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VOLUTID SNAILS AS AN ALTERNATIVE RESOURCE FOR ARTISANAL FISHERIES IN NORTHERN PATAGONIC GULFS: AVAILABILITY AND FIRST SUGGESTIONS FOR DIVING CATCHES

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ABSTRACT Volutid snails have been identified as a potential resource for artisanal fisheries in northern patagonic gulfs. We explored their availability in two gulfs of Chubut Province (Patagonia, Argentina) by means of SCUBA diving and baited traps. CPUE and biomass were estimated from visual counting densities. CPUE of all the volutes was 65.85 kg·diver^{-1}·h^{-1} and 59.5 kg·diver^{-1}·h^{-1} in San Matías (SMG) and San Jorge (SJG) Gulfs, respectively. Estimated biomass was 89.7 (±28.9) and 44.4 (±19.2) tons in SMG and SJG. The species *Adelomelon ancilla* and *Odontocymbiola magellanica* could supplement the potential clam fishery existent at SJG. In SMG *Zidona* followed by *O. magellanica* could be the main commercial target. We suggest minimum catch sizes of 16 cm for *Z. dufresnei*, 9 cm for *O. magellanica*, and 12 cm for *A. ancilla*. Protection of the egg capsules and females would help the protection of the resource. These measures could ensure the sustainability of a small-scale multispecific fishery.

KEY WORDS: edible snails, diving fisheries, artisanal resources, north Patagonia

INTRODUCTION

Gastropods of the Volutidae family have been identified as a potential resource for artisanal diving and trawling fisheries in north patagonic gulfs (Ciocco 1995, Ciocco 1999) and for the semi-industrial trawling fleet centered in Mar del Plata (north coast of Argentina) (Lasta et al. 1998). The most common volutid species in Argentinean coasts are: *Zidona dufresnei* (Donovan, 1832), *Odontocymbiola magellanica* (Gmelin, 1791), *Adelomelon ancilla* (Solander, 1786), *Adelomelon brasiliana* (Lamarck, 1811) and *Adelomelon beckii* (Broderip, 1836). The only commercially exploited species recorded until now is *Z. dufresnei* from Mar del Plata coasts, with landings of up to 1,700 tons in 1997 (Lasta et al. 1998, Giménez et al. 2005). In the gulfs of northern Patagonia, the catches of the "tehuelche scallop" *Aequipecten tehuelchus* (d'Orbigny, 1846) are considered the only mollusc fisheries of significance for local economies (Ciocco et al. 2006). In the case of volutid snails, regular commercial landings are still infrequent in Patagonian coasts, with the exception of sporadic small catches. However, in other regions of the world marine gastropods are starting to be incorporated as new fishery resources because of their high economic value. This can lead to overexploitation and, because of the biological fragility of this kind of resource, to the collapse of the fisheries in some cases (Tegner 1989, Castilla 1996, Hobday et al. 2001). The study of reproductive cycles and population dynamics of fisheries resources is necessary when stating management policies. In the last years reproductive biology of Argentinean volutids have been studied (Giménez & Penchaszadeh 2002, Giménez & Penchaszadeh 2003, Miloslavich et al. 2003, Cledón et al. 2005a, Bigatti 2005; Arrighetti & Penchaszadeh 2006, Bigatti et al. in press) as well as ecology and longevity of some species (Giménez et al. 2004, Cledón et al. 2005b, Bigatti et al. 2007). Some of these species are present in northern patagonic gulfs, so the previous knowledge achieved must be taken into account when assessing the sustainability of the fisheries of these potential resources.

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In this study we explore the availability of volutid snails in the coasts of Chubut Province (Patagonia, Argentina) and suggest the first management rules for potential diving artisanal fisheries targeting this resource.

