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The non-consumptive economic value of wildlife: the case of three cetacean species

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Summary: The conservation of wildlife is one of the most pressing issues in the current times, but wildlife conservation economic values have often been largely ignored due to an absence of market prices, as setting an economic value on biodiversity or whole ecosystems can be challenging. Nevertheless, valuing wildlife can be of great significance to improve decision-making in the conservation field, as it can provide a complementary perspective based on economic principles. Whale-watching provides an opportunity for the economic valuation of wildlife. Specifically, it offers a framework in which the economic revenue allows the economic valuation of the targeted cetaceans to be estimated through the direct and indirect expenditure of the tourists who purchase whale-watching tours. Here, we performed an economic analysis based on population abundances of the three main species targeted by the whale-watching companies in the Strait of Gibraltar (Spain): long-finned pilot whales (*Globicephala melas*), common dolphins (*Delphinus delphis*) and killer whales (*Orcinus orca*). These species generated a total annual income of €4,089,056, €1,876,833, and €505,389, respectively, and each individual would generate an average of €14,048, €951, and €36,099 each year, respectively. Incorporating life expectancy, this corresponded to a total population value of €112,426,185, €16,685,147, and €19,171,107, respectively, over their lifetime. These values provide an idea of the potential contribution of cetaceans to the local economy but only represent their non-consumptive value based on tourism. Our results reinforce the idea that a sustainable, high-quality whale-watching culture, under ACCOBAMS High-Quality Whale-Watching requirements, should be promoted to ensure a sustainable industry, stable economic income and the viability of cetacean populations in the Strait of Gibraltar.

Keywords: common dolphin; killer whale; long-finned pilot whale; Mediterranean; whale-watching; wildlife economic valuation.

El valor económico no consumitivo de la vida salvaje: el caso de tres especies de cetáceos

Resumen: La conservación de la vida salvaje es uno de los retos clave del mundo actual. Sin embargo, los valores económicos derivados de la conservación de la vida salvaje a menudo han sido pasados por alto debido a la ausencia de precios de mercado, ya que asignar un valor económico a la biodiversidad o a ecosistemas enteros puede ser complejo. No obstante, valorar la vida salvaje puede ser de gran importancia para mejorar la toma de decisiones en el campo de la conservación, ya que puede proporcionar una perspectiva complementaria basada en principios económicos. El avistamiento de cetáceos brinda una oportunidad para realizar este tipo de valoración económica. Específicamente, ofrece un marco en el cual los ingresos económicos generados permiten la evaluación y estimación del valor económico de los cetáceos objetivo basado en el gasto directo e indirecto de los turistas que realizan tours de avistamiento de cetáceos. En este estudio, realizamos un análisis económico basado en las abundancias poblacionales de las tres principales especies objetivo de las compañías de avistamiento de cetáceos en el Estrecho de Gibraltar (España): calderones comunes (*Globicephala melas*), delfines comunes (*Delphinus delphis*) y orcas (*Orcinus orca*). Estas especies generaron respectivamente un ingreso total anual de 4.089.056 €, 1.876.833 € y 505.389 €, donde cada individuo generaría un promedio de 14.048 €, 951 € y 36.099€ cada año. Al incorporar la esperanza de vida, esto se correspondió con un valor total de la población de 112.426.185 €, 16.685.147 € y 19.171.107 € a lo largo de su vida. Estos valores brindan una idea de la contribución potencial de los cetáceos a la economía local, pero solo representan su valor no consumitivo basado en el turismo. Nuestros resultados refuerzan la idea de que se debe promover una cultura de avistamiento de cetáceos sostenible y de alta calidad, bajo los requisitos de observación de cetáceos de alta calidad de ACCOBAMS, para garantizar una industria sostenible, ingresos económicos estables y la viabilidad de las poblaciones de cetáceos en el Estrecho de Gibraltar.

Palabras clave: delfín común; orca; calderón común; Mediterráneo; avistamiento de cetáceos; valoración económica de la vida salvaje.

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INTRODUCTION

The conservation of wildlife is among the most pressing environmental issues faced by contemporary society (Mace et al. 2018), and an effective way to highlight the severity of biodiversity loss and the need to enhance its conservation is to put an economic value on it (Beaumont et al. 2008, Salles 2011). The total economic value of biodiversity has been described to be the result of two main units: (i) total economic use value; and (ii) total economic non-use value (Tisdell and Wilson 2003). Use values are divided into a) consumptive use values, i.e. goods provided by a species or an ecosystem that can be consumed and used by people, and b) non-consumptive use values, i.e. those which generate use-benefits for humans but do not require the good or service to be consumed (Loomis and White 1996, Campbell and Smith 2006). Conversely, non-use values are subdivided into a) legacy values, i.e. willingness to preserve it for future generations, b) existence values, i.e. knowledge of presence, and c) option values, i.e. knowledge that a good will exist for one's personal experience sometime in the future (Loomis and White 1996, Jakobsson and Dragun 2001).

