Universidade de Aveiro
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Beatriz da Silva Pereira Ribeiro Vieite

Fishermen's Knowledge and Conservation Attitudes: Focus on the Great Cormorant in the Minho River, Portugal.

Conhecimento e Atitudes Conservacionistas dos Pescadores: Foco no Corvo-Marinho-de-Faces-Brancas no Rio Minho, Portugal.

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Aplicada, realizada sob a orientação científica do Doutor Ulisses Azeiteiro, Professor Associado com Agregação e do Doutor Heitor Braga, Investigador Post-Doc, ambos do Departamento de Biologia da Universidade de Aveiro.

À própria.

o júri

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palavras-chave

Controlo populacional do corvo-marinho, Conhecimento tradicional, Zonas húmidas, Etnoornitologia, *Stakeholders.*

resumo

Compreender as atitudes das comunidades tradicionais e o seu conhecimento ecológico local (CEL) pode contribuir para uma melhor formulação de políticas e planos de gestão mais adequados. Assim, neste estudo procurou-se partilhar o CEL dos pescadores do rio Minho sobre o corvo-marinho-de-faces-brancas *Phalacrocorax carbo* (Linnaeus, 1758), bem como revelar as suas atitudes conservacionistas em relação a esta espécie. Descrevemos e analisámos qualitativamente o CEL dos entrevistados, e, por outro lado, as suas atitudes foram analisadas quantitativamente através da correlação com variáveis do perfil dos pescadores. Os pescadores foram capazes de identificar as características ecológicas do corvo-marinho como habitats, espécies-presa, e comportamento de alimentação. Mostraram também uma atitude globalmente moderada em relação à conservação dos corvos-marinhos-de-faces-brancas. O CEL foi frequentemente apoiado por dados publicados, mas encontrámos diversas informações em alguns tópicos, tais como habitat e dieta alimentar. Encontrámos uma correlação negativa significativa entre a idade e as atitudes dos pescadores ($p = 0,02$), e os pescadores que pescavam frequentemente diferem significativamente dos que raramente pescavam ($p = 0,02$). Por último, reafirmamos a importância de recolher mais dados científicos sobre a estrutura da população de *P. carbo* em Portugal e a relevância dos estudos etnobiológicos na tomada de decisões.

keywords

Cormorant population control, Traditional knowledge, Wetlands, Ethno-ornithology, Stakeholders.

abstract

Understanding the attitudes of traditional communities and their local ecological knowledge (LEK) can contribute to better policymaking and more fitting management plans. Thus, this study strived to share the Minho River's fishermen LEK about great cormorant *Phalacrocorax carbo* (Linnaeus, 1758), as well as it reveals their conservation attitudes towards this species. We described and analysed interviewees' LEK qualitatively, while their attitudes were analysed quantitatively through correlation with variables from fishermen's profile. Fishermen were able to identify cormorant's ecological characteristics like habitats, prey species, and foraging behaviour. They also showed an overall moderate attitude towards the conservation of great cormorants. The LEK often was supported by published data, but we found diverse information in some topics, such as habitat and diet. We found a significant negative correlation between fishermen's age and attitudes ($p = 0.02$), and fishermen who often fished differed significantly from those who rarely fished ($p = 0.02$). We lastly reaffirm the importance of collecting more scientific data regarding *P. carbo* population structure in Portugal and the relevance of ethnobiological studies in decision-making.

This dissertation was submitted in the form of a manuscript to an international-refereed journal.

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1. Introduction

Ethnobiology embraces the understandings of traditional practices and knowledge of indigenous communities, and subsequently ethno-ornithology when concerning what is culturally designated as birds (Tidemann and Gosler, 2010). These people gain this kind of knowledge, mainly, by interacting with the environment and its living beings on their everyday life. Such knowledge is commonly designated as Indigenous, Tradition and Local ecological knowledge (IEK, TEK and LEK) (Tidemann and Gosler, 2010). Thus, local knowledge is then transmitted to following generations through cultural practices like art and language (Tidemann and Gosler, 2010).

Over the past few decades, the interdisciplinary complex between local knowledge and scientific knowledge has been growing and earning more attention (Huntington, 2000). Hence, local ecological knowledge (LEK) has been proven to be a very functioning and accurate complementary tool to scientific data, filling in gaps and providing new information regarding the environment (Gilchrist *et al*., 2005; de Magalhães *et al.*, 2012; Frans and Augé, 2016; Alati *et al*., 2020; Cheng *et al*., 2021). Yet, even with several published works about traditional knowledge, the stigma around it did not disappeared (Aswani *et al*., 2018; Ogar *et al*., 2020). LEK is still not considered as valid as western science by many and is noticeably being lost (Aswani *et al*., 2018; Ogar *et al*., 2020).

Besides LEK, traditional communities also offer views, feelings, and attitudes towards the environment. Attitude has not a clear and unique definition, but according to Perloff (2020), it consists in a psychological construct around an object that has an effect on ways of thinking and actions. Knowledge can also have an impact on the attitudes, since it has been revealed that higher knowledge reflects on more favourable attitudes (Kuentzel *et al*., 2012). Studying attitudes can also bring insight to the existence, or not, of conflicts between stakeholders and wildlife (Vasudev *et al*., 2020), to the need of more educational programs and awareness regarding the environment (Portman and Camporesi, 2020), or to community-based conservation actions (Störmer *et al*., 2019).

In Portugal, several ethnobiology studies were published in the past 10 years, ranging from ethnobotany (Carvalho and Frazão-Moreira, 2011), to ethno-herpetology (Ceríaco, 2012), to ethno-ichthyology (Braga *et al*., 2020), to ethno-mammalogy (Lopes-Fernandes *et al*., 2018), even to ethnobiological studies related to ecosystem services (Sousa *et al*., 2013) evidencing a growing interest in this area. Stakeholders often participate and contribute to these works, namely fishermen, whose knowledge and perception cover not only commercial fish, but also sharks ecology and coastal regulation (Barbosa-Filho *et al*., 2014; Liao *et al*., 2019; Morado *et al*., 2021). However, in Portugal only very few ethnobiology-related studies were made and most of them focus on fish species that are relevant for fisheries (Braga *et al*., 2017a, 2017b, 2019, 2020).

Great cormorant *Phalacrocorax carbo* (Linnaeus, 1758) is a migratory and aquatic bird species and is considered a wintering species in Portugal (Aves de Portugal, 2021). It is distributed worldwide, except in South America and Antarctica, and breeds in many countries from North America to Oceania (BirdLife International, 2019). The breeding season can differ according to the geographic distribution, and consequently with the

subspecies, counting with a peak in April and June in the Northern Hemisphere temperate regions (del Hoyo *et al*., 1992). It mostly habits wetlands, such as rivers and large lakes, usually breeds in cliffs or on trees near to a water mass (Nicolai *et al*., 2001; Svensson *et al*., 2017). Cormorants, in general, normally fish alone and by pursuit-diving, a technic where birds plunge from the air into the water vertically and pursuit their prey underwater (del Hoyo *et al*., 1992).

Phalacrocorax carbo diet is mostly based on fish, but it was also found that polychaetes, crustaceans, and amphibians can sometimes be a part of their meal (del Hoyo *et al*., 1992; Leopold and van Damme, 2003). Yet, prey appears to vary from region to region. In Norway, *P. carbo* mainly consumes fish from the families Gadidae and Ammodytidae (Barret *et al*., 1990), whereas in Scotland they seem to feed more on Salmonidae, Cyprinidae and Pleuronectidae (Carss and Marquiss, 1997). In Cech Republic, Cyprinidae and Percidae are the most predominant fish in cormorants' diet (Čech and Vejřík, 2011), while in Germany they have a similar diet, preying mostly on Cyprinidae, Percidae and Esocidae (Gaye-Siessegger, 2014). In Portugal, Mugillidae is the most frequent prey, and variations from locations are also noticeable. Cormorants in the northern region of Portugal also prey on Pleuronectidae and Cyprinidae (Dias *et al*., 2012), whereas in the southern region they additionally prey on Batrachoididae and Sparidae (Catry *et al*., 2017).

Phalacrocorax carbo, currently, is considered "Least Concern (LC)" in IUCN Red List, both globally and in Europe, with an increasing population trend (BirdLife International, 2019). This resulted from creating legislation to protect birds and their habitat, such as Council Directive 79/409/EEC (also known as The Birds Directive), that was amended in 2009 – Directive 2009/147/EC – and Council Directive 92/43/EEC (also known as The Habitats Directive). Nevertheless, in 1997, it was removed from The Birds Directive because of its non-concerning conservation status (Kindermann, 2008; European Commission, 2021). To our knowledge, there is no legislation regarding great cormorants in the Iberian Peninsula.

