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Protection of the goose barnacle *Pollicipes pollicipes*, Gmelin, 1790 population: the Gaztelugatxe Marine Reserve (Basque Country, northern Spain)

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SUMMARY: Marine protected areas are expected to play a prominent role in the conservation of marine resources and fisheries management. In the Basque Country (northern Spain) the small Marine Reserve of Gaztelugatxe (158 ha) was established in 1998. One of the aspects taken into account in protecting this area was the overexploitation of the goose barnacle *Pollicipes pollicipes*. Now, after five years of protection, differences in density, biomass, size and weight of the goose barnacle are investigated inside the protected area (Aketze and Gaztelugatxe locations) and outside of it, at the nearest locations (Izaro and Ogoño) which have been continuously exploited. This contribution demonstrates that the reserve could be an efficient tool in preserving the goose barnacle populations in the area. Hence, density, biomass and allometric coefficients are higher in the protected areas. These locations are also associated with higher percentages of juveniles, together with a high number of large-sized individuals.

Keywords: goose barnacle, exploitation, conservation, resources, marine reserve, wave exposure.

Resumen: CONSERVACIÓN DE LAS POBLACIONES DE PERCEBE (*POLLICIPES POLLICIPES*, GMELIN, 1790) EN LA RESERVA MARINA DE GAZTELUGATXE (PAÍS VASCO, NORTE DE ESPAÑA). – Las áreas marinas protegidas juegan un papel relevante en la conservación de los recursos marinos y la gestión de pesquerías. En el País Vasco (norte de España) se creó la pequeña (158 Ha) reserva marina de Gaztelugatxe en 1998. Uno de los aspectos más importantes para su protección fue la sobreexplotación a la que se encontraba sometido el percebe *Pollicipes pollicipes*. Tras cinco años de protección se llevó a cabo un estudio para investigar las diferencias en densidad, biomasa, tamaño y peso de los percebes, tanto dentro del área protegida (Aketze y Gaztelugatxe), como fuera de ella, en las cercanas localidades de Izaro y Ogoño, que han sido explotadas permanentemente. Los resultados del estudio demuestran que la reserva es una herramienta adecuada para preservar las poblaciones de percebe en la zona. Así, la densidad, biomasa y los coeficientes alométricos son mayores en las áreas protegidas. Estas zonas presentan también mayores porcentajes de juveniles y un mayor número de individuos de gran tamaño, por comparación con las zonas explotadas.

Palabras clave: percebe, explotación, conservación, recursos, reservas marinas, exposición al oleaje.

INTRODUCTION

Marine protected areas are expected to play a prominent role in the conservation of marine resources and fisheries management, as advocated by international organisations, such as the World Conservation Union (Attwood *et al.*, 1997). There are many types of marine protected areas worldwide, with different conservation goals, such as: (i) protecting habitats; (ii) managing sensitive species; (iii) protecting biodiversity; or even, (iv) fisheries management (Jamieson and Levings, 2001; Botsford *et al.*, 2003).

The World Conservation Union proposed the goal of conserving 20% of the world's coastline with marine protected areas by the year 2000 (IUCN, 1992). In the case of the Basque Country (northern Spain), the Basque Department of

Agriculture and Fisheries decided in 1993 to create a network of marine reserves along the coast, with the following aims: (i) to protect marine resources including habitats and threatened species of commercial and ecological interest; and (ii) to integrate several ecosystems along the coast, acting as 'natural spreading areas' (Castro *et al.*, 2004) for several species. A preliminary selection of the most interesting sites along the coast was undertaken in 1994 (Borja *et al.,* 1999), based on ecological, landscape setting and cultural values. Among the areas studied during the 1990s, the most interesting was Gaztelugatxe (Fig. 1); this included submarine caves, rocky marine arches and islands, summer upwelling, and high quality water (in terms of the absence of contaminants and low turbidity levels; see Borja *et al.*, 2000). There was also significant exploitation of the goose barnacle resource, *Pollicipes pollicipes*. Finally, there are two important species of seabirds nesting in the area: *Phalacrocorax aristotelis* and *Hydrobates pelagicus* (Borja *et al.*, 2000; Franco *et al.*, 2004).