MATERIALS AND METHODS

To detect areas with volutids availability compatible with commercial shellfish catches, prospecting surveys in the southwest of the San Matías (SMG) and the San Jorge (SJG) Gulfs were performed (Fig. 1). Studied area in SMG was delimitated from Puerto Lobos (42°00′S, 65°04′W) and the region comprised between Barranca Blanca and Punta Quiroga (42°13′S; 64°40′W); in SJG sampling was done between Punta Castillos (65°56′W) and Punta San Roque (65°39′W). A total of 32 transects were performed in SJG and 29 in SMG (Fig. 1). Those were defined between 2–5 to 20–25 m depth, perpendicularly to the line coast, each 1′ (latitude = 1,800 m; longitude ≈ 1,200 m), or fraction (30″ or 15″) according to coast line characteristics. Observations were made by a SCUBA diver that was "trawled" using a boat at a speed of 3 to 5 km h^{-1}. Each transect included 150-m length semitransects, in which the diver counted and registered underwater the number of snails observed in a band wide of 1 m. Stock assessment estimations were carried out from the number of snails recorded at each transect using equations to estimate total N and associated standard error from surveys data in simple random sampling following Thompson (1999). Mean individual wet weight by gulf (all captured individuals from different species grouped) was assigned to the estimated total N to calculate total biomass. Additionally, in SJG experimental catches using snail traps with bait were done; 5 to 20 traps were anchored at different depths for 3 to 6 h. In the transects with higher snail densities and commercial possibilities, CPUE was estimated by a diver fishing snails by hand during 5 min, and extrapolating results to kg diver^{-1} hour^{-1}. Shell length (precision: 0.1 mm) and wet weight (precision: 0.1 g) of all snails caught during the CPUE sampling were registered. For the species *O. magellanica* and *A. ancilla* foot performance weight percentage was calculated as: (foot wet

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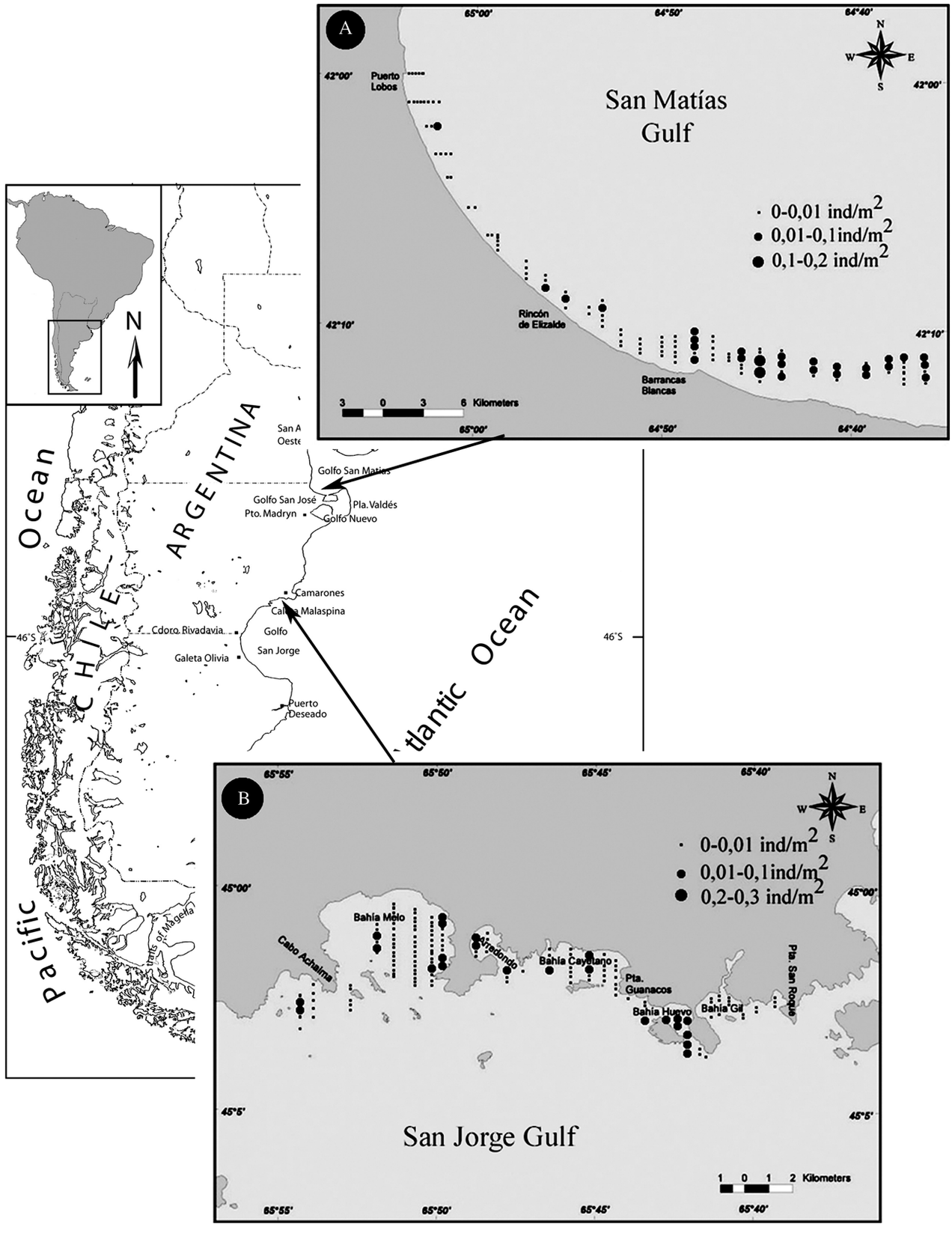

Figure 1. Sampling sites and snail densities (black dots). (A) South of San Matiás Gulf (SMG) and (B) north of San Jorge Gulf (SJG).

