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8.9 Azores case study

Partners: IMAR-UAz (Portugal)

8.9.1 Introduction

The Azores is an oceanic archipelago in the mid North Atlantic Ocean, between the continental Europe and North America (Figure 36). It has a vast exclusive economic zone of 1 million km^2 and largely contributes to the Portuguese claimed 2.1 million km^2 extended continental shelf. The seafloor is mostly deep but over 100 seamounts, a fraction of the Mid Atlantic Ridge, and the slopes of the islands compose the shallowest parts. After the first expeditions to the deep sea in the late 19th century, extensive scientific research based in the Azores has opened a window on the functioning of large oceanic, deep-sea and seamount ecosystems and on the impacts of human activities in such ecosystems.

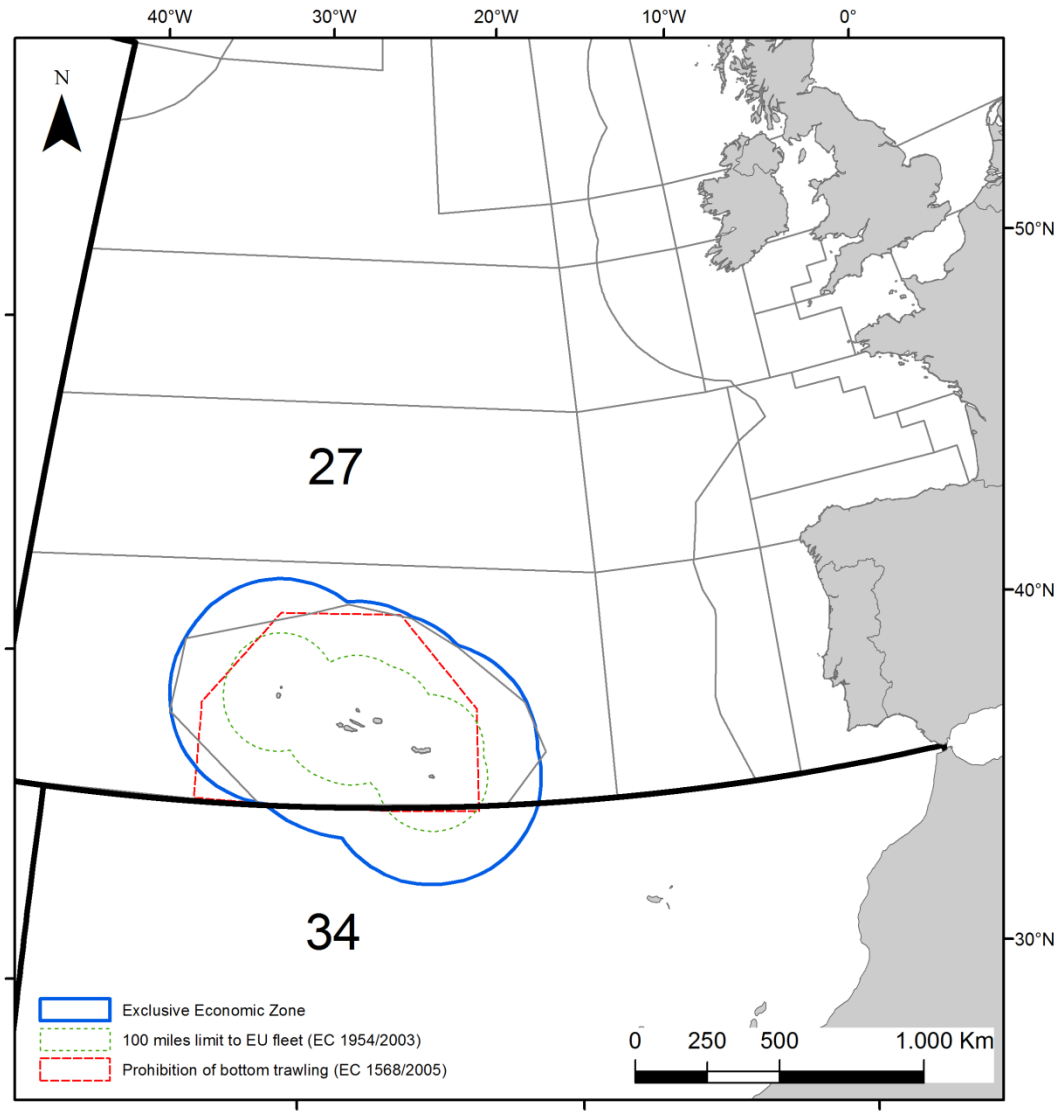

Figure 36: The Azores archipelago, its exclusive economic zone, 100-mile limit to EU vessels, area prohibited to bottom trawling, FAO statistical area, and ICES rectangles.

With the absence of a continental shelf and surrounding great depths, fishing occurs around the island slopes and the many seamounts present in the area (Silva and Pinho, 2007; Morato et al., 2008). Commercial whaling was the first large-scale commercial fishery, peaking in the 1940s and decreasing by the 1960s, being substituted with the more profitable fisheries such as the pole-and-line tuna and demersal fisheries using handlines (Martin and Melo, 1983). The Azorean fishing industry saw significant changes during the 1980s as bottom and surface longlines were introduced (Pereira, 1988; Menezes, 1996). Today, the Azorean fishing industry is composed of five main components: a small-net fishery for small pelagic species (blue jack mackerel, *Trachurus picturatus*, and chub mackerel, *Scomber colias*) with total catch of 1,500 t in 2010 (data obtained from Lotaçor, 2011), a pole-and-line tuna fishery (14,000 t in 2010), bottom longline and handline targeting mainly deep-sea demersal fishes such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), alfonsinos (*Beryx* spp.) or the blackbelly rosefish (*Helicolenus dactylopterus*) with total catch of 3,000 t in 2010, drifting bottom longline for black scabbardfish (*Aphanopus carbo*), and pelagic longline targeting swordfish (*Xiphias gladius*).

