Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area, concluded under the auspices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Accord sur la Conservation des Cétacés de la Mer Noire, de la Méditerranée et de la zone Atlantique adjacente, conclu sous l'égide de la Convention sur la Conservation des Espèces Migratrices appartenant à la Faune Sauvage (CMS)

Seventh Meeting of the Parties to ACCOBAMS

Istanbul, Republic of Turkey, 5 - 8 November 2019

01/10/2019
English
Original: English
ACCOBAMS-MOP7/2019/Inf40

RE-ASSESSMENT OF THE IUCN STATUS OF KILLER WHALES IN THE STRAIT OF GIBRALTAR

Draft

Orcinus orca Strait of Gibraltar subpopulation - (Linnaeus, 1758)

ANIMALIA - CHORDATA - MAMMALIA - CETARTIODACTYLA - DELPHINIDAE - Orcinus - orca - Strait of Gibraltar subpopulation

Common Names: Killer Whale (English); Epaulard (French); Espadarte (Spanish; Castilian); Orca (English); Orca (Spanish; Castilian); Orque (French)

Synonyms: No Synonyms

Taxonomic Note:

Based on studies of photo-identification data, mitochondrial DNA and microsatellite genetic markers, and other biomarkers, the killer whales of the Strait of Gibraltar are distinct from other subpopulations in the Northeast Atlantic (Foote *et al.*, 2009; Esteban *et al.*, 2016a, 2016b). There have been no recorded sightings in the Mediterranean Sea, beyond the Alboran Sea in recent times, despite increasing dedicated survey effort, suggesting that the basin has no resident population of killer whales and is not frequented by the subpopulation of the Strait of Gibraltar (Esteban *et al.*, 2016b). Similarly, there have been no identifications of the known individuals from the Strait of Gibraltar in any of the photo-identification catalogues of resident populations outside of the Strait in Northeast Atlantic waters (Esteban *et al.*, 2016b). During dedicated surveys of the Strait between 1999-2011, photo-identification records have identified 47 individuals. One adult was found dead stranded, additionally young individuals, 2 juveniles and 5 calves, were not observed within their pods for at least three consecutive years, and they were considered dead. Consequently the population size estimate, based on dedicated photo-identification data is 39 individuals, of which 33 were re-sighted in different years, suggesting site fidelity to the Strait (Esteban *et al.*, 2016c). The killer whale of the Strait of Gibraltar are stratified into discrete social clusters (Esteban *et al.*, 2016d), which differ in their association patterns, demography, seasonality of occurrence, area usage, isotope ratios and mitochondrial DNA, but connectivity between these social clusters is suggested by genetic analysis (Esteban *et al.*, 2016a). Two groups of killer whales sampled off the Canary Islands were found to be the closest genetically affiliated Northeast Atlantic groups to the Strait of Gibraltar killer whales (Foote *et al.*, 2009). However, in addition to the lack of photo-id matches noted above, the Canary Islands whales also differed in their mitochondrial DNA, stable isotope ratios and contaminant load from the Strait of Gibraltar killer whales (Esteban *et al.*, 2016a; Jepson *et al.*, 2016). Based on analysis of microsatellite loci, 1-9% of individuals in the Strait of Gibraltar are derived from the same population as the Canary Islands, whereas 9-33% of the Canary Islands individuals were derived from the same population as the Strait of Gibraltar (Esteban *et al*. 2016a). We infer these values to reflect historical connectivity between the Strait of Gibraltar and Northeast Atlantic populations, but consider the results from multiples markers (Esteban *et al.*, 2016a) of contemporary movement and migration (Esteban *et al.*, 2016b, 2016a), to indicate that those whales are now geographically isolated. We can conclude that Strait of Gibraltar killer whales could be considered as a subpopulation, as they are clearly geographical distinct and there is far less than one migrant individual entering the subpopulation per year.

Red List Status
CE – Critically Endangered, (IUCN version 3.1)

Red List Assessment

Assessment Information

Date of Assessment: 2018-09-22

Assessor(s): Esteban, R. & Foote, A. D.

Reviewer(s): Taylor, B. L., Reeves, R. & Notarbartolo di Sciara, G.

Facilitators/Compilers: Lowry, L.