Considering the population growth and a fish-based diet, great cormorants began to clash with commercial fisheries (Kameda *et al*., 2003; Steffens, 2010; Arlinghaus *et al*., 2021) Kindermann (2008) proposed the European Cormorant Management Plan (2008/2177(INI)), and it was approved. That is, a community plan for the management of great cormorant populations. It pretends to monitor cormorant population across Europe, to understand the populations' structure and size, and supporting and financing the fishery sector. Yet, in Portugal, there is not any management plans that comprise *P. carbo*.

Thus, understanding fishermen's beliefs and perceptions towards great cormorants can help to identify issues that they can be causing to the environment, or benefits that they can bring. Or at least, bring attention to the need for updated scientific data on this species in order to evaluate its impact. Although other works about LEK and attitudes towards *P. carbo* were made (Pyrovetsi and Daoutopoulos, 1989; Daoutopoulos and Pyrovetsi, 1990), this is the first one in Portugal. The main goal of this study was to share the LEK and evaluate the degree of conservation attitudes towards great cormorant of fishermen in the main portuguese villages of Minho River: Valença, São Pedro da Torre, Campos, Vila Nova de Cerveira, Gondarém, Lanhelas, Seixas, and Caminha. We described their ethno-ornithological knowledge, such as folk taxonomy, population history, habitat and

distribution, and diet and foraging habits. We also assessed the management of this species in the portuguese side of the Minho River.

2. Material and methods

2.1. Study area

Minho or Miño is a 300 km long international river, located in Portugal and Spain, serving as a natural barrier between these countries in its last 70 km (Figure 1). It is born in Serra de Meira (Spain), at 750 m of altitude, and drains into the Atlantic Ocean, between Caminha (Portugal) and La Guardia (Spain). The hydrographic basin of the Minho River comprises an area of 9 091.45 km², in which 814.45 km² (8.96%) belong to the Portuguese territory (Plano de Gestão de Região Hidrográfica, 2016).

Part of Minho River (42.00ºN, 8.39ºW) is integrated in the Natura 2000 Network as a Site of Community Importance (SIC: PTCON0019) situated in the Atlantic biogeographical region with a total area of 4 554 ha (Portaria nº 829/2007). Besides, it covers three types of habitat included in the Habitat Directive (Council Directive 92/43/ECC): Atlantic salt meadows (Habitat 1330), Coastal lagoons (Habitat 1150), and Mediterranean temporary ponds (Habitat 3170), in which the last two are considered high priority habitat types (Resolução do Conselho de Ministros nº 142/97). The Minho's estuary area is also considered an Important Bird Area (IBA), serving as place of passage for migratory birds, such as great cormorants. This is due to the fact that this region is constituted by saltmarshes, mudflats, and alluvial forests, as well as having an accentuated water salinity gradient (BirdLife International, 2021b).

We performed this study in eight Portuguese fishing communities along the Minho River that are also considered the most critical sites for fishing in this region, such as Valença, São Pedro da Torre, Campos, Vila Nova de Cerveira, Gondarém, Lanhelas, Seixas, and Caminha (Costa *et al*., 2001). In this region, there are two fishing associations: Fishermen's Association of Ribeira Minho and Association of Professionals of Fisheries of the River Minho and the Sea, with its headquarters located in São Pedro da Torre and Caminha, respectively. According to DGAM (2020), in Minho River there are registered 196 local fishing boats, of which 134 have a licence for local fishing.

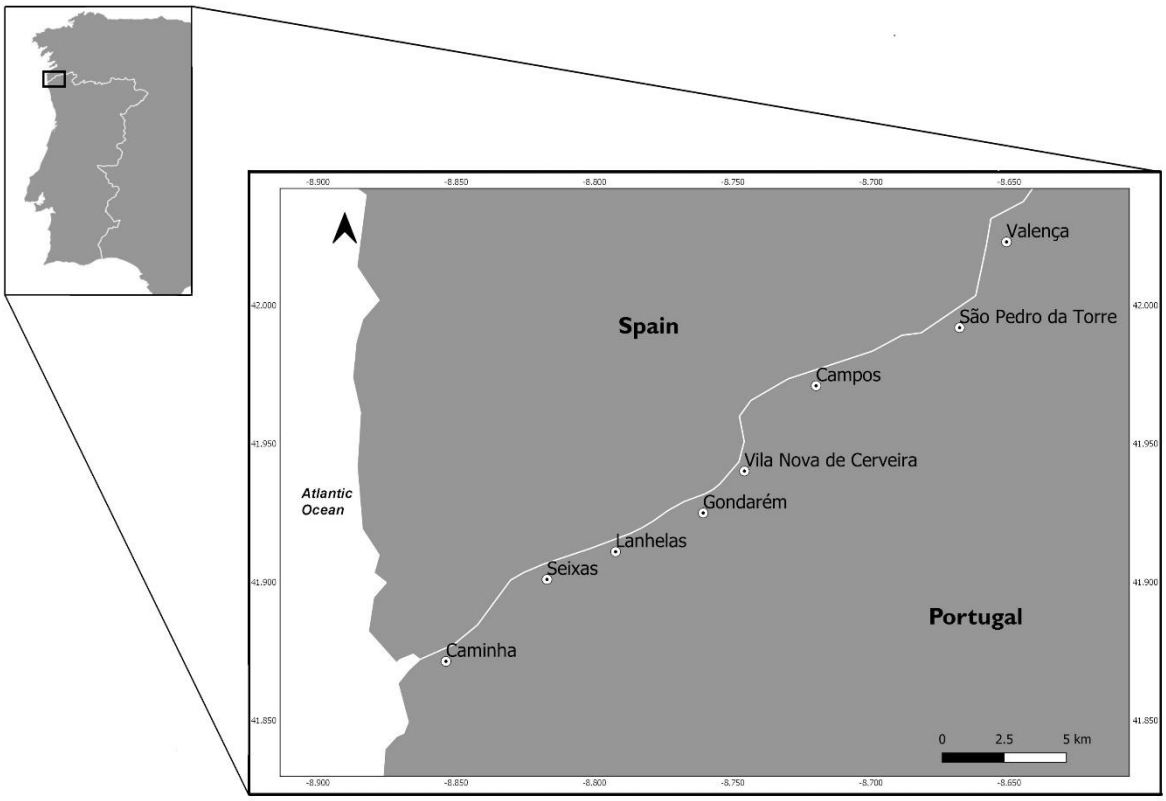

Figure 1. Map showing the location of the main fishing communities on the Minho River, Portugal.

2.2. Data collection

In seeking to understand the attitudes and local ecological knowledge (LEK) of fishermen about the great cormorant (*Phalacrocorax carbo*), we applied individual semi-structured interviews (Albuquerque *et al*., 2014). This study was conducted in eight fishing communities along the Minho River (Valença, São Pedro da Torre, Campos, Vila Nova de Cerveira, Gondarém, Lanhelas, Seixas, and Caminha) during September and October 2020. Establishing a safe and trustworthy environment was a very relevant aspect that was achieved by temporarily living in a locality near the fishing villages, as well as visiting places frequented by fishermen regularly (Brook and McLachlan, 2008). Fishermen were approached and interviewed individually to avoid any interference of other fishermen that may be around.

During this period and considering the current COVID-19 pandemic, fishing activity was very weak, which made data collection difficult. To overcome this issue, we used social media as a tool to find and connect with fishing communities, as well as the snowball sampling (Bailey, 2008) where one interviewee recommended another fisherman. Prior to the interview, we handed a Statement of Informed Consent (Appendix 1) to the interviewee, where we briefly explain our study and our aims, as well as the importance of fishermen's knowledge to our work, disclaiming that all data is preserved and will only be used for this study. At last, it was presented our contact information (phone number and email), in case of need for any clarifications. It is important

to refer that fishermen were able to choose whether they were or not interested in collaborating, and they could give up the interview at any time.

The questionnaire consisted in three parts: (1) fishermen's profile, (2) fishermen's LEK of great cormorant, and (3) their attitudes towards its conservation (Appendix 2). Fishermen's profile contained information about their social-demographic characteristics (age, locality and time of residence, education, number of children, income, and access to the internet) and their fishing activity (if they still fishing, fishing experience, fishing time, fishing effort, fishing sites, fishing gear, and target species).

Fishermen's LEK concerning great cormorant included a projective test (Costa Neto *et al.*, 2009) where we showed an illustrative image of a specimen of *P. carbo* to see if fishermen were able to recognize and identify it, as well as multiple questions about our target species' ecology (staying period and preferred sites in Minho River, preference for prey species and size, daily food intake, foraging behaviour), fisherman's personal opinion about *P. carbo* and beliefs or taboos towards it.

