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An endangered gigant marine gastropod : *Adelomelon beckii* (Broderip,1836) in Uruguayan waters

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Abstract: *Adelomelon beckii* (Broderip,1836) is the largest Volutidae from the Western Atlantic, and one of the largest marine gastropods worldwide. We analysed data from 516 trawls performed in the Uruguayan continental shelf between 5 and 300 m depth and developed a predictive species distribution model, identifying shelf areas in which fleet activity should be monitored in relation to landings of *A. becki*. According to our model, the fleets potentially affecting the Uruguayan population of *A. beckii* include the coastal industrial fleet and, to a lesser extent, the fleet targeting Argentinean Hake in the outer shelf. In order to minimize the likelihood of further reduction of the population of *A. beckii* within Uruguayan waters, management measures should include the implementation of specific fishery regulations for the commercial fleet and ships' crews, including a) closed areas, that ensure the reproductive success of the population and/ or b) prohibition of shell trade in stores along the coast, aiming to definitively stop landings of *A. beckii*. An appropriate understanding of the ecological and spatial structure, resilience and dynamics of the species is critical to this end.

Keywords: large benthic gastropods, Volutidae, conservation, fishery management

Resumen. Un gasterópodo gigante amenazado: *Adelomelon beckii* (Broderip,1836) en aguas uruguayas. *Adelomelon beckii* (Broderip 1836) es el volútido más grande del Atlántico occidental, y uno de los gasterópodos marinos más grandes del mundo. Se analizaron datos de 516 arrastres de fondo realizados en la plataforma continental uruguaya entre 5 y 300 m de profundidad y se desarrolló un modelo predictivo de distribución de especies, identificando las áreas de plataforma en las que se debe controlar la actividad de la flota en relación con los desembarques de *A. beckii*. En particular, las flotas que afectan potencialmente a la población uruguaya de *A. beckii*, según el modelo predictivo de distribución de especies aquí presentado incluyen la flota industrial costera y, en menor medida, la flota dirigida a la pesca de merluza en plataforma exterior. Con el fin de minimizar la probabilidad de una mayor reducción de la población de *A. beckii* en aguas uruguayas las medidas de manejo deben incluir regulaciones específicas para las pesquerías comerciales y sus tripulaciones, incluyendo: a) áreas cerradas que aseguren el éxito reproductivo de la población, y/ o b) prohibición del comercio de conchas de *A. becki* como forma de detener definitivamente los desembarques. Una comprensión adecuada de la estructura ecológica y espacial, asi como sobre la resiliencia y dinámica de la especie es fundamental para este fin.

Palabras clave: grandes gasterópodos marinos, Volutidae, conservación, manejo pesquero

Introduction

Adelomelon beckii (Broderip 1836) is the largest Volutidae from the Western Atlantic (Clench & Turner, 1964), and one of the largest marine gastropods worldwide, reaching over 492 mm in shell length and a body weight of 4 kg, or higher

(Ayçaguer, 2001). The species is distributed from Espírito Santo (Brazil; 20°S) to San Matías Gulf (Argentine; 41°S), on littoral sandy-muddy bottoms, in depths from 20 to 75 m (Kaiser 1977, Scarabino 2004, Bigatti & Ciocco 2008, Carranza *et al.* 2008). As all South-western Atlantic Volutidae, *A. beckii* undergoes direct development, producing a single hemispheric large egg capsule (about 50 mm in basal diameter and 35 mm in height), usually attached to scallop shells, containing 7-9 embryos. At hatching, juveniles have shells measuring between 16.0 to 18.6 mm length (Penchaszadeh *et al.* 1999, Arrighetti 2009). *A. beckii's* potential lifespan in Mar del Plata (Argentina) region is 29 years, being long lived compared to other large gastropods. The age of sexual maturity is around 14 years for females and 11 years for males (Arrighetti & Penchaszadeh 2010a).

