# CHARACTERISATION OF SHELLFISHING ON THE NORTH COAST OF GRAN CANARIA

**Master's Final Project**

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## ABSTRACT

Shellfishing has been practised in the Canary Islands since pre-Hispanic times. Currently, there are regulations that regulate it, both at professional and recreational level. However, there is no monitoring of the activity, especially of recreational shellfishing, which is why it is a data-poor fishery. In this work, a series of surveys were carried out among shellfish harvesters on the north coast of the island of Gran Canaria, with the aim of obtaining information on the state of these resources in order to improve the scarce knowledge of this fishery. It was found that the regulation is frequently not complied with in several of its sections and that it is likely that some of the stocks of the target species (limpets in particular) could be fully exploited. Control of the activity and other measures are necessary to avoid the collapse of these resources.



## KEY WORDS

*Shellfishing, limpet, octopus, intertidal, recreational.*


## INTRODUCTION

The aim of this Master's Final Project is to analyse shellfishing on the north coast of the island of Gran Canaria. According to the Royal Academy of the Spanish Language (R.A.E.), shellfishing is the action and effect of shellfishing, which is the activity of catching shellfish, a gastronomic and not a zoological term, which includes edible invertebrate marine animals or those that serve as bait. Therefore, shellfishing is the extraction of natural resources, generally live, from the aquatic environment, which is why it is included in the fishing sector.

It is an activity that has been practised since Palaeolithic times, both in the sea and in rivers and lakes (Shackleton and Van Andel, 1986; Waselkov, 1987). Shells and other remains of aquatic invertebrates demonstrate the human consumption of these organisms, whether by Australian aborigines (Catterall and Poiner, 1987), or by pre-Columbian settlers in Uruguay (Gascue *et al*., 2019), who also made ornamental, funerary and tool-like use of mollusc shells.

The Canary Islands have not been left out of these practices; shellfishing has existed since pre-Hispanic times, as a source of food, to make utensils, for ornamental, decorative or even religious purposes. After the Castilian conquest, these resources were used as food or as currency to exchange for other products (Batista, 2001). This has been a global phenomenon, especially in areas with a strong coastal character, such as Galicia, generating a subsistence activity (Frangoudes *et al.*, 2008).

In the Canary Islands, from the second half of the 20th century, with the population explosion, the pressure exerted on these resources increased in the same proportion (Falcón, 2012). This led to overexplotation, leading to the disappearance of the Majorero limpet (*Patella candei*), except in Fuerteventura and the Wild Islands (Nuñez *et al.*, 2003), and the near disappearance of the Canary mussel (*Perna perna*) (Espino *et al.*, 2006).

However, despite its age and the effects it can have on harvested species, there are hardly any studies on shellfishing (Noguera and Riera, 2011; Forner *et al.*, 2018). And this lack of knowledge is not exclusive to the Canary Islands: it is a global problem.

Why is shellfishing the most neglected of the activities that make up the fishing sector? It is not easy to give an explanation, although it is undoubtedly the sum of different factors. One possible cause is that society does not consider it as part of fishing. If one were to ask the general population, a large majority would say that fishing is an activity carried out by fishermen, a specialised sector (whether professional or recreational), which uses certain means for this purpose (boats, gear). However, they see the shellfish gatherer as a person (including children), who does not necessarily have to be a fisherman, and who catches "*small animals*" on the seashore without gear (or very basic gear), or as a marginal, subsistence activity (Kyle *et al.*, 1997).

Another "*burden*" imposed on shellfishing is that, within fisheries, the small scale of such resources and their lack of economic value often do not justify management research (Hartill et al., 2005). However, this argument is "*falsified*"

since, in many regions of the world, open access shellfishing generates a subsistence economy for part of the population (Kyle *et al.*, 1997; *Frangoudes et al.*, 2008). This unmanaged system (common in many fisheries around the world) implies the "*tragedy of the commons*", i.e. fishermen, who do not own the resource (commons), see it as an income and increase their effort to catch more and increase their income, which ends up causing the collapse of the fishery (Gómez-Lobo *et al.*, 2013).

On the other hand, the previous argument of "...*lack of economic value*...", is not applicable to the Canary Islands where, as will be explained later, there is explotation with the aim of selling them. Furthermore, the supposed lack of economic profitability of these resources should not be an excuse for not studying and knowing the state of their populations and, by extension, of the coastal ecosystem.

Currently, the number of professional fishermen with a licence for shellfishing on foot in the archipielago is known, but given the system established by the administration, it is impossible to know the exact number of recreational fishermen, since there is no exclusive licence for this activity. And although the regulations establish closed periods, quotas, days on which fishermen can fish, quantities per species, etc., there is no record of what each recreational fisherman catches. Therefore, without knowing the number of people who shellfish, as well as the quantities, frequencies and areas where they go, it is very difficult to establish the state of these resources and the repercussions that their extraction has on the coastline. In fact, it is considered by the administration as a complementary activity within the fishing sector.

It was not until the 1980s that the regulation of the activity in the archipielago began (*Royal Decree 2133/1986 of 19 September 1986* and *Decree 154/1986 of 9 October 1986*, repealed by *Law 17/2003 of 10 April 2003 on fishing in the Canary Islands*, amended on several occasions, as well as its regulations, contained in *Decree 182/2004*), and the legal framework regulating fishing, shellfishing and aquaculture was established. The *Order of 2 May 2011* (amended by the *Order of 18 May* of the same year), currently legislates

shellfishing in the Canary Islands. However, even so, the species subject to shellfishing have been exploited with little control and lack of monitoring, which does not allow it to accurately determine the state of their populations. It can therefore be considered a data-poor fishery (Pilling *et al.*, 2008).

Therefore, shellfishing in the Canary Islands is today a "*data-poor fishery*", which is why this paper has been prepared with the aim of providing some information that will allow progress to be made towards more appropriate management of this fishing activity.

## MATERIAL AND METHODS

### 1. Study area

The study of shellfish activity has been limited to the northern slope of the island of Gran Canaria, between Punta de Sardina, in the west, and La Isleta, in the east (Fig. 1). This coastal strip is dominated by low cliffs, but it also has abrasion platforms, as well as beaches of callaos. The low platform and the exposure to intense and long period swell storms (swell) make it difficult to find fine-grained beaches.


**Figure 1:** Zoning of shellfishing off the north coast of Gran Canaria according to the standard. In red, the coastline closed to this activity. Modification of the image obtained from the idecanary viewer.

## 2. Sources of data

Data collection for the characterisation of shellfish activity was based on surveys (in the sense of Silvano and Valbo-Jørgensen, 2008 and FAO, 2020) of different social groups associated with fishing, artisanal or recreational activity, research or management of the resources being exploited. This survey consisted of 52 questions, 40 of which were aimed at obtaining biological data, and the rest were established with the aim of gathering socio-economic information (see Annex). The aim of these surveys is also to value the knowledge that fishermen have of the coastline, which has historically been neglected when making decisions on fisheries management (Silvano and Valbo-Jørgensen, 2008; Pita *et al.*, 2020).

However, it is necessary to clarify that in social research it is common to work with qualitative variables and data through groups of individuals that are classified into two or more categories that are mutually exclusive. As already indicated by Howarth *et al.* (2021), for the Ontario fisheries sector, this method of assessment is gaining ground with increasing research demonstrating its validity (Forgasz *et al.*, 2018; Schneider and Harknett, 2019), but even so, and as indicated by Howarth *et al.* (2021), the scope of this type of survey is limited, often with little social participation, so we must consider our results as exploratory and preliminary and not make inferences from the results obtained to the entire population of the fisheries sector in the Canary Islands.

