



OSPAR
COMMISSION

*Protecting and conserving the
North-East Atlantic and its resources*

Background Document for Azorean barnacle *Megabalanus azoricus*



Acknowledgement

This report was prepared by António Teixeira and Maria Ana Dionísio and is submitted by DGRM (Ministry of the Sea) in collaboration with the Regional Administration of the Azores.

Cover page acknowledgement: Azorean barnacles - *Megabalanus azoricus* (Pilsbry, 1916) © Maria Ana Dionísio

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l'Allemagne, la Belgique, le Danemark, l'Espagne, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède, la Suisse et l'Union européenne.

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Background Document for Azorean barnacle *Megabalanus azoricus*

Executive Summary

This Background Document on the Azorean barnacle *Megabalanus azoricus* has been developed by OSPAR following the inclusion of this species on the OSPAR List of threatened and/or declining species and habitats ([OSPAR Agreement 2008-6](#)). The inclusion of the feature on the list was supported by an analysis against the Texel-Faial criteria ([OSPAR Agreement 2019-03](#)), as presented in the case report ([publication 358/2008](#)). This Background Document provides proposals for action and includes measures that could be taken to improve the conservation status of the species. In agreeing to the publication of this document the OSPAR Contracting Parties have indicated the need to further review these proposals. However, the publication of this background document does not imply any formal endorsement of these proposals by the OSPAR Commission. On the basis of the further review of these proposals, OSPAR will continue its work to ensure the protection of *Megabalanus azoricus*, where necessary in cooperation with other competent organizations. This background document may be updated to reflect further developments or additional information that become available on the status of the species.

Récapitulatif

Le présent document de fond sur la grande balane des Açores *Megabalanus azoricus* a été élaboré par OSPAR après l'inclusion de cette espèce dans la Liste OSPAR des espèces et habitats menacés et/ou en déclin ([Accord OSPAR 2008-6](#)). L'inclusion de l'espèce a été soutenue par une analyse par rapport aux critères Texel-Faial ([Accord OSPAR 2019-03](#)), qui se trouve dans le rapport de cas ([publication 358/2008](#)). Ce document fournit des propositions d'actions et des mesures qui pourraient être prises dans le but d'améliorer l'état de conservation de l'espèce. En se mettant d'accord sur la publication de ce document, les Parties Contractantes OSPAR ont indiqué la nécessité de réviser de nouveau ces propositions. La publication de ce document ne signifie pas, par conséquent, que la Commission OSPAR adopte elle-même et à titre formel ces propositions. Après la nouvelle révision de ces propositions, OSPAR poursuivra ses travaux dans le but d'assurer la protection de la balane des Açores, le cas échéant avec la coopération d'autres organisations compétentes. Ce document de fond pourra être mis à jour pour tenir compte de nouvelles avancées ou des informations nouvelles qui deviendront disponibles concernant le statut de l'espèce.

1. Background information

Name of species

Megabalanus azoricus (Pilsbry, 1916)

Azorean barnacle

The Azorean barnacle *Megabalanus azoricus* (Pilsbry, 1916) was nominated for the OSPAR List as a Macaronesian species considered to be endemic to the Azores archipelago. The case report published in 2008 provides details on the species and an assessment against the Texel-Faial criteria.

The phylogenetic relationship of the Azorean barnacle to the *Megabalanus* populations occurring on Madeira and further south in St. Helena was studied by Southward (1998) as reflected in the case report. The species was included in a checklist of the Cirripedia occurring at Madeira (Wirtz *et al.* 2006) and is also described in the Canary Island (DGOT, 2005; Wirtz and Debelius 2003). The taxonomy of this barnacle and the relationships among forms inhabiting isolated North Atlantic oceanic islands has been revisited in a recent study involving state-of-the art techniques and molecular analysis (Quinteiro *et al.*, 2015).