For their attitudes towards conservation of great cormorants, we explored matters like the need (or not) for population control and the impact of these birds in fishing activity and commercially important fish species. In addition, we must stress that this process followed the code of ethics of the International Society of Ethnobiology (ISE, 2006). In the present study, we formulate the concept of attitudes as tendencies that are expressed by judging a certain entity in a position of some agreement or disagreement (Bogardus, 1924; Eagly and Chaiken, 1993; Crano and Prislin, 2006).

2.2.1. COVID-19 pandemic

Acknowledging the spreading of the SARS-CoV-2 virus, preventive measures needed to be taken. Therefore, our study followed all the recommendations from General Directorate of Health of Portugal and World Health Organization. So, the interviewers were tested for COVID-19 beforehand, and when interviewing, it was required to use a mask, as well as social distancing.

2.3. Data analysis

2.3.1. Qualitative analysis

Data obtained from the interview transcript allowed us to share and access fishermen's LEK about great cormorant's ecology. Fishermen's knowledge was analysed through an emic-etic approach, where both emic and etic methods coexist. That is, we integrated both cultural-specific and cultural-comparative (universal) elements, respectively. This allowed us to overcome the restrictions of each approach, by combining them to acquire a more sensible perception (Cheung *et al*., 2011). In this study, such method reflects on gathering local knowledge and scientific knowledge to assess data regarding cormorant's ecology. Education levels were divided into three classes according to the portuguese system: Low level (no education and 1s cycle of Primary school – 1st to 4th years), Basic level (2nd and 3rd cycles of Primary school – 5th to 9th years) and Intermediate (Secondary school or higher – 10 and above). All scientific names mentioned were described according to the Catalogue of Life database (COL, 2020), except for one species, that we followed the BirdLife International database (BirdLife

International, 2021a). Fishermen's attitudes were also analysed qualitatively, where we assessed their general opinion regarding cormorants by questioning them if they discontented with the presence of this species.

2.3.2. Quantitative analysis

We developed 10 questions with a three-point Likert scale to assess fishermen's attitudes. Although the most common variation of the Likert scale is the five-point scale (Bertram, 2006), we decided to use a three-point scale to prevent confusion in differentiating a scale from another. To analyse attitudes quantitatively, we followed the methodology presented in both Braga and Schiavetti (2013) and Braga *et al.* (2018). Hence, we converted the three-point Likert scale into scores from 0 to 1 (unfavourable attitude = 0, moderate attitude = 0.5, favourable attitude = 1). Attitudes were considered favourable when fishermen showed no conflict with cormorants, moderate when showed indifference or unfavourable when showed conflict. To evaluate the individual mean index of attitudes, we calculated the average score for each fishermen. Then, we obtained the overall mean index of attitudes by calculating the average of individual mean indexes of attitudes, to understand the general perception of Minho River's fishermen. The mean index of attitudes was then classified into three classes (0-0.33: negative attitudes; 0.34-0.66: moderate attitudes; 0.67-1: positive attitudes).

For statistical analysis, we tested the normality of our data through the Shapiro-Wilk test. We then used the Spearman's rank correlation coefficient to test correlation between the mean index of attitudes and fishing experience, average fishing time, fisherman's age, and number of children. To analyse significant differences between the mean attitude's index and fishing effort, education level, and income, we performed the Kruskal-Wallis *H* test and or the Mann-Whitney *U* test, depending on the number of independent groups. Thereafter, for the variables that showed significant differences, we performed the post-hoc Dunn test with Bonferroni adjustments to understand which groups of that variable were significantly different from another. We also tested the reliability of our semi-structured interview by applying the Cronbach's alpha coefficient. All analyses were carried out through R version 4.0.3, using packages from R Studio Version 1.4.1103 library - dplyr, rstatix, corrplot, ggplot2 and psych (R Core Team, 2013; RStudio Team, 2020).

3. Results

3.1. Fishermen's profile

We managed to interview a total of 50 fishermen in Minho River's fishing communities (Valença, n = 6; São Pedro da Torre, n = 5; Campos, n = 5; Vila Nova de Cerveira, n = 7; Gondarém, n = 3; Lanhelas, n = 5; Seixas, n = 4; Caminha, n = 15). The average fishermen's residence time in their fishing community was 53.02 ± 17.14 years (± sd). Hence, the mean age of interviewees was 57.06 ± 13.47 years old (± standard deviation, sd), all of whom were men, and had, on average, 1.32 ± 1.20 children (± sd). Almost half (n = 24; 48%) of the respondents had basic level of education (5 to 9 years of education), 26% of the respondents (n = 13) had a low level of education (1 to 4 years of education), 26% (n = 13) had an intermediate level of education (10 or more years of education).

In terms of income, 34% of fishermen (n = 17) do not have any other income source besides fishing, while most of them (n = 33; 66%) have or had other jobs (e.g., construction work). Additionally, 17 interviewees (34%) are retired, of which three interviewees (17.6%) made their living only from fishing. Thus, 42% of fishermen (n = 21) claimed that they earn between 601 and 1200 euros (€) monthly, 32% (n = 17) earn up to €600, and 24% (n = 12) earn above €1200. Also, most interviewees (n = 38; 76%) had access to the internet (Table 1).

Table 1. Social-demographic traits of Minho River's fishermen (n=50).

	Minimum	**Mean**	**Maximum**	**Standard deviation (sd)**
Age (years)	33.00	57.06	86.00	±13.47
No. of children	0	1.32	6.00	±1.20
Time of residence (years)	8.00	53.02	86.00	±17.14
Income	**n**		**Education level**	**n**
Up to 600€	17		Low (1-4 years)	13
601-1200€	21		Basic (5-9 years)	24
Above 1200€	12		Intermediary or High (≥10 years)	13
Income source	**n**		**Access to the internet**	**n**
Fishing activity	17		Yes	38
Others	33		No	12

Currently, most respondents (n = 43; 86%) still practice fishing activity. We were able to question fishermen with little knowledge (e.g., 6 years of fishing experience) to plenty of knowledge (e.g., more than 60 years of fishing experience), counting with, on average, 35.53 ± 16.93 years of experience (± sd). For the most part, fishermen (n = 43; 86%) went fishing 5 to 7 days a week, while 10% (n = 5) only fished 3 to 4 days a week, and 4% (n = 2) fished 1 to 2 days a week. Moreover, the mean fishing time was 6.87 ± 3.5 hours per day (Table 2). No fisherman claimed to fish 7 days a week, often mentioning that fishing activity is closed between 11 pm on Saturday and 11 pm on Sunday.

Table 2. Characteristics of the fishing activity of Minho River's fishermen (n = 50).

	n			
Current fisherman's activity				
Active	33			
Retired	17			
Fishing effort (days/week)				
1-2 days a week	2			
3-4 days a week	5			
5-7 days a week	43			
	Minimum	**Mean**	**Maximum**	**Standard deviation (Sd)**
Fishing experience (years)	6.00	35.53	69.00	±16.93
Average fishing time per trip (hours)	2.50	6.87	16.00	±3.50

3.2. Great cormorant's folk taxonomy

When applied the projective test, all fishermen (n=50; 100%) recognized the target species when shown the images. *Corvo-marinho* was the most mentioned (n=47; 94%) common name used to identified *P. carbo*. Other common names given by the interviewees was *pato-funduche* (n=3; 6%), *cormorante*, *garça*, and *flamingo* (n=1; 2% each).

3.3. Abundance

Seven fishermen (14%) noticed an increase of great cormorant specimens, compared to the past, and four fishermen (8%) said they only appeared recently. One of the four fishermen added that was an exponential growth of population about 20 to 30 years ago. On the other hand, two fishermen (4%) claimed that nowadays they sight great cormorants much less often. One of the two fishermen pointed out the construction of walkways as the leading cause.