Worldwide, the catches of marine gastropods may be broadly classified as commercial, recreational or scientific (Weis *et al.* 2004). In Uruguay, this species is landed to be sold as ornaments (Figure 1), thus constituting a mixture of commercial and recreational fishery, which developed during 15 years with a fishing effort involving at least 20 vessels (Riestra *et al.* 2000, Scarabino 2004, Scarabino *et al.* 2006). Although not targeting this species, the coastal fleets in the coasts of Maldonado and Rocha (Uruguay, 30-70 m depth), report most of total landings. The catches of this species, previously negligible, increased to 40 tons in 1999, with specimens size over 300 mm suggesting the removal of reproductively active individuals (Ayçaguer 2001, Arrighetti & Penchaszadeh 2010b). Currently, there is no information on the status of individual catches, but according to first authors`s onboard experience, most might by trawled alive. Further, empty, cleaned shells were commonly landed as by catch of *Zidona dufresnei* fisheries (Fabiano *et al.* 2000, Riestra *et al.* 2006), being reported as occurring in 87% of the analysed trawls (Riestra *et al.* 2006). In addition, data from fishery surveys targeting white croakers (*Micropogonias furnieri*) showed that the species may exhibit low population densities within the studied area (Carranza *et al.* 2008).

Currently, there are no regulations on the exploitation of this species in the Uruguayan coast. This is of particular concern, since the direct development and slow somatic growth, coupled with small population densities, makes the volutid species particularly vulnerable to overexploitation and population collapse (Orensanz *et al*. 1996, Scarabino, 2004, Scarabino *et al*. 2006, Bigatti *et al*. 2007). In this vein, the aims of this paper are: a) to summarize available information on the distribution and ecology of *A. beckii* in Uruguayan waters, and b) to develop a predictive species distribution model in order to design an appropriate, spatially explicit management scheme directed to ensure the conservation of the species in the study area.

Materials and methods

We analysed data from the Uruguayan continental shelf between 5 and 300 m depth. The Uruguayan shelf is characterized by a singular hydrographical system composed of water masses of contrasting thermohaline characteristics, e.g., Subantarctic waters, Tropical waters, Subtropical waters, and Coastal waters, which are defined by salinities < 33.2 (Ortega & Martínez 2007). The shallow Coastal waters, that dominate the study area, are strongly influenced by the freshwater runoff from Río de la Plata, which flows into the Atlantic Ocean with an average discharge of 22,000 m^3s^{-1} (Framiñan & Brown 1996, Guerrero *et al.* 1997). The shelf is dominated by soft bottom sediments, with a mean grain size increasing with distance from the mouth of the estuary, presenting little consolidated substrata (Correia *et al.* 1996).

Presence-absence data were gathered from surveys made onboard research and fishing vessels during the last 40 years (see Appendix S3; Table S5 in Carranza *et al.* 2010 for detailed information). Special care was taken to only include records for live animals, and to only analyze data obtained with similar gears (bottom trawl net). Despite the huge number of points sampled, there are still vast extensions of the shelf with out available data on the species. This is mainly due to the fact that surveys were designed based on the ecological features of targeted species (i.e. white croaker *Micropogonias furnieri* and Argentinean hake *Merluccius hubsii*). This determined the existence of two well defined sampling areas (see figure 2) roughly corresponding to the inner and outer shelf, leaving an intermediate unexplored area, more notoriously off the mouth of Rio de la Plata. Thus, we adopted a predictive species distribution model (PSDM; see Guisan & Zimmermann 2000) to detect areas where the species is very likely to occur based on oceanographic features (depth, salinity, temperature of sea bottom water) but that lack reliable presence-absence data. Coupled with the existence of presence-absence data, predictive maps will aid to suggest spatially explicit management areas for the species.

Figure 1. *Adeomelon beckii* is commonly sold as ornaments in most Uruguayan resorts along the Atlantic coast.

The environmental layers were constructed using oceanographic data provided by Guerrero *et al.* (1997) gathered over 30 years and included minimum, maximum, and mean annual near-bottom seabed salinities and temperatures as well as their ranges of variation. This was done using seasonal values, with a spatial definition of 0.5º latitude x 0.5º longitude quadrats (ca. 2500km^2). Sediment features were not included due to the lack of available data at an appropriate spatial scale. To build the predictive maps, a binomial GLM with logistic link (e.g. Franklin 1998, Lischke *et al.* 1998) was used to predict the occurrence of *A. beckii* along the study area. The potential distribution maps can be defined as a cartographic representation of the probability of occurrence of *A. beckii* based on the predictions of the logistic GLM (Guisan & Zimmermann 2000). For each analysis we selected the best model from among all possible combinations of simple variables (latitude, longitude, salinity, temperature, depth and the quadratic expression of these variables), choosing the model that minimized the Akaike information criterion (AIC) statistic (Burnham and Anderson, 1998). Regression residuals were examined for spatial autocorrelation based on Moran's I for a connectivity matrix constructed using distance criterion and weighing connections by the inverse of the distance between points (Lag distance = 50 km) using SAM (Spatial Analysis in Macroecology) V1.1 software (Rangel *et al.*, 2006). We considered all the environmental variables for each sampling point, as well as the quadratic term for each variable.

