



Development and perspectives for community-based management of the goose barnacle (*Pollicipes pollicipes*) fisheries in Galicia (NW Spain)

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Abstract

The goose barnacle, *Pollicipes pollicipes*, is an intertidal cirripede that lives attached to rocks on very exposed shores, forming dense aggregations. It occurs in the northeast Atlantic (from 48 to 14°N). Commercial fisheries have been developed in several countries, but except for a short-lived local consumption, most of the production is traded in the Spanish market, where the price can reach ?80/kg in first-sale auctions. This species shows a strong spatial structure, constituting metapopulations with local adult populations sharing a common larval pool. Advection of larvae depends largely of oceanographic conditions that govern larval transport and survival. In Galicia (NW Spain), the regional government regulations promote a co-management system between fishers' organisations ("cofradías") and the fisheries authority through territorial user rights for fishing (TURFs). Since 1992, the exploitation is granted to "cofradías" after presentation of an annual plan of exploitation and management, where fishing (daily allocation of effort, maximum individual quotas and area of exploitation), surveillance and the commercialisation processes are established. The recent implementation of a geographic information system (GIS) designed for the management of *Pollicipes* in Galicia will allow for new ways to improve the elaboration and control of management plans by fishers' organisations using a combination of the available statistical data and computer-based methods. The system, including databases and software for the visualisation of geographic information, was designed for independent use in each "cofradía" or in a network, and its results are accessible in a web site (<http://sigremar.cesga.es>).

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1. Introduction

Goose (or gooseneck) barnacles are marine pedunculate cirripedes. They are found in all oceans of the world, but only three species are truly intertidal and all of them belong to the genus *Pollicipes*; *P. pollicipes* is distributed on the Atlantic coast of Europe and

North Africa, between 48°N (UK, France) and 15°N (Dakar, Senegal); *P. polymerus* on the north American west coast (from 64 to 27°N), and *P. elegans* on the west coast of South America (from Mexico to Peru) (Barnes, 1996).

The three species have a similar morphology, comprising a well-developed capitulum with calcified plates, which protects the soft parts of the animal, and a strong peduncle with a thick integument covered with small, calcified scales that contain the ovary (Barnes, 1996). The soft parts of several species of

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cirripedes have been a source of food for local inhabitants in different parts of the world, and the peduncle of all species of *Pollicipes* is much sought in areas where they are common (Bernard, 1988). A strong market demand for this resource, however, only exists in Spain and Portugal. Since 1970, after local stocks were severely depleted, the Spanish market demand was partly met through importation from France (Girard, 1982), Portugal, Morocco and even Canada (Bernard, 1988) and Peru (Kameya and Zeballos, 1988).

In Galicia, an autonomous region in NW Spain, fishery authorities reacted initially to over-exploitation concerns with temporal closures (from May to September, both inclusive) (Goldberg, 1984). In 1992, a co-management system was initiated using territorial user rights for fishing (TURFs), where responsibility for the exploitation of goose barnacle was shared between fishers' guilds ("cofradías de pescadores"; fishers' organisations supervised by the regional government) and fishery authorities. This change opened new opportunities for innovation and improvement in the management system following an adaptive process. The principal innovations were the increased management authority of the "cofradías", which had undergone organisational changes, and the introduction of information technology. This process is described in the present paper, after reviewing, in short, some aspects of the goose barnacle biology and fishing.

2. Biological knowledge of exploited goose barnacle stocks

Little attention was devoted in the past to the biology of *Pollicipes pollicipes*. This lack of knowledge was partially solved in the last decade by De la Hoz and García (1993), who studied the ecology and reproduction of the species in the north of Spain; Cruz (1993, 2000) and Cruz and Hawkins (1998), who worked on the distribution, reproduction, embryonic development, recruitment and growth in southwest Portugal; Molaes (1994, 1998) and Molaes et al. (1994a,b), who analysed the life history and exploitation of this species in Galicia and described gametogenesis and larval development; Cardoso and Yule (1995), who investigated the reproductive biology in

southwest Portugal; Kugele and Yule (1996), who studied larval morphology and settlement. There has not been an attempt, however, to gain an in-depth understanding of the processes that regulate the population dynamics of this species such as mortality, the stock-recruitment relationship, larval transport and survival (although at present, some efforts are being made in this direction).