Regions: Global

Assessment Rationale

As a species, killer whale is listed on the IUCN Red List as Data deficient (Reeves *et al.*, 2017), as well as at regional level in Europe (IUCN-SSC, 2007), since they are numerically abundant and very widely distributed. In both assessments experts agreed that some small regional subpopulations would qualify for threatened status, as they can be small and highly specialized, and therefore vulnerable to over-exploitation and habitat deterioration. The Strait of Gibraltar subpopulation, was provisionally assessed in 2006 as Critically Endangered (C2a(i,ii); D) (Reeves and Notarbartolo di Sciara, 2006). C2a(i,ii) because there were far fewer than 50 mature individuals and a continuing decline in the number of mature individuals was projected based on reports (unverified) of direct killing by fishermen and the growing resentment evoked by the whales' depredation on tuna drop long-line fisheries. That assessment remarked that their identification as a subpopulation was problematic and therefore research was needed to identify their relationship to other populations in the North Atlantic (Cañadas and de Stephanis, 2006).

There has not been any confirmed direct killing of adult whales from fishermen in the area since this last assessment (Esteban *et al.*, 2016a). Conversely in the last years there has been some reports of injured individuals, however it has not been possible to found a due cause (Otero-Sabio *et al.*, 2018). Dedicated photo-identification studies maintained from 1999-2011, allowed the direct abundance estimation of 37 individuals, of which 31 were considered adults in 2011 (Esteban *et al.*, 2016c). An updated abundance estimate of 50 individuals was reported, in 2015 (B.O.E.-A-2017-5474, 2017), with no detail of the age-composition of the subpopulation, however, we could infer that at most 43 individuals could be considered as adults (Otero-Sabio *et al.*, 2018). Overfishing of their main prey, Atlantic bluefin tuna (*Thunnus thynnus*) (ICCAT, 2011), has been identified as the major factor responsible of their low number, and it was also associated with the death of most their offspring during the period 1999-2011 (Esteban *et al.*, 2016c). A range of other factors could be affecting this subpopulation: either indirect effects related with the decreasing depredation on the tuna drop long-line fishery (Esteban *et al.*, 2016c), high concentration of pollutants found in their system (Jepson *et al.*, 2016), or a combination of all this factors as well as effects of other threats that still needs to be studied. Through collaborative studies of multiple markers, it was determined that this subpopulation is geographically isolated from any other studied killer whales in the North Atlantic (Esteban *et al.*, 2016a).

Considering that the number of adult individuals within this subpopulation is still under 50 individuals, we recommend listing the subpopulation of killer whales in the Strait of Gibraltar as Critically-Endangered under criteria D (small population size).

Distribution

Geographic Range

This subpopulation of killer whales occurs mainly in the Strait of Gibraltar and surrounding waters (Guinet *et al.*, 2007; de Stephanis *et al.*, 2008; Esteban *et al.*, 2013), with few sporadic sightings in the surrounding waters of the Strait, i.e. Gulf of Cadiz and the Alboran sea, in the 2000s (Esteban *et al.*, 2016b), so far there has only been one sighting of killer whales in the Strait at ACCOBAMS Survey Initiative (ASI), which is the first synoptic survey of the whole Mediterranean which is still in process and only preliminary results have been shared (http://www.accobams.org). There are also sporadic sightings at the western and northern coast of the Iberian peninsula (Marcos-Ipiña *et al.*, 2005; Ruano *et al.*, 2005; Marcos-Ipiña and Salazar-Sierra, 2006; Salazar-Sierra and Marcos-Ipiña, 2006; Kiszka and Macleod, 2007; Quinta, 2017). In addition their presence in the Strait during summer and spring is closely related with the migration of their main prey (de la Serna *et al.*, 2004).

Area of Occupancy (AOO)

Continuing decline in area of occupancy (AOO)	Qualifier	Justification
Unknown	-	-

Extreme fluctuations in area of occupancy (AOO)	Justification
Unknown	-

Extent of Occurrence (EOO)

Continuing decline in extent of occurrence (EOO)	Qualifier	Justification
Unknown	-	-

Extreme fluctuations in extent of occurrence (EOO)	Justification
Unknown	-

Locations Information

Continuing decline in number of locations	Qualifier	Justification
Unknown	-	-

Extreme fluctuations in the number of locations	Justification
Unknown	-

Elevation / Depth / Depth Zones

Depth Lower Limit (in metres below sea level): - 1087 m (Towers *et al.*, 2018)

Depth Upper Limit (in metres below sea level): 0 m

Depth Zone: Shallow photic (0-50m), Deep Photic (51-200m)

Biogeographic Realms

Biogeographic Realm: Palearctic

Occurrence

Countries of Occurrence

Country	Presence	Origin	Formerly Bred	Seasonality
France	Presence uncertain	Vagrant	-	Occurrence uncertain
Gibraltar	Extant	Native	-	Resident
Morocco	Extant	Native	-	Resident
Portugal	Extant	Vagrant	-	Seasonal
Spain	Extant	Native	-	Resident