3.4. Habitat and distribution

3.4.1. Temporal distribution

When questioned about great cormorant's staying period on Minho River (Figure 2), more than half of the fishermen (n=31; 62%) alleged that this bird appears all year, of which some (n=4) even mentioned that, nowadays, it does not migrate, and it is a resident species. However, of the thirty-one, four fishermen claim there is a greater abundance of cormorants in winter, while two other fishermen claim they observe a greater abundance between January and May (because of the fishing season and, consequently, fishermen go to the river

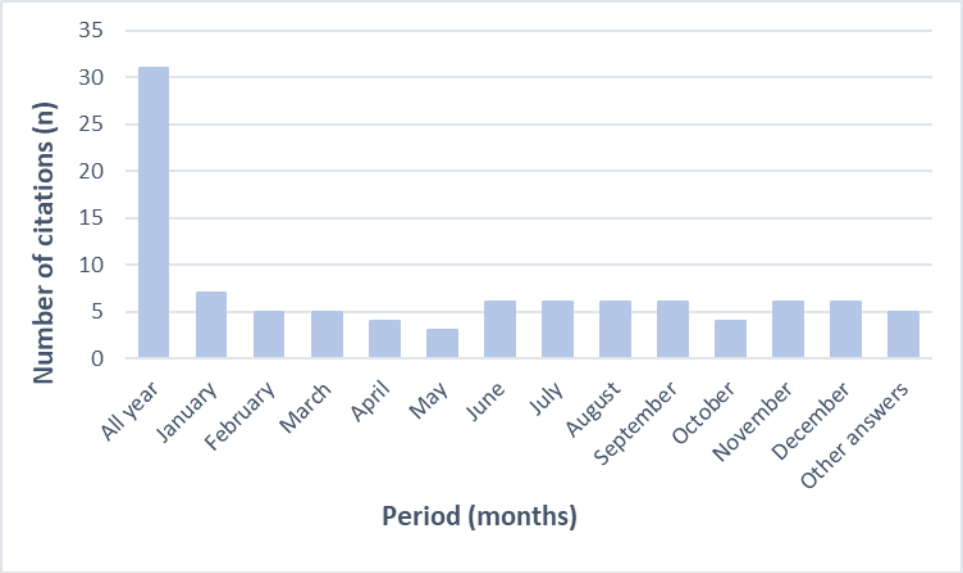

Figure 2. Great cormorant's (*Phalacrocorax carbo*) temporal distribution on Minho River, according to fishermen.

more often). On the other hand, one fisherman claims he sees these birds in greater abundance and more grouped in late January.

The remaining fishermen (n=19; 38%) cited several periods when it came to temporal distribution of great cormorants in Minho River, of which some (n=14) were able to tell exact months and others only mentioned seasons (n=5). The most cited month was January (n=7), followed by June, July, August, September, November, and December, which were cited six times each. February and March were mentioned five times, April and October were only mentioned four times, while May was the least cited month by fishermen (n=3). On the other hand, three fishermen (6%) mentioned winter as the time when cormorants were present in Minho River, one fisherman mentioned autumn (2%) and another fisherman (2%) mentioned warmer seasons, when the water is hotter. Only one fisherman (2%) was not able to answer.

3.4.2. Spatial distribution and habitat

Fishermen's answers allowed us to gather information not only about the great cormorant's geographical distribution but also about its habitat (Table 3). The most common answer for the distribution of *P. carbo* was through all Minho River (including the estuary) (18 citations), followed by Fort of Insuã (4 citations), Isle of Boega, Islets (in general) and the mouth of the river (3 citations each), Isle of Canosa and Lanhelas (2 citations). With only one citation each, fishermen mentioned Gondarém, Isle of Amores, Isle of Areeiro, Monção, Mota Quay (in Gondarém), São Pedro da Torre, and São Sebastião (in Seixas). Some interviewees identified Fort of Insuã (4 citations), Isle of Amores (1 citation), Isle of Areeiro (1 citation) and Monção (1 citation) as dormitories for great cormorants. The fisherman who mentioned Monção added cormorants rest on the eucalypts, specifically on the Portuguese margin. The fisherman who cited São Pedro da Torre said that is the only locality where he fishes, therefore that is the only place where he has spotted cormorants. Another fisherman (2%), who mentioned

both Lanhelas and Gondarém, explained that cormorants are often in these regions because there is a higher abundance of flounders (*Platichthys flesus*). Two other fishermen (4%) also claimed cormorants rest on the margins. Another fisherman (2%) said cormorants look for islets (like the Isle of Amores, the Isle of Boega and the Isle of Canosa) to dry their wings to be more protected.

For the habitat, fishermen often mentioned the margins of the river (23 citations). Other answers include sandbank (4 citations), trees (2 citations), deeper waters, reeds, the riverbed, rocks, shallower waters, stream entrances, stream exits and the surf zone (1 citation each). Two fishermen (4%) justified the presence of great cormorants in the margins because there is a higher abundance of European eel (*Anguilla anguilla*) in those spots. According to one of the two fishermen, it is due to whirlpools at the bottom of the river. Two other fishermen (4%) pointed out that cormorants look for isolated locations, and one of the two added they go away when anyone gets closer. Fishermen (n=2, 4%) also claimed that the accumulation of great cormorants' droppings in Fort of Insuã killed all the specimens of Hottentot-fig (*Carpobrotus edulis* (L.) N. E. Br.), and another one (2%) mentioned the same type of situation in a tree where the fisherman often spotted great cormorants. At last, two fishermen (4%) who sighted great cormorants through all Minho River added that this species goes after spots where more fish is available.

Table 3. Great cormorant's spatial distribution and preferential habitat, according to fishermen (n=50).

Areas	n	Habitat	n
Fort of Insuã	4	Deeper waters	1
Gondarém	1	Margins	23
Isle of Amores	1	Reeds	1
Isle of Areeiro	1	Riverbed	1
Isle of Boega	3	Rocks	1
Isle of Canosa	2	Sandbanks	4
Islets	3	Shallower waters	1
Lanhelas	2	Stream entrances	1
Monção	1	Stream exits	1
Mouth of Minho River	3	Surf zone	1
Mota Quay (Gondarém)	1	Trees	2
São Pedro da Torre	1		
São Sebastião (Seixas)	1		
Through all Minho River	18		

3.5. Diet and foraging behaviour

3.5.1. Prey

Most fishermen (n=37) reported great cormorants preyed fish species that are also targets of fishing activity, which includes *Alosa alosa* (Linnaeus, 1758), *Petromyzon marinus* Linnaeus, 1758, *Platichthys flesus* (Linnaeus,

1758), *Anguilla anguilla* (Linnaeus, 1758) in the stage of glass eel, *Dicentrarchus labrax* (Linnaeus, 1758), *Salmo salar* Linnaeus, 1758, and *Salmo trutta* Linnaeus, 1758.

The most cited fish species as prey of great cormorants were *A. anguilla* (n=37) and *P. flesus* (n=31). Other prominent preys include *P. marinus* (n=18), *A. alosa* (n=15), *D. labrax* (n=9), *Pseudochondrostoma duriense* (Coelho, 1985) (n=7), and *Chelon ramada* (Risso, 1827) (n=6). On the other hand, some fish species were mentioned only once or twice – *Achondrostoma arcasii* (Steindachner, 1866), *Chelon labrosus* (Risso, 1827), *Mugil cephalus* Linnaeus, 1758, and *Squalius carolitertii* (Doadrio, 1988) (n=2 each); *Carassius auratus* (Linnaeus, 1758), *Cyprinus carpio* Linnaeus, 1758, *Micropterus salmoides* (Lacepède, 1802), *S. salar* and *Solea solea* (Linnaeus, 1758) (n=1 each). One fisherman added cormorants eat not only fish, but also mussels (Mytilidae).

Table 4. Species mentioned by fishermen as prey of great cormorants in the Minho River region, Portugal (Cabral *et al.*, 2005; Froese and Pauly, 2020; Guterres, 2019, Aquamuseu do Rio Minho, 2020). (a) One fisherman differentiated glass eels as its own species.

Common/Local name	**Scientific name**	**Red Book of Vertebrates in Portugal**	**IUCN Red List (Global)**
Bogardo [pt]	*Achondrostoma arcasii*	Endangered – EN	Vulnerable – VU
Allis shad [en], Sável [pt]	*Alosa alosa*	Endangered – EN	Endangered – EN
European eel [en], Enguia-europeia [pt] [(a)]	*Anguilla anguilla*	Endangered – EN	Critically Endangered – CR
Goldfish [en], Pimpão [pt]	*Carassius auratus*	Not available	Least Concern – LC
Thicklip grey mullet [en], Negrão [pt]	*Chelon labrosus*	Not available	Least Concern – LC
Common carp [en], Carpa [pt]	*Cyprinus carpio*	Not available	Vulnerable – VU
European seabass [en], Robalo [pt]	*Dicentrarchus labrax*	Not available	Least Concern – LC
Thinlip grey mullet [en], Mugem [pt]	*Chelon ramada*	Not available	Least Concern – LC
Largemouth black bass [en], Achigã [pt]	*Micropterus salmoides*	Not available	Least Concern – LC
Flathead grey mullet [en], Tainha [pt]	*Mugil cephalus*	Not available	Least Concern - LC
Sea lamprey [en], Lampreia-marinha [pt]	*Petromyzon marinus*	Vulnerable – VU	Least Concern – LC
Flounder [en], Solha-das-pedras [pt]	*Platichthys flesus*	Data Deficient – DD	Least Concern - LC
Northern straight mouth nase [en], Boga [pt]	*Pseudochondrostoma duriense*	Not available	Vulnerable - VU
Atlantic salmon [en], Salmão-do-Atlântico [pt]	*Salmo salar*	Critically Endangered – CR	Least Concern - LC
Brown trout [en], Truta [pt]	*Salmo trutta*	Critically Endangered – CR	Least Concern – LC
Common sole [en], Linguado [pt]	*Solea solea*	Not available	Data Deficient – DD
Iberian chub [en], Escalo-do-norte [pt]	*Squalius carolitertii*	Not available	Least Concern – LC
Mussels [en], Mexilhões [pt]	Mytilidae	Not available	Not available

When questioned about *P. carbo* preferences regarding prey's life stage/size, nineteen fishermen (38%) told it does not have a preference, claiming it feeds on what is available. However, 28% of interviewees (n=14) claimed cormorants prefer smaller/juvenile fish. Six fishermen (12%) said these birds hunt both larvae and juvenile fish, while seven other fishermen (14%) mentioned they prefer both juvenile and adult fish.