Non-consumptive and non-use values of wildlife are usually closely linked to cultural ecosystem services (i.e. ecosystems' contribution to the non-material benefits that arise from human-ecosystem relationships), and they are usually the most difficult to value in economic terms (Kareiva et al. 2011). However, the Economics of Ecosystems and Biodiversity initiative identified a subset of cultural ecosystem services that are generally suitable for traditional economic valuation such as cultural heritage, educational values and tourism (de Groot et al. 2010, Ring et al. 2010). The case of tourism is especially worth mentioning, as it has been one of the most consistently growing global industries, rising from 25 million up to 1.5 billion international arrivals (i.e. tourist visits) from the 1950s to 2019 (World Tourism Organization 2020). Equally, nature-based tourism (i.e. with the specific motive of enjoying wildlife) is an expanding sector, mainly due to the increase in natural protected areas worldwide and the popularity of wildlife documentaries (Middleton and Hawkins 1993, Dicken 2010, Mangubhai 2020). These nature-based activities are particularly linked to the non-consumptive value of wildlife from an economic point of view (Gallagher and Hammerschlag 2011). Concurrent with the sector's growth, the industry of nature-based tourism changed towards being more socially and environmentally responsible and became collectively known as "ecotourism" (World Tourism Organization 2020). Ecotourism has now spread globally, but it has caused controversy in the field of conservation field since its emergence in the late 1980s, as case studies have shown tourism to be either detrimental or beneficial to the conservation of the target species and local economies (Burns and Howard 2003, Kirkby et al. 2011, Pérez-Jorge et al. 2016, Shawky et al. 2020).

Ecotourism is based on the observation and appreciation of nature, and the money generated by the activity may come from a range of sources. First, direct expenditure comes from the price paid by consumers (i.e. the ticket price; Samonte-Tan et al. 2007, David-Negre et al. 2018) which is not only influenced by market prices but also by the money that a potential consumer is willing to pay for the experience offered. This concept is known as "willingness to pay" (Just et al. 1982), and it is not evenly distributed among wildlife species. Several studies have found that consumers' willingness to pay for a species is strongly influenced by several factors, such as the species itself and whether the species is considered as "charismatic megafauna" (Loomis and White 1996, Martín-López et al. 2007, Richardson and Loomis 2009, Van Tonder et al. 2013). Second, indirect expenditure is the money that consumers may also spend on accommodation, food, communication, souvenirs and domestic travel, constituting the indirect gross revenue of ecotourism (Samonte-Tan et al. 2007, David-Negre et al. 2018). Within marine tourism, whale-watching has expanded dramatically as a commercial tourist industry over the last three decades. The most recent estimate of the economic value of the industry suggests that it generated a total global revenue amounting to US$2.1 billion while supporting around 13,200 jobs in 2008 (O'Connor et al. 2009). However, these numbers are likely to be considerable underestimates compared with the potential current revenue of whale-watching, as they were calculated more than a decade ago. Assuming a steady rate of increase (3.7%; Hoyt and Parsons 2014) and ignoring inflation, whale-watching could have a current global revenue of roughly US$ 3.6 billion. Furthermore, whale-watching can be an example of sustainable ecotourism when it places a strong emphasis on education and conservation, benefits the local population, and complements (rather than replaces) existing activities. However, when conducted irresponsibly, it can harm the targeted cetacean populations (Magalhães et al. 2002, Visser et al. 2011, Rossi-Santos 2016).

The Strait of Gibraltar is a whale-watching hotspot (Carbó-Penche et al. 2007, de Stephanis 2008a). There, long-finned pilot whales (*Globicephala melas*), killer whales (*Orcinus orca*) and common dolphins (*Delphinus delphis*) are the main species targeted by whale-watching operators and support the existence of the activity (de Stephanis et al. 2008a, Esteban et al. 2016b). We used the cetaceans of the Strait of Gibraltar as a case study to (i) quantify the economic value of the whale-watching activity in the Strait of Gibraltar and the Bay of Algeciras and (ii) calculate the non-consumptive value of three cetacean species in the study area while setting up a baseline that can be useful for comparisons with more contemporary estimates, particularly after the COVID-19 outbreak.

MATERIAL AND METHODS

Study area and cetacean species

The study area encompasses the Strait of Gibraltar and the Bay of Algeciras (Fig. 1). The Strait is nearly 60 km long and has a mean width of 20 km. Its oceanography is characterized by mixing processes through a pulsed upwelling induced by tides (Echevarría et al. 2002). This is reflected by the "boiling water" phenomenon, which produces vertical advection and mixing dynamics that ultimately lead to enhanced productivity (Bruno et al. 2002). This may explain the high density of cetaceans encountered regularly (seven out of the nine Mediterranean common species; Reeves et al. 2006, de Stephanis et al. 2008a). In this setup, one may suggest that the relatively high diversity of cetacean species observed at the entrance to the Mediterranean Sea could be related to a large number of cetaceans transiting in and out of the basin. However, photo-identification studies showed that several species are year-round residents in the Strait [i.e. long-finned pilot whales (Verborgh et al. 2009), common dolphins (Giménez et al. 2011) and bottlenose dolphins (*Tursiops truncatus*; Tenan et al. 2020)]. Long-finned pilot whales are observed year-round in the central area of the Strait, south of Tarifa (de Stephanis et al. 2008b, Verborgh et al. 2009; Fig. 1). Common dolphins are found year-round but especially during the summer season, when a large number of individuals tend to concentrate to feed and breed inside the Bay of Algeciras (Giménez et al. 2011). In contrast, killer whales have been described as seasonal residents in the Strait of Gibraltar, as the same individuals (or social groups) are regularly resighted in spring and summer (Esteban et al. 2016b). This seasonality is due to the gametic migration performed by their main prey, Atlantic bluefin tuna (*Thunnus thynnus*) in late spring, when killer whales forage actively on tuna around trap nets (Guinet et al. 2007) or the artisanal drop-line fishery (Esteban et al. 2016b). The abundant presence of cetaceans in the Strait of Gibraltar has allowed the development and growth of a whale-watching activity that focuses