The small Marine Reserve of Gaztelugatxe (158 Ha) was created in 1998 (229/1998 Decree of 15 September of the Basque Government), with the aim, amongst others, to protect the goose barnacle populations (Borja *et al.*, 2000) and the subsequent damage of the associated communities, as described in other countries (Jamieson *et al.*, 1999).

Although no data are available on the goose barnacle populations of Gaztelugatxe, before 1998, the Fisheries Service Guard verified the depletion of captures of this species before the creation of the reserve, probably due to overexploitation. The managerial decision to establish the marine reserve was based partially on the hypothesis that prohibiting the exploitation of *P. pollicipes* would result in increased density, biomass and other parameters of this barnacle (Borja *et al.*, 2000). Hence, after five years of protection, several studies were undertaken at this location (Borja *et al.*, 2004).

The present authors have hypothesised on the possibility that the protection afforded in the marine reserve (at Aketze and Gaztelugatxe (Fig. 1)), when compared with non-protected or exploited areas (Izaro and Ogoño) could, for the goose barnacle: (i) increase density, biomass, size and weight; and/or (ii) modify adult-juvenile proportions. However, such differences could be controlled by other factors, such as wave energy, in this particular case, represented by coastal orientation (González *et al.* (2004) have determined that westerly-oriented coasts receive more wave energy in the Basque Country than easterly-oriented). Similarly, distribution of tidal levels, i.e. intertidal or subtidal, could act as another controlling mechanism. Hence, the objective of this contribution is to determine the suitability of the reserve for protecting the goose barnacle population.

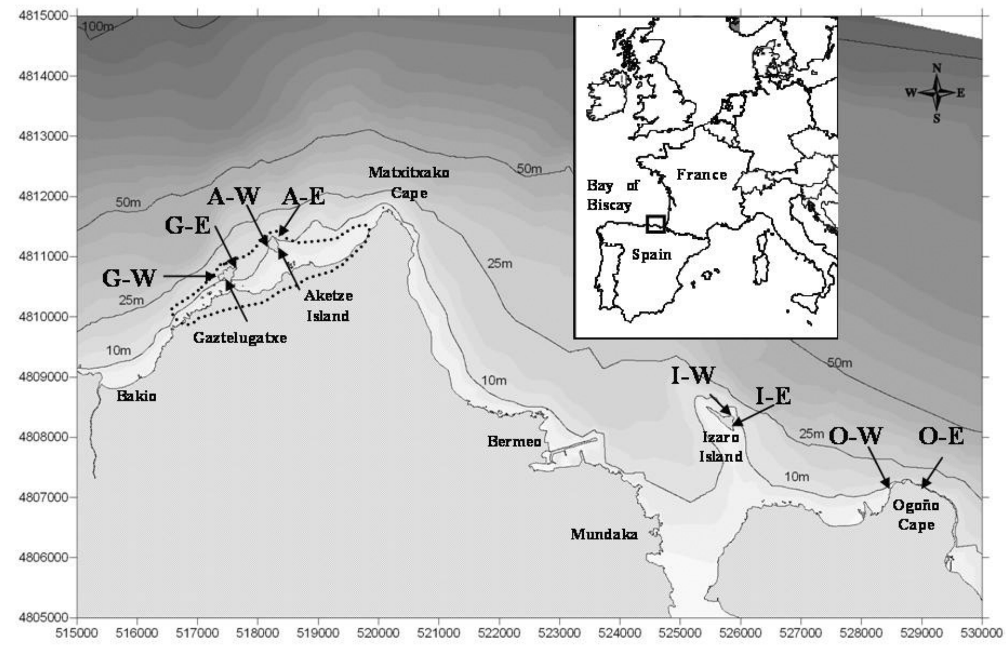

FIG. 1. – Location, within a European context, of the sampling locations used in comparing protected and unprotected (exploited) areas for goose barnacles. The dotted line represents the limits of the Gaztelugatxe Marine Reserve. The coordinates are in UTM. Key: W = northwest-oriented areas; E = northeast-oriented areas; G = Gaztelugatxe; A = Aketze; I = Izaro; and O = Ogoño.