Large Marine Ecosystems (LME) Occurrence

	Presence	Origin	Formerly Bred	Seasonality
2.1.1. Westerlies Biome -> Atlantic Provinces -> Mediterranean Sea	Extant	Vagrant	-	Seasonal
2.1.2. Westerlies Biome -> Atlantic Provinces -> Canary Current	Extant	Native	-	Resident

4.2.10. Coastal Biome -> NE Atlantic Shelves Provinces -> Iberian Coastal	Extant	Vagrant	-	Seasonal

FAO Area Occurrence

	Presence	Origin	Formerly Bred	Seasonality
27 Atlantic, Northeast	Extant	Native	-	Resident
37. Mediterranean and Black Sea	Extant	Vagrant	-	Seasonal

Population

Killer whales in the Strait of Gibraltar were assigned to a unique population in the North Atlantic, together with individuals sampled in the Canary Island (Foote *et al.*, 2009). None of the individuals identified in the Canary Islands had ever been sighted in the Strait of Gibraltar (Esteban *et al.*, 2016a). Additionally, genetic analyses indicated that only about 1–9% of the Strait of Gibraltar individuals were derived from the same subpopulation as Canary Islands individuals, while no complete mitogenome haplotypes were shared and no close kinship were detected between the two areas (Esteban *et al.*, 2016a). The low genetic differentiation in combination with low levels of migration and the lack of any recent bottleneck signal were consistent with a recent vicariant population split. Isotopic values and pollutant loads also suggested ecological differences between Strait of Gibraltar and Canary Islands killer whales included in those studies (Esteban *et al.*, 2016a).

In the Strait, from the 5 pods defined (Esteban *et al.*, 2016d), Pod D was never seen in association with any of the other four pods (A1, A2, B, and C) from the Strait (Esteban *et al.*, 2016d). The only individual sampled from pod D was the female ('Vega') that stranded in 2006, this female was identified as belonging to a potential migrant lineage based on intermediate isotopic values and contaminant between the Strait and the Canary Islands (Esteban *et al.*, 2016a). In conclusion, killer whales in the Strait of Gibraltar should be considered as a subpopulation for this assessment.

This subpopulation uses at least two different hunting techniques to feed on tuna. In spring, whales have been observed to chase tuna for up to 30 min at a relatively high speed (3.7-0.2 m s^{-1}) until they captured them (Guinet *et al.*, 2007). This has been named as an "endurance exhaustion technique", killer whales drive tuna beyond their aerobic limits until the fish are exhausted and easy to be captured. They capture small to medium size (0.8–1.5 m) tuna (Guinet *et al.*, 2007). They have also been observed actively hunting in summer (Esteban *et al.*, 2013). However, the whales were more frequently observed interacting with the artisanal drop long-line fishery (Esteban *et al.*, 2016c). The fishery began operating in 1995 (every year from July–August) in the central waters of the Strait of Gibraltar (Srour, 1994). The whales have been interacting with the fishery since at least 1999 (de Stephanis *et al.*, 2008). The whales patrol the vicinity of the boats until they find a tuna hooked on a line, and then depredate the fish before fishermen can bring it to the surface. Not all the killer whales sighted in the Strait have been observed to interact with the fishery (Esteban *et al.*, 2013, 2016d). Esteban *et al.* (2016d) classified the whales into two categories: 'interacting individuals' observed interacting with the fishery at least once (INT, pods A1, A2 and C), and 'not interacting individuals' that were never observed interacting (NOT, pods B and D).

Photo-identification analyses have identified 47 individual killer whales between 1999 and 2011 (Esteban *et al.*, 2016c). Eight individuals were considered to have died over the study period (one female stranded in 2006, known as 'Vega'; two juveniles; five calves that were considered dead, as they were not seen with their mother or within their pod for at least three consecutive years). Therefore 39 individuals remained alive in 2011, of which 31 were considered as adults, or to be capable to reproduce (IUCN Standards and Petitions Subcommittee, 2017), including males presenting a prominent dorsal fin and females that were mature individuals accompanied by calves or juveniles (Esteban *et al.*, 2016c).

An updated census was presented with the official publication of their conservation plan, resulting in a total of 50 individuals identified up to 2015 (B.O.E.-A-2017-5474, 2017), without any information about how many of those were adult individuals. In 2018, a study based on opportunistic data, from whale watching platforms, was published, where they were able to follow the INT individuals from 2011 to 2015 (Otero-Sabio *et al.*, 2018). Seven individuals that were born survived to their first year of life during this period (Otero-Sabio *et al.*, 2018), but will not be considered as adults during for this period. Consequently this subpopulation consisted at best of 43 mature individuals in 2015, but probably there are more individuals that should be considered as non-adults, or could be post-reproductive females. Lastly, this recent estimate did not contain any information on individuals not interacting with the fishery. Therefore, the uncertainty from the 2015 estimate does not allow us to estimate any trend, and we consider more reliable the first estimate for the purpose of this assessment.