In terms of fish consumption, 24% of all fishermen (n=12) were not able to tell great cormorant's daily food intake (DFI), that is how many kilograms (or grams) great cormorants eat per day. The lower value mentioned by fishermen was 0.150 kg, and the higher value was 10 kg, resulting in an average of 1.96 ± 1.86 kg day $^{-1}$ (± sd). Also, for those who could name a value for great cormorant's DFI, the mode was 1kg day $^{-1}$.

3.5.2. Foraging habits

About cormorants' foraging habits, interviewees, for the most part, claimed this species hunt alone (n=44; 88%) or, sometimes, in pair (n=2; 4%). However, few said they hunt in a group (n=3; 6%), while one fisherman (2%) mentioned they both hunt alone and in group. Almost half of the fishermen (n=23; 46%) alleged cormorants forage both in the morning and in the afternoon, while twelve other fishermen (24%) alleged they forage more often in the morning. Less frequent responses included both afternoon and evening (n=2; 4%), afternoon only (n=2; 4%), both early morning and sunset (n=1; 2%), and the entire day (n=1; 2%). When hunting in the morning (including "mornings only" and other answers that include this time of day), according to six fishermen (12%), *P. carbo* is usually seen at the break of day and early morning. One of these fishermen even points out that it happens because there is too much movement after those hours, which scares away the cormorants. Furthermore, some of the fishermen who deny that cormorants hunt in the evening (n=3; 6%) stated they collect for sleeping upstream and cannot locate the prey at night. However, nine other fishermen (18%) responded that it does not depend on the time of the day but the tides. So, of the nine, seven respondents claimed that great cormorants hunt when tides start lowering until they start rising. One even pointed out that this behaviour is because of fish being stuck in small wells when the tides lower, facilitating predation. On the other hand, two fishermen said cormorants preferred high tides, of which one mentioned it is because fish start entering the river and that creates more opportunity for predation.

3.6. Conservation attitudes

3.6.1. General opinion

Most fishermen (n=27; 54%) showed no dissatisfaction, of which eight fishermen showed a neutral opinion, claiming cormorants' presence was indifferent. On the other hand, 23 fishermen (46%) reveal themselves discontent for one main reason – consumption of commercial fish species. Four fishermen (8%) added the fact that cormorants eat mostly juvenile specimens, which prevents them to grow and reproduce, and one of the four even reinforced the problem was not necessarily the quantity of fish consumed, but the stage of life that fish are consumed.

3.6.2. Data analysis

The average value of the attitudes' index was 0.64 ± 0.27 (±sd), which suggests a moderate attitude of fishermen towards great cormorants, when classified according to the defined classes. Index of attitudes ranged from 0.15 to 0.95. Besides, half of the interviewees (n=25; 50%) presented positive attitudes towards our target species, while 34% of interviewees demonstrated moderate attitudes. Only eight fishermen (14%) held negative attitudes. The Cronbach's alpha for the part of the questionnaire that concerns the conservation attitudes' questions was 0.89, counting with a 95% confidence interval.

On the other hand, a significant and negative correlation was found between the age of fishermen and their conservation attitudes (r_s = -0.34, p = 0.01) (Figure 3). Hence, in this study, older fishermen tended to have more negative attitudes towards the conservation of great cormorants in Minho River.

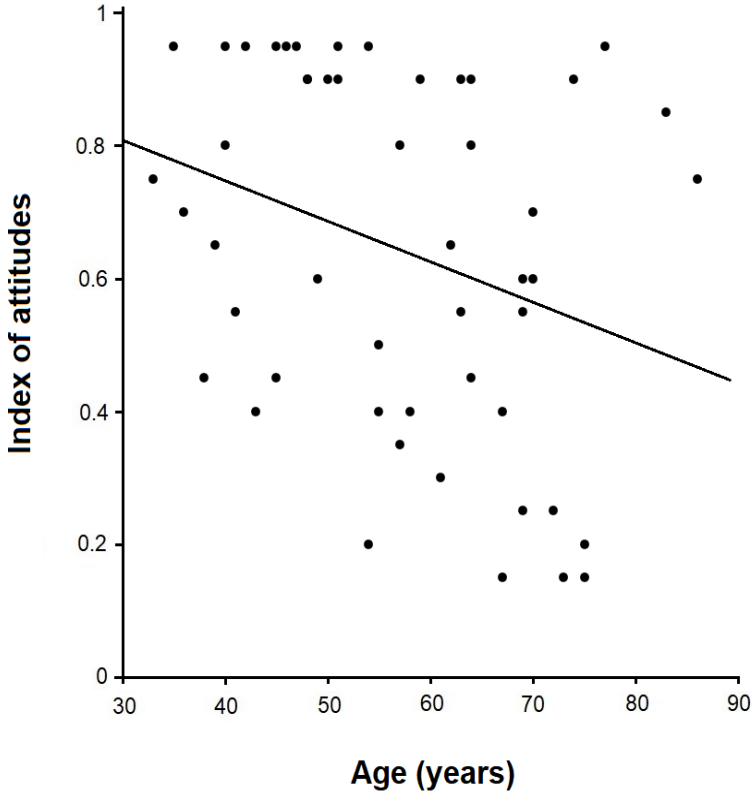

Figure 3. Significant and negative correlation between the mean index of attitudes and fishermen's age (years) (p = 0.02).

Also, Kruskal-Wallis *H* test's results showed significant differences between the median of groups A, B and C, regarding the index of attitudes ($\chi 2$ = 5.81, df = 2, p = 0.05). No other differences among groups were

significant (Figure 4). Then, the pairwise post-hoc Dunn test with Bonferroni adjustments, at a significance level of 5% ($\alpha = 0.05$), revealed only significant differences between individuals who fish 1 to 2 times a week – group A – and those who fish 5 to 7 times a week – group C ($p = 0.02$). Therefore, other comparisons did not show different behaviours in attitudes' index.

Ultimately, no significant correlations were found between attitudes and other variables in fishermen's profile – fishing experience (S = 25652, p = 0.11), average fishing time per trip (S = 20471, p = 0.91), number of children (S = 18359, p = 0.41), education level ($\chi 2 = 1.90$, df = 2p = 0.39), income ($\chi 2 = 0.13$, df = 2p = 0.94), and access to the internet (W = 200, p = 0.53).

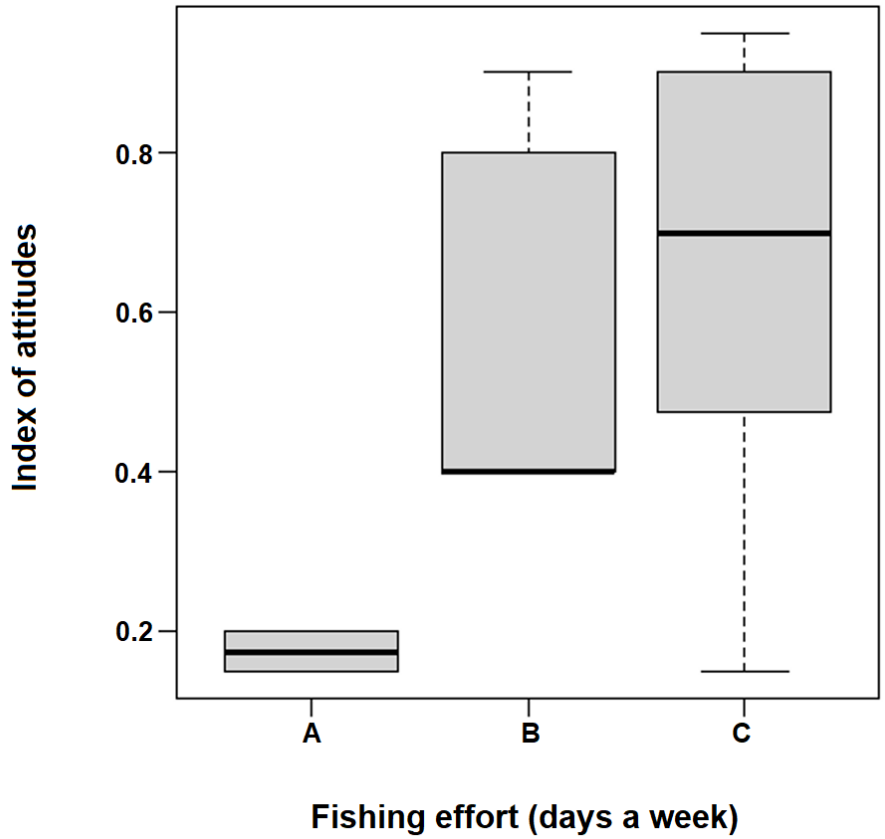

Figure 4. Comparison of the index of attitudes and fishermen's fishing effort. A=1 to 2 times a week; B= 3 to 4 days a week; C=5 to 7 days a week. Group A and Group B are significantly different (p = 0.02)