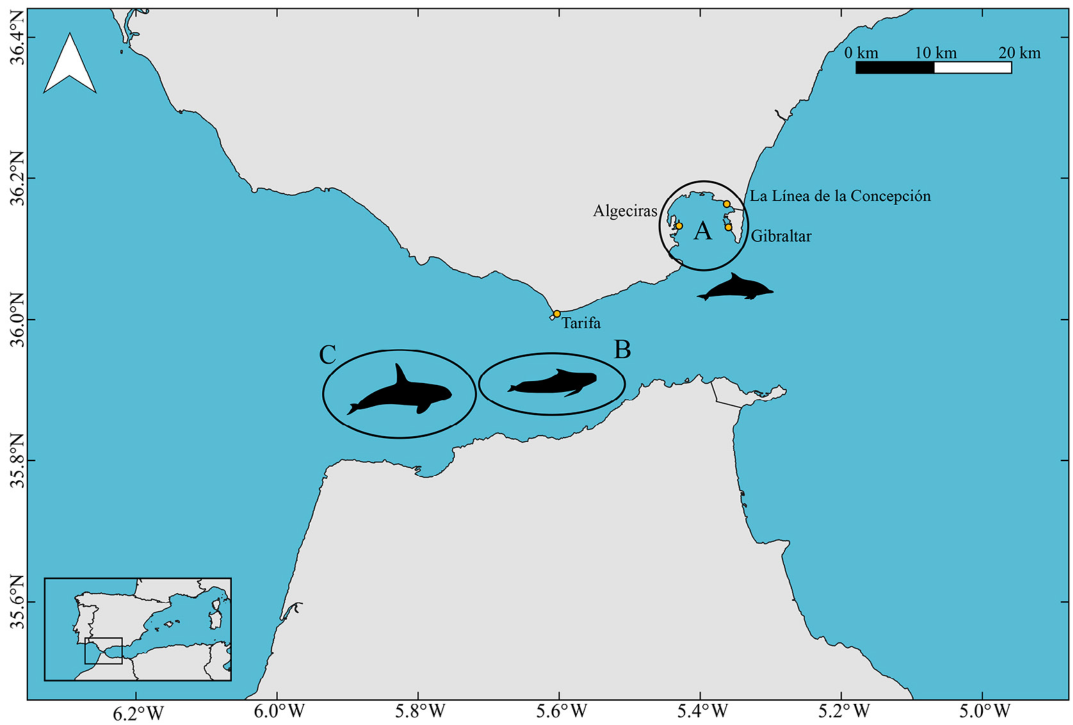

Fig. 1. – Whale-watching areas. A: Bay of Algeciras; common dolphins. B: Strait of Gibraltar; long-finned pilot whales. C: Strait of Gibraltar; killer whales. Yellow dots show the four main departing harbours of the whale-watching trips.

on the sightings of long-finned pilot whales, common dolphins and killer whales.

Abundance estimates

We used the abundance estimates from Verborgh et al. (2019) and Esteban et al. (2016a) for long-finned pilot whales and killer whales, respectively. For common dolphins, we generated an abundance estimate using a capture-recapture approach based on a boat photo-identification survey conducted between June and August 2010. We used a Canon EF100-400mm lens with an image stabilizer on Canon 30D, 50D and 5D cameras during the photo-identification encounters, as described in Verborgh et al. (2009). To estimate the abundance, we used closed population capture-recapture models (Otis et al. 1978). These models derive from a basic model (the "null model" or M_0), with the following underlying assumptions (Otis et al. 1978, Pollock et al. 1990): (*a*) the study population is closed demographically (no death or birth) and geographically (no emigration or immigration); (*b*) all individuals have the same probability of capture on each capture or recapture occasion; (*c*) all marks are correctly read and recorded on each occasion; (*d*) marks are not lost nor overlooked. Given the low fecundity of this species and the long lifespan compared with the study period, we assumed that the study population was approximately closed, i.e. mortality, birth and emigration were negligible over the study period. The assumption of homogeneity in capture probabilities can be relaxed by using other general models that allow two sources of variation in capture and recapture probabilities: a time variation (t) and heterogeneity among individuals (h). These sources of variation were combined in different models (M_t, M_h and M_{th}). Finally, the photo-identification catalogue was checked by two different observers to minimize the misidentification of individuals. We are confident that natural marking was not lost or changed in such a short period of sampling (three months). All models were run in the programme CAPTURE (Otis et al. 1978) inside the interface of programme MARK 9.0 (White and Burnham 1999; updated version 2022). Finally, a correction factor (ĉ) was calculated to transform the abundance of the marked population (N) estimated by the models into the total population abundance (N'), using a ratio of individuals that were reliably marked (Equations 1 and 2).

$$N' = N \times \hat{c} \tag{1}$$

$$\hat{c} = \frac{num + nm}{nm} \tag{2}$$

where ĉ is the correction factor, *num* is the number of fin pictures of unmarked individuals and *nm* is the number of fin pictures of marked individuals. The proportion of marked individuals (P) was calculated as the inverse of the correction factor (ĉ) and allows the standard deviation to be estimated.