Esteban *et al.* (2016c) estimated survival rate for the two groups (INT, NOT), for the 1999-2011 period, using multistate mark-recapture models (Hestbeck *et al.*, 1991; Brownie *et al.*, 1993). Adult survival rate for INT whales

(12 adult individuals) was estimated at 0.991 (SE: 0.014; 95% CI: 0.837–1.000). Those are similar results than stable population as the northern resident, in British Columbia (Olesiuk *et al.*, 1990, 2005). Adult survival for NOT whales (19 adult individuals) was estimated at 0.901 (SE: 0.067; 95% CI: 0.672–0.980). This low rate was similar to Crozet Archipelago whales (Poncelet *et al.*, 2010), where the most reasonable explanation for the high losses was direct killing by Patagonian toothfish (*Dissostichus eleginoides*) fishers during the late 1990s early 2000s (Guinet *et al.*, 2014).

A growth rate of 1.039 (SE: 0.025; 95% CI: 0.986–1.091) for INT individuals (18 individuals) was also estimated (Esteban *et al.*, 2016c), which is equivalent to a 3.9% growth rate. In comparison, southern Alaska resident killer whale population growth rate was estimated to be 3.5%, and the population was thought to have reached a maximum growth rate thanks to the increasing return of their main prey, Chinook and coho salmon (*Oncorhynchus kisutch*) (Matkin *et al.*, 2014).On the other hand, growth rate was almost stable for NOT pods (pods B, C, and D) at 0.995 (SE: 0.053; 95% CI: 0.832–1.159), with almost no recruitment over 12 years and lower adult survival, putting them a greater risk due to the already very low number of animals (21 individuals). Their situation could be similar to other populations currently on the verge of extinction such as the AT1 transient killer whales in Alaska, a group of seven individuals in which no recruitment had been reported since the Exxon Valdez oil spill in 1989 (Matkin *et al.*, 2008, 2012), and to the group of nine killer whales around north-west Scotland and western Ireland, in which no calves had been reported for 19 years (Beck *et al.*, 2013).

Moreover, it was more concerning the situation for the offspring, between 1999-20111. Juvenile survival rate could only be estimated for INT whales and was 0.966 (SE: 0.031; 95% CI: 0.819–0.994). For INT whales, calf survival was one in 1999–2005 as all individuals survived their first year of life during this first period, and zero in 2006–2010, as no calf survived during this second period (Esteban *et al.*, 2016c). Simultaneously, from 2005 to 2011 drop long-line catches declined dramatically, reflecting the decline of tuna abundance in the Strait. Differences in survival rates between the two groups could be explained by the fact that depredation is a good opportunity for killer whales to feed in summer, when tuna are leaving the Strait for the Atlantic (Wilson and Block, 2009). These tuna use deep waters to cross the Strait and would likely be unavailable to killer whales (Aranda *et al.*, 2013). However, drop long-line fisheries bring tuna to the surface and could be acting as an accumulator of fish, locally increasing prey availability. This is likely especially important for killer whales when abundance of tuna is low. Food provisioning through depredation could have positively affected INT (pods A1 and A2) killer whale life history parameters in the years in which the tuna stock was at its lowest (Esteban *et al.*, 2016c).

Mean calving rate estimated for INT whales in the Strait of Gibraltar was 0.219 (SE: 0.034) and was higher than the rate of 0.020 estimated for the NOT whales (SE: 0.013) (Esteban *et al.*, 2016c). Only two births, from different females, were documented within the Strait of Gibraltar NOT whales, and calving interval and fecundity rate were not estimated. Within the INT group, 13 births were documented. However, only two intervals between viable calves of two females were observed and ranged from six to eight (mean¼seven) years, producing a fecundity rate of 0.14 calves per year (Esteban *et al.*, 2016c). These values were within the same ranges as for other populations available in the literature.

In conclusion there are not enough data to determine the trend of the subpopulations of killer whales in the Strait of Gibraltar.

