Spatial distribution

The suitable habitat for blackspot sea bream is spatially restricted to the island coasts and major nearby banks with the central group of islands having the highest proportion of suitable habitat for this species (Figure 1). Some seamounts were also suitable along the Mid-Atlantic Ridge, between the central and western

Table 1. Data used as input on the pseudo-cohort and YPR analysis.

Age	Mean catch in number (Ci-10^3) 1995–2010	Mean weight (kg)	Proportion of female mature	Mean price per kg (Euros)
1	553	0.11	0.00	2.4
2	205	0.22	0.00	2.4
3	581	0.36	0.00	2.4
4	386	0.53	0.05	6.6
5	217	0.72	0.31	6.6
6	84	0.91	0.55	6.6
7	56	1.11	0.69	13.0
8	48	1.31	0.78	13.0
9	38	1.50	0.84	13.0
10	31	1.69	0.88	13.0
11	21	1.86	0.91	13.0
12	16	2.02	0.93	13.0
13	7	2.17	0.95	13.0
14+	3	2.31	0.96	13.0

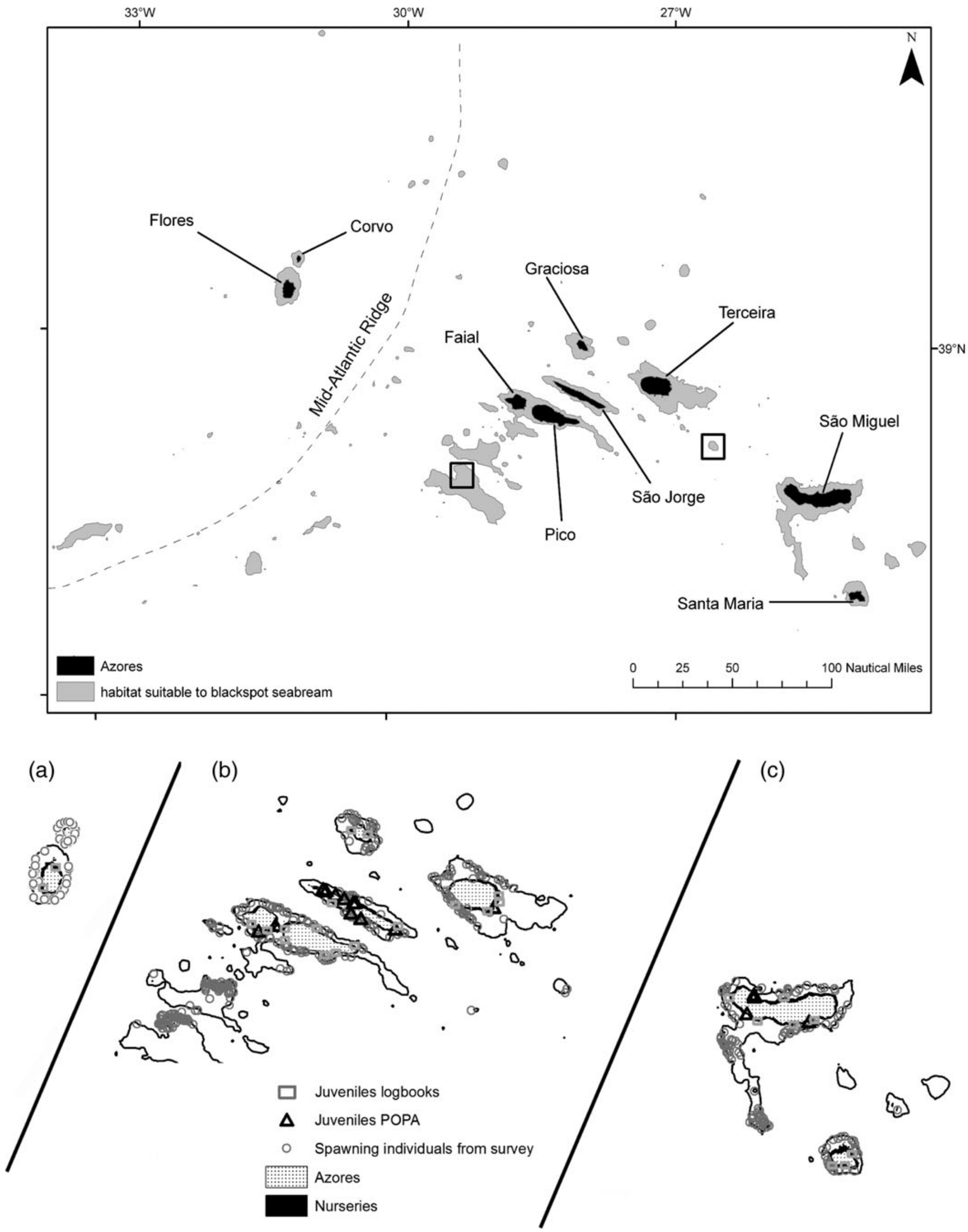

Figure 1. (Upper panel) Spatial distribution of potential habitat of blackspot sea bream (*P. bogaraveo*) limited to 700 m depth in the Azores. Squares indicated seamounts where shallow depths strata (<50 m) are found. (Bottom panel) Spatial distribution of juvenile and spawning blackspot sea bream (*P. bogaraveo*) in the Azores. Positions of juvenile (age groups 0 and 