Productivity and Susceptibility Analysis (PSA) is a method for assessing the vulnerability of a fishery, species or stock using a set of established, measurable and scorable attributes. It analyzes both the productivity of the fishery species (determined by its life history) and the susceptibility to impacts from fishing. One mechanism used for this PSA analysis is an "Attribute Table" (such as Table 1 below), developed by the ORCS (Only Reliable Catch Stocks) Working Group (Free et al., 2017).

| Table 1: Example of PSA Analysis Attributes Table | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Attribute** | **Description** | **Under-exploited** | **Score (1)** | **Fully Exploited** | **Score (2)** | **Overexploited** | **Score (3)** |
| 1 | Stock status | <10% | | 10-25% | | >25% | |
| 2 | Shelters | >50% | | 50-75% | | >75% | |
| 3 | Behaviour | | | Non-gregarious | | Gregarious | |
| 4 | Vulnerability | Low | | Medium | | High | |
| 5 | Discards/By-Catch | <10% | | 10-25% | | >25% | |
| 6 | Target species | No | | Occasional | | Always | |
| 7 | Natural mortality | High | | Equivalent | | Low | |
| 8 | Occurrence | <10% | | 10-25% | | >25% | |
| 9 | Price | <3€ | | 3-10€ | | >10€ | |
| 10 | Trend catches | Increase | | Stable | | Decrease | |
| 11 | Habitat loss | No | | Partial | | Always | |
| 12 | Effort trend | Decrease | | Stable | | Increase | |
| 13 | Abundance | Increase | | Stable | | Decrease | |
| 14 | Protected population | Majority | | Part | | None | |

**Stock status:** **<1.5=Under-exploited** **1,5-2,5= Full Exploitation** **>2.5= Overexploited**

With the 14 attributes of this table, we obtain the average state of the fishing stock, which can be under-exploited (value <1.5), so it could support an increase in catches, fully exploited (values between 1.5 - 2.5), which could maintain the level of extraction, and over-exploited (value >2.5), which should reduce or even stop its exploitation. Using questions 18, 19, 20, 31, 32, 33, 34, 35 and 37 of the survey, attributes 6, 8, 13, 1, 2, 3, 4, 5 and 11 shown in the table above can be obtained respectively.

The survey of scientists and technicians from fisheries administrations was limited to only the 21 questions with a biological profile, in order to contrast the results of those who shellfish with scientific knowledge.

The results obtained were worked with Microsoft Office Excel software, which facilitates the handling of the information and allows for easy-to-interpret graphs and tables, as well as JAMOVI software, a statistical spreadsheet.

Data on the first sale of white and black limpets and the number of recreational fishing licences were obtained from the Directorate General for Fisheries of the Canary Islands Government

(*https://www.gobiernodecanarias.org/agp/sgt/temas/estadistica/pesca/index.html*). The fishermen's associations of Agaete and San Cristóbal provided the number of fishermen with professional licences.

### 3. Statistical Analysis

An analysis of the normality of the data series obtained from the surveys was carried out (applying the Kolmogorov-Smirnov test). The series of data obtained showed a non-normal distribution, so non-parametric tests were applied for their analysis, such as the contrast hypothesis test or Chi-Square test ($X^2$ - observed vs. expected).

## RESULTS

A total of 25 surveys were carried out, 6 to professional fishermen, 14 to recreational fishermen and 5 to technicians of the administrations. A large number of recreational fishermen did not wish to be interviewed. The following results were obtained from the surveys carried out:

### 1. Target species

Shellfish resources in the islands are made up of more than twenty species (Armas, 2017), grouped into crustaceans, molluscs, echinoderms and even some annelids, although most of the fishing effort is oriented towards a few species. These species develop along one or more of the three bands or strips into which the eulittoral or intertidal in the Canary Islands is divided (upper, middle, lower) according to Ramírez *et al*. (2008), depending on the different physiological and ecological requirements of each species.

**Figure 2:** White limpet (*Patella aspera*) on the left and black limpet (*P. crenata*) on the right.

The species most prized by shellfish gatherers are limpets. With the extinction of the sun limpet, there are currently three species in Gran Canaria: *Patella ulyssiponensis aspera*, white limpet (Fig. 2 left), *P. tenuis crenata*, black limpet (Fig. 2 right), and *P. piperata rustica*, curvaceous limpet (Fig. 3).

**Figure 3:** Curvaceous limpets (*Patella rustica*) next to a top-shell snail (*Osilinus atratus*) in the middle eulittoral fringe, with an abundance of sculpin (*Chthamalus stellatus*).

Other gastropods collected are the top-shell snail (Fig. 3), *Osilinus atratus*, the top-shell snail *O. sauciatus*, the *Littorina striatta*, called periwinkle or chirrimil, and the *Stramonita haemastoma*, also known as purple or red-mouthed rock-shell. Two other molluscs are the mussel *Perna perna*, and the octopus *Octopus vulgaris*.

The other zoological group is that of the decapod crustaceans, principally the sally lightfoot crab, *Grapsus adscensionis*, the talon crab *Plagusia depressa*, the nimble spray crab *Percnon gibbesi*, the three species of runner crab *Pachigrapsus* spp., and the jaguar round crab *Xantho* spp., of which three species are also known and which, as its name indicates, is used as bait for fishing for the parrotfish (*Sparisoma cretense*) (Espino *et al*., 2006, Noguera and Riera, 2011). Finally, among the echinoderms, there is one species that is targeted for shellfishing, mainly for bait, the common sea urchin *Paracentrotus lividus*.

100% of professional fishermen target limpets (black and white, Fig. 4), which are also the main target of recreational fishermen (Fig. 5). Interestingly,

technicians/scientists highlight octopus as one of the main target species for shellfishers (Fig. 6).

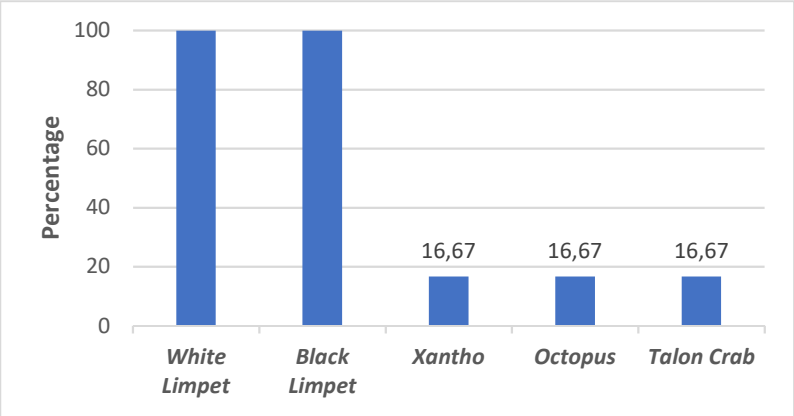


**Figure 4:** Target species professional sector. All interviewees catch both species of limpets.

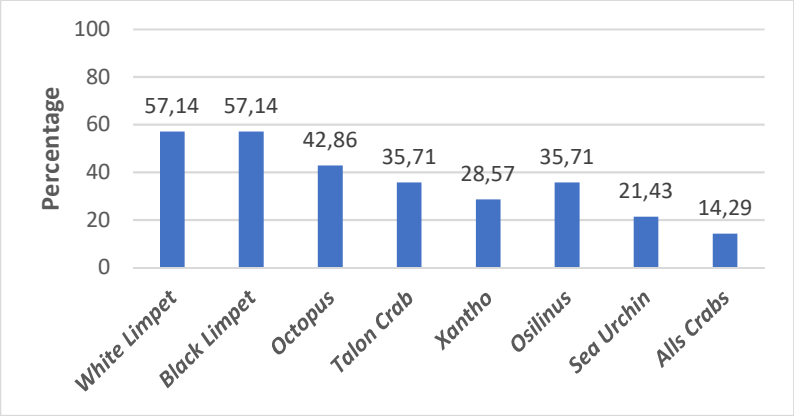


**Figure 5:** Target species for recreationalists.

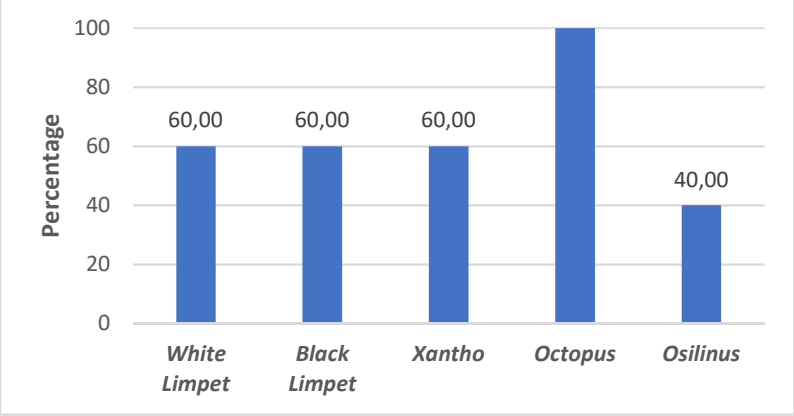


**Figure 6:** Target species for scientists.

Figures 7 and 8 show the evolution of the catches of white and black limpet in the first sale points located in Gran Canaria, as well as the economic profitability of this fishery. With the exception of the drop in 2011, the progressive increase in kilos landed can be seen, especially for white limpet, as well as the increase in price from around 3 €/kilo in 2007 to just over 5 €/kilo in 2019 (with a peak of 10 €/kilo in 2018 for white limpet). With some years without data, Agaete and San Cristóbal always landed white limpet (Fig. 9) and black limpet (San Cristóbal only from 2017 for the latter) (Fig. 10). This would explain why limpets are a target species for the professional sector.

