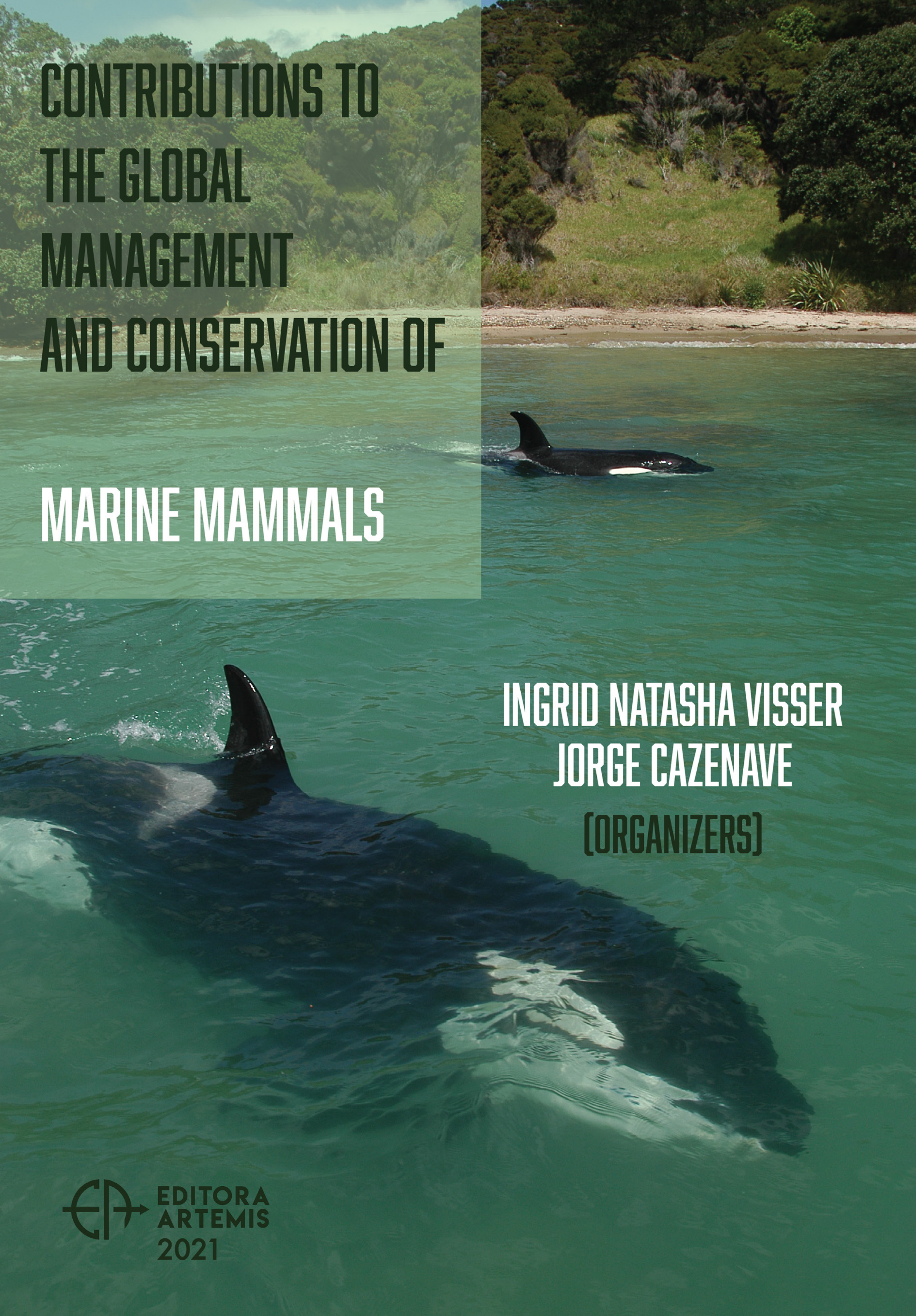

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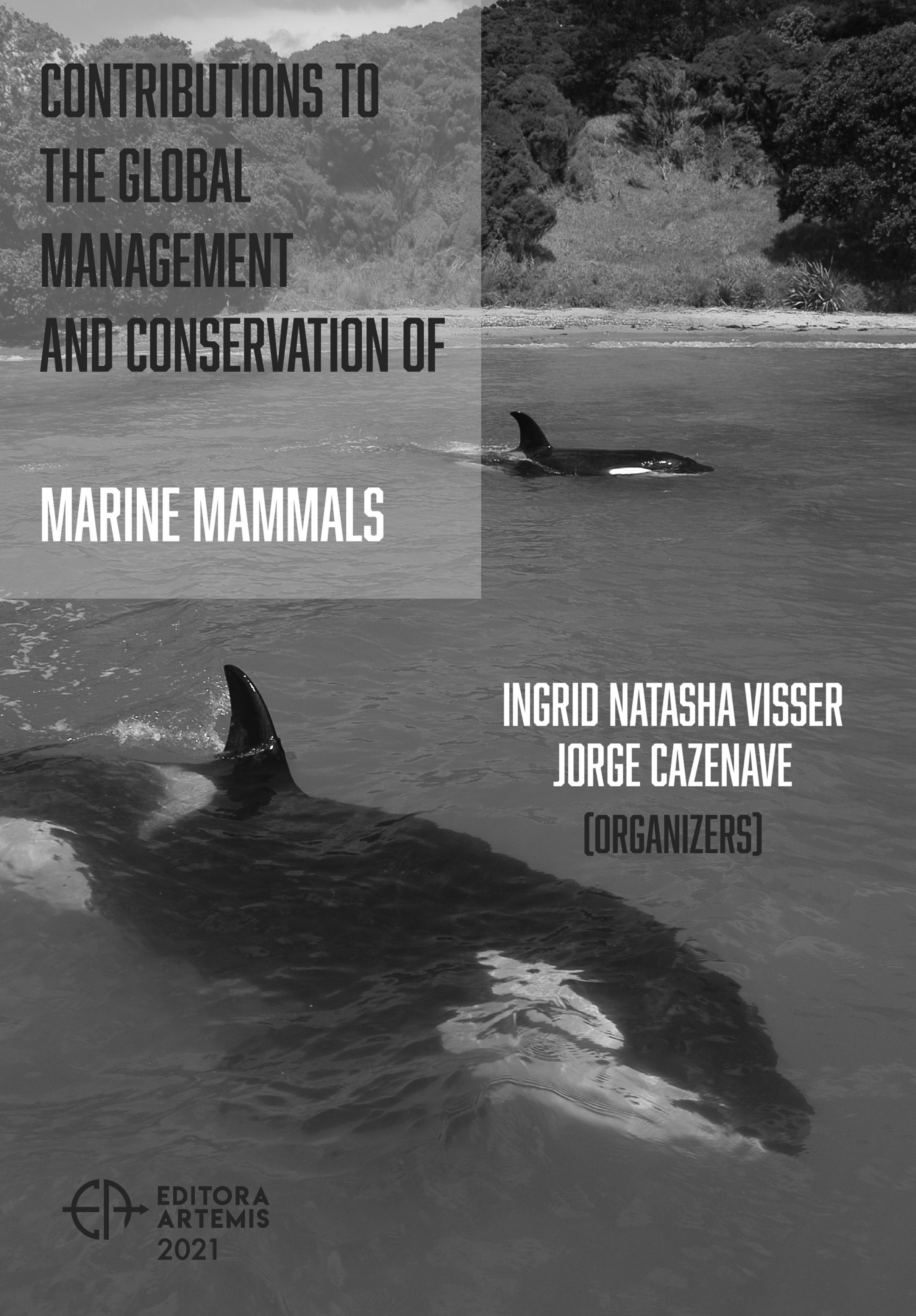

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PREFACE

Contributions to the Global to Management and Conservation of Marine Mammals.

I write the introduction to this book after just having returned from a day out researching wild orca along the New Zealand coastline. During that encounter I had the opportunity to not only see the orca hunting for rays in the shallow waters, but an adult male orca, known to me since he was born, became stranded as he followed his family over a sand bank. His calm demeanour was indicative to me that he had experienced such an event before. Whilst stranded, he patiently tested the water depth, and his ability to get off the sand bank, by gently rolling from side to side every 10 mins or so. During the time that he was stranded our team poured water over him in order to prevent his skin drying out. Eventually the tide had returned enough for him to focus all his energy into getting off and into deeper water. Within minutes of freeing himself he was back with his family and within an hour he was catching rays again. It struck me as I was watching him, that he was around 30 years old, older than I was when I started studying his family. The changes he had seen in his lifetime are changes that I've documented too. Encroachment into his habitat with new marinas, wharfs, reclamation and dredging. Exclusion from prime hunting area from all of these man-made features as well as aquaculture farms expanding so fast it is hard to document them all. He has seen the numbers of vessels increase exponentially and the volume of noise pollution expand with it. He has experienced raw sewage flowing around him when he has entered into harbours and he has swum past floating garbage and viewed sunken junk discarded in his home. He has seen members of his social network drown when entangled, die when stuck on a beach and suffer from severe wounds when hit by boats. It is a wonder he has survived as long as he has with all this and more that he must contend with. But, despite all these negative aspects, there is some hope; New Zealand now has more than 30 marine reserves (protected areas to prevent fishing and habitat destruction). Although they are comprised of only a tiny part of the entire coastline, they are a start. I also see a growing number of scientists, lawyers, researchers and field biologists interested in contributing towards conservation and management issues. My hope is that this volume will provide a platform for some of those studies to reach a wide audience and to make a difference for individual cetaceans, their populations and the habitats that they not only live in but require to survive. The book is arranged by author, rather than, species, region or topic as the first two categories ranged across multiple species and around the globe and yet at times also overlapped, whilst the topics were just as diverse.

Ingrid N. Visser (PhD), New Zealand

In December 2019, the Society for Marine Mammalogy (SMM) and the European Cetacean Society (ECS) jointly hosted the World Marine Mammal Conference in Barcelona, Catalonia, Spain. That conference, the starting point for gathering the authors of this book, was the largest gathering of marine mammologists that had ever occurred, with over 2,700 registered attendees, from more than 90 countries. It was only the second World Marine Mammal Conference, with the first being in 1998 in Monte Carlo, Monaco (and where approximately 1,200 people from 50 countries attended). With the Covid-19 pandemic now rampant across the globe it may be many years before such a similar gather occurs again. Regardless, the work of all those conference attendees will continue and this volume is just one of the many published works that are resulting from ongoing research.

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CHAPTER 1

ARGENTINEAN ORCA (*ORCINUS ORCA*) AS AN UMBRELLA SPECIES: CONSERVATION & MANAGEMENT BENEFITS

Submitted: 25/12/2020
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ABSTRACT: When apex predators, and their habitat, are appropriately protected they can act as 'umbrella species' enhancing potential ecosystem-wide benefits. If combined with long-term studies of individually recognised animals, the positive spin-offs expand. At Punta Norte, Península Valdés, Argentina, a unique ecotype of orca intentionally strands to capture sea lion pups. For 16 years our team of researchers has photographed individuals and documented their hunting. We have recorded multi-generational groups, the complexities of social networks and the success of individuals as parents and as hunters. Recognising a need to prevent tourists from disturbing their main prey in the area, the Punta Norte Orca Research team secured private donations and installed over 12 km of fencing to protect sensitive beach zones. Since the installation of the fence the number of orca have increased two-fold. However, the population is still at a critically low number of approximately 20 key individuals. We call for official recognition of this unique orca ecotype and their listing as endangered by the Argentinian Authorities as well as in the Red Data list of the IUCN.

KEYWORDS: killer whale (*Orcinus orca*), conservation, photo-identification, tourism impact, umbrella species

ORCA ARGENTINA (*ORCINUS ORCA*) COMO ESPECIE PARAGUAS: BENEFICIOS DE CONSERVACIÓN Y MANEJO

RESUMEN: Cuando los depredadores ápice y su hábitat están adecuadamente protegidos, pueden actuar como 'especies paraguas' y aumentar los beneficios potenciales para todo el ecosistema. Si se combina con estudios a largo plazo de

animales reconocidos individualmente, los efectos secundarios positivos se expanden. En Punta Norte, Península Valdés, Argentina, un ecotipo único de orca se encalla intencionalmente para capturar crías de lobos marinos. Durante 16 años, nuestro equipo de investigadores ha fotografiado individuos y documentado su caza. Hemos registrado grupos multigeneracionales, las complejidades de las redes sociales y el éxito de los individuos como padres y como cazadores. Reconociendo la necesidad de evitar que los turistas molesten a sus principales presas en el área, el equipo de Investigación de Orcas de Punta Norte consiguió donaciones privadas e instaló más de 12 km de vallas para proteger las zonas de playa sensibles. Desde la instalación de la cerca, el número de orcas se ha duplicado. Sin embargo, la población todavía se encuentra en un número críticamente bajo de aproximadamente 20 individuos clave. Pedimos el reconocimiento oficial de este ecotipo de orca único y su inclusión como en peligro por las autoridades argentinas, así como en la lista Red Data de la UICN.
PALABRAS-CLAVE: conservación, foto-identificación, impacto del turismo, especies paraguas.

1. INTRODUCTION

A. STUDY SITE

The Argentinean orca who intentionally strand to capture pinnipeds do so predominantly at Punta Norte (42°05'S, 63°46'W, Figure 1) which is found inside Estancia La Ernestina (an ecotourism lodge and sheep farm) on the north-eastern tip of Península Valdés. The peninsula is situated approximately 900 km south-west of Buenos Aires and is a UNESCO World Heritage Site in Patagonia. Protruding into the Atlantic Ocean, Península Valdés is characterized by a narrow isthmus, flanked to the north and the south by large gulfs, almost creating an island. Along the entire coastline there is a diversity of habitats, from high sandstone cliffs to large rock platforms with both sandy and gravel beaches between (e.g., see Bunicontro et al., 2017 for Golfo Nuevo examples).

The peninsula was lifted above sea level by the rise of the Andes (Codignotto, 2008) and it has two large inland salt lakes below sea level. The Andes mountains, along the western border of Argentina, capture most of the moisture streaming in across South America from the Pacific, creating a terrestrial biogeographical barrier (Aragón et al., 2011). As such, when the west winds blow they are typically dry by the time they reach the Atlantic side of the country, where Península Valdés is situated. The peninsula is also exposed to the cold southerlies roaring up the coast from Antarctica and, combined with the blustery winds coming in from the Atlantic, these generate a regional climate with scarce rainfall, strong (and often salt-laden) winds and cool temperatures. Although there is a narrow band of slightly increased rainfall (during extremely limited singularities and typically within June-August) along the coastline, the result creates a marine influence on the vegetation (Coronato A., et al., 2017). However, overall the area is windswept, dry, dusty and is cool in the winter (average day and night temperatures of ~7°C in July) and warm in the summer (average day and night temperatures of ~18°C in January) (Coronato F., et al., 2017), although there are isolated pockets on the coast where the temperatures have been known to reach more than 25°C (Coronato F., et al., 2017).

The terrestrial biodiversity of the area is well recognised with at least 200 species of insects and spiders, 139 species of terrestrial birds, 23 species of native land mammals and 12 species of reptiles inhabiting the island-like peninsula (Daciuk, 1977; Baldi & Cheli, 2017, UNESCO Península Valdés 2001-2017).

In addition to its terrestrial importance, it is a site of significance for a diverse range of marine macrofauna (Irigoyen et al., 2011) and megafauna including 29 species of teleost marine fishes (Galván et al., 2009), at least 10 species of elasmobranchs (Chiaramonte, 1998; Menni et al., 2008) and more than 15 species of shorebirds and seabirds (Daciuk, 1977; Couve & Vidal, 2003). This includes a minimum of four colonies of Magellanic penguins *Spheniscus magellanicus*, one of which is located inside Estancia La Ernestina at Punta Norte (Boersma et al., 2009), and at least seven species of marine mammals (López & López, 1985; Würsig & Bastida, 1986; Campagna et al., 1993; Nowak, 1999; Daneri et al., 2011; Zerbini et al., 2016).

When Península Valdés was nominated and later ratified as a UNESCO Site, the listing specifically included four marine mammal species, emphasising how important these were to the biodiversity but also for the conservation and management of area;

> *"Península Valdés contains very important and significant natural habitats for the in-situ conservation of several threatened species of outstanding universal value, and specifically its globally important concentration of* ***breeding southern right whales****, which is an endangered species. It is also important because of the* ***breeding populations of southern elephant seals and southern sea lions. The area exhibits an exceptional example of adaptation of hunting techniques by the orca to the local coastal conditions.****"* [emphasis added] World Heritage Committee (1999).

Southern right whales (*Eubalaena australis*) gather between June and December in the two gulfs that abut the peninsula and orca attacks on the species have been documented since at least the 1970's (Cummings et al., 1972; Thomas & Taber, 1984; Sironi et al., 2008). The peninsula has the only known continental reproductive colonies of Southern elephant seals (*Mirounga leonina*) worldwide. They come ashore between late August to early November to breed and give birth (Campagna et al., 1993). Although South American sea lions (*Otaria flavescens*) can be found around the coastline of Península Valdés all year round, they concentrate in reproductive colonies, including at Estancia La Ernestina, in December and pup in January to early February (Vila et al., 2008).

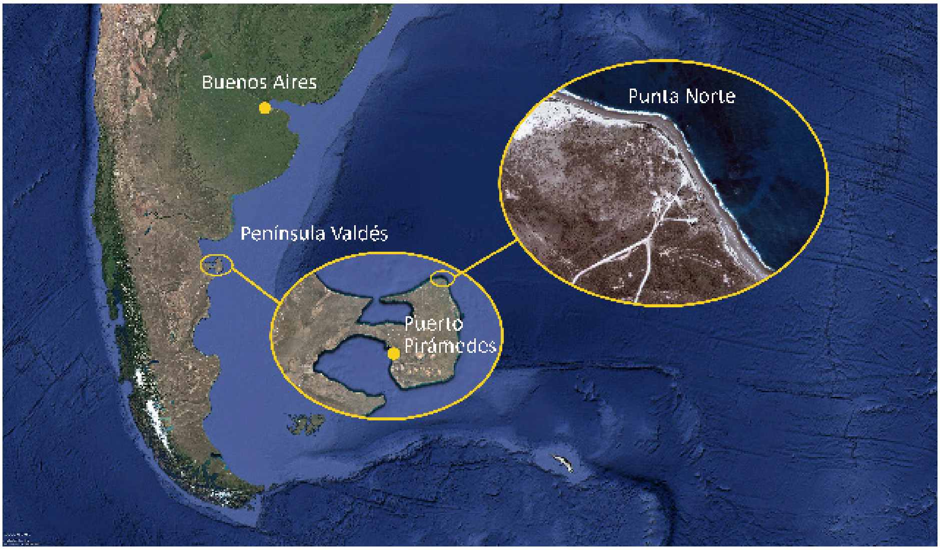

Figure 1. Punta Norte is on the northernmost tip of Península Valdés, situated approximately 900 km south-west of Buenos Aires. The whole peninsula, including the small township of Puerto Pirámides, is a UNESCO World Heritage Site, in Patagonia, Argentina. Image created by Punta Norte Orca Research, using Google Earth (2020).

Figure 2. An adult female known as Maga (catalogue # PTN-004) is accompanied by her daughters Valen (PTN-009) (middle) and Mica (PTN-008) (left), as she intentionally strands to capture a South American sea lion pup, at Estancia La Ernestina, Punta Norte, Península Valdés. Photo © Jorge Cazenave (2012).

B. ORCA BACKGROUND

Orca are perhaps one of the most recognisable of all the cetacean species (Ford, 2018). Although unlikely to be confused with other species, within the genus *Orcinus* there is substantial variation of morphological features at a population-level. These distinct populations, which have been defined not only by their morphology but also by their genetics and ecology (with a strong emphasis based on their dietary differences), have resulted in what can be characterized as a 'species-complex'. Within that, the terms 'subspecies', 'races' 'populations', 'sub-populations', 'forms', 'geographic forms' 'morphotypes' and 'ecotypes' have all been used to describe the variations that can be found around the world (e.g., Reeves et al., 2002; Jefferson et al., 2015; Ford, 2018; Würsig et al., 2018).

In the UNESCO online listing for Península Valdés, the local orca and their specialised hunting method is highlighted a number of times, including some of the species which are prey for the Punta Norte orca;

> *"The small local population of Orca has developed a spectacular hunting method by intentionally stranding on the shores to catch offspring of Southern Sea Lion and Southern Elephant Seals."* World Heritage Committee (1999).

We describe our more than 16 years of research on the orca who intentionally strand to capture sea lions (Figure 2). These orca exhibit what is arguably the most recognized hunting technique of the species, globally. Although individuals from this population have been documented along parts of the southern Atlantic coast of South America (Lichter, 1992b), this population is seen most frequently at Punta Norte, Península Valdés, Argentina (Figure 1) and as such they are known locally as the Punta Norte orca.

Yet, despite the population's notoriety and international exposure through multiple documentaries (e.g., see www.pn-orca.org/documentaries), for reasons unknown this ecotype is typically overlooked (or at best just briefly mentioned). For example, when the species-complex *Orcinus* is discussed, including on orca ecotype identification 'posters' or in general marine mammal reference and guide books, they either don't appear (e.g., Reeves et al., 2002; SWFSC & NOAA, 2011; Jefferson et al., 2015) or receive only a cursory mention (Ford, 2018; Würsig et al., 2018).

Regardless, the Punta Norte orca clearly are not only a distinct ecotype but they also are a draw for some of the hundreds of thousands of tourists who go whale watching in Argentina each year (Hoyt & Iñíguez, 2008). It has long been recognised that humans can have an impact on wildlife (both negatively and positively, e.g., see (Lalas & Bradshaw, 2001; Madden, 2004) and references therein). This is no different for whales and dolphins who can be negatively impacted (Orams, 2002; Gales et al., 2003) or positively impacted, both directly or indirectly, e.g., through a switch from whale hunting to whale watching (Hingham & Lusseau, 2008; Chen, 2011) or via improved education, marine protected areas and conservation movements to improve habitat (Hoyt, 2005; Fonseca et al., 2014; García-Cegarra & Pacheco, 2016; Smith J.S. et al., 2019) as well as through legislation (Valentine et al., 2004; Lukesenburg & Parsons, 2014).

In the case of the Punta Norte orca, these individuals have been threatened by live captures, hunting and impacted by tourism, but conversely the orca have also helped produce positive impacts, including as sentinel and ‘umbrella’ species. By managing and conserving their habitat and the prey they rely on, these orca provide direct and indirect protection for this ecological community.

2. LONG-TERM RESEARCH

A. HISTORIC RESEARCH

The first studies of the Punta Norte orca started in the 1970’s, when Juan Carlos and Diana López, local Guardafaunas (Park Rangers), started documenting individuals as they patrolled the coast. They noted specific characteristics for each orca, such as the shape and size of their dorsal fin, cuts or notches in the trailing edges of the fin or distinctive scars or markings on their bodies. They sketched these distinctive features or took photographs and over a period of years identified several individuals in three different groups (López & López, 1979). Over the next decade they amassed a wealth of data, including details on the incredible foraging strategy the Punta Norte orca had developed. This resulted in the first scientific publication on intentional stranding by orca (López & López, 1985). From their description of the pre-attack strategies and the attack methods the orca used, including cooperative hunting, it was clear that the 568 hunting attempts they had witnessed gave them a strong understanding of the phenomenon.

But López and López (1985) had also flagged that during the more than 900 times they had observed the orca, it was the same individuals returning time and time again. They had identified 26 individuals by this point but estimated that there were “*probably not more than 30 adult and juvenile animals*” in the population.

The next publication compared the orca of Punta Norte to those found near Vancouver, Canada, as part of a PhD thesis by Rus Hoelzel. Again, the unique situation of being able to see the orca capture their food ashore allowed for not only identification of the prey, but who was doing the hunting and how successful they were (Hoelzel, 1989). Hoelzel found that of the three groups he observed, one group excluded the others from the hunting area and that “*Energetic calculations suggested that the rate at which these whales captured sea lion prey was just sufficient to sustain them.*” He also added another layer of information by looking at their DNA and found that orca within groups were more closely related than orca between groups. Hoelzel then published a paper exclusively on this population, focused on their hunting strategies and included details of food-sharing and provisioning (Hoelzel, 1991).

Still concentrating on their hunting behaviour, but using acoustics to try and better understand how these predators were selecting their prey, John Ford, one of the founders of orca acoustic research, collected recordings in the early 1990's (Ford, 1992). He discovered that the whales were silent prior to their attack "*perhaps ... as a strategy for surprise attack*" and that there was a lack of echolocation clicks as the orca milled about waiting for their prey. Ford speculated that "*perhaps the whales locate prey by listening for their splashing sounds as the sea lions swim in the shallows*" and he confirmed that the orca were very vocal after a successful hunt.

Local cetacean researcher Miguel Iñíguez spent nearly 40 weeks waiting for orca during the sea lion pupping seasons of 1988-1997. During these nine years he spotted them at Punta Norte on 125 days. He also documented three groups, but now there were only 17 animals who regularly used the area (Iñíguez, 2001). As his study progressed the numbers dropped; with two groups and a total of only 10 orca visiting the area at the end of his research. He also described the seasonal distribution of the orca, stating that "*most* [orca] *leave Punta Norte after May*".

During all of this time, the researchers were working on the coastline abutting the sheep farm Estancia La Ernestina, where the Copello family has resided since 1907. The senior author grew up with the orca swimming past this farm and vividly recalls seeing them when he was younger, including a juvenile which was discovered dead on the beach not far from the Copello family home (Figure 3).

Figure 3. Juan Copello (left) with a dead juvenile orca on 12 June 1988, near the homestead of Estancia La Ernestina. Photo © courtesy Copello archives (1988).

B. CURRENT RESEARCH

In 2004, recognising the need for a long-term research project to build on these historic studies, Punta Norte Orca Research (PNOR) was founded and is based at Estancia La Ernestina. As a wildlife conservation and science organization, it not only researches the orca whom it is named after but also promotes protection of their habitat and the other animals who live in the vicinity.

Like earlier researchers, we use photo-identification to monitor the presence of individuals and to document the behaviour they are exhibiting. The value of long-term studies, where individuals are identified and monitored has been recognised since the 1930's when birds were ringed and monitored as individuals (Nice, 1934; Kluijver, 1951). Such studies allow us to answer fundamental questions about animals and their lives (Clutton-Brock & Sheldon, 2010). Nowadays, with advanced camera technology and powerful zoom lenses, photography allows for precise individual identification and monitoring of changes of scars over time and for 'capturing' details that were never possible before. For example, we are able to capture images of calves when they are only days old and follow their development, including when they first begin practice stranding (Figure 4), or when they capture their first sea lion.

Figure 4. At only four years old, Shotel (catalogue # PTN-026), remains the youngest orca we have documented who intentionally strands. Although born in 2014, as yet we don't know if Shotel is a male or a female, but we do know his/her mother is Llen (catalogue # PTN-010), who is a proficient hunter. Practicing stranding, not just in calm waters, but also in larger waves which 'dump' onshore, helps the animals become successful hunters. Photo © Juan M. Copello (2018).

Collecting what might be considered 'basic data', such as which individuals show up each season, who is seen with whom and when calves are born, can be painstaking but the rewards are impressive if you are willing to put in the effort. We have witnessed extraordinary events, such as when more than 70 attempts were made to capture sea lion pups in a single day, the most hunting ever recorded in a 24 hour period at La Ernestina (Copello et al., 2019). Monitoring each attack by an individual can show us who is a great hunter (or who is rarely successful). We have recorded six different prey species taken at Punta Norte (in order of prevalence; South American sea lions, Southern elephant seals, Southern right whales, Magellanic penguins, Southern giant petrels (*Macronectes giganteus*) and cormorants (*Phalacrocorax* sp.) (Copello et al., 2019)).

By recording mother-calf pairs we have constructed family trees (Figure 5) and can monitor changes over time. Following a single orca for decades gives insight into their lives, not only providing information on how many offspring they have but also their grandchildren. We can establish the dynamics of social networks and begin to understand the driving forces behind group fission and fusion and link that to hunting abilities. We can observe when a matriarch dies, how the remaining orca function and if they continue to maintain family bonds or fracture into smaller groups.

By 2008 we had documented 15 orca and photo-identified them with high-resolution images of both their left and right dorsal fins, saddle patches and eye patches (Punta Norte Orca Research, 2008) and noted that seven of those were stranding to capture sea lions. One was an iconic adult male, known as Mel (catalogue # PTN-001), (Figure 6). He was first documented as a youngster on 4 May 1975 (López, 2000) and has continued to be a part of all the historic studies, as well as the current one by PNOR where his role in the social network was documented in our database. Mel became world famous in the mid 1980's when he featured in magazine articles and documentaries, in which his prowess as a hunter was showcased (Gentry, 1987; Lichter, 1992a; López, 2000). His story includes being shot in the dorsal fin by Government employees (creating a permanent slight bend to his left side), having his DNA profiled by Hoelzel and becoming a movie star (Lichter, 1992a; López, 2000, In Press). Mel was so iconic that the first logo we designed for the research project featured him in profile (Punta Norte Orca Research, 2008).

He was at least 50 years old when he was last seen in 2011 and although we are unsure if Mel fathered any of the orca seen at Punta Norte today, his legacy lives on, not only in the generations of people he inspired through his appearances in the media, as well as 'in person' at the Mirador (lookout) at Punta Norte but also in the scientific data he contributed throughout all the research projects.

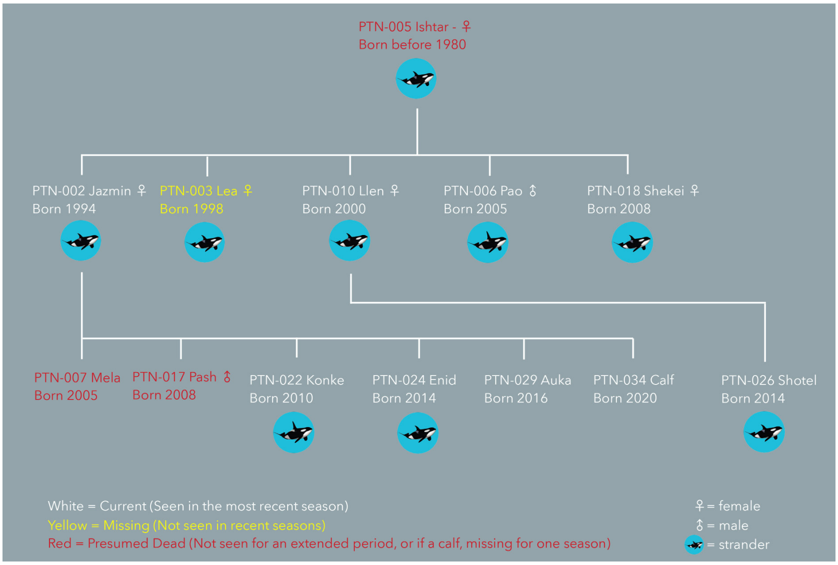

Figure 5. The family tree of Ishtar's group at the end of the 2020 sea lion pupping season. She was alive at the start of our research and produced at least five calves, four of which were documented in 2020 (white names, top line). She had seven grandchildren (red and white names, bottom line), five of which were documented in 2020. Three of those have already begun to intentionally strand to capture sea lions (indicated by the orca icon circled in blue). Graphic by Mark Enarson, for Punta Norte Orca Research 2020 ID Guide.

By 2020, more than 30 orca had been photo-identified (Copello et al., 2019), albeit that during the intervening years some, like Mel, were no longer seen and therefore this was a cumulative number. For example, in the 2020 season, 12 previously catalogued orca were no longer seen (Punta Norte Orca Research, 2020). Like previous studies we too documented three main groups, however one, known as Maga's group (Figure 2), had 12 members in 2020, five more than the total number of orca documented in the 1987-88 study (Hoelzel, 1991) and three more than the total number in the most recent study in the 1990's (Iñíguez, 2001).

As this research project has now been running for more than 16 years, we have a database of information that is robust and will only get stronger as it continues to build. The advantages of persistent and continuing field research on wild animals has been recognised for other long-term studies (Clutton-Brock & Sheldon, 2010). For example, spending hours watching animals allows us to also recognise personalities. Some individuals will have particular styles of hunting or never even attempt certain methods of foraging. There are times when we can predict who will be the most likely to play or who is more likely to intentionally strand, who is likely to just 'scare' the pups out of the water and who is likely to capture a pup and take it to the others in the group to help affirm social bonds through 'food sharing'. This 'intimate' data also allows us to recognise conservation challenges that these animals face.

Figure 6. The iconic adult male orca known as Mel (catalogue # PTN-001) was first recorded at Punta Norte in 1975 and has featured in all the research projects since then. We photographed him from the inception of our research in 2004. He was last documented in 2011 and only one adult male orca has been recorded intentionally stranding to hunt since then. Photo © Ingrid N. Visser.

3. CONSERVATION CHALLENGES

Clutton-Brock & Sheldon (2010) noted six key benefits to long-term studies that, like this one, were based on individually recognised animals. But they also highlighted a number of challenges for these projects. For one, they stated "*Researchers based in national parks and natural reserves are often subject to restrictions on their activities and many conservation authorities have become increasingly sceptical of the value of long-term research unless it provides direct guidance to management*." They also noted "*Of all the obstacles faced by long-term studies, the greatest single problem is the difficulty of maintaining funding without interruptions.*" John Ford, one of the early founders of orca research, in a chapter specifically discussing long-term studies of marine mammals noted similar challenges for their research on the orca who traverse the boundary between Canada and the USA;

> *"As with most long-term studies, finding sufficient and reliable funding has, at times, been a struggle. Each year, many weeks of on-the-water field work are needed. Analysis of identification photos and updating of databases requires many more weeks of work in the laboratory. The annual photo-identification effort can appear to be rather mundane to funding agencies, but it is critical to the success of our studies as well as to the conservation of these populations. For example, longterm unbroken effort to maintain a precise annual registry of individuals in the population enabled us to detect subtle year-to-year changes in age-specific survival rates in resident killer whales, and to link these to varying prey abundance. Although not considered a funding priority by federal agencies on either side of the border, a sharp decline in the abundance of resident killer whales in the late 1990s resulted in a listing under the Canadian Species at Risk Act and the US Endangered Species Act."*

PNOR has faced similar challenges and more. Research permits are only issued for a one-year timeframe and applications involve direct face-to-face consultation with the authorities for each renewal, with proof of 'outputs' from the previous season. Recommendations for management improvements are typically not implemented and PNOR receives no funding from the Government, Universities, or corporate sponsors. The duration of the PNOR project, now more than 16 years long, illustrates the tenacity of the project members, who desire to see these animals and their habitats protected. As impacts such as marine heatwaves (Oliver et al., 2018; van den Berg et al., 2020), ocean acidification (Ríos et al., 2015), over-fishing (Ainley & Blight, 2008) and the like continue to increase and accumulate, these fragile ecosystems face harsher times and higher chances of collapse. A study such as the PNOR research project provides a data set of a key sentinel species and highlights where issues may lie.