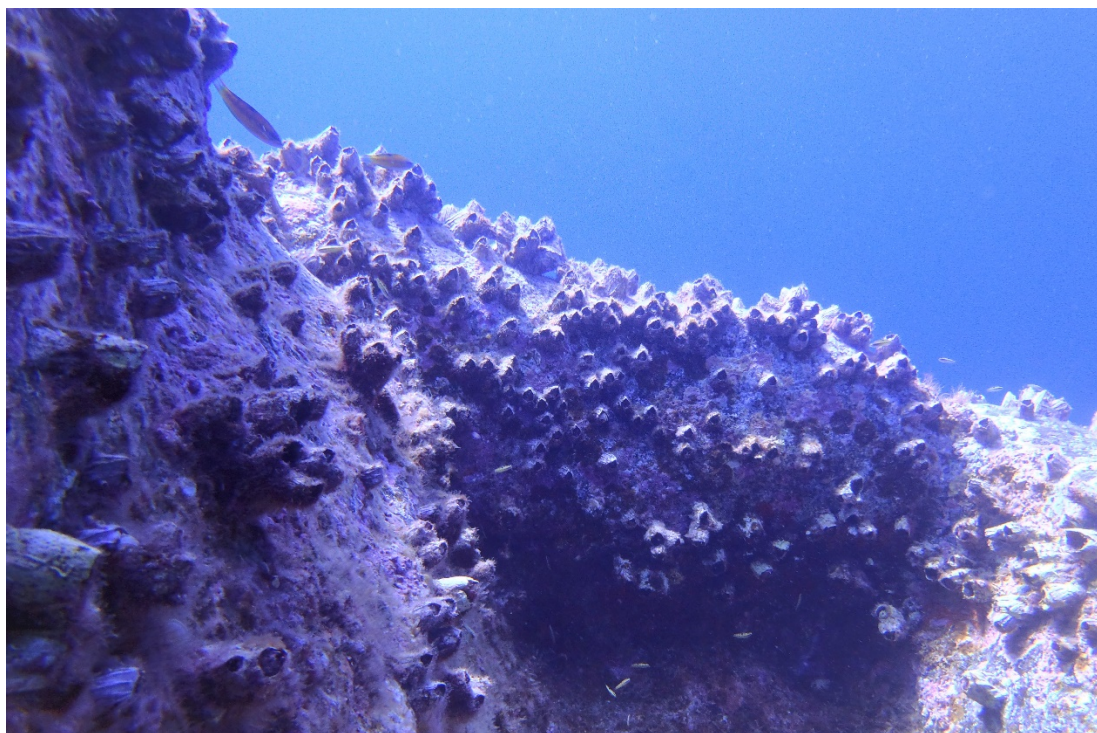


Fig.1 – The Azorean barnacle *Megabalanus azoricus* (Pilsbry, 1916) has distinctive morphology among the Cirripedia and is a prominent habitat forming species on the low intertidal and adjacent infralittoral areas on rocky shores of the archipelago. (Photo: © Maria Ana Dionísio)

2. Threat and link to human activities

Cross-reference to checklist of human activities in OSPAR MPA Guidelines

Relevant human activity: Fishing, hunting, harvesting: *Category of effect of human activity:* Biological – removal of target species

The main threat to *M. azoricus* is overexploitation that results from a combination of commercial fishery interests and widespread picking for food by members of the local population. *M. azoricus* is the largest and third most common shallow water barnacle of the Azores, where it is heavily exploited for food since the colonization of the islands (Dionísio *et al.*, 2012). Locally known as “craca” the species *Megabalanus azoricus* (Pilsbry, 1916) is widely collected for human consumption in all the islands of the Azores archipelago and it is highly prized as a delicacy in the Azorean cuisine. Consequently, many stocks are currently overfished (Santos *et al.*, 1995; Morton *et al.*, 1998).

Further to its significance in the local traditions this barnacle has considerable economic value. It is a living marine resource customarily exploited by the local human population and supports a long-standing artisanal fishery in the Azores. The barnacles are picked by hand in shallow water using hammer and chisel to help separate the animals from the underlying rock substrate (Barrois, 1896; Santos *et al.*, 1995; Dionísio *et al.* 2009).

In order to study the *M. azoricus* population, a study of the official fishing landings was performed on the official data supplied by Lotaçor S.A. between 1990 and 2011. Official landing statistics were analyzed and evaluated for the entire archipelago and for each island. The harvesting licenses issued for the entire archipelago were also analysed using official data provided by the competent authorities: Lotaçor S.A. and Direção Regional das Pescas (DRP). Lotaçor S.A. is responsible for managing the regional fisheries and auction houses where the first sale of all commercial marine landings must take place while DRP is the governmental

body with responsibility on fisheries administration. Complementary information was obtained directly from consumers in the local population and among visiting tourists (Dionísio, 2013).