The current fishery resource management strategy of the Azores is based on the EU Common Fishery Policy, implemented primarily through total allowable catches (TACs) for various species including blackspot seabream, alfonsinos, and deepwater sharks such as *Deania* spp., *Centrophorus* spp., *Etmopterus* spp., *Centroscymnus* spp., and kitefin shark (*Dalatias licha*) (EC Reg. 2340/2002; EC Reg. 2270/2004). Apart from fish quotas, the regional government of the Azores has implemented technical measures over the years, such as minimum landing sizes or weights, minimum mesh sizes, limitation of licences for some specific gears (e.g. trammel nets), area and temporal closures, and bans on the use of specific gear. An example is the Azores regulation that prohibited deep-sea trawling, which recently became an EC regulation (EC 1568/2005).

Recently, the reported and the illegal, unregulated and unreported (IUU) catches inside the Azores EEZ were estimated for all fishing fleets from 1950 to 2010 (Pham et al., 2013) as 0.9 million t. This value is 111,000 t higher than the amount reported in official Azorean statistics (15%), excluding whales and catch landed outside the Azores that cannot be considered to be true IUU fishing as it is actually landed and entered into fishery statistics elsewhere (Pham et al., 2013). The overall low level of unreported catches compared to other locations reflects the small-scale nature of the fisheries, the geographic isolation of the islands, and the small size of its community. Unreported catches from the bottom longline fishery represent one of the largest part of IUU catches in the Azores (Pham et al. 2013).

A recent study has described some of the discard patterns in the region (Canha, 2013). About 90 species of bony fish and elasmobranchs are regularly discarded (i.e. returned unwanted catches to the sea) by the fisherman operating this multi-specific gear (Canha, 2013). However, the bulk of the discards (80% of all rejected individuals) can be attributed to only three species (*P. bogaraveo*, *H. dactylopterus* and *B. splendens*). It was suggested that the establishment of a TAC system for the multispecific bottom fishery greatly increased discard rates of deep-sea species

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without decreasing catch levels. Such unreported mortality undermines the effectiveness of the TAC system to manage those species, as was previously suggested for other European fisheries. Discards from bottom longline is of concern because it includes many deep-water sharks listed in the IUCN red list of endangered species. For example, the "critically endangered" blue skate (*Dipturus batis*), the "near threatened" kitefin shark (*Dalatias licha*), greenland shark (*Somniosus microcephalus*), and Portuguese dogfish (*Centroscymnus coelolepis*), the "vulnerable" leafscale gulper shark (*Centrophorus squamosus*) and gulper shark (*Centrophorus granulosus*), and the "least concern" arrowhead dogfish (*Deania profundorum*), birdbeak dogfish (*Deania calcea*), longnose velvet dogfish (*Centroscymnus crepidater*), and the smooth lanternshark (*Etmopterus pusillus*).

8.9.2 The fisheries

The Azores case study will focus on discards from the deep-sea fishery inside the EEZ: the bottom hook and-line (longline and handline) and drifting bottom longline (seeTable 39).

The bottom hook-and-line (which includes LLS-DEF2, LLS-DEF1 and LHP_FIF1) is the most important fishery in the region both in terms of landed value, number of boats and jobs (Carvalho et al., 2011). It is considered a small scale fishery operating all year round from coastal areas to offshore seamounts. Since 2000, the use of bottom longlines (LLS-DEF1 and LLS-DEF2) in the coastal areas has significantly been reduced, as a result of the banning of its use in a range of 3 miles from the shore (Morato et al., 2012). As a consequence, the smaller boats that operate in this area have changed their gears to several types of handlines (LHP_FIF1), which may have increased the pressure on some species. According to Carvalho et al. (2011), in 2005 there were about 75 bottom longliners of different sizes operating in the Azores while the number of handline boats was estimated to 378. The bottom longline fisheries directly employed about 350 crew members while the handline fishing about 930 fishermen, representing about 60% of all professional fishermen in the Azores (Carvalho et al. 2011). These numbers are only approximations because of the difficulties in assigning components or gear type to each vessel. Catches from demersal fisheries usually include more than 20 species of commercial interest. In the last 10 years the total landings of the bottom longline and handline components of the Azores commercial fisheries averaged 4.2 thousand tonnes, contributing in average for 42% of all landed weight in the Azores. The bottom longline and handline fishing is by far the most valuable in terms of landed value with an average annual landed value of 18-29 million Euros, representing about 76% of all landed value in the Azores.

Although stock assessment methods and abundance indices show somehow healthy stocks of demersal deep-water species in the Azores, there is a common perception among fishermen that some stocks may be facing serious problems. Additionally, local fishers fear that open access regime under the current CFP reforms will allow foreign vessels to decimate their fish stocks (Carvalho et al., 2011). They argue that they are an ultra-remote island community, with fragile resources and economies and many rural communities heavily dependent on the fishing sector for their economic wellbeing (Carvalho et al., 2011). They need special recognition and special protection from the threats of open access and free-for-all fishing, which would encourage over-exploitation of fish stocks. Additionally, there are some concerns on the potential exploitation of demersal fish stocks outside the Azores EEZ by international trawlers.