It is accepted that this species has a metapopulation structure, with adult local populations sharing a common larval pool, and that the stock-recruitment relationship is rarely evident in this kind of resource at the subpopulation scale (Freire and García-Allut, 2000). Another important factor is that advection of larvae is probably largely dependent on oceanographic conditions (unpublished data). With a structured population of this type, a significant effort is required to assess all local populations in order to manage the resource. Additionally, *P. pollicipes* lives firmly attached to rocks and to one another, forming dense aggregations in highly exposed shores where waves break with extreme violence. This restricts the capacity to work in certain areas and to collect the necessary data for direct assessment of populations. Two different direct assessment methods have been proposed (Girard, 1982; Molaes, 1998), but they are only workable on shores with a low slope and in relatively calm conditions. Alternative methods based on the use of catch statistics and fishers' behaviour would enable retrospective or real-time stock assessments and thereby avoid the considerable finance and time needed for direct assessment of stocks (Freire and García-Allut, 2000).

3. Harvesting techniques and fishers behaviour in Galicia

The harvesting technique for goose barnacles is simple but very risky. During low tide, fishers separate animals from the rock surface with a scraper (Pérez, 1996). Frequently, a fisher is held with a rope by another fisher in order to gain access to the most difficult sites. Prior to the start of harvesting, fishers make a visual inspection of the ground to detect aggregations composed mainly of commercial-sized barnacles (total length >4 cm). Once the individual daily quota is attained (between 3 and 10 kg per fisher), they start an

in situ selection of the catch, breaking aggregations to remove undersized goose barnacles and other organisms. By-catch is an important part of the harvest, peaking (approximately 50% of the biomass) in bad weather conditions.

4. Management systems for goose barnacle fisheries in Galicia

Since 1992, goose barnacle exploitation in Galicia has been managed by a community-based co-operative system. From 1992 to the present, access to natural grounds of this resource has only been granted to licensed fishers belonging to “cofradías” that develop an annual plan of exploitation. There are 63 “cofradías” located in the coastal villages and cities of Galicia,

but only 30 have harvestable goose barnacle stocks in their territory (Fig. 1). Size of territory, organisational level and capacity for effective management of marine resources by these institutions are very variable. Some of the “cofradías” have their own surveillance service, which effectively enforces individual harvesting limits. They collaborate with the government fishery inspection service to avoid intrusions of illegal fishers. Furthermore, they have the capacity to commercialise the catch, because they generally manage the first-sale markets. In recent years, some of the organisations have improved their capacity, attaining external technical support to design and implement exploitation plans (with financial and/or human resources provided in part by the autonomous government, in response to the level of management success shown). In “cofradías” with scarce financial and human resources, however,