In the Azores, and particularly for the giant barnacle, the evidence of exploitation mentioned by Santos *et al.* (1995) seems to be taking alarming proportions especially considering that the decrease of catches does not reflect what is going on the true market. However, it gives warning signs about decrease in the availability of the resource as a recent decline of catches (Fig.2) is observed in association to an exponential increase (Fig. 3) in the total number of the licenses issued (Dionísio, 2013).

Human activities that may cause a major threat to the barnacle population in the Azores are commercial fishing and informal harvesting for food. The increase in landings, subsequent crash of the fishery, and limited recovery following temporary closure and improved licensing arrangements for the harvest of barnacles suggests that there is a strong link between the threat to *M. azoricus* populations and the harvesting of barnacles in the Azores. However, illegal harvesting can severely influence the success of possible conservation strategies (Kritzer, 2004; Guidetti *et al.*, 2008; Solomon *et al.*, 2012). The intertidal suffers especially with this kind of harvest and a single collection can be very extensive, resulting in long-lasting effects. In this sense, it is assumed that the extraction volume is much greater than recorded, since illegal catches seems to be common. Furthermore, in this gregarious species small and immature barnacles may be harvest accidentally once they are attached to the big ones.

There are also new threats associated to climate change and to the introduction of non-indigenous species that may affect the Azorean barnacle in the future (Torres *et al.*, 2012; Dionísio, 2013).

It should be pointed out that the number of licenses issued for barnacle harvesting has increased exponentially in the last 18 years (Fig. 2). Licenses issued and official landings are unequally distributed among the islands and there was an historical maximum of 180 permits in 2012, which means a twentyfold increase in just two decades. This tendency upwards must be checked carefully against the marked decrease in landings registered after 2007 (Fig. 2) as it may suggest an overall scenario of overexploited barnacle stocks, resulting in much reduced catch yields to the individual harvesters. The possibility of widespread unreported catches by some permit holders in recent years must also be checked out carefully (Dionísio, 2013).

Data on the Azorean barnacle fishery was discussed in a recent survey by Dionísio *et al.* (2009) and there is a subsequent PhD thesis on the subject (Dionísio, 2013).

The official landing statistics of *M. azoricus* increased significantly in 2001, from *ca.* 1.4 tons per year in the decade of 1990-1999 to reach a peak value of *ca.* 7 tons in 2004. A sharp decline was then noted and the landing values processed by Lotaçor in subsequent years were down to *ca.* 2.4 tons in 2007 (Fig 2.). There was a small recovery to *ca.* 3.7 tons in 2010 but landings were down again and below the 2 ton mark in 2011, despite the exponential increase in the number of harvesting permits issued since 1994. This may relate to exhaustion of the resource as a consequence of overexploitation and strongly suggests that recovery measures are necessary in some areas to keep the fishery sustainable (Dionísio *et al.* 2009).

These studies provide important information about historical catch values and suggest that strategic action is necessary to help ensure sustainability.