Drifting deep-water longline targeting black scabbard fish is still considered a "new" deep-water fishery in the Azores. The number of fishing vessels involved in commercial drifting deep-water longline in 2010 is unknown. However, according to a report prepared by Ramos et al. (2013) there might be about 10 fishing vessels with a mean length of 14m operating the drifting deep-water longline in the Azores. This fishery is still in an experimental phase in the Azores and landings are small but have peaked at 450t in 2012. Bycatch species of this fishery accounted for about 4.0–7.5% of the total number of fish caught, however no data on discards is available. In the Azores as in other regions, deep sea sharks composed the main bycatch (Machete et al., 2011), mainly leafscale gulper shark and the Portuguese dogfish. Other species reported as bycatch of this fishery but with low numbers include *Etmopterus* sp., *Mora moro*, *Deania* cf. *calcea*, *Centroscymnus crepidater*, *Alepochepalus rostratus*, *Deania profundorum* and *Chiasmodon niger*. There is a growing concern with the bycatch of some of these species and Machete et al. (2011) suggested that those catches should be closely monitored in the future if the fishery is to be expanded in the Azores.

Table 39. Métiers targeting demersal and deep-water fish in the Azores.

Métiers	**Code**	**Main species landed**
Bottom longline-demersal species	LLS-DEF2	*P. bogaraveo*, *H. dactylopterus*, *Beryx splendens*, *Pontinus kuhlii*
Bottom longline-deep-water species	LLS-DEF1	*M. moro*
Handline	LHP_FIF1	*P. bogaraveo*, *P. americanus*
Drifting deep-water longline	LLD-DWS	*A. carbo*

8.9.3 Causes of discarding

8.9.3.1 Bottom hook-and-line (LLS-DEF1, LLS-DEF2 and LHP_FIF1)

The main causes of discarding (Figure 37) for the bottom hook-and-line has been assessed during the project PORPESCA and were analysed by Canha (2013). Since there is a great overlap in the target species between handline and longline, these are grouped together under "bottom hook-and-line" gear. Although the gear technology are distinct, we believe that the underlying discard strategies to be very similar between the two gear types.

Observer data on discarding suggest that the incidental catch of individuals smaller than the Minimum Landing Size (MLS) to be the main cause of discarding in the hook-and-line fishery. This is exemplified in Figure 38 for five different species, showing that a large fraction of the catch is composed of small individuals.

The low market value of captured species was identified as the second causes for discards in the fishery. About 40% of the captured species have no commercial value and includes mostly deep-water elasmobranchs. In their analysis, Canha, (2013) included discards of species that have

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reached their Total Allowable Catch (TAC) in "low market value". For example, in the years when the TAC for alfonsinos was reached, landings stopped whilst discards increased (Figure 39).

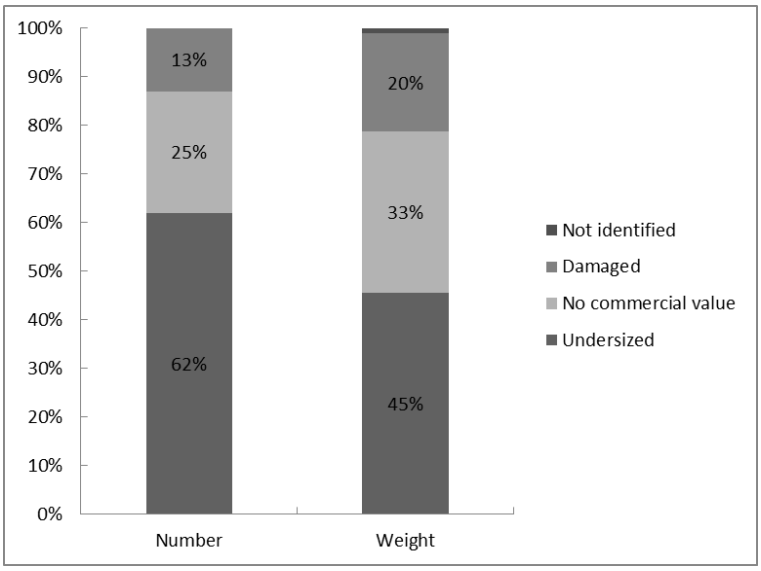

Figure 37. Relative proportion of the different causes for discards in the bottom longline fishery in the Azores based on observer data for the period 2004-2011 (data from Canha, 2013). (Note that "low market value" includes situations where a particular quota has been reached).