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mass/total wet mass) × 100. In the case of *Z. dufresnei* we use the foot performance reported by Giménez et al. (2005).

On the other hand a survey between fishermen and restaurant owners was performed to assess the sale price of snails in the zone.

RESULTS

San Matías Gulf (SMG)

A total of 158 semitransects were done, prospecting 23,700 m^2 by direct visual counting (Fig. 1A). The following species were registered (Fig. 2A): *Zidona dufresnei* (65.2% of total snails registered), *Odontocymbiola magellanica* (24.6%), *Adelomelon beckii* (8.7%), and *Adelomelon ancilla* (1.4%). In the oriental zone (from Barranca Blanca to Pta. Quiroga area) the volutids density (all the species together) was up to 0.2 ind. m^{-2}, whereas the biomass oscillated between 50–80 g m^{-2}. For *Z. dufresnei* the estimated CPUE ranged between 33–110 Kg $diver^{-1}$ h^{-1}, with specimens of more than 200 mm in shell length and a mean individual weight of 500 g. In only one case (transect 27, located near the east end of the explored area) a CPUE of 65.85 Kg $diver^{-1}$ h^{-1} was recorded for the group of *A. beckii*, *A. ancilla*, and *Z. dufresnei* (Fig. 2D). The biggest individual of *A. beckii* captured weighed 3,175 g with a shell length of 365 mm. Estimated total N in the SMG surveyed area (equivalent to 30.9 Km^2) was 150,066 (±46,485) individuals, representing in general terms a mean of 0.5 snails/100 m^2 and a biomass of 89.7 (±28.9) tons (Table 1).

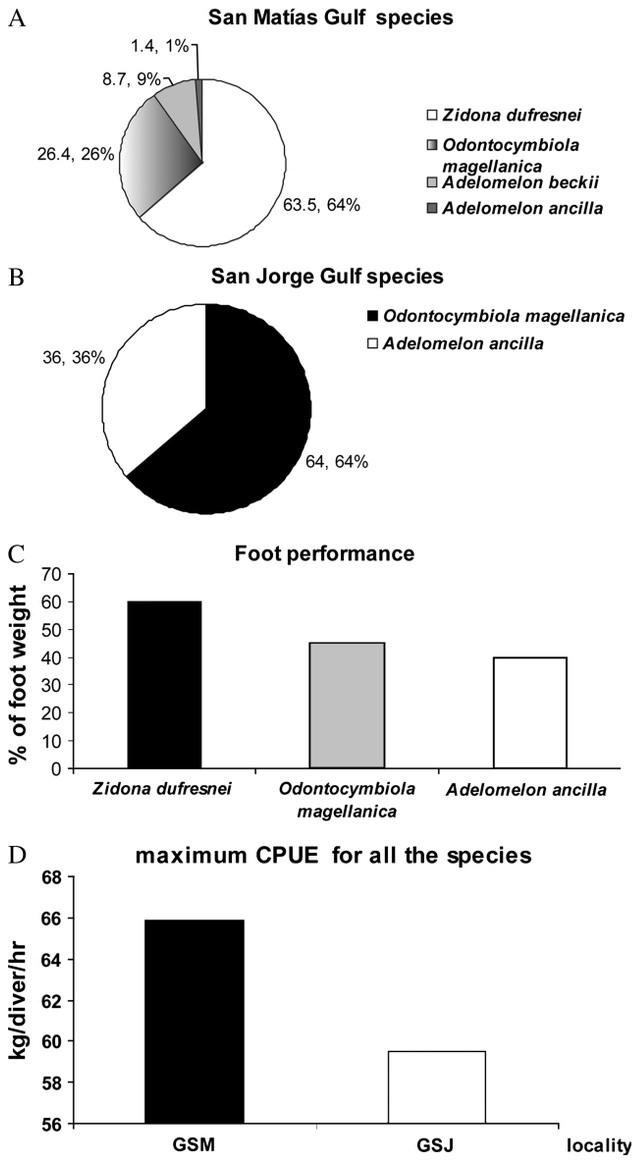

Figure 2. (A) Percentage of species sampled in SMG; (B) percentage of species sampled in SJG; (C) foot performance (% of foot weight from total weight); (D) CPUE for all the species together in SMG and SJG.

