DER ZOOLOGISCHE GARTEN

THE ZOOLOGICAL GARDEN

doi:10.53188/zg0019 Zool. Garten N.F. 91 (2023) 83-100

Integrated Conservation Action for Small Cetaceans: A new Role for Modern Dolphinaria

Integrierte Artenschutzmaßnahmen für Kleinwale: Ein Paradigmenwechsel für moderne Delfinarien

Lorenzo von Fersen[1*] & Philip S. Miller[2]

[1]Nuremberg Zoo and YAQU PACHA e.V., Am Tiergarten 30, D-90480 Nuremberg, Germany
[2]IUCN SSC Conservation Planning Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN-55124 Minnesota, USA

Abstract

The world is facing a biodiversity loss crisis that could be irreversible in the foreseeable future. The in situ protection of wildlife and their habitats may not be enough to stop the continued decline and extinction of some species. In these cases, new strategies for effective conservation must be employed. One such strategy is the One Plan Approach (OPA), which was launched by the Conservation Planning Specialist Group (CPSG) and later adopted by the International Union for Conservation of Nature (IUCN). Unlike conventional species conservation strategies, which primarily focus on the protection of species in their natural habitats, the OPA encompasses the broad spectrum of animal management across the in situ–ex situ spectrum, engaging all relevant stakeholders for improved collaborative decision-making. With the OPA, zoos have not only been assigned another important task but have now taken on responsibility for species conservation. While there is a consensus on the implementation of integrated conservation measures for most threatened plant and animal species, opinions differ regarding small cetaceans. This article aims to highlight this discrepancy and to show that many small cetacean species are not only calling for OPAs, but that first steps have already been taken to implement such an integrated approach. Zoological institutions that keep dolphins should be aware of the important role they now play and act responsibly.

Keywords: In Situ/Ex Situ Conservation, Cetaceans, Integrated Conservation, Zoos, Dolphinaria

*Corresp. author:
E-Mail: lorenzo@vonfersen.org (Lorenzo von Fersen)

Integrated conservation in zoos

Nearly 100 years ago, zoos initiated a new era of conservation breeding when the first coordinated breeding programme was started for a species that was extinct in the wild. The European bison had disappeared from the wild by 1927, with only 54 individuals surviving in zoos. The first breeding programme was established in Bialowieza, Poland, and focused on the lowland line of this species. The descendants of just 12 animals were used for species restoration (Pucek, 1991) and were the founding animals for a zoo population that grew over the years and provided the basis for reintroducing animals into the wild. Since then, Poland has continued to lead the way in conservation breeding, with several breeding centres across the country. This programme also helped to establish new populations in other parts of Europe (Tokarska et al., 2011).

Other species then benefited from similar conservation breeding efforts, including the black-footed ferret (Jachowski & Lockhart, 2009), Arabian oryx (Spalton, 1993; Stanley Price, 2016) and Przewalski's horse (Wakefield et al., 2002). Conservation breeding programmes and habitat protection have contributed to the successful reintroduction of the California condor. In 1982, only 22 condors survived in the wild. To prevent the extinction of the species, those responsible for the project made a risky decision and that was to capture all the animals still surviving in the wild. Five years later a breeding programme to save the species was initiated. Over 500 condors are currently living in the wild again (Walters et al., 2010). Another good example of how zoos can contribute to the conservation of species is the Golden Lion Tamarin (*Leonto-*

Fig. 1: The golden lion tamarin: a species that has benefited from integrated conservation and is now back in its natural habitat. Photo © Andreia Martins/Associação Mico-Leão-Dourado

pithecus rosalia; Kierulff et al., 2012). By the early 1960s, the Golden Lion Tamarin was nearly extinct in its natural habitat (Atlantic Tropical Forest) in southern Brazil. The population living in zoos consisted of about 200 animals but was not stable due to low rates of reproduction and survival. In the 1970s, after many improvements, the captive population began to grow. At the same time, the Poço das Antas Biological Reserve was established to protect this species. The reintroduction of the Golden Lion Tamarin was a complex process involving several phases. First, captive breeding in zoos, in parallel with habitat restoration, allowed them to finally be released into the wild. Numerous zoos participated in the breeding programme, and some of them also supported additional project activities. A recent published paper estimates that in 2014, there were approximately 3700 golden lion tamarins in 41,400 hectares of the Atlantic Forest (Ruiz-Miranda et al., 2019).