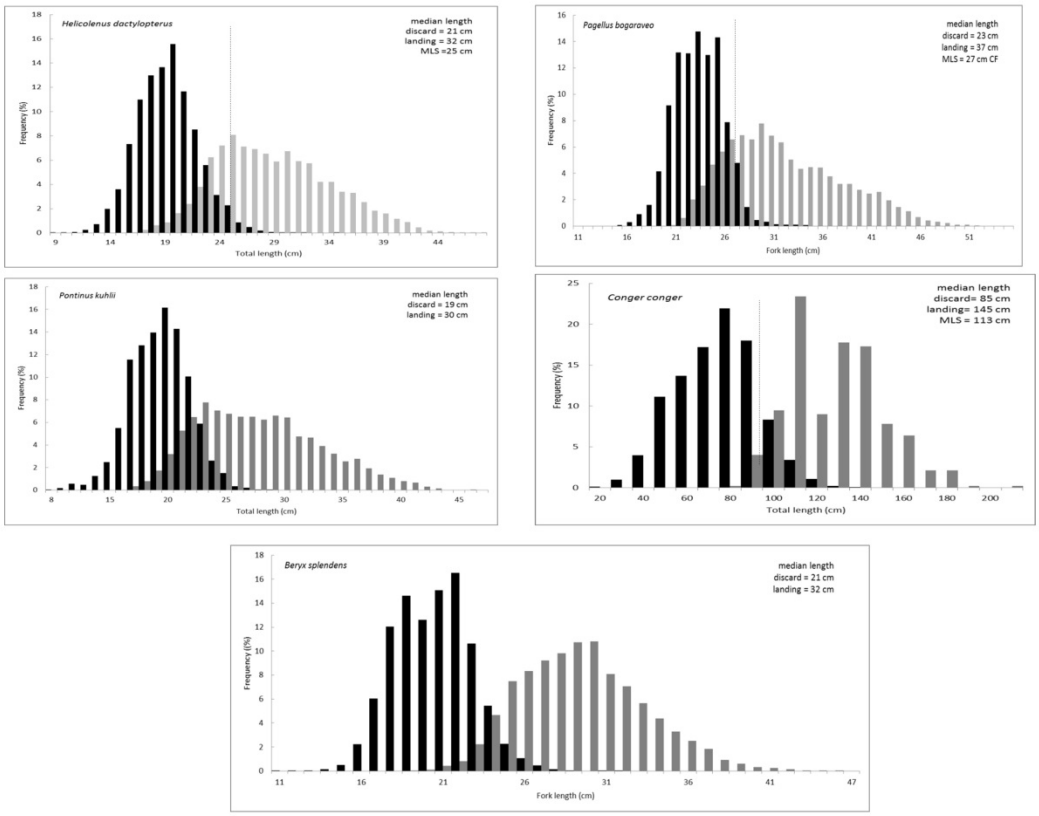

Figure 38. Length frequencies of rejected (black lines) and landed (grey lines) for five species of fish caught by bottom longline between 2004 and 2011. The dashed line indicates minimum landing size (data from Canha, 2013).

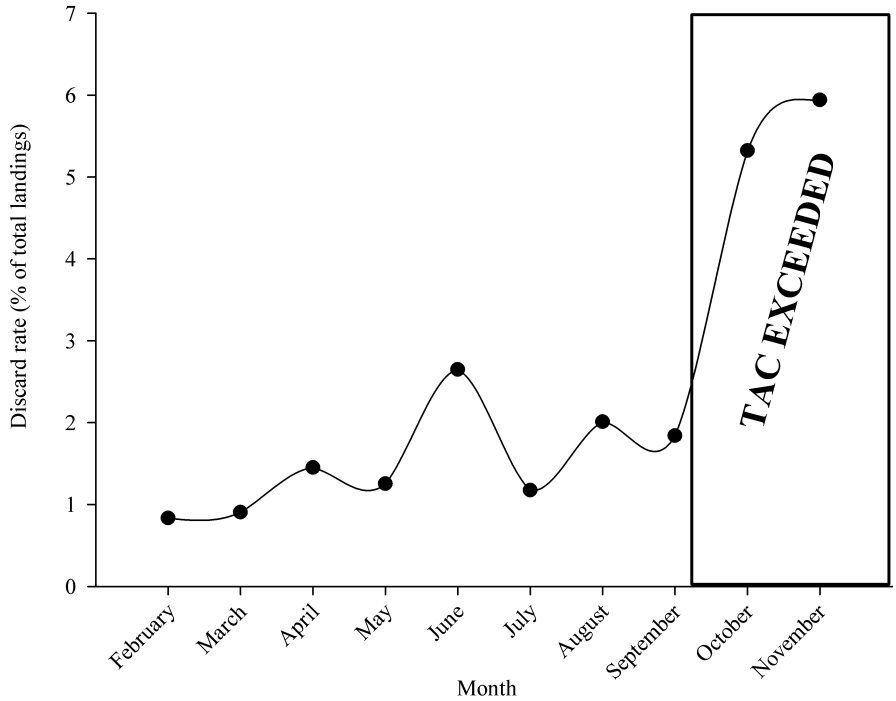

Figure 39. Mean monthly discard rate as a proportion of total landings for the splendid alfonsino (Beryx splendens) from observer data for three consecutive years (2008, 2009, and 2010). The box displays the time when the total allowable catch (TAC) was reached (Pham et al., 2013).

The capture of individuals of commercial interest but damaged during hauling is another important cause for discards and was particularly important for *Phycis phycis* and *Trachurus picturatus* as a result of predation. The reason for this species to be more subject to predation in comparison to other species has not been assessed (Canha, 2013).

8.9.3.2 Drifting deep-water longline (LLD-LPF)

Although this fishery remains to be analyzed in more details, some experimental fishing sets were accompanied by qualified scientific observers of the Azorean Fisheries Observer Programme (POPA) between 1999 and 2005, providing some insights on the by-catch associated with this gear (Machete et al., 2011). The main causes for discarding appear to be related to the low commercial value of the bycatch species. Deep-sea sharks (mainly leafscale gulper shark, *C. squamosus*) are the main bycatch organisms (Machete et al. 2011).

8.9.4 Effects of discarding

The ecological effects of discards in the Azores marine ecosystem have not been quantified yet. Also, the mortality rates of discards have not been measured. It is however assumed, based on mark and recapture or telemetry studies (Afonso pers. comm.), that the most discarded species (*P. bogaraveo*, *B. splendens*, and *H. dactylopterus*) have very high survival rates after discarding.

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8.9.5 Discard Data

8.9.5.1 Discard sampling

Discard data has been collected in the Azores during the PORPESCA project (Programa de Observação das Rejeições da Pesca Comercial) from 2004 to 2011 with observers onboard some bottom longline (LLS-DEF1 and LLS-DEF2) and handline (LHP_FIF1) fishing vessels. For the deep-water drifting longline (LLD-DWS), some observers covered some experimental fishing sets between 1999 and 2005. Other observers programs have collected some data on the pelagic longline fishery (LLD-LPF) and the pole-and-line tuna fishery (LHP-LPF). The pole-and-line fishery is the fleet with most consistent observer coverage, with about 50% of the total tuna catch covered each year since 1998. In opposite, no dedicated observer programs exist for the remaining fleets. Therefore, for these métiers, fisheries data are only collected punctually.

At present, none of this data is being used for stock assessment or management of the local fisheries resources.

