

## Megabenthic gastropods in the outer Uruguayan continental shelf: composition, distribution and some effects of trawling

Gasterópodos megabentónicos en la plataforma continental exterior uruguaya: composición, distribución y algunos efectos de la pesca de arrastre

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**Resumen.-** Este estudio tuvo como objetivo profundizar el conocimiento de los efectos de la pesca de arrastre en los gasterópodos megabentónicos con concha, de la plataforma continental uruguaya. La composición, distribución de las especies, daños directo en la concha y mortalidad directa, así como la frecuencia de cicatrices en la concha fueron analizadas a partir de datos recolectados a bordo del barco de investigación 'Aldebaran'. Un total de 12 especies de gasterópodos megabentónicos se registró en las 35 estaciones monitoreadas, tanto como especímenes vivos o como conchas vacías. De ellos, los gasterópodos con concha *Adelomelon beckii*, *Adelomelon ancilla*, *Odontocymbiola magellanica*, *Fusitriton magellanicus* y *Zidona dufresnei* dominaron numéricamente la captura incidental. Se observó una segregación espacial de las asociaciones de gasterópodos a lo largo de un gradiente batimétrico y latitudinal, con *O. magellanica*, *F. magellanicus* y *A. ancilla* ocurriendo en la porción sur del área de estudio, mientras que *A. beckii* y *Z. dufresnei* estuvieron restringidos a las áreas más norteñas y someras, respectivamente. Raramente se observó mortalidad directa, pero las conchas de *A. ancilla*, *O. magellanica* y *Z. dufresnei* resultaron dañadas frecuentemente durante las operaciones de pesca y posterior procesamiento de la captura. De acuerdo con esto, se encontró una alta correlación positiva entre la frecuencia observada del daño reciente de la concha y la presencia de cicatrices, una evidencia sugerente pero no concluyente acerca de la relación entre la incidencia de cicatrices en la concha y la perturbación ocasionada por la pesca de arrastre.

Palabras clave: Efectos sub letales, *Adelomelon*, *Odontocymbiola*, *Zidona*, *Fusitriton*

**Abstract.-** This study aims to advance knowledge on the effects of bottom trawling in the shelled megabenthic gastropods from Uruguayan continental shelf. Composition of by-catch, species distribution, direct shell damage and mortality, and frequency of repaired shell damage were analysed from data collected on board of the research vessel 'Aldebaran'. A total of 12 megabenthic gastropod species was registered from 35 stations surveyed, either as live specimens or empty shells. From these, the shelled gastropods *Adelomelon beckii*, *Adelomelon ancilla*, *Odontocymbiola magellanica*, *Fusitriton magellanicus* and *Zidona dufresnei* dominated numerically the by-catch. We observed a spatial segregation of the gastropod assemblages along a bathymetric and latitudinal gradient, with *O. magellanica*, *F. magellanicus* and *A. ancilla* occurring at the southern portion of the study area, whereas *A. beckii* and *Z. dufresnei* were restricted to the northern and shallower areas respectively. Direct mortality was barely observed, but shells of *A. ancilla*, *O. magellanica* and *Z. dufresnei* were frequently damaged during the fishing operation and capture handling. Accordingly, we found a high positive correlation between the observed frequency of recent shell damage and the presence of scars, suggestive but not conclusive evidence on the relationship between incidence of repaired shell damage and trawling disturbance.