METHODOLOGY

The absence of quantitative goose barnacle data, prior to establishing the Gaztelugatxe Reserve, prevents some approaches being used, such as the BACI design (Underwood, 1992). Hence, in order to establish possible differences between protected and unprotected areas for goose barnacles, two location groups were selected: (i) the areas of Izaro Island and Ogoño Cape, which are exploited regularly; and (ii) the areas of Aketze Island and Gaztelugatxe tombolo (both inside the marine reserve), which are protected and unexploited (Fig. 1). All of the locations where the goose barnacles were sampled are only accessible by boat. In addition, the effects of coastal orientation were studied: (i) northwest-orientated substrata (NW), receiving high wave energy; and (ii) northeast-orientated substrata (NE), which are more protected from waves. Moreover, in each of the orientations, two different levels were studied: (i) intertidal (I) (samples collected between 1 and 2 m above the lowest astronomical tide (LAT)); and (ii) subtidal (S) (samples collected between –0.5 and 0 m water below the LAT). In each of the possible combinations 4 replicates were taken, totalling 64 replicates in 4 locations, 2 orientations and 2 tidal levels.

At each of the locations, the samples were collected on a randomly stratified basis by scraping 30x30 cm quadrats totally using a metallic spatula (adapting the De la Hoz and García (1993) methodology). All samples were collected between 18 July and 5 August, 2002.

In the laboratory, the individuals were sorted and counted, including both adults and juveniles. Minimum capitulum length for maturity of the female gonad ranges between 12 and 12.5 mm (Cruz and Hawkins, 1998; Cunha and Weber 2001); similarly, sperm production is achieved in smaller individuals (10 mm). Hence, in the present contribution goose barnacles <10 mm in length were considered as juveniles, and the remainder as adults. Fresh and dry (80ºC, 48 h) weights were determined (individually and by sample). Individuals were measured to the lowest millimetre (Bernard, 1988), in terms of: (i) total length (including capitulum and peduncle); and (ii) capitulum length.

Data sets were studied by means of the *Statgraphics* © software, using a Shapiro-Wilks test to analyse if data fitted a normal distribution at each location, orientation and tidal level. As the data sets were not normally distributed, using a three-way ANOVA for comparing the three factors studied simultaneously (location groups, coastal orientation and tidal level), was not possible. Hence, non-parametric statistics were used, including: (i) the Kruskal-Wallis test, to check differences in density, biomass, *capitulum* length and total length between locations, with non-orthogonal contrasts between protected and non-protected sampling stations, as a *post hoc* test; (ii) the Kolmogorov-Smirnov test, for comparing tidal levels and orientations; and (iii) regression between the total length (TL), the capitulum length (CL), and the fresh and dry weights (FW, DW), in deriving the allometric relationships.

The regression model selected was the multiplicative ($y= a x^b$), in studying relationships between length and weight (this is an old allometric model, based on Nomura (1926) and Barybina and Sanina (1975). Likewise, the regression model, in comparing FW and DW, was the simple linear model ($y= ax + b$), because their relationships are always linear. A comparison between the regression lines was undertaken. In the case of the multiplicative model, the data were previously log-transformed, due to the model requirements.

Finally, the proportion of the mean juvenile-adult abundance was compared using a *t*-test.

RESULTS

Density and biomass per replicate, individual mean fresh weight, and capitulum and total length data, as obtained from each of the sampling locations, are listed in Table 1. In terms of density and biomass, significant differences are found between locations ($p<0.05$), both in terms of coastal orientation (exposed and non-exposed areas, orientated to NW and NE respectively) and tidal levels (Table 2). Density and biomass are always significantly higher ($p<0.05$) in the protected areas (Aketze and Gaztelugatxe) than in the non-protected areas (Izaro and Ogoño).

Conversely, there are significant differences in capitulum length ($p<0.05$) between a NE-orientated coast (non-exposed stations), at both tidal levels (Table 2). For this variable, there are no significant differences between protected and non-protected areas at the subtidal level. However, there are differences at the intertidal level ($p<0.05$), where the mean capitulum length is higher.

TABLE 1. – Density and biomass, mean total length (TL), mean capitulum length (CL) and mean fresh weight (FW), of each of the replicates sampled at different orientations, tidal levels and from exploited and unexploited (protected) areas.