4. Discussion

4.1. Great cormorant's folk taxonomy

Corvo-marinho was the common name of *P. carbo* most cited by fishermen of Minho River. In both national and international databases (Aves de Portugal, 2021; Avibase, 2021), the target species is commonly designated, in Portuguese, as *corvo-marinho-de-faces-brancas*. However, Avibase repository displays other synonyms such as *corvo-marinho* and *corvo-marinho-comum*. Fishermen also cited names such as *pato-funduche, cormorante, garça* and *flamingo*. *Pato-funduche* can translate to *funduche* duck, alluding to a duck that dives deep/to the bottom. This nomenclature may be due to fishermen claiming great cormorants dive deep and the fact they may think cormorants and duck look alike. Also, *cormorante* is very similar to the English common name – great cormorant (Avibase, 2021). Thus, *cormorante* and *pato-funduche* could be possible new folk names. On the other hand, *garça* and *flamingo* are already associated with Ardeidae (Herons) and Phoenicopteridae (Flamingos), respectively (Avibase, 2021). Therefore, those common names do not seem appropriate for *P. carbo*.

Additionally, in Portugal, there are two species of Phalacrocoracidae, *P.carbo* and *Gulosus aristotelis* (scientific name according to BirdLife International, 2021a). One of the Portuguese vernacular names for *G. aristotelis* is *corvo-marinho-de-crista*, an identical common name to *P. carbo*, which could lead to misidentification of our target species. Yet, *G. aristotelis* is very rare in our study site (Aves de Portugal, 2021), so it is unlikely fishermen have misidentified specimens of *P. carbo*.

4.2. Abundance

The last survey we encountered on the wintering *P. carbo* population in Portugal was in 2013 and counted with 15 000 specimens (Leitão *et al.*, 2013 in Meirinho *et al.*, 2014). Nevertheless, Costa and Rufino (1996) found that the national wintering population of great cormorants increased fourfold between the 1980's and the 1990's, counting with 4.000 individuals. This could be a result of the adoption of The Birds Directive (Council Directive 9/409/EEC) in 1979, and, nationally, Decreto-Lei nº 75/91. Starting to ban dichloro-diphenyl-trichloroethane (DDT) in the 1970's can also be a promoter of the increase of great cormorant's population, since this pesticide is responsible for affecting birds' reproduction success and their feeding behaviour (Mitra *et al.*, 2011). This data coincides with those fishermen who noticed the increasing trend of great cormorant's population, especially with the exponential population growth 20 to 30 years ago mentioned by one fisherman.

Yet, few interviewees declared they do not see cormorants very often nowadays, which one of them blames the construction of walkways. Bötsch *et al*. (2018) found that recreational trails had a negative impact on forest birds. They also concluded that the main source of disturbance was not the process of construction, but the presence of humans. The same situation might be happening in Minho River in certain locations, scaring cormorants away to other areas.

4.3. Habitat and distribution

4.3.1. Temporal distribution

It is known that *P. carbo* does not breed in Portugal and stays in this country from September to April, which makes it a wintering species. Nonetheless, there are a few specimens who are resident in Portugal, such as immature and non-breeding individuals (Bregnballe *et al.*, 2014; BirdLife International, 2019; Aves de Portugal, 2021). Most fishermen (n=31, 62%) affirmed great cormorants appear in Minho River throughout the entire year, and, also, some (n=4; 8%) told this species is resident. Therefore, it is possible that the specimens sighted by fishermen between May and August were non-breeding or even immature. January was the most cited month (7 citations) as staying period of cormorants in Minho River, supporting the literature, as well as September, November, and December (6 citations), February and March (5 citations), and April and October (4 citations), and other answers like "winter" and "autumn". Yet, with six citations each, June, July, and August may represent sighting of those two types of individuals mentioned earlier, as well as another type of answer like "warmer seasons".

On the other hand, a study by Almeida (2008) found one couple of great cormorants breeding for the first time in Portugal, in a colony of herons in Dejebe Creek. In the following year, three couples were found again breeding nearby the previous location, nesting in aspen trees (*Populos* sp. L.). Even though this location is far away from our study site, it allows the possibility of similar events occurring in the future in other regions of this country.

4.3.2. Spatial distribution and habitat

Wetlands are the main type of ecosystem inhabited by *P. carbo*, and it is present in the Minho River region (Sousa *et al*., 2008; Meirinho *et al*., 2014). Also, this species is often associated with habitats such as sandbanks, rocks, large lakes, and trees near to a water mass (Nicolai *et al*., 2001). Sandbanks (4 citations), trees (2 citations), and rocks (1 citations) were a few habitats also mentioned by our interviewees. Reeds were also cited by one fisherman and are typically found in wetlands. Shallow waters are also mentioned by one fisherman, and are considered favourable for hunting (Musil *et al.*, 1995; Johansen *et al.*, 2001). No published data showed any evidence of deeper waters, riverbeds, and surf zones to be a preferential habitat for cormorants. Great cormorants are spotted in streams, without any specification about being present particularly in the entrance or in the exit (Sutter, 1995). Minho River's fishermen often mentioned margins as cormorants' main habitat. Throughout the course of the river, margins are mostly composed by trees and riparian vegetation, an important type of vegetation in wetland ecosystems (Nilsson *et al*., 2010). Therefore, the concept of margin may not be the actual preferential habitat for great cormorants, but the vegetation associated with it.

Regarding the distribution of *P. carbo* in Minho River, there is not any literature to corroborate the fishermen's LEK. However, according to observation reports registered on eBird (2021), great cormorants are spotted all through the Minho River, like fishermen (18 citations) revealed in the present study. It is also shown a

higher number of observations in the mouth of the river, as well supporting our data. These records depend only on people registering observations, meaning it does not represent the entire distribution of a species.

4.4. Diet and foraging behaviour

4.4.1. Prey-species

Fishermen of Minho River reported great cormorants' prey on some fish species that they fish. Allis shad (*A. alosa*), European eel (*A. anguilla*), sea lamprey (*P. marinus*), Atlantic salmon (*S. salar*), and brown trout (*S. trutta*) are not only both fishing targets and great cormorant's prey, according to the interviewees, but are also endangered, vulnerable or critically endangered in Portugal (Cabral *et al.*, 2005; Table 4). If *P. carbo* feeds on these fish species and theirs conservation statuses can reflect smaller population size, it could lead to a conflict between fishermen and cormorants.

In Portugal, there are few studies regarding great cormorant's diet (e.g., Dias *et al*., 2012; Catry *et al*., 2017). Dias *et al.* (2012) showed that Cyprinidae, Mugilidae and Pleuronectidae (e.g., *P. flesus*) were the most frequent fish families consumed by *P. carbo* in Minho estuary. Likewise, *P. flesus* was also one of the most cited preys in our study. Other fish species found simultaneously in this work and Dias *et al.* (2012) include *A. anguilla, C. carpio, C. labrosus, C. ramada, D. labrax, S. solea,* and *S. truta*. Fishermen also cited Iberian chub (*Squalius carolitertii*), but literature only identified samples up to the genus (*Squalius* sp.). In parallel, Catry *et al*. (2017) found that mullets (Mugillidae) were *P. carbo*'s most common prey in Sado estuary, followed by seabreams (*Diplodus* sp.), toadfish (*Halobatrachus didactylus* (Bloch & Schneider, 1801)), and soles (*Solea* sp.). Therefore, in comparison with this work, we also found similar results in cormorants' diet, which includes *C. labrosus, C. ramada, D. labrax,* and *M. cephalus.* However, fishermen mentioned common carp and common sole as preys, while Catry *et al*. (2017) were only able to identify specimens as Cyprinidae and *Solea* sp., respectively.