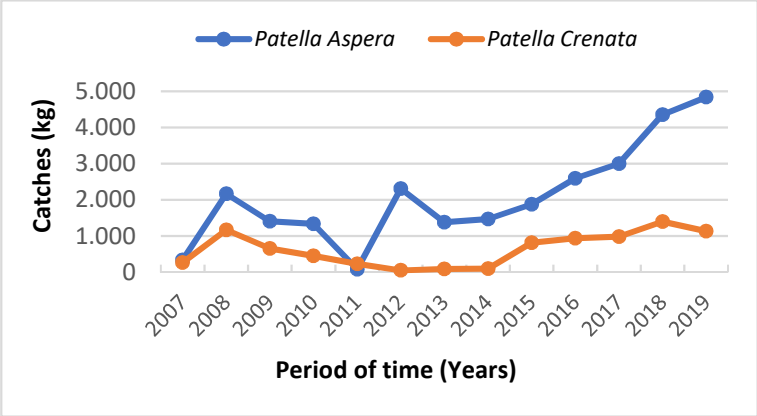


**Figure 7:** Total catch of white limpet (blue) and black limpet (orange) recorded at the first sale points on the island of Gran Canaria (Source: Government of the Canary Islands).

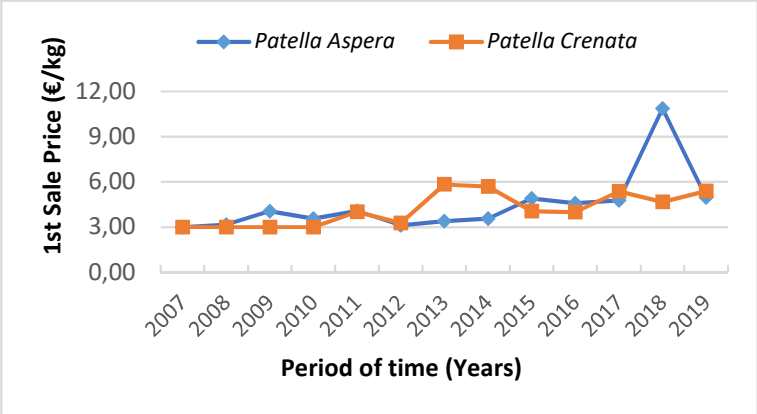


**Figure 8:** Price (€/kg) white limpet (blue) and black limpet (orange) 1st Sale - G. Canaria. (Source: Government of the Canary Islands).

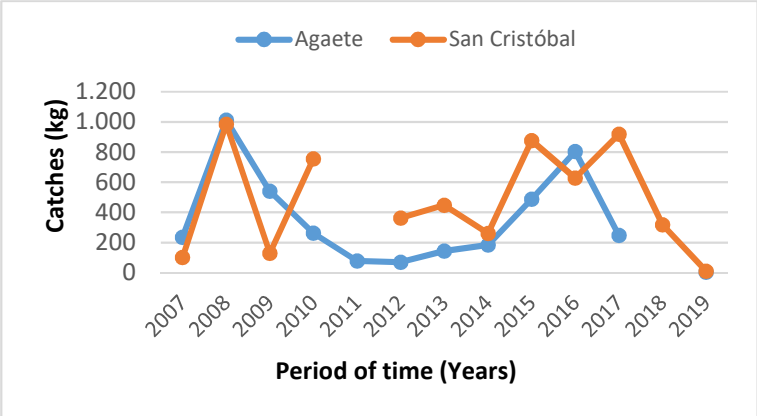


**Figure 9:** Catch (kg) of white limpet recorded at the first sale points of the Agaete (blue) and San Cristóbal (orange) docks (Source: Government of the Canary Islands).

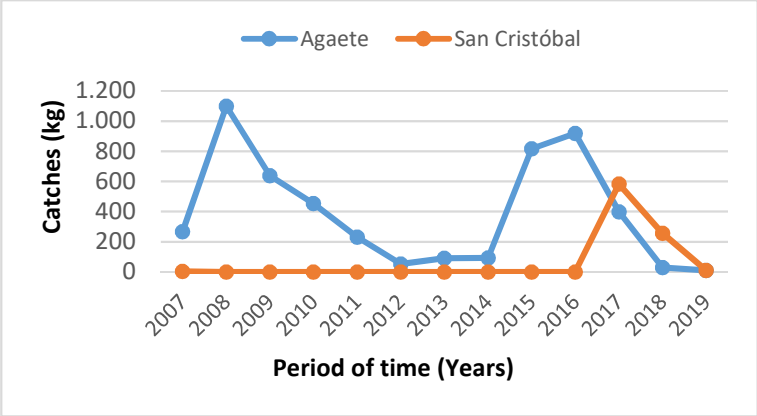


**Figure 10:** Catch (kg) of black limpet recorded at the first sale points of the Agaete (blue) and San Cristóbal (orange) docks (Source: Government of the Canary Islands).

The month of maximum catch for both limpets is variable according to the professionals, while the summer period dominates for recreationalists (67%), which is evidence of seasonality in the fishery. Sixty-two percent of recreational fishermen indicate that there is seasonal variation in the production of white limpets and 50% also indicate seasonal variation for black limpets. There are no significant differences or inconsistencies between the sets of responses given on the seasonality of the fishery and the month(s) of maximum catch for both limpet species (white limpet $\chi 2 = 2.31$, $p=0.315$; black limpet $\chi 2 = 2.10$, $p=0.350$).

Of the intertidal bands, 66.7% of the professionals and 55.6% of the recreational fishermen fish in the lower band, as they consider, in agreement with the

scientists, that as they approach the tidal limit, the size of the specimens and the abundance increase. The contrasting hypothesis seems to confirm this relationship in the case of white limpets ($\chi 2 = 2.49$, $p=0.249$), but not in the case of black limpets ($\chi 2 = 7.14$, $p=0.028$). However, although 83.3% of recreational fishermen who catch octopus do so in the lower intertidal zone, the same percentage say that the size of octopus is constant throughout the intertidal zone and 67% consider that its abundance does not vary across the width of the intertidal zone either.

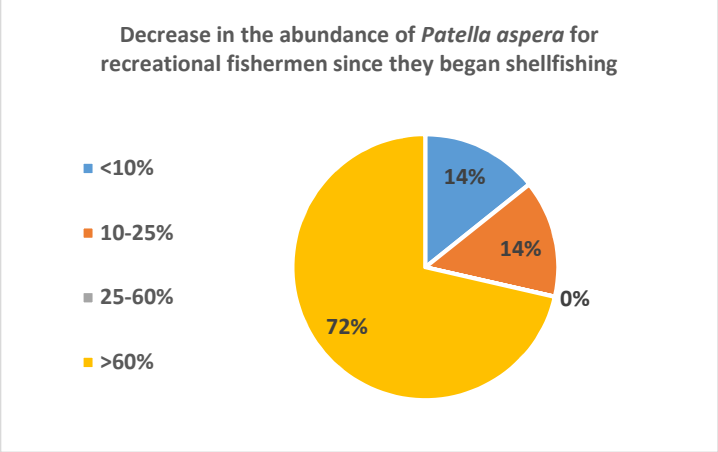


**Figure 11:** Percentage decline in white limpet abundance on the north coast of Gran Canaria for recreational fishermen according to years since they started shellfishing.