A recent paper (Smith et al., 2023) reviewed the status of 84 species of plants and animals classified at one time as extinct in the wild (EW) on the IUCN's Red List of Threatened Species. Both extinction and recovery are possible fates for these species; given this reality, it is particularly encouraging that 12 species have regained their wild status today. Examples including the red wolf and European bison demonstrate that extinction can be reversed and that we can prevent extinction through carefully planned and executed conservation strategies. The tools to do this are available. Species that were thought to be lost could have a future again.

These and other examples share a consistent and – at the time of their application – an overdue zoo strategy: to maintain and breed species through thoughtful and dedicated ex situ management. It is no longer practical (or, for that matter, ethical) for zoos to acquire individuals from wild populations to display in their facilities. Successful ex situ breeding of many endangered species has been the result of good husbandry, improved environmental conditions and an exponential growth of knowledge in all areas of zoo biology (Kleiman et al., 2010 Irwin et al., 2013).

During these years, there has been a shift in the roles and responsibilities that zoos have set for themselves: from simply displaying wild animals to creating species conservation centres with a focus on scientific research, public education and active partnership with those engaged in species conservation in the wild (Conde et al., 2011). As a result, wildlife conservation is no longer the sole domain of wildlife biologists working to preserve populations in their natural habitats. The success of zoological institutions in maintaining a healthy breeding population for many endangered species has ultimately led to their recognition as a valuable component of a holistic species conservation strategy. The real value of zoos and aquaria for species conservation is best achieved through integrated collaboration with the wild population management community. Effective integrated conservation requires detailed planning, engaging all relevant actors or stakeholders in the planning process and optimising the use of limited resources across the ex situ-in situ management spectrum. This philosophy has been formalised through the One Plan Approach (OPA) developed by the Conservation Planning Specialist Group (CPSG) of the IUCN's Species Survival Commission (Byers et al., 2013). While a formal description of the OPA is relatively recent, it should be recognised here that the broad process undertaken by all responsible parties to jointly develop a set of management strategies and conservation measures within a comprehensive species conservation plan is not entirely a new concept. This approach has been practiced in parts – although rarely in its totality – for some decades. We have good examples of successful integrated conservation in the cases of golden lion tamarins in Brazil (Mickelberg & Ballou, 2013), Puerto Rican crested toads (Lee, 1992) in the Caribbean and Arabian, and scimitar-horned oryx in the Middle East (Stanley Price, 2016).

While conservation breeding and the release of captive-born individuals can make a key contribution in appropriate circumstances to improving the status of endangered species in the wild, it represents just one of many tools that ex situ facilities can use to participate in integrated species conservation. For example, insurance populations maintained ex situ can prevent local