8.9.6 Measuring Discards

8.9.6.1 Bottom hook-and-line

The rate of discards for bottom hook-and-line gear is presented inTable 40, in relation to official landing, both in terms of number of individuals and landed weight. The majority of discards can be attributed to five species of commercially important fish (*P. bogaraveo*, *H. dactylopterus*, *B. splendens, C. conger, L. caudatus)* and one deep-sea shark (*E. spinax*). Based on observer data between 2004 and 2011, Canha (2013) used two methods to estimate annual discard amount for the entire Azorean hook-and-line fleet. Estimates of annual discards based on landings varied from 163 t in 2009 (CV = 40.7%) and 249 t in 2007 (CV = 26.7%) while estimates based on fishing effort (number of hooks) ranged between 750 t in 2009 (CV = 7.1%) and 1345 t in 2011 (CV = 3.8%).

8.9.6.2 Drifting deep-water longline

Table 3 shows the total weight of accessory species captured by the deep-water drifting longline dedicated to the black scabbard fish (Machete et al. 2011). It is important to note that most of this bycatch was probably not discarded. It is likely that all elasmobranchs were discarded but there is no data available to ensure that this was the case. As a result, there is currently not enough data to estimate total discards from this fishery. Yet, considering it is a new fishery in the Azores, it is likely that the discards are negligible at the moment.

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Table 40. Discard ratio in number and weight of the ten species mostly discarded from the hook-and-line fishery in the Azores, between 2004 and 2011.

	Species	Number	% discarded		Species	Weight (kg)	% discarded
1	*Helicolenus dactylopterus*	32504	35,2	1	*Beryx splendens*	6167	12,9
2	*Beryx splendens*	18880	20,4	2	*Helicolenus dactylopterus*	4925	10,3
3	*Pagellus bogaraveo*	8839	9,6	3	*Conger conger*	3942	8,3
4	*Etmopterus spinax*	7952	8,6	4	*Lepidopus caudatus*	2748	5,8
5	*Lepidopus caudatus*	4417	4,8	5	*Pagellus bogaraveo*	2690	5,6
6	*Conger conger*	3493	3,8	6	*Etmopterus spinax*	1359	2,8
7	*Coelorinchus caelorhinchus*	2823	3,1	7	*Dipturus batis*	1271	2,7
8	*Pontinus kuhlii*	2762	3,0	8	*Prionace glauca*	991	2,1
9	*Malacocephalus laevis*	1697	1,8	9	*Raja clavata*	826	1,7
10	*Etmopterus pusillus*	1132	1,2	10	*Deania profundorum*	600	1,3
[...]				[...]			
12	*Trachurus picturatus*	783	0,8	14	*Phycis phycis*	406	0,9
14	*Phycis phycis*	647	0,7	16	*Pontinus kuhlii*	382	0,8
15	*Raja clavata*	533	0,6	19	*Beryx decadactylus*	327	0,7
21	*Beryx decadactylus*	294	0,3	20	*Trachurus picturatus*	304	0,6
22	*Scomber colias*	268	0,3	25	*Polyprion americanus*	173	0,4
50	*Polyprion americanus*	23	0,0	26	*Scomber colias*	153	0,3
	All other 81 species	5386	5,8		All other 81 species	20436	42,8
	Total	92431	100		Total	47698	100

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Table 41. Species caught during a black scabbard fish experimental fisheries in the Azores between 1999 and 2005 but excluding 2001 and 2002 (Machete et al. 2011).

Species	Common name	1999	2000	2003	2004	2005	Total
Aphanopus carbo	Black scabbard fish	7817	23720	28755	3576	46376	110244
Other teleost fish							
Alepisaurus ferox	Longnose lancetfish		7	4	11		22
Alepisaurus brevirostris	Shortnose lancetfish	1					1
Alepocephalus agassizii	Agassiz' slickhead					5	5
Alepochepalus rostratus	Risso's smooth-head				23	74	97
Balistes carolinensis	Trigger fish					1	1
Bathylaco nigricans	Black warrior	1					1
Beryx splendens	Splendid alfonsino	6	2				8
Brama brama	Atlantic pomfret	1		1			2
Centrolophus niger	Blackfish					2	2
Chiasmodon niger	Black swallower		40				40
Conger conger	European conger		1				1
Coryphaena hippurus	Common dolphinfish	1	4	4			9
Epigonus telescopus	Bulls-eye		7	2			9
Kali macrodon		1					1
Lepidion eques	North Atlantic codling	10			1		11
Lepidocybium flavobrunneun	Escolar	2	2	1		1	6
Lepidopus caudatus	Silver scabbard fish		1		1	3	5
Mora moro	Common mora	3	39	233	25	77	377
Nesiarchus nasutus	Black gemfish	1		1	1	14	17
Polyprion americanus	Wreckfish					1	1
Promethichthys prometheus	Roudi escolar	4	3	1		1	9
Rouleina maderensis	Madeiran smooth-head				1		1

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Scombrolabrax heterolepis	Longfin escolar		1			1	2
Seriola sp.		1	1				2
Synaphobranchus kaupii	Kaup's arrowtooth eel					3	3
Taractichthys longipinnis	Bigscale pomfret		4			1	5
Thunnus obesus	Bigeye tuna		2	1	1		4
Xenodermichthys cope	Bluntsnout					1	1
Xiphias gladius	Swordfish	1	8	4		2	15
Zeus faber	John dory	3					3
Zu cristatus	Scalloped ribbonfish					1	1
	Fish	18	3			12	33
Elasmobranches							
Centrophorus granulosus	Gulper shark					2	2
Centrophorus squamosus	Leafscale gulper shark	419	897	930	124	1643	4013
Centroselachus crepidater	Longnose velvet dogfish		11			107	118
Centroscymnus cryptacanthus	Shortnose velvet dogfish	7	6			585	598
Dalatias licha	Kitefin shark				1	9	10
Deania cf. calcea	Birdbeak dogfish	18	11	32	38	67	166
Deania profundorum	Arrowhead dogfish					46	46
Deania spp.			1			12	13
Etmopterus sp.			9		3	605	617
Prionace glauca	Blue shark					22	22
	Sharks		2			460	462
Other species							
Ommastrephes bartramii	Red flying squid		1				1
	Squid	4	1		1	2	8
	Turtle	1				1	2

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8.9.7 Methods for reducing discards

Gear alterations have been suggested to reduce the bycatch in the pelagic longline fisheries. This measure was put forward to decrease the unwanted catch of marine turtles. To our knowledge no other methodology has been adopted to for reducing discards.