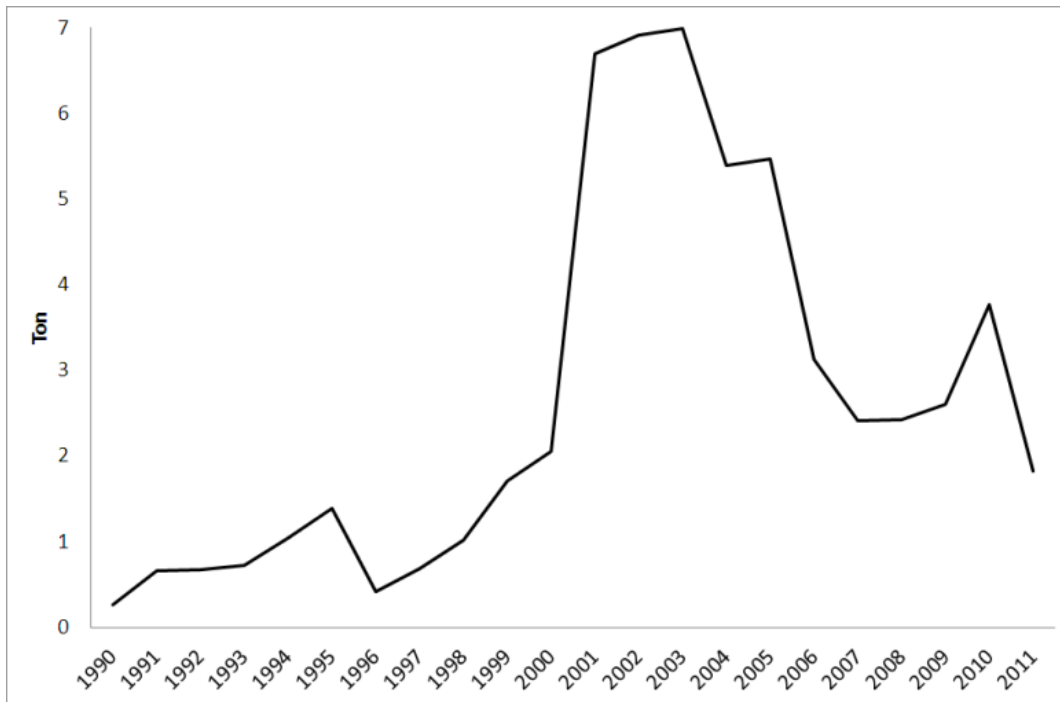


Fig. 2 - *Megabalanus azoricus* official landings in tons between 1990 and 2011 for the Azores archipelago, in Dionísio (2013).

The number of licenses that are issued by the competent fishing authority in the Azores (Direção Regional das Pescas) has increased exponentially since 1994 (Dionísio, 2013).

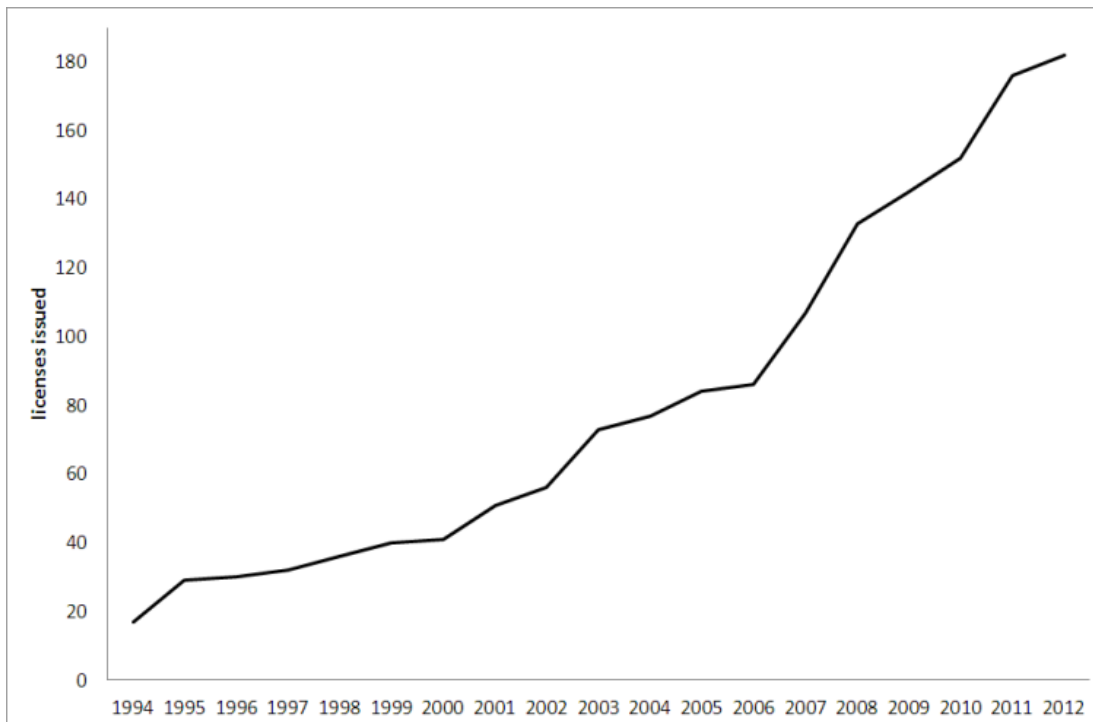


Fig. 3 – Total number of licenses issued between 1994 and 2012 for the barnacles catch in the Azores archipelago, in Dionísio (2013).