Key words: Sub lethal effects, *Adelomelon*, *Odontocymbiola*, *Zidona*, *Fusitriton*

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### Introduction

Recently, increasing concerns have been raised with regard to bottom trawling due to the significant alterations to the benthic communities that may result from this activity (Alves *et al.* 2003, Badino *et al.* 2004, Bergman & van Santbrink 2000, de Groot 1984). Accordingly, there is an increasing need to document the effects of trawling on non-target invertebrate species (Jennings *et al.* 2001, Philippart 1998, Probert *et al.* 1997). These may be subject of considerable impact due to increasing mortality

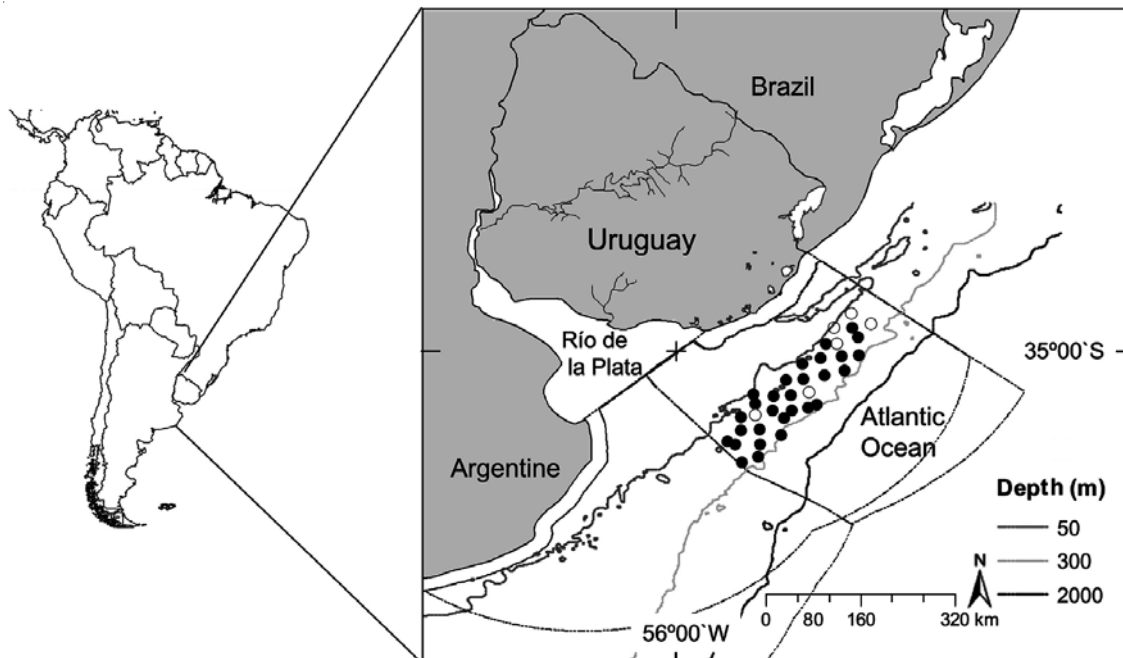
or injuries received following direct contact with the gear (de Groot 1984, Lindeboom & de Groot 1998). In addition, discarded or damaged benthos may be rapidly consumed by opportunistic scavenger species, such as crabs, starfish and fish among others (Demestre *et al.* 2000, Kaiser & Spencer 1994). In this context, the knowledge about the effects of the fishing array and onboard capture handling on particular non-target taxa is of particular interest, allowing a closer understanding on the impacts of trawling in the benthic community.

In the south-western Atlantic shelf, shelled megabenthic gastropods are a conspicuous component of the benthic biota, due to their abundance and large size, some species reaching up to 40 cm in shell length. Despite the fact that the hake trawl fishery is among the most important fisheries in the Uruguayan shelf, the current knowledge of the discards generated by the fleet is limited, as well as on the possible impacts on megabenthic gastropod's populations (Carranza 2006). However, in shelled gastropods, sublethal effects can be evidenced by the presence on repaired skeletal injuries, an approach already validated for other ecosystems and species (Witbaard & Klein 1994). The relative proportion of shells bearing scars is thus likely to be correlated with the degree of trawling disturbance. Therefore, the aim of this paper is twofold, first to shed light on the general qualitative and quantitative aspects of the by-catch of megabenthic gastropods, focusing in sublethal effects, and, finally, to explore the utility of the collected information regarding the assessment of trawling effects on the different species of gastropods.