Around the world, and no matter the species, the risks for top predators are often linked to anthropogenic sources. In the case of cetaceans, entanglements are one of the high-impact risks, including in the Península Valdés region where Southern right whales have been entangled (Bellazzi et al., 2012). So far, no orca in the Punta Norte population have been found entangled, but entangled orca often die (Visser & Hupman, 2019) and their bodies may not be recovered as they tend to sink upon death (Dahlheim & Matkin, 1994), so the orca no longer sighted by us may have succumbed to this fate, particularly as we know at least some spend time outside of the Punta Norte region.

But these world-famous orca have not escaped the other high-risk threat to cetaceans; that of boat strike (Van Waerebeek et al., 2007). At least three orca from the Punta Norte population have been hit by boats. One, a calf born in 2019 was struck sometime between when it left the Punta Norte area at the end of the sea lion season and its return in March 2020. The calf, whose sex is not yet known, survived but it sustained at least four strikes from a boat propeller and lost the end of its left tail fluke (Figure 7).

Boat strikes at such a young age have been known to impact an orca for the rest of its life, including stunting growth and slowing swimming capacity (Visser, 1999). The long-term monitoring of this calf and how its family supports it is part of our ongoing research plan. It is likely, if it cannot hunt proficiently, that it will be provisioned by the other members of the group, as has been documented for other orca who have been injured or have mobility issues (Visser, 1999; Stenersen & Similä, 2004).

Figure 7. A young calf, offspring of Maga (catalogue # PTN-033 and born a year before these photographs were taken), was run over by a boat. Although it has survived, the long-term impacts from such an injury could be extreme. The propeller cut into the calf at least four times (white arrows, left), and sliced off the end of the calf's left tail fluke (right). Photos © Juan M. Copello (2020).

There are no boat-based whale-watching tours to see the orca off Punta Norte, so the injury the calf sustained must have occurred elsewhere. Boats of any kind are severely restricted around the UNESCO Site, with the exception of licensed tour operators departing from Puerto Pirámides, who focus on watching Southern right whales during the breeding season (and other wildlife outside of this time and therefore they only occasionally encounter the orca). These operators have a 'Code of Conduct' and regulations with speed restrictions and the maximum number of boats near the whales at any one time (Provincial Laws No 2381/84 & No 2618/85).

But the pressure is high to see orca as they are considered "*... among the most spectacular of all animals to see in the wild*" (Duffus & Dearden, 1993). With the high profile that this specific population of orca has, based partly on their impressive method of hunting, they have become one of the 'must see' wildlife attractions in Argentina. Although the data is dated, by 2008 about 35% of visitors to the peninsula were hoping to see orca as "*Punta Norte is a legendary site for watching orcas beach themselves.*" (Hoyt & Iñíguez, 2008). Since the founding of PNOR we have seen a dramatic increase of both domestic and foreign tourists at the Punta Norte 'Mirador' (Figure 8), where at times buses and cars overflow the parking area and spill out onto the main road and it can be hard to find a spot along the fence line when the orca swim by.

Although the key sites to watch wildlife on the peninsula are patrolled by uniformed Guardafauna and all tourists entering the Península Valdés UNESCO Site are informed of the rules (e.g., to stay within the designated wildlife watching areas and not to go down to the beaches to view the wildlife up close), an increasing number were found in the off-limits areas. Most of these sites are highly sensitive areas, for example where breeding sea lion colonies form, pups are born and youngsters learn to swim or where elephant seals give birth or moult. Tourists were not only parking on the side of the road and walking down to the beach but also driving across the pebble ‘platforms’ (large flat zones from previously uplifted beach areas, e.g., see (Pedoja et al., 2011)), crushing vegetation and shore bird nests. Their cars would get stuck and tow trucks or tractors would have to come to remove them, creating even more damage. Years later these tracks are still visible (Figure 9). But the interloper’s impacts didn’t stop there. Nearly all of them disturbed the sea lions to the point where the whole colony would stampede into the water, potentially crushing pups along the way, but also exposing the youngsters to an elevated chance of predation from the orca if they were nearby. It got to the point where PNOR and Guardafauna were extracting tourists on a more or less daily basis from the key areas where the orca hunt.

The long-term implication of constantly disturbing the sea lions and elephant seals was of course that the colonies would be abandoned. If there was no prey, the predators would stop coming. The cascade effect would include animals that might not even be considered by the tourists that were interfering with the ecosystem, such as the scavengers who feed on the discards from orca; not only sea and terrestrial birds (Quintana et al., 2006; Pavés et al., 2008; Formos et al., 2019), but also sea creatures such as starfish, amphipods and other benthic scavengers – e.g., see Smith et al., (2015); Quaggitoo et al., (2017). It was therefore abundantly clear that that something needed to be done to curb these disturbances.

Figure 8. A visitor respectfully watching for orca at the designated wildlife area, the ‘Mirador’, Punta Norte. From here, although orca are often the species most sought after, elephant seals, sea lions, a multitude of bird species, terrestrial animals such as armadillos and foxes, can all be seen. Photo © Ingrid N. Visser (2013).

Figure 9. Vehicle tracks on the pebble platforms (uplifted previous beaches). The vehicles crush slow-growing specialist vegetation as well as potentially kill ground-nesting birds and/or crushing their eggs. Their tracks are visible years later. Photo © Ingrid N. Visser.

4. CONSERVATION & MANAGEMENT BENEFITS

As the pressure from tourists continued to rise, in 2013 La Ernestina and PNOR joined forces with private donors and fenced the roadside along the beach area from near the Mirador to the southern boundary of the ranch – a distance of more than 12 km. Attached to the fence were signs warning people not to trespass. Once the fence was completed, there wasn't a single instance of a car on the pebble zone and people walking down the beach have been reduced significantly, with perhaps just one or two culprits during an entire season.

We have seen an apparent increase in the number of sea lions and elephant seals using the beach areas and although this cannot be shown to be directly linked to the installation of the fence, as other factors may be at play, a lack of one would have seen the disturbances continue. Furthermore, now that they are no longer disturbed by people rushing down onto the beach, the pinnipeds have grown habituated to the research team and ecotourism guests, with some individuals coming up the beach to check out our temporary human colonies (Figure 10).

Figure 10. Three sea lions approach the PNOR research team with accompanying ecotourism guests. The pinnipeds have become habituated to the team and will at times fall asleep in the middle of us, demonstrating how comfortable they now are with the researchers. Photo © Ingrid N. Visser

It may also be only a coincidence, but there has been a rise in the number of orca who intentionally strand since the fence was installed. A potential increase in prey for the Punta Norte orca may be linked to this current population growth as pregnancy success was directly linked to availability of prey for the endangered Southern Resident ecotype (Wasser et al., 2017).

In the past studies at Punta Norte, and in the early years of ours, in any given year there were typically less than eight orca within the population who intentionally stranded to hunt this way. At times, successful orca would provision the rest of the group and some of these unfortunate pups were batted into the air (Figure 11), perhaps to affirm social bonds, to debilitate the pup or to loosen the skin for ease of removal. By 2020, there were 15 confirmed stranders, the highest number ever documented in a season, with four of those forming their own group.

It could be argued that the pinnipeds were acting as the umbrella species, because the fence directly protects them, not the orca. However, in reality, as much as the fence protects the pinnipeds, ultimately it was concern for the orca that was the motivation behind its installation. It would, nonetheless, be logical to consider that the result occurs due to a combined and overarching multi-species umbrella effect.

No matter the driving force behind the growth in orca numbers, the population is still incredibly small. Fewer than 20 core members have visited the area in the past few years. Although this is higher than found for previous studies, this population is incredibly vulnerable. It would only take one oil spill or one outbreak of disease (within the orca or their prey) and the whole population could go extinct in less than a generation (Dahlheim & Matkin, 1994; Matkin et al., 2008). Outbreaks of disease are at the forefront of most people's minds with the global pandemic of SARS-CoV-2 (Covid-19). Of concern is that cetaceans are also susceptible to coronaviruses, with two species of bottlenose dolphins (*Tursiops truncatus*) (Wang et al., 2020), (*Tursiops aduncus*) (Woo et al., 2014) and beluga (*Delphinapterus leucas*) (Mihindukulasuriya et al., 2008), each having their own novel coronavirus, albeit so far only in captivity. However, the risks for cetaceans are clearly high; one study found there was a 'cluster' of dolphins at a facility in Hong Kong who tested positive and the results indicated that the coronavirus was associated with acute infections (Woo et al., 2014), while the beluga died after generalized pulmonary (respiratory) disease and terminal acute liver failure (Mihindukulasuriya et al., 2008). Another study, investigating the risk to animals from Covid-19 found that orca fell into the category of 'high', where their protein sequences had a propensity for binding to the amino acids corresponding to the known Covid-19 residues, i.e., they are at high risk of contracting the virus should it enter their environment (Damas et al., 2020). Furthermore, orca as highly social animals are frequently in 'respiratory contact' by passing through the breaths of one another, which would amplify the spread of a respiratory disease like Covid-19. Simulations of an infectious disease spreading through the endangered Southern Resident orca ecotype resulted in predicted mortality rates being at least twice the maximum annual mortality (Weiss et al., 2020). The vulnerability of the Punta Norte orca is increased if their pinniped prey is also susceptible to Covid-19 (Damas et al., 2020), including through reverse transmission from humans (Damas et al., 2020; Barbosa et al., 2021).

To help increase stakeholder investment in the preservation of this population, PNOR has engaged with the local community through school groups, who choose the names of the orca, as well as presentations for the public (including online webinars). We collaborate with documentary film crews in order to have quality productions increasing the public's knowledge about Punta Norte and the orca. Our social media presence continues to grow and we have a number of educational projects underway. Our website (www.pn-orca.org) naturally has a focus on the Punta Norte orca ecotype, including a high-definition identification guide. But it also lists a range of scientific publications our team members have produced regarding orca populations around the world, as a way to help widen the public's understanding of the species and the risks they face. A global perspective also helps to emphasise how unique the Punta Norte orca ecotype is, particularly with their iconic intentional stranding culture (Figure 12).

Not discussed in detail within this chapter, but of relevance to ensure that the free-ranging orca are protected, is the work done by PNOR team members with regards to the controversy of keeping orca in captivity. Argentina has only one orca held captive in a marine theme park, therefore the problem is not expansive. However, 'only one orca' is an issue in itself, given the species is so highly social and the one adult male has been kept in conspecific isolation for decades. Although our team have been involved in varying degrees with legislation, reports and workshops for the Government and ongoing discussions with the industry and other stakeholders, no viable solution has yet been found to move the orca, known as Kshamenk, into a sea pen sanctuary. However, the wild population is now protected by law from any captures and individuals cannot be exported. The probability that another orca (even from a rescue) could be kept in captivity in Argentina is now negligible. As such, this commercial industry will eventually expire in Argentina through a lack of new animals and the public's growing awareness of the issues (Visser et al., 2021, Chapter 5, this volume).

Also, as part of our wider outreach the PNOR team members are involved with the health and welfare of orca (and other cetaceans) via a range of other initiatives. Two of our team are veterinarians specialising in wildlife, including cetaceans, and they collaborate with a network of other wildlife vets, conducting necropsies and publishing research on their findings (e.g., Alzugaray et al., 2020; Raverty et al., 2020). Within Argentina, and internationally, we have founded and run a range of rescue networks specialised in this area of marine mammal conservation at a local and international level. Many, if not all of the cetaceans we rescue would die without assistance. The effects are far-reaching; with one orca who was rescued in 1997, resighted in 2020 (Visser et al., 2021, Chapter 6, this volume) and although this occurred in New Zealand, the evidence of such long-term success validates rescues. For the PNOR orca, they have their own success stories from rescues; On 7 December 1990, Ishtar (catalogue # PTN-005), along with another orca, stranded on the rocky reef in front of the Mirador, while foraging for sea lion pups (López, 2000). The Guardafaunas and members of the public kept them both wet and waited five and half hours for the tide to return so that they could be refloated. Both the orca survived and Ishtar went on to become a mother of five (Figure 5). She was last photographed in the season of 2010 and is now presumed dead, but her legacy survives through her five grandchildren alive in the 2020 season. We can only now, 10 years after her death, really begin to recognise the contribution her rescue has made to ensuring the viability of this ecotype. Ishtar was the founder of two core matriarchal groups comprised of more than 50% of the current orca population seen around Punta Norte today. This emphasises how important it is to consider these animals at not only the population level, but also at the individual welfare level. It also emphasises the importance of long-term studies of individually recognised animals and how they can contribute to long-term conservation and management models. It provides examples of success where rescue measures were implemented effectively.

Figure 11. An orca hits a Southern sea lion pup into the air. The likelihood of the pup surviving this is minimal as they typically suffer broken ribs and internal organ damage. Some make it back ashore, only to die. Photo © Ingrid N. Visser (2013).

Figure 12. Sheuen, a female orca (catalogue # PTN-021), begins to turn seaward after capturing a sea lion pup at Punta Norte. Although the population has been growing slowly, it is comprised of an incredibly small number of <20 core individuals in 2020, making this ecotype one of the rarest in the world. Photo © Jorge Cazenave.

5. CONCLUSIONS

Clutton-Brock & Sheldon (2010) identified six key benefits from long-term studies based on individually recognised animals;

(i) analysis of age structure;

(ii) linkage between life history stages;

(iii) quantification of social structure;

(iv) derivation of lifetime fitness measures;

(v) replication of estimates of selection;

(vi) linkage between generations.

Given the incredibly long lifespans of free-ranging orca - in the order of 80 years for females and 70 for males (Olesiuk et al., 1990; Olesiuk et al., 2005), our project is only in its infancy, especially if we are to analyse multi-generational data. Adding in that the Punta Norte ecotype is comprised of a very small number of individuals who concentrate their visits close to shore during certain parts of the year, there are constraints to this land-based research. Despite these restrictions, the PNOR project has already succeeded in contributing towards benefits (i), (ii), (iii), and (vi), with aspects of (iv) under investigation (e.g., number of surviving offspring).

Península Valdés was listed as a globally significant heritage site due in part to it being a hotspot for marine mammals. That listing specifically included the Punta Norte orca and their hunting methods;

> *"Península Valdés in Patagonia is a site of global significance for the conservation of marine mammals. It shelters an important breeding population of the endangered southern right whale as well as important breeding populations of southern elephant seals and southern sea lions.* ***The orcas in this area have developed a unique hunting strategy to adapt to local coastal conditions****."* [emphasis added] UNESCO Site listing #937.

Combined with the historic studies conducted on this population, a clear picture has emerged and been reinforced. These orca are unique and the population is comprised of an extremely small number of individuals. As such, they are particularly vulnerable to catastrophic events at an individual or population level, but also susceptible to more subtle changes such as marine heatwaves and prey shifts.

Protecting them, as well as their habitat, has already shown to provide a suite of benefits. Continued land-based observations will build on this current project, however expansion by using new technologies such as drones will increase the data that can be gathered during intentional strandings. Additional non-invasive research, such as boat-based surveys and hydrophones will improve our ability to monitor them. Hydrophones can, for example, not only gather data 24/7 but also improve our understanding of the social complexities of the groups. Surveys conducted on the water will allow researchers to gain a better understanding of the movements of these orca outside of the core Punta Norte region. However, a precautionary principle should be applied and only non-invasive research methods used, while invasive research should be strictly prohibited. There is precedence for this type of restriction as, for example, tagging has been directly linked to the death of an orca from another endangered population (Raverty & Hanson, 2016) and a dolphin who was biopsied died (Bearzi, 2000) and in both cases the invasive research was halted.

All orca deaths in Argentinean waters, no matter the cause, should involve comprehensive necropsies and recovery of samples as well as collection of skeletal material, using best practise protocols for each of these scenarios. The issuing of longer-term permits to established research teams would benefit all cetacean research throughout Argentina. Ultimately, expanding the zones where research is conducted should help answer questions about the home range of this population and may provide insights into their diet outside of the Punta Norte region.

The Punta Norte orca were once shot at with Mauser guns by Government Officials, nowadays they are shot with HD cameras. They were once vilified as 'enemies' and 'intruders' and moves were afoot to kill them with explosives. Today they are extolled as icons and tourist drawcards, all the while now also being recognised as the rightful apex predators that they are. The time is ripe for the next steps to be taken. The Punta Norte orca must be acknowledged formally as a distinct ecotype and with that should come the recognition of their extremely small population. As such, we call for the Punta Norte orca ecotype to be officially 'listed' as endangered by the Argentinean Authorities as well as added to the endangered inventory in the Red Data list of the IUCN (International Union for Conservation of Nature).

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CHAPTER 2

INCREASING THE UNDERSTANDING OF MULTISPECIES FEEDING EVENTS IN MARINE HOTSPOTS BY MEDIUM TERM INSTRUMENTATION AND TRACKING

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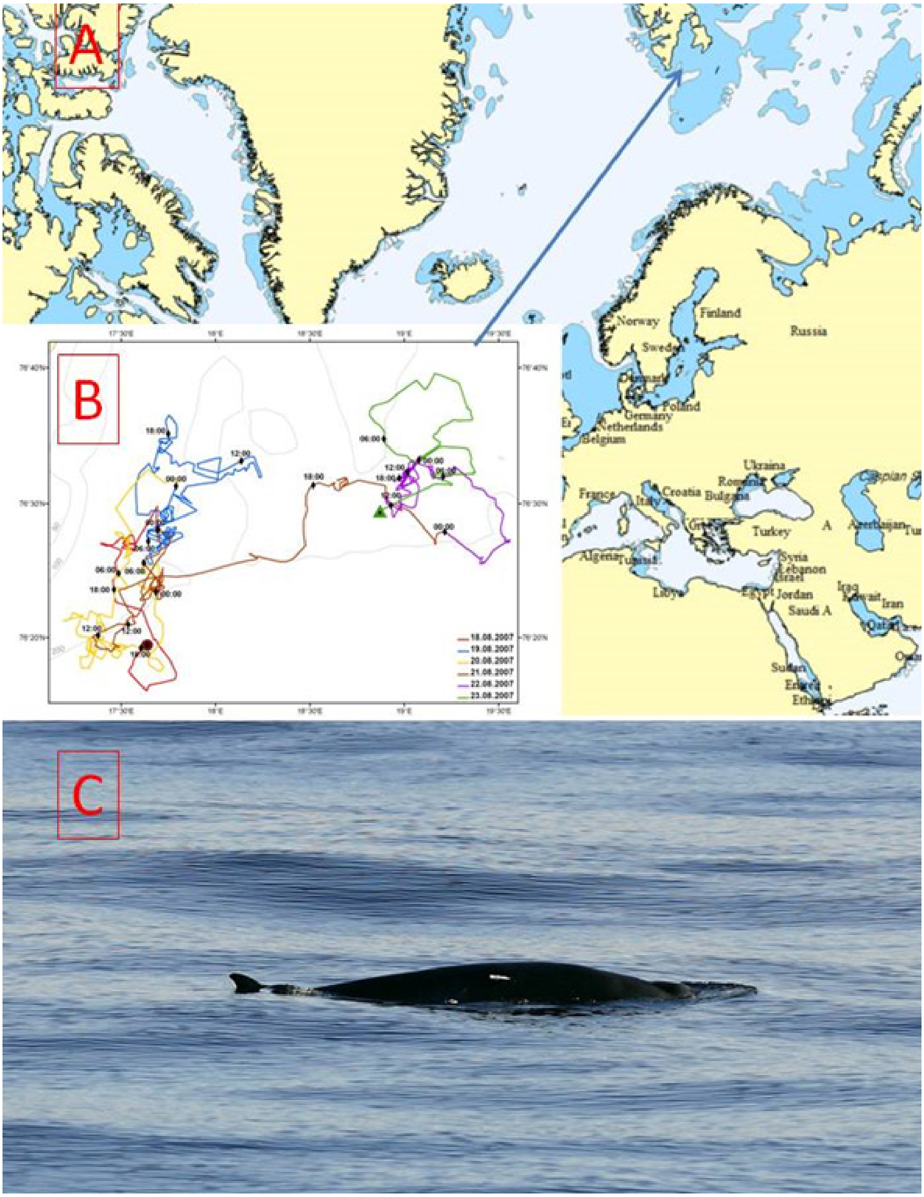
From a case study focusing on surface rate behaviour of minke whales, we tracked a vhf tagged whale for 5 days in the waters south of Svalbard, Norway (Øien et al. 2009). The tag was deployed with the whale-tag-launcher ARTS (Aerial Remote Tag System), and the tracking was enabled by the radio direction finder ADF setup with 4 yagi antennas. Tag position was vital in this project due to the need of hundred percent registration of surface rate activity of the whale, and albeit to ensure good tracking. The VHF tag had a signal path of 240ppm, with 30ms signals length, which gave us 4 to 8 signals during a surfacing. The data was sampled by a custom made voice recorder including a computer linked to a GPS and a microphone. For tagging and tracking details we refer to Kleivane et al (in prep).

However, the spinoff of this project was all what the tag did not record during the 116 hours tracking event in August 2007, and this is what we would like to spotlight here. Especially with focus on the time between and the resident time at different “Hotspots”, and the mix of co-species and other species in the four “Hotspots” observed. A total of 193 nm track was registered during these days, crossing in the waters of the outer Storfjorden, with the mapping of “Hotspot 1 and 2” to the West of the outer fjord with a duration of 6 and 2 hours, respectively, while the “Hotspots 3 and 4” were registered East of this, with a duration of 3 hours and 12 hours, respectively. Typically the hotspots were in the slops of the fjord at depth of 100m to 200m, all from dense areas up to about 3nm in spacing. On tracking day 3, no other observations were registered other than 2 white-beaked dolphin groups of each 20-30 animals, resulting in evading behaviour of the tagged minke whale, speeding up and turning away. Observations during the presence in “Hotspots 1-4”, included for all a number of minke whales and fin whales, while for some also humpback whales, sperm whales, white-beaked dolphins, harp seals, fulmars and kittiwakes. The boomerang registrations observed during the tracking events with the returning pattern of the tagged whale to the "Hotspots", indicate the need of periodic feeding events as well as the need of scouting for new feeding grounds. Especially for "Hotspot 4", where the tagged whale seeking out on SE for 7nm before returning to find no activity, then seeking out to the North, returning and then a third time seeking to the East and returning to the same area. Same returning pattern was seen at "Hotspot 1". The development of tag sensors (depth, GPS, orientation, acoustics and video), tag attachment and tracking abilities the last 10 years, make this type of ecological approach to an ecosystem interesting, using an individual tagged whale as a biological track. This type of novel approach would also be an interesting add and supplement to standard line transect and station surveys applied during ecosystem surveys. Especially with the option to observe the feeding strategies of different species, by applying sensors (datalogers) and visually observe these events, and then combine this with data collected from prey mapping and samples from trawl settings. In short: Ecosystem research in "Hotspots", with the help of simple tracking sensors and sophisticated datalogers, combined with standard instruments and equipment on modern research vessels.

Figure 1. Showing the map (A), with the details of the boat during the tracking days (B), and the the tagged minke whale (C).



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CHAPTER 3

PARASITES AS INTEGRAL ELEMENTS OF CETACEAN BIOLOGY: THE DIGENEAN *PHOLETER GASTROPHILUS* AS A CASE STUDY

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ABSTRACT: Cetaceans harbor a rich and high-specific parasite fauna that can influence hosts' population dynamics and be used to unveil aspects on their biology. Furthermore, these biotic associations are interesting models to investigate coevolutionary processes in the marine environment. In this chapter, we select a digenean exclusive to cetaceans, *Pholeter gastrophilus*, as a case study to illustrate the potential of parasitological studies to understand historical and present-day host-parasite interactions in this group of marine mammals. First, we present a brief account of the helminth diversity in cetaceans, as well as the systematics and host records for *P. gastrophilus*. Second, we discuss evidence on the origin of the association and phylogeography of this species with cetaceans, emphasizing the gaps in basic aspects such as the life cycle and the population structure, especially of Pacific and Black Sea populations. Third, we sum up information on microhabitat selection and life-history strategy, also identifying the relevant spatial scales and host sampling scheme necessaries for future research. Finally, we examine the pathogenic effects of *P. gastrophilus* and its potential impact at individual and population level. Our bottom-line message is that a comprehensive analysis

of parasites of marine mammals also sheds light on host and ecosystem features.
KEYWORDS: *Pholeter gastrophilus*, phylogeography, life history, microhabitat selection, pathogenic potential.

PARASITAS COMO ELEMENTOS INTEGRAIS DA BIOLOGIA DOS CETÁCEOS: O DIGÊNEO PHOLETER GASTROPHILUS COMO ESTUDO DE CASO

RESUMO: Os cetáceos abrigam uma fauna parasitária rica e altamente específica que pode influenciar a dinâmica populacional dos hospedeiros e ser usada para revelar aspectos de sua biologia. Além disso, essas associações bióticas são modelos interessantes para investigar processos coevolucionários no ambiente marinho. Neste capítulo, selecionamos um digeneano exclusivo para cetáceos, *Pholeter gastrophilus*, como um estudo de caso para ilustrar o potencial dos estudos parasitológicos para compreender as interações parasita-hospedeiro históricas e atuais neste grupo de mamíferos marinhos. Primeiramente, apresentamos um breve relato da diversidade de helmintos em cetáceos, bem como a sistemática e registros de hospedeiros de *P. gastrophilus*. Em segundo lugar, discutimos evidências sobre a origem da associação e filogeografia desta espécie com cetáceos, enfatizando as lacunas em aspectos básicos como o ciclo de vida e a estrutura populacional, especialmente das populações do Pacífico e do Mar Negro. Terceiro, resumimos as informações sobre a seleção de microhabitats e estratégia de história de vida, também identificando as escalas espaciais relevantes e os esquemas de amostragem de hospedeiros necessários para pesquisas futuras. Finalmente, examinamos os efeitos patogênicos de *P. gastrophilus* e seu impacto potencial a nível individual e populacional. Nossa mensagem final é que uma análise abrangente de parasitas de mamíferos marinhos também esclarece as características do hospedeiro e do ecossistema.
PALAVRAS CHAVE: *Pholeter gastrophilus*, filogeografia, história de vida, seleção de microhabitat, potencial patogênico.

1. THE IMPORTANCE OF PARASITISM IN CETACEANS

Parasites are an inextricable element of the biology of their hosts since they stablish relationships of close dependency with them. Precisely because of the nature of these associations, parasites are suitable entities to reveal a broad range of aspects on their host's biology. For instance, many parasites of cetaceans have been used as biomarkers in studies concerning, *inter alia*, the behavior, health status or population structure of their hosts (AZNAR et al. 2002; FRAIJA-FERNÁNDEZ et al. 2016b and references therein). Furthermore, by definition, parasites exert a negative effect, sometimes generating a considerable population impact on their hosts (AZNAR et al. 2002). Among microparasites, for instance, cetacean morbilliviruses are of particular concern because they can cause mass mortality events in wild host populations (WEISS et al. 2020 and references therein). Likewise, parasites of genus *Crassicauda*, which occur in the urogenital system, mammary glands, abdominal muscle and cranial sinuses of cetaceans, may provoke serious pathologies including bone lesions (GERACI and AUBIN, 1987; VAN BRESSEM et al. 2020) or congestive renal failure (LAMBERTSEN, 1986). These pathogenic effects have been proposed as a major cause of natural mortality of hosts (LAMBERTSEN, 1986; GERACI and AUBIN 1987; AZNAR et al. 2002). In short, there is evidence that parasites can significantly impact cetacean populations and, since several cetacean species are seriously endangered, conservation programs should include parasites as a relevant component of assessment.

Although cetaceans harbor a rich and highly specific parasite fauna (see below), a great deal of viruses, bacteria, as well as parasitic protozoans and metazoans, are yet to be described (AZNAR et al. 2002; RAGA et al. 2009; FRAIJA-FERNÁNDEZ et al. 2016b). Moreover, our knowledge about the biology of these parasites, as well as about the relationships they stablish with their hosts, is still very scarce in most cases. It is particularly challenging to obtain information about life cycles due to the cryptic nature of these animals, the difficulties of field sampling and the virtual impossibility of experimental approaches (e.g. HERMOSILLA et al. 2015; LEMPEREUR et al. 2017). However, it is worth making an effort to undertake a biological and ecological study of these parasites, not only for the reasons stated above, but also because parasites of cetaceans are models of great interest to investigate coevolutionary phenomena in the marine environment, especially oceanic.

In this chapter, we select a species of digenean exclusive to cetaceans, i.e. *Pholeter gastrophilus*, as a case study. This species infects a large number of odontocetes (FRAIJA-FERNÁNDEZ et al. 2016b; 2017) and represents a suitable model to illustrate the type of research that can be carried out regarding host-parasite associations in this group of marine mammals. First, we will place this species in the context of helminth diversity in cetaceans. Second, we will trace the taxonomic history of the species and its relationship with allied taxa. Third, we will discuss the origin of the association of *P. gastrophilus* with cetaceans and their phylogeographic patterns. Fourth, we will point out what is known about its ecology, including its life cycle and life history strategies, as well as their microhabitat selection in cetaceans. Finally, we will comment on the pathogenic impact of this species. We will conclude with a brief reflection on the implications of these findings and the areas for future research.

2. HELMINTH DIVERSITY IN CETACEANS

To date, 175 species of helminths have been reported in cetaceans (FRAIJA-FERNÁNDEZ et al. 2016b; EBERT et al. 2017) belonging to Acanthocephala (20 spp); Cestoda (38 spp.); Nematoda (62 spp.) and Digenea (54 spp.).

Acanthocephalans of cetaceans belong to genera *Bolbosoma* and *Corynosoma* (family Polymorphidae) and, similarly as other acanthocephalans infecting endotherms, they occur in the intestine of mysticetes and odontocetes (FRAIJA-FERNÁNDEZ et al. 2016b); a striking exception is *Corynosoma cetaceum*, which mainly favours the stomach of dolphins (AZNAR et al. 2001). Life cycles of these parasites have not been fully elucidated but, presumably, pelagic euphausiids and copepods act as intermediate hosts, fishes as paratenic (i.e. transport) hosts and marine mammals as final hosts (RAGA et al. 2009). Marine mammals, including cetaceans, are thought to have ancestrally acquired polymorphids due to a host switching event involving aquatic birds (GARCÍA-VARELA et al. 2013).

Among cestodes, the families Diphyllobothriidae, Tetrabothriidae and Phyllobothriidae contain species infecting cetaceans (FRAIJA-FERNÁNDEZ et al. 2016b). Species of the first two families inhabit the intestines of mysticetes and odontocetes, which are known to be final hosts (RAGA et al. 2009); data about the rest of the life cycle is limited, although zooplanktonic crustaceans are known to serve as first intermediate hosts for other cestodes in the oceanic realm (RAGA et al. 2009). Available evidence suggests that marine mammals acquired tetrabothriids from marine birds in the Tertiary (HOBERG et al. 1999). On the other hand, larvae of phyllobothriids are found in the subcutaneous blubber, the mesenteries of the abdominal cavity and the digestive tract of many odontocetes; apparently, large sharks are final hosts and get infected when feeding on cetaceans (AZNAR et al. 2007; RANDHAWA 2011). Historically, cetaceans were likely incorporated as intermediate hosts in a pre-existing life cycle that involved crustaceans and teleosts as intermediate hosts, and sharks as definitive hosts (AZNAR et al. 2007; RAGA et al. 2009).

Nematodes reported in cetaceans are grouped into the families Anisakidae, Pseudaliidae and Tetrameridae (FRAIJA-FERNÁNDEZ et al. 2016b). Species of the Anisakidae use invertebrates as first intermediate hosts, fishes and cephalopods as paratenic hosts, and marine mammals as final hosts, where worms typically inhabit the stomach (MATTIUCCI and NASCETTI, 2008). Some anisakids (i.e. *Anisakis* spp.) occur worldwide in mysticetes and odontocetes, whereas others (i.e. some species of *Pseudoterranova* and *Contracaecum*) are restricted to a few odontocete species (FRAIJA-

FERNÁNDEZ et al. 2016b). The anisakids infecting marine mammals appear to have a marine origin, with a secondary colonization of *Anisakis* spp. in some freshwater dolphins (HOBERG and KLASSEN, 2002; RAGA et al. 2009). Pseudaliids, on other hand, exploit a wide range of microhabitats of mysticetes and odontocetes, including the respiratory system, the middle ear, the eustachian tube and the cranial sinuses (MEASURES 2001; LEMPEREUR et al. 2017). Information concerning their life cycle is rather scarce, although there is convincing evidence for vertical transmission in some species (MEASURES 2001; POOL et al. 2020), and data on putative paratenic fish hosts in others (LEHNERT et al. 2010). It is thought that pseudaliids have a terrestrial origin and made it to the sea with ancestors of marine mammals (LEHNERT et al. 2010 and references therein). Finally, the family Tetrameridae is represented by *Placentonema gigantisima*, which is restricted to the placenta of sperm whales (*Physeter macrocephalus*), (DHERMAIN, SOULIER and BOMPAR, 2002) and species of *Crassicauda*, which are typically found in the circulatory and urogenital system of both mysticetes and odontocetes, and in the cranial pterygoid sinuses of odontocetes (KEEMAN-BATEMAN et al. 2018; MARCER et al. 2019; VAN BRESSEM et al. 2020). The life cycles of tetramerids are also poorly known, but some species of *Crassicauda* are thought to reach cetaceans by trophic transmission (LEMPEREUR et al. 2017).