Megabalanus azoricus official landing statistics showed an increase of over 115% per year, from about 1.4 tons unloaded in the nineties to approximately 7 tons discharged between 2001-03 (see Fig. 2) Afterwards it

is possible to observe a sharp decline in the catches, reaching values close to 2 tons in 2007. The volume increases again between 2009 and 2010 with another drop in 2011 to 1.8 tons (Dionísio, 2013).

Further analysis of available data shows that important differences are present when the three island groups in the archipelago are compared. Islands in the Central Group (Pico, Faial, Terceira, São Jorge and Graciosa) contribute to 58% of the total catch by weight, however only had 35% of the total number of licenses issued. The Eastern Group (the islands of São Miguel and Santa Maria) had most of the licenses issued (65%) but only contributed to 41% of the total catch by weight. The islands in the Western Group (Flores and Corvo) had no licenses issued but nevertheless they contributed 1% to the total catch (Dionísio, 2013).

There are virtually no landing records or statistical data for the barnacle fishery in the Azores before *ca.* 1980. Since then the fishery has drawn some attention from the competent authorities and landings are now recorded from the different islands in the archipelago in relation to permits issued to the individual harvesters on a regular basis. However, there is widespread belief that the official reports only cover a fraction of the activity going on. The relative importance of this underreporting has not been quantified so far.

3. Existing management measures

Megabalanus azoricus is regularly harvested for food in the Azores. The fishery includes a growing number of commercial harvesters holding licenses issued by competent authorities.

There are many informal harvesters with access to the resource but their numbers remain unchecked. The study made by Dionísio (2013) proves that the illegal harvesting of this barnacle is widespread across the archipelago, with particular emphasis to the islands in the Western Group where no licenses were issued however small catches did occur. In Flores there is a high consumption of this barnacle in private homes and also in restaurants. A common statement by the restaurant owners relatively to these islands is that “In some islands the giant barnacles were mainly gathered for self-consumption or for door to door bartering”.

A number of management measures, based on the precautionary principle, were introduced by the competent authorities to regulate the barnacle fishery in the Azores. The scientific basis for developing some of these measures remains obscure and results obtained in practice are often inconclusive. Framework legislation applicable to regulate the fishery of *M. azoricus* was published in 2012 but there is widespread concern that it may be insufficient to grant sustainability and enforcement is lacking. There is a legal limit of 20 kg/day to the catch of individual harvesters in the commercial fishery for barnacles but the recreational fisheries are not monitored with quite the same effectiveness as the commercial fishery.

There are now 34 marine reserves in the archipelago (Decreto Legislativo Regional 15/2012/A, from April 2nd) that were designated specifically to halt the decrease of the Azorean barnacle and to enhance the conservation status of the population. Each island has a minimum of three closed areas where the harvesting of barnacles is not allowed. Overall up to 20% of the shoreline in the archipelago is closed to exploitation and in the remaining areas the exploitation of barnacles is based on a licensing scheme managed by the Fisheries Directorate of the Azores.

Effectiveness of Management Measures

Existing management measures are not effective as they should be in protecting the barnacle population and the coastal habitats where it occurs. Illegal harvesting is the major threat so far identified as the barnacles are collected all year round in most areas suitable for harvesting.

Existing management is based on a system of permits issued by the Fisheries Directorate in the Azores and there is a network of closed areas that includes all islands across the archipelago. Landings declared in the

official fishery statistics did reach an historical maximum in 2003 but the captures are now considerably reduced when compared to former values. There is also wide consensus about the depletion of the barnacle populations in many areas. The decrease in captures should be related to a decrease in the populations and informal surveys point out to a sizeable reduction in all the islands that were sampled.

Landings are much reduced following a major crash in landings after 2003. Future prospects for the species and sustainable use of the marine environment are moderately optimistic, on the condition that excessive harvesting is eliminated and science-based management measures are enforced.

The biology of this species, its ecology and the official fishery statistics are fairly well known. Dedicated research did overcome long-standing gaps of knowledge in relation to critical aspects in the taxonomy and life history of this barnacle. Young (1998) and Regala (1999) have published their observations on this barnacle but most studies about it are from 2006 to 2015. For detailed results please see Dionísio *et al.* 2007, Dionísio *et al.* 2009, Dionísio *et al.* 2012, Dionísio 2013, Dionísio *et al.* 2013 a) and b), and Quinteiro *et al.* 2015.