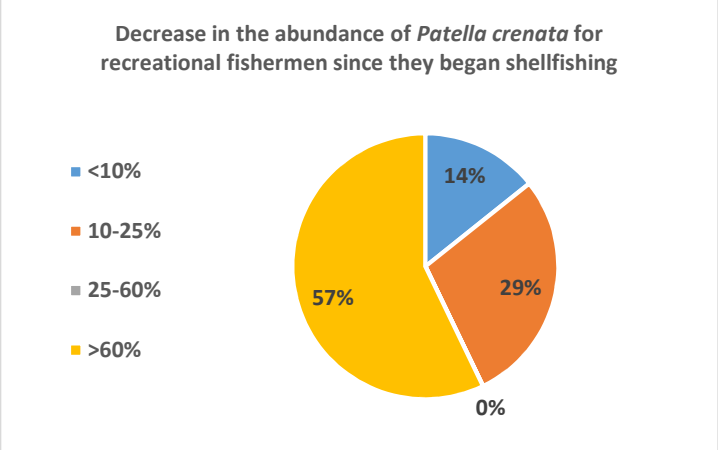


**Figure 12:** Percentage decline in abundance of black limpet on the north coast of Gran Canaria for recreational fishermen by years since they started shellfishing.

A high proportion of recreational fishermen estimate that white and black limpets have declined in abundance by more than 60% from the year they started fishing (72-57% respectively; Figs. 11 and 12), a less widespread feeling among professionals (10-25% decline). Significantly ($\chi 2 = 5.0$, $p=0.025$), older fishermen who started fishing in the 1970s-1980s indicate a greater decline in abundance than those who started fishing in the 2000s or later. The scientific sector is unanimous in the idea that the populations of both limpets have declined, but the lack of data is the reason why not everyone dares to give a percentage of decline. In the case of the octopus, 40% of recreationalists consider that its stock has fallen by between 10-25%, although scientists again allude to the lack of information to give a percentage, and those who do, see a fall of no more than 25%, citing its great capacity for recovery.

## 2. Level of fishing effort

There are 2 types of licence that allow recreational shellfishing (article 50.3 *Decree 182/2004*) with a validity of 3 years. As shown in Figure 13, according to the data provided by the Directorate General of Fisheries through its website, the average number of licensed recreational fishermen between 2010 and 2020 on the island of Gran Canaria was 31,174 people.

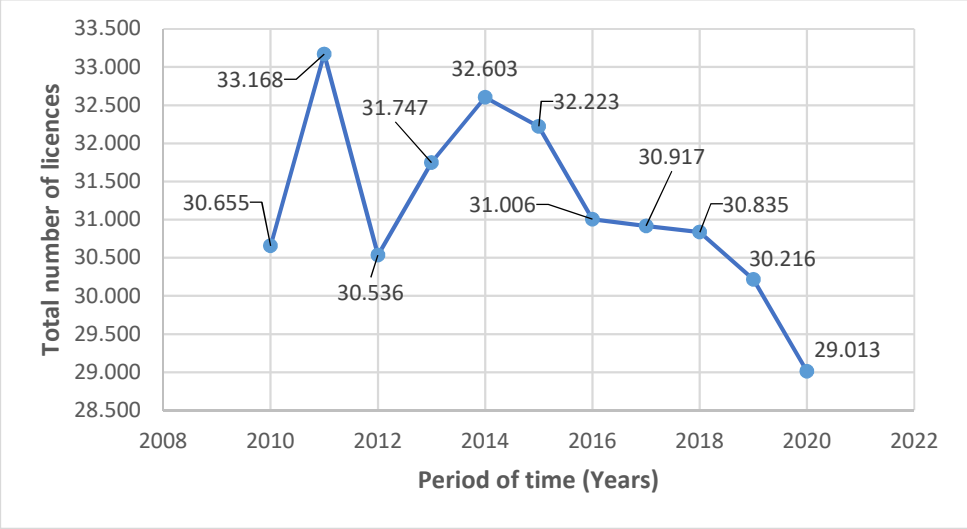


**Figure 13:** Evolution of the number of recreational fishing licences in force allowing shellfishing in Gran Canaria between 2010-2020. (Source: Government of the Canary Islands).

To the above it should be added that there is an undetermined number of people who, without any type of licence, practice the activity, but that could be around 10% of the total according to Jiménez-Alvarado (2016), exceeding the national average for the entire recreational sector that Gordoa *et al*. (2019) estimate at around 5%. One respondent claimed not to currently hold any of the permits (7.1%).

Only 26 professionals shellfish on the north coast, 5 associated with the Agaete fishermen's association (from 6 to 7 between 2008 and 2020) and 21 with the San Cristóbal fishermen's cooperative (Pescatobal) (increasing its average of 5 fishermen between 2012 and 2017). Of these, 6 (2 from Agaete and 4 from San Cristóbal) responded to the interview, representing 23.1% of the total number of licensed professional shellfishermen on foot in 2021 that go to the coastline of the study area.


**Figure 14:** North Coastal Division for the survey in relation to shellfish zoning. Modification of the image obtained from the idecanary viewer.

The coast was divided into four shellfishing zones (Fig. 14): GC/N1, between Sardina and Guanarteme points, where shellfishing is prohibited. 14): GC/N1, between the points of Sardina and Guanarteme, where shellfishing is prohibited; GC/N2, between Punta de Guanarteme and San Felipe, where it is permitted, but a large part is not very accessible due to the presence of cliffs; GC/N3, between San Felipe and El Puertillo, where the activity is permitted and the coast is very accessible; GC/N4, between El Puertillo and Roque Ceniciento, where shellfishing is not permitted for the most part. Of these, the greatest fishing effort is made in GC/N3 (83.3% professional; 85.7% recreational), although 71.4% of

recreational fishermen also visit GC/N2. It is worth noting that 42.7% of recreational fishermen go to GC/N1 and another 35.7% to GC/N4, even though these are areas where shellfishing is prohibited. One professional fisherman (16.7%) also shellfishes on the coast of La Isleta where shellfishing is prohibited.

## 3. PSA analysis

According to the values obtained, the limpet stocks can be considered fully exploited, with a value of 2.36 (Table 2, carried out jointly for both species of limpets). Octopus is also in a similar situation, with an index of 2.07 (Table 3). However, the values obtained are very close to the upper limit of the interval, particularly in the case of limpets, which indicates that they are at high risk of overexploitation. Attributes 1, 2, 3, 4, 5, 6, 8, 11 and 13 were obtained from the results of the survey, while the remaining attributes come from different sources of the Government of the Canary Islands (9 price of 1st sale, 10 catches of 1st sale, 12 number of licenses and 14 from the Idecanarias viewer). Natural mortality (attribute 7) is assumed low in limpets, as it is estimated to be around 0.5 yr-1 for similar species (Sousa *et al.*, 2017; Henriques *et al.*, 2012), while it is high in octopus, as it does not exceed two years of longevity (Grant *et al.*, 1981).

**Table 2: Attributes of the PSA analysis for both limpet species (*Patella aspera* and *P. crenata*)**

| Attribute | Description | Under-exploited | Score (1) | Fully Exploited | Score (2) | Overexploited | Score (3) |
|---|---|---|---|---|---|---|---|
| 1 | Stock status | <10% | | 10-25% | | >25% | **3** |
| 2 | Shelters | >50% | | 50-75% | | >75% | **3** |
| 3 | Behaviour | | | Non-gregarious | | Gregarious | **3** |
| 4 | Vulnerability | Low | | Medium | | High | **3** |
| 5 | Discards/By-Catch | <10% | **1** | 10-25% | | >25% | |
| 6 | Target species | No | | Occasional | | Always | **3** |
| 7 | Natural mortality | High | | Equivalent | | Low | **3** |
| 8 | Occurrence | <10% | | 10-25% | | >25% | **3** |
| 9 | Price | <3€ | | 3-10€ | **2** | >10€ | |
| 10 | Trend catches | Increase | **1** | Stable | | Decrease | |
| 11 | Habitat loss | No | | Partial | **2** | Always | |
| 12 | Effort trend | Decrease | | Stable | **2** | Increase | |
| 13 | Abundance | Increase | | Stable | **2** | Decrease | |
| 14 | Protected population | Majority | | Part | **2** | None | |
| | **Average stock status:** | | **2,36** | | **Fully exploited** | | |