$$sd = \sqrt{\frac{P(1-P)}{n}} \tag{3}$$

where *sd* is the standard deviation, *P* is the proportion of marked individuals and *n* is the sum of unmarked and marked fin images (total number of fin images of high quality (Q2) and taken at an angle perpendicular to the individual). Upper and lower bounds of 95% confidence intervals for the total estimation of the population abundance (UCI(N') and LCI(N'), respectively) were calculated according to the formula used by Whitehead et al. (1997) in Equation 4a and 4b:

$$LCI(N') = N' * \left(1 - 2 * \sqrt{\left(\frac{N - LCI(N)}{2N}\right)^2 + CV(\hat{c})^2}\right) \tag{4a}$$

$$UCI(N') = N' * \left(1 + 2 * \sqrt{\left(\frac{UCI(N) - N}{2N}\right)^2 + CV(\hat{c})^2}\right) \tag{4b}$$

where *LCI(N)* and *UCI(N)* are the 95% CI estimated for the abundance of the marked individuals *(N)* and *CV* is the coefficient of variation. The *CV(ĉ)* was calculated as the ratio of the standard deviation to the proportion of all marked individuals (*P*). Finally, the coefficient of variation for the total population estimate [CV(N')] was calculated by Equation 5 according to Whitehead et al. (1997):

$$CV(N') = \sqrt{CV^2(N) + CV^2(\hat{c})} \tag{5}$$

Life span estimates

The mark-recapture models of Esteban et al. (2016b) for killer whales and of Verborgh et al. (2021) for long-finned pilot whales were re-run by pooling all age classes to obtain a population survival rate. Then the inverse of the mortality rate (1/1 survival rate) was used to estimate the longevity of the population and used on the 95% CI to obtain the uncertainty around those values. The estimated longevity was then 24.4 years (95% CI: 9.3-66.7) for killer whales and 23.3 years (95% CI: 13.3-41.7) for pilot whales. Survival rates for common dolphins in European waters are not available, so we considered the age distribution of common dolphins stranded in European Atlantic waters (Murphy et al. 2009) to calculate the mean age of the population. We obtained a mean age of 8.91 years (6.43 SD).

Quantification of the individual value of cetaceans

Total expenditure values were extracted from O'Connor et al. (2009). All the economic values are expressed in euros (€). When the original source was in US$, the value was converted with the mean exchange value of 2011 (€1= US$1.3313), as it was in the year when information on the boat numbers and the distribution of customers in the tours were obtained from the industry. The Individual cetacean value (ICV) was quantified for long-finned pilot whales, killer whales and common dolphins with the following equation:

$$ICV = \left(\frac{DE+IE}{N\prime}\right) \times LS \qquad (6)$$

Other parameters such as the annual individual value (how much an individual would contribute yearly to the economy) and the total population value (overall economic value of the population, including lifespan and abundance) were derived from the ICV with the following equations:

$$Annual\ individual\ value = \frac{ICV}{LS} \qquad (7)$$

$$Total\ population\ value = ICV \times N' \qquad (8)$$

where DE is direct expenditure, IE is indirect expenditure (DE + IE = total annual expenditure, which was extracted from O'Connor et al. 2009), N' is total population abundance and LS is life span.

There is some inherent uncertainty in the calculation of ICVs (and derived parameters). The primary source of uncertainty arises from life span and population abundance estimates. We considered the 95% CI (for killer whales and long-finned pilot whales) or standard deviation (for common dolphins) around population estimates and life spans and conducted 100,000 iterations of the ICV, annual individual value and total population value calculations by randomly selecting age and population size values in each iteration. The mean and standard deviation values are reported in Table 1.

RESULTS

Whale-watching activities in the study area

The whale-watching industry in the Strait of Gibraltar has witnessed significant growth, aligning closely with the conceptual models that outline the evolution of a typical whale-watching destination, including the typology of business operators and visitors participating in the activity (Forestell and Kaufman 1996). The industry was first established in 1982 when the first tours started to operate in the Bay of Algeciras. In the Strait of Gibraltar, the business started in 1996, when two specialized entrepreneurs started to offer whale-watching tours with 15 pax-capacity boats. Between 1998 and 2001, local business people with experience in the nautical sector started their own whale-watching companies, resulting in the establishment of five new operators by the end of this short period. As the industry matured, the smaller boats used during the first few years were progressively replaced with higher-capacity motor boats. In 2009, a third type of business seeking to offer a differentiated product with the incorporation of new types of vessels (small rapid inflatable boats and sailing vessels) started to operate. In 2011, seven boats with a total capacity of 400 people were used by two companies (Fig. 2). Then, (as at present), three types of whale-watching tours were offered in the region. The first type consisted of two-hour trips departing from the ports of Algeciras, La Línea de la Concepción, and Gibraltar to encounter mainly common dolphins in the Bay of Algeciras (Fig. 1; common dolphin tours hereafter), but other species such as striped dolphins and bottlenose dolphins may also be encountered regularly. The second type consisted of two-hour tours from the port of Tarifa (Fig. 1; long-finned pilot whale tours hereafter). These trips targeted mainly long-finned pilot whales, but other species may also be sighted, such as bottlenose dolphins, sperm whales (*Physeter macrocephalus*) and common and striped dolphins (*Stenella coeruleoalba*; Carbó-Penche et al. 2007, de Stephanis et al. 2008a). They also take advantage of opportunistic sightings of fin whales (*Balaenoptera physalus*) migrating mainly between May and July (Gauffier et al. 2018). Finally, whale-watching trips of 3-4 hours were organized solely to observe the interactions between killer whales and bluefin tuna fisheries occurring from mid-June to August (Esteban et al. 2016b, killer whale tours hereafter). These three- to four-hour trips are organized only when interactions take place (i.e. spring and summer) and also depart from Tarifa.