Population Information

Current Population Trend: Unknown

Extreme fluctuations? (in # of mature individuals)	Justification
Unknown	-

Severely fragmented?	Justification
No	-

Continuing decline in mature individuals?	Qualifier	Justification
No	-	-

Habitats and Ecology

Killer whale distribution in the southern Iberian Peninsula is related to the migration of bluefin tuna (Esteban *et al.*, 2013). This migratory pelagic tuna undertakes annual reproductive migrations, entering the Mediterranean Sea from the Atlantic Ocean during late spring, in search of suitable spawning areas (Sella, 1928). And later it comes back to the Atlantic in search of foraging areas in summer (de la Serna *et al.*, 2004). The presence of killer whales during summer and spring has been modeled through generalized additive models (GAMs) at the whole southern Iberian Peninsula (Gulf of Cadiz, Strait of Gibraltar and Alboran Sea). Spring model predicts killer whale presence in shallow waters close to the west coast of the Strait, were they would be capable of hunting schools of tuna entering the Mediterranean, using the endurance-exhaustion hunting technique (Guinet *et al.*, 2007). While during summer, depth longitude and temperature had a significance effect on their presence probability, restricting their distribution area to the Strait of Gibraltar (Esteban *et al.*, 2013).

It was determined that their main prey is the bluefin tuna by using stable isotope analysis of skin samples (collected from May to July) (García-Tiscar, 2009). However there was a special case among them, the female known as Vega, which had a different isotopic signal, indicating that the animal fed on other coastal fishes (García-Tiscar, 2009).

Annual energy requirements for the entire subpopulation of 39 whales in 2011, were estimated at the equivalent of approximately 1,600 tons of tuna (Esteban *et al.*, 2016c). By interacting with the drop long-line fishery killer whales are provided with larger tuna (2 m), than the ones that they are able to actively hunt (tuna 0.8–1.5 m). Consequently INT whales needed fewer number of tuna to meet their energy requirements (8 tuna per day) compared to those actively hunting (21–141 tuna per day) (Esteban *et al.*, 2016c).

Esteban *et al.* (2016d) found that foraging strategies are different between pods (INT and NOT), and all members within each pod participate in the same strategy. Those differences could arise through a combination of vertical transmission of information within matrilineal pods or by vertical and horizontal transmission with individuals aligning their behaviour with that of other pod members (Boyd and Richerson, 1985). Notably, all members of pod A were interacting with the drop long-line fishery as early as 1999, indicating that this behaviour spread throughout this pod in less than a generation, knowing that the fishery began in 1995. Consequently, the transmission of this new behaviour could not have occurred only vertically, from mother to calves. The fact of uniformity within-pod uniformity and differentiation between-pod, in such a recently derived behaviour is consistent with, but not proof of, selective transmission via social learning (Galef, 1992). Hence social structure can have influenced the spread of novel foraging behavior.

In the early 2000s, only one cohesive pod (A) interacted with the drop-line fishery, but after pod A underwent fission to form two socially differentiated pods (A1 and A2), probably caused by an increase in numbers of calf. Therefore, social structure may drive population fragmentation in this already small subpopulation. Experiences of social changes at the earliest steps of divergence in foraging behaviour and social fragmentation may provide insights into the processes that ultimately result in the formation of socially isolated discrete ecotypes in killer whales (Esteban *et al.*, 2016d).

Taylor *et al.* (2007) estimated the generation time of killer whales as 24 years, using a single population with complete data (southern resident killer whales), rather than averaging between what may even be separate species or subspecies, as there is a considerable taxonomic uncertainty. For the killer whales in the Strait of Gibraltar, the only value available used to determine this parameter would be the age at first reproduction for one individual as 11 years old (Esteban *et al.*, 2016c). In the southern resident population females typically gave birth to their first viable calf between 12 and 16 years of age (Olesiuk *et al.*, 1990), so generation time estimated by Taylor *et al.* (2007) appears to be applicable to the Strait of Gibraltar killer whales.

IUCN Habitats Classification Scheme

Habitat	Season	Suitability	Major Importance?
9.1. Marine Neritic -> Marine Neritic - Pelagic	Resident	Suitable	Yes
10.1. Marine Oceanic -> Marine Oceanic - Epipelagic (0-200m)	Resident	Suitable	Yes
10.2. Marine Oceanic -> Marine Oceanic - Mesopelagic (200-1000m)	Resident	Suitable	No

Continuing Decline in Habitat

Continuing decline in area, extent and/or quality of habitat?	Qualifier	Justification
Unknown	-	-

Life History

Generation Length	Justification	Data Quality

24	Taylor et al. 2007 -

Age at maturity: female or unspecified
11 years in the Strait (Esteban *et al.*, 2016c) or 12-16 years in the Pacific (Olesiuk *et al.*, 1990, 2005)

Age at Maturity: Male
15 years (Olesiuk *et al.*, 1990, 2005)

Gestation Time
17 months (Duffield *et al.*, 1995)

Movement Patterns

Movement Patterns: Not a Migrant

Systems

System: Marine

Use and Trade

General Use and Trade Information

Species not utilized: true

In the past there were several reports of actual and incidental captures of some killer whales in the Strait and surrounding areas, including inside the Mediterranean. One specimen was captured in the Mediterranean coast of France in 1787 (Van Beneden, 1888). A female was harpooned in 1902 near the Strait for scientific purposes during a survey of the first Albert of Monaco (Casinos and Vericad, 1976), the skeleton is now mounted in the oceanographic museum of Monaco (Notarbartolo di Sciara, 1987). Another animal was accidentally caught in a coastal tuna net, between Sicily and Malta, in 1972 (Di natale and Mangano, 1983). Finally, incidental captures of killer whales during fishing activities were reported from southeast Spain (Duguy *et al.*, 1983). However there is not recent record of actual or incidental capture at least during this century.