1) catches are from the tuna fishery logbooks (juveniles from logbooks) and observers programme (juveniles from POPA), positions of catches of individuals in spawning condition are from the spring, bottom longline survey (spawning individuals from survey). (a) Western group of islands; (b) central group of islands; (c) eastern group of islands. The thin line is the outer contour of the suitable habitat (700 m) depicted in the upper panel.

groups of islands. Few, if any, seamounts with suitable habitat for the species were found around the western island group (Flores and Corvo).

Juveniles were caught only along the coast, in waters shallower than 50 m (Figure 1). Within the spawning stock, however, males and females in spawning condition were found in all areas and depths

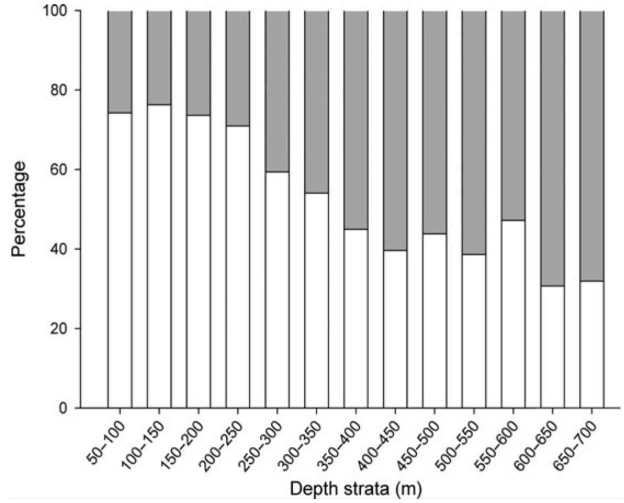

Figure 2. Proportion of matures and immature individuals of blackspot sea bream by depth strata captured by the spring bottom longline survey. The mature individuals are represented by the grey colour, while immature individuals in white.

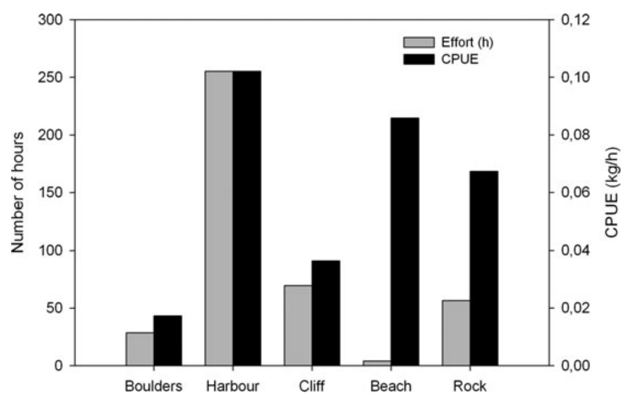

Figure 3. Effort (h) and cpue (kg/h) of juvenile blackspot sea bream (*P. bogaraveo*) by habitat from shore angling data.