Digeneans are the most specific taxa at species level among cetacean helminths, and are distributed into four families, i.e. Brachycladiidae, Brauninidae, Notocotylidae and Heterophyidae (FRAIJA-FERNÁNDEZ et al. 2015a, 2016b; EBERT et al. 2017). The family Brachycladiidae is the only one whose members exclusively infect marine mammals as final hosts (FRAIJA-FERNÁNDEZ et al. 2016a; KREMNEV et al. 2020). Seven of its genera are restricted to mysticetes and odontocetes, occurring in bile ducts, intestine, lungs and air sinuses (DAILEY et al. 2007; FRAIJA-FERNÁNDEZ et al. 2016a). The life cycle of some brachycladiid species infecting pinnipeds has been elucidated recently; it appears to comprise gastropods as first intermediate hosts and bivalves as second intermediate hosts (KREMNEV et al. 2020). However, transmission pathways for species dwelling in oceanic cetaceans are still an enigma (FRAIJA-FERNÁNDEZ et al. 2016a). The association of brachycladiids with marine mammals likely resulted from a host-switching event from fishes to the ancestors of odontocetes that preyed on them; subsequent colonization of mysticetes followed (RAGA et al. 2009; FRAIJA-FERNÁNDEZ et al. 2016a). The family Brauninidae contains a single species i.e. *Braunina cordiformis*, which attach to the stomach wall and in the duodenal ampulla of several odontocetes (FRAIJA-FERNÁNDEZ et al. 2015a; 2016a); its life cycle is not known (TORRES et al. 1992). With regard to family

Notocotylidae, species of the genus *Ogmogaster* infect the intestines of mysticetes (FRAIJA-FERNÁNDEZ et al. 2015a, 2016a); whales are thought to acquire these parasites when feed on crustaceans. Both the associations of *B. cordiformis* and *Ogmogaster* spp. with cetaceans appear to have resulted also from host-switching events (FRAIJA-FERNÁNDEZ et al. 2015a). Finally, *Pholeter gastrophilus* (Fig.1) is the only species of family Heterophyidae that exhibits an exclusive association with cetaceans; this species selects the wall of the stomach (rarely the duodenum) of odontocetes (FRAIJA-FERNÁNDEZ et al. 2015a, 2016b). The life cycle of this species, as well as other aspects of its biology, are addressed in what follows.

3. THE BIOLOGY OF *PHOLETER GASTROPHILUS*

3.1 Specificity and geographical distribution

The genus *Pholeter* Odhner, 1914 (Digenea: Heterophyidae) currently comprises two species: *Pholeter gastrophilus* (Kossack, 1910) Odhner, 1914 and *Pholeter anterouterus* Fischthal and Nasir, 1974.

The taxonomic affiliation of species of *Pholeter* has been controversial. *Pholeter gastrophilus* (Fig. 1) was firstly described as *Distomum gastrophilum* Kossack, 1910, from an intestinal cyst of a harbor porpoise (*Phocoena phocoena*) in the Baltic Sea. Later, Odhner (1914) provided a more detailed description and included this species within the family Troglotrematidae Odhner, 1914 (PRICE, 1932) as *Pholeter gastrophilus*. Troglotrematids comprised a miscellaneous group of parasites that where not phylogenetically related but that all shared the trait of living within nodules of host tissue (BLAIR, TKACH and BARTON, 2008). Given the artificial nature of troglotrematids as a taxon, Dollfus (1939) included the genus *Pholeter* in a specific family, Pholeteridae, which was in turn included into superfamily Heterophyoidea Odhner, 1914 (currently known as Opisthorchioidea Looss, 1899) (PEARSON and COURTNEY, 1977). Later, Yamaguti (1958) reduced the family Pholeteridae to subfamily status (i.e. Pholeterinae) and it was included within the family Opisthorchiidae Looss, 1899 (PEARSON and COURTNEY, 1977; RAGA, RADUAN and BLANCO, 1985).

Courtney and Forrester (1974) reported a probable new species of *Pholeter* in the small intestine of two pelican species from Florida, but no morphological description was provided. Almost simultaneously, Fischthal and Nasir (1974) described *P. anterouterus* from the intestine of a neotropical cormorant (*Phalacrocorax olivaceus*) and suggested that Courtney and Forrester's finding was very likely *P. anterouterus*. The new species was included together with *P. gastrophilus* within the family Opisthorchiidae, with an emended diagnosis of the genus (PEARSON and COURTNEY, 1977). Few decades later, and due to morphological similarities with other heterophyids, members of the genus *Pholeter* were finally assigned to the family Heterophyidae Leiper 1909 (PEARSON and COURTNEY, 1977; BLAIR, TKACH and BARTON, 2008).

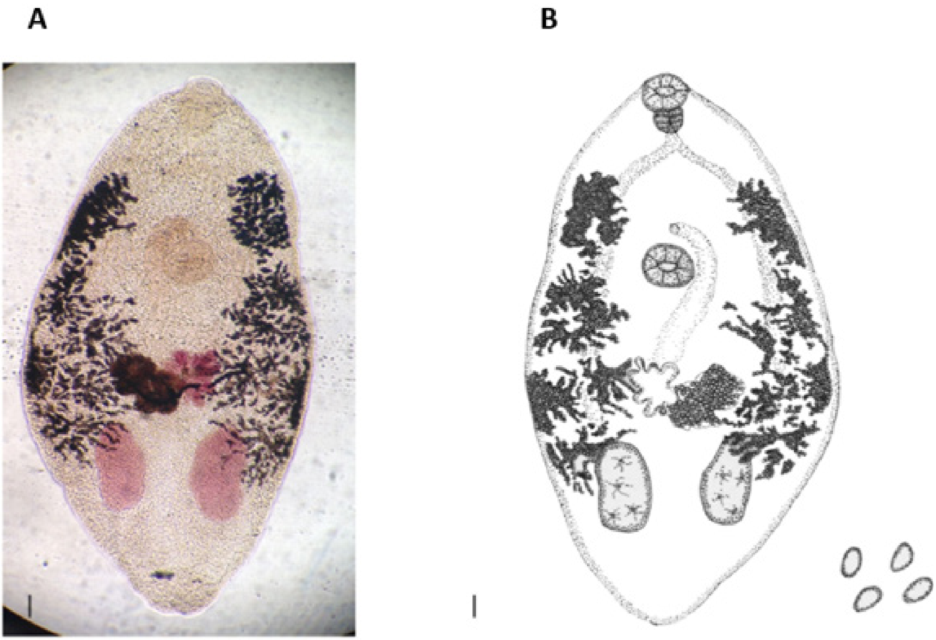

Figure 1. Adult of *Pholeter gastrophilus*. A) microscopic view. B) Schematic drawing, including eggs (on the right). Scale-bars: 0.1mm.

Currently, records of *P. gastrophilus* are well documented (Table 1). Fraija-Fernández et al. (2017) reported the last update in terms of distribution and host-parasite associations, which included 21 odontocetes worldwide belonging to 6 families, mostly delphinids. Only one host species was missed in this review, namely, the pygmy killer whale (*Feresa attenuata*) (CONTI and FROHLICH, 1984) as well as a few host records in the North Sea (Table 1). Recently, Groch et al. (2018) found numerous trematode eggs compatible with those from *P. gastrophilus* in the pyloric stomach of Guiana dolphin (*Sotalia guianensis*). Accordingly, the list of definitive hosts for *P. gastrophilus* currently includes 23 spp. (Table 1).

Table 1. Updated list of definitive host species and geographical areas where the digenean *Pholeter gastrophilus* (Trematoda: Heterophyidae) has been recorded. Abbreviations: AR, Amazon River; AO, Atlantic Ocean; BaS, Baltic Sea; BlS, Black Sea; MS, Mediterranean Sea; NS, North Sea; PO, Pacific Ocean; RS, Red Sea; SA, South Australia.

Host species	Locality	References
Family Delphinidae		
Cephalorhynchus commersonii. Commerson's dolphin	AO	[1] [2]
Delphinus delphis. Short-beaked common dolphin	AO, BlS, SA	[1] [11]
Feresa attenuata. Pygmy killer whale	AO	[3]
Globicephala macrorhynchus. Short-finned pilot whale	AO	[2]
Globicephala melas. Long-finned pilot whale	AO, NS, MS	[4] [5] [1] [2] [6]
Grampus griseus. Risso's dolphin	AO, MS	[1] [2]
Lagenodelphis hosei. Fraser's dolphin	AO	[2]
Lagenorhynchus acutus. Atlantic white-sided dolphin	AO, NS	[1] [2] [7]
Lagenorhynchus albirostris. White-beaked dolphin	AO, NS	[1] [2] [7]
Lagenorhynchus obscurus. White-sided dolphin	AO, PO	[1] [2]
Sotalia guianensis. Guiana dolphin (*)	AO	[7]
Stenella frontalis. Atlantic spotted dolphin	AO	[1] [2]
Stenella coeruleoalba. Striped dolphin	AO, MS	[1] [2]
Steno bredanensis. Rough-toothed dolphin	AO	[1] [2]
Tursiops aduncus. Indo-pacific bottlenose dolphin	RS	[1] [2]
Tursiops truncatus. Common bottlenose dolphin	AO, BlS, MS, PO	[1] [2]
Family Iniidae		
Inia geoffrensis. Amazon river dolphin (¹)	AR	[1] [2]
Family Kogiidae		
Kogia breviceps. Pygmy sperm whale	AO	[2]
Kogia sima. Dwarf sperm whale	AO	[2]
Family Phocoenidae		
Phocoena phocoena. Harbor porpoise	AO, Bas, BlS, NS	[9] [10] [1] [2] [11]
Phocoena spinipinnis. Burmeister's porpoise	AO, PO	[1] [2]
Family Physeteridae		
Physter macrocephalus. Sperm whale	AO	[2]
Family Pontoporiidae		
Pontoporia blanvillei. Franciscana	AO	[1] [2]

References: [1] FRAIJA-FERNÁNDEZ et al. 2016b and references therein; [2] FRAIJA-FERNÁNDEZ et al. 2017 and references therein; [3] CONTI and FROHLICH, 1984; [4] JAUNIAUX et al. 2002; [5] IJSSELDIJK et al. 2015; [6] IJSSELDIJK and GRÖNE, 2019; [7] SCHICK et al. 2020; [8] GROCH et al. 2018; [9] HERRERAS et al. 1997; [10] SIEBERT et al. 2006; [11] VAN ELK et al. 2019. (*) Eggs compatible with *P. gastrophilus*, but no morphological description was given; (¹): this record requires further confirmation.

3.2 Origin and phylogeographic patterns

How the exuberant diversity of digeneans became associated with the ancestors of cetaceans been extensively debated during the recent decades; a major issue was the extent to which such associations are of terrestrial or marine origin. We can assume that the terrestrial ancestors of cetaceans harbored their own parasite fauna, but life-cycles were likely compromised when these definitive hosts began to colonize the marine environment (HOBERG and KLASSEN, 2002; RAGA et al. 2009). Even though some parasites could have exceptionally cope with the new marine conditions, there is consensus that mass extinctions of parasites must have happened (HOBERG and KLASSEN, 2002; RAGA et al. 2009). Thus, most of the current helminth fauna of cetaceans was probably acquired via host switching events in the ocean. Since marine mammals radiated after seabirds and teleost fishes in the marine realm (PYENSON, KELLEY and PARHAM, 2014), cetaceans could most likely acquire marine parasites from the later taxa, an scenario that is supported by phylogenetic evidence (FERNÁNDEZ et al. 1998; FRAIJA-FERNÁNDEZ et al. 2015a).

Pholeter gastrophilus is included in the family Heterophyidae, whose members use fish as intermediate hosts and fish-eating birds and mammals as final hosts. Specifically, adults of the putative sister taxon of *P. gastrophilus* (i.e. *P. anterouterus*) are found in fibrotic nodules of the intestinal wall of at least 3 families of fish-eating birds (Table 2). Thus, it seems plausible that the presence of *Pholeter* spp. in non-related hosts, i.e., odontocetes and seabirds, was driven by the similarity of hosts' trophic guild that historically favored contacts with infective stages, and potential exchange of parasites. In fact, ancient odontocetes were presumably piscivorous (THEWISSEN et al. 2009 and references therein). Although the available evidence does not allow to clarify whether cetaceans acquired *Pholeter* spp. from aquatic birds or vice versa, the affinities of allied heterophyid taxa with birds point to the possibility that the association of *P. gastrophilus* with cetaceans occurred at sea. Once this association got established, *P. gastrophilus* could have expanded its host range into other piscivorous cetaceans; this is a phenomenon that has been reported in other digeneans from cetaceans, i.e. the family Brachycladiidae (FERNÁNDEZ et al. 1998; FRAIJA-FERNÁNDEZ et al.2016a).

Table 2. Records of the digenean Pholeter anterouterus (Trematoda: Heterophyidae). Abbreviations: FL, Florida; Ven: Venezuela.

Host species	Locality	References
Family Ardeidae		
Ardea alba. Great egret	FL	[1]
Egretta caerulea. Blue heron	FL	[2]
Family Phalacrocoracidae		
Phalacrocorax olivaceus. Neotropic cormorant	Ven	[3] [4]
Family Pelicanidae		
Pelecanus erythrorhynchos. American white pelican	FL	[5] [6]
Pelecanus occidentalis. Brown pelican	FL	[7(*)] [5]

References: [1] SEPÚLVEDA et al. 1999; [2] SEPÚLVEDA et al. 1996; [3] FISCHTHAL and NASIR, 1974; [4] NÚÑEZ, 1999; [5] PEARSON and COURTNEY, 1977; [6] KINSELLA, SPALDING and FORRESTER, 2004; [7] COURTNEY and FORRESTER, 1974. (*): Probably *P. anterouterus*: no morphological description was given.

As noted above, *P. gastrophilus* is the most generalist and geographically widespread digenean species that infects cetaceans (FRAIJA-FERNÁNDEZ et al. 2017). This raises the question of whether or not *P. gastrophilus* may actually comprise a complex of sibling species, a phenomenon that has been documented in other generalist helminths of cetaceans (e.g. MATTIUCCI and NASCETTI, 2008). However, FRAIJA-FERNÁNDEZ et al. (2015b; 2017) did not detect significant genetic divergence between specimens from different cetacean species, or between populations geographically apart (south western vs. north eastern Atlantic). This apparently suggests that there is ample genetic flow between populations and *P. gastrophilus* represent a single species. However, this should be confirmed by including molecular data from individuals from Pacific and Black Sea populations (Table 1), which presumably are the most ecologically and geographically isolated.

In fact, among the surveyed populations, FRAIJA-FERNÁNDEZ et al. (2017) found a certain degree of genetic structure at a regional scale. In particular, worms sampled in hosts from the North Sea showed significant divergence with respect to those from other Atlantic and Mediterranean populations. This was related to at least two ecological factors that limit gene flow (FRAIJA-FERNÁNDEZ et al. 2017 and references therein). First, gene flow in digeneans is crucially related with the dispersion potential of its most mobile hosts (typically the definitive hosts), and the species of cetaceans that were sampled in North Sea are sedentary and strongly linked to coastal areas. Second, the southern Bay of Biscay represent a transition zone between boreal and subtropical regions, acting as an oceanographic barrier to marine organisms, including some cetaceans. Further studies are required to investigate gene flow in other presumably isolated areas, e.g., the Black Sea.

3.3 Life cycle and life history strategies

Among parasitic taxa, digeneans exhibit particularly complex life cycles (CRIBB et al. 2003; FRAIJA-FERNÁNDEZ et al. 2017) that involve at least three distinct generations of both parasitic and free-living forms (CRIBB, BRAY and LITTLEWOOD, 2001). As a general scheme, ciliated miracidia emerge from the eggs released to the aquatic environment; miracidia swim and look for the first intermediate host (typically a mollusc) and penetrate in them. After a series of metamorphoses inside the mollusc, miracidia turn into cercariae, which leave the mollusc and actively look for the second intermediate host, which can be an invertebrate (typically an arthropod), or a vertebrate (typically a fish). Within the second intermediate host, cercariae lose their capacity to swim and transform into encysted metacercariae. Finally, when the second intermediate host is ingested by the final host, metacercariae are released from prey and migrate into the characteristic microhabitat within the host body where they reach sexual maturity and reproduce. These adult worms release eggs to the aquatic environment through the host feces (CRIBB, BRAY and LITTLEWOOD, 2001).

In the case of *P. gastrophilus*, currently there is only evidence about the identity of the final hosts (Table 1). Speculation on the specific identity of intermediate hosts has been made using the information available from allied digenean species, given the similarity among the stages in their life cycles. Digeneans show a high level of phylogenetic conservatism regarding their first intermediate host (CRIBB, BRAY and LITTLEWOOD, 2001). Since the first intermediate hosts known for heterophyids include 3 superfamilies of bottom-dwelling snails, namely Cerithioidea, Littorinoidea and Rissoidea, it is plausible that the first intermediate host (s) for *P. gastrophilus* is (are) species from any of these superfamilies, although the specific identity may vary depending on the geographical area (FRAIJA-FERNÁNDEZ et al. 2017 and references therein). This hypothesis would be supported by the fact that *P. gastrophilus* infects both neritic and oceanic cetaceans and, therefore, its first intermediate host(s) is (are) expected to tolerate a wide bathymetric range, as most cerithoids and rissoids do (WELCH, 2010).

The second intermediate hosts in other heterophyids are typically fish (CRIBB, BRAY and LITTLEWOOD, 2001). Interestingly, most cetaceans in which *P. gastrophilus* has been reported are mainly piscivorous (PAULY et al. 1998). However, this parasite has been extensively detected in cetaceans that consume a great variety of fish prey (neritic, oceanic, pelagic and demersal), as well as in cetaceans that feed almost exclusively on cephalopods (AZNAR et al. 2006). These observations strongly suggest that *P. gastrophilus* must use many prey species of both fish and cephalopod to infect its final hosts. In this context, it is rather striking that metacercariae of *P. gastrophilus* have never been detected after many decades of parasitological surveys on both fish and cephalopods that serve as prey for cetaceans (MATEU et al. 2015).

In any event, the completion of the life cycle of *P. gastrophilus* in the oceanic environment is particularly challenging. Oceanic ecosystems are characterized by low productivity, meaning less density of organisms, and therefore less probabilities for infective stages to contact hosts compared with neritic habitats, which are by far more productive (FRAIJA-FERNÁNDEZ et al. 2015b and references therein). In particular, the tiny miracidia of *P. gastrophilus* should be able to contact the putative mollusk first intermediate host in both the vast and “empty” oceanic space, and the more “friendly” coastal area. How could this be accomplished? Available evidence preliminarily suggests that individuals of coastal and oceanic populations of *P. gastrophilus* make different investments in offspring. Although the number of eggs *in utero* does not seem to differ between worms infecting an oceanic cetacean, the striped dolphin (*Stenella coeruleoalba*), and a coastal cetacean, the common bottlenose dolphin (*Tursiops truncatus*), eggs are significantly larger in the former. Apparently, worms infecting the oceanic cetacean would make a greater provision of resources per capita for their offspring to withstand their lower probability of contacting the first intermediate host (FRAIJA-FERNÁNDEZ et al. 2015b). Conversely, in a costal habitat with more intermediate hosts available it would be wiser to divide the investment into more offspring. This hypothesis assumes that a larger egg translates in both longer times for hatching and larger hatched miracidia, and these two factors would increase the chances of initial survival in a harsh environment. However, the study by FRAIJA-FERNÁNDEZ et al. (2015b) was based on just two host species, and replication using other coastal and oceanic cetaceans is peremptory to confirm this pattern.

3.4 Microhabitat selection in cetaceans

The study of habitat selection by parasites can be approached at different hierarchical scales, from the most general (the choice of host) to the most specific environment (i.e. the microhabitat) and, at each scale, the processes driving habitat occupation may be shaped by different selective pressures and phylogenetic restrictions (AZNAR et al. 2006 and references therein). The case of *Pholeter gastrophilus*, is particularly complex (Fig. 2).

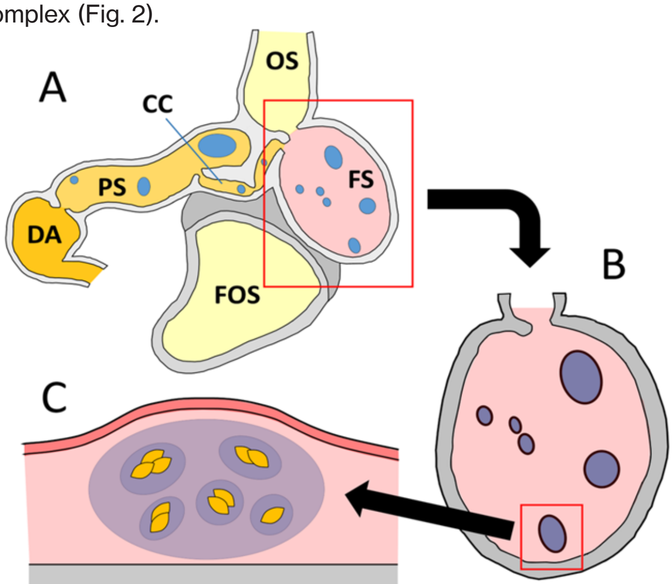

Figure 2. Spatial scales at which the microhabitat selection by the digenean *Pholeter gastrophilus* can be investigated in cetaceans. A) Among stomach chambers. The oesophagus (OS) expands to form a so-called forestomach (FOS), which, in turn, connects to the fundic stomach (FS). A narrow connecting channel (CC) regulates the pass of chyme into the pyloric stomach (PS). The pyloric sphincter separates the stomach from the intestine which, in most cetaceans, begins with a funnel-shaped expansion of the duodenum, the duodenal ampulla (DA). *Pholeter gastrophilus* favours the stomach proper, where it form nodules (in blue). However, the distribution among chambers can differ between cetacean species. B) Within chambers. Worms form aggregations (nodules) of variable size and distribution in each chamber. C) Within nodules. Nodules are composed of a number of cavities containing a variable number of worms (typically 2-3). (See the text for details).

At the broadest scale, the habitat selected by *P. gastrophilus* is the stomach of odontocete cetaceans. This organ is composed of 3 chambers (i.e. forestomach, fundic and pyloric stomachs) that differ in both morphology and physiology (Fig. 2A). There is also a narrow connecting channel between the last two chambers. The forestomach (actually an oesophageal pouch) stores prey and starts the mechanical and chemical digestion thanks to digestive enzymes coming from the fundic stomach. The main chemical digestion takes place in the latter. The connecting channel regulates the passage of food (at this point, in state of chyme) to the pyloric stomach, where its pH is regulated before it passes into the duodenum (HARRISON, JOHNSON and YOUNG,1970).

AZNAR et al. (2006) found that, at this (organ) scale, *P. gastrophilus* is restricted to the glandular part of the stomach, namely, the fundic and pyloric chambers, as well as the connecting channel. However, the distribution among chambers were found to differ between cetacean species. In both common bottlenose dolphins (*Tursiops truncatus*) and harbour porpoises (*Phocoena phocoena*), which are mainly piscivorous, *P. gastrophilus* tended to occupy the fundic stomach; in long-finned pilot whales (*Globicephala melas*), which mostly feed on cephalopods, it was more commonly found in the pyloric stomach; in striped dolphins, which have a mixed diet of both fish and squid, the distribution of *P. gastrophilus* was more even among chambers. Accordingly, the location of *P. gastrophilus* along the 3 compartments would be driven, at least in part, by the digestive physiology of cetaceans and the energetic content of prey. In particular, it would take longer to digest fishes than cephalopods due to their higher caloric content and elevated lipid concentration, as well as their higher resistance of their tissues to enzymatic action. Thus, fish prey would stay in the fundic stomach for longer, which would give more time to the infective stages of *P. gastrophilus* to excyst and attach to the wall of this chamber. On the contrary, in a diet dominated by cephalopods digestion is presumably faster, thus excystation would tend to occur in the pyloric stomach. This hypothesis is based on two reasonable assumptions that are yet to be confirmed, i.e. that (1) *P. gastrophilus* uses both fish and cephalopods as intermediate hosts and (2) chambers do not differ in quality as microhabitats.

At a lower spatial scale, i.e. within chambers, the distribution of *P. gastrophilus* is clearly not random (Fig. 2B). After excystation, infective stages are thought to penetrate the stomach wall down into the submucosa where they become adult, reproduce, and eventually die. Eggs are void to the stomach lumen through narrow conducts (Fig. 3A, black arrows). Obviously, the host's immunity system reacts to the presence of worms by forming fibrotic nodules to isolate them (JABER et al. 2006; HRABAR et al. 2017, and references therein). Interestingly, nodules of different sizes are clearly recognizable on the stomach wall (Fig. 3A), and this begs one obvious question, i.e., what are the factors that drive the aggregation of worms and the distribution of such aggregations in the stomach? It is striking that, in a microhabitat with high physical disturbance (the stomach lumen), the worms released from prey may end up aggregating in groups of variable size. In fact, nodules can encompass from just 1 to 300 worms (unpub. data). An additional question here is whether worms from the same nodule belong to one or several recruits. The occurrence in the same nodules of worms from several infection events would suggest that the first colonizers may attract other worms. These interesting questions should be addressed in the future.

At an even lower spatial scale, individuals of *P. gastrophilus* are neither randomly distributed within nodules (Fig. 2C). Worms are found isolated in cavities containing a variable number of individuals, but most commonly two or three (Fig. 3B). Apparently, cavities are the basic "units" that are connected with the lumen of the stomach through ducts (unpub. data). Although there are obvious functional reasons for worms to congregate in pairs (i.e., exogamy), it is very intriguing how they adaptively interact with the host's immune response to generate the complex architecture found in the nodules, and how they manage to keep multiple (an perhaps interconnected?) ducts open during the reproductive period. These questions definitively deserve a closer look.

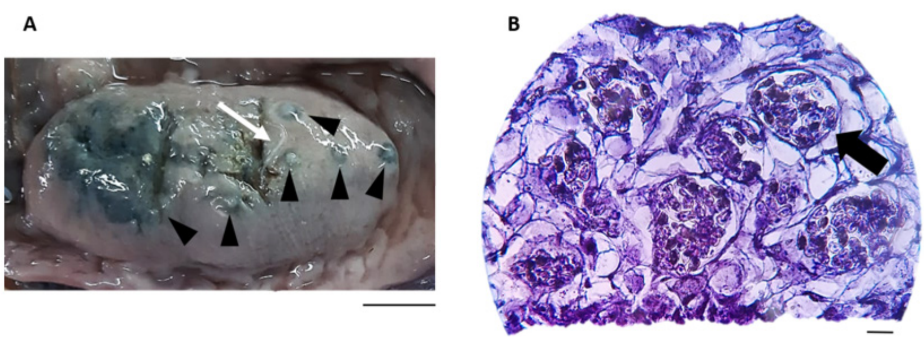

Figure 3. Microhabitat of *Pholeter gastrophilus* (Trematoda: Heterophyidae) within the glandular stomach of odontocetes. A) Oval nodule in the pyloric stomach of a common bottlenose dolphin (*Tursiops truncatus*) stranded in the Galician coast (Spain) in 2019. Black arrows: holes of the ducts connecting cavities containing worms to the stomach lumen. White arrow: larva of *Anisakis* sp. emerging from an ulcer presumably caused by the nematode after the nodule was formed. Scale-bar: 1cm. B) Histological cross section of a nodule found in the fundic stomach of a common bottlenose dolphin (*Tursiops truncatus*) stranded in the Mediterranean coasts of Valencia (Spain) in 2018. Black arrow: Cavity full of eggs. Scale-bar: 1mm.

3.5 Pathogenic potential

Infections by *Pholeter gastrophilus* cause an intense inflammatory response in cetaceans, characterized by the formation of fibrotic cysts that severely affect the stomach submucosa (WOODARD et al. 1969; GERACI and AUBIN, 1987; see above). This gastro-intestinal pathology (pholeterosis), properly described as an infiltrated fibrogranulomatous gastritis (BIRKUN et al. 2002; LEHNERT, RAGA and SIEBERT, 2005) also implies an acute accumulation of cytotoxic T-cells, proinflammatory cytokines and the execution phase of cell apoptosis in the altered area (JABER et al. 2006; HRABAR et al. 2017).

In mild infections, pholeterosis leads to limited pathological consequences (WOODARD et al. 1969; JAUNIAUX et al. 2002; HRABAR et al. 2017) thus being rarely associated with severe disease in cetaceans. However, heavy infections of *P. gastrophilus* can seriously comprise host health. Firstly, they can cause pyloric stenosis, which has been reported as the direct cause of death of common bottlenose dolphins (*Tursiops truncatus*) (KIRKWOOD et al. 1997; JAUNIAUX et al. 2002). Secondly, profuse alteration of the stomach wall due to nodule formation can produce hemorrhages and the perforation of the gastric cavity (BIRKUN et al. 2002), eventually leading to peritonitis (JABER et al. 2006). Thirdly, the damage caused in the gastric walls may facilitate the entry of other pathogens, especially in the area where the opening of the cyst connects the inner tissues of the host with the lumen (Fig. 3A, black arrows). Accordingly, not only bacterial infections can occur, but also other gastric parasites can benefit from the previous damage, particularly those that attach to the walls such as Anisakis spp. (Fig. 2A, big arrow) (C. Pons-Bordas personal observations). Finally, massive infections dispersed throughout the entire stomach cavity can lead to the fibrotic connection of nodules, hardening most of the wall of the gastric chamber (C. Pons-Bordas personal observations) or tearing the muscular fibers (Woodard et al. 1969).

The pathological effects associated to *P. gastrophilus* has hitherto been analyzed from the point of view of individual hosts. It would also be interesting to investigate what the role is (if any) of this parasite at a population level.

4. CONCLUSIONS

Based on the previous discussion we hope that the reader is now convinced that the digenean *Pholeter gastrophilus* represents an excellent example of how parasites can reveal important facets of coevolutionary processes between host-parasite associations in the marine realm. However, there are many gaps in our knowledge of this host-parasite system. In what follows, we summarize key areas of further research that should be addressed in the near future:

1. A complete phylogeographic analysis is peremptory to establish whether *P. gastrophilus* is a single species regardless of geographic area and species of cetacean host. To this end, molecular data are required from the Pacific and Black Sea populations. Furthermore, to shed light on the origin of the association between *Pholeter* spp. and marine vertebrates, it would be necessary to carry out a co-phylogenetic study of the family Heterophyidae, including both *P. gastrophilus* and *P. anterouterus*.

2. The identity of the intermediate hosts should urgently be ascertained. At a minimum, this would require, in suitable localities, (i) a thorough visual examination of large samples of common prey of the most infected cetacean hosts, as well as benthic and pelagic gastropods and bivalves; (ii) the use of new sampling techniques, such as environmental DNA (TABERLET et al. 2018). In addition, the putative differences of life history traits between coastal and oceanic populations of *P. gastrophilus* should be confirmed using other cetaceans, and further aspects (e.g. local adaptation vs. phenotypic plasticity) should be explored with molecular methods.

3. Patterns of habitat selection should be investigated at a more inclusive (host specificity) and more detailed (within chamber, within nodule) scales. I would be important to explore how, and why, individuals become aggregated in different points on the surface of the stomach, and how individuals of *P. gastrophilus* adaptively interact with the host's immune response to generate nodules that seems to be clearly dynamic in both architecture and size.

4. As it is the case for other helminths from cetaceans (AZNAR et al. 2002), the virulence of *P. gastrophilus* should be put into a host population context. Beyond the harm produced in individual hosts, it would be worth to investigate whether *P. gastrophilus* may play a significant (additive) role in shaping host population dynamics.

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CHAPTER 4

STRANDING MONITORING PROGRAMMES ON BRAZILIAN COAST: ANALYSIS OF REPORTS

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ABSTRACT: The existence of a pre-salt oil region in Brazil, brought a major concern related to marine tetrapods threats, as it is a huge area where the number of boats has been increasing, besides seismic studies, underwater noise, oil spill, number of ports among others. As part of oil and gas licensing, government environmental agencies require the development of environmental programs, including stranding monitoring programmes (Projeto de Monitoramento de Praia-PMP) along the coast. The main goal of PMPs programmes is to collect data in order to evaluate the interference of hydrocarbons extraction on stranded marine tetrapods. Different institutions throughout the country were hired by Oil Companies to execute PMPs. Most of those institutions are members of the Brazilian National Stranding

Network (REMAB) coordinated by the National Aquatic Mammal Center (ICMBio/CMA) who analyze the reports. This paper aims to describe and show the analyses of PMPs reports from five geographical areas along the country (~3.388km) between Ceará and Santa Catarina States. From 2010 to 2017 PMPs institutions reported a total of 3658 stranded cetaceans, of which 2886 belong to species classified as threatened at the Brazilian List of Endangered Species. Besides remarkable spatial-temporal variation in mortality and the overall high number of stranded animals, the most immediate issue is the stranding of 1.396 Guiana dolphins (*Sotalia guianensis*) and 1.253 Franciscanas (*Pontoporia blainvillei)*, classified respectively as EN and CR. Together, both species represented 92% of the total recorded mortality for threatened species analyzed. Stranding occurred throughout the year, with peaks during the months of August, September and December in the Northeast coast, and between June to October in the Southeast coast. The analysis provided an overview of marine mammal stranding information which can guide implementation of management and conservation actions.
KEYWORDS: Cetaceans, impact, industry, pre-salt, conservation actions.