Table 1. – Economic non-consumptive value (€) of each species. Abundance shows the mean estimate of the number of individuals and the 95% CI from the capture-recapture models; life expectancy shows the mean years each species is expected to live and the 95% CI (for long-finned pilot whales and killer whales) and the SD for common dolphins (estimated from Murphy et al. 2009). Total annual expenditure values were extracted from O'Connor et al. (2009), and the rest of the columns show our economic estimates in € (mean ± SD). *Interacting killer whales (Esteban et al. 2016).

Species	Abundance	Life expectancy	Total annual expenditure	Annual individual value	Individual cetacean value	Total population value
Long-finned pilot whales	285 (259-326)	23.3 (13.3-41.7)	4,089,056	14,048 ± 948	386,290 ± 118,913	112,426,185 ± 33,643,974
Common dolphins	1966 (1590-2414)	8.91 ± 6.43	1,876,833	951 ± 115	8452 ± 3704	16,685,147 ± 6,987,263
Killer whales	14*	24.4 (9.3-66.7)	505,389	36,099	1,369,365 ± 598,046	19,171,107 ± 8,372,647

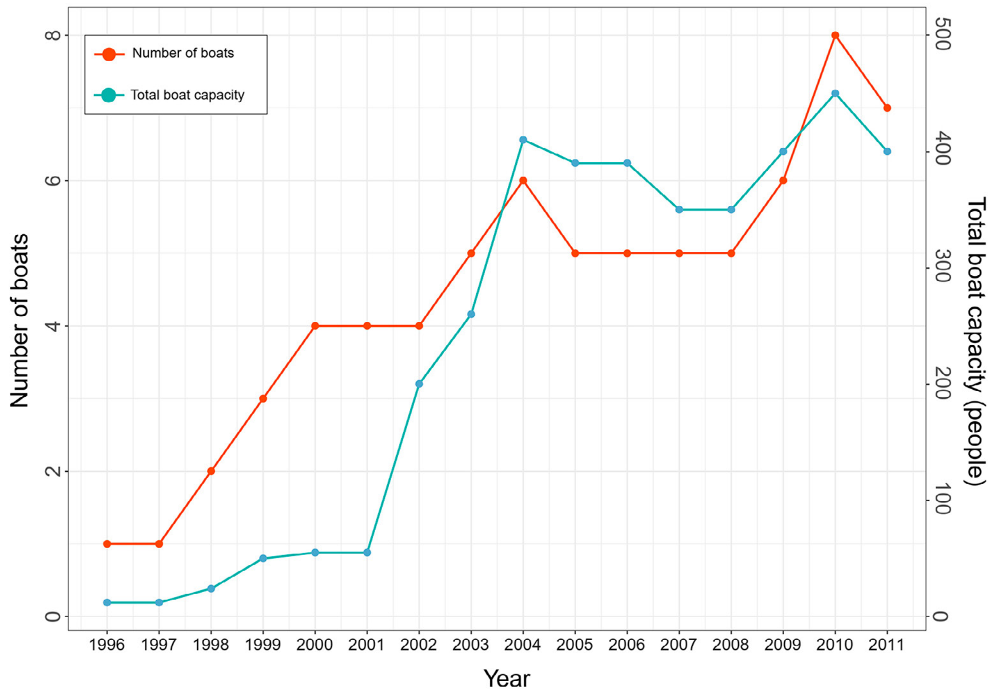

Fig. 2. – Evolution of the whale-watching industry in the Strait of Gibraltar area by boat number and passenger capacity (1996- 2011).

Number of tourists and total income

The whale-watching industry in the study region employed approximately 40 professionals during the high season (summer months) in 2011. In Tarifa, where two types of whale-watching tours were available, representatives of the whale-watching operators estimated that nearly 39,000 tourists participated in whale-watching tours that year. Approximately 35,000 of them (about 89%) booked long-finned pilot whale tours, while 4000 (approximately 11%) chose killer whale tours. Data on the number of tourists participating in the activity in the Bay of Algeciras was not available, but since only one type of whale-watching tour was offered there (i.e. common dolphin tours), 100% of tourists opted for those. The data on tourists' expenditure was extracted from O'Connor et al. (2009), who reported that tourists provided a total annual income of €1,876,833 in the Bay of Algeciras (Table 1). Regarding Tarifa, O'Connor et al., (2009) does not provide a site-specific calculation, but states that, in 2008, Tarifa accounted for 75% of all whale watchers in Spain. Therefore, we could derive the total expenditure in Spain (€6,125,927) to estimate the total expenditure in Tarifa, which would be approximately €4,594,445.