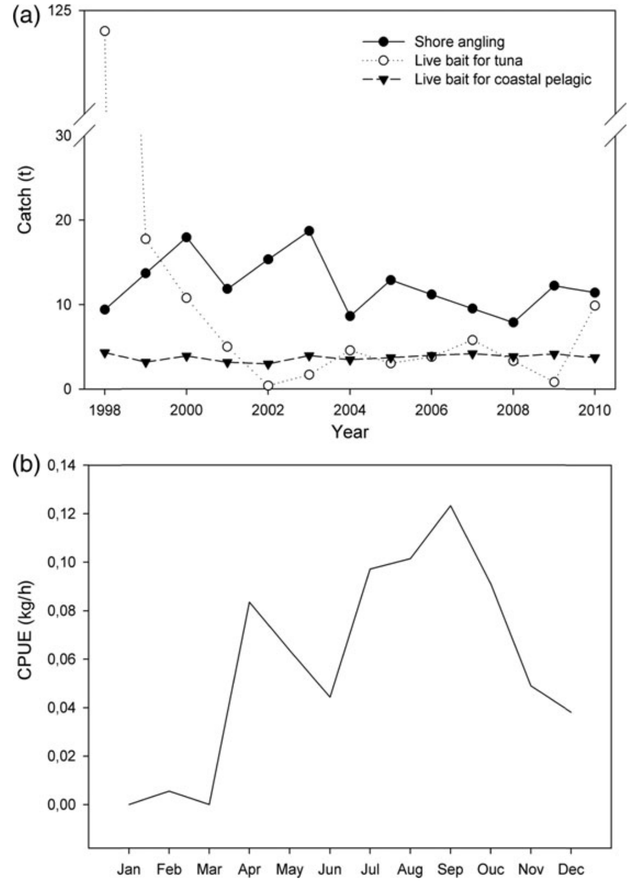

Figure 4. Estimated catches of juveniles of Black spot sea bream (*P. bogaraveo*) from life-bait fisheries and shore angling (a). Monthly abundance of blackspot sea bream (*P. bogaraveo*) from the shore angling fishery (b).

suitable for the species, except nurseries (cf. Figures 1 and 2). Blackspot sea bream catches from tuna vessels were recorded in all islands, except Corvo; however, catches were mainly concentrated in five islands: São Miguel, Terceira, São Jorge, Faial, and Pico (cf. Figure 1). Fishing areas that favoured juveniles were exclusively, close to the shoreline in waters shallower than 50 m. At least two seamounts (*Dom João de Castro* and *Princesa Alice*) have a summit shallower than 50 m, but juveniles were never caught there (Figure 1).

Data from recreational shore angling showed that juvenile blackspot sea bream occurred in all five habitat categories, but the highest cpues were observed in harbours where ~62% of the recreational shore angling fishing effort with hook and bait appropriate to catch them was expended (Figure 3).

Harvesting

Estimated historical catches for shore angling presented higher catches in 2000 and 2003 (Figure 4a). Lower catches were estimated for 2004–2010.

The largest juvenile blackspot sea bream catch (124 t) from the tuna live-bait fishery was recorded in 1998. The catch decreased strongly in the two following years and stabilized below 10 t year^{-1} after 2000, with almost no catch in 2002 and 2009. The annual catch of live bait for the pole-and-line, coastal, pelagic fishery was stable over the study period, being typically from 3 to 4 t (Figure 4a).

The maximum estimated catch of juvenile blackspot sea bream was reached in 1998 (138 t), mainly resulting from the success of the tuna fishery during that year. In subsequent years, the recreational shore angling fishery was the main contributor to the total catch, with an annual average of 13 t caught from 2000 to 2010.