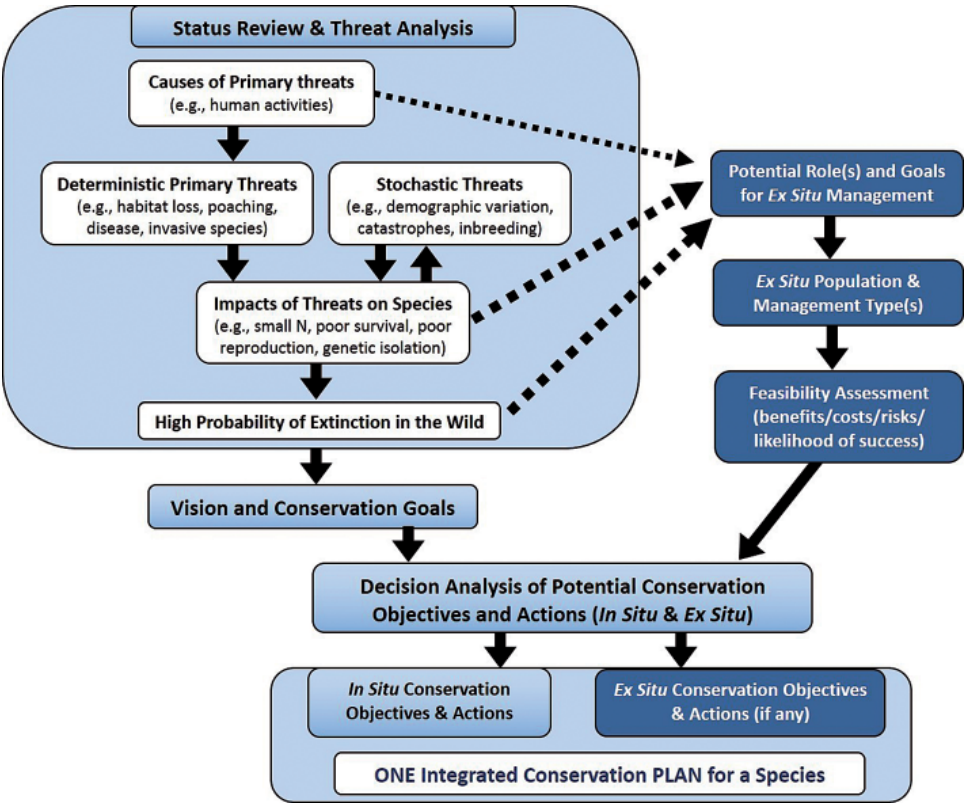

Fig. 2: Graphical representation of the One Plan approach, in which the decision-making steps featured in the IUCN Ex Situ Guidelines (boxes on the right side of the diagram) are incorporated into the traditional species conservation planning process. Graphic adapted from IUCN/SSC (2014).

or global species extinction; head-start programmes can remove individuals from the wild temporarily to reduce the mortality of vulnerable life stages and then can be returned to safer wild environments; and individuals can be used in research, training or public awareness programmes to improve our understanding of species biology or to educate citizens on specific threats to biodiversity. A logical decision-making process has been developed (IUCN-SSC, 2014) to assess whether ex situ management can effectively support species conservation and, if so, what form that management should take and how it can be most effectively implemented, given our current knowledge and finite resources.

Today, an integrated approach to species conservation is essential. When a species declines in abundance to a critically low number in the wild and the threats that have caused that decline cannot be controlled, the argument for ex situ management intervention is loud and clear. If an ex situ population exists and conservation breeding can be done effectively, it is possible to use that population as a source for the release of individuals to the wild. In cases where the species is not held in zoos or aquaria, an integrated approach can take the form of capturing animals from the wild and placing them temporarily in controlled conditions to avoid anthropogenic mortality. A crucial factor influencing the success of such an intervention is the timing of the action. If one waits too long, the wild population can decline to such a small number of individuals

that the probability of success is reduced and cannot outweigh the risks associated with capture and handling. Another important consideration is the choice of species for which this kind of intervention is recommended. Particularly relevant in this context are the prominent objections when it comes to capturing and handling small cetaceans. Due to the special history of dolphin husbandry, there are numerous organisations that are against this kind of intervention. Also certain parts of our society, as well as some members of the scientific community, are opposed to a hands-on conservation option. Simply stated, they would rather accept the disappearance of the species than capture individuals of a rapidly declining population and transfer them to controlled areas.

Integrated conservation of small cetaceans

In the following sections, we argue for an integrated approach to the conservation of small cetaceans and the potential for dolphinaria to play an active role in the conservation of these species. This potential has been developed by dolphinaria in a short period of time, and it is therefore important to show how this has been achieved. Therefore, the history of dolphinaria will be discussed first, but it will also be shown that in addition to this positive development, dolphins – in this case, bottlenose dolphins – have always been subjects of biological research, the results of which have been used to optimise husbandry and, above all, to identify key criteria for creating self-sustaining ex situ populations. We have learned a lot about keeping these animals in human care and it is no exaggeration to say that no other zoo animal has provided as much knowledge about species biology as the dolphin. Even if this development almost always refers to only one dolphin species, namely the bottlenose dolphin, many examples have shown that the acquired knowledge can also be transferred to other species. The bottlenose dolphin is therefore a good model for integrated species management, as it covers a broad spectrum of ex situ management and is a good example of how animal husbandry can quickly become an important source of knowledge that benefits not only this species but others as well.

History of dolphin husbandry

To adequately evaluate the development of dolphin husbandry, it is helpful and important to describe its history. Furthermore, when dolphins are mentioned here, we refer to the bottlenose dolphin (*Tursiops truncatus*). Most dolphinaria originated from travelling circuses where these animals were shown. The first permanent facility where dolphins were kept was established in the United States (Florida) in 1938 (Defran & Pryor, 1980). Dolphins were on display in the facility known as Marine Studios, and the facility mainly served the film industry, which wanted to introduce people to marine life through film. Interestingly, this facility is also where systematic research on dolphins was first conducted. Most notable are the studies on echolocation (McBride, 1956), behaviour (McBride & Hebb, 1948) and breeding (McBride & Kritzler, 1951; Wood, 1977). Well-known American researchers took advantage of this unique opportunity to study aspects of dolphin biology under controlled conditions that may have never been studied in the field until decades later (Reeves & Mead, 1999).