Non- Consumptive Use

Explanation of non-consumptive use: Killer whales are subject to whale-watching activities.

Threats

Depletion of prey may force predators to spend more of their time foraging, which could lead to energetic and nutritional stress and subsequent reduction of reproductive rates and increased mortality rates. The eastern stock of Atlantic bluefin tuna has been exploited for centuries in a sustainable manner, however in 1960 the industrial purse-seine and long-line fleets replaced traditional fisheries in many areas (Fromentin and Powers, 2005). In 1970s, the development of sushi and sashimi market had made it a highly profitable fishery (Fromentin and Ravier, 2005). These new factors have caused a decline of tuna since the 1960s (Taylor *et al.*, 2011). The International Convention for the Conservation of Atlantic Tunas (ICCAT) routinely establishes quotas for tuna. Between 2005 and 2011, quotas were exceeded by 44%, since most of the catches were not being declared (Gagern *et al.*, 2013; ICCAT, 2014). Consequently, Atlantic bluefin tuna was listed as “Endangered” in 2011 (Collette *et al.*, 2012). Between 2009 and 2011, the ICCAT fully endorsed scientific committee advice and enforced a low total allowable catch (TAC) around 18,500–22,000 tons (ICCAT, 2014). As a result, the most recent assessments show signs of biomass increase (ICCAT, 2014). Assessment of tuna indicated that spawning stock biomass peaked over 300,000 tons in the late 1950s and early 1970s, then declined to about 150,000 tons until the mid-2000s and stabilized around TAC levels established by the ICCAT at the end of the 2010s.

Conservation of the eastern Atlantic stock of bluefin tuna is essential for the future of killer whales in the Strait of Gibraltar, as they have a highly specialized diet (García-Tiscar, 2009). Relation between demographic parameters and prey abundance, in other highly specialized killer whales populations has been studied. In the north-eastern

Pacific, the fecundity of the southern resident population has been strongly related to the abundance of their main prey, and a decrease in Chinook salmon populations caused a reduced calving rate (Ward, 2009). Moreover, Ford *et al.* (2010) showed that the population decline was more affected by increased mortality than reduced calving rate. In the Strait of Gibraltar, the amount of tuna captured by drop-line fishery has been related to the survival of killer whale calves (Esteban *et al.*, 2016c). Any decrease in the abundance of tuna could put the population of killer whales in the Strait of Gibraltar at greater risk. The 1,600 tons estimated as the Strait of Gibraltar killer whale energy requirement in 2011 represents 9% of the quota (18,500 tons) established by the ICCAT for the eastern stock Atlantic bluefin tuna. Esteban et al. (2016c) proposed the use of ecosystem based management (Pikitch *et al.*, 2004) to allocate a specific annual quota for killer whales based upon their energy requirements.

Considering that apparently the interaction between the INT individuals, and the drop long-line fishery is beneficial for the animals, as a short-term urgent action, it has also been proposed to allocate a non-transferable quota to the artisanal drop-line fishery in the, at least until the subpopulation shows clear signs of stability and recovery (Esteban *et al.*, 2016c; B.O.E.-A-2017-5474, 2017). There is little evidence for bycatch of killer whales by the fishery: one individual was spotted without a pectoral fin, and deep cuts behind its dorsal fin, but it could not be directly related to the fishery (Otero-Sabio *et al.*, 2018). Further, there was an unverified report from whale watch boats of a juvenile entangled in fishing gear off southern Portugal in 2018.

The Strait of Gibraltar is an area of heavy maritime traffic, due to the increase in commercial vessels, whale watching, ferries, and sports fishing boats in recent decades. Whale watching has become a major tourist industry in many places around the world since the 1980s (Hoyt, 2001, 2002). In addition to boosting the economy of coastal communities and providing an economic reason for the conservation of marine mammals stocks, whale watching has also proved beneficial to increase public awareness of marine mammals and the environmental problems that they face (Tilt, 1986; Duffus and Dearden, 1993; Lien, 2001). In the Strait of Gibraltar, and especially Tarifa, whale watching began in the mid-1990s and in a few years has become a profitable activity in the tourism sector, with a clear upward trend: from 400 visitors in 1998 to 26,228 in 2007 (Urquiola and de Stephanis, 2000; Martín and Urquiola, 2001; Carbó-Penche *et al.*, 2007).