Temporal patterns

The abundance index obtained by the shore angling fishery pointed to the presence of juvenile blackspot sea bream at the coastline almost all year-round, except January and March; highest abundances were observed from July to September (Figure 4b).

Size composition

The length distribution of juvenile blackspot sea bream by month clearly indicated the presence of two cohorts inhabiting the same areas (Figure 5). From February to May, the length distribution appeared to be unimodal; fish ranging from 9 to 13 cm. In June, smaller fish of 6–8 cm appeared and co-occurred with fish of 10–13 cm; a bimodal length distribution. By July, fish larger than 10 cm had disappeared and the length distribution became

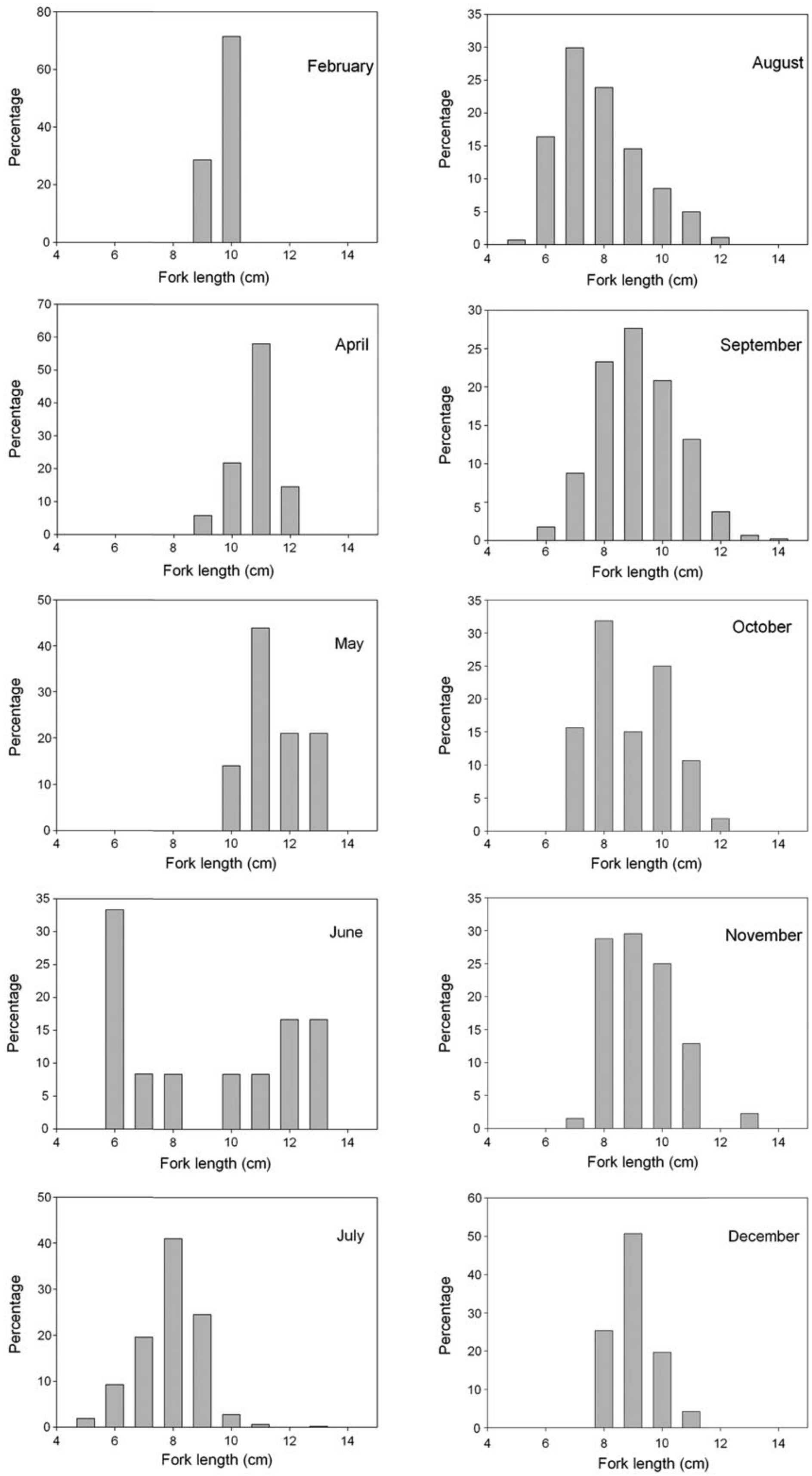

Figure 5. Monthly length (fork length, cm) frequency distribution of blackspot sea bream (*P. bogaraveo*) captured by the shore angling fishery.

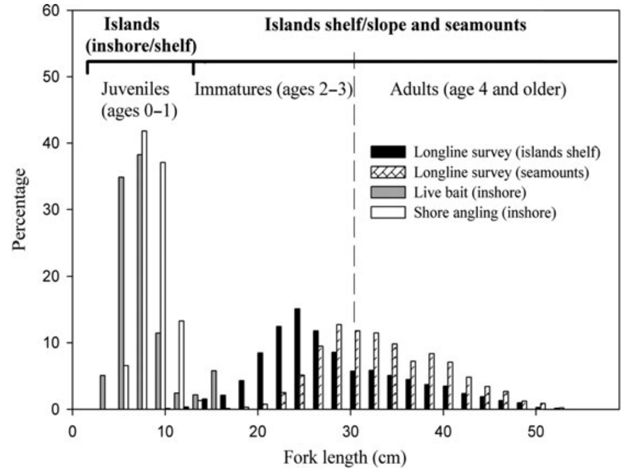

Figure 6. Size distribution of blackspot sea bream (*P. bogaraveo*) captured by commercial tuna fleets, shore angling, and spring, demersal longline survey. Dashed line represents the first maturity length of females (ICES, 2012).

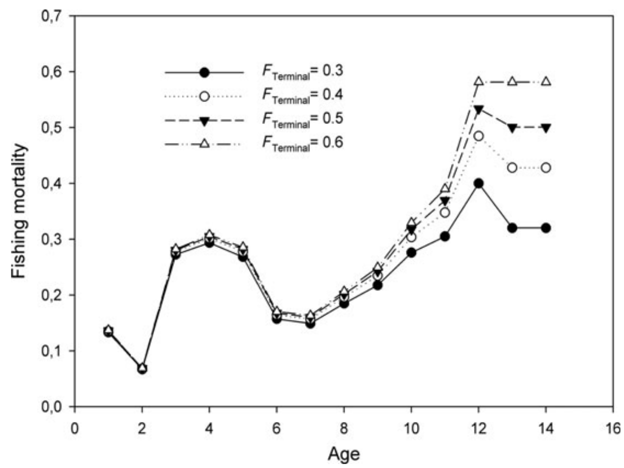

Figure 7. Fishing mortality by age estimated from the pseudo-cohort analyses for different terminal fishing mortalities values. The current fishing mortality (used in the YPR) is represented by the vector correspondent to $F_{terminal} = 0.5$.