There are still substantial limitations to our current knowledge of the population size.

Metal accumulation, biomonitoring and human health implications

The giant barnacle *Megabalanus azoricus* is a popular seafood in the Azores. It is mainly caught in coastal environments and sold for domestic human consumption. This species is a filter feeder and can be used as a biomonitor of trace metals bioavailability (Dionísio *et al.*, 2013b).

The Azores have a highly remote location in the middle of the Atlantic Ocean and there is no significant heavy industry in the archipelago (Depledge *et al.*, 1992, Ramos *et al.*, 2009). However, volcanism is one of the most powerful natural geological phenomena and is responsible for the presence of metals in soils and waters (Ferreira and Oskarsson, 1999). The volcanic origin of the Azores most likely influences the natural release of trace metals in the environment and in the biota (Depledge *et al.*, 1992). Volcanic activity such as lava emissions, diffuse degassing from soils, and hydrothermal activity (Ferreira *et al.*, 2005) may cause trace metals to be continuously available to the biota (Zaldibar *et al.* 2006). Consequently, organisms living in such an environment may be continuously exposed to metals like As, Cu, Pb, Mn, Rb, and Zn, either as particles or associated with gases (Hansell *et al.* 2006).

The barnacle *M. azoricus* is a high metal accumulator when compared to other marine invertebrate species in the archipelago acting as potential biomonitoring organisms for heavy metals (see Dionísio *et al.*, 2013b). The study carried out by Dionísio *et al.* (2013b) on heavy metals reveals that the edible barnacle *M. azoricus* clearly has high levels of Cadmium (Cd) and Rubidium (Rb) and these metals may be available in nature as a result of volcanic activity (Renzoni *et al.*, 1998). This species can be useful for monitoring heavy metals bioavailability in volcanic islands and may also be considered a sentinel species for Arsenic (As), Cd, Rb, Selenium (Se) and Strontium (Sr) (Dionísio *et al.* 2013b).

Megabalanus azoricus is included in the local human diet and the observed metal concentrations may pose safety consumption and public health threats (Dionísio *et al.*, 2013b). The concentrations of metals considered safe for human consumption in seafood are regulated by legislation. As part of the Portuguese territory, the Azores are in the European Union (EU) and have therefore adopted the European reference limits for metal concentrations in human food. The European limits for Hg, Cd and Pb in food are defined by European Commission (EC) Regulation No 78/2005 regarding hazardous metals, while other countries may also include more metals, such as Cr, As and Zn. It is important to realize that we are dealing with an edible species and biomagnification poses a true problem for human health because heavy metals are transported through the food chain at increasing concentrations until consumption by humans (Wang and Wong 2006).

Regarding their safety as part of an edible resource, the metal contents found in commercial species of invertebrates around the world were compared and *Megabalanus azoricus* did come out as the second highest As accumulator (Dionísio *et al.* 2013b). The Azorean barnacle also presented the highest value of Cd in the sample; it was 9 times higher than those found in crabs collected by the Food Standards Agency (EC 2006). It also showed the highest Se content. No differences were detected however in the metal concentrations in *M. azoricus* specimens from different sampling sites across the archipelago (Dionísio *et al.* 2013b).

In the same study, the As values of *M. azoricus* exceeded the maximum limit (ML) established in legislation, except those established by the Philippines and the United States of America, which allow an As content of 30 lg g⁻¹ ww and 76 lg g⁻¹ ww, respectively. The Cd values also exceeded the legal values for ML in all tissues. Moreover, the muscle tissue showed 25 times more Cd than the 0.5 lg.g⁻¹ ww allowed for crustaceans in Portuguese law; the cirrus and ovaries had 12 and 20 times more than the allowed limits, respectively (Dionísio *et al.* 2013b).

A compilation of metals accumulated by different species of edible marine invertebrates shows that the Azorean barnacle is a Pb free shellfish and Se rich seafood (Dionísio *et al.* 2013b). Selenium has structural and enzymatic roles, which can protect the cells against oxidative damage. This essential metal is needed for proper functioning of the immune systems. An elevated Se intake may be associated with reduced cancer risk (Finley 2007). However, benefits from the consumption of Se rich *M. azoricus* can be seriously jeopardized by the effects of high levels of other metals like Cd (Dionísio *et al.* 2013b).