8.9.8 Ecosystem modeling of the open-ocean and deep-sea environments of the Azores

An Ecopath with Ecosim and Ecospace model for the Azores deep-sea ecosystem was developed and fitted to time series data of relative abundance and catch, to describe the trophic structure of the Azores ecosystem, to identify keystone species and, most importantly, to identify the main drivers of ecosystem variability including fishing and environmental signals (Morato et al., submitted).

The Azores is a Portuguese archipelago composed of nine isolated islands situated on the Mid-Atlantic ridge (Figure 40) and has an extensive EEZ of about 1 million km^2. The islands have narrow shelves and steep slopes, and the surrounding waters have an average depth of 3,000 m. Only 0,8% of the EEZ is less than 500 m deep. The highly irregular submarine topography, consisting mainly of rocky bottoms, contain vast undersea mountain ranges, with an estimated 63 large and 398 small seamounts-like features (knolls, hills or guyots), deep-water coral reefs and volcanic hydrothermal vents (Morato et al., 2008, 2013; Braga-Henriques, 2013). The climate is oceanic subtropical to temperate. In winter a deep mixed layer is present at 150 m and average sea surface temperature (SST) is about 15°C to 16°C. While during summer, a seasonal thermocline develops at 40 to 100 m and average SST is typically 22 - 24°C (Santos et al. 1995). The region is characterized by very complex ocean circulation patterns. Large scale circulation is dominated by the eastward-flowing Gulf Stream jet, which forms a current system with many unstable eddies and meanders, the cold North Atlantic Current in the north, and the warm Azores Current in the south (Santos et al., 1995; Alves and Verdière, 1999; Johnson and Stevens, 2002). Various water masses are present around the Azores. North Atlantic Central Water occurs above a permanent thermocline, located at depths shallower than 700 m, North Atlantic Deep Water is the dominant water mass below 2,000 m depths, and at intermediate depths, northern sub-polar waters and Antarctic Intermediate Water predominate, but Mediterranean Water can also occur (Santos et al., 1995; Mann and Lazier, 1996; Johnson and Stevens, 2002). We developed a model for the EEZ of the Azores that includes the deep-sea, open-ocean, some seamounts, parts of the Mid Atlantic Ridge and island slopes (Figure 40). The total area of the model considered is 954,563km^2 and the limit is defined by the boundary of the EEZ. The year 1997 was chosen as reference since most of the data used to construct the model (diet and growth parameters) originated from that year.

The Azores fisheries can be divided in four main components: the small pelagic fisheries targeting amongst others blue jack mackerel (*Trachurus picturatus*) and chub mackerel (*Scomber colias*), the pole-and-line tuna fishery, the pelagic longline fishery targeting swordfish (*Xiphias gladius*) and blue shark (*Prionace glauca*) and the bottom longline and handline fisheries targeting demersal fishes. Furthermore, a drifting deep-water longline fishery targeting

black scabbardfish (*Aphanopus carbo*) is a recent and fast growing fishery in the Azores (Machete et al., 2011). An overview of the main fisheries in the Azores, their gear types, target species, fishing vessels and regulations was taken from Carvalho et al. (unpublished data). A total of 10 Azorean fishery fleets were modelled: the deep longline and handline, regional pelagic longline, Portuguese mainland pelagic longline, foreign pelagic longline, pole and line tuna (including the pole and line live-bait fishery), small pelagic, drifting deep-water longline, commercial coastal invertebrates, recreational fishing, bottom trawling and the squid (*Loligo forbesi*) fleets. Total marine catch data for the period 1997-2010 was obtained from Pham et al., (2013) and this dataset was expanded with total marine catch data for the period 2011-2014 (Christopher Pham, unpublished data). The dataset contains a complete account of both the official fishery statistics and estimated illegal, unreported, and unregulated catch of marine species catches within the Azores EEZ for the period 1950-2012. The present version of the model does not separate discards from the rest of unreported catches. Species catch data was assigned to the different fishing fleets and the functional groups. All catch data that could not be assigned to a specific functional group or fleet (e.g. unidentified marine species) were redistributed into the groups exploited by the various fleets (Figure 41).

The model was constructed with a focus on the intermediate and deep water species present in the Azores ecosystem and where possible, recent and local data was used for the model parameterization. A critical first step in the model construction consisted of grouping the species present in the ecosystem into functional groups (defined biomass pools), essentially biologically and ecologically defined groups with similarities in, amongst others, size, feeding habits and habitat. The model presented here consists of 45 functional groups, including a detritus group, two primary producer groups, eight invertebrate groups, 29 fish groups, three marine mammal groups, a turtle and a seabird group (Table 42). Model parameters, P/B, Q/B and P/Q were estimated for all groups and a preliminary diet matrix was assembled using preferentially local literature on stomach content analyses, completed with other literature and adapted using empirical knowledge. The model pedigree describing the origin and quality of each parameter was documented and used to assign confidence intervals to the data using a sensitivity analysis routine included in the Ecoranger module. The model was calibrated by fitting it to time series data of relative biomass, fisheries catches, fishing effort. Forcing functions were applied to the model to account for other interactions between the components of the food web and physical or environmental factors affecting the ecosystem.