San Jorge Gulf (SJG)

A total of 192 semitransects were performed by direct visual counting, covering an area of 28,800 m^2. At the same time 65 snail baited traps were submerged. Relevant concentrations of *A. ancilla* (64% of total snails counted) and *O. magellanica* (36%; Fig. 2B) were detected in Bahía Huevo and Bahía Cayetano, with maximum densities of 0.2–0.3 ind. m^{-2}, whereas the snail biomass ranged from 45–65 g m^{-2}. In Bahia Cayetano, medium shell length for *A. ancilla* was 147 mm (SD = 20.8; n = 16) and for *O. magellanica* 151 mm (SD = 9.9; n = 9). Medium individual weight for both species together was 285.32 g (SD = 60.85; n = 11). The estimated CPUE for both species together oscillated between 29–89 Kg $diver^{-1}$ hr^{-1}, and the mean for the species group was 59.5 Kg $diver^{-1}$ hr^{-1} (Fig. 2D). No volutids were caught in the 65 snail baited traps. Estimated total N in the SJG surveyed area (equivalent to 16.6 Km^2) was 155,550 (±66,752) individuals, representing a mean of 0.9 snails/100 m^2 and 44.4 (±19.2) tons of volutid biomass (Table 1).

Foot Performance and Commercialization

The muscular foot weight (used for human consumption) represents around 40% to 45% of the total weight for *O. magellanica* and *A. ancilla* (Fig. 2C) in both gulfs.

In the Chubut Province there has not been massive commercialization of volutid snails until present. Consumption is restricted to local restaurants and families. The sale price of *O. magellanica* reported by artisanal fishermen in Riacho San José (San José Gulf, approximately 100 Km south from SMG) is around 0.30 US dollars per unit, which gives a mean of 6.50 US

TABLE 1.

Volutid stock assessment.

Gulf	Total N	Biomass (tons)	Mean Weight (g)	Surveyed Area (Km^2)
SMG	150,066 (±46,485.4)	89.7 (±28.9)	597.6 (±53.9)	30.9
SJG	155,550 (±66,752.4)	44.4 (±19.2)	285.3 (±18,3)	16.6

SMG = San Matías Gulf; SJG = San Jorge Gulf; standard error between parenthesis.

Mean weight corresponding to SMG was estimated from 69 snails (45 *Z. dufresnei*; 17 *O. magellanica*; 6 *A. beckii*; 1 *A. ancilla*), and Mean weight from the SJG estimated from 11 snails (7 *A. ancilla*; 4 *O. magellanica*).

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dollars per Kg of fresh foot meat (without the shell) or 4 US dollars per Kg (entire animal) when sold to restaurants or locally consumers.

DISCUSSION

Marine snails represents approximately 2% of the molluscs global catches, and several gastropod genera such as *Haliotis*, *Concholepas*, *Strombus*, and *Busycon* show high economic values in international markets and play substantial roles in small scale artisanal fisheries (Leiva & Castilla 2002). In the north patagonic gulfs, marine snails are still captured occasionally and are consumed locally. In Argentina and Uruguay, *Z. dufresnei* occurring in the fishing area common to both countries, has been exploited for the last 30 y (Giménez et al. 2005). The mean price of *Z. dufresnei* in the Argentinean internal market is 2–2.5 US dollars/Kg (Ciocco 1999). The sale price of *O. magellanica* (4 US dollars/Kg) for local consumption reported in this work is quite similar to that of *Z. dufresnei*. On the other hand, overall growth performance (OGP) of *Z. dufresnei* and *O. magellanica* is within the range of other commercial snails from temperate regions (Cledón et al. 2005b, Bigatti et al. 2007), which would make profitable its commercialization.

According to the registered abundances, the snails that could be commercially exploited in the SMG would be mainly *Z. dufresnei* followed by *O. magellanica*. Performances observed in the catches of *Z. dufresnei* set this resource as a support of a novelty fishery in the zone between Barranca Blanca and Punta Quiroga, area where 88.4% of the total volutid biomass estimated from SMG is concentrated, which results in around 79 tons of *Z. dufresnei*. Although individuals of *A. beckii* bigger than 3 Kg of total weight were registered in the zone, the observed densities are low, suggesting that the fishing of this species would not be profitable. Even though volutids present high sizes and somatic production, their slow growth rate, their late sexual maturity, and direct development lacking a free swimming larvae stage make this group extremely vulnerable to overexploitation (Bigatti et al. 2007), which would result in the loss of an important link in the trophic webs of the shallow waters benthic communities from north Patagonia.