Results

The assembled data base used for model building comprised information from 516 trawls, including 28 records of *Adelomelon beckii*. These records were distributed in the eastern portion of the shelf, in depths ranging from 24 to 100 m, associated with near-bottomtemperatures from 11.17 to 13.98º C and salinities from 32.38 to 33.83. The best model (AIC=171.83) included Longitude, its quadratic term and depth, all with significant contributions to the model. The PSDM showed that *A. beckii* is distributed in the eastern portion of the Uruguayan shelf, within Uruguayan EEZ, and that its distribution may present a gap off the mouth of Río de la Plata (Figure 2).

Discussion

The need for urgent conservation actions in Uruguay for the giant volute *Adelomelon beckii* is being increasingly recognized (Ayçaguer 2001, Scarabino 2004, Scarabino *et al.* 2006). Arrighetti *et al*. (2011) already stated that, in the Argentinean shelf, the current exploitation regime exerts a high fishing pressure and will be unsustainable in the long run. However, research priorities in Uruguay have been mainly directed to the main fishing resources (hake and white croaker). As a consequence, the proposal of management measures has been dampened by the lack of reliable information on the species distribution and catches. In this vein, Ayçaguer (2001) claimed for the implementation of "data-less and/or data-poor management" as the only viable alternative. For many years in Argentina, *A. beckii* was captured as by-catch by trawl fishing, but in the last 30 years it became the main objective of artisanal fishermen from Mar del Plata (Arrighetti *et al*. 2011). In agreement with our proposal, these authors asserted that current exploitation regime will be unsustainable within a short period of time. Arrighetti & Penchaszadeh (2010a,b) claimed that taking into account the longevity of this snail