Cephalopods, pelagic sharks and toothed whales were identified as groups with key ecological roles in the ecosystem. The fitting procedure resulted in a considerable improvement in goodness-of-fit to historical and current fishing effort and biomass estimates. Optimal sets of predator-prey relationships and environmental variability were explored. This proved a big step forward in developing credible ecosystem models that can simulate the effect of different management options for the Azorean fisheries on the ecosystem.

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Table 42. Input and main output parameters for Azores ecosystem model. Output parameters are presented in bold. P/Q: production rate over biomass. Q/B: consumption rate over biomass. EE: ecotrophic efficiencies. P/Q: production rate over consumption rate. OI: omnivory index.

	Group name	Trophic level	Habitat area (fraction)	Biomass in habitat area (t/km^2)	Biomass (t/km^2)	P/B (yr^{-1})	Q/B (yr^{-1})	EE	P/Q	OI
1	Phytoplankton	1	1	2.9	2.9	576.29		0.12		
2	Algae	1	0.0003	2619	0.9072	4.34		0.02		
3	Small Zooplankton	2.00	1	4.3925	4.3925	11.21	43.29	0.90	0.26	
4	Large Zooplankton	2.58	1	3.4092	3.4092	4.78	15.50	0.90	0.31	0.29
5	Shrimp	2.77	1	2.2264	2.2264	1.45	9.67	0.95	0.15	0.41
6	Cephalopods	3.72	1	0.3186	0.3186	3.28	12.29	0.95	0.27	0.57
7	Crabs	2.26	1	1.9685	1.9685	1.60	10.00	0.95	0.16	0.27
8	Benthic filter feeders	2.05	1	2.1463	2.1463	0.80	9.00	0.95	0.09	0.05
9	Benthic worms	2.20	1	1.1508	1.1508	2.28	11.40	0.95	0.2	0.16
10	Other benthos	2.17	1	1.0283	1.0283	3.00	10.00	0.95	0.3	0.15
11	Shallow water S	3.16	0.0014	11.0420	0.0149	2.49	8.31	0.95	0.3	0.29
12	Shallow water M	3.28	0.0014	12.7074	0.0172	1.26	6.30	0.95	0.2	0.56
13	Shallow water L	3.57	0.0014	1.2635	0.0017	0.44	4.42	0.95	0.1	0.58
14	Pelagic S	2.99	1	0.5047	0.5047	2.84	9.47	0.95	0.3	0.39
15	Pelagic M	3.86	1	0.1202	0.1202	0.87	4.33	0.95	0.2	0.18
16	Pelagic L	4.47	1	0.0008	0.0008	0.73	2.50	0.95	0.29	0.22
17	Mesopelagics	3.35	1	0.9538	0.9538	2.59	8.62	0.95	0.3	0.23
18	Bathypelagic	3.90	1	0.6589	0.6589	0.44	4.90	0.95	0.09	0.33
19	Demersal S	3.56	0.0048	12.5824	0.0603	2.23	7.43	0.95	0.3	0.11
20	Demersal M	3.83	0.0048	3.8912	0.0186	0.93	4.66	0.95	0.2	0.34
21	Demersal L	4.31	0.0048	0.8363	0.0040	0.46	3.82	0.95	0.12	0.32
22	Bathydemersal S	3.29	0.9939	0.9701	0.9641	0.50	4.95	0.95	0.1	0.05
23	Bathydemersal M	3.83	0.9939	0.0035	0.0034	0.33	3.31	0.95	0.1	0.23
24	Bahtydemersal L	4.39	0.9939	0.0003	0.0003	0.35	3.53	0.95	0.1	0.24
25	*Helicolenus d. dactylopterus*	4.09	0.0056	3.6871	0.0205	0.46	4.57	0.95	0.1	0.31
26	*Conger conger*	4.61	0.0052	1.1887	0.0062	0.13	2.99	0.95	0.04	0.21
27	*Pontinus kuhlii*	4.00	0.0025	0.1709	0.0004	0.25	3.62	0.95	0.07	0.26
28	*Raja clavata*	4.25	0.0019	0.3157	0.0006	0.29	4.10	0.95	0.07	0.23
29	*Phycis phycis*	4.08	0.0024	2.1902	0.0052	0.22	4.50	0.95	0.05	0.36
30	*Pagrus pagrus*	3.39	0.0012	0.8064	0.0010	0.32	4.73	0.95	0.07	0.29
31	*Beryx splendens*	3.75	0.0051	0.4408	0.0023	0.40	3.58	0.95	0.11	0.15
32	*Beryx decadactylus*	3.73	0.0070	0.3452	0.0024	0.26	2.74	0.95	0.10	0.15
33	*Pagellus bogaraveo*	4.04	0.0048	2.6250	0.0126	0.31	4.68	0.95	0.07	0.22
34	*Mora moro*	4.27	0.9939	0.0014	0.0014	0.17	2.69	0.95	0.06	0.27
35	*Lepidopus caudatus*	4.32	1	0.0450	0.0450	0.25	4.79	0.95	0.05	0.13
36	Rays and other sharks	4.16	0.0061	0.0916	0.0006	0.31	3.13	0.95	0.1	0.46
37	Deepwater sharks	4.39	0.9939	0.0029	0.0029	0.36	3.57	0.95	0.1	0.27
38	Pelagic sharks	4.30	1	0.0486	0.0486	0.27	2.68	0.95	0.1	0.15
39	Tunas	4.09	1	0.0883	0.0883	0.36	3.03	0.95	0.12	0.13
40	Turtles	3.63	1	0.0404	0.0404	0.15	3.50	0.95	0.04	0.04
41	Seabirds	4.15	1	0.0001	0.0001	0.25	84.39	0.23	0.00	0.18
42	Dolphins	4.31	1	0.0019	0.0019	0.10	11.41	0.38	0.01	0.15
43	Baleen whales	3.49	1	0.0208	0.0208	0.06	5.56	0.46	0.01	0.11
44	Toothed whales	4.64	1	0.0560	0.0560	0.02	10.27	0.13	0.00	0.06
45	Detritus	1	1	1	1			0.05		