| Table 3: Attributes of the PSA analysis for octopus (*Octopus vulgaris*) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Attribute** | **Description** | **Under-exploited** | **Score (1)** | **Fully Exploited** | **Score (2)** | **Overexploited** | **Score (3)** |
| 1 | Stock status | <10% | | 10-25% | | >25% | **3** |
| 2 | Shelters | >50% | | 50-75% | **2** | >75% | |
| 3 | Behaviour | | | Non-gregarious | **2** | Gregarious | |
| 4 | Vulnerability | Low | | Medium | **2** | High | |
| 5 | Discards/By-Catch | <10% | **1** | 10-25% | | >25% | |
| 6 | Target species | No | | Occasional | | Always | **3** |
| 7 | Natural mortality | High | **1** | Equivalent | | Low | |
| 8 | Occurrence | <10% | | 10-25% | | >25% | **3** |
| 9 | Price | <3€ | | 3-10€ | **2** | >10€ | |
| 10 | Trend catches | Increase | | Stable | **2** | Decrease | |
| 11 | Habitat loss | No | | Partial | **2** | Always | |
| 12 | Effort trend | Decrease | | Stable | **2** | Increase | |
| 13 | Abundance | Increase | | Stable | **2** | Decrease | |
| 14 | Protected population | Majority | | Part | **2** | None | |
| | **Average stock status:** | | **2,07** | | **Fully exploited** | | |

## 4. Estimation of catches and catch per unit of effort

Catch per unit effort (CPUE) reported by recreational fishermen is relatively low, although several respondents reported frequently catching amounts above the legal limits in both the professional and recreational sectors. Table 3 shows the estimated values of catch (in kg), fishing effort (in fishing hours) and CPUE (kg/hour) in the professional and recreational shellfish fisheries.

| Table 3: Catches per Unit of Effort | | | |
|---|---|---|---|
| | **Quantity (Kg)** | **Time (hours)** | **CPUE (Kg/h)** |
| Professionals: | 10 | 2 | 5 |
| Recreational (they don't go to crabs): | 3 | 2,5 | 1,2 |
| Recreational (go to crabs): | 0,5 | 1,5 | 0,33 |

Only 10% of the respondents indicated that sometimes they did not catch anything, while the majority of them always caught something on every fishing trip. 67% of the artisanal fishermen do this activity between 5 and 8 times a month, while 71.4% of the recreational fishermen do it 1 to 2 times in the same

interval, mostly (67% and 79% respectively), both on shallows or intertidal platforms and on calm beaches. On the other hand, discarding is also low or almost nil, due to the high selection capacity of these fishermen, both for the species and the size of the specimens.

## 5. Catch trends

A significant proportion of both professional and recreational fishermen indicate that catches have declined somewhat, which they attribute mainly to increased pressure from recreational shellfish harvesters (83.3% and 78.6%, respectively) (Figs. 15 and 16). They also identify pollution of coastal areas as a relevant cause for the loss of productivity, although this is an argument used by only half of the recreational and only 16.7% of the artisanal ones (Figs. 15 and 16). In this context, and only scientists associate the loss of productivity of shellfishing areas mainly to excessive fishing pressure and, secondly, to the loss of habitats.

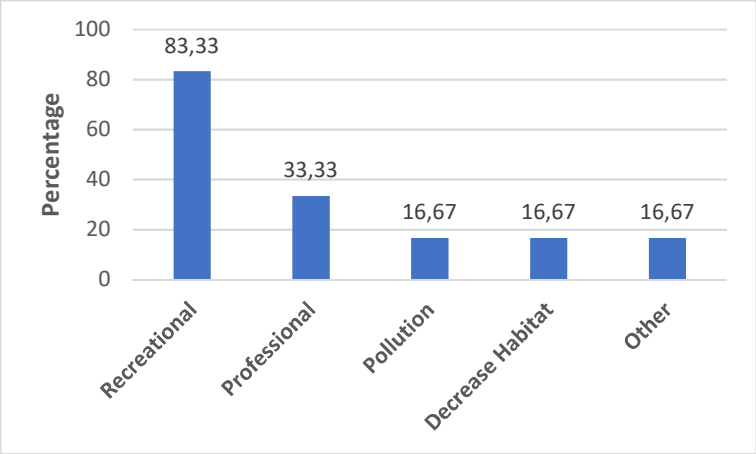


**Figure 15:** Factors argued by professional shellfish gatherers for the decrease in their catches on the north coast of Gran Canaria.

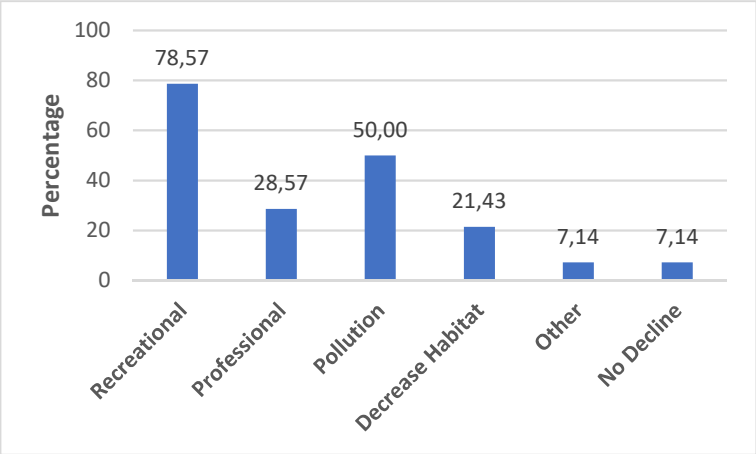


**Figure 16:** Factors argued by recreational shellfish gatherers for the decrease in their catches on the north coast of Gran Canaria.

## 6. Socio-economic data

Almost all professional fishermen (except one) started fishing after 2000, while among recreational fishermen, the oldest started in 1958 and the most recent in 2013. All artisanal fishermen were men, while among recreational fishermen, there were at least 2 women (14.3%) who responded to the survey.

The initial investment in equipment to carry out this type of fishery is very low, with 67% of professionals and 69% of recreational fishermen indicating that this investment was zero euros. Similarly, the average annual expenditure does not exceed 60 € in the case of artisanal fishermen, being even lower among recreational fishermen. Thus, the expenditure per trip for both sectors is much lower than 10 €, mostly on fuel because they frequently visit different shellfishing areas. In this sense, it is noteworthy that 14% of recreational fishermen travel on foot to the shellfishing areas.

## 7. Management proposals

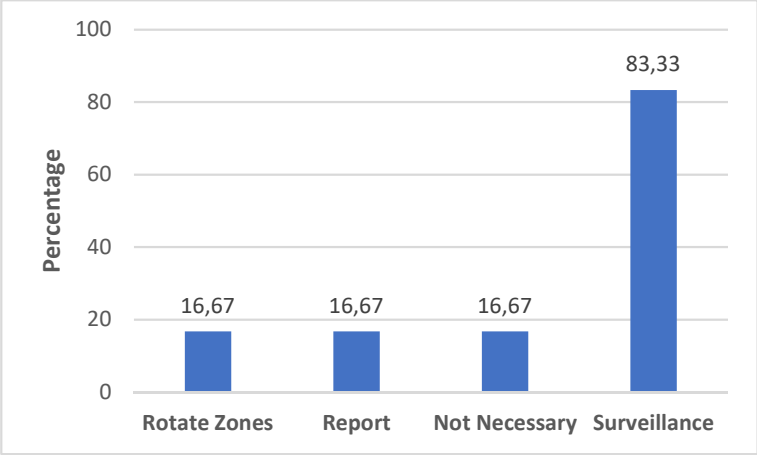


**Figure 17:** Management measures for the recovery of target species stocks proposed by professional fishermen for the north coast of Gran Canaria.