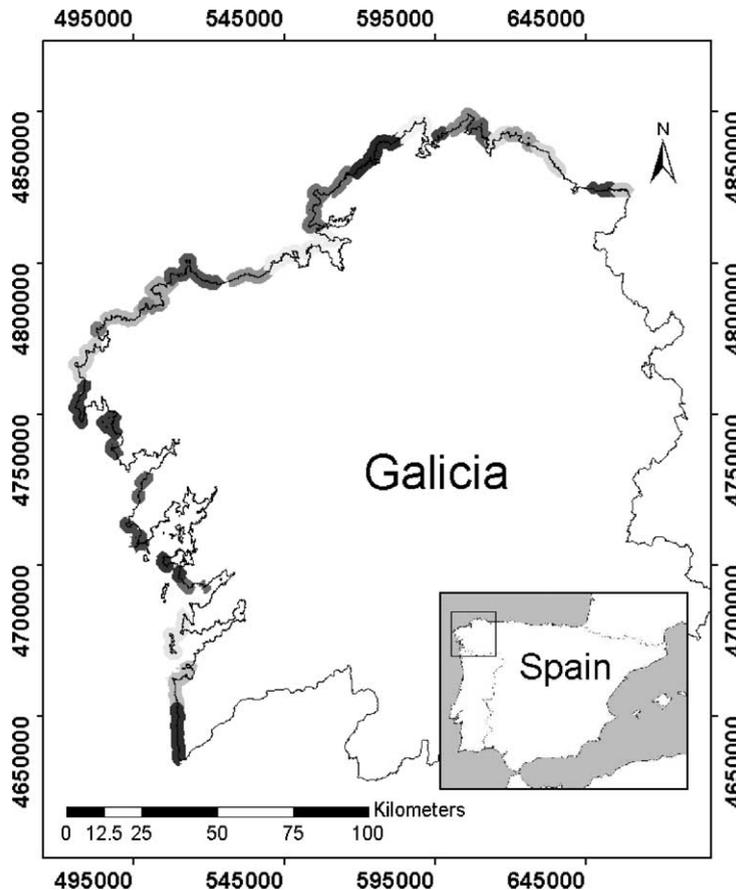


Fig. 1. Map of Galicia (NW Spain) showing the territory of “cofradías” with exploitation plans for goose barnacle in 2001 (the coastline is coded with different shades representing the different territories).

the plans have to be designed and elaborated by only one (or a few) person(s), restricting considerably their value as an actual management tool.

This annual plan of exploitation defines the different components of the management system: number of authorised fishers, grounds where fishing is allowed, economic and production objectives, stock assessments, number of working days, individual quotas per day, sites designated to control catches and to market the production, and a financial programme including expected total yearly incomes and expenses. In 2000, the generic model of the exploitation plans was modified to add the nominal relations (a list with the names and identification number of every person with a license to fish in a specific ground) of fishers and crews included in the plan, a detailed map of the grounds exploited and information about the daily effort and production in the last year (Table 1). Plans

are designed by “cofradías” so that they fulfil the requirements of the generic official state model and are evaluated by fishery biologists of the public administration. Early every year, the regional government publishes a General Plan of Exploitation for that year where all plans presented by “cofradías” and evaluated positively are included. Despite large improvements in the management system of this resource in Galicia, resulting in a continuous increase in production during the last decade, important problems remain unsolved.

Brown (2001) identifies a series of key factors for the performance of community-based fisheries management. A comparative analysis of the evolution and performance of management systems for goose barnacle implemented by different fishers’ organisations along the coast of Galicia have corroborated the importance of these organisational and socio-economic factors:

Table 1

Information necessary for fishers’ guilds (“cofradías”) to fulfil the requirements of the official general state model for exploitation plans of goose barnacle stocks in Galicia

General data

Number and nominal list of fishers
 Number of boats and nominal relation of crews
 Harvest grounds (detailed map)

General objectives

Production objectives (year total catch)
 Economic objectives (total and per capita yearly incomes)

Stock assessments

Methods used and results obtained

Implementation of methods to control the exploitation

Daily effort (surveillance methods)
 Daily production (catch recording and inspection at specific points close to fishing grounds and first-sale markets)

Harvesting and trade plans

Foreseeable calendar
 Total number of fishing days
 Maximum individual daily quotas
 Gears used
 Market system: first-sale places, minimum prices

Actions for stock enhancement

Description
 Costs

Financial plan

Incomes
 Expenses
 Inversions
 Capitalisation

- parties have clear motives compatible with public interest, and agree on the problem/situation/context that has to be addressed;
- respective agendas are compatible, well defined and openly acknowledged;
- participants in the fishery are organised, ready to participate and speak in a united voice;
- appropriate representative organisations and necessary infrastructures are in place;
- the community of eligible users is clearly defined;
- there are clear geographic or other boundaries to the resource system over which the users have control and the community of users is able to exclude outsiders;
- the community involved is highly dependent on the resource and is vulnerable to a non-sustainable use;
- the resource users are relatively immobile: if the resource is overused or the resource system is damaged, the users cannot easily move to another location or another livelihood;
- users are able to enforce management rules both against each other and against outsiders;
- although users may not be homogeneous in a cultural sense, they share relatively homogeneous interests in the resource;
- users invest their own resources in activities such as enhancement and enforcement: the cost of management and mismanagement are borne by those who benefit directly from the resource.