The foot of *Z. dufresnei* represents 60% of the total body weight and is the only portion that is consumed (Giménez et al. 2005), whereas the foot of *O. magellanica* and *A. ancilla* representing approximately 40% to 45% of the total body weight. Although the performance is higher in *Z. dufresnei*, fishing of all these species could be done alternatively, allowing the sustainable growing of the populations. In the SMG the CPUE value for the group of all the volutes was 65.85 kg diver^{-1} h^{-1} (*A. beckii, A. ancilla*, and *Z. dufresnei*), whereas in the SJG the CPUE was 59.5 kg diver^{-1} h^{-1} (*A. ancilla* and *O. magellanica*). Taking into account that the mean yield of all the species is around 50%, it could be obtained a mean CPUE of fresh meat of 32 kg diver^{-1} h^{-1}. In the SJG *A. ancilla* and *O. magellanica* could be a complementary target of a potential clam fisheries in the zone. By means of seasonal alternation of target species [the "red octopus," *Enteroctopus megalocyathus* (Gould, 1852), and infralitoral bivalves as the hard shell clam *Protothaca antiqua* (King and Broderip, 1832)] the local availability of resources could support a multispecific small scale fishery.

The fact that no snails were caught in the baited traps in SJG could be related to the feeding mechanism of the Volutidae family in the norpatagonic gulfs. *O. magellanica* feeds mainly on live molluscs that are previously narcotized by means of a salivary liquid produced by the predator salivary and accessory salivary glands; the feeding on carrion was registered at a low rate (Bigatti 2005).

Giménez et al. (2005) propose a minimum capture size of 16 cm for *Z. dufresnei* on the coasts of Mar del Plata (north coast of Argentina) taking into account the first maturity size: 15 cm for males and 15.7 cm for females. These sizes correspond to individuals of 8 and 9 y old respectively (Giménez et al. 2004). In this study, no data about reproductive season are available in the SMG, but the minimum size proposed by Giménez et al. (2005) could be used as a parameter for the fisheries of *Z. dufresnei* in the Chubut province. Further studies about reproductive seasons of this species are recommended, because latitudinal (and environmental) variations lead to changes in reproductive physiology. First maturity size for *O. magellanica* in Nuevo Gulf (Chubut Province) is 80 mm for males and 90 mm for females (Bigatti et al. in press), corresponding to 7 and 8 y-old individuals respectively (Bigatti et al. 2007). Females lay egg capsules from July to December and embryos complete their development in 2–3 mo (Bigatti 2005). The modal wet weight of the animals is 62.8 g, reaching an age of up to 20 y; maximum individual somatic production is 29.3 g yr^{-1} at a size of 145 mm (12 y old), and decrease thereafter (Bigatti et al. 2007). In the case of *A. ancilla* no aging studies were performed until now, but the minimum size of females observed laying egg capsules in the field is 114 mm and the minimum size of individuals analyzed with developed gonads is 102 mm in Nuevo Gulf. The main oviposition season is from June to November and intracapsular development takes approximately 3 mo in the same zone (Penchaszadeh et al. 2006).

Regarding the reproductive studies available for the species, we propose a minimum catch size of 16 cm for *Z. dufresnei*, 9 cm for *O magellanica*, and 12 cm for *A. ancilla*. Fisheries of *A. beckii* are not recommended because of the lack of reproductive and ecological studies of this species in the coasts of Chubut province and for the low density registered in the present work.

Volutid juveniles or immature individuals live mainly buried in the substratum (Bigatti 2005), which could protect them from the capture of artisanal diving fishermen or by trawling nets with mesh sizes exceeding the minimum catch sizes proposed in this paper. For the diving fisheries, instructing fishermen to discriminate between sexes by the pedal gland observation in volutid females (Ayçaguer 2002, Bigatti 2005), as well as the protection of the egg capsules and females found, would help to protect the resource. In all the cases, when fished volutids are in the reproductive season, the capture of females should be avoided. These policies, together with a seasonal alternation of target species of other shellfish could support a small-scale multispecific fishery (Ciocco 1999), which would assure the stocks of artisanal volutid fisheries in the coasts of the north patagonic gulfs.

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