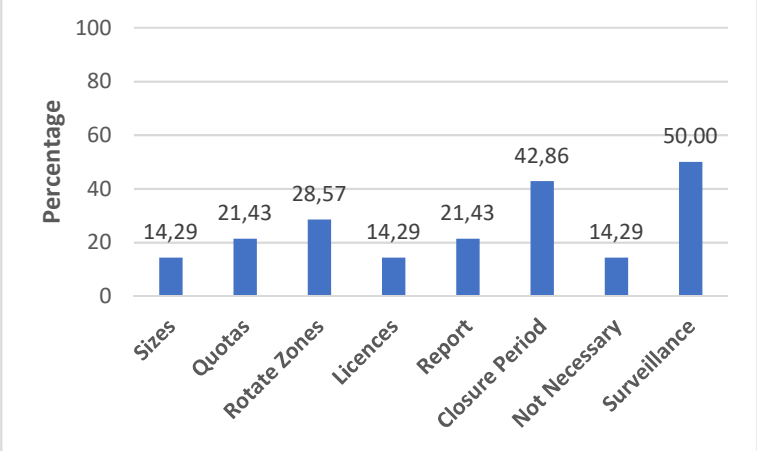


**Figure 18:** Management measures for the recovery of stocks of target species proposed by recreational fishermen for the north coast of Gran Canaria.

A very high percentage (83.3%) of the professional fishermen suggest that greater vigilance would be the first measure to avoid overfishing, a measure that only 50% of the recreational fishermen support. Also, a significant proportion of recreational fishermen (more than 40%) consider that it would be appropriate to extend the closed period established in the current regulations, especially for crab species, as well as to rotate the areas where shellfishing is allowed in order to avoid overexplotation of these species (almost 30%). Moreover, 21.4% of them

believe that it is appropriate to provide training/awareness-raising courses prior to the granting of recreational fishing permits, an aspect on which the majority (60%) of the technicians consulted agree. The latter (60%) also consider the implementation of a timetable control of the activity to be appropriate, especially avoiding night fishing because the vulnerability of the species is greater.

Finally, and in relation to the impact on the biotope, and consequently on other sessile organisms, only 14.3% of recreational fishermen put the stones back after moving them to catch crustaceans, while half of them never do so. Artisanal fishermen do not do this because they do not fish for crabs, only for limpets.

## DISCUSSION

Although fishermen's knowledge of the marine ecosystem has generally been underestimated, the trend is to change this approach, as shown by many studies carried out in different parts of the world (Silvano and Valbo-Jørgensen, 2008; Pita *et al.*, 2020), where information provided by recreational fishermen has been considered to assess the state of marine ecosystems (Orensanz *et al.*, 2014; Rosa *et al.*, 2014; Tesfamichael *et al.*, 2014). The main problem inherent to this type of work is the low participation and, consequently, the limited representativeness of the results (Howarth *et al.*, 2021), and we must therefore be cautious with the results obtained in this study and consider them as preliminary.

Unlike in other areas where shellfishing is mainly carried out on fine aggregate beaches (Taylor, 2013; García-García *et al.*, 2015; Gray, 2016), on the north coast of Gran Canaria, both professionals and recreational fishermen collect mainly on beaches of callaos and abrasion platforms, as the resources in the Canary Islands are typical of hard substrates or boulder beaches (Espino *et al.*, 2006; Ramírez *et al.*, 2008). Among the target species, the white limpet (*Patella ulyssiponensis aspera*) and the black limpet (*P. tenuis crenata*) stand out, whose economic profitability has increased in the last decade, according to the data reported by the fishermen's associations. 100% of professional fishermen who shellfish on foot are dedicated almost exclusively to catching these species, to

which we must also add the pressure exerted by a large number of recreational fishermen.

The relatively low catch yields of limpets reported by recreational fishermen, with CPUEs of 1.2 kg/hour (catching the maximum allowed 3 kg in 2.5 hours), but which many confirm they frequently exceed, despite the established limitation, highlights the high extraction pressure on these species, which can lead to their collapse, as has occurred with Patella candei on several islands (Nuñez *et al*., 2003; Espino *et al*., 2006). A clear indicator of the state of these populations is that fishermen indicate that both species of limpets, but mainly the white one, increase in abundance and size towards the lower part of the intertidal (lower eulittoral) and subtidal.

To this "*regulated*" pressure must be added a poaching rate that appears to be high, not only because more than 7% of fishermen fish without a licence, but also because of the demand covered by illegal sales to restaurants by non-professionals. For example, among those who did not wish to be surveyed, there were 3 recreational fishermen who in March (when the closed season was closed), offered limpets to the first point of sale of the San Cristóbal Cooperative, an action that was rejected by the cooperative.

The results of the PSA indicate that the stocks of both limpets are fully exploited, at the limit of overexplotation, while octopus is also fully exploited, again at high levels of the range.

There are studies confirming the excessive explotation of gastropods for profit elsewhere (Palmer, 2004), such as with Concholepas concholepas in Benthic Resource Management and explotation Areas (AMERB) on Mocha Island in Chile (Bandin and Quiñones, 2014), but also the existence of unregulated sales of limpets to restaurants in Gran Canaria (Falcón, 2012). Some recreationalists claimed that there is a similar business with crabs (jaguar round crab and talon crab), in order to sell them as bait to other recreational fishermen.

From the surveys, it can be deduced that the activity of shellfishing limpets by recreational fishermen is subject to a certain seasonality, linked to the availability of free time, since 67% of recreational fishermen indicated that it is in summer when they fish the most limpets, coinciding with their holiday period. A similar situation has also been described in other parts of the world, such as South Africa (Majiza and Lasiak, 2002) or the Italian Adriatic coast (Airoldi *et al.*, 2005). This seasonality is only seen among recreationalists, as professionals collect during the whole permitted period.

The fishermen's impression of the state of the resources and how their abundance has evolved over the years is remarkable. The professionals estimate that limpet populations have experienced a decline of between 10-25%, while recreational fishermen report a drop of 57% for black limpets and 72% for white limpets. This discrepancy can be explained by the fact that most of the artisanal fishermen have been shellfishing since 2010, while most of the recreational fishermen have been shellfishing since the 1980s, so the starting point for the state of the populations is very different. The disappearance of the Majorero limpet from Gran Canaria (Nuñez *et al.*, 2003) and the reduction to near extinction of the mussel (Espino *et al.*, 2006) are two signs. But they are not the only ones. Studies have shown that the populations of gastropods (*Patella* spp. and *Osilinus* spp.) on the uninhabited islet of Alegranza, where there is no shellfishing, have densities up to 15 times higher than on Lanzarote and La Graciosa (Ramírez *et al.*, 2009, b), with numerous large specimens and a well-defined population structure. The *Stramonita haemastoma* snail inhabits the intermediate intertidal, where it preys on other gastropods. However, in Gran Canaria and Tenerife, it is more frequent in the shallows, probably because its food is scarcer in the intermediate strip due to excessive shellfishing (Ramírez *et al.*, 2009, a).

The two cases above are examples of a process observed in other regions of the planet with excessive shellfishing, i.e. the change in intertidal communities. In addition, on rocky coasts, "*bald spots*" are generated, areas depopulated of organisms, which take years to regenerate and when they do, it is with variation with respect to the species that were originally present (Dye, 1992; Airoldi *et al.*, 2005).

Despite the above, there are still stocks of the different resources and there could be some reasons for this. Regulations may be playing a role. The minimum sizes established have been based on reproductive biology (Brito, 2008). This measure gives a viability to stocks, especially when abundance is low and there is no management of the activity (Hartill *et al.*, 2005). Surveys show that a percentage of fishermen seem to comply with the size regulation..

The regulation also establishes a closed period for all species (except octopus, which can be caught all year round), coinciding with reproduction (Brito, 2008). This closed season seems to be respected by interviewees.

On the other hand, the presence in some of these species of breeding adults in the subtidal (white and black limpets, octopus, talon and nimble spray crabs), where they take refuge and make capture difficult, may be helping to avoid the collapse of their stocks (Catterall and Poiner, 1987).

The north coast of Gran Canaria is steep. This orography makes access difficult, as was mentioned by those surveyed, who mostly go to the accessible areas (GC/N2 and GC/N3), so that the cliffs have probably become refuges for adult specimens, exporting larvae to the rest of the coast. In addition, storm surges are intense and frequent (October-April), making access even more impossible during these events, as occurs with species such as the barnacle (*Pollicipes pollicipes*) in Galicia, which lives on steep coasts exposed to intense swells, making it difficult to collect them and study their populations (Morales and Freire, 2003). Therefore, although there may be other factors, it is likely that the minimum sizes and the closed period based on reproductive biology, the ability of some species to shelter adult specimens in the subtidal and especially the environmental conditions of the coast, are reasons that prevent the collapse of the stocks.