4. Management needs and actions to be taken by OSPAR

4.1 Proposed management actions which would be undertaken individually thorough national action

Enforcement of the protective measures already considered in national legislation should be improved.

After analyzing all data from studies about the biology and ecology of this species and considering also a social view and the economic value of this resource, at least one closed season in the year is suggested by Dionísio (2013). This closure should be defined in legislation and it must include two summer months - June and July - since they correspond to the reproductive peak of *M. azoricus* and are also the months in which demand for barnacles in restaurants increases. The closure is very important as a management tool to help in the recovery of the resource and to bring sustainability into the exploitation of *M. azoricus* but it would still allow the commercial harvesters to sell their barnacles in August and September, when there is still considerable demand for them. The protection of the species in the winter breeding peak (Fig. 4) is assured by natural means as weather conditions in winter are often tempestuous and strong wave action prevents the barnacle fishery in dense population settlements which are in highly exposed locations.

The primary reason for enacting a closure is to allow barnacles recruitment in the breeding season, which would increase the populations that provide opportunities for subsistence, recreational, or commercial fishing. Given these effects, a closure can help maintain high adult population densities and make them fit for successful reproduction, also providing young for recruitment, and even raising the possibility of self-recruitment.

Another measure that would benefit the management and protection of this resource is the establishment of no-take areas in all islands across the archipelago. This has been suggested as a viable alternative with several advantages. In fact there is evidence from other studies that marine reserves with no-take areas have multiple effects in the marine communities which are generally regarded as positive. However, in order to be fully effective this initiative will require widespread public support in the community and effective vigilance of these areas.

There is an urgent need for new data on the commercial side of this fishery. This must consider a checkup of any exports going on to third countries and to the Azorean communities overseas. *Competent authorities:*

Authorities	Role
Azorean Fisheries Directorate	License issuing
Azorean Fisheries Inspection	Inspection of activity
Maritime Police	Inspection of activity
Economic Activities Inspection	Inspection of activity
Azorean Environment Directorate	Environmental protection/MPA management
University of the Azores	Scientific research and monitoring

Table 1 - A list of the competent authorities and partners involved in the management of the barnacle fishery in the Azores and the scientific study of its wild populations.

Management matters which should be drawn to the attention of other relevant bodies: Increased focus should be put on the role of the local authorities. They should be encouraged to take further action to help protect the barnacle population because it is no longer in good environmental condition and this may cause other problems in the near future.

The protection of the Azorean barnacle certainly is a matter of relevant economic importance but there are other aspects involved and they deserve further consideration. This endemic barnacle is a major cultural asset playing a key role in the traditional Azorean cuisine. It is also a species of great ecological importance because barnacles are a keystone species on the rocky shores of the archipelago. Their exoskeletons form habitat for other species and as a zoological group the barnacles are quite unique in the way they fulfill that role.

Dredging operations that are necessary to maintain navigation in harbours and to develop new port facilities are not considered a major threat for the Azorean barnacle in the archipelago. However, the OSPAR Guidelines developed at Sintra to address this issue (OSPAR 1998) should be strictly observed and may provide additional guidance in the monitoring programmes for this species and its environment.

Brief summary of proposed monitoring system (see Annex 1)

Over the last three decades there has been a set of evaluation actions for this species although they were carried out on an irregular basis. A long term monitoring program has been considered but never came out to be fully implemented.

Monitoring involves:

- 1) Checking the catch declared by the licensed harvesters at the Azorean fish auction (Lotaçor) which is information available at regular intervals from the Fisheries Directorate;
- 2) Conducting a regular series of independent dives in randomly pre-selected stations in order to assess catch per unit of effort (CPUE);
- 3) Depletion experiments induced in selected stations to study resilience and rates of recovery.

Assessing commercial data available on barnacles harvested in the Azores and exported to the overseas markets is also a necessary asset to make for adequate law enforcement and to help at developing management measures that are adequate to ensure sustainability of the fishery.

4.2 Proposed management actions which would be undertaken collectively by all OSPAR Contracting Parties

Tourism and economic connections: Tourism has flourished in recent years and it is of considerable importance to the economy of the Azores (Ressurreição *et al.* 2012). Further to the traditional consumption by the locals at home there is now a wide demand for barnacles in restaurants. Many restaurant owners have no easy access to the barnacles sold in auction at the official shellfish market. Therefore, many of them go for other options and they purchase barnacles directly from the harvesters who catch them on the shore and subsequently avoid the official fish market. The big gap between auction prices and the price paid by barnacle consumers in restaurants keeps this informal trade flourishing (Dionísio 2013).