## Material and methods

The study area comprised a belt between the 50 and 300 isobaths of the Uruguayan continental shelf, and it is localized between the latitudes 34 and 37°S and longitudes 52 and 54°W (Fig. 1). It is characterized by a particular hydrographical system composed by water masses of contrasting thermohaline characteristics (i.e. confluence of Brazil and Malvinas currents) (Acha *et al.* 2004, Ortega & Martínez 2007).

We registered the specific composition of megabenthic gastropods, direct mortality, degree of directly inflicted injuries and the frequency of repaired shell damage in both live specimens and empty shells. Observations came from 35 stations surveyed during a cruise of R/V 'Aldebaran' from the National Direction of Aquatic Resources (DINARA). Over each station, the trawling was held for 30 minutes at a mean speed of 3.5 knots, using an Engel type bottom trawl net with a 24 m horizontal opening and a 100 mm stretched mesh in the cod ends. Voucher material for gastropod species is



**Figure 1**

**Study area showing the Uruguayan shelf, bathymetry and position of the surveyed stations. Presence of gastropod by-catch is shown by full circles**

Área de estudio mostrando la plataforma continental uruguaya así como la batimetría y la ubicación de las estaciones muestreadas. La presencia de gasterópodos en la captura incidental se indica con círculos llenos

deposited at Museo Nacional de Historia Natural of Montevideo.

Mean by catch per unit effort (BPUE) was calculated for all species ( $n^\circ$  individuals  $30' \text{ haul}^{-1}$ ), taken only in consideration live animals. Multivariate analysis was carried out using PRIMER (Plymouth Marine Laboratory). Hierarchical agglomerative clustering was undertaken using group-average sorting of Bray-Curtis similarity coefficients calculated from BPUE/stations species data. Samples lacking live gastropods were not included in the analysis. For the assessment of frequencies of repaired shell damage (RSD) we considered all shells with external, macroscopically visible shell scars. Both scars and recently inflicted damage were classified following Alexander (1981), and Elliott & Bounds (1987) as localized and severe damage. Significance of the relationship between the percentage of recent damage and frequency of repaired shell damage was assessed by means of ordinary least square regression (OLS), in order to examine the inter-specific consistency of the damage patterns. To this end, we performed a regression analysis between frequency of occurrence of recent damage and frequency of occurrence of repaired shell damage, each species being an independent observation. The species with the higher concordances are thus considered to be potentially good indicators of trawling disturbance.

## Results

A total of 12 megabenthic gastropod species were registered from the 35 stations surveyed, either as live specimens or dead shells (Table 1). From these, the limpet *Fissurellidea megatrema* and at least one undetermined nudibranch, were not analyzed due to its particular anatomical features (i.e. loss or extreme reduction of the shell). Other shelled gastropods, collected only as dead shells (*Trophon patagonicus* and *Pachycymbiola brasiliensis*) and the nassarid *Buccinanops cochlidium* (only one live specimen collected) were also excluded from the condition analysis. With the exception of *T. patagonicus*, both species are typical inhabitants of inner shelf areas (Carranza *et al.* 2008a).

We observed a spatial segregation of the gastropod assemblages along the latitudinal and bathymetric gradients, with *O. magellanica*, *F. magellanicus* and *A. ancilla* occurring at the southern portion of the study area, *Z. dufresnei* occurring mainly at the shallower stations, whereas *T. galea* and *A. beckii* were restricted to the northernmost portion. Accordingly, cluster analysis discriminated two main groups of stations: group 1 comprised N stations characterized by the presence of *O. magellanica*, *F. magellanicus* and *A. ancilla*, while *Z. dufresnei*, *A. beckii* and *F. megatrema* characterized group 2. One station (station 11) did not cluster on any group, due to the only record of *T. galea* (Fig. 2).