PROGRAMAS DE MONITORAMENTO DE PRAIA NA COSTA BRASILEIRA: ANÁLISES DOS RELATÓRIOS

RESUMO: A existência de uma grande região petrolífera do pré-sal no Brasil, trouxe uma grande preocupação relacionada às ameaças de tetrápodes marinhos, por se tratar de uma área onde o número de embarcações, estudos sísmicos, ruído subaquático, derramamento de óleo, número de portos entre outros aumentam pela atividade. Como parte do licenciamento de óleo e gás, as agências ambientais governamentais exigem o desenvolvimento de condicionantes ambientais, incluindo Projeto de Monitoramento de Praia-PMP ao longo da costa. O principal objetivo dos PMPs é coletar dados para avaliar possíveis impactos da extração de hidrocarbonetos em tetrápodes marinhos encalhados. Diferentes instituições em todo o país foram contratadas por empresas petrolíferas para executar PMPs. A maioria dessas instituições é integrante da Rede Nacional de Encalhes e Informação de Mamíferos Aquáticos do Brasil (REMAB) coordenada pelo Centro Mamíferos Aquáticos (ICMBio/CMA) que analisa os relatórios. Este trabalho tem como objetivo descrever e mostrar as análises de relatórios PMPs de cinco áreas geográficas ao longo do país (~3.388km) entre os estados do Ceará e Santa Catarina. De 2010 a 2017, as instituições que compõem os PMPs relataram um total de 3.658 cetáceos encalhados, dos quais 2.886 pertencem a espécies classificadas como ameaçadas na Lista Brasileira de Espécies Ameaçadas de Extinção. Além da notável variação espaço-temporal na mortalidade e o alto número de animais encalhados, o problema mais imediato é o encalhe de 1.396 botos-cinza (*Sotalia guianensis*) e 1.253 toninhas (*Pontoporia blainvillei*), classificados respectivamente como EN e CR. As duas espécies representaram 92% da mortalidade total registrada para as espécies ameaçadas analisadas. O encalhe ocorreu ao longo dos anos, com picos durante agosto, setembro e dezembro no litoral nordeste, e entre

junho a outubro no litoral sudeste. A análise forneceu uma visão geral das informações sobre encalhes de mamíferos marinhos, que podem orientar a implementação de ações para conservação.
PALAVRAS-CHAVE: Cetáceos, impacto, indústria, pré-sal, ações para conservação.

INTRODUCTION

Marine mammals strandings occur worldwide due to natural and human-related factors (e.g. fisheries, oil exploration, mining, ports among others) providing invaluable data to infer key aspects of its ecology, like health status, mortality rates, regional occurrence and potential threats (CANTOR et al., 2020). Notwithstanding the real effect of those different activities are still unknown. The global increase in anthropogenic pressures on wildlife populations comes with a responsibility to manage them effectively (IJSSELDIJK et al., 2020). However in order to understand these potential threats along time and space, monitoring programs should be carried-out, which can inform managers of the effectiveness of different actions and provides long-term trends to inform research (MACLEOD, et al. 2011).

In this sense, as part of Oil and Gas Licensing, the Brazilian government environmental agency requires the development of environmental programs, including tetrapods stranding monitoring programmes (Projeto de Monitoramento de Praia; PMPs). The main goal of PMPs is to collect data to evaluate the effects of hydrocarbons exploration on marine tetrapods. PMPs institutions generate an annual complete report with the information of the stranding monitoring. Thus, with the aim to analyze altogether the five geographical areas PMPs reports, the Instituto Chico Mendes para Conservação da Biodiversidade (ICMBio) created a working group, coordinated by the National Aquatic Mammal Center (CMA).

Within this manuscript, we aim to: i) show the results of the analyzes of the PMPs report working group, focusing on spatial and temporal threatened species strandings and ii) discuss the importance of monitoring stranding programmes working groups in order to provided information that can guide implementation for management and conservation actions.

MATERIALS AND METHODS

Between the years of 2010 to 2017, PMPs reports from five different regions of Brazil were analyzed by CMA. PMPs covered around 3388 km of shoreline along the Brazilian coast from Ceará to Santa Catarina (Figure 1). The five different regions were covered by the following PMPs: *i*) BP - Monitoramento dos Encalhes de Biota Marinha em

Praias do Litoral Potiguar e Cearense; *ii*) PRMEA - Programa Regional de Monitoramento de Encalhes e Anormalidades na Área de Abrangência da Bacia Sergipe – Alagoas; *iii)* BC-ES - Projeto de Monitoramento de Praias Bacia de Campos e Espírito Santo; *iv*) BS-1 - Projeto de Monitoramento de Praias da Bacia de Santos – fase 1; *v*) BS-2 - Projeto de Monitoramento de Praias da Bacia de Santos – Fase 2 (Table 1).

CMA analyzes focussed mainly on the number of threatened cetacean species strandings (considering the Brazilian List of Endangered Species) and the region of strandings,with the aim to elaborate technical documents proposing actions that minimize the impacts and the mortality of the reported species.

Stranding data were gathered by different member institutions which most of them are members of the National Stranding Network (REMAB) coordinated by ICMBio/CMA.

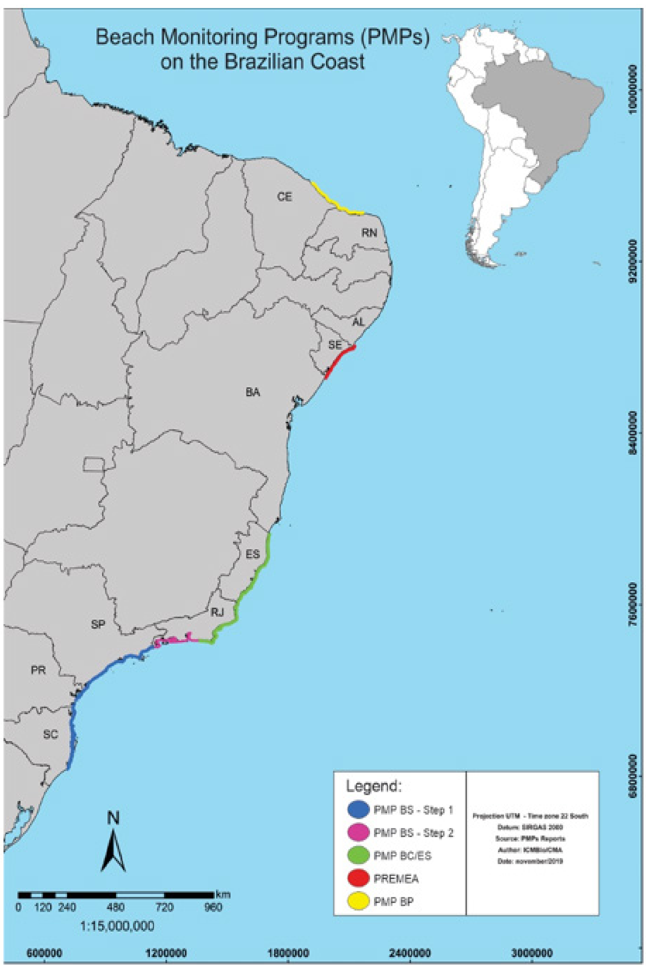

Figure 1. Coverage of the stranding monitoring program (PMPs programmes) in Brazil.

RESULTS

A total of 3658 stranded marine mammals were reported for the five different areas (PMPs). Of those 3658, a total of 2.886 belong to seven different threatened species (Table 2). Among the high number of stranded animals, a huge concern arises after 1.396 Guiana Dolphin (*Sotalia guianensis*) and 1.253 Franciscana (*Pontoporia blainvillei*) individuals were recorded for the different PMPs (Table 2). Boths species are classified as EN and CR in the Brazilian National List of Endangered Species, respectively (ICMBio/MMA, 2018).

The highest strandings numbers occurred during August, September and December along the Northeast coast (BP and PRMEA PMPs), and between June to October in the Southeast coast (BC/ES, BS-1, BS-2 PMPs).

Table 2. Number of stranded records of threatened cetacean species.

Species	CNL	BP	PRMEA	BC/ES	BS-2	BS-1	Total
Balaenoptera physalus	EN	0	0	0	0	1	1
Eubalaena australis	EN	0	0	1	0	3	4
Megaptera novaeangliae	NT	4	6	149	6	41	206
Physeter macrocephalus	VU	10	1	5	0	1	17
Pontoporia blainvillei	CR	0	0	180	5	1068	1,253
Sotalia guianensis	VU	212	68	657	66	393	1,396
Trichechus manatus	EN	9	0	0	0	0	9
Total Geral		**235**	**75**	**992**	**77**	**1507**	**2,886**

Table 3. Effort and regions for the different PMPs.

PMPs	Regions	Effort (km)	Period
BP	Caiçara do Norte/RN - Aquiraz/CE	325	2010-2017
PRMEA	Sítio do Conde/BA - Pontal do Peba/AL	275	2010-2017
BC/ES	Saquarema/RJ - Conceição da Barra/ES	763	2010-2017
BS-Step 2	Paraty/RJ -Saquarema/RJ	984.5	2016-2017
BS-Step 1	Laguna/SC - Ubatuba/SP	1,040.5	2015-2017

DISCUSSION

Brazil has a remarkable stranding monitoring programme composed by the brazilian stranding network (REMAB) and the different PMPs mentioned and reported here. These programmes are important as it allows the government to analyze anthropogenic impacts on marine mammals and develop actions to their conservation such as the Marine Cetaceans and Franciscana National Action Plans (Portaria ICMBio n° 655/375, 2018). Analysis data collected during a stranding monitoring program asked by the Brazilian government environmental agencies during the environmental licensing process, besides contributing to different conservation actions (e.g. National Action Plans), serves to subsidize government actions for new ventures within a conservation framework (e.g. technical notes).

In our analysis we identified Guiana and Franciscana dolphins as the species with the largest stranding records. This may be mainly due to different non-exclusive reasons: both are coastal species which certainly makes it more common to find it on the beaches, both faces different anthropogenic issues including pollution and accidental capture or negative interaction with fishing due to the cumulative impacts suffered by the species, oil and gas exploration, marine traffic among others.

Although marine mammal bycatch has been reported throughout the Guiana and Franciscan dolphin range, this threat has been poorly monitored and not well understood. Moreover, as mentioned before, other impacts could be affecting these species, however those are very difficult to identify and measure in a short term, but may be seriously affecting these animals in a long-term. Thus, the PMPs programmes can subside important information to better understand these different impacts and at some point identify how cumulative effects can explain this high number of strandings.

The next steps in the analysis of the PMP data will be to evaluate the existence or not of a relationship between the months with the highest strandings in relation to the areas with the highest fishing intensity.

CONCLUSION

The data collected by PMPs are very important as they allow the monitoring of anthropogenic impacts on aquatic mammals, especially the long-term and cumulative impacts. Also this allows ICMBio/CMA to conduct analysis which increase the overview of marine mammals information and improve management and conservation actions to protect those species (Portaria ICMBio n° 655/375, 2018). This is one of the largest and long-term stranding monitoring programmes in the world. It is important that these programs have continuity, as well as being extended to cover the entire brazilian coast. This allows monitoring the various impacts to which aquatic mammals are subjected due to developments in the marine environment. It is also important that other activities that use the marine environment also carry-out stranding monitoring programmes.

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CHAPTER 5

WILDLIFE CONSERVATION AND PUBLIC RELATIONS: THE GREENWASHING OF MARINE MAMMAL CAPTIVITY

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ABSTRACT: Genuine wildlife conservation and management typically requires participation by all sectors of humanity, *inter alia* the public, NGO's, commercial businesses and governments. With so many stakeholders involved, there is great potential for management success and real conservation impacts to be made at the individual animal level, as well as at the population level. Conversely, there are some who claim to be conducting wildlife conservation, yet they prioritize 'box office' proceeds/income, whilst also 'greenwashing' their image by using distorted messaging in order to solicit funds, garner public sympathy and create social license. Ironically, despite claims of 'wildlife conservation', these actions can have dire consequences for the management and conservation of both free-ranging and captive populations. We provide examples through the lens of marine mammals of how greenwashing transpires in the captivity industry, which include: rescue; rehabilitation and release programs; breeding programs; informing and educating the public; animal interactions; investments in conservation; and wildlife sourcing. Further, we discuss the effects of greenwashing activities on both *in situ* and *ex situ* conservation and furnish examples of good practices which support wildlife conservation. Inappropriate practices and interactions with captive marine mammals cause harm to the very same animals which the facilities are meant to protect and send the wrong messages to the public. The responsibility lies with the individual trainers, the facilities, and their membership associations to phase out these archaic practices. We conclude that ethical wildlife conservation can and should be achieved through realigning business models to better reflect true wildlife conservation messaging and management.

KEYWORDS: greenwashing, captivity, rescue, rehabilitation, entertainment.

PRESERVAÇÃO DA FAUNA SELVAGEM E RELAÇÕES PÚBLICAS: O BRANQUEAMENTO ECOLÓGICO DO CATIVEIRO DE MAMÍFEROS MARINHOS

RESUMO: A real preservação e gestão da fauna selvagem normalmente requerem a participação de todos os setores da humanidade, incluindo, entre outros, o público, organizações não-governamentais, empresas comerciais e governos. Devido à existência de muitas partes interessadas e envolvidas, há grande potencial de sucesso na gestão dos resultados reais de preservação a serem realizados no nível de animais individuais, bem como no nível populacional. Por outro lado, há pessoas que alegam estar preservando a vida selvagem ao mesmo tempo em que priorizam receitas e lucros de bilheteria por meio do *greenwashing* (branqueamento ecológico) de sua imagem, utilizando mensagens distorcidas para arrecadar fundos, conquistar a simpatia do público e obter a aprovação da sociedade. Ironicamente, e apesar das afirmações de "preservação da vida selvagem", tais ações podem gerar consequências graves para a gestão e a preservação das populações selvagens e daquelas mantidas em cativeiro. Fornecemos aqui alguns exemplos de *greenwashing* relacionado a mamíferos marinhos e de como ele se perpetua pela indústria de animais em cativeiro, incluindo programas de resgate; reabilitação e soltura; programas de procriação; informação e educação do público; interações com animais; investimentos em preservação; e a aquisição de animais selvagens. Além disso, discutimos os efeitos do *greenwashing* na preservação *in situ* e *ex situ* por meio de exemplos de boas práticas que favorecem a preservação da vida selvagem. Tal responsabilidade recai sobre os próprios treinadores, instalações e suas associações, visando descontinuar práticas e interações inadequadas com mamíferos marinhos em cativeiro, visto que prejudicam os mesmos animais que alegam proteger, além de passarem mensagens equivocadas para o público. Por fim, concluímos que a preservação ética da vida selvagem pode e deve ser alcançada ao se redefinir os modelos comerciais, de modo a melhor transmitir a mensagem e melhor gerir a verdadeira preservação da vida selvagem.

PALAVRAS-CHAVE: branqueamento ecológico, cativeiro, resgate, reabilitação, entretenimento.

I. INTRODUCTION

A key element of maintaining conservation programs in aquariums and zoos is the engagement of the stakeholders who fund, influence, and sometimes implement and govern them. Vital to all of this are public relations (PR) which, since the 1940's, have been recognized as an intrinsic part of moving a wildlife conservation program forward (Schoenfeld, 1957). In order to implement conservation programs, most, if not all, aquariums and zoos, as well as their membership-based associations, have dedicated PR departments who promote the work that the entity is conducting and, for example, “*position* [themselves] *as the world's preeminent wildlife conservation association”* (Association of Zoos and Aquariums, 2020a).

PR can inspire, educate and have powerful effects. However, it can also be detrimental when it is in the form of ‘greenwashing’ (i.e., disinformation presented by an entity so as to present an environmentally responsible public image). Greenwashing can occur in several different manners at aquarium and zoo facilities, including but not limited to: the dissemination of misinformation or propaganda, which may also be disguised as education; normalising inappropriate or harmful interactions with animals (Figure 1); implementing breeding programs that do not support conservation; creating ‘rescue’ programs that in fact facilitate the acquiring of, or continued captivity of animals; and camouflaging the way in which animals are sourced. In all instances greenwashing is harmful to animals, whether *in situ* or *ex situ* populations.

Furthermore, wildlife conservation PR at aquariums and zoos may be used to solicit money from the public who believe they are contributing to the wellbeing of individuals in captive collections and helping to conserve wild populations, but which may not be the case in instances of greenwashing. Greenwashing also undermines the work of conservationists in the field and could taint those marine mammal captive facilities which do infuse legitimate conservation through their education, programs and practices.

When greenwashing occurs, it needs to be exposed by both the public and peers, and the individuals and institutions involved must be held accountable. The prevalent nature of greenwashing by the industry can have a desensitizing effect on the general public, caused by the constant PR drumbeat and an ever changing (drifting) rationale in search of the right ‘message’ to legitimize captive ‘entertainment’. There are, however, examples of facilities which do not employ greenwashing and use PR to genuinely educate the public, demonstrating that authentic wildlife conservation programs are achievable.

In this chapter, we look at marine mammal captive facilities, which include sanctuaries, rescue and rehabilitation centres, research centres, aquariums and zoos, which we refer to as specific facilities or collectively as ‘the industry’, and the PR that they use for wildlife conservation messaging. This is not a comprehensive global analysis, but rather highlights examples of PR and practices that can support or undermine wildlife conservation programs. Our analysis focuses on the following key points of greenwashing by the industry, highlighting the detrimental ripple effect that greenwashing has on the public and the animals, and compares these with examples of best practices:

- Rescue, Rehabilitation & Release
- Breeding Programs
- Informing and Educating the Public

- Animal Interactions
- Investing in Conservation
- Wildlife Sourcing

The dichotomy between principle and income plagues every business sphere and as such it is not a new phenomenon, or one unique to the field of wildlife conservation (Watson, 2017). Wildlife (in these examples marine mammals), unlike their human counterparts, have no direct recourse of their own and should not bear the costs of putting 'box office' proceeds/income before principle. Captive facilities ask that marine mammals under their care be ambassadors for the species; accordingly, it is only fair that facilities be ambassadors of how to treat marine mammals with respect and dignity.

Figure 1. The mixed messages exhibited by some facilities are clear. Here, two higher-echelon trainers mimic 'surfing' on two orca forced into shallow water at SeaWorld Parks & Entertainment in Orlando, Florida USA. The younger orca (right) not only has its blowhole nearly submerged, but the spine, neck and skull are not fully developed at this young age (the calf was approximately 1.5 years old during this event and as such skeletal structures were potentially impacted by the weight of an adult male human standing on her). Normalising harmful interactions such as this contradicts the PR of respect, kinship and bonds as well as any conservation messages. It may also have spillover effects with interactions in the wild and draws into question the management cultures of facilities, as well as the fee-based and industry-driven associations which find practices such as this acceptable. Photo supplied to authors (*circa* 2009).

II. RESCUE, REHABILITATION & RELEASE

The Triple-R's (Rescue, Rehabilitation, Release) are positive conservation measures, if conducted appropriately. Through Triple-R programs, the industry can play a vital role in mitigating the damaging effects that humans have on marine mammals in the wild. However, some within the industry greenwash by using only part of this process, i.e., 'rescues', as a socially acceptable source for collecting cetaceans to stock their facilities. Although we recognise that particular individuals who have been rescued may not be suitable candidates for return to the wild (e.g., those who were injured in such a way as to be unable to survive), others, who may be contenders for release, are at times handled in a manner to prepare them for captivity rather than their potential release, creating self-fulfilling prophecies. The rescued animals may at that point become commodities, and exploited through trading, for breeding, in shows and also used in pay-to-experience programs for public entertainment. When rescued animals are not released, these individuals are effectively prevented from contributing to the wild populations (Lott and Williamson, 2017) and thus to wildlife conservation.

One study found at least 13 facilities around the world are using 13 different species of 'rescued' cetaceans for commercial purposes and although the data allowed for an analysis at the species level, it precluded the study from ascertaining the exact number of individual animals rescued and retained (Visser, 2015). Whilst genuine sanctuaries typically have 'open books' and online access to their animal databases, conversely many who are conducting greenwashing generally keep their records as closed as possible to public scrutiny (e.g., necropsy reports, Rally et al., 2018).

However, in some cases records can be obtained through official government document requests and from one such instance, preliminary research shows that between 1984-2013 at least 90 cetaceans were taken in by SeaWorld Parks & Entertainment USA ("SeaWorld") as part of their rescue program (Office of Protected Resources, 2015). The data also indicates that 66 died and of the remainder, only two were released (one each in 1995 and 1997). What happened to the other twenty-two animals is unclear, however four of them are likely the 'rescued' short-finned pilot whales (*Globicephala macrorhynchus*) who have been, or currently are, part of SeaWorld's collection and are performing in shows (SeaWorld Entertainment Inc, 2019).

In contrast, there are examples of altruistic marine mammal wildlife conservation efforts, such as the Sea Otter Program, conducted at the Monterey Bay Aquarium, Monterey , California USA. That program has rescued, rehabilitated and released scores of sea otters (*Enhydra lutris*) as part of its conservation efforts (Johnson and Mayer, 2015).

The rescue, rehabilitation and release of one of its most famous alumni, otter "501" was chronicled in a feature film "*Saving Otter 501*" (Shelly and Talbot, 2012; Spiegl, 2012). Since 2001, the facility has released over 100 rehabilitated sea otters back into the wild (many tagged with transmitters and flipper tags to facilitate long-term monitoring), including 37 surrogate-reared pups utilizing a stringent protocol for human interactions (Hetter, 2019), (Figure 2).

Figure 2. When young sea otters are rescued in the Monterey Bay area, appropriate protocols for interactions are utilized and maximise the potential for return to the wild. Caregivers at the Monterey Bay Aquarium, California, USA, wear what is affectionately termed the "Darth Vader" suit, so that the young sea otter does not imprint or associate a positive experience with humans. This is in stark contrast to the bottle feeding done at some facilities breeding animals (see Figure 3). Furthermore, the sea otter pups are placed with surrogate adult sea otters, before being released, in order for them to learn how to forage, groom and generally survive like a wild otter. Photo © Angela Hains / Monterey Bay Aquarium (2019).

These types of programs fulfil legitimate conservation needs whilst facilitating bona fide research by scientists and responsibly educating the general public. Instilling 'the next generation' with a genuine appreciation of the value of wildlife conservation and the role we (humans) play in our coexistence with all animals and as an inherent part of an authentic conservation program.

Keeping a focus on California, two other marine mammal facilities provide examples of conducting laudable conservation work. In Laguna Beach, the Pacific Marine Mammal Center, a non-profit organization, performs rescues and strives to release all its animals back into their natural habitat. The facility does not charge for guests to visit and provides online live cameras for the public to view the 'patients', who on average stay for three months (Pacific Marine Mammal Center, 2020). Similarly, the Marine Mammal Center in Sausalito includes a ‘patients’ page on its website with updated information on each animal being cared for on-site, as well as a ‘released’ page with details on each individual case (more than 100 animals are listed as being released from January - September 2020 alone) (Marine Mammal Center, 2020).

We note that such legitimate marine mammal conservation work is found all around the world and includes programs of various sizes, many of which concentrate their work locally or on specific species. Just one example is the Wildtracks Manatee Rehabilitation Centre in Belize which focuses on the endangered Antillean manatee (*Trichechus manatus manatus*). They use a ‘soft’ release program where the animals choose when they wish to leave or to return for supplemental feeding until the point that they are fully integrated into the wild. The facility works closely with a wide variety of national and local entities to promote integrated biodiversity solutions (e.g., linking forests to the oceans) (Wildtracks, 2020). Their education program has had long-term and far reaching impact in the community and for wildlife conservation;

> *“Past students have grown to be environmental stewards, now leading conservation organizations, sustainable tourism initiatives, and inspiring new generations - demonstrating the success of sustained outreach programs.”* (Wildtracks Education, 2020).

III. BREEDING PROGRAMS

Under the EU Zoos Directive, captive breeding of species is recognized as a legitimate conservation measure – but only *“where appropriate”* (Article 3, Council Directive 1999/22/EC.) With that in mind, and using the largest of the dolphins as an example species (albeit that one could frame this for almost any marine mammal species), one might ask when, if ever, is it appropriate to breed orca (*Orcinus orca*) in captivity for *“conservation purposes*”? The species is considered ‘Data Deficient’ (Reeves et al., 2017), notwithstanding that some populations are listed as endangered and one of those is ironically placed in this position due to extractions from wild populations for display in aquariums (Pollard, 2014).

Seventy orca have been born in captivity (33 living and 37 deceased as of September 2020, Inherently Wild, 2020), yet not one could be released into the wild, due to a range of issues such as imprinting on humans and/or erosion of an individual’s ability to function in the wild through lack of survival skills. Therefore, each had little, if any, ability to contribute to genuine conservation of the species.

Different jurisdictions, including the State of California (California Legislature, 2016) and Canada (Parliament of Canada, 2019), have recently recognized that breeding orca in captivity provides no conservation benefit and have therefore prohibited it. In the USA, SeaWorld voluntarily agreed to stop its practice of breeding orca (including artificial insemination), after accepting society's growing distaste for this practice (Hampton and Teh-White, 2019). SeaWorld, which held the largest collection of orca in the world, announced this historic action on the 17th of March 2016, stating;

> *"Now we need to respond to the attitudinal change that we helped to create — which is why SeaWorld is announcing several historic changes. This year we will end all orca breeding programs — and because SeaWorld hasn't collected an orca from the wild in almost four decades, this will be the last generation of orcas in SeaWorld's care. We are also phasing out our theatrical orca whale shows."* (Manby, 2016).

But marine parks holding orca in other locations continue this practice in the name of so-called 'conservation'. For example, the Chimelong Group in Zhukai, China, holds nine wild-caught orca from the Sea of Okhotsk, Russia; five males and four females. The facility apparently aims to "*raise public awareness about killer whales and their conservation status*" whilst breeding them (Actman, 2017). Another facility, Loro Parque, in Tenerife, Spain, displays bottlenose dolphins (*Tursiops truncatus*), California sealions (*Zalophus californianus*) and orca in daily circus-like shows, yet label themselves as a 'conservation center' (Loro Parque, 2020a). In 2016, when the SeaWorld company orca breeding ban was announced, all six of the orca housed at Loro Parque were listed as belonging to SeaWorld, including a rescued, wild-born female orca from Norway, named Morgan. Despite assurances by SeaWorld, that the breeding ban extended to cover those orca held at Loro Parque (McManus, 2017; Free Morgan Foundation, 2019), Loro Parque was clearly on the radar as not accepting the breeding ban;

> *"For the last year, we* [Humane Society of the United States] *have been advocating that SeaWorld challenge attempts by Loro Parque to breed Morgan with any of the orcas it transferred there ...Loro Parque, which, like SeaWorld, had a chance to embrace the high ground by making a commitment not to breed orcas... we're also outraged by Loro Parque's rejection of the understanding we reached with SeaWorld. What the team at Loro Parque is doing cuts against the swell of feeling that keeping orcas in captivity is an enterprise that should be phased out with all deliberate speed."* (Pacelle 2017).

Disregarding public sentiment and SeaWorld's company policy, in 2017, Loro Parque bred Morgan with a captive-born orca from SeaWorld's breeding stock, named Keto (Loro Parque, 2020b). This resulted in the birth of an anthropogenic genetic hybrid female orca named Ula (Black Cove, 2018; Free Morgan Foundation 2019, Figure 3). Not only was Keto not an ethically suitable individual for breeding as he had killed trainer Alexis Martinez at Loro Parque in 2009 (Zimmerman, 2010; Zimmermann, 2011), but the scientific consensus is that Ula cannot be released into the wild in order to contribute to conservation as she is not genetically representative of any wild orca population (IUCN/SSC, 2013; Rose and Parsons, 2019) and rather is from stocks that are widely-divergent ecotypes/hybrids, which would naturally be geographically isolated (Spiegl and Visser, 2015).

A baby orca, however, is a powerful PR tool to draw in visitors and boost ticket sales in the name of wildlife conservation, even though its birth is clearly not contributing to *"conservation purposes"*. Although it could be argued that in the past the captive breeding of orca slowed the pace of wild-takes for a period, the PR-driven orca shows concurrently doomed generations of orca – both wild and captive – to an association with a corporate logo and their plush merchandizing blitzes that raked in hundreds of millions of dollars for the captive facilities (Ventre and Jett, 2015; Lott and Williamson, 2017).

Figure 3. This orca calf called Ula, was born in captivity. Shortly after her birth, she was separated (by the staff at Loro Parque) from her wild-born mother (Morgan). Ula was hand fed and thereby allowed to imprint on the trainers. The calf exhibits a malformed melon and some type of pathology (skin problems are visible in the variable pigmentation in the pale eye patch and in the (not shown) left pectoral fin) (Voice of the Orcas, 2019). In nature, orca are one of the most socially complex species of animals documented (Rendell and Whitehead, 2001), however all three orca calves born at this facility have been rejected by their mothers and have required hand raising in isolation from the other orca, calling into question management decisions and conservation implications of this breeding program at multiple levels. Photo © Georg Volk (2019).

It is instructive to compare the current controversy surrounding justifications for breeding orca in captivity with the decision by the Association of Zoos and Aquariums (AZA) in 2011, to speak out against the breeding of white tigers (of which Loro Parque has two). AZA formally took a position prohibiting the practice by its members;

> *"Interestingly, the very instinct that appears to draw humans towards novel patterns and diversity in general also seems to underlie our fascination with unusual and abnormal patterns and phenotypes expressed only rarely, or occasionally, in nature. The spectacle provided by displays of calves with two heads, five toed cats, and traits such as albinism, melanism, or dwarfism, continues, even today, to provide an attraction to many, unaware of the biology underlying such odd occurrences. Even among today's frequently well informed and educated zoo visitors, the interest in seeing white tigers, white lions, white alligators, or king cheetahs continues often in preference over the 'normal' looking individuals of the same species. ...Of greater concern, in some cases, there exists the misconception that these unusual color morphs, or other phenotypic aberrations, may represent a separate endangered species in need of conservation."* (AZA, 2011).

AZA clearly recognized that the practice of breeding white tigers created conditions that could seriously compromise the welfare of individual animals. In addition, such breeding practices could also be problematic from a population management and conservation perspective, impairing AZA members ability to develop and maintain sustainable captive populations for the future and to deliver appropriate animal welfare and conservation education messages.

In contrast, the European Association of Zoos and Aquaria (EAZA) and World Association of Zoos and Aquariums (WAZA) apparently support the breeding of orca, despite the threat to the orca's welfare, the absence of a true conservation purpose and, an indefinable education message;

> *"It is not true that EAZA and WAZA do not recognize the possibility of breeding orcas, in fact both organizations made clear statements against the unilateral decision of SeaWorld of not breeding them...within the Marine Mammal Taxon Advisory Group of EAZA there is a Monitoring Breeding Program for Killer whales (Orcinus orca), hence it is clear that the European Association of Zoos and Aquaria does not have any problem or limitation on the breeding of the species."* (Almunia, 2018).

The ethics and efficacy of captive breeding and unnatural hybridization as a conservation measure is subject to increasing scrutiny. Rose and Parsons (2019) note that;

> *"...the birth of an orca of mixed Atlantic and Pacific genetic background is an event that has virtually no connection to the conservation of orcas or their habitat, because, among other things, the animal is genetically mixed and cannot be released into either population, due to concerns about introducing maladaptive genes to a population."*

While much attention has been focused on the breeding of orca in captivity under the guise of conservation, the issue of unnatural hybridization through captive breeding extends beyond marine mammals. For example, in the primate world, captive breeding programs for gibbons, which are listed on the IUCN Red List of Threatened Species, has been soundly criticized as detrimental to true conservation measures benefitting wild populations;

> *"it should be ensured in captive breeding programmes, both within zoos and rescue centres, that unnatural hybridization does not occur, as this will preclude the gibbon being released in the future (Mootnick, 2006)."* (Campbell et al., 2015).

> *"It is extremely important not to hybridize species or subspecies through captive breeding programs if the progeny of those gibbons will possibly be released into an area where gibbons coexist." ..."If our intentions are to save species from becoming extinct, it is of the utmost importance to make sure hybridization at the subspecific level does not occur in conservation programs."* (Mootnick, 2006).

Similarly, the United Kingdom's Department for Environment Food and Rural Affairs (DEFRA, 2012) recognized such a conundrum in its 2012 Zoos Expert Committee Handbook where it cautioned that;

> *"breeding animals in the collection may not in itself be a conservation contribution, indeed there are examples of zoos using 'baby' animals as "Conservation PR" and care must be taken that conservation contribution through breeding is by being part of managed programmes and working within them."*

The handbook also noted;

> *"Some zoos have successfully utilised hybrid and non-breeding animals for public awareness and conservation fund-raising. In so doing zoos should take great care not to suggest that breeding hybrid animals is contributing to conservation in itself."* (DEFRA, 2012).

IV. INFORMING AND EDUCATING THE PUBLIC

Greenwashing in the form of (mis)informing the public is achieved through advertising, signage in the facility (Figure 4), narration of shows by trainers and dialogues with facility guests by docents, as well as other methods. A visit to a local captive marine mammal facility can be an opportunity to educate. The communication of information that is accurate and pertinent, including *"the many types of marine mammals, their habitat, diet, behavior, population trends, and conservation status"* (Marine Mammal Center, 2020), stands in opposition to a focus on an animal's entertainment value, how amusing they are or how much fun it is to interact with the animals. For example, the 'Gold Dome Sea Lion Show' at Miami Seaquarium, Miami, USA, touts the show as a chance to;

> *"Enjoy the hilarious adventures of Salty the Sea Lion and his Reef Rangers. This comedic playlet allows the sea lion and seal stars to show off their athletic and comedic abilities as they explore the reef searching for a littering diver."* (Miami Seaquarium, 2020).

Whilst the 'Dolphin Odyssey' interactive experience as a way to;

"Explore the ocean's most loved creatures during this deep-water experience. You'll have approximately 30 minutes to share all sorts of behaviors, including kisses, handshakes, rubs, training techniques and feeding your new friend. The experience is highlighted by an awesome dorsal pull." (Miami Seaquarium, 2020).