In 2007, the Spanish Royal Decree for the protection of cetaceans (R.D. 1727/2007, 2007) was promulgated to prevent or minimize the impact of whale watching activities for tourist, scientific, recreational, or educational purposes (or any other circumstances in which people might interact with cetaceans). This Decree defines minimum approach distance (60 m) and maximum speed (4 knots) that must be met so as not to injure or disturb the cetaceans. However, in that same year 47% of manoeuvres displayed by commercial whale watching boats around cetaceans did not meet these standards (Salazar-Sierra *et al.*, 2008). Several studies have linked changes in the short-term behaviour of killer whales with boats maneuvers (Kruse, 1991; Williams *et al.*, 2002, 2006; Foote *et al.*, 2004), due to the presence and activity of vessels, the sounds produced by vessels, or a combination of these factors. These reactions have been associated with a decrease in killer whale energy efficiency, whereby individuals need to spend more time foraging to capture the same amount of food than in the absence of boats (Kriete, 1994; Williams *et al.*, 2002, 2006). However, individuals may react in different ways to boats. In some cases no response to the vessels was observed. Evasive tactics often differed between encounters with vessels (and sex of the whale), with the number of vessels and vessel proximity, activity, size, and the noise all affecting the killer whale responses (Williams *et al.*, 2002, 2006). In the Strait of Gibraltar, whale watching companies organize special trips to observe killer whales during July and August, when whales spend most of the time interacting with the drop long-line fishery. The increased presence of vessels around the whales may affect foraging efficiency, making it harder for whales to obtain food in a noisier environment. During spring, when killer whales are based at the shallower waters of the north-western most part of the Strait of Gibraltar, vessel presence is low because it is outside of the main maritime traffic lanes. However, because whales are actively hunting (Guinet *et al.*, 2007), they may be more affected by vessel noise, which could mask detection of the tuna by the whales using passive listening and thus could cause a reduction in feeding efficiency.

Every year in spring, military exercises occur in the main distribution area of killer whales in the Strait. For example, in 2015 the North Atlantic Treaty Organization (NATO) coordinated the Trident Juncture exercise in that area, with 36,000 personnel of 30 different countries. Two seasonal critical areas for the killer whales were proposed by the Spanish Ministry of Environment to regulate possible disturbance activities such as commercial and recreational whale watching and military exercises in the main habitat of killer whales in spring and summer (B.O.E.-A-2017-5474, 2017).

Organochlorine contaminants such as polychlorinated biphenyls (PCBs) pose a constant health threat to animals and humans. These components are lipophilic and persistent thus accumulate in the blubber of marine mammals. They were banned in developed countries in the 1970s and 1980s but can be still found in the blubber of animals, including marine mammals such as killer whales (Jepson *et al.*, 2016). In cetaceans, concentrations of PCBs increase with age in males, but are reduced in females during lactation (Ross *et al.*, 2000). Haraguchi *et al.* (2006) found higher concentrations of PCBs and polybrominated diphenyl ethers (PBDEs) in calves of lactating females, indicating that large amounts of halogenated organic compounds are transferred from female to offspring via lactation. In their recent meta-analysis of European data on summed 18–25 chlorobiphenyl congeners (PPCB) concentrations (mg/kg lipid weight (lw)) in odontocete cetaceans that were stranded or biopsied, Jepson *et al.*

(2016) included tissue samples from 24 killer whales. Mean PPCB lipid concentrations in killer whales from the Northeast Atlantic were among the highest recorded in cetaceans globally. Killer whales of the Strait of Gibraltar (n=7 biopsied; n=1 stranded—Vega) had some of the highest PPCB concentrations among cetaceans sampled (mean concentrations of 243.43 mg/kg lipid for males, and 186.74 mg/kg lipid for females of all ages sampled), markedly exceeding all known PCB toxicity thresholds for marine mammals (Jepson *et al.*, 2016). Adult female killer whales in the Strait of Gibraltar had mean PPCB concentrations of 215.43 mg/kg lipid (Jepson *et al.*, 2016). Tuna sampled in the Strait of Gibraltar also presented high levels of pollutants (Sprague *et al.*, 2012). The transfer of organic compounds from female to calf can negatively affect calf survival, and this may have been a factor when bluefin tuna stocks were at their lowest (2005–2011), as food deprivation in the lactating females could have promoted the metabolism of lipid stores, releasing sequestered pollutants into circulation (Aguilar *et al.*, 1999; O'Shea, 1999).