Orientation	Tidal Level	UNEXPLOITED AREAS Density (ind.sample^{-1})	Biomass (g.sample^{-1})	TL (mm)	CL (mm)	FW (g)	EXPLOITED AREAS Density (ind.sample^{-1})	Biomass (g.sample^{-1})	TL (mm)	CL (mm)	FW (g)
				AKETZE					IZARO		
West	Intertidal	573	882.9	33.1	12.0	1.5	60	178.3	41.6	19.1	3.0
		220	455.6	47.5	15.0	2.1	19	65.0	40.7	18.6	3.4
		229	606.6	43.9	15.4	2.7	26	85.9	38.6	19.1	3.3
		159	224.2	31.5	13.8	1.4	15	73.0	44.0	23.9	4.9
	Subtidal	115	252.0	31.1	14.2	2.2	9	76.7	56.1	29.5	8.5
		57	172.6	34.2	17.7	3.0	139	108.0	20.3	9.7	0.8
		192	396.7	31.6	13.7	2.1	76	108.6	31.0	15.4	1.5
		135	480.1	41.7	18.1	3.6	33	64.9	31.8	16.7	2.0
East	Intertidal	65	182.0	38.5	18.5	2.8	22	38.7	31.3	15.5	1.8
		139	332.5	36.0	17.1	2.4	18	26.9	28.7	16.0	1.5
		87	209.6	34.4	14.8	2.4	30	69.0	39.0	18.9	2.3
		57	265.0	56.0	24.0	4.7	13	35.3	35.0	18.6	2.7
	Subtidal	81	111.3	25.0	12.5	1.4	45	110.8	38.8	16.5	2.5
		115	285.7	33.4	13.3	2.5	10	28.8	30.5	21.1	2.9
		99	286.1	41.3	17.9	2.9	20	50.5	32.8	19.5	2.5
		69	409.6	65.2	25.6	5.9	27	79.9	35.4	20.8	3.0
				GAZTELUGATXE					OGOÑO		
West	Intertidal	151	270.1	31.5	15.9	1.8	67	230.7	53.4	16.6	3.4
		160	254.5	25.8	13.1	1.6	68	138.4	44.5	15.7	2.0
		293	292.2	19.0	10.1	1.0	155	181.9	27.7	11.0	1.2
		355	255.7	17.7	9.5	0.7	110	220.6	35.6	13.3	2.0
	Subtidal	1038	562.3	16.1	7.6	0.5	62	104.2	29.1	11.9	1.7
		358	418.5	24.2	12.1	1.2	84	154.5	30.3	13.7	1.8
		302	408.0	26.0	13.8	1.4	124	239.9	33.5	13.3	1.9
		300	398.8	24.4	13.0	1.3	76	109.4	23.8	11.5	1.4
East	Intertidal	177	184.5	24.2	12.5	1.2	31	69.1	33.4	19.0	2.2
		101	169.1	32.8	16.1	1.7	104	151.8	32.3	14.2	1.5
		68	191.3	46.9	19.9	2.8	54	125.4	37.1	18.2	2.3
		144	417.1	45.2	19.6	2.9	70	123.6	34.3	17.5	1.8
	Subtidal	118	231.8	29.1	15.7	2.0	51	116.5	29.7	18.2	2.3
		137	212.3	28.5	14.3	1.5	74	92.2	20.8	14.2	1.3
		238	190.6	15.6	9.1	0.8	89	106.7	20.8	13.1	1.2
		128	252.1	26.9	15.0	2.0	77	124.9	25.6	16.1	1.6

TABLE 2. – Comparison of density, biomass, capitulum length and total length: (a) between protected and non-protected areas, for each orientation and tidal level; (b) between tidal levels for protected and non-protected areas, for each orientation; and (c) between orientations, for protected and non-protected areas and each tidal level. Kruskal-Wallis (K-W) and Kolmogorov-Smirnov (K-S) statistical and p-values are presented, for each comparison. Significant differences (p<0.05) are underlined. (-) A non-orthogonal test was not undertaken, because there are no differences between locations.