Figure 4. A sign displayed in 2016 (and subsequently removed), at Planète Sauvage in Port-Saint-Père, France, prominently listed bottlenose dolphins (*Tursiops truncatus,* "Grand dauphin") as part of the facilities breeding program for the European Endangered Species Program (EEP), run by the European Association of Zoos and Aquaria. The other species featured on this sign were on the spectrum of 'endangered'; Addax (critically endangered, IUCN 2016), oryx (extinct in the wild, IUCN 2016), tiger (endangered, IUCN 2014) Giraffe (vulnerable, IUCN 2016), white rhino (near threatened, IUCN 2020). However, bottlenose dolphins, although classified as Appendix II under CITES, were not endangered and, rather, were listed as 'Least Concern' by the IUCN in their 'Red List'. The species last assessment was in 2018 and their status remains unchanged. Such portrayal of a species by a facility misleads the public into believing that the species is endangered. By default, it implies that it is therefore appropriate to breed them in captivity (for example the sign above states that this facility *"contributes to the safeguarding of 7 species").* It also subtly suggests by association with these genuinely Red Listed species that offspring are released into the wild as part of a conservation program. Yet, globally, no bottlenose dolphins born in captivity have been released (although a small number of individuals who were born in the wild and taken into captivity have since been rehabilitated and released back into the wild). Photo © Ingrid N. Visser (2016).

But such marketing of marine mammals as if they were domesticated companions or props for our entertainment is not limited to only those facilities with a commercial face. The Dolphin Research Center, Grassy Key, USA, a non-profit organization who state they are *"Providing Sanctuary and a Forever Home"* for rescued dolphins, also state they provide education and perform research (Dolphin Research Center, 2020). Yet at the same time they offer no less than eight experiences where you can, for example, 'Play with the dolphin' (*"who will have the most fun – you or the dolphin?"* US$60 for 20-25 mins), 'Paint with a dolphin' (*"Hold your Dolphin Art shirt while a dolphin paints it for you"* US$65 for 10 mins), 'Ultimate Trainer for the Day' (*"Accompany trainers all day during this intensive interactive adventure!"* US$695 for 7.5 hrs) or even a 'Zoom With A Dolphin' (*"Enjoy a private play date with your favorite dolphin from the comfort of your home"* US$225 for 20-25 mins) (Dolphin Research Center, 2020).

Endeavours are being made to respond to the misinformation being provided at some facilities. *SeaWorld Fact Check* (2018) is one example of efforts to counter one facility's greenwashing campaigns by providing fact-based scientific information. The consciousness-raising of these greenwashing issues was galvanized by the documentary *"Blackfish"* (Cowperthwaite, 2013), which called into question many of the messages SeaWorld was trying to disseminate, including welfare, rescues and conservation of orca. Members of the industry have also attempted to clarify their own messaging through the courts. In one instance Loro Parque brought a case against People for the Ethical Treatment of Animals (PETA) for alleged defamation related to the publication of photographs of orca at Loro Parque. The photos were accompanied by a veterinarian's assessment of medical issues, including scars, wounds and dental trauma, caused in her expert medical opinion from captivity. In ruling for PETA, the Spanish judge found that PETA's opinion that orca were suffering, which was based on research and expert analysis, was protected under the constitutional right to freedom of expression (Benito Bethencourt, 2019).

V. ANIMAL INTERACTIONS

A. Photos and Selfies

The draw of adorable baby animals to cuddle and kiss, as well as captive wildlife doing unnatural but 'cute' activities is often an easy sell to the general public. But there are real-world consequences and negative impacts of such behaviour (e.g., see Figure 5).

Is it just 'human nature', 'curiosity,' or is this desire to touch animals a 'learned behaviour', deemed acceptable because the public sees trainers in marine theme park shows handling dolphins and other cetaceans like they are pets or domesticated animals? What about the role that facilities play in promoting photo-opportunities with marine mammals, such as posing with dolphins which by default create unrealistic expectations for free-ranging wildlife experiences, as discussed in one marine wildlife swim-with study?;

> *" "Wildlife-selfies", as one of the latest trends in social media, may form unrealistic expectations of wildlife encounters and simultaneously put humans and animals at risk, for example through defensive behaviour expressed by wildlife and inappropriate behaviour shown by tourists."* (Pagel et al., 2020).

The ethics of such programs must be called into question, not only for the individual animal, but for the suite of genuine wildlife conservation messages that these types of activities contradict. The spillover of these actions into marine mammal conservation has yet to be investigated, however, the research by Ross et al., (2011) for endangered chimpanzees, revealed that;

> *"those viewing a photograph of a chimpanzee with a human standing nearby were 35.5% more likely to consider wild populations to be stable/healthy compared to those seeing the exact same picture without a human. Likewise, the presence of a human in the photograph increases the likelihood that they consider chimpanzees as appealing as a pet"*

Additionally, the authors noted;

> *"... the public is less likely to consider chimpanzees as endangered compared to other great ape species. This phenomenon was linked to the prevalent use of chimpanzees in movies, television shows and advertisements, where chimpanzees are often inaccurately displayed. These results were the first to link the manner in which chimpanzees are portrayed in popular media to public attitudes that may influence support for critical in-situ conservation efforts."*

Figure 5. In February 2016, two La Plata dolphins were found near a popular beach, Argentina. Lifted out of the water and passed around for photographs, at least one of the two died during this incident. The next year, not far from this location, another dolphin was killed in a similar manner (Bale, 2017) and in the same year another young dolphin died in Mojácar in southern Spain when tourists caught it in shallow water and took photos as they lifted it out of the water (Carr and Broom, 2018). The promoting of 'selfies' and 'posing' with wildlife that many aquariums and zoos sell is likely contributing to such obsessions and as such more responsible messaging should be implemented. Photo Hernan Coria (sourced via Facebook, circa 2016).

B. Normalising Human Interaction

Modelling appropriate behaviour is an important tool for education and messaging, as people, in particular children, who observe the behaviour of peers, adults, teachers, experts and the like, will often imitate the modeller. This results in cultural transmission or social learning. Through entertainment shows and interaction 'experiences' with marine mammals, the industry normalises behaviours that are often harmful to the marine mammals and undermines conservation messaging. Therefore, rather than being educated about conservation, customers are taught that it is acceptable to ride on, stand on, pat, approach close to (Figure 6) and even feed marine mammals. Such behaviour is damaging in its first instance for the individual animal involved in the captive pay-to-participate activity, but it also has secondary effects as it encourages inappropriate behaviour in the wild, especially if the viewer then attempts to emulate what they have seen during one of these captivity events. It is a fair question to ask then, why most of these same activities, that are deemed 'acceptable' in captive facilities, are illegal if conducted in the wild?

Figure 6. Posing with wildlife has been condemned around the world (e.g., Cerullo, 2017), yet many aquariums and zoos continue to sell this experience and promote it as a way to create a 'bond' to the animal for the public. The message this type of interaction gives, however, is not one of conservation and likely helps to promote inappropriate behaviour with wild dolphins (see Figure 5). This dolphin, held in a pen at Miami Seaquarium is required to come out of the water regularly (at least daily) and maintain its position (including holding its mouth open) in the tropical heat of Miami, USA. It shows signs of compromised welfare: its skin is drying out (paler grey area on melon); its teeth are worn to the gums; and it has an open wound on the end of its mandibles (see overlay image which is close-up section of main photo). Photo © Ingrid N. Visser (2015).

Again, referencing the chimpanzee study, by Ross et al., (2011) the authors suggested that;

> *"... images of chimpanzees in close proximity to humans may convey the inaccurate perception that these animals are easily handleable and manageable in ways similar to traditional domesticated species and thereby promote the perception that chimpanzees may make suitable pets. These effects may serve to counteract the efforts of scientific and conservation organizations that have formed strong policy statements condemning the use of primates as pets, citing risks to public health and safety, concerns about animal welfare, and adverse effects on wild populations"*

1. CAPTIVE SWIM-WITH PROGRAMS

Swim-with programs, with dolphins or sea lions in captivity, are becoming more the norm that the exception (of the 336 facilities worldwide that keep dolphins, 66% of them offered swim-with programs) (World Animal Protection, 2019). For-profit enterprises beholden to shareholders and not-for-profit facilities (and even some 'research' facilities), provide these add-on 'experiences' that significantly increase income (see Section IV and Figure 7 for examples). Twenty years ago, when swim-with permits had only been issued to four USA facilities on *"an experimental and provisional basis"* (NOAA and NMFS, 1990), it was estimated that those four facilities received more than US $2.2 million in gross revenues annually from these interactive programs alone (Frohoff and Packard, 2015, and references therein). But, as the number of facilities conducting these types of programs increases, genuine conservation messaging decreases.

Interactive experiences with dolphins at captive facilities can range from an 'in-water' experience (where swimming is not permitted, but the clients stand in the water) (Figure 7), to a 'true' swim-with program (which typically involves the dolphin(s) dragging or pushing a human through the water) (Figure 7), to snorkelling or scuba-diving with captive dolphins, to Dolphin-Assisted Therapy (DAT). The latter touts dolphin interactions as therapy for people with illnesses and/or psychological or physical disorders or disabilities, despite there being major methodological concerns with studies claiming the effectiveness of DAT (Brakes and Williamson, 2007; Fiksdal et al., 2012). In addition, risk to vulnerable participants is often overlooked and injuries occur (Frohoff and Packard, 2015).

Collectively, these various interactive programs typically require dolphins or sea lions to pull or push humans through the water, to jump through hoops, toss balls, tow boats and otherwise interact with the human participant. In the wild, such interactions are illegal in most countries and presenting them in captivity only blurs the lines between what is acceptable and respectable treatment. Certainly, keeping marine mammals in captivity has a cost, but with these programs that cost is born by the captive marine mammals and at the loss of conservation messaging.

Figure 7. **Top.** Nineteen tourists line up for an in-water encounter with cetaceans at Sea Life Park Hawaii, USA. Such experiences, depending on the extent of the interaction, range from approximately US$150 to $200 per person (as of September 2020) and last for 30 minutes. The online schedule indicated they were offered three to four times a day at this facility. **Bottom**. A tourist during a swim-with program at the same facility is dragged through the water by a bottlenose dolphin (near camera) and a 'wholphin' (a captive bred hybrid between a false killer whale (*Pseudorca crassidens*) and a bottlenose dolphin). Photos © Ingrid N. Visser (2012).

2. DISRESPECTFUL AND HARMFUL TREATMENT

Unnatural behaviours, and in fact behaviours injurious to marine mammals under captive care, are typically demonstrated during shows at facilities or swim-with experiences and photo opportunities, even whilst that same facility purports to provide education and conservation messaging. Yet, in contrast, the 'mission values' of the International Marine Animal Trainers' Association (IMATA) includes the statement;

> *"The public's experience with these animals fosters emotional and personal connections that promote conservation of our marine environments and respect for marine species."* (IMATA, 2020a).

Globally, trainers are typically presented in shows as having 'special bonds' and to be 'best friends' with the animals. They position themselves as *"the experts in the field of marine mammal care and research"* and also state that they should be *"permitted to make decisions that are aligned with what's best for the welfare of animals"* (IMATA, 2019). IMATA also has a Code of Professional Ethics, for which the first point is that members exercise *"the highest levels of respect and humaneness for all animals"* (IMATA, 2020b). Nevertheless, despite their narrative, some trainers are seen to publicly mistreat these same animals, thereby teaching children that, for example, using a dolphin as an advertising 'billboard' by writing on it (Figure 8), or riding on the backs of wildlife (for instance, IMATA's home page (Sep 2020c) features a trainer standing on and 'surfing' on two fast-swimming dolphins), is acceptable behaviour.

Figure 8. During a 'swim-with' encounter, a dolphin was used as a 'living billboard' when it was painted with the text '2018 IMATA'. We concede that the paint may be non-toxic (although we have no information either way), but the messaging is not. The messaging that it is ok to use an animal in this way was evident at the time and when video of this event was used as part of the promotion of the IMATA Annual conference. IMATA notes that *"Each year, a remarkable, fun and entertaining musical compilation is created from video footage submitted from organizations around the world and then debuted at the Annual IMATA Conference."* (photo; IMATA, 2020).

These actions translate into real consequences for wildlife. For example, a woman in Florida was arrested in 2012 for riding on a manatee (Peralta, 2012; Tenney, 2012). The woman claimed to not know that riding a manatee was against the law, however regardless of whether it was illegal, she must have thought, in contrast to biologist and law enforcement's opinions, that riding a manatee was acceptable behaviour (Peralta, 2012; Tenney, 2012). She is not the first, nor was she the last (Anon., 2013).

But riding marine mammals is not the only 'over the line' behaviour; sadly other examples abound. One study documented interactions of up to 70 times per hour with "Beggar", the wild dolphin, including petting him and feeding him unnatural foods such as hotdogs and beer (Howard, 2012, Christensen et al 2016), despite such activities being illegal under the U.S. Marine Mammal Protection Act, which provides for fines up to $100,000 and/or jail time of up to one year, per violation (NOAA, 2018). In September 2020 a video from Uruguay showed a man who had lassoed an adult male sealion and was whipping it (COENDU, 2020), wielding the whip in a similar fashion to what is seen with 'lion tamers' (Johnson, 2012).

The next level of objectionable messaging is reached when trainers ridicule the animals by commanding them to perform demeaning tricks (e.g., 'sit-ups', 'break-dancing' etc., Figure 9), often accompanied by loud popular music.

Figure 9. At a number of facilities, such as Dolphinarium Harderwijk in Harderwijk, Netherlands, animals are portrayed as comical characters or ridiculed in some way. In this case a walrus is mocked for its size and blubber (despite these being natural attributes of an adult walrus), all the while being required to do unnatural 'sit-ups' (**left**) and another is required to lift people by having them sit on his face (**right**). Photos © Ingrid N. Visser (2015).

For the casual observer, the wrong messaging is also prolific, e.g., when children are placed in a boat which is towed around the show-tank by dolphins or seals (Cachia, 2020) and when one can pay to 'paint art' with a seal (Woznikowski, 2015), do yoga with dolphins (Suppa, 2017) or get married with a beluga in attendance (Figure 10).

Figure 10. The 'normalisation' of interacting with marine wildlife is big business. The Mystic Aquarium, Connecticut, USA and the associated 'Ocean Blue Catering' offer *"A lovely setting next to our Beluga Whales for wedding ceremonies, cocktails and hors d' oeuvres"* and state that *"Dining amongst the world's most interesting sea creatures is priceless. There is a real romance that is associated with the sea, and being on the same level with these creatures adds to its allure."* They also sell beluga themed birthday parties for children aged 7-13 (with or without pizza). Photo © Studio A Images (2011).

More than 100 psychologists have noted concern over the consequences for children who attend circuses and other shows in which animals are improperly kept and used. They note that such exposure;

> *"may promote a lack of respect for living beings, lead to the denial of pain messages and hinder the development of empathy which is critical during the development and growth process as they may solicit an incongruous response – that is, amusement and joy – to punishment, discomfort and injustice."* (Psychologists' Statement).

When marine mammal facilities, claiming to put conservation, rescue and welfare above all, allow not only the trainers (Figure 11), but also the public to ride on, stand on, kiss and hug the animals in their facilities, any logical points of reference for the public are distorted and compromised. It becomes almost impossible for a visitor to separate the propaganda from the facts as, at times, the two are so comingled as to be indiscernible to all but an expert. How then, can a passionate visitor reasonably distinguish what is ethically and morally right for the conservation and management of a species, when they receive such mixed messages?

Figure 11. Riding on, being dragged by, or propelled through the air by marine mammals is typical in most industry shows around the world. These actions place undue stress on the animals' and there is no appropriate conservation message that can be given during such displays, yet they persevere. **Clockwise** from top left, trainer stands on two bottlenose dolphins, SeaWorld, Orlando, USA (2015); trainer stands on a beluga, Beijing Zoo, Beijing, China (2018); trainer is propelled through the air by two dolphins, Marineland Antibes, Antibes, France (2016); trainer dragged through the water by two bottlenose dolphins, Sea World Gold Coast, Southport, Australia (2016). Photos © Ingrid N. Visser.

Figure 12. At Sea World Gold Coast, Australia, a small boat powered by an outboard engine is run at high-speed during a show. This activity provides the wrong messaging as it actively encourages bad boating behaviour when interacting with wild dolphins. Typically, regulations for marine mammals require travelling at slow speeds when in close proximity to dolphins, to avoid propeller cuts and boat strike. In Queensland, the rules include (but are not limited to) not approaching within 50m, travelling with no wake and at no more than 6 knots (11km/hr) and to not approach from directly behind the animal (diagram, **insert**, Queensland Government). All of these rules are broken during this show. Additionally, at the point the photo was taken the trainer was focused on the audience, not the dolphins. Photo © Ingrid N. Visser (2016).

At least one facility (Sea World Gold Coast, Australia) uses a fast-moving boat to 'entice' dolphins to bow-ride at speed during its dolphin show, effectively telling the public *'if you want dolphins to play with you, drive your boat fast'* (Figure 12). Once again, there is no conservation messaging and certainly nothing in the narration or actions that draw attention to respect and consideration for dolphin mothers and calves, resting individuals or their physical safety. In fact, not only does this this particular boating spectacle put the show dolphins at risk (e.g., the trainer is not watching the dolphins as he drives the boat at high speed), it is in violation of the local marine mammal rules (Australian Government, 2019, & see insert Figure 12).

At times it seems as if the bounds of decency know no end. In Figure 13, seals perform demeaning and irreverent pantomimes in military ‘costumes’, complete with replica guns, all while in an incredibly small tank indoors at the Nerpa Aquarium in Irkutsk, Russia.

Figure 13. Baikal seals (*Pusa sibirica*), at the Nerpa Aquarium in Irkutsk, Russia perform in an indoor tank no more than 2 x 10m (**top**). There, in front of paying visitors they are forced to paint pictures, play fake musical instruments and clasp replica guns while wearing berets with the hammer-and-sickle insignia (**bottom**). Images from video, courtesy of and © to Ruptly (2017).

3. FEEDING MARINE MAMMALS

A number of facilities conduct feeding sessions for the marine mammals on display, where the public can pay to participate (Figure 14). These sessions may include 'patting' and/or 'kissing' and typically include a photo session where the photos are subsequently available for purchase with an additional fee. Customers are led to believe that the dolphins are friendly and docile, which creates surprise when instead they are aggressive, bite, and even throw objects at customers (Caulfield, 2014; Couwels, 2012; Libbert, 2019; Leo, 2019). However, the facilities know that there are very real risks, as outlined in their liability release forms, for example;

> *"Examples of such INHERENT RISKS include but are not limited to swimming; being in deep water; being near, interacting with and/or touching land or marine animals; scrapes; cuts; bruises; physical trauma; sunburn; broken or fractured bones; sprains, strains or muscle tears; and/or more serious injuries or illnesses, including death"* [their emphasis] (SeaWorld (Discovery Cove), 2017-2020).

These types of interactions likely encourage inappropriate human behaviour with wild cetaceans. In a 2016 study, researchers found that over a 20-year period there was a more than seven-fold increase in the number of dolphins in the wild who were conditioned to human interactions, including through food provisioning (Christiansen et al., 2016). The study also found that conditioned dolphins had a higher likelihood of being injured and also cause human injuries, including one death (Christiansen et al., 2016). Although no direct link to aquariums and zoos was made within the study, the types of messages a facility conveys to the public, i.e., promoting the feeding of, and interaction with, marine mammals are increasing and it would only be logical to assume that messaging spillover occurs.

VI. WALKING THE TALK: INVESTING IN CONSERVATION

1. Financial Altruism by the Numbers

AZA Zoos and Aquariums reportedly contributed US$24 billion to the USA economy in direct spending in 2018 (AZA 2019) with similar numbers (US$20 billion) in 2012 (Fuller 2012). A recent report by World Animal Protection (2019), provided a startling value to the dolphin captivity industry;

> *"A single dolphin can generate between 400,000 and 2 million USD per year for a venue, depending on the frequency of use. This means that all captive dolphins in the tourism industry annually generate between 1.1 and 5.5 billion USD. Add to that additional income channels through merchandise, food and accommodation, and the revenue is even greater. It is literally a multi-billion dollar industry".* (WAP, 2019).

This type of spending generates tremendous influence, and political capital, which can facilitate a 'business as usual' attitude when it comes to conservation reform. But how much goes to actual conservation of the animals? Rose and Parsons (2019), in their chapter *"The Conservation/Research Fallacy"* state;

> *"The claim that conservation is a primary purpose of the public display industry as a whole is highly misleading at best. Fewer than 5 to 10 percent of zoos, dolphinaria, and aquaria are involved in substantial conservation programs either in natural habitat or in captive settings, and the amount spent on these programs is a mere fraction (often less than 1 percent) of the income generated by the facilities."*

As of September 2020, AZA states that their *"more than 230 accredited members, … spend on average $160 million on conservation initiatives annually"* (AZA, 2020b), a considerable amount, but only 0.8% of their direct spending. Contrast that combined 0.8% figure for all AZA member facilities in the USA, with the non-profit Monterey Bay Aquarium (AZA accredited through March 2023) which had nearly 2 million visitors in 2019. They reported $104 million in expenses, of which nearly 12 percent ($12.5 million) went to conservation and science (Monterey Bay Aquarium, 2019).

It would be obtuse not to recognize that aquariums are *"subject to economic pressures and that making money is key to continuing their conservation and research endeavors (even if the Aquarium is a non-profit institution)"* (Knauer, 2015). However, best practices show that it can be done without marine mammals at the facility, and in the wild, bearing the burden. Aquariums are beginning to progress in this direction and the recent movement and establishment of sanctuaries supports that the business of marine mammal captivity need not be at the cost of true conservation.

2. Peter Parker Principle

With such financial leverage, the industry of aquariums and zoos wields incredible power. As owners or custodians of sentient wildlife, one could reasonably expect marine mammal facilities to apply the Peter Parker Principle (*"with great power comes great responsibility"*, Lee, 1962) and that naturally the best interests of the marine mammals would come first. To help protect the animals, there are a range of local and national regulations and legislation, as well as international conventions to which facilities may be subject (e.g., Bowman et al., 2011 and references therein).

Figure 14. **Top**, At MarineLand, Niagara Falls, Canada, during one beluga feeding session more than a dozen people were participating (the three trainers were wearing white hats and sunglasses) and more than 20 were lined up buying tickets (background); **Bottom**, At SeaWorld Orlando, USA, during one bottlenose dolphin session seven people were participating, with two other similar sized groups interacting with other dolphins in the background. Note the trainer (centre wearing hat with hand raised), is directing the clients to look at the photographer. Photos © Ingrid N. Visser (2018, 2016).

However, at times these regulations lag behind the current science, they do not give enough direction, and/or there is a wide variation of standards between countries (Hassan, 2016; Rose et al., 2017). Additionally, a number of countries' violations of wildlife protections are met with lax enforcement (e.g., see the International Consortium on Combating Wildlife Crime, 2009 and Sina et al., 2016) and as such, even countries flout the rules (e.g., European Commission 2011), setting poor examples for the facilities themselves. In such instances it falls on the trainers and the management of each facility to ensure that their internal standards are best practice and based on current science.

Some step up to this challenge but others do not; exploiting regulatory loopholes (for a case study see Spiegl and Visser, 2015; Spiegl et al., 2019) and may use greenwashing as a way to present their actions to the public. Disconcertingly, there are instances of active lobbying by the industry against legislative reform, that would benefit the animals under their care. For example, in 2017 in France;

> *"After learning that captive dolphins and whales are being drugged, Environment Minister Segolene Royal amended the legislation she signed last Wednesday — which already banned direct contact between animals and the public (like petting the animals and swimming with dolphins) and required holding tanks to be enlarged — to phase out captive breeding"* Schweig (2017).

However, that decree was overruled as *"... several marine parks opposed the measure, saying that putting the ban into practice could be cruel."* (Anon., 2018). The chief executive of Marineland Antibes, France, the largest marine park in Europe, stated; *"This is great news for our animals and zoos. This decree could have been a threat to our institutions."* (Anon., 2018). In 2020, the French government renewed its efforts and proposed legislation to ban the possession of orca and dolphins for commercial performances. This will be phased in, however the legislation immediately bans the breeding of cetaceans in captivity (French National Assembly, 2020; Boring 2020). Despite this effort, supported by science and welfare, WAZA indicated that it did not support the legislation (WAZA, 2020).

The Animal Legal Defense Fund (ALDF) lobbied the Florida legislature for two years to codify SeaWorld's promises to end captive breeding by passing the Florida Orca Protection Act (Wolf, 2018), which would make it illegal to hold orcas in captivity (Wells, 2019) . Yet despite being its corporate policy and thereby creating no change to its business model, SeaWorld resisted these efforts;

> *"SeaWorld responded by sending a team of seasoned corporate lobbyists to kill the proposed legislation both years, arguing that the law was unnecessary due to their corporate policy to end orca shows by 2019... Why would SeaWorld oppose a law that simply codifies its own promises? Because you can break promises, but you can't break laws."* Wells (2019).

ALDF had reason to be concerned that SeaWorld would renege on their promise to the public, as just one year after the announcement to stop breeding, SeaWorld, in conjunction with Loro Parque, bred their orca held at the 'offshore breeding facility', in Spain (McManus, 2017, Free Morgan Foundation, 2019).

3. Genuine Sanctuaries

A paradigm shift recognizing the cost of human interaction with marine mammals to wildlife conservation is taking place. Genuine sanctuaries (e.g., see GFAS, 2020), which provide space for natural behaviours, do not hold performance shows or interactive experiences and do not breed the animals, are becoming more prevalent. Two sanctuaries at opposite sides of the world are already operational and hosting cetaceans. One, the Umah Lumba Rehabilitation, Release and Retirement in Bali, Indonesia has been hosting rescued dolphins since August 2019. As of September 2020, it hosted three bottlenose dolphins confiscated from a heavily chlorinated hotel swimming pool at the Melka Excelsior Hotel, where the dolphins were used for a swim-with program (Ric O'Barry's Dolphin Project, 2020). In June 2019, the Sea Life Trust Beluga Whale Sanctuary (SLTBWS) transported two belugas from Changfeng Ocean World, Shanghai, China, to Heimaey Island, Iceland, where they underwent quarantine and health checks until August 2020. They have since been moved into a seapen sanctuary in the ocean, although they have been moved temporarily into a critical care pool for their first winter on-site (SLTBWS, 2020). In addition, at least two facilities currently holding dolphins have proposed, and made efforts towards, moving their animals into sanctuaries; Baltimore National Aquarium, Baltimore, USA (Grimm, 2014; Reed, 2019) and Dolphin Marine Conservation Park, Coffs Harbour, Australia (Anon., 2020). A number of cetacean sanctuaries are currently being constructed, although they do not, as yet, have occupants (e.g., The Whale Sanctuary Project (TWSP), which announced on 25 February 2020, that it had selected Port Hilford, Nova Scotia, Canada, for its first sanctuary site, TWSP, 2020).

VII. WILDLIFE SOURCING (THE WHALE IN THE ROOM)

Sourcing cetaceans from the wild, particularly from 'drive hunts', has been shown to be inhumane and yet it has been associated with the acquisition of live dolphins for international facilities (Butterworth et al., 2013; Vail et al., 2019). As Vail (2015) described;

> *"A significant body of peer-reviewed scientific literature exists detailing the physiological, behavioral, psychological, and socio-ecological impacts that chase, encirclement and capture have on dolphins. The majority of the literature reveals that acute and chronic stress-related impacts, as well as direct mortality, may result from prolonged and sustained capture techniques, such as those associated with the drive hunts, but also with other capture operations."*

Japan has one of the most infamous drive hunts that takes place annually in Taiji and with, until recently, the participation of many aquariums around the world through membership organizations such as the Japanese Association of Zoos and Aquariums (JAZA) (Sugisaka and Henmi, 2013). The inescapable reality – the whale in the room – is that cetaceans sourced in these drive hunts, find their way into institutions accredited by the major aquarium and zoological associations such as AZA, WAZA, EAZA and JAZA (Vail and Risch, 2006). However, these same institutions can be the catalyst for positive change and positively effect wildlife conservation. Recognizing that 68% of the facilities holding cetaceans in Japan were JAZA members (Sugisaka and Henmi, 2013) and the strong public condemnation of the capture operations, WAZA in April 2015, suspended membership of JAZA. This in turn, combined with the scientific the evidence and public pressure, led JAZA to withdraw from participating in the brutal hunts (Vail, 2015; Anon., 2015a).

> *"The AZA strongly believes that the killing of dolphins and whales in drive fisheries is inhumane and should be terminated immediately. We applaud the decision by the members of JAZA to stop acquiring dolphins for their aquariums from Taiji."* (AZA 2015).

Comparably, the plea for principle over income was expressed in response to the so called 'Whale Jail', when the public, which included international celebrities (DiCaprio, 2019), voiced their distaste on social media. The orca and belugas were held at the notorious Center for the Maintenance and Adaptation of Marine Mammals at Srednyaya Bay, Primorsky Region, Russia. The facility was originally reported, in 2018, to hold over 100 cetaceans (11 orca and 90 beluga) (Free Russia Whales, 2019). By April 2019, 97 remained; 87 belugas were held in 10 tiny outdoor pens, alongside 10 orca who were separated into three slightly larger pens housed inside flimsy floating sheds (Figures 15 & 16). The facility, which is co-owned by four Russian firms that supply marine animals to aquariums, also trained cetaceans and pinnipeds for a life in captivity. Groups of children were permitted to visit the facility while the cetaceans were held there (Anon., 2019a).

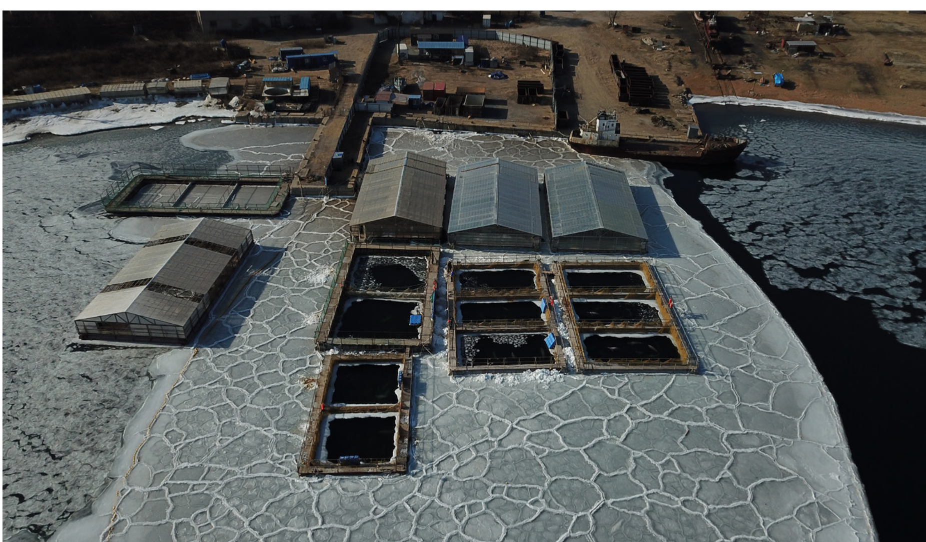

Figure 15. The 'Whale Jail', also known as the Center for the Maintenance and Adaptation of Marine Mammals at Srednyaya Bay, Primorsky Region, Russia. The 10 orca were contained in the three floating 'sheds' adjacent to each other (approx. 27 X 15m with the nets 4.5m deep, TWSP, unpublished data) (background). The 87 belugas were held in the 10 open-air pens (foreground and Figure 16). The pens to the left were uninhabited. Note the tightly packed ice is contained within the 'barrier net' (an outer net to contain any animals that might escape the netted pens). Photo © Ilia Ryzhkov (2019).

Figure 16. At least ten belugas are held in these two pens. The ice around the outside of the pens is packed tightly whilst the water inside the pens is kept 'open' due to the surfacing of the belugas. These pens were approximately 9x9m and only 4.5m deep (TWSP, unpublished data). The air temperature during the period this photo was taken (Jan 2019) was -17 to -7°C. Photo © Ilia Ryzhkov (2019).

Due to global outcry over the situation, the Russian Government invited an international team of marine mammal experts, convened by the Whale Sanctuary Project, including ocean explorer Jean-Michel Cousteau, to evaluate the health and welfare of the animals (Anon., 2019b; Anon., 2019c) and make recommendations for their rehabilitation and release. Upon their arrival, the expert team observed that the animals showed signs of compromised welfare including physical (injuries, pathogens) (e.g., Figures 17 & 18), and behavioural (stereotypies etc) issues (TWSP, unpublished data). The experts negotiated an agreement, that was co-signed by the Russian Government, recommending that the animals be released back into their native habitat (Daly & Antonova, 2019). This was eventually completed in November 2019 (Katz, 2019; Daly, 2019). Despite the agreement, the operation did not incorporate the most critical recommendations from the experts (TWSP, 2019) and 50 belugas were not released back into the area where they were captured (Cousteau & Vinick, 2019).

Figure 17. Two of the 10 orca held in the 'Whale Jail', Russia. **Top.** The epidermis was missing over much of the gular region of this orca from an undisclosed event(s) whilst held at the Whale Jail and skin pathologies are also visible (discoloured and raised areas on mandible). Insert shows wounds beside the teeth created by the orca repeatedly grasping the pen nets (TWSP, unpublished data). **Bottom.** This orca had various skin pathologies as well as a broken tooth with exposed pulp which was left untreated (insert). In most captive facilities such a tooth would undergo a modified pulpotomy procedure, where the primary objectives would be pus drainage, removal of diseased pulp tissue and clearing of impacted food and debris (Jett et al., 2017), or the tooth would be removed. Photos © Ingrid N. Visser (2019).

Figure 18. Two of the 87 beluga held in the 'Whale Jail', Russia. **Top**. A very young beluga exhibits multiple issues, including deep cuts to the upper 'lip' area of unknown etiology and wrinkled skin (indicative of dehydration). **Bottom.** This beluga shows signs of fungal or other skin pathogens (circle patches) as well as peeling epidermis (pale area on middle of back) from potential 'frost bite' due to the extreme low temperatures it was exposed to while held in tiny pens without appropriate protection (see Figure 16). Photos © Ingrid N. Visser (2019).

VIII. CONCLUSION

Advocating for principle over income is a lofty goal in these uncertain times. In this chapter, we have purposely not factored in the effects of COVID-19 on the animals, the institutions, or the general public as patrons. However, the broader discussion of wildlife conservation cannot wait until the 'dust settles' and must not be swept aside as 'inconvenient' at this time. This is not the first time that an outside catastrophe has impacted animals in captivity. An orca and other animals died due to extreme weather and floods at Marineland Antibes France, (Anon., 2015b), and during hurricane Irma a number of animals died at Miami Seaquarium, including two dolphins (Kendall, 2017). Such events can be used as an opportunity to evaluate and modernize business models and practices to be more consistent with appropriate wildlife conservation messaging.