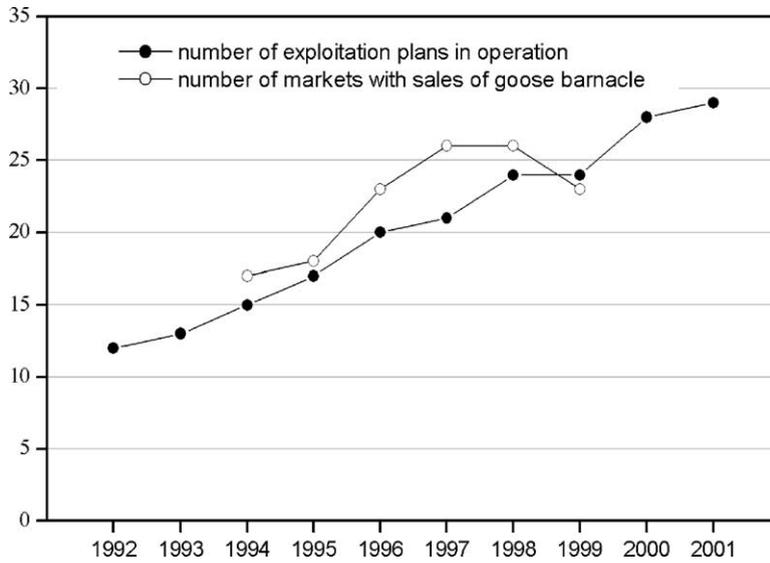


Fig. 2. Evolution of the number of exploitation plans in operation for the goose barnacle and of first-sale markets with goose barnacle trade in Galicia since 1992.

Most of these factors are present in some “cofradías” and the number of them reaching a minimum level of organisation that enables them to present exploitation plans for goose barnacle is increasing every year (Fig. 2). At present, practically

all natural grounds available are included in plans of exploitation accepted by the fisheries authorities. Apparently, the performance of the fisheries managed by the community using the plans is generally positive, because production (both in biomass and in economic

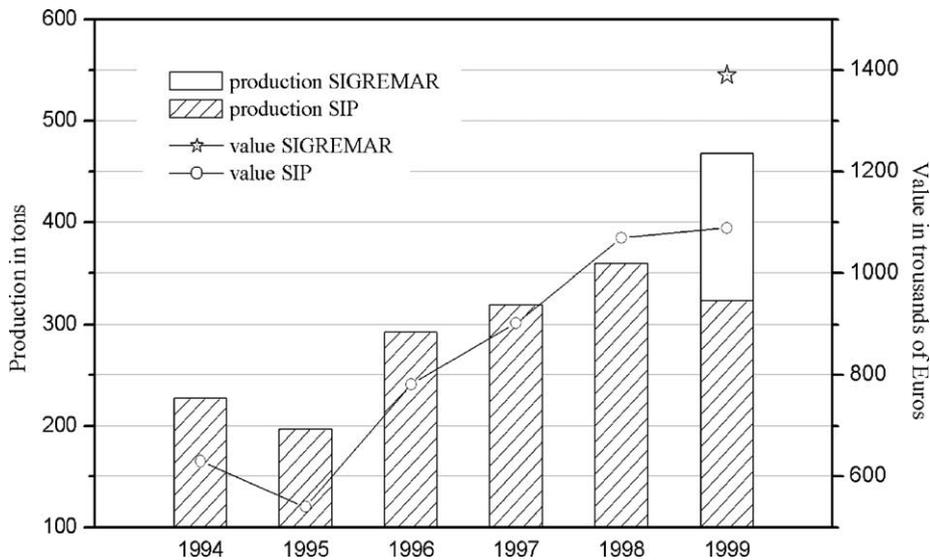


Fig. 3. Results of exploitation plans for goose barnacle in Galicia comparing the statistics provided by the fisheries information service of the autonomous government (1994–1999) and the project SIGREMAR (1999).