	Density		Biomass		Capitulum length		Total length	
Protection	K-W statistic	*p*	K-W statistic	*p*	K-W statistic	*p*	K-W statistic	*p*
Non-exposed intertidal	6.35	0.012	11.29	0.001	5.83	0.016	-	-
Non-exposed subtidal	8.65	0.003	9.93	0.002	0.01	0.916	0.01	0.916
Exposed intertidal	10.60	0.001	10.60	0.001	-	-	-	-
Exposed subtidal	5.84	0.016	10.60	0.001	-	-	-	-
Tidal Level	K-S statistic	*p*	K-S statistic	*p*	K-S statistic	*p*	K-S statistic	*p*
Non-protected non-exposed	0.50	0.964	0.75	0.627	0.75	0.627	0.25	1.000
Non-protected exposed	0.75	0.627	0.75	0.627	1.00	0.271	1.25	0.088
Protected non-exposed	0.75	0.627	0.75	0.627	1.25	0.088	1.50	0.022
Protected exposed	0.75	0.627	0.75	0.627	0.50	0.964	1.25	0.088
Orientation	K-S statistic	*p*	K-S statistic	*p*	K-S statistic	*p*	K-S statistic	*p*
Non-protected intertidal	0.75	0.627	1.00	0.271	0.50	0.964	1.25	0.088
Non-protected subtidal	0.75	0.627	0.50	0.964	0.75	0.627	0.50	0.964
Protected intertidal	1.75	0.004	1.25	0.088	1.25	0.088	1.00	0.271
Protected subtidal	1.00	0.271	1.25	0.088	0.50	0.964	0.50	0.964

TABLE 3. – Allometric relationships for each of the locations. Key: FW=fresh weight; DW=dry weight; TL=total length; CL=capitulum length; r=correlation; r^2= explained variability (%); *p*-significance; and *** significant correlation, at $p<0.001$.

Location	Regression Equation	Data number	r	r^2	*p*
Fresh Weight and Total Length					
Aketze	$FW= 1.2\ 10^{-5} \times TL^{3.11}$	2,391	0.952	90.7	0***
Izaro	$FW= 6.6\ 10^{-5} \times TL^{2.83}$	559	0.950	90.9	0***
Ogoño	$FW= 6.9\ 10^{-5} \times TL^{2.76}$	1,295	0.958	91.7	0***
Gaztelugatxe	$FW= 2.2\ 10^{-5} \times TL^{3.09}$	4,048	0.969	94.1	0***
Dry Weight and Total Length					
Aketze	$DW= 4.9\ 10^{-5} \times TL^{2.52}$	327	0.906	81.9	0***
Izaro	$DW= 3.8\ 10^{-5} \times TL^{2.76}$	106	0.923	85.3	0***
Ogoño	$DW= 7.1\ 10^{-5} \times TL^{2.56}$	234	0.929	86.3	0***
Gaztelugatxe	$DW= 1.4\ 10^{-4} \times TL^{2.41}$	383	0.917	84.1	0***
Fresh Weight and Capitulum Length					
Aketze	$FW= 6.2\ 10^{-5} \times CL^{3.5}$	2,391	0.955	91.3	0***
Izaro	$FW= 5.1\ 10^{-4} \times CL^{2.81}$	559	0.981	96.3	0***
Ogoño	$FW= 4.9\ 10^{-4} \times CL^{2.84}$	1,295	0.983	96.5	0***
Gaztelugatxe	$FW= 1.1\ 10^{-4} \times CL^{3.29}$	4,048	0.979	96.0	0***
Dry Weight and Capitulum Length					
Aketze	$DW= 9.8\ 10^{-5} \times CL^{3.09}$	327	0.990	98.2	0***
Izaro	$DW= 3.6\ 10^{-4} \times CL^{2.67}$	106	0.968	93.8	0***
Ogoño	$DW= 5.3\ 10^{-4} \times CL^{2.58}$	234	0.973	94.7	0***
Gaztelugatxe	$DW= 1.4\ 10^{-4} \times CL^{2.99}$	383	0.980	96.1	0***
Dry Weight and Fresh Weight					
Aketze	DW= 0.08 + 0.40 FW	327	0.982	96.5	0***
Izaro	DW= 0.08 + 0.40 FW	106	0.984	96.9	0***
Ogoño	DW= 0.07 + 0.44 FW	234	0.983	96.6	0***
Gaztelugatxe	DW= 0.08 + 0.47 FW	383	0.983	96.7	0***

There are no significant differences in total length between locations for any orientation or tidal level ($p>0.05$), except for non-exposed (NE-orientated) subtidal locations (Table 2). However, even at these locations, mean total length is not significantly higher in protected areas than in non-protected areas.