Abundance estimate of common dolphins in the Bay of Algeciras

During nine encounters with common dolphins in the Bay of Algeciras in 2010, a total of 4991 pictures were taken and 606 individuals were identified in the catalogue. Of these, 77.06% of individuals were seen only once, 19.14% twice, 3.3% three times and 0.5% four times. The best model selected by CAPTURE was M_{th} with the estimator of Chao et al. (1992) estimating the abundance of the marked population (N) in 1631 common dolphins (CV=0.09, 95% CI=1389-1948). The total population size (N') after the correction was estimated at 1966 common dolphins (CV=0.11, 95% CI=1590-2414).

Quantification of cetaceans' economic value

All the economic results for the three species are summarized in Table 1.

Long-finned pilot whales

The resident long-finned pilot whale clan of the Strait of Gibraltar comprises approximately 285 (95% CI: 259-326) individuals (Verborgh et al. 2019) distributed in the deep waters of the Strait, 10 km from the port of Tarifa (de Stephanis et al. 2008a). Their average life span was estimated at 23.3 years (95% CI: 13.3-41.7; Verborgh et al. 2019). Therefore, given that the total annual expenditure of tourists on whale-watching tours targeting this species was approximately €4,089,056 (89% of the total expenditure in Tarifa), each long-finned pilot whale individual would generate €14,048 ± €948 (mean ± SD) annually. Assuming constant visitor numbers (those of 2011) and considering the life expectancy of the species, each individual will generate an average of €386,290 ± €118,913 over its lifetime, corresponding to a total population value of €112,426,185 ± €33,643,974.

Common dolphins

Whale-watching operators in the Bay of Algeciras targeted a group of about 1966 (95% CI: 1590-2414) common dolphins. Their life span was estimated at 8.91 ± 6.43 years (mean ± SD; derived from Murphy et al. 2009). Therefore, given that the total annual expenditure of tourists on whale-watching tours targeting this species was approximately €1,876,833 (O'Connor et al. 2009), each common dolphin generated an average of €951 ± 115 annually. Assuming constant visitor numbers (those of 2011) and taking into account the life expectancy of the species, each individual will generate €8452 ± 3704 over its lifetime, corresponding to a total population value of €16,685,147 ± €6,987,263.

Killer whales

In the case of killer whales, 47 individuals were identified in the Strait of Gibraltar from 1999 to 2011 (Esteban et al. 2016a). However, only 14 individuals were identified while interacting with Atlantic bluefin tuna fisheries in the summer (Esteban et al. 2016b), and these were the ones targeted by the whale-watching industry. Using the average survival rate for adult and juvenile interacting individuals (Esteban et al. 2016b), an estimate of lifespan was calculated as the inverse of the mortality (1-survival rate; Charnov 1993), providing a mean lifespan of 24.4 years (95% CI: 9.3-66.7). Therefore, given that the total annual expenditure of tourists on whale-watching tours targeting this species was approximately €505,389 (11% of the total expenditure in Tarifa), each killer whale generated €36,099 annually. Assuming constant visitor numbers (those of 2011) and taking into account the life expectancy of the species, each individual will generate €1,369,365 ± €598,046 over its lifetime, corresponding to a total population value of €19,171,107 ± €8,372,647.

DISCUSSION

Whale-watching is one of the fastest-growing sectors of the ecotourism industry (3.7%/year; Corkeron 2004, O'Connor et al. 2009). Specifically, the last estimates (O'Connor et al. 2009) showed it to be worth US$2.1 billion globally, and it is currently the greatest economic activity in relation to cetaceans (Parsons 2012). The United States, Canada and Australia are pioneering countries and leading destinations in terms of numbers of whale watchers, followed by South Africa, the Canary Islands (Spain) and New Zealand. Other renowned destinations include Argentina, Scotland, Brazil and Chile, while other regions in Asia, Central America and the Caribbean show signs of development (O'Connor et al. 2009). In Europe, the Mediterranean Sea has established as an area that offers a large potential to develop a sustainable high-quality whale-watching industry (Elejabeitia et al. 2012). Accordingly, this industry has established and developed there since the 1980s in countries such as Spain, Italy, Greece, and Egypt (Notarbartolo di Sciara et al. 2002). Within these circumstances of growth and expansion in the last four decades, whale-watching provides an opportunity for the economic valuation of wildlife, which is often a challenging task, especially when it is not clearly linked to an economic activity (Subroy et al. 2019, Chapagain et al. 2020). Specifically, it offers a framework in which the economic revenue allows the economic value of the targeted cetaceans to be estimated based on the direct and indirect expenditure of the tourists who purchase whale-watching tours (Parsons et al. 2003). Based on population abundance estimates and information from the local whale-watching companies, we assessed the individual and population economic non-consumptive value of three cetacean species targeted by the whale-watching tours that operate in the Strait of Gibraltar and the Bay of Algeciras and provide estimates of such values for 2011, to establish baseline values, as this is the first analysis on this topic in the study area.