MPAs were designated under Regional legislation to protect the habitat of the barnacle but their overall effectiveness in relation to the management of the fishery has not been assessed.

Public awareness initiatives could be helpful to promote the protection of the species.

Action/measures that OSPAR could take, subject to OSPAR agreement

As set out in Article 4 of Annex V of the Convention, OSPAR has agreed that no programme or measure concerning a question relating to the management of fisheries shall be adopted under this Annex. However where the Commission considers that action is desirable in relation to such a question, it shall draw the question to the attention of the authority or international body competent for that question. Where action within the competence of the Commission is desirable to complement or support action by those authorities or bodies, the Commission shall endeavor to cooperate with them.

Dedicated environmental awareness actions are needed and they should be welcome by all partners involved either in the management of the barnacle fishery in the Azores or the scientific study of its populations.

If the demand for barnacles can be reduced it should be possible for the populations to recover from the current depleted status and the resource may be exploited subsequently at sustainable levels. Alerting consumers (the local population, visiting tourists and many Azorean emigrants living abroad) through environmental awareness campaigns designed to promote the moderate consumption of barnacles and obedience to the legal measures regulating their harvest could help in reducing the current pressure upon the resource. This may contribute to keep the fishery sustainable.

Pressure for effective management of the resource and enforcement of the marine reserves network should help in the protection of this species. This should be associated to wide public diffusion about the rationale for inclusion of this species in the OSPAR List.

Annex 1: Detailed description of the proposed monitoring and assessment strategy

Rationale

The main threat to this species is human exploitation (“fishing” and/or “gathering”). In fact the barnacles *M. azoricus* have peculiar life-history traits that make them especially vulnerable in their initial life phases. The gregarious behavior in their settlement puts the new recruits at risk when the adults are heavily harvested in a given area, therefore limiting the number of recruits available for subsequent re-colonization of the rocky substrate and to allow a successful recovery by the species. The wild population of giant barnacles has been heavily exploited in the Azores and the fishery may be unsustainable in the long term due to excessive harvesting, which is threatening the recovery of the barnacles.

Use of existing monitoring programmes

The monitoring programmes that are carried out at *Natura 2000* marine sites and elsewhere in the Azores should be used to monitor the barnacle populations too but some adaptations are necessary and they must be incorporated in the protocols.

Synergies with monitoring of other species or habitats

Megabalanus azoricus must be a key species in the monitoring actions of the *Natura 2000* sites whenever the species occurs in the Azores. There is an obvious connection that must be made to associate the monitoring of the Azorean barnacle to equivalent actions that involve the Azorean limpet *Patella aspera* in the archipelago.

Assessment criteria

The effectiveness of specific conservation measures must be part of the assessment criteria. These would include a closure season in June and July to protect the summer breeding season and a network of dedicated marine protected areas with adequate management actions, including no-take areas to protected sites of special concern. These could be put forward by scientists and harvesters working together and they must be established in accordance to biological criteria.

CPUE by independent divers shall be measured as catch per unit of time/effort and in relation to the length of the coastline included in the surveys. Recruitment studies must also be part of the assessments.

Techniques/approaches

The barnacles shall be accessed only by divers using traditional gear like snorkeling or wadding the shoreline at extreme low tides.

Selection of monitoring locations

These must include a minimum of three islands across the archipelago, one of them in the Oriental group (São Miguel), another in the Central group (Faial), and still another in the Western group (Flores).

Timing and frequency of monitoring

They should be determined later and would not exceed 3 month intervals. This timing is necessary and must be set out properly in order to allow for accompanying successive phases in the breeding season and the different recruitment stages (see Dionísio *et al.*, 2007).

Data collection and reporting

To be established jointly by the research teams involved in the monitoring actions and their partners in the Azorean administration.

Quality assurance

The independent surveys are controlled by scientists with no direct interests in the fishery. They are reliable and should be an unbiased source of information. When compared to these independent scientific surveys, the catch information that comes from commercial sources may be biased and it shall not be taken as fully reliable.

Annex 2: References

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