The regulations stipulate the distances that shellfish gatherers must keep from port areas and discharges, both of waste and treated water. In both cases it is 3 nautical miles, i.e. 5.5 km.

On the north coast, if the zoning were complied with, there would be no problem with respect to the ports, since the areas enabled for the activity (GC/N2 and GC/N3) are at greater distances from the two nearest port infrastructures, the Port of Las Palmas (to the east) and the Port of Las Nieves (Agaete), to the west.

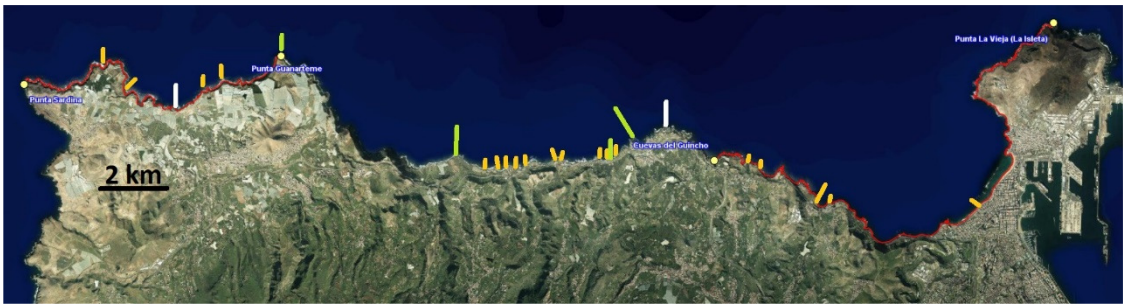


**Figure 19:** Dumping points on the north coast (2017 data). In the area where shellfishing on foot is allowed there were 15 discharges, 10 unauthorised (orange), 1 in process (white) and 4 authorised (green). Modification of the image obtained from the idecanary viewer.

However, as can be seen in Figure 19, there is a clear failure to comply with the distances with respect to the discharge points. The image shows those existing in 2017 (IDECanarias viewer). Strictly applying the regulations, shellfish could not be harvested in the whole of the permitted area, given that, with these 2017 data, there is no point in GC/N2 and GC/N3 that complies and is at a greater distance than the minimum required with respect to any of the 15 outfalls.

It is clear that there are still doubts about the state of the different stocks of the species subject to shellfishing on the north coast of Gran Canaria, but it is important to highlight that there is a high degree of agreement between professional, recreational and scientific fishermen that the high number of recreational fishermen, and the high fishing pressure they exert, is the main factor in the situation of imbalances described in this work.

## MANAGEMENT PROPOSALS

### A) - SHORT TERM

1º) – **More studies**, both surveys and field studies (sampling and/or transects), to determine the status of the populations.

2º) - **More means to control the activity.** There is a need for more agents to patrol the coastline continuously, all year round (open and closed season), with powers to sanction restaurants that buy illegally. They generate a dissuasive effect.

3º)- **Specific licensing for recreational shellfishing.** It should no longer be seen as a complementary practice but as a fishery in its own right:

3.1.- **Higher fee for this licence.** Given that the expenditure of those who go shellfishing is very low, it is likely that an increase in the fee exclusively for this licence would not generate great social rejection (Jiménez-Alvarado *et al.*, 2019). And these revenues could be invested for the purposes outlined in section 2, as well as in the following.

3.2.- **Course for those applying for the licence.** Prior to obtaining the licence, a minimum amount of training must be provided, explaining the regulation, the rights and duties of the licence holder, and the effects of this activity. This measure has been positively accepted in places such as Galicia (Frangoudes *et al.*, 2008).

4º)- **Adapt the current regulations in**:

4.1.- **Wider closure for crabs.** Crabs are currently caught for 8 months. Literature indicates that they reproduce in spring (Brito, 2008). Several respondents said that they always see females with eggs in that season. Therefore, extending their closure, even if it is only for one month (coinciding with limpets), could be positive.

4.2.- **Periodic total closure.** The resilience and regenerative capacity of the marine environment and these organisms is high. Several respondents stated that, with the 2020 pandemic closure, which forced the recreational sector not to go out until later than the permitted dates, they saw an increase in resources. A periodic total closure could be an effective mechanism to regenerate resources. The time interval should be determined on the basis of scientific knowledge, such as coinciding with the North Atlantic Oscillation (NAO) cycle, which seems to be related to the increase in octopus catches (Caballero, 2008), or any other criteria based on empirical data.

**B) - LONG TERM**

1º) – **Educate.** What is not known, is not cared for. To teach what the Canarian coastline is like, how it works, which species inhabit it, which are harvested and the consequences of their explotation.

2º) – **Consumer information.** Advertising campaigns on shellfishing and the state of the resource.

3ª)- **Control of discharges.** The detrimental effects caused by the numerous discharges put the sustainability of resources and ecosystems at risk.

## CONCLUSIONS

1.- On the north coast of Gran Canaria, the white limpet (*Patella ulyssiponensis aspera*) and the black limpet (*Patella tenuis crenata*) are target species for the entire professional sector and a large percentage of the recreational sector. Octopus (*Octopus vulgaris*) is the next most important target species for recreational fishermen.

2.- The economic profitability generated by the sale of both limpets explains why they are the main target species.

3.- Populations of both limpet species may have declined by a very significant amount compared to only 30-40 years ago.

4.- While the number of licences allowing recreational shellfishing is known, the exact number of those licences actually practising the activity is not known, unlike for the professional sector.

5.- There is a high percentage of people practising the activity who do not comply with the zoning established by the regulation in the study area.

6.- The state of the stocks of the two species of limpets and octopus on the north coast of Gran Canaria could be fully exploited.

7.- If they comply with the quantities allowed by the regulation, the CPUEs reported by recreationalists are relatively low, although quite a few reported that they often catch more kilograms than they are allowed.

8.- Although several reasons are given, the main cause for the decline of the resource in the study area is the pressure exerted by recreational shellfishing.

9.- Shore-based shellfishing is a fishery that involves minimal initial and annual investments for both sectors.

10.- Different measures are proposed to conserve the resource, the most requested being clearly the control and monitoring of the activity.

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- 2011. Order of May 2, 2011, establishing certain aspects of shellfishing on foot for the harvesting of some species of shellfish in the Canary Islands.

- 2011. Order of May 18, 2011, by which the Order of May 2, 2011, which fixes certain aspects of shell fishing on foot for the harvesting of some species of shellfish of the Canary Islands is modified.

# ANNEX:

## SURVEY FOR SHELLFISHING ON FOOT ON THE NORTH COAST OF GRAN CANARIA

Date: ..... Location: .....
Interviewer: .....

**1. Age** ☐ <18 ☐ On 18 y 30 ☐ On 31 y 45 ☐ >45

**2. Do you have a fishing licence?** ☐ Yes ☐ No

**3. Which mode?** ☐ 2º Clase ☐ 3º Clase ☐ 2º and 3º Clase ☐ Alls

**4. In which year did you start shellfishing on foot?** .....

**5. In which area do you usually practice the activity? Indicate as many as necessary.**

☐ GC/N1: Punta de Sardina – Punta de Guanarteme
☐ GC/N2: Punta de Guanarteme – San Felipe
☐ GC/N3: San Felipe – Puertillo (Bañaderos)
☐ GC/N4: Puertillo (Bañaderos) – Roque Ceniciento (Isleta)
☐ Others (Indicate): .....
.....
.....
.....

**6. Knows how to differentiate the species it catches?** ☐ Yes ☐ No

**7. Do you think that the season of the year influences the presence or absence of certain species?**

Species: ..... (period of maximum abundance)
☐ Winter ☐ Spring ☐ Summer ☐ Autumn ☐ No change
Species: ..... (period of maximum abundance)
☐ Winter ☐ Spring ☐ Summer ☐ Autumn ☐ No change
Species: ..... (period of maximum abundance)
☐ Winter ☐ Spring ☐ Summer ☐ Autumn ☐ No change

**8. In which month does the shellfish season start and when does it end?**
Starting month: ..... Month of completion: .....