value) has shown an increasing trend from 1995 onwards (Fig. 3), although during this period cases of over-exploitation of some specific grounds have been recorded.

5. Introduction of information technologies for the management of goose barnacle fisheries (SIGREMAR)

The allocation of the correct level of fishing is crucial to the success of the management plan in each goose barnacle fishing ground. Due to the problems inherent in the methods of direct stock assessment of this species outlined previously, the fishery statistical data are enormously important in enabling indirect assessments. Obviously, this information can only be used if it is unbiased, complete, updated and disaggregated in time and space. The autonomous Galician government has a fisheries information service in charge of official statistics (“Servicio de Información Pesquera”, SIP), but, until now, this service has not been providing the level of quality and detail in the information needed for effective management of this species. “Cofradías”, however, have the complete, original information resulting from the first-sale markets and important complementary data, such as actual catch and effort recorded at control points close to fishing grounds (daily and in every ground) or size frequency distributions of the catch. This information is not available at the SIP, but it is essential for a successful design and implementation of the exploitation plans.

Although “cofradías” have potential access to the relevant information, their personnel do not have the time or the knowledge necessary to manage and analyse it. These problems were the origin of the project SIGREMAR (“Sistema de Información Geográfica para Recursos Marinos”). The main aim of the project was to develop a geographic information system (GIS) and related software applications (initially implemented in Microsoft Access) to help with the design and implementation of exploitation plans by each user (“cofradía”) or to be used in a network including information from all goose barnacle plans of Galicia by the fisheries administration. The GIS is available for use on the Internet (<http://sigremar.cesga.es>), and the web application has been programmed in HTML,

using JAVA for graphs and ArcView and Map Objects Internet Map Server of ESRI for the presentation of maps. The software allows the user to run numerous routines that produce reports and graphical results. Some of the more useful outputs are:

- printing of official documents requested by the fishery authorities, such as the official model of the plan and the request to open areas to fishing;
- statistical and graphical analyses of daily effort and catch;
- statistical and graphical analyses of data from direct assessments of natural populations;
- statistical and graphical analyses of size frequency distributions from sampling carried out at control points before first sale;
- comparative analyses of plans (of different years or “cofradías”);
- analyses of the rotation system, grouping data from different fishing grounds;
- environmental data (especially tidal height and timing) needed to decide on working times and locations.

In 2001, three workshops were organised with personnel from “cofradías” and government involved in the management of *Pollicipes*, to (a) learn the use of the software and web application of the project, and (b) discuss the methods for assessment and management of goose barnacle populations. After the workshops, the application was distributed to the participants free of charge.

At present, the system has information from all of the Galician exploitation plans for goose barnacle since 1992, although daily fishing catch and effort data are available only since mid 1998 for some “cofradías”. Before that time, catch was aggregated by year and fishing effort was not recorded. Direct stock assessments and sampling of size frequency distributions are now being implemented in Galicia, and the system will allow their analysis.

It is not the objective of the present paper to analyse the results of the application of the SIGREMAR system, but as a simple example, an important difference between the values of catch corresponding to the official statistical service SIP and the values obtained from the SIGREMAR databases (reported by the fishers’ organisations) has been noted. In 1999, SIGREMAR data showed that the biomass and economic value of

catch was actually 42 and 28% higher, respectively, than the official statistics indicated (Fig. 3). These results are indicative of the well-known fact that a part of the harvest is marketed directly to distributors and consumers, and is not included in the auctions carried out in first-sale markets.