Reform of greenwashing begins with *bona fide* conservation principles, practices and projects which need to be presented to the public in an honest and forthright manner (e.g., see Johnson and Mayer, 2015). Financial transparency and 'sunshine' policies concerning stakeholder interests are essential. 'Firewalls' to protect the animals must be maintained when institutions serve dual roles as Triple R centres and commercial public display entertainment facilities (Spiegl and Visser, 2017).

It is necessary for facilities holding marine mammals to adapt to emerging science, as well as society's evolving understanding of wildlife and science – from captivity to conservation. As many facilities have demonstrated, it can be achieved. As the public becomes more informed, they are increasingly using their wallet to say "no" to facilities that source their wildlife – 'laundered' or not – from inhumane practices and illegal captures. Humans *will* visit and support facilities that do not allow kissing, touching, selfies, or riding on the backs of the animals under their care, as evidenced by those who visit marine mammal rehabilitation centres.

We acknowledge that we have only presented a fragment of the examples available for both sides of this story. Despite this, it is the authors' hope that the dichotomy between principle and income will not sit on the end of the spectrum of 'irreconcilable difference', but rather, as facilities have shown possible, that the separation will eventually be extinguished. Furthermore, we hope that those facilities who currently greenwash their practices to guard income instead of the animals, see the sense in ethical reasoning and realign their business models to better reflect true wildlife conservation and management. As part of that process, we anticipate that, although this chapter will be viewed by some as a contentious topic, by others it will be the basis for, and start of, a lively discussion about the role for each facility in today's society. We believe in striving for a world where the public increasingly values authentic wildlife experiences in natural settings and where there is a growing emphasis on investing money for *in situ* conservation programs. This sits alongside an acknowledgement of the important role of genuine rescue, rehabilitation and release services, which some facilities provide, for marine mammals who are under increasing anthropogenic stress in the wild. We can see only value, for humans and animals alike, in developing wildlife conservation and education experiences which are not reliant on some of the current models of concrete tanks and metal cages.

Dressing chimpanzee's for tea parties, having tigers jump through flaming hoops, bears dancing or riding bicycles, and forcing elephants to balance on their trunks, are all tricks that are no longer acceptable to reputable aquariums and zoos (Johnson, 2012). We would hope, and certainly expect, a similar paradigm shift to be led by the industry, which will result in major changes of management policies for marine mammals. By 'choice editing' for their guests (i.e., choosing to display animals respectfully, rather than disrespectfully), facilities can take on the mantle of responsibility that comes with housing these sentient beings and thereby create appropriate wildlife conservation messaging.

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CHAPTER 6

TRIALS AND TRIBULATIONS: THE CONSERVATION IMPLICATIONS OF AN ORCA SURVIVING A STRANDING AND BOAT STRIKE. A CASE STUDY.

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ABSTRACT: Although thousands of stranded cetaceans have been rescued in the past few decades, evidence of the outcomes from these interventions is not abundant. There is a paucity of comprehensive case studies, even though management and conservation strategies are often based on evidence of effective results. We present details of the successful rescue of a male orca who stranded on the New Zealand coast and who has now been documented for more than 23 years. Nearly 1.5 years after his rescue he was hit by a boat and his dorsal fin was severely cut. He recovered from both incidents and has since been documented travelling with conspecifics, cooperatively and independently hunting for rays and sharks, food sharing with conspecifics (an important social bonding aspect for this species) and alloparenting. He has been photographed 98 times, from which the minimum distance he has travelled can be calculated. He has travelled ~37,700 km (of which >36,600 km were in the 22 years after the boat strike). The three highest average daily distances he travelled were 145, 170 and 193 km. The scars he sustained at his stranding were still visible 7,831 days (i.e., 21 years, 5 months, 10 days) later, setting a new record for scar longevity on orca.

KEYWORDS: Stranding, boat strike, *Orcinus orca*, killer whale, survival, intervention.

RESUMEN: Aunque se han rescatado miles de cetáceos varados en las últimas décadas, la evidencia de los resultados de estas intervenciones no es abundante. Hay una escasez de estudios de caso completos, aunque las estrategias de manejo y conservación a menudo se basan en evidencia de resultados efectivos. Presentamos detalles del exitoso rescate de un macho de orca que quedó varado en la costa de Nueva Zelanda y que ahora ha sido documentado por más de 23 años. Casi un año y medio después de su rescate, fue golpeado por un

bote y su aleta dorsal fue cortada severamente. Se recuperó de ambos incidentes y desde entonces ha sido documentado viajando con conespecíficos, cazando de manera cooperativa e independiente rayas y tiburones, compartiendo alimentos con conespecíficos (un aspecto importante de la vinculación social para esta especie) y aloparentalidad. Ha sido fotografiado 98 veces, a partir de las cuales se puede calcular la distancia mínima que ha recorrido. Ha nadado ~37,700 km (de los cuales > 36.600 km fueron en los 22 años posteriores al choque con el barco). Las tres distancias diarias promedio más altas que nadó fueron 145, 170 y 193 km. Las cicatrices que sufrió en su varamientos aún eran visibles 7.832 días (es decir, 21 años, 5 meses, 10 días) más tarde, estableciendo un nuevo récord de longevidad de cicatrices en orca.
PALABRAS CLAVE: varamiento, colisión con barco, *Orcinus orca*, supervivencia, intervención.

1. INTRODUCTION

Cetacean strandings have been occurring for thousands of years (De Smet, 1996; Aaris-Sørensen et al., 2010), but it is only relatively recently that government authorities, marine mammal scientists, stranding networks, animal welfare communities and other stakeholders have made concerted efforts to rescue them when they are ashore (Zimmerman, 1991; St. Aubin et al., 1996; Geraci & Lounsbury, 2005). Other issues such as entanglements and boat strikes have been more recent issues for cetaceans to contend with and trained disentanglement teams and mitigation techniques are also relatively newly developed (Moore et al., 2013; Cates et al., 2017).

In New Zealand (NZ), which has a relatively long coastline (between 15-18,000 km, Gordon et al., 2010), at least 38 of the world's 90 cetacean species have been documented (Baker, 1983; Jefferson et al., 2015). Within those 38, one species, the orca (*Orcinus orca*, also known as killer whale), has five different ecotypes (distinct populations) which have been recorded in NZ waters; Antarctica Type B, Type C, Subantarctic or Austral (also known as Type D), Pelagic and NZ Coastal (Visser, 1999a; Visser & Mäkeläinen, 2000; Dwyer & Visser, 2011; Lauriano et al., 2015; Visser & Cooper, 2020a, 2020b).

As part of the research conducted by the Orca Research Trust (ORT) (www.orcaresearch.org), orca are photographed and identified individually (photo-ID) using congenital and acquired pigmentation, scars and marks. They are then assigned numbers in a catalogue (see Visser, 2000 for specific details). The population is small, with fewer than 200 individuals catalogued in nearly three decades of research (Visser, 2000; Visser & Cooper, 2020a). Yet, despite such relatively low numbers, the NZ orca have one of the highest rates of both strandings and boat strikes (Visser, 1999c, 2000, 2013; Visser & Hupman, 2018).

Within NZ, the species is listed as 'Nationally Critical' (Baker et al., 2019) which is one of the three 'Acutely Threatened' categories and the highest threat ranking given by the NZ Government (Townsend et al., 2008). In 2004, the NZ Government implemented its first (and only) 'Marine Mammal Action Plan' to cover the years 2005-2010 (Suisted & Neale, 2004). That Action Plan included comments such as *"Stranded killer whales can be successfully refloated"* and that the Department of Conservation (DOC), who are the legally mandated authority for the protection of NZ cetaceans *"... aims to focus management on: seeking to mitigate the disturbance of killer whales by recreational vessels in northern New Zealand"* and *"maintaining effective stranding and incident response."*

The conservation implications of rescuing stranded cetaceans or providing other assistance such as disentanglement can be diverse and produce mixed results (Zagzebski et al., 2006). In the USA, 69 cases involving 10 species of odontocetes, were evaluated to assess postintervention survival (Wells et al., 2013). The longest duration an individual was documented to have survived was 132 days (Wells et al., 2013). Their data set did not include any cases of orca or their survival rates.

Herein, the long-term survival of a male NZ Coastal orca (catalogue # NZ101, also known as Ben), who stranded and was successfully rescued and then was subsequently run over by a boat, is discussed. Although the original details from these events were described in Visser & Fertl (2000), the intervening 20 years provide an extended dataset, delivering what we believe to be the longest postintervention survival documented for this species globally.

2. METHODS

In order to better understand if NZ101 exhibited long-term effects from his stranding and/or if he was hampered by his injury, we assessed and compared subsets of data delimited by time and by event. The time data sets were comprised of (A) 1996-1999 (i.e., covered by Visser & Fertl, 2000) and (B) 2000-2020 (i.e., the 'current' dataset). Period (A) was punctuated by two events (a stranding and a boat strike) resulting in four subsets of data; (1) pre-stranding, (2) post stranding, (3) between stranding and boat strike and (4) post boat strike. However, as the post stranding and post boat strike data continued to be collected during the 20 years after period (A), two subsets of that data (1 and 3) fell exclusively within time (A); and two (2 and 4) overlapped between (A) and (B).

In addition to field research, we collated photo-ID records of NZ101 from a range of sources *inter alia*; citizen scientists, cetacean watching companies, coastguard, marine police, navy, ferries and members of the public (e.g., beach walkers). However, with the very distinctive appearance of NZ101, we also recorded sightings where photographs were unavailable. In some instances, the observer was familiar with NZ101 (e.g., a dolphin watching boat skipper who had encountered him before). We questioned observers with non-leading questions such as *'can you describe the dorsal fin?'* and *'did the orca have any specific features that would allow you to identify it?'*. Descriptions of NZ101 from observers included aspects such as having a *"split fin with one section hanging over on the left side".*

The complete data set consisted of 152 sightings, of which a number were repeat sightings in the same general area, therefore we standardised the latitude and longitude of each and refer to them as a 'location'. When the location was a harbour/fjord/sound or similar, we chose the narrowest section of the entrance of each, as the standardised waypoint for that location. However, we note that at times NZ101 may have been documented 10's of kilometres inside the waterway from the waypoint.

We then used 'aquaplot' (https://www.aquaplot.com/) a software application that calculates the distances (by sea and using navigable ships channels) between two locations. Although we recognise that orca do not typically travel such a track (and instead NZ orca tend to 'hug the coastline' e.g., to enter small bays, harbours and estuaries) (Visser, 1999b, 2000), the program standardised the measurements and removed human bias/error. We emphasise that the distances calculated are absolute minimum distances.

We then assessed;

(i) resighting durations

(ii) average daily distances travelled

(iii) minimum overall distances travelled

(iv) minimum distances between sightings

(v) association/social networks and behaviour with conspecifics

(vi) foraging behaviour (*inter alia*, prey types, cooperative hunting, food sharing)

The data from (ii) were at times heavily skewed, given that there may have been significant timeframes between consecutive sightings (i.e., during long periods it is reasonable to assume that NZ101 had travelled to other locations, but was not documented between any two temporally distant sightings).

We noted (v) & (vi) to ascertain if NZ101 could be considered a long-term candidate for successful reintegration into his social network and if he was able to sustain himself despite his injury (i.e., he was not a 'burden to society').

We also considered the entire dataset within the framework of results from other cetaceans of various species who were also provided some form of intervention.

3. RESULTS

A. CASE STUDY HISTORY

On 14 June 1997, NZ101 was found stranded on a sandy beach near Mangawhai, east coast of the North Island, NZ (Figure 1). He remained on the beach for approximately 21 hours and, with assistance (Figure 2), he was successfully refloated. Effectively, for cetaceans the pectoral fin is not adapted to cope with the impact of a stranding as *"in the terrestrial sense the flipper* [pectoral fin] *is non-weight-bearing"* (Felts, 1966) and the scapula-humerus joints are orientated in such a way that articulation is limited (Felts & Spurrell, 2005). The typical angles of the pectoral fins when an orca is free swimming (i.e., hanging at approximately 45° from the body) are illustrated in Figure 3 compared to the sternum (i.e., where the animal would lie if stranded). Therefore, to avoid damage, species-specific rescue techniques were applied – such as digging pits in the sand (Figure 2) in order to alleviate the pressure on the scapula-humerus joints and his pectoral fins were positioned outside of the rescue mats (Figure 2) to ensure that the joints were not compromised during the moving process.

On the fifth post stranding sighting (16 October 1998), NZ101 was observed with substantial damage to his dorsal fin, caused by a boat strike. Details of wound healing and sightings are chronicled in Visser & Fertl (2000), however, for direct comparison we reproduce some details here. After the boat strike and prior to the publication of Visser & Fertl (2000), NZ101 was resighted 11 times with their last record on 15 October 1999 (see their Table 1 for details and Table 1 herein for summary information).

NZ101 was documented 18 times in Visser & Fertl (2000) over a period of 1,136 days (or 3 years, 1 month, 11 days, between 04 September 1996 and 15 October 1999). During this period, he was documented in nine different locations (Figure 1) and two of those (Bay of Islands and Whangarei Harbour), he visited three or more times. Since the publication of Visser & Fertl (2000), but within the same time period (i.e., 1996-1999), two additional historic sightings have been collected, resulting in a total of 20 records at 11 locations for period (A), with all sightings off the northern North Island (see Table 1 in Visser & Fertl, 2000 and Table 1 herein).

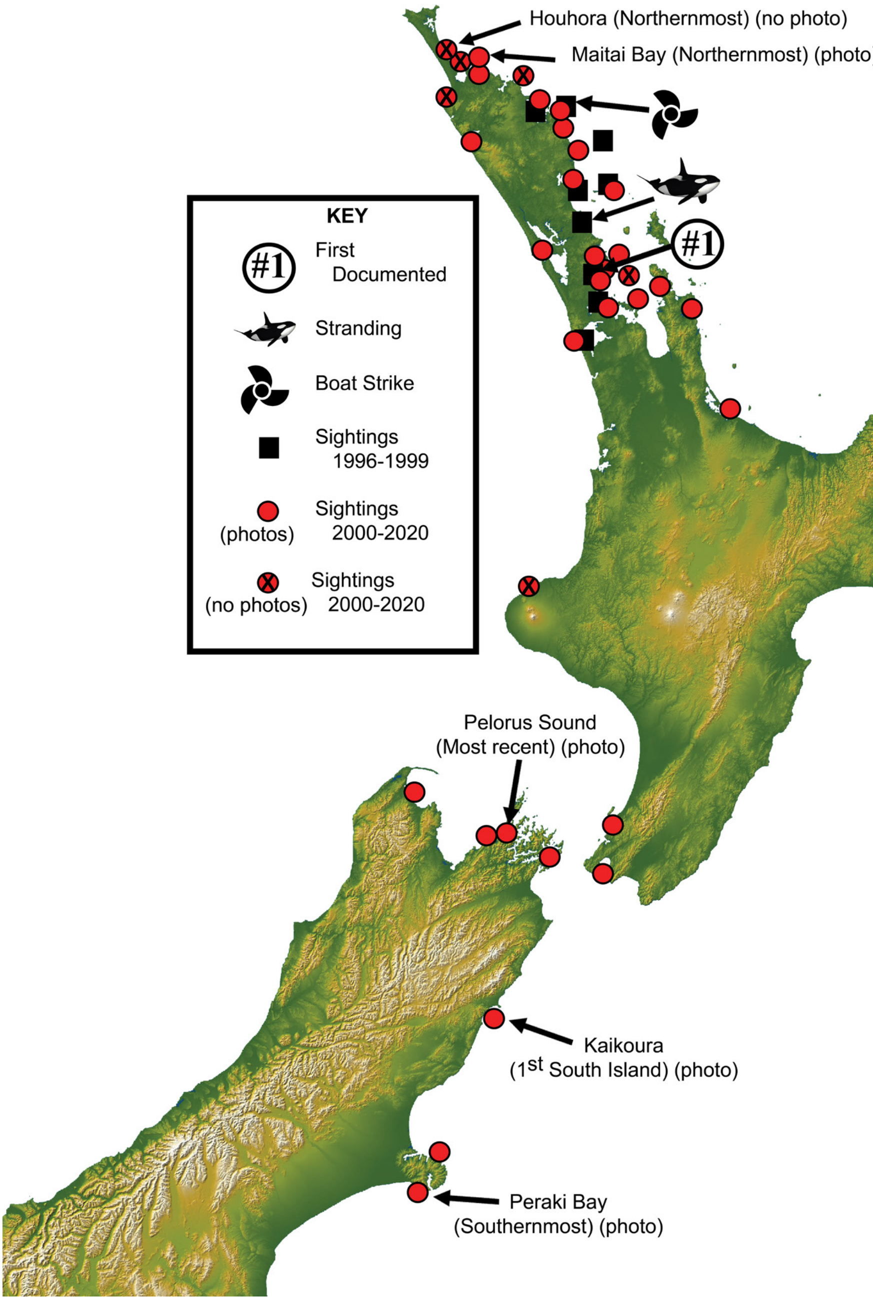

Figure 1. Sighting locations of NZ101 (Ben), a male orca who stranded (orca icon) on 14 June 1997 and has been resighted 152 times. His most recent sighting, 05 December 2020 (Pelorus Sound), was 8,574 days (i.e., 23 years, 5 months 20 days) after he was refloated. The black squares indicate locations from Visser & Fertl (2000) and the red circles indicate locations where he has since been documented (note that multiple resightings occurred at some locations from within both the Visser & Fertl (2000) and current data sets).

Figure 2. As part of the rescue of NZ101, he was cared for on the beach overnight. Assistance included covering him with sheets and keeping him wet (top left). Holes were dug for his pectoral fins to alleviate the pressure on his scapula-humerus joints (top right & bottom). To return him to the water, mats were placed under him and 'spreaders' were used to ensure that he was not excessively compressed during the lifting process. Note that his pectoral fins were kept outside the mats to prevent damage to them and the scapula-humerus joints. His dorsal fin was leaning to his left side (top left), which caused a pressure blister during the stranding and may have contributed to the direction the posterior portion of his fin collapsed after he was hit by a boat propeller, Figures 4, 5, 7-13). Photos © Top, Ingrid N. Visser, bottom Terry M. Hardie.

B. CASE STUDY UPDATE

Sightings, Resightings & Photo-ID of NZ101

Between when NZ101 was first documented on 04 September 1996 and his most recent sighting on the 05 December 2020 (i.e., periods (A) and (B) combined), he was observed a total of 152 times (Table 2), 145 of those since his rescue and of those 140 since the boat strike. Despite his distinctive appearance, the first sighting of NZ101 in period (B) was not until 214 days after he was last reported in period (A). That resighting occurred on 16 May 2000 in the Bay of Islands and although NZ101 was documented by a cetacean watching company with guides familiar with him, he was not photographed. The first time he was photographed after period (A) was on 15 November 2000, in Whitianga Harbour, 397 days (1 year and 1 month) after he was previously photographed (Table 1).

Since the last sighting in period (A), NZ101 has been documented over a period of 7,722 days (or 21 years, 1 month, 20 days between 15 October 1999 and 05 December 2020) and documented in 48 locations (including all of those locations documented in Visser & Fertl, 2000). In period (B), NZ101 visited three locations (Bay of Islands, Whangarei Harbour and Hauraki Gulf) more than 10 times and he visited another two locations (Tauranga Harbour and Kaikoura) seven and nine times respectively, the latter being the only location off the South Island where he was photographed more than once.

In the period (B) dataset, NZ101 was documented 136 times off the North Island (in 40 locations, 34 off the east coast, five off the west and one off the south). His northernmost sighting (no photograph) was on the east coast at Houhora Harbour, whilst his northernmost sighting (with a photo) is Maitai Bay (Table 1). That location is only 5 km south of Houhora Harbour (but is situated 30 km to the east) and Maitai Bay is approximately 80 km north of the Bay of Islands, his northernmost location in period (A).

On 16 March 2003, NZ101 was reported (and photographed) for the first time off the coast of the South Island (at Kaikoura, Figure 1, Table 1). He has since been photographed off the South Island 15 times; with a further eight encounters in the Kaikoura area. His most recent sighting on 05 December 2020, in Pelorus Sound, is also off the South Island (Figure 1, Table 1). NZ101's southernmost sighting was when he was photographed at Peraki Bay, on the south coast of Banks Peninsula on 27 December 2011 (Figure 1, Table 1).

Irrespective of the size of the data set, there remain noticeable gaps between the distribution of both sightings and locations; for example, there are no sightings/locations south of Banks Peninsula on the east coast or anywhere on the west coast of the South Island. As NZ101 typically forages in close to the shore (Visser & Fert (2000), ORT, unpublished data), he likely traversed the coastline between the clusters of sightings. But, as described in Visser (2000), observer bias may be influencing the data for NZ101, e.g., the comparative number of people living/boating along parts of the NZ coastline where there are few/no sightings is lower than the northern part of the North Island and therefore the potential for sightings/data collection is lower.

Additionally, there were instances where NZ101 was documented consecutively in the same location but there may have been days, months or even years between these sightings (Table 3). For example, in period (A) he was sighted in the Bay of Islands on 06 and 16 October 1997 (i.e., 10 days apart) and there were no other sightings between these. Five days later he was photographed in the Waitemata Harbour. NZ101 then returned to the Bay of Islands on 11 November 1998 and again on 04 May 1999 (i.e., 174 days apart) with no sightings between these two.

Similar instances occurred in period (B), where NZ101 was photographed in the Bay of Islands on 24 May 2002 and again on 08 October 2002 (137 days apart) with no sightings between these two. Given that the Bay of Islands has high boat traffic, that there were at least three whale/dolphin watching companies operating in the area during both periods (A) and (B) and that we have never documented an orca remaining in any one location for longer than three days (unless injured or compromised in some way, e.g., Visser et al., 2017), the probability that NZ101 remained in the Bay of Islands between these dates is negligible. This again emphasises that the distances documented herein are absolute minimums.

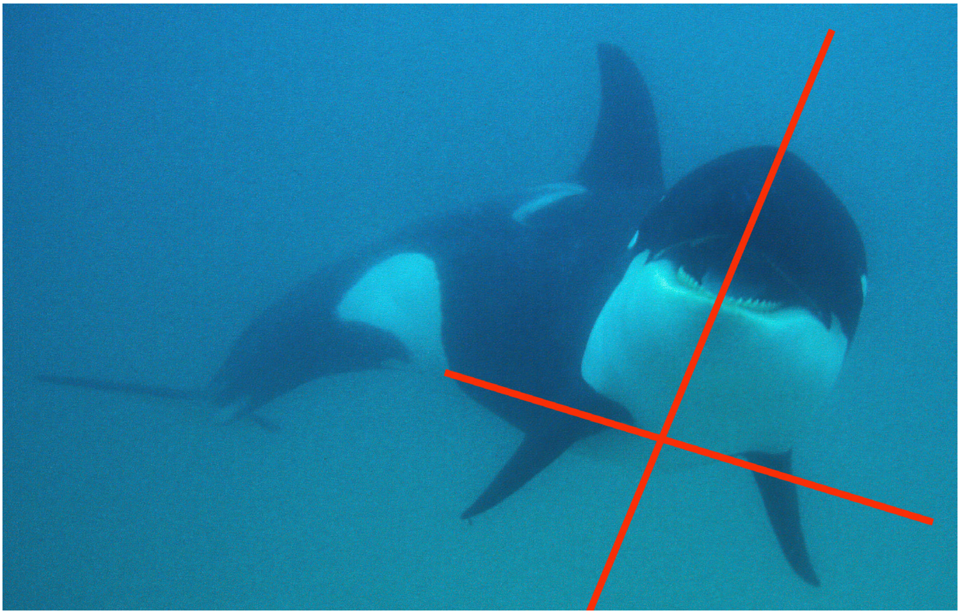

Figure 3. A juvenile female orca, showing the typical 45° angle for the species' pectoral fins, when compared to a medial line and an approximate 'base line' of her sternum. The potential damage to the scapula-humerus joints increases in sub-adult and adult males, due to their larger pectoral fins. Species-specific protocols should always be implemented when intervening (e.g., see Figure 2). Photo © Ingrid N. Visser.

Table 1. Key events and dates for NZ101 who has been resighted 152 times. Of those, 145 sightings were since his rescue and of those 140 were since the boat strike. Only a selection of key dates from the Visser & Fertl (2000) data (white rows) and the current set (grey rows) are listed. See Table 2 for details durations and distances and Figure 1 for locations. N/A = not applicable, ORT = via Orca Research Trust, TEC = Tracy E Cooper, V & F (2000) = Visser & Fertl (2000). Distances are calculated using www.aquaplot.com and sightings with & without photos.

Date yyyymmdd	Event Details	Location	Days since first documented	Days post rescue	km's post rescue	Days post boat strike	km's post boat strike	Source
19960904	First record in database (photo)	Kawau Channel	0	N/A	N/A	N/A	N/A	V & F (2000)
19970614	Stranded (photo)	Mangawhai Heads	283	N/A	N/A	N/A	N/A	V & F (2000)
19970615	Rescued (refloated) (photo)	Mangawhai Heads	284	1	N/A	N/A	N/A	V & F (2000)
19970616	First resighting after rescue (video)	Hen & Chicken Islands	285	2	28	N/A	N/A	V & F (2000)
19971006	Northernmost sighting, first documentation of white scar at base of dorsal fin (photo)	Bay of Islands	397	113	198	N/A	N/A	V & F (2000) (see Fig. 4)
19981016	Boat strike (photo)	Bay of Islands	772	488	766	N/A	0	V & F (2000)
19981024	First resighting after boat strike (photo)	Manukau Harbour	780	496	1,340	8	603	V & F (2000)
19991015	Last sighting in V & F (2000) (photo)	Hibiscus Coast	1,136	852	2,759	364	2,022	V & F (2000)
20000516	First resighting after V & F (2000) (214 days since previous sighting) (no photo)	Bay of Islands	1,350	1,066	3,020	578	2,283	J. Halliday
20001115	First photo-ID after V & F (2000) (397 days) (photo)	Whitianga Harbour	1,533	1,249	3,357	761	2,620	ORT
20030316	First sighting South Island (photo)	Kaikoura	2,384	2,100	6,290	1,612	5,374	S. Lock
20030531	Northernmost sighting (photo)	Maitai Bay	2,460	2,177	11,493	1,688	10,756	N. Scott
20111227	Southernmost sighting (photo)	Peraki Bay, Banks Peninsula	5,592	5,308	36,150	4,820	35,413	E. Slooten & S. Dawson
20190316	Most recent documentation of white scar (duration scar visible = 7,831 days, i.e., 21 years, 5 months, 10 days) (photo)	Kaikoura	8,228	7,945	52,940	7,456	52,203	TEC & Dolphin Encounter Kaikoura (see Fig. 8)
20200606	Northernmost sighting (no photo)	Houhora Harbour	8,676	8,392	54,932	7,904	54,016	ORT
20201205	Most recent resighting (photo) (from first photo = 8,858 days i.e., 24 years, 3 months, 1 day) (from rescue = 8,574 days i.e., 23 years, 5 months, 20 days) (from boat strike = 8,086 days i.e., 22 years, 1 month, 19 days)	Pelorus Sound	8,858	8,5754	55,831	8,086	54,915	N. Howard

Durations & Distances

From when he was first documented, until his most recent sighting, NZ101 was resighted over a period of 8,858 days (24 years, 3 months, 1 day) during which he was documented 152 times (Tables 1 & 2). He was resighted 136 times off the North Island and 16 off the South Island. He was resighted most frequently in the Bay of Islands, where he was observed on 18 occasions (Table 2).

During the entire time that NZ101 has been recorded the longest duration between sightings was 360 days, where NZ101 travelled a minimum of 255 km between the Waitemata Harbour and the Bay of Islands (Figure 1 & Table 1), with the average distance <1 km per day. In the latter encounter he was first documented with injuries from the boat strike. The following sighting was in the Manukau Harbour, eight days later and in all three locations photographs were taken, confirming his presence. The minimum distance between the Manukau Harbour and the Bay of Islands was 603 km, giving an average distance per day of 75 km.

The maximum distance between sightings (with photo-ID at both locations) was 1,219 km when NZ101 was sighted first off Waitemata Harbour and then 95 days later off Kaikoura (Table 2). The shortest distance between locations was 0 km, when NZ101 was resighted in the same location on consecutive sightings (e.g., the Hauraki Gulf to Hauraki Gulf example in Table 3, but we note that these two sightings were 111 days apart). In contrast, there were 16 instances where NZ101 was photographed between consecutive sightings at locations which were more than >1,000 km apart. The timeframe between these was never less than 34 days and up to 186 days, with the resulting average daily distances calculated as low as 5 km and never more than 35 km. Such lower daily rates are likely skewed due to the extended timeframes between consecutive sightings and lack of documentation of his movements during those timeframes. This becomes more apparent when comparing distances where NZ101 was photographed only one day apart (n=6) which were 145, 136, 71, 43, 28 and 0 km, with zero kilometres occurring when he was resighted in Whangarei Harbour (Table 3) and 28 km occurring when he was first resighted the day after his refloating.

In contrast, NZ101 has been documented travelling an average of 193 km per day (Table 2), over a period of five days (with a total distance with 964 km between the two sightings and with photo-ID at both locations). The next two highest daily distances were 145 and 136 km. All three of these relatively high daily distances occurred after the boat strike, indicating that although the injury was extreme, it has not severely impacted his ability to swim large distances in short periods of time.

Table 2. Summary data for the male orca NZ101 (Ben). Records are presented as two subsets; 'with or without' and 'with' photo-ID at sightings. Distances were calculated using aquaplot (www.aquaplot.com).

WITH or WITHOUT photo-ID at sightings	
SIGHTINGS	
Total number of sightings	152
Number of sightings since refloating	145
Number of sightings since boat strike	140
Number of locations sighted off North Island	40
Number of locations sighted off South Island	8
Maximum number of sightings in one location	18 (Bay of Islands)
DURATIONS	
Duration between first and most recent sighting	8,858 days (24 years, 3 months, 1 day)
Duration between refloating & most recent sighting	8,574 days
Duration between boat strike & most recent sighting	8,086 days
Maximum duration between two sightings	360 days
DISTANCES (minimum)	
Distance between all sightings	55,814 km
Distance between refloating & most recent sighting	55,635 km
Distance between boat strike & most recent sighting	54,898 km
Maximum distance between two sightings	1,219 km
Maximum daily distance (calculated)	193 km
Maximum daily distance (single day)	170 km
WITH photo-ID at sightings	
SIGHTINGS	
Number of sightings	98
Number of sightings since refloating	90
Number of sightings since boat strike	86
Number of locations sighted off North Island	33
Number of locations sighted off South Island	7
Maximum number of sightings in one location	12 (Whangarei)
DURATIONS	
Duration between first and most recent sighting	8,858 days
Duration between refloating & most recent sighting	8,574 days
Duration between boat strike & most recent sighting	8,086 days
Maximum duration between two sightings	360 days
DISTANCES (minimum)	
Distance between photographed sightings	37,772 km
Distance between refloating & most recent sighting	37,593 km
Distance between boat strike & most recent sighting	36,856 km
Maximum distance between two sightings	1,219 km
Maximum daily distance (calculated)	193 km
Maximum daily distance (single day)	145 km

Furthermore, with the standardised locations and the direct line measurements, the distances are likely to be much greater than indicated from these calculations. For example, from our experience watching the NZ coastal orca in the Bay of Islands, we know that they utilise an area that covers a minimum of 200 km^2 within this one complex embayment. Within that area they are often found 10 or more kilometres from the 'standardised' location in the Bay of Islands, e.g., at the north end of the Te Puna Inlet (13km away), or the south-eastern end of the Waikare Inlet (15 km away). Also, the minimum distance calculations do not take into account the highly dynamic movements of orca, who not only conduct vertical dives but also typically travel along the coastline, entering into small bays and estuaries when foraging.

Over the total period that NZ101 has been documented (i.e., 24 years, 3 months, 1 day), the minimum distance that he travelled was 55,814 km (Table 2). If only those instances where NZ101 was photographed are used to calculate the distance he travelled, the minimum distance was 37,772 km (37,593 km of those were post his stranding and 36,856 km of those were post the boat strike injury) (Table 2).

White Blister Scar & Pigmentation

NZ101 was observed on 6 October 1997, i.e., 113 days after his rescue and refloating, with a white (depigmentation) scar on his left side just below his dorsal fin (Figure 4), presumed to be the result of a large pressure blister that occurred during the stranding (Visser & Fertl, 2000). That white scar was still visible 375 days after his rescue on 16 October 1998, when NZ101 was first documented with severe injuries from a boat strike (Figure 5). The white scar has remained visible in subsequent encounters see (Figures 7-12), including during one of the most recent sightings in which his left side was photographed (see Figure 8). This sets a new record for scar longevity on orca at 7,831 days, (i.e., 21 years, 5 months, 10 days), where the previous records for depigmentation scars on orca were rake marks which were documented for a minimum of 1,529 days (or 4 years, 2 months, 7 days) and a cookie cutter shark bite scar which was visible for 4,090 days (or 11 years, 2 months, 12 days) (Visser et al., 2020).

Pressure blisters are typically considered a minimally invasive and superficial injury (Kutlu & Svedman, 1992). Greenwood (2013), a cetacean veterinarian, suggested that the previous severity of a healed wound can be assessed based on depigmentation alone when he stated;

> "[the captive orca] *carried numerous fine linear scars from previous interactions with other whales, but these were all long since healed. None of these scars had caused depigmentation, indicating that the wounds had been superficial."*

Yet, in the case of NZ101 the superficial blister had caused depigmentation and the extreme trauma from the boat strike, which resulted in a severe laceration and splitting of his dorsal fin, resulted in no depigmentation (Figures 7- 13). Additionally, when NZ101 later received wounds to the anterior portion of his dorsal fin (Figure 11), these were significant enough to have gaping wide lesions and necrotic tissue, yet they healed leaving no depigmentation areas. These two examples call into question retroactive assessment of wound severity based solely on depigmentation (such as conducted by Greenwood).