Concurrent with the global increasing trend of whale-watching (O'Connor et al. 2009), this activity has experienced intense growth in the 1996–2011 period in the study area, as shown by the trends in the number of boats operating and their passenger capacity. The companies offered three different types of whale-watching tours depending on the main cetacean species targeted: long-finned pilot whales, common dolphins and killer whales. Due to the biological traits (i.e. behaviour, phenology and demography) of each species and the characteristics of the tours targeting them (duration, location, and species diversity), we found different values for each species. Specifically, our results showed that tourists made the smallest total annual expenditure on killer whales, followed by common dolphins, and the largest on long-finned pilot whales. This can be explained by the fact that killer whales are seasonal residents in the Strait of Gibraltar (Esteban et al. 2013), so they can only be sighted from early spring to late August, thus limiting the number of tours for whale-watching companies and thus the amount of income they can generate. By contrast, long-finned pilot whales and common dolphins are resident species undergoing their whole biological cycle in the Strait of Gibraltar (de Stephanis et al. 2008b, Verborgh et al. 2009, 2019), so they are available to whale-watching operators all year round. Other specific features can explain the difference in expenditure between these two species (which is ~2 times greater in the case of long-finned pilot whales). Long-finned pilot whale tours are conducted offshore (as in the case of killer whales), which offers the opportunity of sighting other cetacean species present in the main channel of the Strait of Gibraltar, including deep-water species (up to seven species; de Stephanis et al. 2008a), and this feature makes these tours particularly attractive for tourists. However, their offshore and open-water component has a limitation, as they can only be conducted in good weather conditions. In the case of common dolphins, tours are conducted inshore, inside the more sheltered Bay of Algeciras. For the companies usually operating from Tarifa, these tours are restricted to bad weather conditions, when eastern winds are too strong to operate in the Strait, which is quite common in this area (285 days/year of strong Levantine winds; García de Pedraza 1990). The companies have thus managed to minimize the limitations arising from bad weather conditions by providing another type of trip when their main attraction is not viable. All of these factors combined (i.e. the possibility of observing the species at any time of the year with a high probability of success) may explain the higher number of tourists choosing the long-finned pilot whale tours (Barnes et al. 1999), which results in the highest total annual expenditure value among the three species.

Conversely, killer whales showed the largest economic values at an individual level, both regarding the annual individual value and the ICV. These two calculations take into account population size, and because killer whale tours rely only on the 14 individuals that are known to interact with the local artisanal tuna fishery (Esteban et al. 2016b), each individual is highly valued. Moreover, killer whales were the qualifying species for the Strait of Gibraltar and Gulf of Cadiz to achieve the status of an Important Marine Mammal Area (IMMA; IUCN 2017). This status highlights the area as a key spot for the biological cycle of killer whales and encloses an area not only important for this species but for the rest of the species found therein, which acquire the role of "umbrella species" and add an extra value to their presence in the area. Following killer whales, long-finned pilot whales showed the second largest values in the individual indexes, as they have an estimated population of 285 individuals (259-326 95% CI; Verborgh et al. 2019). Finally, common dolphins, with an estimated population of 1966 (1590-2414 95% CI) individuals within the Bay of Algeciras (this study) show the third largest values.

We found that long-finned pilot whales and killer whales produced more absolute mean income than common dolphins at a population level, mainly due to their resident character (long-finned pilot whales) and large life spans (killer whales). However, we argue that the three species are key for the economic sustainability of the whale-watching activity, as they are all sighted in different setups, allowing continuity of the whale-watching activity all year round and in diverse weather circumstances. Moreover, the Strait of Gibraltar offers an excellent spatial framework for this activity due to the permanent presence of cetaceans (with several resident species), and their accessible distribution within a short distance (<15 km) from the coast (de Stephanis et al. 2008a). However, this optimal setup and abundance of cetaceans may lead to income-oriented practices by whale-watching companies that can add stressors to these cetacean populations. This has occurred in a range of whale-watching destinations, where behavioural changes have been observed, such as diving behaviour alterations, acoustic communication disruption, group cohesion loss, swimming speed and direction alteration, and modifications to feeding and resting patterns (Corkeron 1995, Foote et al. 2004, Bejder et al. 2006, Timmel et al. 2008, Visser et al. 2011). Disturbance has also been linked to cetaceans temporarily or permanently abandoning areas (Bejder et al. 2006, Carrera et al. 2008), which can have significant economic consequences from the companies' perspective but can also have ecological implications in terms of ecosystem functioning (Roman et al. 2014). In addition to the immediate responsive effects, all the listed short-term behavioural changes resulting from irresponsible and non-sustainable whale-watching practices can ultimately lead to long-term negative effects on cetacean population dynamics and individual fitness loss. The latter was detected in the work by Lusseau and Bejder (2007), when cetaceans could not elude the proximity to the disturbance caused by whale-watching boats.

In the Strait of Gibraltar, which is the second most navigated channel of the world, with over 100.000 vessels crossing it every year (112,943 in 2010; Informe Anual de Salvamento Marítimo 2010), a long-term study was carried out to assess the role of navigation on the survival of bottlenose dolphins (Tenan et al. 2020). Their results identified ferry traffic as a potential threat, considering that more than 70% of the temporal variance of apparent survival was explained by that variable. However, whale-watching boats showed a weaker effect. Another important consideration is the fact that population size may play a key role in the amount of disturbance produced by whale-watching boats. When populations are in decline, impacts could be directed at fewer individuals, gradually increasing the amount of stress received by each individual cetacean. This may be happening with the three species considered here. Common dolphins were declared as endangered in the Mediterranean, as a population decline has been detected (Bearzi 2012). The long-finned pilot whale population in the Strait of Gibraltar decreased by 26.2% after the surge of a morbillivirus epizootic in 2007 (Verborgh et al. 2019), and it sustained a post-outbreak decline at least until 2013 (Pons et al. 2022). Previous analyses already predicted a negative population growth rate associated with a decline of 50% from 341 to 172 animals over 100 years (Verborgh et al. 2021). For these reasons, it has been recently declared critically endangered (Verborgh and Gauffier 2021). From an economic perspective, this could lead to a decline in the revenue produced by whale-watching, as a smaller cetacean density could make the area less attractive for tourists. Other sources of mortality, such as bycatch, have been described as problematic for whale-watching (e.g. humpback whales off the coast of Ecuador; Álava et al. 2011). Finally, the Strait of Gibraltar killer whale management unit was also declared as critically endangered due to the very limited number of adult individuals and their decline (Esteban et al. 2016a, Esteban and Foote 2019). For this reason, regular monitoring of abundance estimates such as the ones presented here for common dolphins is essential to ensure the sustainability of whale-watching in the area.