However, it cannot be denied that the real reason for keeping dolphins at this time was primarily commercial. The charisma of the animals and their trainability (Pryor, 1975; Defran & Pryor, 1980) were key arguments in favour of making a profit from them. The suite of behaviours displayed in these shows made people believe that dolphins were highly intelligent. The negative thing about the dolphin show industry at that time, however, was the fact that dolphins had to be captured by the hundreds to keep the industry going. Breeding was undesirable at that time and therefore rare. However, animal husbandry was greatly improved, even in the early days

of the industry, mainly because of the fact that the animals were very valuable commercially.

The passage of the United States Marine Mammal Protection Act (MMPA) in 1972 severely restricted the capture of dolphins from the wild and led to a change in thinking about the handling of these animals. For many purely commercial businesses, this law meant the end for many dolphinaria in both the US and England. This new legislation initiated a long-overdue paradigm shift in dolphin management. The main goal of the leading institutions was now breeding and thus building a self-sustaining population in human care. Although successful breeding was a rarity at first, this change in thinking led to rapid development in the husbandry and management of these animals (Schroeder, 1990; McBain, 1999). Coordinated breeding programmes, in the USA under the aegis of the American Zoo and Aquarium Association (AZA) and in Europe in the form of the conservation breeding programme EEP of the European Association for Zoos & Aquaria (EAZA), were the key to success. In just a few decades, these programmes resulted in the fourth generation of dolphins being bred in dolphinaria and, in the case of the EEP, in 81.6% of all dolphins living in Europe being born in human care (EAZA-EEP, data as of 2023).

In addition to improved breeding success, the life expectancy for dolphins is also increasing in ex situ facilities. A recent study (Jaakkola et al., 2019) clearly showed that the life expectancy of dolphins in US zoos and aquaria has more than tripled over recent decades and is now at least as high as in some wild populations for which comparable data are available. A similar development can also be observed in Germany (see Baumgartner, et al in this volume).

Although the previous sections refer to only one dolphin species – the bottlenose dolphin – it is important to emphasise that other dolphin species have also been kept in zoos and dolphinaria. The challenges in creating a self-sustaining cetacean population, as demonstrated by the bottlenose dolphin, can have many reasons. As Curry et al. (2013) rightly pointed out, there are still many information gaps that need to be addressed before ex situ strategies are adopted as ubiquitous tools to conserve species. Many species, such as the vaquita, are not suitable for human care due to their vulnerability to capture/transport mortality (Rojas-Bracho et al., 2019). However, many species have already been kept and partly bred under controlled conditions and have tolerated acclimation, including the Amazon River dolphin (*Inia geoffrensis*; Boede et al., 2018; Ternes, 2022), the tucuxi (*Sotalia guianensis*; Bossenecker, 1978), the Commerson dolphin (*Cephalorhynchus commersonii*), the harbour porpoise (*Phocoena phocoena*) and the beluga (*Delphinapterus leucas*). The lack of results comparable to those from bottlenose dolphins is not necessarily related to the inability of these species to adapt to ex situ conditions. Above all, the lack of foresight in terms of long-term husbandry and science-based management led to failure. This includes the capture methods, the sex ratio of the captured animals, the lack of planning for new animal husbandry and the lack of a breeding programme involving experts and institutions that are devoted to species conservation.

The need for an integrated conservation approach for small cetaceans

According to the latest report of the IUCN SSC Cetacean Specialist Group, 46% of all cetacean species, subspecies and subpopulations are threatened (IUCN-CSG, 2022). In the last 20 years, we witnessed the functional extinction of the baiji (*Lipotes vexillifer*) in 2007 (Turvey et al., 2007). This river dolphin became extinct just over a decade ago because the management tools available at that time were not used effectively or in a timely manner. Today, we are witnessing the next cetacean extinction. According to recent counts, there are only eight vaquitas left in the Upper Gulf of California (Rojas-Bracho et al., 2021). Mexico's vaquita is thus about to follow the baiji's fate because fishery practices that are inadvertently causing their demise cannot be changed quickly enough. A field programme launched in 2017 to catch the last vaquitas and transfer them into a protected ex situ environment had to be stopped after two unsuc-

cessful capture attempts (Rojas-Bracho et al., 2019). Both cases clearly show that efforts made thus far to save dolphin species from extinction have had only a limited effect.

These two examples illustrate the problems faced by many cetacean species. Many of the threatened species and populations most vulnerable to extinction or extirpation have shallow water distributions that entirely overlap areas used intensively by people. Most of them are declining, at least in part, due to unsustainable bycatch mortality in fishing nets (Brownell et al., 2019), and extinction for some species is imminent unless concerted action is taken to save them. One thing is certain: to prevent further species extinctions, the range of tools available for conservation should be expanded. It is no longer enough to understand the causes of population decline; aggressive action must now be taken to reduce their impacts on population and/or species persistence. Consequently, all conservation options, including ex situ measures, should be evaluated to ensure the survival of a species.