In agreement with these two studies, fishermen's local knowledge also shows that *P. carbo* has a very diverse diet, feeding on pelagic (e.g., *A. alosa, S. trutta*), benthopelagic (e.g., *S. salar, P. duriense*), and demersal fish (e.g., *A. anguilla, P. flesus*). Although not supported by published data on trophic ecology, one fisherman even claimed that cormorants can eat mussels. This suggests that great cormorants take advantage on what fish is available, implying they are opportunistic and generalist feeders, which as be proven to be true before (Carss, 2003; Kirby *et al*., 1996; Dias *et al*., 2012; Catry *et al*., 2017).

4.4.2. Prey size

Some studies revealed that *P. carbo* prey on juvenile and smaller fish, which can affect the recruitment, and lead to a decreasing population trend (Källo et al., 2020; Mustamäki et al., 2014; Troynikov et al., 2013). According to Gagliardi *et al*. (2015), cormorants seemed to select smaller sized fish (fish with body mass bellow 0.110 kg). However, the same study showed that our target species consumed burbot *Lota lota* (Linnaeus, 1758) of different life stages. This could suggest that great cormorants may not select fish according to its life stage, but

according to its size. Our results are partially supported by published data, since 28% of fishermen claim that great cormorants prefer smaller/juvenile fish. However, 38% of fishermen say cormorants prey on what is available and have no preference. We mentioned before that *P. carbo* is an opportunistic feeder, which can indicate that they do not necessarily have a preference. A possible explanation is that they often prey on smaller fish, because it could be an easier catch. Ovegård *et al*. (2017) mentioned that cormorants often suffocate while trying to swallow bigger fish, sometimes resulting in death, and showed a case where a cormorant was strangled by an eel. Therefore, bigger fish can be harder to swallow and more resistant.

4.4.3. Daily food intake (DFI)

There is not a precise number when it comes to great cormorant's daily food intake, since it can vary according to different parameters, such as body mass, time resting, time in water, and water temperature (Grémillet *et al*., 2003). Grémillet (1997) revealed that the mean DFI for great cormorants was 0.828 kg day $^{-1}$, whereas Čech and Vejřík (2011) obtained a mean DFI of 0.397 kg day $^{-1}$. Alternatively, Grémmilet *et al*. (2003) modelled the daily food intake for *P. carbo* through published data and data obtained from captive cormorants, resulting in a mean DFI of 0.672 kg day $^{-1}$. According to the Minho River fishermen, cormorant's daily food intake was, on average, 1.96 kg day $^{-1}$. Although the mean DFI that we found much higher than the studies previously mentioned, some fishermen (n = 10; 20%) did mention values that agree with those previous studies. Also, the most mentioned value by fishermen was 1 kg day $^{-1}$, which is similar to the results found in Grémillet (1997). Therefore, it is important to understand that published data can support some of the answers from fishermen.

4.4.4. Foraging habits

Phalacrocoracidae is considered gregarious, but *P. carbo* may not always be a social species (Heinzel *et al*., 1995). Lekuona and Campos (1996) found that cormorants hunt solitarily most of the time, but they also observed social hunting in 33% of the time. On the other hand, van Eerden and Voslamber (1995) proposed that our target species changed from foraging alone to foraging in group, as an adaptation to water turbidity. In Minho River, we also obtained various types of information, even if most fishermen (88%; n=44) alleged that *P. carbo* hunts alone. Thus, we suggest that solitary foraging could be the most common behaviour in great cormorants, which can be altered due to adaptation to external factors, like water turbidity in van Eerden and Voslamber (1995).

White *et al*. (2007) found that great cormorants have very poor visual performance for a predator, especially when compared with terrestrial birds. Grémillet *et al.* (2005) revealed that light conditions did not interfere with cormorants' daily activities during Polar night, maintaining their diving behaviour, which usually occurred between 5am and 8pm. Yet, Johansen *et al.* (2001) showed that *P. carbo* fed mainly in the morning and afternoon but concluded that was due to metabolic demands and length of the day. That is, poor insulation and shorter days resulted in less foraging sessions. In our study, almost half of the fishermen observed the same results as the last-mentioned study – hunting bouts in the morning and afternoon. Fishermen also were supported

by published records when saying cormorants feed at the break of day. However, three interviewees told that these birds cannot locate the prey at night, which proves to be false, according to Grémillet *et al.* (2005). When it comes to the fact that foraging depends on the tides, there is no evidence. Although, it has been proven that *P. carbo* seems to prefer hunting in shallow waters (Musil *et al*., 1995; Johansen *et al*., 2001). Nevertheless, one fisherman pointed out that cormorants prey on fish stuck in wells during low tides, which can be an interesting predation strategy to analyse in the future.

4.5. Conservation attitudes

The high Cronbach's alpha value indicates that our interviews were consistent internally and reliable to analyse fishermen's attitudes (Gliem and Gliem, 2003). Fishermen in Minho River showed an overall moderate conservation attitude towards great cormorants, where half of them showed a positive attitude. However, in other studies, fishermen seem to have a more unfavourable perception towards this bird, blaming it for depredating the environment and supporting its extermination (Pyrovetsi and Daoutopoulos, 1989; Daoutopoulos and Pyrovetsi, 1990; Peeva *et al*., 2017).

Besides, we found that younger fishermen tended to have more positive attitudes towards the conservation of our target species. The same relation was found in Braga *et al*. (2017b), where older fishermen tended to have a more negative conservation attitude towards the European sardine *Sardina pilchardus* (Walbaum, 1792). Shuib *et al*. (2012) also found that age was correlated with attitudes towards the conservation of the deltaic mangrove forest areas, where the younger generation had more positive attitudes. However, Allendorf *et al*. (2006) did not notice a significant relationship between age and attitudes towards protected areas in Myanmar.

We propose three reasons for our results. The first one is that the younger fishermen might be more aware of environmental issues and the importance of conserving biodiversity. Since all the fishermen we interviewed are older than 30 years different interviewed cohorts were educated under a different educative, socio-environmental, socio-cultural and political scenarios (namely under different environmental pressures). Also in 1986, Portugal became part of the European Union, which led to a greater focus on conservation programmes (European Union, 2021). The second one is that, in the past when older fishermen were more active, the same environmental issues were not such a priority, and, therefore, there were probably less environmental restrictions. At last, if great cormorants have, in fact, a considerable impact on fish stocks, their recent increase in abundance can be another reason for older fishermen have had unfavourable attitudes towards this species.

Fishing effort was also correlated with fishermen's attitudes, that is, fishermen who went fishing very often (5 to 7 days a week) tended to have more positive attitudes than fishermen who went fishing less often (1 to 2 times a week). To our knowledge, this is the first time that was found a relationship between the number of fishing trips and fishermen's attitudes. A possible reason for that can be that fishermen who spend more time in the river can be more accustomed to the presence of great cormorants.

One interesting point we noticed throughout some interviews was a change of a pre-conceived thought. At the beginning of the projective test, where fishermen tried to identify *P. carbo*, they often mentioned this species was "the destroyer of the river", "the biggest predator of the river", that it "ate all the fish", among other variations of these negative claims. Nonetheless, during the rest of the interview, some (n=10) ended up showing a moderated attitude towards the presence of great cormorants in Minho River. This suggests that interviewees may have shaped their perceptions by reflecting on our questions. Nevertheless, attitudes are mouldable, but it takes time and effort to change a perception (Pickens, 2005). Thus, it might be ambitious to claim that they in fact changed perceptions that quickly. Perhaps those comments were an instant reaction, coming from a stigma around cormorants, and then when asked particular questions fishermen were able to answer with their own observations.

The fact that *P. carbo* is not under any degree of threat makes its conservation a non-priority matter. Yet, its impact on the fish stocks has been a constant concern for fishermen around the world (Volponi *et al*., 2005). Local control of these birds is being attempted in few locations (Volponi *et al*., 2005). It is legal to only kill a low number of cormorants, when compared with the total number of individuals (Volponi *et al*., 2005). Therefore, it is not significantly affecting the population, and proves to be not effective (Volponi *et al*., 2005). Chamberlain *et al*. (2013) also showed that license control at local scales did not have a significant impact on population level in the following winter.