When NZ101 was first photographed on 16 October 1998 with boat strike wounds, his right saddle patch was 'rounded' and 'smooth' (Figure 13 and see Sugarman (1984) for examples of saddle patch types). By 27 September 2010, his saddle patch had changed shape, in that it then had a 'hard angle' below the cut (arrow, Figure 13). This appears to have resulted from tension applied to his skin and body from his damaged dorsal fin as it creates drag and pressure as NZ101 moves through the water (see *'Injury & Hydrodynamics'* below). This is the first instance that we could find of a saddle patch changing shape in an orca (albeit that saddle patches develop as a calf matures).

Injury & Hydrodynamics

Cetaceans do not have bones in their dorsal fins (Cozzi et al., 2016) and as such the appendage is only supported by fibrous tissue such as ligamentous layers of collagen bundles (Felts, 1966; Pavlov, 2003). From the first day that NZ101 was cut by a propeller, the posterior portion of his dorsal fin leaned towards his left and over time it collapsed (Figure 9). A year after the boat strike the posterior portion had arched over and was impacting his hydrodynamics as evidenced by the water disturbance he was causing when at the surface (e.g., see Figures 7-13) and apparent cavitation when submerged underwater (ORT, unpublished data). The posterior portion of his fin has grown 'longer' (rather than taller as would be expected for an upright dorsal fin) resulting in a larger proportion of the fin dragging as he has aged (e.g., compare Figure 7 with Figures 8-13). Also, the distal end of the posterior portion of his fin has begun to 'roll under' itself (Figures 7-12). With his dorsal fin dragging in the water in such an unnatural manner, there is significant tension on the base of the fin (red arrows, Figure 12). This has created a ridge of raised tissue, visible as a darker line through his left saddle patch (yellow arrows, Figure 12).

As of 2021, NZ101 is approximately 40 years old and his dorsal fin should not grow any 'longer', since his adolescent growth spurt and subsequent 'filling out' as an adult should have finished by the time he was 20 years old, when compared to other male New Zealand coastal orca (ORT, unpublished data) or by 18 years old when compared to Pacific Northwest orca (Olesiuk et al., 2005).

Figure 4. On 06 October 1997, the first day NZ101 was resighted and photographed after his rescue and refloating on 15 June 1997, a white scar (white arrow) from the blister that formed at the base of his dorsal fin, was visible. The black arrow indicates a dark scar that straddles the spinal ridge. See subsequent Figures for comparisons. Photo © Ingrid N. Visser.

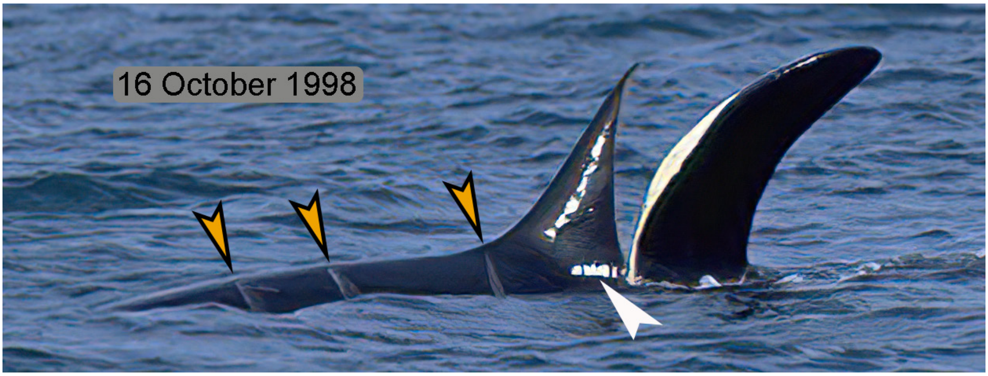

Figure 5. On 16 October 1998, NZ101 was photographed with injuries from a boat strike. Parallel wounds on his dorso-thorax (orange arrows) and extensive damage to his dorsal fin were apparent. The leading edge of the open wound on his dorsal fin exposed the connective tissue and appeared bright white. At the base of his dorsal fin, the white scar remained visible (white arrow), 1 year and 10 days after it was first documented. Another area of white (on the anterior upright part of his fin) was from light reflecting off his fin and was not depigmentation. See subsequent Figures for comparisons. Photo © Ingrid N. Visser.

Table 3. Examples of locations where NZ101 was photographed, with minimum distances and average daily distances (calculated using www.aquaplot.com). Four categories of examples are presented; (A) sightings one day apart, (B) sightings 2 days apart, (C) repeat sightings between locations and (D) sightings at locations >1,000 km apart. Cells in grey indicate maximum durations or distances. These examples are representative of the data for NZ101, but are not an exhaustive list of each category.

Sighting Category	Locations	# of Days between	Distance between (km)	Average Daily distance (km)
A (1 day)	Hen & Chicken Islands (Northland) – Bay of Islands (Northland)	**1**	**170**	**170**
	Whangarei Harbour (Northland) – Mahurangi Harbour (Auckland region)	1	145	145
	Mimiwhangata (Northland) – Whangarei Harbour (Northland)	1	71	71
	Cavalli Islands (Northland) – Bay of Islands (Northland)	**1**	**32**	**32**
B (2 days)	Bream Bay (Northland) – Cavalli Islands (Northland)	**2**	**196**	**98**
	Ahipara (Northland) – Rangaunu Harbour (Northland)	2	187	94
	Whangarei Harbour (Northland) – Waitemata Harbour (Auckland region)	**2**	**174**	**87**
C (repeat)	Hauraki Gulf (Auckland region) – Hauraki Gulf (Auckland region)	**111**	**0**	**0**
	Whangarei Harbour (Northland) – Whangarei Harbour (Northland)	17	0	0
	Hen & Chicken Islands (Northland) – Hen & Chicken Islands (Northland)	7	0	0
	Whangarei Harbour (Northland) – Whangarei Harbour (Northland)	1	0	0
D (>1,000 km)	Whangarei Harbour (Northland) – Kaikoura (South Island)	**160**	1,182	7
	Mercury Bay (Coromandel) – Kaikoura (South Island)	109	1,020	9
	Kaikoura (South Island) – Hauraki Gulf (Auckland region)	105	**1,185**	11
	Kaikoura (South Island) – Whitianga Harbour (Coromandel)	83	1,024	**12**

The injury to NZ101 illustrates the physical ramifications that a boat strike can have on a cetacean. Although the population of NZ Coastal orca is relatively small it has one of the highest rates of boat strikes in the world (Visser & Hupman, 2018). It therefore stands to reason that there must be factors influencing such a high rate, such as large numbers of vessels and their operating zones overlapping critical habitat for the orca. In Figure 6, just one aspect of vessel traffic around the NZ coastline, i.e., commercial ships, is illustrated. Of note is that although this only shows data for ships *"... recreational craft use in NZ is significant, with the country being recorded as having one of the highest boat ownership rates per head of population in the world."* (Riding et al., 2016). These smaller pleasure craft, like the ships, overlap areas where NZ101 has been documented (see Figure 1 for comparison of distribution of NZ101 sightings).

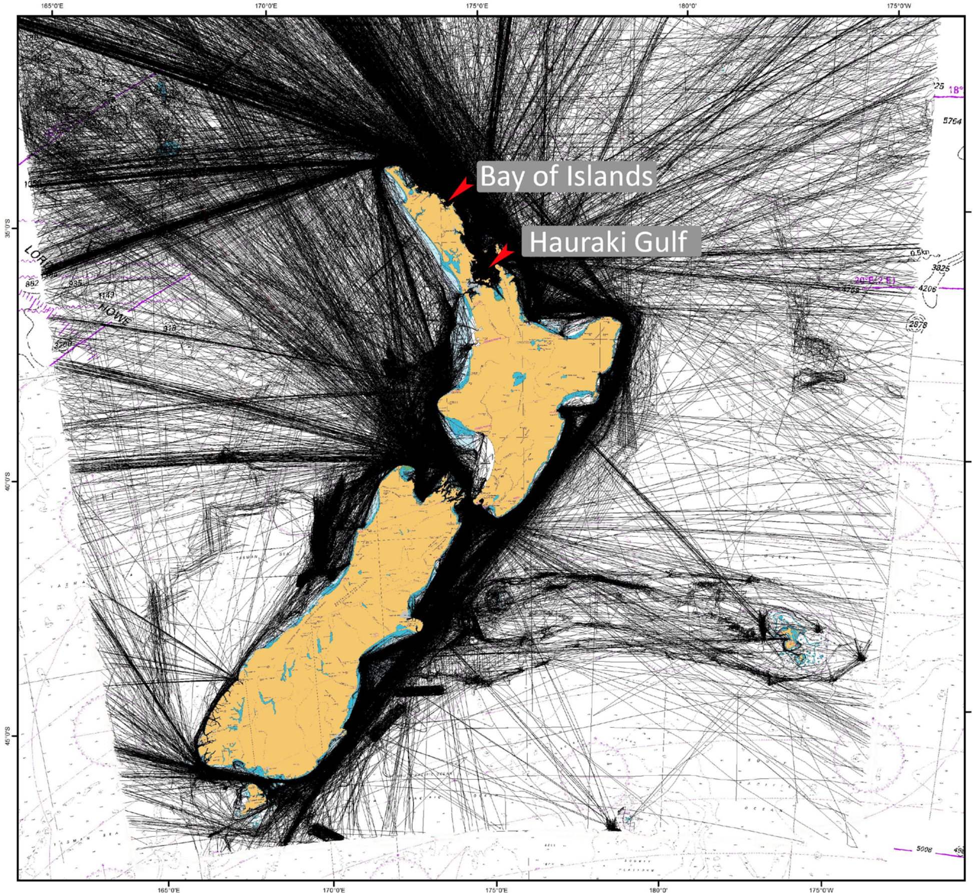

Figure 6. Tracking data of commercial ships from July 2014 to June 2015, extracted from Riding et al., (2016). Although the data in is now six years old, the extent of the exposure is significant. It is of note that this figure does not include commercial tour operators such as whale and dolphin watching, diving tours, ecotours or similar. Nor does it include private vessels/pleasure craft and such smaller vessels are typically concentrated around areas of high human habitation/recreation such as the Bay of Islands and the Hauraki Gulf (arrows), which are also two areas where NZ101 has been sighted the most often. NZ101 was struck by a vessel in the Bay of Islands.

Associations

Visser & Fertl (2000) documented NZ101 travelling with orca prior to his stranding and after both the stranding and the boat strike and there were a number of individuals that he was repeatedly seen with during that period. The social networking pattern for NZ101 has remained comprehensive during the entire time he has been documented. For example, NZ101 travelled with at least 26 orca in the ORT catalogue during period (A) prior to his boat strike including with NZ4, an adult female (he was photographed with her *n*=9 times), NZ6, an adult male (*n*=11) and NZ63, an adult female (*n*=9) and he was therefore presumed to have a strong association with those individuals. He was subsequently documented with each of these orca in period (B).

Other key individuals he was sighted with in period (A) e.g., NZ1 and NZ9, adult females and NZ8 and NZ21, both males, where NZ8 was a juvenile when first documented with NZ101 in 1996 and NZ21 was an adult male when first documented with NZ101 in 1999, have also been recorded travelling with him in period (B). After his boat strike, he was documented with 33 orca in the ORT catalogue. Of these, he has been seen with some individuals multiple times such as NZ1, an adult female (*n*=9), NZ3, an adult male (*n*=8) and NZ68 (*n*=7), who was a juvenile when first sighted with NZ101 but is now an adult male (ORT, unpublished data).

However, as time has progressed NZ101's association network has shifted as, although he may have continued to associate with some individuals listed in the 2000 publication, others are now presumed dead (e.g., NZ3, was last documented travelling with NZ101 on 30 December 2005 and has not been documented at all since November 2007 and NZ4, was last photographed travelling with NZ101 on 20 August 2006 and has not been documented at all since January 2007). As part of his social interactions, NZ101 has been documented alloparenting/babysitting young orca and engaged in other social interactions with conspecifics (e.g., male-male interactions, play behaviour and foraging).

Foraging Behaviour

NZ101 has been documented feeding on rays in both periods (A) and (B). He has been documented feeding on and cooperatively hunting for short-tailed stingray (*Dasyatis brevicaudata*), long-tailed stingray (*Dasyatis thetidis*) and eagle ray (*Myliobatis tenuicaudatus*). In both periods he has also been documented food sharing (an important social bonding interaction in this species), with both males and females (of all age classes except neonates who are not yet taking solid food). In period (B) he was documented cooperatively hunting and killing a broadnose sevengill shark (*Notorhynchus cepedianus*).

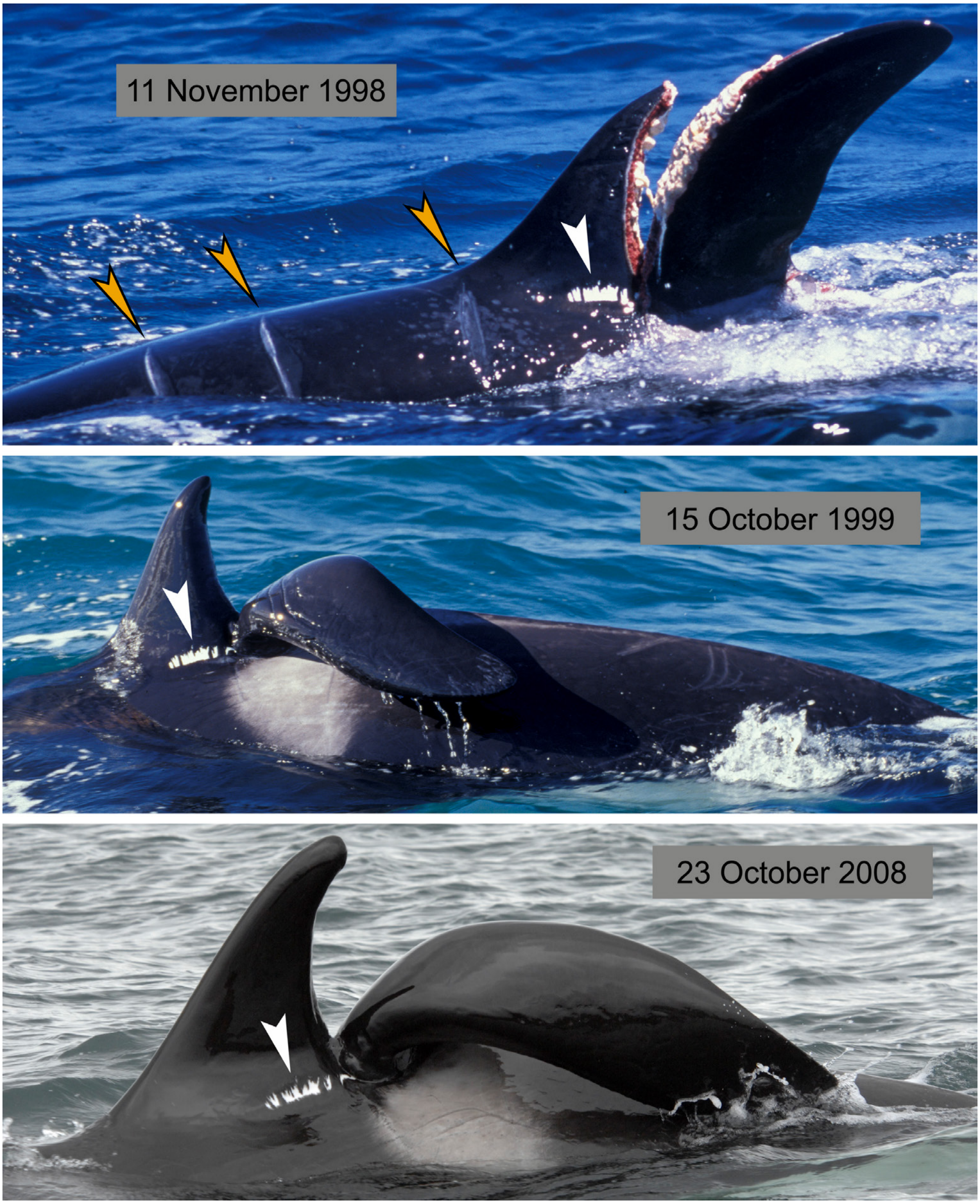

Figure 7. Photographs of the left side of NZ101 show the progression of collapse of the posterior portion of his dorsal fin. Shallow cuts on his dorso-thorax area from the propeller strike are visible one month after they were inflicted (orange arrows, top panel and compare to Figure 5). The wound slicing his dorsal fin had healed by 15 October 1999 (middle panel), including re-pigmentation of the skin. This is in contrast to the persistence of the depigmentation creating a white scar from a pressure blister (white arrows, all panels). Photos © Ingrid N. Visser.

Figure 8. NZ101 was photographed off Kaikoura on 05 February 2019. Over time, the posterior portion of his dorsal fin has been swept further back and 'rolled under' due to water flow as he swims. The white scar at the base of the anterior portion of his fin (white arrow) is still visible (see Figure 4, 06 October 1997 for first documentation). This is the longest duration a depigmentation scar has been documented on an orca, at 7,831 days (i.e., 21 years, 5 months, 10 days). A scar (just on the shadow line, black arrow, insert) that indents and straddles the spinal ridge, was also visible in 1997 (see Fig. 4). The insert was post-processed using TopazLabs Stabilize AI and Gigapixel AI software. Photo © Tracy E. Cooper/Dolphin Encounter.

Table 4. Some examples of the distances which orca have been documented travelling, in order of duration of tracking. Tagging data typically gives a daily 'waypoint' (although some tags provide more frequent location data), whereas photo-ID only gives data at each location where the photo was taken. Neither method accounts for any deviations from a minimum straight-line distance between datapoints. N/D = Not documented.

Time Frame (days)	Distance as Direct line (km) or Area covered (km²)	Daily Distance Average (km)	Daily Distance Maximum (km)	Notes	Source
28	49,351 km²	56.8 ± 31.8	114.3	Satellite tag, Ross Sea, Antarctica	Andrews et al., (2008)
48	4,717 km	98	N/D	Satellite tag, Norway	Dietz et al., (2020)
77	3,267 km	42.4	N/D	Photo-identification, Kodiak, Alaska – Monterey, California, USA	Dahlheim et al., (2008)
90	>5,400 km	159.4 ± 44.8	252	Satellite tag, Canadian Arctic and into the North Atlantic	Matthews et al., (2011)
104	7,608 km	73	N/D	Satellite tag, Norway	Dietza et al., (2020)
109	9,392 km (in 42 days)	N/D	N/D	Satellite tag Antarctica – South America return	Durban & Pitman (2011)
8,858	37,772 km	Variable	193	Photo-identification New Zealand	This study

Figure 9. When NZ101 was photographed swimming towards the camera on 16 October 1998 (left), the anterior portion of the fin was upright whilst the posterior portion began to collapse to his left, the same direction it had started to collapse during the stranding a year and half prior. On 25 October 2010 (right), the anterior portion remained upright, whilst the degree to which the posterior portion of the fin was compromised is obvious. The white scar can also be seen in both photos (white arrows). Photos © Ingrid N. Visser.

Figure 10. When NZ101 was photographed swimming away from the camera on 21 May 2007 (left), the collapse of his fin is clearly visible. By 25 October 2010, the posterior distal end of the collapsed portion was beginning to 'roll under'. See Figure 8 for comparison to 2019. The black arrows (also see inserts) indicate a small dark scar that is an indent which straddles the spinal ridge (see Figures 4, 11 & 13 for comparison). Photos © Ingrid N. Visser.

Figure 11. On 20 August 2006, NZ101 was photographed with two wounds on the anterior section of his dorsal fin (top & insert). The aetiology of these is unclear, but by 03 September 2015 (bottom) they had completely healed and like the rest of the skin on his dorsal fin, there was no depigmentation. A dark scar is visible across his spinal ridge (upper image, black arrow, also see Figures 4, 8, 10 & 13). Photos Top; © Ingrid N. Visser (2006), Bottom © Terry M. Hardie (2015).

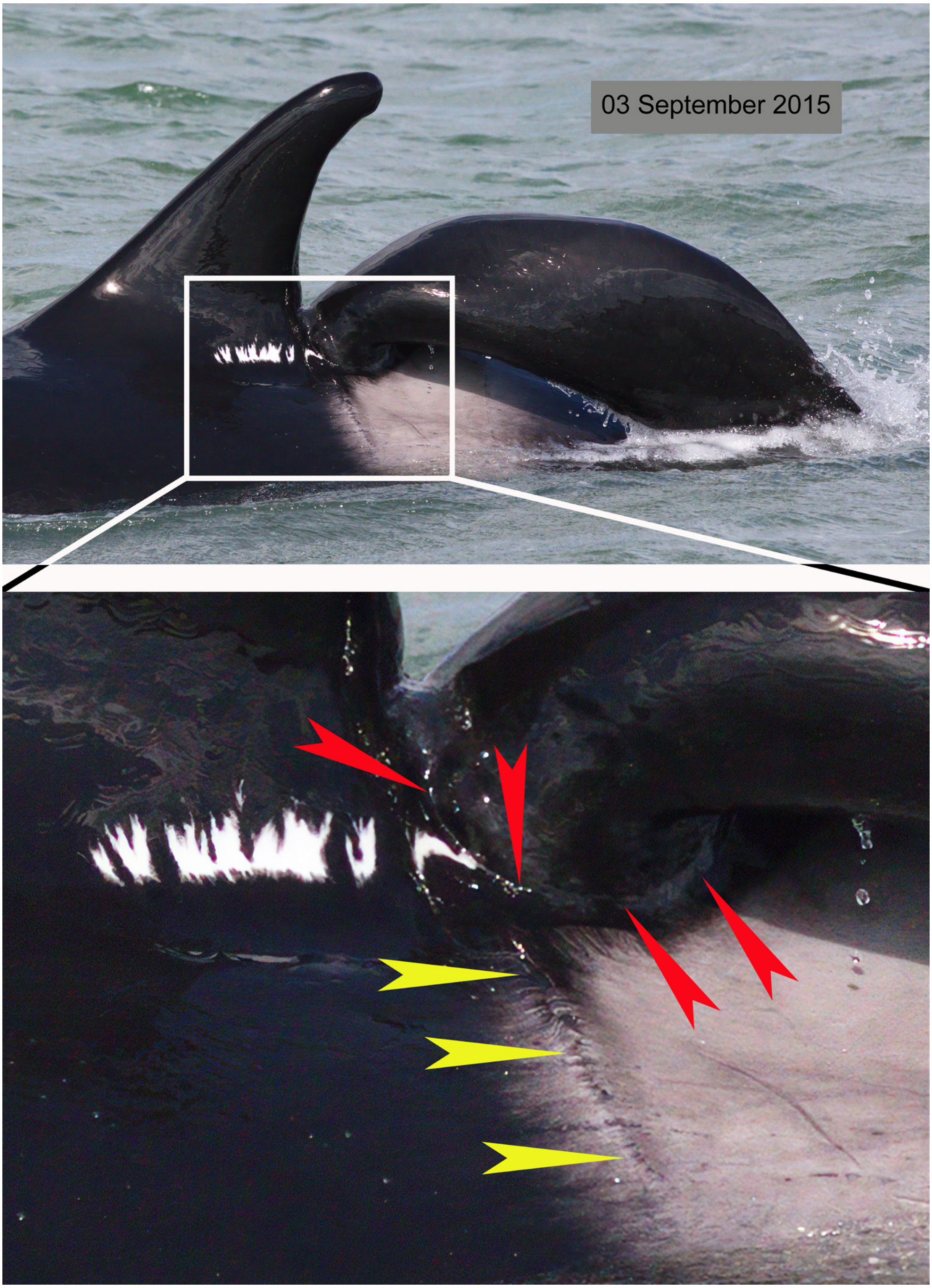

Figure 12. NZ101 photographed on 03 September 2015. The posterior portion of his dorsal fin hanging in the water creates drag and disturbs water flow. This in turn creates a significant amount of pressure on the base of the dorsal fin, as evidenced by the raised ridge and scar (yellow arrows) and the pressure ridge around the base of the fin, noting that this ridge continues around and 'into' the split of the fin (red arrows). The white depigmented scar from a pressure blister is still clearly visible (also see Figures 4, 5, 7-9). Photo © Ingrid N. Visser.

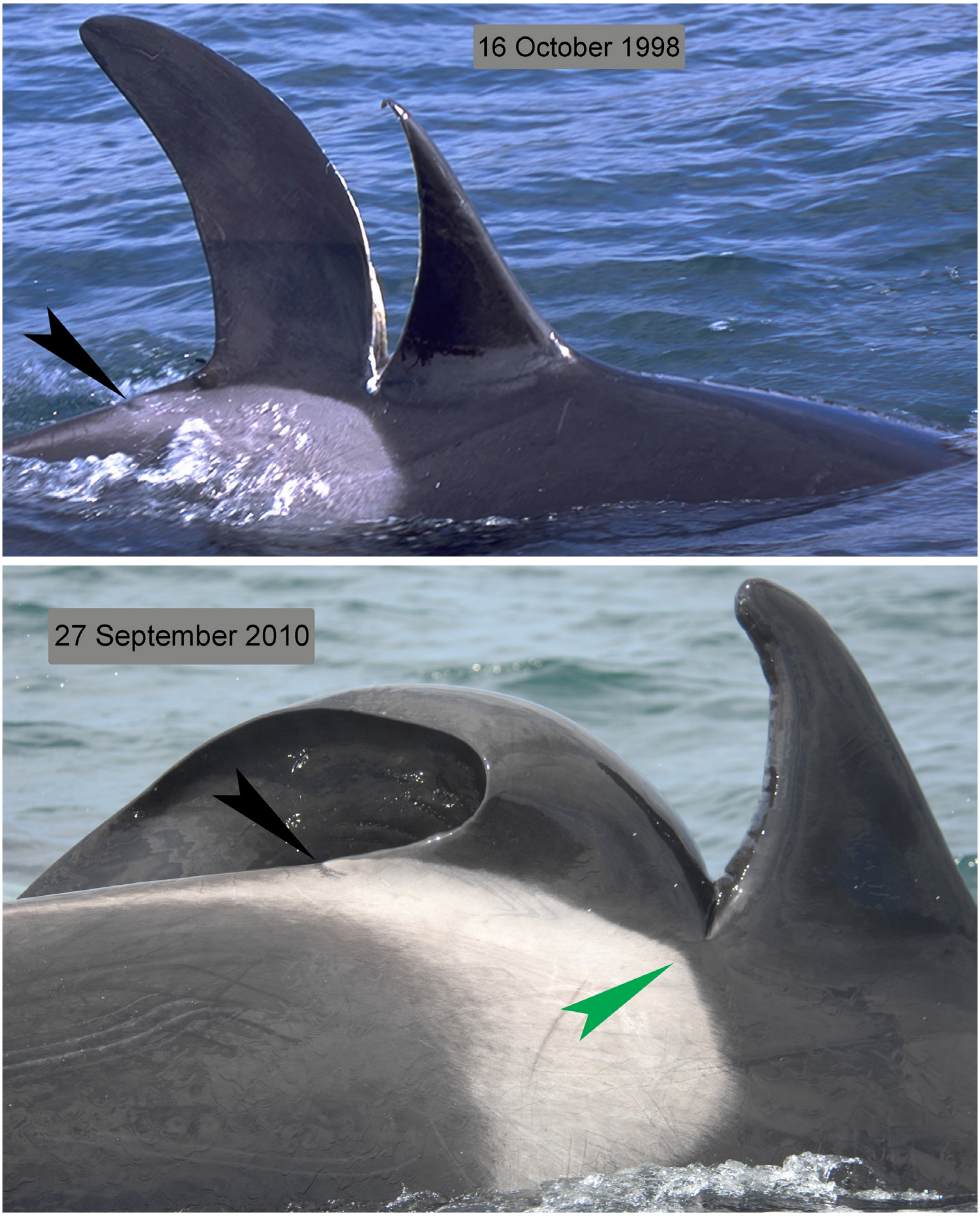

Figure 13. The right side of NZ101 was photographed 16 October 1998 (top), and on 27 September 2010 (bottom). A small scar, straddling his spinal ridge (black arrows) is visible in both images (also see Fig. 8). Of note is that the grey area of his saddle patch has changed shape; originally it was rounded near the apex of the cut (top) whilst in the bottom image it had an angled 'corner' to it (green arrow). This is likely due to the pressure of his dorsal fin as it is dragged through the water, distorting his skin on his right side. Photos © Ingrid N. Visser.

C. ONE OF THESE IS NOT LIKE THE OTHER

We have become aware of another orca who has a remarkably similar injury to NZ101 (Figure 14). That individual, a female, was photographed off the east coast of Australia, but has never been documented outside of that area. Although similar, there are some differences between the wounds on the two orca (see Figure 14 caption for details). By 2003 the dorsal fin of NZ101, a growing male, was hanging much further into the water than the Australian female orca.

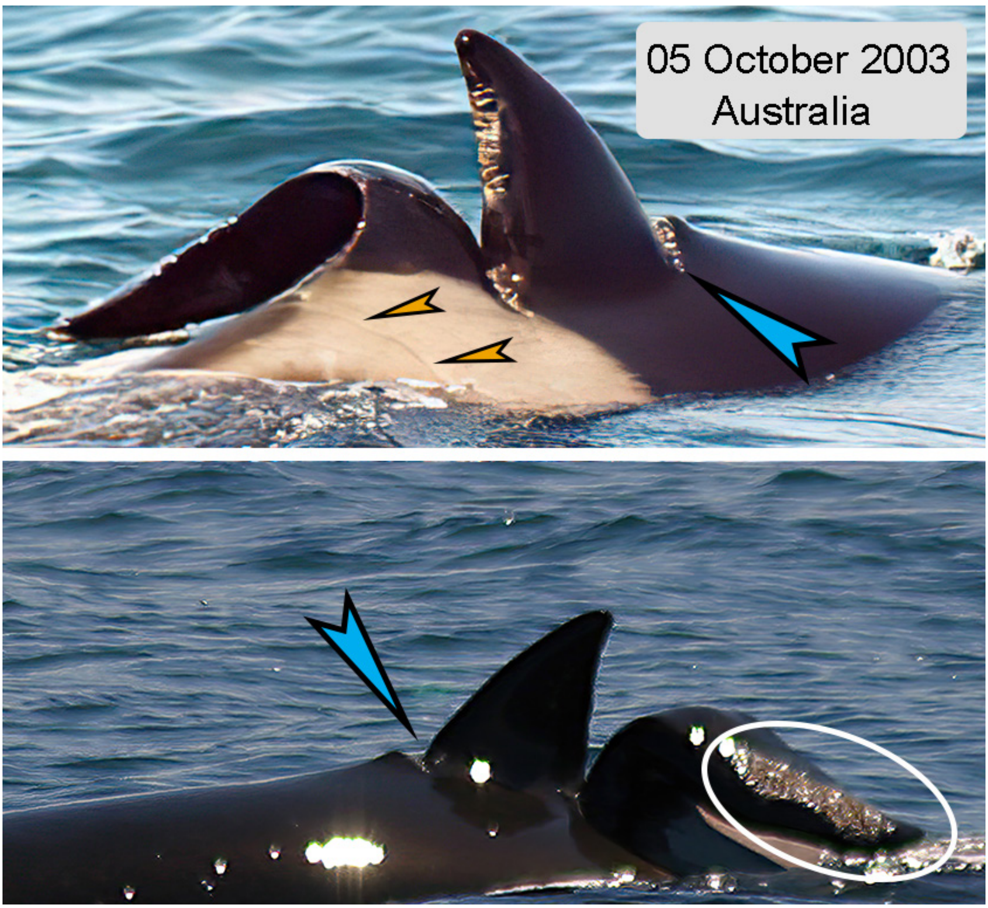

Figure 14. A female orca, photographed on 05 October 2003 at Twofold Bay, New South Wales Australia, shows remarkably similar boat strike wounds to NZ101. However, her injuries differed from his in that she had a deeper cut from the propeller anterior to her dorsal fin (blue arrows), the portion of her dorsal fin that remained upright was more triangular and the cut which sliced her dorsal fin extended down into the pale grey area of her saddle patch (upper panel). Additionally, she had a shallow healed scar on her right saddle patch (orange arrows, upper panel) which was spaced a similar distance to the other deeper cuts and was therefore indicative that the propeller strikes occurred along her right side (see Figures 5 & 7 for similar shallow wounds on NZ101). Furthermore, this female had no white blister scar (rather, the bright white areas in the lower panel are from the sun reflecting off her wet skin). She also had some type of growth or external infestation, perhaps of cyamids, on the posterior portion of her fin (circled, lower panel). Photos © Amy Hellrung.

D. OTHER CETACEANS POSTINTERVENTION

Wells et al., (2013), when evaluating survival rates of cetaceans who had been provided assistance, noted that;

> *"Stranded beached cetaceans were less successful than free-swimming rescued animals. Rehabilitated animals were less successful than those released without rehabilitation. Mass stranded dolphins fared better than single stranded animals."*

Geraci & Lounsbury (2005) stated in their book '*Field Guide for Strandings*', that a cetacean which;

> *"... has come ashore in a mass stranding, ... may have a better chance than a singly stranded animal which is more likely to be sick and debilitated."*

Based on both of these statements, NZ101 had a reduced chance of survival as he filled at least two of the 'less successful' categories; (1) he was stranded on the beach and (2) he stranded as a single animal and furthermore he was 'debilitated' due to his potentially broken shoulder joint. Perhaps to his advantage, he was not rehabilitated in a facility, as intervention at that level was found to hinder a successful rescue of a cetacean (Wells et al., 2013).

In NZ, where there are high rates of orca strandings (Visser, 2013), most events involve single stranded animals who are in good health, but who strand as a result of their method of foraging in shallow waters for rays (Visser, 1999b). Towers et al., (2020a) also believed that the strandings of another orca ecotype (Bigg's) were *"accidental out-comes resulting from the intent to capture prey"* and in those cases the prey were marine mammals. Likewise, (Shelden et al., 2003) describes at least three events where orca stranded in association with hunting marine mammals and one adult male orca *"regurgitated a large chunk of beluga blubber and a harbor seal paw"* whilst stranded.