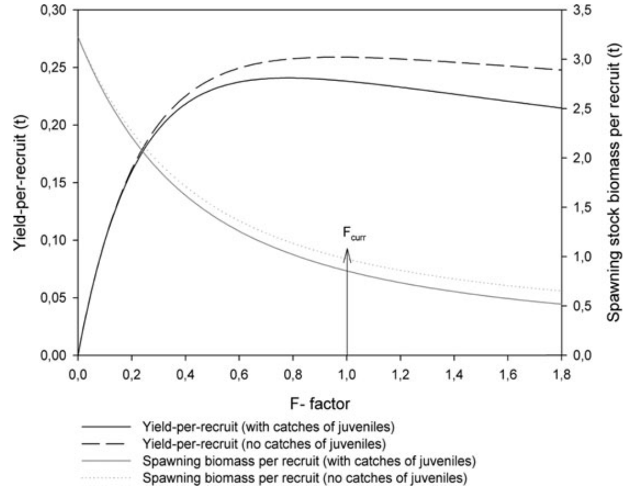

Figure 8. YPR simulation of the Azorean blackspot sea bream stock, showing the simulated yield and stock biomass produced by 4784 recruits at age 1 (ages 0 and 1 combined) with fishing of juveniles at age 1 (current situation, solid lines) and with a ban of juvenile catch (dashed lines). F_{curr} correspond to the current exploitation pattern.

unimodal once again ranging from 6 to 9 cm. During the second half of the year, the size range and the mode seem to increase, and in December, a length distribution similar to that of February was observed (Figure 5).

The length distributions of fish caught by the recreational shore angling fishery and the live-bait fishery, aggregated over the year, were similar, ranging from 5 to 14 cm and from 3 to 15 cm, respectively. The mean length was 8.7 $\pm$ 1.6 cm in the recreational shore angling fishery and 7.6 $\pm$ 2.6 cm in the tuna live-bait fishery (Figure 6).

Juvenile blackspot sea bream $\leq$13 cm were found exclusively along the coastlines of the islands, and were rarely caught in the spring, bottom longline survey, where catches of fish smaller than 14 cm are exceptional (0.16% of all blackspot sea bream caught from 1995 to 2013). In these surveys, fish smaller than 20 cm in length were a minor component (4%) of catches from island shelves, and an even smaller component on seamounts (0.3%; Figure 6). The same maximum length (50–54 cm) was observed on the island shelves and seamounts; however, a larger proportion of larger fish was observed on seamounts (mode of the length distribution at 28–30 and 24 cm, respectively; Figure 6).

Yield per recruit

Average recruitment of 4784 individuals at age 1 was estimated from the pseudo-cohort analysis. The sensitivity analysis conducted for different values of terminal fishing mortality showed that the potential error in terminal fishing mortality poorly affects this recruitment estimate due to the convergence property achieved around age 8 (Figure 7). Long-term simulations for different levels of fishing mortality showed that a fishing ban on juveniles ($F = 0$ to age 1) provide a long-term increase of 15% in spawning-stock biomass and 8% in adult catches (Figure 8). This additional adult catch provides an increase of 13% on the catch in value. The YPR simulation further suggested that yield similar or higher to the current level could be obtained at fishing mortality twice as low with much higher stock biomass.