When comparing the tidal levels, the only significant differences ($p<0.05$) are found in the protected and non-exposed (NE-orientated) locations, where the total length of the barnacles is higher at the intertidal level (Table 2).

When comparing the two orientations (NE and NW), significant differences ($p<0.05$) are found only in the protected intertidal sampling stations, where the density is higher in exposed stations than in non-exposed stations (Table 2).

All the biometric relationships are highly significant (Table 3), with the coefficient relating length (total or capitulum) and weight (fresh or dry) around 3, with a large number of individuals studied (between 559 and 4,048 g, in the case of FW, and between 106 and 383 g in DW). The smallest coefficients are reached at Izaro and Ogoño (values from 2.58 to 2.84), and are highest at Aketze and Gaztelugatxe (2.99 to 3.5). The variability explained by the relationships lies between 90 and 98%, with the exception being the total length/dry weight relationship (Table 3).

TABLE 4. – Allometric relationships between capitulum length (CL) and dry weight (DW), depending on the tidal level, orientation and protection in the locations. The comparison between regression lines was made after log-transforming data sets. Key: r=correlation; r^2= explained variability (%); and *p*-significance; *** significant correlation at $p<0.001$.

Tidal Level	Regression Equation	Data number	r	r^2	*p*
Intertidal	$DW= 2.4\ 10^{-4} \times CL^{2.81}$	516	0.972	94.6	0***
Subtidal	$DW= 3.2\ 10^{-4} \times CL^{2.73}$	536	0.977	95.4	0***
Comparison between regression lines		1,042	0.971	95.1	0***
Orientation					
NW	$DW= 3.4\ 10^{-4} \times CL^{2.71}$	688	0.973	94.6	0***
NE	$DW= 1.1\ 10^{-4} \times CL^{3.05}$	364	0.987	97.3	0***
Comparison between regression lines		1,042	0.976	95.3	0***
Protection					
No	$DW= 5.0\ 10^{-4} \times CL^{2.59}$	342	0.971	94.3	0***
Yes	$DW= 1.2\ 10^{-4} \times CL^{3.04}$	711	0.986	97.2	0***
Comparison between regression lines		1,053	0.979	95.9	0***

However, the allometric coefficients are higher in the intertidal, NE-orientated and unexploited locations (Table 4); this indicates that individuals here weigh more, for the same size, than in the subtidal, NW-orientated and exploited locations. The correlations are highly significant in these particular cases (Table 4). In all cases comparison between the regression lines shows highly significant differences (Table 4), even in the slopes and intercepts.

The juveniles (<10 mm capitulum length) were more abundant in the subtidal (51.5%), rather than the intertidal (41%) locations; they were more abundant in NW-orientated (52.1%) than NE-orientated (34.4%) locations. Similarly, juveniles were more abundant in unexploited (50.6%) than exploited (33%) locations. All of these differences were significant (p<0.05).

DISCUSSION

Some of the reasons for establishing marine reserves include, amongst others: (i) protecting breeding stocks of certain commercially-important species; (ii) rehabilitating depleted stocks; (iii) protecting habitats representative of different coastal ecosystems; and (iv) conserving areas of outstanding richness and diversity (Attwood *et al.,* 1997; Botsford *et al.,* 2003). Hence, the role of marine protected areas in fisheries management is in relation to the importance of conserving ecosystem structure, as the framework for stable fishery production; likewise, in utilising the value of undisturbed ecosystems, for comparative studies, among others (Attwood *et al*., 1997).

In the Basque Country, there are significant differences concerning the density and biomass between the exploited and protected locations; they are both higher in the latter case (as mentioned also by Halpern (2003)). A similar pattern was revealed by the number of large individuals within the capitulum length of >22.5 mm. Hence, in protected locations (Aketze and Gaztelugatxe) individuals exceeding this length represent 24.3% of the total; at exploited locations (Izaro and Ogoño), this represents only 19.2% (with differences being significant at p<0.05). Cunha and Weber (2001) found it difficult to find individuals larger than 22.5 mm in capitulum length in overexploited areas. Once again, this demonstrates the success of the marine reserve in accomplishing the reasons outlined by Attwood *et al*. (1997) and Botsford *et al*. (2003), for their establishment.