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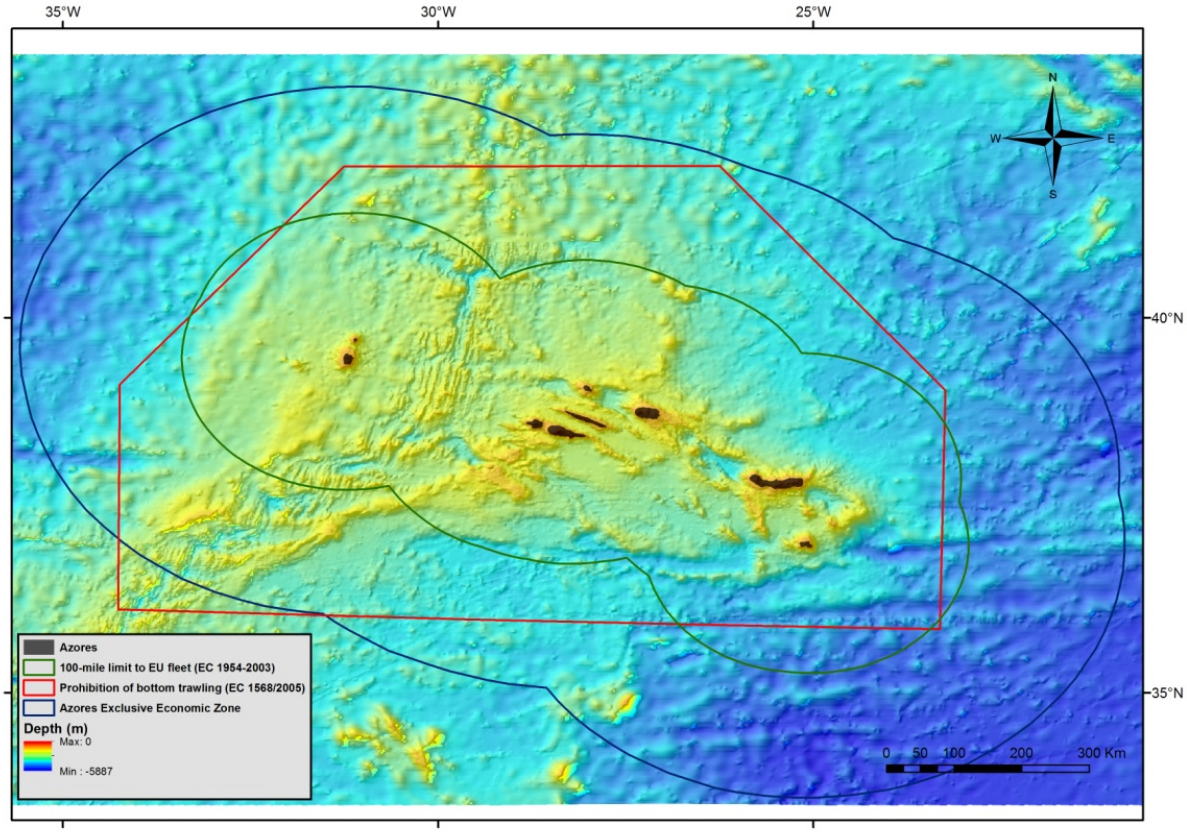

Figure 40. Bathymetry map of the Azores archipelago region, its exclusive economic zone, 100-mile limit to EU vessels and area prohibited to bottom trawling (Bathymetry layer source: Ricardo Medeiros, ImagDOP).

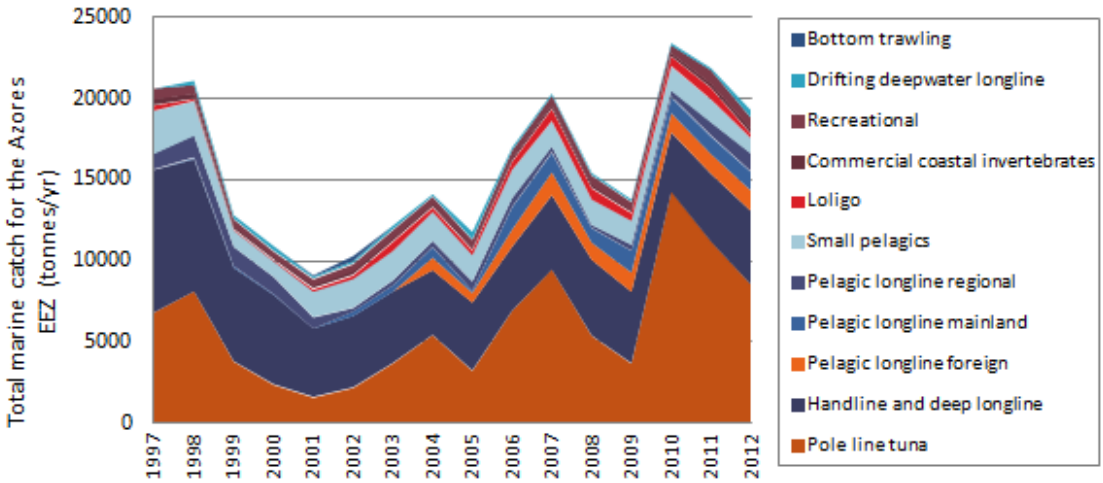

Figure 41. Total marine catch time series for the different modelled fleets for the entire Azores EEZ over the period 1997-2012.

8.9.9 References

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