Threats Classification Scheme

Threat	Timing	Scope	Severity	Impact Score
3.1. Energy production & mining -> Oil & gas drilling	Future	-	-	No/Negligible Impact: 1
5.4.3. Biological resource use -> Fishing & harvesting aquatic resources -> Unintentional effects: (subsistence/small scale) [harvest]	Ongoing	-	-	Low Impact: 3
5.4.4. Biological resource use -> Fishing & harvesting aquatic resources -> Unintentional effects: (large scale) [harvest]	Ongoing	-	-	Low Impact: 3
6.1. Human intrusions & disturbance -> Recreational activities	Ongoing	-	-	Low Impact: 3
6.2. Human intrusions & disturbance -> War, civil unrest & military exercises	Ongoing	-	-	Low Impact: 3
9.1.3. Pollution -> Domestic & urban waste water -> Type Unknown/Unrecorded	Ongoing	-	-	Low Impact: 3
9.2.3. Pollution -> Industrial & military effluents -> Type Unknown/Unrecorded	Ongoing	-	-	Low Impact: 3
9.3.3. Pollution -> Agricultural & forestry effluents -> Herbicides and pesticides	Ongoing	-	-	Low Impact: 3
9.3.4. Pollution -> Agricultural & forestry effluents -> Type Unknown/Unrecorded	Ongoing	-	-	Low Impact: 3
9.6.3 Excess Energy -> Noise Pollution	Ongoing	-	-	Low Impact: 3

Conservation

The killer whale is listed in Appendix II of the Convention on International Trade in Endangered Species and Appendices I and II of the Convention on Migratory Species (CMS), in Appendix II of Convention on International in Endangered Species (CITES), and in Annex II of the Protocol on Specially Protected Areas and the Biological Diversity in the Mediterranean of the Barcelona Convention. It is also protected under Appendix II Convention on the conservation of European wildlife and natural habitats (Bern Convention).

The subpopulation of killer whales in the Strait of Gibraltar are protected under the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean and contiguous Atlantic waters (ACCOBAMS). They were proposed as Critically Endangered by ACCOBAMS-IUCN (Cañadas and de Stephanis, 2006). In 2007, the Small Cetaceans' sub-committee of the International Whaling Commission (IWC) recommended that "two governments (Spain and Morocco) to co-operate to monitor the status of the killer whales and to assess the need for conservation action" (IWC, 2007). In Spain, there are regulations and guidelines for manoeuvring in the proximity of cetacean (R.D. 1727/2007, 2007). In 2011, the Spanish Ministry of Environment catalogued them as vulnerable (R.D. 139/2011, 2011), and a conservation plan was approved by the Spanish government in 2017 (B.O.E.-A-2017-5474, 2017). Some of the measures contemplated in the plan are the exclusion in "Critical areas for the killer whales" of seismic surveys, the regulation of the recreational activity of observation of cetaceans, or the maintenance of an non-transmissible fishing quota of bluefin tuna for the drop long-line fishery of the Strait. However all those actions still need to be implemented a proper management and monitoring plan should be still established for this subpopulation

Further studies on this subpopulation structure, annual abundance and life history are needed. Population trends and it is fully recommended a Population Viability Analyses, to be able to understand the consequences of the actual and possible future threats that they are facing. In that manner Conservation Actions (such as designation of

Protected Areas, not just critical areas without a real protection figure) could evolve with the actual situation of the population and their projected trend.

Conservation Actions In- Place

Action Recovery Plan	Note
No	-

Systematic monitoring scheme	Note
No	-

Conservation sites identified	Note
Yes	“Critical areas for the killer whales” (B.O.E.-A-2017-5474, 2017)

Occur in at least one PA	Note
No	-

Area based regional management plan	Note
No	-

Included in international legislation	Note
Yes	CMS Appendix II CITES Appendix II Barcelona Convention Appendix II Ben Convention Appendix II ACCOBAMS

Subject to any international management/trade controls	Note
Yes	CITES Appendix II

Important Conservation Actions Needed

Conservation Actions	Note
1.1. Land/water protection -> Site/area protection	-
2.1. Land/water management -> Site/area management	-
5.2. Law & policy -> Policies and regulations	-
5.4.2. Law & policy -> Compliance and enforcement -> National level	-
7.3 External Capacity Building -> Conservation Finance	

Research Needed

Research	Note
1.2. Research -> Population size, distribution & Past trends	-
1.3. Research -> Life history & ecology	-
1.5. Research -> Threats	-
1.6. Research -> Conservation Actions	-
2.2. Conservation Planning -> Area-based Management Plan	-
3.1. Monitoring -> Population trends	-

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