Almost half of fishermen (n=21; 42%) revealed they believe that the population of great cormorants in Minho River should be controlled. Some propositions for control methods include hunting in certain periods of the year, "scientific methods" and the method that was used in yellow-legged gulls (*Larus michahellis* J. F. Naumann, 1840) in the Berlenga Island (that was referred as "chemical system"). Yet, this last proposition was not a chemical procedure, but a birth control. In Berlenga Island, Portugal three methods have been tested throughout the years: destruction of eggs, egg-oiling, and egg puncture. The first one is the most effective and the most used (SPEA, 2019). However, this methodology was applicable because yellow-legged gulls nest in the Berlenga Island. Using destruction of eggs in great cormorants implies that they nest in Minho River, which has not yet been proven. Hence, this method would not be the most fitting.

The question remains: is it necessary to control the population of great cormorants in Minho River? It is not possible to tell now. The lack of current and updated scientific data is an obstacle in the progress of establishing a management plan. The present study establishes a base on the LEK of Minho River's fishermen and their perceptions on great cormorants. Sharing this information with the scientific community brings the attention to issues that need to be addressed, like this one. Even if presenting an overall moderate attitude, some fishermen agree that there should be a population control, and few do attribute all the culpability to cormorants. Some mention pollution and even overfishing as reason for decreasing fish stocks.

5. Conclusion

This was first study in Portugal related to the local ecological knowledge and conservation attitudes towards *Phalacrocorax carbo.* Minho River's fishermen showed knowledge about this species and brought up the need for more information about wintering cormorants in Portugal. Their conservation attitudes towards this bird were moderate, unlike other studies on the same subject. Yet, older fishermen tended to show more negative attitudes. Significant differences were also noticed between those who fish very often (group C) and those who fish more rarely (group A). That it, those who went fishing frequently tended to have more positive attitudes.

In addition to previous ethnobiology-related studies, we express the importance of local ecological knowledge and community's attitudes to the environment. The gap in updated ecological and biological information about *P. carbo* can be complemented by LEK, but we reinforce the need for more studies regarding population structure nationally. Only then, it is possible to merge both scientific knowledge and traditional knowledge to form a plan that regards the fishing community preoccupations and needs. In parallel, educational programmes using the information that it currently available for our target species can be useful. It has been shown that greater knowledge can reflect on more positive attitudes (Kuentzel *et al*., 2012). Addressing other issues like pollution and its impact on fishing activity and fish stocks can also be relevant. At last, since Minho River is an international river, ethnobiological studies regarding the great cormorant can also be important to understand Spanish fishermen's perceptions towards this species. Subsequently, their findings can be compared with our results, in order to better assess the conflict in both margins.

6. References

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7. Appendix

Appendix 1**:** Statement of Informed Consent that was given to the fishermen.

Statement of Informed Consent

Dear respondent,

My name is Beatriz da Silva Pereira Ribeiro Vieite. I am a master's degree student in Applied Biology at the University of Aveiro and I am doing a study about Minho River fishermen's knowledge regarding the great cormorant. The main goal of this study is to know the local ecological knowledge of fishermen concerning the great cormorant (*Phalacrocorax carbo*), such as its diet, in particular its main prey-species in this region and understand the interaction between fishermen and this species. Thus, I will assess fishermen's attitudes towards this bird, exploring topics like population control and impacts on fish stocks.

To accomplish this work, I need to talk with a few fishermen, just like you. If you are comfortable in participating in this study I will, then, apply a questionnaire with questions regarding the great cormorant. If you allow, interviews can be recorded through a smartphone. Those recordings with registered information would be kept in safe in the university facilities. If authorized, I will take some pictures of the fishing gear, of the fishing activity or of the target species. Those images can only be released in scientific journals or reunions as illustrative images. If you want to quit the interview at any point you will not be affected in any way. Your identity will be kept confidential and only the information will be registered. If you allow, your name can be noted in the interview guideline in case I need to contact you again to collect other data.

Your views will be very important for this study because the data collected in the interviews could contribute to the conservation of the environment, to the local ecological knowledge about great cormorants and to preserve the culture and tradition of artisanal fishermen. Collected data is not only going to be part of work that could be published in scientific journal, but also part of my master's thesis that you be presented to the university. This information will subsequently be disseminated to the Minho River's fishermen for everyone's knowledge, by means of posters or self-explanatory leaflets.

If you agree to participate in this interview, please sign this statment of consente, that will also be signed by me, the responsible researcher. Thereby, one copy will stay with me and another copy will be given to you. If you do not want to sign, that is your decision to make, and it will be respected. When in doubt, please ask. Thank you in advance. My work address is in the Department of Biology, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.

Phone number:(+351)939268691 E-mail: bea.vieite@ua.pt.

I, _____, age: ____, agree to participate in the research entitled "Fishermen's conservation attitudes and local ecological knowledge about the great cormorant (*Phalacrocorax carbo*) in the Minho River, Portugal.", having been duly informed and clarified as set out above.

_____ _____

Beatriz Vieite
(Responsible researcher)

Volunteer signature

_____, ____ / ____ / ____.

Locality day month year

Appendix 2: Semi-structured interview script applied to the fishing villages of the Minho River regarding the great cormorant (*Phalacrocorax carbo*).

Semi-structured interview

*Prior to the interview, the Statement of Informed Consent is read.

1- Fisherman's profile

Age: _____. **Locality:**_____ **Time of residence in Minho region (years):** _____.

Education level ( ) A: Low (1 – 4 years of studying). ( ) B: Basic (5-9 years of studying). ( ) C: Intermediary or High (>10 years of studying).

Monthly Income: ( ) A: Up to 600€. ( )B: 601€ to 1200€ ( ) C:Above 1200€.

Other sources of income:_____.

Access to the internet? ( ) Yes. ( ) No.

Currently fishing ( ) Yes. ( ) No. **Retired** ( ) Yes ( ) No.

Fishing experience (years)? _____.

How often do you go fishing? ( )A :1 to 2 days/week. ( )B: 3 to 4 days/week. ( )C: 5 to 7 days/week.

How many hours do you usually go fishing ? _____ hours.

Main fishing sites?

_____

What fish species do you fish? What type of gear do you use?

_____

_____

2- Fisherman's Local Ecological Knowledge (LEK):

a. **Have you ever seen this species in Minho river/estuary? (Projective test)**

b. ( ) Yes. What do you call it? _____. ( ) I do not recognize it.

c. **In what time of the year do you see great cormorants more often in Minho River?**

_____

d. **Does this bird feed on the same fish that you usually catch?** ( ) Não. ( ) Sim.

e. **What fish species?**

_____

f. **Can you cite any other fish species that great cormorants also feed on in Minho River?**

_____

g. Does this bird have a preference for the fish size?

( )A: Larvae. ( )B: Smaller/Juvenile. ( )C: Bigger/Adult. ( )D: It does not have a preference

h. Does it usually hunt alone or in group? _____

i. **How much fish do you think it eats in a day (grams or kilograms)?** _____ g or Kg.

j. **When does it hunt (time of day)?** ( ) Morning - 6am-12am ( ) Afternoon – 12am-6pm. ( ) Night – 7pm-6am.

k. **In which sites does it appear more often?**

_____

l. Do you have any negative feeling or are you discontent with the presence of great cormorants in Minho River? Why?

_____

_____

m. Do you have any belief or superstition associated with this species?

_____

_____

3- <u>Conservation attitudes:</u>

a. How have you proceed in your interaction with cormorants?

( ) You try not to disturb them or fishing in areas where they were not present. Their presence was indifferent. – Positive Attitude (PA).

( ) If needed you would scare them away, but not to a point of causing any harm. You prefer them alive in the environment – Moderate Attitude (MA).

( ) You try to scare them away in any way, without concerning. You think they hinder the fishing activity and bring no benefit.– Negative Attitude (NA).

b. Do you believe it is possible to coexist with cormorants while fishing?

( ) Totally agree – PA. ( ) Neither agree nor disagree – MA. ( ) Do not agree –NA.

c. Do you believe cormorants are the main cause of the decreasing fish stocks?

( ) Totally agree – NA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – PA.

d. Do you believe the cormorants' population should be reduced in the Minho region by environmental managers?

( ) Totally agree – NA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – PA.

e. Do you believe that are too many cormorants and that they cause negative impacts on humans and other animal?

( ) Totally agree – NA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – NA.

f. Do you believe cormorants can bring any benefit for the fishing activity and for fish stocks?

( ) Totally agree – PA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – NA.

g. Do you believe hunting cormorants either recreationally or for consumption should be legal?

( ) Totally agree – NA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – PA.

h. Do you believe using instruments that can scare cormorants away (without having negative effects on them) would be a good option?

( ) Totally agree – PA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – NA.

i. In case you witnessed any situation of illegal hunting or killing of cormorants, would you report to the authorities?

( ) Totally agree – PA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – NA.

Notas:_____
_____

j. Do you believe cormorants have the right to live in your region?

( ) Totally agree – PA. ( ) Neither agree nor disagree – MA. ( ) Do not agree – NA.