The web site of the project has been available from May 2001. The monthly number of visits to this page increased continuously and in September 2001 there were 540 visits with 1988 printings.

6. Future perspectives for goose barnacle management

The main organisational and social benefits of community-based co-operative management, as outlined by Brown (2001), have also been identified in the case of goose barnacle fisheries in Galicia. These are:

- co-operation among individual fishers and local fishing groups in planning the improvement or conservation of local fish stocks;
- commitment among local fishers to share both the costs and benefits of their efforts toward enhancement and conservation;
- conflict resolution among fishers; increased motivation to negotiate sharing of access, which is perceived as equitable;
- a more equitable negotiating relationship between local fishers and other marine resource users (i.e. harvesters of mussel seed);
- a higher degree of organisation and mutual commitment among fishers, so that they have a stronger bargaining position;
- a higher degree of trust between fishers and government and greater willingness on the part of government to allow a range of self-management responsibilities to be assumed by fishers, and to explore options for regulation which reduce inefficiencies for fishers.

These processes are giving spectacular results in some “cofradías” at the organisational, social and economic level, and it is important to note that fishers involved in the change are showing a high level of personal commitment. This change could not be taking place if the Galician government was not already

promoting co-management of some marine resources 9 years ago. Furthermore, current legislation provides rules that prevent conflict and support co-operation. This solves four particular issues that fishers cannot provide by themselves and that requires government involvement in enforcement (Scott, 2001):

- compulsory membership, a new fishery requirement; this prevents free riding and threats of defection;
- limited entry, an old requirement; this complements compulsory membership in preventing free riding;
- voting rules: the government makes these now for different institutions, and these rules would complement compulsory membership and safeguard minorities;
- fixed shares: the government already provides these in some fisheries; these make support of and participation in fisheries risk-free.

Galician laws directly include the three first principles. The fourth is included in the exploitation plans, because each “cofradía” exploits a territory with a different extension and abundance of resources. Besides, the number of fishers is different and in some cases is not related to the productivity of the territory. In the different Galician *cofradías*, the daily individual quota for goose barnacle ranges from 3 to 10 kg (after selection of the catch).

It is risky to manage a goose barnacle fishing ground using only information on catch provided by first-sale market records. In most “cofradías”, the catch and effort data are cross-validated with data coming from control points, located strategically close to fishing grounds, and recorded daily by the surveillance service of the “cofradías”. A control point is a crossroad or a geographic point where surveillance personnel weigh and control the whole catch of each fisher after harvesting, in order to avoid catches larger than the daily individual quota and the marketing of undersized individuals. In some cases, there are also technicians sampling monthly body size frequency distributions of catch. This information is valuable because it allows the detection of over-fishing as indicated by a rapid decrease in the mean body size (unpublished results). The fishing method is size selective to a large extent because fishers remove barnacles only from patches with a large proportion of large individuals, if this kind of patches are available (although, obviously, patches

include also small barnacles). In this sense, the mean body size of the catch reflects the abundance of the commercial population of a ground (if the catch is composed of large individuals, it means that the fishers have been able to be very selective because abundance was high and large barnacles were readily available).

Using the SIGREMAR system, the information is analysed in real-time, and managers of exploitation plans can limit fishing effort or change the active fishing grounds (in plans with a rotation system) immediately. This interactive, adaptive system of management could be sufficient and adequate to avoid over-fishing or to optimise profitability. The development of a more sophisticated management model would need unavailable historical time series of data. SIGREMAR could provide these in the future if the system remains in use. Some of the “cofradías” involved in goose barnacle fisheries in Galicia have been successfully using this computer tool to design and control exploitation plans during the year 2002. However, some other “cofradías” have urgent problems to solve (such as an increase in organisational and human resource levels, illegal fishing, excessive fishing effort and price collusion at auctions) before it would make sense to apply this new tool for management.

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