We reviewed a range of other published studies to assess the duration that cetaceans were resighted postintervention. However, we could find only four cetacean species which have been documented for more than 100 days after they were rescued/released; long-finned pilot whale (*Globicephala melas*), in which two individuals were satellite tagged post stranding and tracked for 127 and 132 days (Nawojchik et al., 2003); humpback whale (*Megaptera novaeangliae*), in which an individual was biopsied during and after a stranding, 2,826 days (7 years, 8 months, 27 days) apart (Neves et al., 2020) and a number of bottlenose dolphin (*Tursiops truncatus*), many of whom were disentangled from fishing gear. The bottlenose dolphin with the longest duration postintervention, was resighted 12,826 days (35 years, 1 month and 12 days) (McHugh et al., 2021).

For orca, we could find few examples outside of NZ where intervention was applied to help rescue an individual and where the resighting data was longer than

100 days. One event involved a female (catalogue # A73, known as 'Springer'), from the Northern Resident population found off the west coast of North America. She was separated from her family after her mother was presumed to have died. A73 became emaciated and intervention involved taking her into short-term (31 days) captivity in a sea pen for rehabilitation (Norberg et al., 2003; Hewlett & Francis, 2007; Schroeder et al., 2007) where she was provisioned and administered medication. She was photo-ID'd (not tagged) and released and has been resighted numerous times, travelling with her extended family (Hewlett & Francis, 2007). She has subsequently given birth twice (in 2013 and in 2017 see Towers et al., 2020b) with her most recent resighting in July 2020 (G. Ellis & J. Towers, pers. comms. to Visser).

Another event involved a juvenile of unknown sex (catalogue # T068C1), from the British Columbia, Canada Bigg's ecotype population. It stranded and was assisted by keeping it cool with bucketed water and as the tide rose around the orca, it required further assistance;

> "... [the orca] *had difficulty lifting its blow-hole above the surface to breathe due to its tail end being positioned higher on the rock than the head. Two oars were quickly acquired and placed between the pectoral fins and upper abdomen to leverage the whale into deeper water. During this effort, the whale began pumping its fluke and became free of the rock after about 4 h of being stranded. At first, T068C1 rolled upside down and became motionless for approximately 2 min. It then righted itself, took a breath, and joined the other two whales in the distance."* and *"T068C1 was next documented 65 d later off the west coast of Vancouver Island. Between this date and the end of 2019, T068C1 appeared healthy on 12 occasions when photo-identified with kin between Juan De Fuca Strait, British Columbia, and Glacier Bay, Alaska"* Towers et al. (2020)

We compared the example of NZ101 to records of other NZ orca who have also received intervention and note that nine have been resighted over a duration of more than 100 days (six examples with the longest durations postintervention are listed in Table 5, including NZ101). The longest duration between an incident and resighting was 9,686 days (26 years, 6 months, 6 days) for a female (NZ63 'Miracle') who stranded when she was a juvenile. She has since had two calves which have survived (Table 5).

Although there are other examples of orca surviving strandings and being resighted more than 100 days after refloating, typically these events involve little or no intervention. For example, Towers et al., (2020a) describe a resighting of two orca (an adult female and her adult male offspring) who stranded in 2011 and were resighted 119 times afterwards (prior to the end of 2019), but there was no intervention applied (other than a single bucket of water). Shelden et al. (2003) describe an adult male orca who survived a stranding in 1991 and was resighted in 1993, but they do not discuss any assistance that was given to the orca.

In comparison, there are a number of orca in NZ who have stranded and received no intervention – and who have also since been resighted, for example NZ21 (aka 'Roundtop'), who has stranded twice whilst foraging for rays and been documented with NZ101 on a number of occasions. He first stranded on the 27 July 2006 and then restranded again on 09 April 2010, with his most recent resighting on 09 June 2020, i.e., the total duration between his first stranding and his most recent sighting was 5,066 days (13 years, 10 months, 13 days) and there were 3,714 days (10 years, 2 months) between his second stranding and his most recent sighting.

Likewise, there are other NZ Coastal orca who have survived boat strikes, without intervention. For example, a female orca (catalogue # 142, aka 'Striker') has a series of at least seven cuts from a propeller strike, running from her dorsal fin to her caudal peduncle (Figure 15). She was first photographed with the boat strike wounds on 19 December 2017, off Kaikoura (her southernmost sighting). At that point the wounds were already healed and therefore we have no indication of where she was injured. She has been documented as far north as the Bay of Islands and has travelled from there to Wellington (a distance calculated by aquaplot as 1,100 km) in 14 days (averaging 79 km per day). In all instances that she has been photographed she was travelling with NZ1, an adult female who has also been documented with NZ101 on numerous occasions in both periods (A) and (B).

Figure 15. A female orca, photographed on 30 August 2019 at the Hen & Chicken Islands, exhibits seven healed wounds (orange arrows) from a boat strike. Photo © Ingrid N. Visser.

A young female orca (catalogue #125, aka 'Anzac') was documented on 25 April 2004 with a cut in her caudal peduncle and in her right tail fluke, that later resulted in her losing part of her fluke. The wounds not only injured her, but appeared to also impact her, either through changing her style of swimming as she would often lift her tail flukes out of the water, or due to irritation (perhaps itching or pain) as she would often tail slap (see

Figure 16 for some examples of this behaviour). She has been resighted every year since the injury and has subsequently produced a calf (ORT, unpublished data).

Figure 16. Injuries from a boat strike have resulted in modified swimming style (tail lifting) and behaviour (tail slapping on the water surface) of NZ125. Photo © Ingrid N. Visser.

Yet another NZ Coastal female orca (known as 'Prop', catalogue # NZ25), has a series of four very deep propeller cuts along her spinal ridge, posterior to her dorsal fin and extending all the way along her caudal peduncle (Visser, 1999c). She was first documented off the North Island in February 1982 when she was an adult and at that point the boat strike wounds had already healed. She has most recently been documented off the South Island in September 2020 and therefore, she has survived at least 38.5 years after the injury. During that time she has been documented with NZ101 on a number of occasions, off both the North and South Islands.

4. DISCUSSION

Recognising and assessing the risks for any endangered population of animals is an important part of their conservation and management. When individuals are exposed to situations where intervention can help their survival, the option to intervene is ethically logical. However, an evaluation of the costs and benefits is often applied to determine if a rescue should be conducted and the calculated outcome typically influences the decision-making process. In those cases, part of that calculation must include case studies that provide evidence of outcomes (survival rates as well as benchmark milestones for thriving). We have endeavoured to provide a comprehensive case study here, with other examples for comparison, to provide evidence to support intervention as well as, at times, 'hands-off' approaches.

NZ101 was involved in two significant incidents; a stranding which he would not have survived without assistance and a boat strike for which he received no intervention. The distances that NZ101 has travelled, after his stranding and after his boat strike injury attest to his successful recovery from both incidents. Comparison to examples of distances which other orca have travelled (Table 4), illustrates that the maximum daily distance of 193 km for NZ101 is not excessive, neither is it an under representation of what an uninjured orca can (and does) travel. In contrast, the low average daily distances for some of the examples are likely a facet of four key factors; (1) the minimum distances calculated between any two locations are not 'real-world' distances, as NZ Coastal orca typically follow the coastline; (2) the long periods between some sightings indicates that NZ101 would have in fact travelled elsewhere; (3) repeat sightings at the same location (when separated by time) are also indicative that he would have travelled to other locations and; (4) the relatively infrequent number of times he has been documented limit our knowledge (i.e., had more data been collected, we would be more aware of the distances he has travelled). Combined, these factors clearly illustrate that the calculations are underestimates. Furthermore, they do not factor in the distances NZ101 covered during vertical travel (i.e., diving) which is relevant when it is understood that orca have been documented diving to over 1,000 m (Towers et al., 2018) and that in NZ they regularly dive to the sea floor when foraging for rays (Visser, 1999b).

The new resighting data herein adds 7,722 days (21 years, 1 month, 20 days) to the last recorded sighting in Visser & Fertl (2000). Now, the total duration between stranding and his most recent sighting is 8,574 days (23 years, 5 months, 20 days). The only other record for orca that we could find, which is comparable in duration for postintervention, was for the female A73 ('Springer') who has been resighted 18 years after rehabilitation and release (G. Ellis & J. Towers, pers. comms. to Visser). Therefore, the data from NZ101, is as best as we can establish, a global record for resighting of an orca postintervention.

One of the early records of tracking a cetacean after a stranding was conducted on a pilot whale, which was monitored for 95 days after it was released and during that period it was documented numerous times with conspecifics (Mate, 1989). Nawojchik et al., (2003) considered the postintervention release of two long-finned pilot whales a success when the two whales, who were released together, were tracked by satellite for 127 and 132 days. They were thought to remain together during that tracking period. Although NZ101 stranded alone, Visser & Fertl (2000) noted that;

> *"At dawn, on the morning of the release, a single unidentified killer whale was sighted from a cliff top near the stranding location, and seen about 7.5 km offshore, swimming parallel with the beach. At 1010 h, when the stranded animal was placed in the water, the killer whale offshore turned and headed towards the coast. An hour after release, the previously stranded killer whale joined up with the unidentified killer whale..."*

In each of the subsequent 145 sightings after his rescue, NZ101 was documented with other orca, including at least 10 of which he was seen with prior to his stranding. This behaviour, combined with the fact that he has also been recorded food sharing with conspecifics, which is considered an important social bonding aspect for the species (Wright et al., 2016), fulfil criteria for 'socially reintegrated', after his rescue and release. Collectively, this all illustrates that NZ101 has not only survived but that he has thrived.

However, originally his life had been in danger, not only from the stranding but also due to management decisions. On the day of his stranding in June 1997, the ORT was alerted that the DOC (i.e., the NZ Government Department legally mandated to protect cetaceans) were going to euthanise NZ101. They stated at the time that this decision was made because NZ101 had a small amount of blood coming from an external cut in the crease of his pectoral fin insert. The ORT team therefore chartered a helicopter to arrive on site before the DOC Marine Ranger could conduct the shooting. The following day, as NZ101 was being prepared for return to the ocean Visser & Fertl (2020) noted that;

> *"Inspection in daylight revealed the left pectoral fin joint could have been broken, since it hung at a different angle from the right fin. The joint was bleeding slightly from the cut running parallel to the body. Standard whale stranding procedures in New Zealand do not cater for rehabilitation in captivity, as there are no suitable facilities. Hence, the whale, although possibly injured, was refloated ready for release."*

The evidence presented here supports that decision to rescue and release him, rather than euthanise. A year later, when NZ101 was first photographed with the boat strike injury to his dorsal fin and then again when he was photographed 26 days later, the tissue surrounding the wound was deteriorating and his fin was beginning to collapse (see Figure 7), and the prognosis for his survival was not high. Although consultations were conducted with regards to potential intervention (including to perhaps administer medication), NZ101 was not relocated until 174 days later and by then the wound had healed over.

Based either on his presumed broken shoulder joint, or the severe trauma from the propeller cuts, rehabilitation in captivity may have been an option had an appropriate sea pen facility been available. However, the added trauma of a capture, along with the forced separation from his family members would have caused significant stress (Marino et al., 2019). Collectively, this may have impeded his recovery rather than enhanced it, as Wells et al., (2013) have noted when evaluating 169 cetacean cases where intervention was applied, that rehabilitation in a facility reduced survival.

The graphic nature of the boat strike injury, compared to the perceived benign nature of a pressure blister, is not reflected in the fact that the white scar from the blister has remained visible for nearly 21.5 years and the wounds on his dorsal fin healed with no depigmentation. Scars on orca appear to have much longer duration when they create a contrasting pigment (in this case white on black, but also see Visser et al., (2020) where cookie cutter shark bite marks were visible when black on grey). The white blister scar on NZ101 was also helpful in providing another identifying feature of NZ101 when the boat strike injury occurred, as he was not lifting his head out of the water high enough to document his white eye patches, which are unique for each individual orca (Visser & Mäkeläinen, 2000).

Table 5. Resightings of some of the NZ coastal orca who were involved in one or more incidents and received intervention. Date format is yyyymmdd.

NZ Coastal Orca Catalogue # & Name	♂/♀ Age class during 1st incident	1st Incident	Resighting post 1st incident & (# days since 1st incident)	2nd Incident [days since 1st incident]	Resighting post 2nd incident [days since 1st incident]	Most Recent Resighting	Days since 1st incident until most recent resighting [2nd incident until most recent resighting]	Comment
NZ63 "Miracle"	♀ juv	19930823 (stranding)	19950818 (725 days)	20190201 (stranding) [9,293 days or 25 years, 5 months, 9 days]	20190209 [8 days]	20200229	9,686 days or 26 years, 6 months, 6 days [393 days or 1 year, 28 days]	1st calf 2001, 2nd calf 2009 Both stranded with her in 2019
NZ101 "Ben"	♂ sub-adult	19970614 (stranding) 19970615 (release)	19971027 (134 days)	19981016 (boat strike) [489 days or 1 year, 4 months, 2 days	19981016	20201205	8,574 days or 23 years, 5 months, 20 days	This Chapter
NZ126 "Putita"	♂ juv	20030702 (stranding)	20040722 (386 days)	20100525 [2,519 days]	20100530 (5 days)	20201017	6,317 days or 17 years, 3 months, 15 days [3798 days or 10 years, 4 months, 22 days]	Presumed brother of NZ91 who stranded in 2003
NZ91 "Rua"	♂ adult	20030711 (stranding)	20060906 (1153 days)	-	-	20201017	6,308 days or 17 years, 3 months, 6 days	Presumed brother of NZ126 who stranded in 2003 & 2010
NZ20 "Double Dent"	♀ adult	20041123 (stranding)	20041123 (same day)	-	-	20201127	5,848 days or 16 years, 4 days	Stranded with presumed son, NZ24, new calf in Oct 2010
NZ24 "Rudie"	♂ adult	20041123 (stranding)	20041123 (same day)	-	-	20201127	5,848 days or 16 years, 4 days	Stranded with presumed mother NZ20 & younger sibling

With regards to the boat strike incident, NZ101 is not the only orca to have extensive injuries from vessels. In a database of 907 ship strikes, orca were the odontocete species with the third highest incident rate (after sperm whales (*Physeter macrocephalus*) and bottlenose dolphins, where the latter were recorded with only one more incident than orca (Winkler et al., 2020). NZ also ranked as the country with the third highest boat strikes (of any cetacean species) after USA and Canada (Winkler et al., 2020). Visser & Hupman (2018) documented 10 boat strike incidents involving orca in NZ waters and since then at least two other individuals from this population have been hit by boats (ORT unpublished data). Even in locations where boat traffic is severely restricted, such as the UNESCO Heritage site of Península Valdés, Argentina, orca have been documented with injuries from propellers (Copello et al., 2021, Chapter 1 this volume).

In a strategic plan specifically written to mitigate the impacts of ship strikes on cetacean populations, Cates et al., (2017) were addressing larger whale species, however their statement is equally applicable to other species and certainly relevant with respect to the NZ Coastal orca;

> *"... it was noted that human-induced mortality caused by ship strikes can be an impediment to cetacean population growth. Populations of whales in the low hundreds of individuals are at risk of continuing declines even if only a small number of ship strikes occur per year. Therefore, it is important to identify populations that are small, are in decline, or for which human activities result in whale deaths or injuries and to monitor these populations to evaluate the extent to which ship strikes are a threat..."*

Despite the large distances that NZ101 has been documented swimming, it is unclear what, if any overall impact the injury has had on his diving ability, his hydrodynamics and/or if the tension from the drag of his fin has had an impact on his skeletal or muscle structures. Although he has been documented travelling relatively large distances, finer aspects such as his ability to turn whilst pursuing prey may be impacted and can be hard to monitor. It has been shown that an orca can turn within 4% of its body length (Fish & Rohr, 1999), which is one of the most efficient turning radii of cetaceans. The morphological characteristics of cetacean appendages influence locomotion and manoeuvrability, with a fine balance having evolved (Fish, 2002). Logically, one would expect that deviations from the optimal placement and design of control surfaces of those appendages would impact efficiency and ultimately the potential survival of an individual. Yet, despite the gross destabilising injury NZ101 has sustained, he has continued to travel widely around NZ. In fact, his range may have extended since the incident, as he had never been documented in the waters around the South Island prior to his injury. However, we do recognise that he may have frequented these locations earlier, but the distinctive nature of his appearance now increases the likelihood of him being documented and reported.

Although the injury to NZ101's dorsal fin makes him very distinctive, there is a small chance of mis-identification – for example when comparing his injury to that of the female orca off the east coast of Australia (see Figure 14), in that both individuals have had their dorsal fin sliced by a propeller and the posterior section has collapsed to their left in both cases. Regardless, we are confident that the sightings we documented were of NZ101, as no other orca has been documented in NZ waters with a similar injury. Likewise, no NZ Coastal orca have ever been documented in Australian waters (ORT, unpublished data).

But the fact that two orca have recovered from similar injuries does speak for the ability of these animals to survive horrendous wounds. Comparable in duration in terms of survival, is a female bottlenose dolphin who, as a calf, was captured to remove fishing gear and was released directly without any further intervention such as rehabilitation. That dolphin has been observed for 35 years postintervention and has successfully produced calves (McHugh et al., 2021). These examples highlight the importance of monitoring individuals during and post both incidents and interventions, in order to document not only their survival but also their ability to thrive. McHugh et al., (2021) stated;

> *"... given the costs associated with interventions, it is important to understand the benefits of these endeavors not only to save individuals, but also to establish if and how saved individuals contribute to social functioning, survival and reproduction within small, resident populations facing multiple concurrent threats."*

We emphasise that it was only possible to confirm that NZ101 survived both events due to photo-ID being conducted at the original stranding event. As such, we note that high-quality photo-ID of each cetacean should be an absolute priority at all rescue events. *Inter alia*, congenital marks and scars (Auger-Méthé et al., 2010) and anomalous pigmentation (Stockin & Visser, 2005; Jefferson et al., 2015), should all be documented. In addition to standard features such as the shape of the dorsal fin, special attention should be paid to species-specific details such as; for orca, saddle patches (Sugarman, 1984) and eye patches (Visser & Mäkeläinen, 2000); for common dolphins, dorsal fin pigmentation (*Delphinus delphis*) (Neumann et al., 2002) and for right whales, callosities (*Eubalaena* sp.) (Vernazzani et al., 2013).

Furthermore, photo-ID of the other orca present during encounters with NZ101 also allowed for his social network to be determined prior to his stranding as well as after both the stranding and his boat strike. Social network studies on bottlenose dolphins in Florida have shown a reduction in associations between individuals for two years after sustaining human-induced injuries (Greenfield et al., 2021). However, the social networking pattern for NZ101 has remained comprehensive during the entire time he has been documented. For example, NZ101 travelled with at least 26 orca in the ORT catalogue prior to his boat strike and after the boat strike, he was documented with 33 orca in the catalogue.

Visser & Fertl (2000) stated;

> *"Successful return to the wild can be assessed on survival and re-incorporation into social groups (Wells et al., 1998). Based on these criteria, NZ101 is considered to be successfully returned to the wild, since he survived for at least 28 months after stranding and was resighted with individuals he was known to associate with prior to stranding."*

And McHugh et al., (2021), when assessing 27 cases of intervention for bottlenose dolphins, stated;

> *"Survivorship rates did not decline substantially between 1 and 5 years post-rescue, meaning survival beyond 1 year may be a useful benchmark of long-term success."*

For NZ101, we have documented him for more than two decades and calculated that he has swum (at an absolute minimum) over 37,700 km since he was refloated. His rescue can be considered nothing short of significant for a plethora of reasons. For example, the conservation implications of rescuing NZ101 include the potential for him to have contributed to the gene pool of the Nationally Critical NZ Coastal orca population, which is comprised of fewer than 200 individuals (Visser, 2000; Visser & Cooper, 2020b). Given that reproductive success for male orca appears to increase with age (Ford et al., 2011) and the fact that NZ101 is now estimated to be approximately 40 years old, the likelihood of him fathering offspring is predicted to increase.

Additionally, NZ101 has been seen to participate actively in alloparenting and food-sharing, as well as cooperative and independent hunting. These factors also contribute positively towards the success of the individuals within his social network. Nonetheless, we recognise that it is likely that during the timeframe immediately following his boat strike injury he may have been more of a burden on the group(s) he accompanied, than an asset, as they may have had to provide him protection and/or provision him. However, we counter this with the sightings data that we have collated for the time shortly afer the boat strike – for example, only eight days after he was documented in the Bay of Islands (where the boat strike occurred on the east coast of the North Island), he was documented a minimum of 600 km away, (i.e., he travelled an average of ~75 km per day), in the Hokianga Harbour on the west coast of the North Island. Two days later he was documented a minimum of 230 km away (an average of ~60 km/day) in the Manukau Harbour, also on the west Coast of the North Island. In both instances he was photographed with conspecifics. These travel distances are not a typical for NZ coastal orca and they are consistent with data collected on NZ101's travels years later. Therefore, although severely injured, NZ101 appeared to place little restriction on his conspecifics with regards to their travel.

Another conservation implication that NZ101 has contributed to is raising awareness of boat strike issues for cetaceans in NZ and at a global level. Images of his injury have appeared in reports to the NZ Government, for the NZ Environmental Court and International Courts, in educational presentations, brochures, ID guides and posters, in various peer-reviewed scientific papers and in a range of books and magazines. He is now an iconic individual and his contributions to education about boat strike (e.g., as a 'poster child') cannot be underestimated, even if it is difficult to ascertain the influence that his story may have had on changing boater behaviour.

Disturbingly, more than 30 NZ orca have died in the past decade primarily due to boat strikes, entanglements and due to ineffective or inappropriate intervention by Government Authorities (e.g., see Visser et al., 2017). And yet, when experienced personnel from species-specific NGO's are involved with interventions the success rate for release/refloating is near 99% (Visser, 2013). This pattern, after nearly three decades of data gathering, is undeniable. The case study of NZ101 perfectly illustrates how an NGO's intervention prevented the death of this individual and contributed to his rescue. The evidence presented here also demonstrates that it is worth the commitment of time, money and effort to provide appropriate intervention and long-term monitoring for orca.

From multi-year studies such as this, science can directly help advise conservation and management actions, such as boat speed restrictions and boater education (Visser, 2008). As negative human influences on the marine environment continue to grow, we should prioritise the mitigation of these, particularly where there are accumulative impacts on critical habitats for keystone species such as orca. Reducing risks, eliminating, restricting, or preventing encroaching infrastructures that cause habitat loss, or exclusion from habitats are all vital areas that need addressing. For example salmon farms have high vessel traffic that impacts cetaceans (Bedriñana-Romano et al., 2021) and mussel and/ or mussel spat farms can have 100's of kms of plastic rope, thereby increasing the risks of entanglement (e.g., see rope calculations for a proposed spat farm in Lampen, 2020).

In NZ, the Resource Management Act was introduced in 1991 with specific regulations for the marine environment implemented in 2010, under the NZ Coastal Policy Statement (NZCPS) (Department of Conservation, 2010). Although Policy 11 of the NZCPS was developed *"To protect indigenous biological diversity in the coastal environment"*, the Policy restricts its level of protection by adding inter alia, the following caveats;

> *(a) avoid adverse effects of activities on:*
> *(i) indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists;*
> *(ii) taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened;*

(iii) indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare;

(iv) habitats of indigenous species where the species are at the limit of their natural range, or are naturally rare;

(b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on:

(ii) habitats in the coastal environment that are important during the vulnerable life stages of indigenous species;

(iv) habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes;

(v) habitats, including areas and routes, important to migratory species; and

(vi) ecological corridors, and areas important for linking or maintaining biological values identified under this policy.

As such, orca and their habitats should fall under the protection of the NZCPS as they are listed under the NZ Threat Classification System. However, exploitation of a wide range of their habitat persists at a rapid pace and is expanding almost unabated. In fact, the NZ Government has an official 'Aquaculture Strategy' to increase the output of annual sales generated by NZ aquaculture from ~$600 million to $3 billion per year, and to increase that within just 15 years. Yet that scheme has no clear mitigation paths or acknowledgement of protection for any marine mammals, or their habitats (New Zealand Government, 2019). That is in spite of the NZCPS Policy 11*(b)(iv)* specifically highlighting the potential conflict of interest between commercial interests and indigenous threatened wildlife. Likewise, the NZCPS requires that commercial use of the marine region must *"avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities"*. The overlap between NZ101's sightings and the core areas for NZ aquaculture is almost all-encompassing – with only one of the six aquaculture hotspots (New Zealand Government, 2019) currently not inside areas that would be considered critical habitat for him (and by default, also the rest of the NZ Coastal orca population).

This case study of NZ101 reveals that the NZ law, Government strategies, policies and 'Action Plans' do not necessarily act as shields for the animals. Rather, they are applied as swords by industry (and the NZ Government) to enable commercial use of the marine environment at breakneck speed. It is therefore often up to local communities to challenge over-exploitation through the legal system, in order to safeguard coastal areas and the animals who live in them (Visser, 2020). We therefore hope that the evidence presented here provides a strong backbone for such undertakings by grassroots groups and thereby helps increase protection for this unique orca ecotype.

If one inspects NZ101's sightings distribution and his patterns of travel, and overlays those with the various commercial industries that he is exposed to, it becomes apparent that the potential risks are accumulative and not minor. From oil exploration and extraction, overlapping habitat use with various marine industries such as fisheries and aquaculture, high concentrations of vessel traffic, noise pollution, destruction of habitat through reclamation and removal of mangroves and foreshore for human developments (ports, marinas etc), raw sewage discharge from cities into the marine environment, overfishing of prey, as well as a myriad of other impacts, it becomes apparent that these are aspects he and his conspecifics face on a daily basis.

Yet despite all these challenges, NZ101 has travelled the equivalent of once around the earth (the circumference of the earth is approximately 40,000 km, NASA, 2018). In light of the distance data presented here and noting that Wells et al., (2013) has evaluated that rehabilitation in a facility can hinder the success of a cetacean intervention, the ability of any rehabilitation facility to be able to provide adequate space for a cetacean should be considered during any intervention decision-making. The small sizes of these facilities are likely one of the contributing factors to reduced success as realistically, no facility will ever be able to meet the daily travel requirement of any cetacean. For example, the largest tank holding orca in captivity is in the USA, at SeaWorld Texas, and it is only 70 m long (Harrison et al., 2017). It is used for commercial shows for the public display of orca, not for rehabilitation. Even if used for rehabilitation, it is approximately 250 km from the ocean and would require at least 2.5 hours of overland transport from the nearest beach.

In light of this assemblage of data, if rehabilitation is required for any cetaceans, we recommend the use of genuine seaside sanctuaries with sea pens, which would not only provide a more natural environment for the animals once their triage period and critical care is over, but also are built with larger areas than any concrete tanks currently provide. At the very least, genuine sanctuaries should be used for the rehabilitation transition period prior to release. Although we recognise that there are only a few sanctuaries for cetaceans currently in operation around the world, more are at various stages of development.

5. CONCLUSIONS

Within NZ, the effectiveness of rescuing stranded orca has been hugely successful, often eclipsing results elsewhere in the world. Yet, despite these encouraging examples, we have seen multiple events transpire since the rescue of NZ101, in which decisions to euthanise (or a disturbing trend of apathy) have prevailed, not only for orca but also for other cetacean species who require assistance at stranding, entanglements and other incidents. There are a number of key points that NZ101 and these other successfully rescued individuals illustrate and, although these should not be the only aspects considered during any intervention, they should feature in the decision-making process and influence the welfare for the animal(s) and the successful outcome of intervention;

1. Rescues should be conducted with the immediate and long-term welfare of the individual(s) given the utmost priority. To facilitate that, these events should be supervised by experienced personnel, while ensuring that species-specific experts are consulted and collaborated with at all times.

2. Euthanasia should only be conducted when it would be in the best interests for the animal and where there are no alternatives (i.e., not because of convenience or costs or other human-orientated aspects).

3. Cetaceans can be inflicted with extensive injuries and yet survive (and thrive) to have lives that reach milestones and achieve benchmarks (e.g., reaching maturity and producing offspring). Such injuries should not be the only determining factor regarding a decision to euthanise. Where feasible, intervention could instead include medication (e.g., pain killers and/or antibiotics).

4. Photo-ID should be a high priority at all incidents. Success or failure of interventions can only be determined through confirmation that individuals have survived. Photo-ID should also be conducted if an animal has died, as it may be possible to 'back-match' to an already known animal and thereby increase our understanding of the population.

5. Where possible, non-intrusive DNA sampling should be conducted during interventions (e.g., skin scrapings), as this may also help confirm later identification of individuals in instances where photographs are not suitable (e.g., a decomposed carcass).

6. Incidents should be reported as soon as possible to researchers to enable them to assist at events, advise on species-specific protocols and to facilitate the on-going monitoring of an individual, as well as to ascertain if there are any matches to known individuals.

7. Non-invasive tagging (such as suction-cup attachments, cotton tape around tail stocks, non-toxic paint) can be helpful for post-intervention monitoring. Although we recognise the value of data collected from longer-term tags (e.g., satellite tags attached with invasive methods such as bolts through dorsal fins), if the animal is already compromised during an intervention, such invasive methods may be the 'last straw' for the animal perhaps further compromising their already stressed systems. Therefore, we recommend that invasive type tagging be a last option and generally only applied after an animal is fully recovered from an incident.

For NZ specifically, at a country-wide and all-species level, it is apparent that the NZ Government's DOC should urgently update their Marine Mammal Action Plan (which is now more than 10 years out of date). To ensure robust, effective and appropriate actions are included and due diligence is applied, thorough consultations and collaborations with all stakeholders, including species-specific experts, should be incorporated. Our view is that DOC should be working urgently and closely with other Government Departments who oversee aquaculture and other habitat encroaching industries, in order to mitigate risks and better protect cetaceans, as per the requirements of Policy 11 of the NZCPS (which was published by the DOC).

Finally, the contributions to marine mammal research from stakeholders such as whale and dolphin watching companies, citizen scientists, Iwi (Māori tribes), NGO's, other operators on the water, as well as the public, is vital. Those contributions have immense value in platforms-of-opportunity research (Hupman et al., 2015), in targeted research (this chapter) and in long-term monitoring of individual animals and populations (e.g., Berghan & Visser, 2001; Hupman et al., 2019). As such, we strongly encourage contributors to take high-resolution (e.g., RAW files) images which improve the chances of matching individuals (Urian et al., 2014; Visser et al., 2020). As technology improves, the outcomes from such collaborations will continue to expand and therefore the information we can derive together will yield increasingly robust and compelling data.

We are confident that the case-study of NZ101 (aka Ben) is inspiring, as despite having stranded and also being a severely injured individual, he has not only survived but he has thrived as a member of the endangered NZ orca population. It is our belief that Ben has become part of a legacy that illustrates the values of rescues and of long-term data sets. His boat strike injury is a warning flag for the risks that these animals face, but as he has overcome these wounds, his story remains encouraging. As such, we are hopeful that Ben's life and what he has overcome will continue to raise awareness and to generate better protection for orca and their habitats, not only in NZ but also worldwide.

ACKNOWLEDGEMENTS

We dedicate this updated information to all those who attended Ben's stranding and helped rescue him and the on-going efforts of all the Whale-Rescue.org team members. A special thank you to all those citizen scientists who take the time to report sightings to 0800 SEE ORCA and send in photos to www.orcaresearch.org. Part of that network is the Dolphin Encounter Kaikoura and the Auckland Whale and Dolphin Safari teams who have contributed orca sightings and photos during the decades this research project has been running. Thank you also Kate Norton for help with the database extractions, Joanne Halliday for her continuous help with monitoring the hotline and to Amy Hellrung who provided the photos of the Australian orca photographed in 2003.

We recognise the efforts that Dagmar Fertl contributed to the original publication about Ben and her support of the Orca Research Trust work ever since. We thank Mr Singh of aquaplot.com who kindly provided access to the software to allow us to standardize the minimum distances, the average daily distances and the total distance calculations that NZ101 travelled.

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ABOUT THE ORGANIZERS

Ingrid N. Visser

Ingrid has had a passion for cetaceans since she was a child. She gained her first University degree, in Zoology, after having spent her teenage years sailing around the world. This was soon followed by a Masters degree also in Zoology. When she started her PhD in Environmental and Marine Science, with the topic of the New Zealand coastal orca, she founded the Orca Research Trust. That non-profit continues to this day and is the foundation for the data collected in Chapter 6. Her research has featured in a number of documentaries, for companies such as BBC, National Geographic, Discovery Channel. Ingrid has observed more than half of the worlds marine mammals and visited all seven continents in her quest to learn more about these fascinating animals. She has published more than 30 scientific articles, along with numerous popular-style articles for wildlife magazines and children's books and an autobiography. Since 2010 she has divided her time between working with wild cetaceans and advocating for those in captivity (see Chapter 5). As part of that work, Ingrid has observed 15 different species of cetaceans (plus other marine mammals; i.e., pinnipeds, sirenians, marine otters and polar bears), in 50 facilities around the world. She has appeared as an expert witness in Environmental and High Courts, as well as before Governments who are investigating the issues of keeping marine mammals in captivity. As part of her conservation work, she has founded (or co-founded) seven non-profit organisations, all with a focus on marine mammals, such as Punta Norte Orca Research (Chapter 1) and Whale Rescue (Chapter 6).

Jorge Cazenave

Jorge started his professional career as a lawyer in Argentina, however after 10 years in this field he switched to tourism. He co-founded (and was President of) Agricultural Tour Operators International and was on the board of the National Tour Association, both whilst photographing wildlife. As an experienced naturalist, he currently guides guests to view and photograph wildlife around the world, specialising in apex predators such as puma, jaguar and orca. His expertise is sought after by documentary making companies such as the BBC, ZED and National Geographic. Since 2001, Jorge has been photographing the unique orca of Punta Norte on the remote Península Valdés, Argentina (see Chapter 1), who exhibit a range of unique behaviours including intentionally stranding to capture sea lion pups. His work with conservation extends to include collaboration with several projects in different regions of Argentina, including Punta Norte Orca Research, of which he is a board member.

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