In general, there is little doubt that whale-watching can be considered an ecotourism activity because it can be conducted sustainably. However, from the companies' perspective, it may be challenging or costly to always fully comply with sustainable practices (Wearing and Neil 2009). For this reason, this activity should be planned and managed in accordance with precautionary principles and sustainability measures that have been widely recognized by experts and proved effective to ensure low impact on natural resources (Senigaglia et al. 2016). Moreover, a mechanism should be provided to improve the conservation of cetaceans, because they are key to the functioning and long-term existence of this activity. So, while whale-watching provides the opportunity to demonstrate the potential of ecotourism to be sustainable and to honour the principles of conservation, it is essential to put these measures into practice (Wearing et al. 2014). Implementing sustainable and respectful practices in whale-watching is a central issue and is in fact beneficial for the companies themselves, as this was the item most valued by tourists in Bentz et al. (2016). Spain issued national legislation regarding whale-watching activities in 2007 that specified appropriate manoeuvres for vessels in the presence of cetaceans to avoid harming, disturbing or stressing cetaceans (Ministerio de la Presidencia 2007; Real Decreto 1727/2007). Since 2012, companies are also required to apply for administrative authorization to legally perform the activity, conditioned by the acknowledgement of the 2007 legislation. However, over 15 years, very little enforcement has been undertaken in the area. Spain is also a party to ACCOBAMS and has therefore adopted its Guidelines for Commercial Cetacean Watching Activities in the ACCOBAMS Area (ACCOBAMS-MOP4/2010/Resolution 4.7). Another step to ensure that whale-watching activities are done in the best possible manner would be to encourage companies to apply for extra labels, such as the ACCOBAMS High-Quality Whale-Watching Certificate, and to contribute to public education and collection of sighting and activity data (ACCOBAMS 2021; http://www.whale-watching-label.com/_en; https://accobams.org/main-activites/high-quality-whale-watching-certificate/).

Aside from the negative impacts that whale-watching can have on the targeted cetaceans, this activity can provide many socioeconomic benefits. Whale-watching tourists support local economies through their purchases, from whale-watching tickets to associated expenses for travel, food, hotels and souvenirs. Beyond economics, the whale-watching industry offers communities a sense of identity and cultural pride and helps foster an appreciation for the marine environment. This supports local businesses, creating jobs and providing income. Moreover, it also can aid conservation and/or allow the public to view cetaceans as an economically important resource (Parsons 2012) from which they can now earn more than from commercial whaling (Swanson and Barbier 1992, Tisdell and Wilson 2001).

In this study, we have provided estimates of the economic value of three cetacean species in the Strait of Gibraltar (southern Spain) by only analysing their non-consumptive value. We have also shown that common dolphins can be studied through photo-identification in this area and that demographic parameters could be obtained with this technique, rarely used previously on this species (Neumann et al. 2002, Bearzi et al. 2008, Genov et al. 2012). A more exhaustive analysis should include the estimated value of the rest of the species that inhabit the Strait. Previous studies conducted in different locations and contexts have used a range of different data sources to those of the present study, including salaries of individuals employed in the whaling industry compared with those working in whale-watching companies and data reported at a country level (e.g., Iceland; Rasmussen 2014). Other studies have taken more comprehensive approaches, exploring the distribution of benefits derived from whale-watching in local communities (Schwoerer et al. 2016). However, we consider that our results are not directly comparable to these studies due to methodological differences.

Additionally, other non-economic values should be considered to obtain a more accurate assessment of the real value of cetaceans in the area. It would be important to disentangle the economic value belonging to each species, as their combination will probably exceed the sum of the values of each species alone. We argue that this economic exercise is necessary to explore the real and potential value of cetaceans in the Strait of Gibraltar and the Bay of Algeciras, and that extrapolation to other areas in the Mediterranean can be useful only in cases in which the whale-watching context (in terms of number of operating boats, cetacean density and number of species) is similar. All in all, our results provide an approximation of the potential contribution of cetaceans to local economic development through nature-based tourism in the Mediterranean Sea. In conclusion, estimating the benefits of environmental goods, such as the presence of cetaceans in the Strait of Gibraltar and the Bay of Algeciras, is necessary to justify the economic rationale of the preservation of these environmental goods. More research has to be done in this field to account for the non-use values of these biological resources, but the total value of the cetacean community of the Strait of Gibraltar and the Bay of Algeciras will probably exceed the tourist economic value estimated in this study.

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