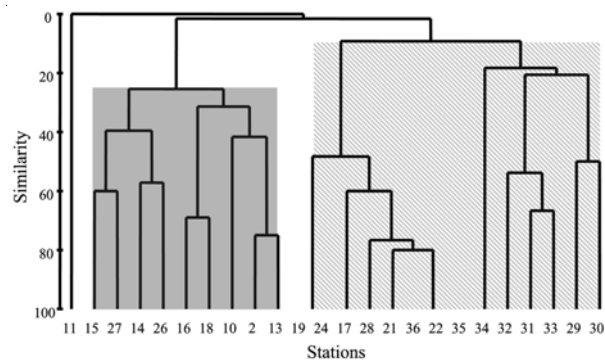
**Table 1**

**Number of observations (n), mean, standard deviation (S.d.) and maximum BPUE (ind x tow<sup>-1</sup>) (Max.), and percentages of empty shells, live specimens with observed recent damage and with scars of repaired shell damage for each species**

Número de observaciones (n), media (Mean), desviación típica (S.d.) y CIPUE máxima (ind x lance<sup>-1</sup>) (Max.), y porcentajes de conchas vacías, especímenes vivos con daños recientes observados y con presencia de cicatrices en la concha para cada especie

Species	n	Mean	S.d.	Max.	% Empty shells	% Damaged shells	% Repaired shell damage
BC	1	0.03	0.2	1.0	0.0	0.0	0.0
TG	35	0.03	0.2	1.0	97.1	0.0	5.7
AB	8	0.22	0.6	3.0	0.0	12.5	0.0
ZD	22	0.36	1.2	5.0	4.3	52.4	31.8
OM	29	0.61	1.2	4.0	34.5	47.4	37.9
FUM	27	0.64	2.7	16.0	7.4	4.0	0.0
FIM	41	1.14	3.3	17.0	0.0	0.0	0.0
AA	80	1.22	3.9	21.0	16.3	25.4	18.8

AB: *Adelomelon beckii*, AA: *Adelomelon ancilla*, OM: *Odontocymbiola magellanica*, FUM: *Fusitriton magellanicus*, TG: *Tonna galea*, ZD: *Zidona dufresnei*, BC: *Buccinanops cochlidium* and FIM: *Fissurellidea megatrema*



**Figure 2**

**Dendrogram showing the results of the hierarchical agglomerative clustering of stations (Bray-Curtis similarity index) based on biological data (BPUE) and spatial distribution of the groups discriminated by the analysis**

Dendrograma mostrando los resultados del agrupamiento jerárquico aglomerativo de las estaciones (índice de similitud de Bray-Curtis) basadas en datos biológicos (CIPUE) y distribución espacial de los grupos discriminados por el análisis

In terms of BPUE (abundance of live collected specimens only), the volutid *Adelomelon ancilla* (n= 67) dominated the gastropods by-catch, followed by the ranelid *Fusitriton magellanicus* (n=25) and the volutids *Zidona dufresnei* (n=21) and *Odontocymbiola magellanica* (n=19). From 201 examined shells, we found that 97.3% of *Tonna galea*, 34% of *O. magellanica* and 19% of *A. ancilla* shells were empty or occupied by hermit crabs.

Overall, 13% of the measured shells had some rupture, with trimmed lips and broken necks accounting mostly of the localized damage. Direct damage was observed in nearly 50% of *O. magellanica* and more than 50% in *Z. dufresnei* (see Table 1 for details). Nature of shell damage differed between species: in *Z. dufresnei* the more frequent lesions were broken apex (36%) and trimmed lips (73%), whereas *A. ancilla* showed 93% of trimmed lips, 25% of broken necks and only 6% of apical lesions. In *O. magellanica*, 22% of the specimens measured were severely crushed, causing most likely a direct mortality. The species-specific frequencies of scars indicating RSD were positively and significantly correlated with the frequency of onboard shell damage ( $R^2= 0.88$ ;  $P<0.05$ ).