Discussion

Life cycle considerations

Suitable habitat for blackspot sea bream in the Azores is very limited and discrete (Figure 1). The fish are caught in different locations, separated by abyssal depths were they have not been observed. Juveniles of age groups 0 and 1 were mostly caught along island coasts, close to the shore, corresponding to patterns seen in the Bay of Biscay (Lorance, 2011) and the Mediterranean Sea (Biagi *et al.*, 1998; Félix-Hackradt *et al.*, 2013). Juveniles were not observed on seamounts, including those with shallow summits (e.g. *Princesa Alice* and *D. João de Castro*). On the other hand, during the spawning period, breeders were found across the entire population distributional area (Figure 1). Spawning aggregations between January and April, with a peak in February and March, were previously suggested to occur (Krug, 1990, 1998); however, mark-recapture data only documented migrations from coastal to offshore areas and movements around the same islands or seamounts (unpublished data; Afonso *et al.*, 2012). This pointed to the absence of a designated spawning area with spawning occurring, instead, throughout their habitat range in winter. Eggs and larvae are then transported to coastal littoral areas through various natural mechanisms (Félix-Hackradt *et al.*, 2013). The spawning peak of blackspot sea bream seems to be timed such that larvae hatch when phytoplankton abundance is highest in Azores (March and April; Martins *et al.*, 2007). There is not enough information on larval dispersal and settlement for this species to relate ontogenetic or ecomorphological changes with habitat use. The only studies of this kind available are from aquaculture experiments (Fernández-Pato *et al.*, 1990; Olmedo *et al.*, 1997; Peleteiro *et al*, 1997, 2000). Information for another species of the same genus (*Pagellus erythrinus*) suggests a pelagic larval duration may be around 40 days (Macpherson and Raventós, 2006). Larvae of the blackspot sea bream are highly dependent on environmental variables such as wind direction to reach nursery grounds, as was recently documented by Félix-Hackradt *et al.* (2013). Santos *et al.* (1995) reported observations of new inputs of juveniles (age 0) in April, 4 months after the beginning of the spawning season. We find juveniles of 5–6 cm (FL) began to be caught by shore angling in June (Figure 6). Aquaculture experiments seem to validate these observations, reporting a mean length of ∼7 cm (TL) for 6-month-old individuals (Olmedo *et al.*, 1997). Moreover, the cohort evolution (Figure 6) shows that juveniles remain in coastal areas, which act as nurseries, for almost 1 year, during which time, they reach 10–13 cm (FL) and begin migrating to shelf and slope areas where they recruit to the demersal, mixed hook and line fisheries (Pinho, 2003; ICES, 2006, 2010a). In conclusion, connectivity between different geographical areas of the Azores archipelago appears to be effected through larval dispersal from offshore areas (seamounts) to insular nursery areas, from which juveniles subsequently disperse offshore.

Fishing impacts

Although adult blackspot sea bream is a highly valuable fishery resource, juveniles are caught in coastal areas by recreational shore angling and commercial fisheries for bait. Adults are caught by targeted fisheries on island shelves and seamounts (Figure 6). Further research should be dedicated to understanding the full extent of the impact of juvenile harvesting on the adult stock in these areas, since the catch of juveniles is generally known to reduce future yields and subsequent recruitment to the fishery with high economic costs (Najmudeen and Sathiadhas, 2008).

Average annual catches of juvenile blackspot sea bream, in the Azores, were estimated to be ∼36 t, which is high, particularly given that the stock is currently overexploited. Shore angling has the most bearing, however, the impact of the tuna and coastal pelagic live-bait fisheries may be greater in certain years, depending on the abundance of other bait species available to the fishery, namely small (8–16 cm) blue jack mackerel (*Trachurus picturatus*), the most important live-bait species in the Azores.

The YPR simulation suggested that halting the current catch of juveniles would provide a long-term increase YPR of 15 and 8% in spawning-stock biomass and adult catch, respectively. Owing to the high average price of blackspot sea bream sold in Azorean auction houses (€6–13 kg^{-1}, depending on size category), this additional catch would correspond to an increase in income of ∼13% on the landing value. It also suggested that lower fishing mortalities than the current level could provide similar catches but with considerable increase in the abundance of the stock (Figure 8). This is in line with previous studies showing that reducing the fishing mortality of juveniles, for a late-changing sequential hermaphrodite such as the blackspot sea bream, allows for higher catches and spawning-stock biomass (Lorance, 2011).

It is quite striking that harbours appear to offer the highest cpues and provide the highest returns to the shore angling sector. To the best of our knowledge, higher abundance of juvenile blackspot sea bream in harbours has not been documented elsewhere. It is unknown whether Azorean harbours were built in areas that were initially preferred habitats or if these infrastructures have provided habitats particularly suitable to this species. It could also be that blackspot sea bream is easier to catch in harbours than in natural habitats; however, higher cpues would still imply that harbours are preferred habitats that replenish throughout the year. By definition, harbours are easily accessible, urban areas, where port and fisheries authorities are usually active. Therefore, it might be cost-efficient and straightforward to set up protection for blackspot sea bream in harbours, by calling public attention to its vulnerability, and value beyond commercial interest, such as its uncommon life history, change sex, and deep-water migrations, as a means of establishing efficient control mechanisms.

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