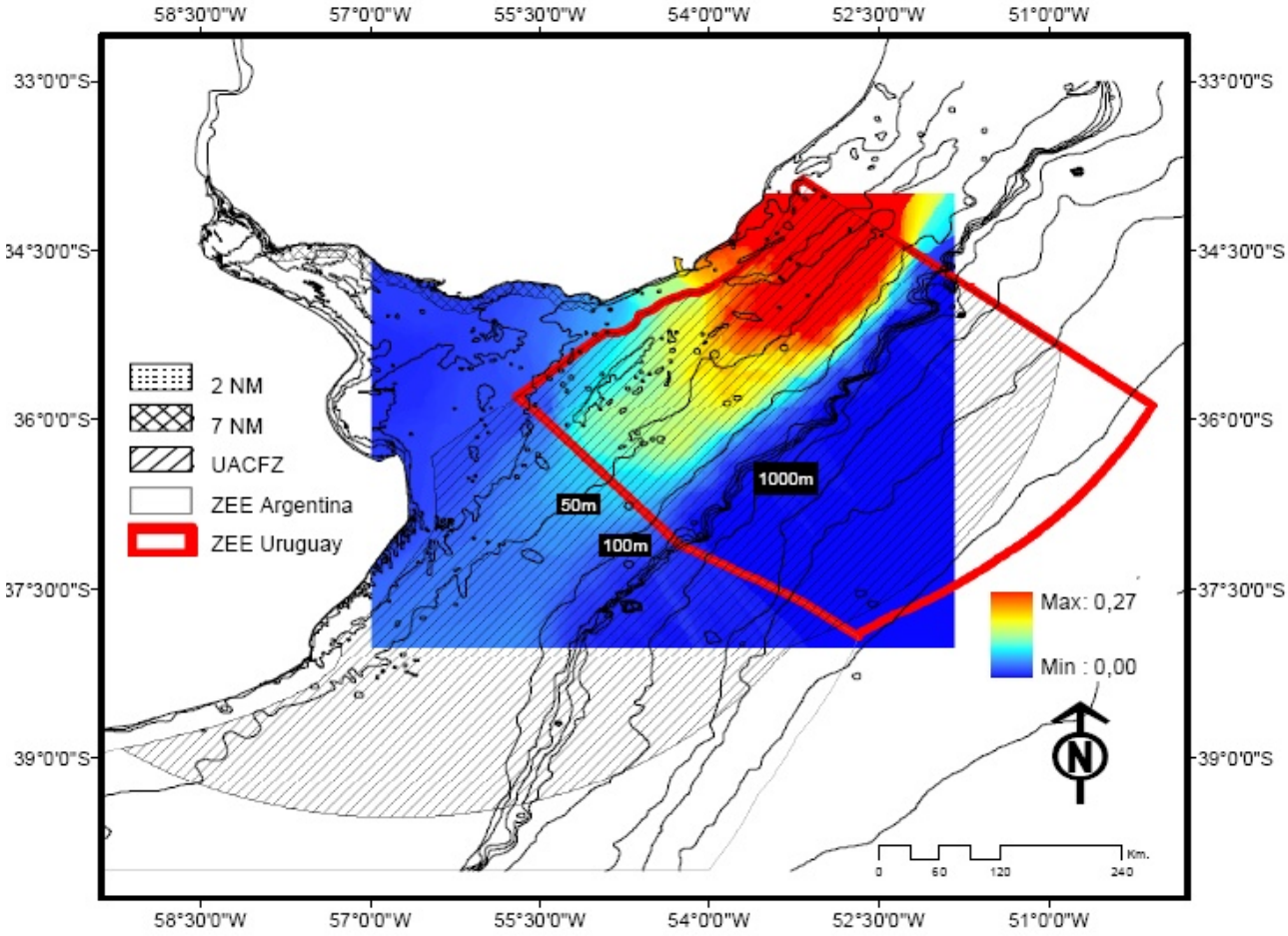

Figure 2. - Predictive species distribution models build for *A. beckii* in Uruguayan waters. Notice that the species seems to be restricted within the eastern most portion of Uruguayan shelf. The colour scale indicates the probability of occurrence. 7 and 2 NM: Uruguayan Exclusive Use Fringes; ZEE: Exclusive Economic Zone; UACFZ: Uruguayan-Argentinean Common Fishing zone. Labels identify isobaths corresponding to 50, 100 and 1000 m.

(29 years in Mar del Plata, Argentina), the absence of larval dispersal and low reproductive output (7 to 9 embryos), and the presence of females with imposex in polluted areas, *A. beckii* is a species very sensitive to exploitation. Accordingly, Bigatti & Ciocco (2008) reported low densities for this species in North Patagonian Gulfs, the species southernmost distribution limit, and suggested that the commercial fishing of this species would not be profitable in that particular area.

Here we identified shelf areas in which fleet and ship's crew activities should be monitored and controlled in relation with landings of *A. becki*. In particular, vessels potentially affecting the Uruguayan population of *A. beckii* according to the PSDM are restricted to the coastal industrial fleet. There are no evidences of artisanal shrimp trawlers vessel targeting or by-catching this species (Segura *et al.* 2008), and most artisanal vessels target coastal fishes using a wide variety of fishing gears that include gillnets, lines, hooks and traps (Defeo *et al.* 2008) that are not thought to capture benthic invertebrates. It must be noted that data used for buiding our PSDM included information from trawls performed both inside and outside the distribution area of *A. beckii*; and amongst the latter only those which retrieved large gastropods, thus providing some confidence on the absence of *A. beckii* in a given area. That allowed us to model the potential distribution taken into consideration real absences, and not pseudo-absence as those used to generate distribution models based in presence-only data. We are thus providing a formal map of probability of occurrence. In this vein, the PSDM should provide decision-makers with a spatially explicit framework to implement management measures in agreement with the fisheries sector directed to minimize or stop the landings of this giant snail. The systematic

removal of this high trophic level species may cause cascading changes in composition, structure and function in benthic ecosystems.

Conclusions

In order to minimize the likelihood of further reduction of the population of *A. beckii* within Uruguayan waters, management measures should include the implementation of specific fishery regulations for the commercial fleet and ships' crews, including a) closed areas, that ensure the reproductive success of the population and/ or b) prohibition of shell trade in stores along the coast, aiming to definitively stop landings of *A. beckii*.

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