## Discussion

To date, no other study has focused on the impact of trawling on the molluscan assemblage of the outer Uruguayan shelf. We found that 12 gastropod species may be potentially affected by trawling. Carranza (2006) already reported the by-catch of some of the species here

treated (*A. ancilla*, *O. magellanica* and *F. magellanicus*) in a survey made onboard a commercial fishing vessel operating at the northern Argentinean shelf. The species we observed at the southern portion of our study area are mostly representative of the Magellanic malacofauna, whereas at the northern stations were representative of the shallow or warm-temperate malacofauna (*T. galea*, *A. beckii* and *Z. dufresnei*). This remarks the existence of a faunal transition zone localised off Río de la Plata (see Fig. 1) coincident with the Brazil-Malvinas currents confluence, that is presumably acting as a barrier for some benthic species inhabiting the continental shelf (Carranza *et al.* 2007, Carranza *et al.* 2008b).

Direct mortality was barely observed caused by aggressive handling but we noticed 22% of *O. magellanica* with severe damage. In addition, Malaquias *et al.* (2006) suggested that while the time discarded species spend on board may be not long enough to cause direct death by anoxia or dehydration, mortality may occur as a consequence of barotraumatism, thermal trauma, predation in the water column, predation during the post-settlement period while the animal is recovering or adapting, or from settling on unsuitable substratum. All these factors were unexplored in the present work, but its potential negative effects must be taken into consideration. Estimates of instant mortality rates based on the ratio live animals/dead shells were not calculated due to uncertainty about the timing of shell degradation.

The observations made on damage patterns in live shells indicated that species more prone to get injured while handling were also those that presented a higher proportion of RSD; as found in other studies (Carranza 2006). The volutid species here analyzed (*A. ancilla* and *O. magellanica*) were more prone to suffer direct shell damage while onboard handling, with the exception of the largest species (*A. beckii*), while *F. magellanicus* did not show any apparent injury. The injuries may also be caused after discarding, since damaged benthos may attract predators and scavengers (Groenewold & Fonds 2000), further altering the natural proportion of damaged and undamaged shells. In this study it was assumed that repaired shell damage was a result of trawling inflicted damage. However, the incidence of scars in live shells may also indicate unsuccessful predation attempts, making it harsh to separate naturally inflicted damage from those caused by onboard handling or later release. Nevertheless, the direct evidence for predation upon large shelled gastropods at the study area is scarce, shelled gastropods seem to be absent from the dietary composition of likely predators, as the Patagonian skate *Bathyraja macloviana* (Scenna *et al.* 2006), although anecdotic evidence suggest the incidence of *O.*

*magellanica* and *A. ancilla* in the diet of unidentified Batoideans (F Scarabino pers. com.<sup>1</sup>). We suggest that *A. ancilla* and *O. magellanica* are suitable species to be used as indicators of fishing disturbance, due to the fact that: a) they are abundant; b) they are frequently damaged onboard; and c) they show a high frequency of RSD, suggesting survival after trawling. Both species occur at the southern portion of the study area, but extends its distribution south to the Magellan strait reaching also the Pacific Ocean. For the above reasons, both species are suitable to direct research efforts along a wide geographical area.

## Conclusions

Several species of gastropods are likely to be affected negatively by bottom trawling, but the degree of the effect varies among species and areas. Sublethal effects were evident in all the volutid species, with the exception of *A. beckii*. We encourage further studies on this subject, explicitly examining damage patterns in the gastropods shells, to see if there is any systematic pattern possibly caused by fisheries. To this end, it would be desirable to separate predation-induced scars from those caused by trawling. In the absence of direct information (e.g. video surveys) that allows quantifying the degree and effects of trawling disturbance, the use of the information stored in the gastropods shells may be a valuable tool. Quantitative assessments of the by-catch of non-targeted species are strongly encouraged.

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