Similarly to the above-mentioned authors, Hockey and Branch (1997) identified a set of 17 criteria for determining whether a marine reserve is achieving the objectives of its creation; two of these (does the area support exploited species?; and will the area supply stocks to adjacent areas?) are related directly to some of the objectives involved in creating the reserve at Gaztelugatxe.

With growing worldwide pressure to increase the level of protection afforded to marine habitats, partial fishing closures are often advocated by groups with direct fishing interests (Denny and Babcock, 2004). Such partial closures are promoted as a 'compromise' solution, allowing both protection and fishing (Willis and Denny, 2000). Other fishing management measures against overexploitation of goose barnacles are related to temporal closures, such as in Galicia (NW of Spain) (Molares and Freire, 2003) or Brittany (NW of France) (Girard, 1982), followed by a co-management system, shared between fisher organisations and fishery authorities.

The genus *Pollicipes* is very selective in terms of settlement, preferring areas exposed to waves and currents (Barnes and Reese, 1960; Barnes, 1996). This suggestion agrees with the results from the Basque coast because, in the NW-orientated locations where the waves break with high energy (González *et al*., 2004), there are higher density and biomass values (with significant differences) than in the NE-orientated locations (more protected). Moreover, there are also more juveniles (52.1%) in the NW than in the NE (34.4%) locations. The relationship between the distribution and abundance of the goose barnacle and the wave regime and energy has been tested and proved by Borja *et al*. (2004, 2006) for the area.

The allometric relationship between size (mm) and weight (g) in the Basque Country (the present contribution) fits with a multiplicative regression model. According to this relationship, the individuals are significantly heavier at the intertidal and protected locations, than at the subtidal and non-protected locations. The protected areas, in our contribution, have higher regression coefficient values (with b near to 3) than the exploited areas (b near to 2.5); this suggests an unmodified relationship between length and weight within the Marine Reserve of Gaztelugatxe. The allometric relationship between size and weight, as obtained by Molares (1993, 1998) for *P. pollicipes* in Galicia, fits with a second-order polynomial equation; for comparison, Goldberg (1984) determined a linear relationship (log FW= 1.142*CL – 1.645). Taking into account these relationships, the Galician goose barnacles have 25% more weight, for the same capitulum length, than those from the Basque coast. The same pattern is found when making comparisons with the Canadian *Pollicipes polymerus* (Bernard, 1988).

Cruz (1993), when studying three Portuguese locations, found that the weight and peduncle length are larger in individuals from locations with more immersion time; here, the food availability is higher. In contrast, along the Basque coast and according to the results obtained in the present contribution, the intertidal individuals are heavier and larger than at subtidal locations.

The lower number of juveniles found in the exploited locations in the present contribution, could be related to: (i) removal of adults, reducing the availability of suitable settlement sites for juveniles; or (ii) juveniles attached to adults being removed by fishermen, as described by Lauzier (1999a and b). Even if the proportion of adults (>10 mm) is higher at the exploited locations (67% compared to 49.4% in protected locations), the density is much lower (see Table 1). Furthermore, size is considered a fundamental factor affecting fecundity of the genus *Pollicipes,* with small animals (<15 mm) producing around 16,200 eggs per brood and large animals (>19 mm) more than 34,000 (Cruz and Araújo, 1999; Cunha and Weber, 2001). Hence, taking into account the smaller mean size and the smaller mean weight, at the Izaro and Ogoño exploited areas, this could produce lower fecundity in these locations. Consequently, the role of these two effects underlines the impact of fishermen's activities, over the fecundation capabilities of exploited populations.

As a conclusion, the Gaztelugatxe Marine Reserve has significant differences in comparison with non-protected areas in preserving the goose barnacle population in terms of higher density, biomass, allometric coefficients, percentage of juveniles, and mean individual size. Hence, this reserve plays the same role as other fishing management measures against overexploitation, such as partial or temporal closures (Girard, 1982; Molares and Freire, 2003; and Bald *et al*., 2006).

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