**9. In which month are the maximum catches made?** Month: .....

**10. In which intertidal zone do they usually shellfish? (Display image)**
Superior: ..... Inferior: .....
Intermediate: ..... Alls: ……

**11. As the tidal limit is approached, do the target species increase or decrease in abundance?**

Species: .....
☐ Increase ☐ Decrease ☐ No change
Species: .....
☐ Increase ☐ Decrease ☐ No change
Species: .....
☐ Increase ☐ Decrease ☐ No change

**12. As the tidal limit is approached, do the target species increase or decrease in size?**

Species: .....

☐ Increase ☐ Decrease ☐ No change

Species: .....

☐ Increase ☐ Decrease ☐ No change

Species: .....

☐ Increase ☐ Decrease ☐ No change

**13. Currently, how much is the total amount of catch per fishing trip?**

☐ 100grs-500grs ☐ 500grs- 1 Kg ☐ More than 1 Kg

**14. What and when was your biggest catch?** ..... Kg; ..... Year

**15. In which proportion of outputs the catch is 0 (zero)?**

☐ <20% ☐ 20-40% ☐ 40-60% ☐ 60-80% ☐ >80%

**16. How many times do you practice this activity per month?** ☐ 1-2 ☐ 3-4 ☐ 5–8 ☐ <1

**17. How many hours do you spend on this activity each outing?**

☐ < 1 ☐ 1 - 2 ☐ 2 – 4 ☐ 4 – 6 ☐ > 6

**18. Which species are targeted?**

Species: .....

☐ Not objective ☐ Occasionally ☐ It is always objective

Species: .....

☐ Not objective ☐ Occasionally ☐ It is always objective

Species: .....

☐ Not objective ☐ Occasionally ☐ It is always objective

Others: .....

**19. Occurrence in their catches**

Species: .....

☐ Sporadic (<10% outlets) ☐ Common (10-25%) ☐ Frequent (>25%)

Species: .....

☐ Sporadic (<10% outlets) ☐ Common (10-25%) ☐ Frequent (>25%)

Species: .....

☐ Sporadic (<10% outlets ☐ Common (10-25%) ☐ Frequent (>25%)

**20. Recent trend in their catches (last 5 years)**

Species: .....

☐ Increase ☐ Stable ☐ Decrease

Species: .....

☐ Increase ☐ Stable ☐ Decrease

Species: .....

☐ Increase ☐ Stable ☐ Decrease

**21. What is the fate of the species you catch?**

☐ Self-consumption ☐ Selling to restaurants

☐ Angling bait ☐ Others: ……

**22. Large specimens are difficult to find?**

Species: ..... Yes ☐ No ☐
Species: ..... Yes ☐ No ☐
Species: ..... Yes ☐ No ☐

**23. Where you usually go shellfishing?**

☐ On rocky shores ☐ On pebble beaches and creeks
☐ On both types of coastline ☐ Others: .....

**24. He believes that species have moved into areas where they were not found before?**

Species: ..... Yes ☐ No ☐
Species: ..... Yes ☐ No ☐
Species: ..... Yes ☐ No ☐

**25. If so, to what factor can this behaviour be attributed?**

☐ Polluting discharges ☐ Presence of bathers
☐ Excessive pressure from shellfishing ☐ Others: ……

**26. Alternating between different shellfishing areas?**

☐ Always in the same ☐ Change of zones
Reasons: .....

**27. How often do you usually visit the same area?**

☐ 1-2 times/year ☐ 3-6 times/year ☐ 7 or more times/year
Reasons: .....

**28. Do you observe a seasonality in catches?**

Species: ..... ☐ Yes ☐ No ☐ DK/DA
Species: ..... ☐ Yes ☐ No ☐ DK/DA
Species: ..... ☐ Yes ☐ No ☐ DK/DA

**29. What do you think have been the causes of the decline in catches in the shellfishing areas you visit?**

☐ Overfishing ☐ Pollution ☐ Habitat depletion
☐ Professional shellfishing
☐ Others reasons: .....
Indicate areas: .....

**30. Compared to when you started shellfishing in those areas, by how much do you think fishing has decreased?**

Species: .....
☐<10% ☐ 10-25% ☐ 25-60% ☐ >60%
Species: .....
☐<10% ☐ 10-25% ☐ 25-60% ☐ >60%
Species: .....
☐<10% ☐ 10-25% ☐ 25-60% ☐ >60%

**31. How do you consider the status of your target species?**

☐<10% overexploited ☐ 10-25% overexploited ☐ >25% overexploited

**32. Do you consider the species in shellfish areas to be accessible?**

Zona: .....
☐<50% of accessible habitats ☐ 50-75% of acces. Hab. ☐ >75% of acces. Hab.
Zona: .....
☐<50% of accessible habitats ☐ 50-75% of acces. Hab. ☐ >75% of acces. Hab.
Zona: .....
☐<50% of accessible habitats ☐ 50-75% of acces. Hab. ☐ >75% of acces. Hab.

**33. Do target species show aggregatory behaviour and does this affect their catch?**

Species: .....Gregarious: ☐Yes☐ No Affects catch: Si ☐ No☐
Species: .....Gregarious: ☐Yes☐ No Affects catch: Si ☐ No☐
Species: .....Gregarious: ☐Yes☐ No Affects catch: Si ☐ No☐

**34. Do you think the morphology of the target species makes them easier to catch with your fishing method?**

Species: .....
☐Low vulnerability ☐Moderately vulnerable ☐ Highly vulnerable
Species: .....
☐Low vulnerability ☐Moderately vulnerable ☐ Highly vulnerable
Species: .....
☐Low vulnerability ☐Moderately vulnerable ☐ Highly vulnerable

**35. During your activity, are discards generated by catches of unwanted species?**

Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch
Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch
Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch

**36. During your activity, do you generate discards of target species for not reaching the minimum size?**

Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch
Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch
Species: .....
☐<10% of the catch ☐10-20% of the catch ☐ >25% of the catch

**37. Have you observed habitat alteration in fishing areas?**

Zone: ..... Reasons: .....
☐Unchanged ☐ Half ☐Highly disturbed
Zone: ..... Reasons: .....
☐Unchanged ☐ Half ☐Highly disturbed
Zone: ..... Reasons: .....
☐Unchanged ☐ Half ☐Highly disturbed

**38. Do you observe litter in your fishing grounds?**

Type of waste: ..... Quantity: ☐ A Little ☐ Quite ☐ A lot
Type of waste: ..... Quantity: ☐ A Little ☐ Quite ☐ A lot
Type of waste: ..... Quantity: ☐ A Little ☐ Quite ☐ A lot

**39. What factors do you think can help stocks to recove?**

☐ Increase minimum sizes
☐ Total annual catch quotas
☐ Zone changes
☐ Reducing the number of licences
☐ Information on the status of resources
☐ Temporary closures.
☐ Limiting fishing hours
☐ Othes: .....

**40. Do you sail alone or in company?** ☐ Alone ☐ Company

**41. Do you belong to any association or entity?**.....

**42. Do you think there is a need for a federation for the practitioners of this modality?**

☐ Yes ☐ No ☐ NS/NC

**43. ¿Está satisfecho con la regulación actual del marisqueo en Canarias?**

☐ Si ☐ No ☐ DK/DA

**44. What would I change?**

.....
.....

**45. Do you put the stones back as they were after moving them?**

☐ Always ☐ Usually ☐ Never

**46. When do you shellfish?** ☐ By day ☐ By night ☐ Both

**47. Are the species caught different if you shellfish during the day or at night?**

Species: .....
☐ By day ☐ By night ☐ Both
Species: .....
☐ By day ☐ By night ☐ Both
Species: .....
☐ By day ☐ By night ☐ Both

**48. To go shellfishing, do you always go on foot?** ☐ Yes ☐ No

**49. How often do you travel by vehicle to go shellfishing?**

☐ <25% ☐ 25-50% ☐ 50-75% ☐ >75%

**50. What has been your initial investment in fishing equipment?** .....euros.

**51. What is your annual expenditure on fishing equipment?** .....euros.

**52. ¿ How much money do you spend on this activity on each outing?**

☐ < 10€ ☐ 10- 20€ ☐ 20–40€ ☐ 40–60€ ☐ 60-100€ ☐ >100€

On what things: .....