The "Ex situ Options for Cetacean Conservation" (ESOCC) workshop, held in Nuremberg, Germany, in December 2018, was designed to address this critical need (Taylor et al., 2020). This includes preparations to lay the political, cultural, scientific and logistical foundations necessary for success. Discussions at the ESOCC workshop focused on seven small cetacean species (with an additional species, the Lahille's bottlenose dolphin, added later) that are on the IUCN Red List as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). The participants recognised the value of the OPA for each of the focal species. The current trend of declining population abundance for each of the eight species could lead to some of them becoming extinct within a short period of time – much faster than the time typically required to develop and implement a successful ex situ action plan. To make matters worse, there are significant gaps in our knowledge of the biology and management of many of these species. Consequently, there is an urgent need to fill these information gaps long before the implementation of ex situ management to prevent extinction can be seriously undertaken. Early preparation means that an action plan can be developed with greater confidence in success, and the expertise will be ready if or when the need arises. Early preparation would also mean knowing how a particular species would react to processes such as capture, transport, captivity or semi-captivity, and medication. In addition, research is needed to better understand individual animal responses to capture and how managers might neutralise problems resulting from confinement. These findings and experiences underline the role that zoos and aquaria play in effective conservation.

In this article, we want to address ex situ measures that are tailored for dolphinaria within the OPA framework and that can be practically applied to small cetacean management. There has never been a greater need for these institutions to become active in species conservation, whether through support for in situ measures, research and education within their own institution, or ex situ individual/population management. Only if they manage to carry out these activities in a thoughtful way will they be perceived as active partners in species conservation. Many examples described in the following sections testify to the feasibility of these tasks.

Ex situ management/conservation breeding

Dolphins have been kept in human care for over 80 years. In all these years, keepers, zoo veterinarians and biologists have learned a vast amount about the animals and have acquired management knowledge that not only benefits the animals kept but can also help wild populations. The term zoo management covers a variety of measures that have been carefully developed to ensure safety for animals and the humans who care for them. In recent years, it has been recognised that this knowledge can also be applied to wild populations. This includes,

for example, the responsible handling of animals, which is one of the most important tools that zoos / dolphinaria have to manage their animals. Many measures that have been increasingly used in the wild in recent years, such as translocation and transport of animals or health assessments, require the capture and handling of animals (Barratclough et al., 2019). In most cases, this knowledge comes from dolphinaria or zoos that have experience with these animals and conduct and support research.

The need to manage animals intensively has grown due to increasing threats to species in the wild. In some cases – such as the baiji (Turvey et al., 2007) or vaquita (Rojas-Bracho et al., 2019) – the last option to preserve the species was to remove animals from their natural habitat and transfer them to a safe environment. Efforts to save the baiji were unsuccessful because no more animals were sighted, even after several weeks of searching. Attempts to rescue vaquita from immediate environmental threats were similarly unsuccessful after one individual had to be released due to significant stress following capture and the other animal died of capture myopathy. There is an important lesson to be learned from both cases. If measures such as capturing individuals from an endangered population are the last option to conserve the species, then one should not wait too long before intervening. Managing individuals in an ex situ environment is certainly challenging and the learning curve is steep. It is necessary to understand the behavioural and physiological responses of a species to the actions required to build an ex situ population before it reaches a critically low level. There will always be a risk that animals will be lost during these periods of adaptation to ex situ conditions and the special needs of the animals, but it is important to analyse and evaluate these findings to gain important insights into how to keep them alive and healthy. In general, important aspects that need to be addressed are how the animal reacts to capture, transport and confinement. It is also important to address key husbandry questions, such as the quality of the facilities housing the animals and the quality of individual animal care (food/veterinary medicine). These considerations are particularly important given that such long-lived animals could remain in ex situ facilities for extended periods of time. In many of these areas, zoos/dolphinaria can make important contributions, as they have the necessary expertise and trained staff to carry out such measures effectively. As these conservation measures will likely increase in scope and intensity in the near future, it is important to be aware of the important roles and responsibilities these facilities will take on.

One dolphin species that is considered vulnerable (Vermeulen et al., 2019) according to the IUCN but is under increasing pressure in its natural habitat is the Lahille bottlenose dolphin (*Tursiops gephyreus*). A maximum of 360 mature individuals remain in the South Atlantic, where this subspecies is endemic (Fruet et al., 2015; Secchi et al., in this volume). Conservation efforts are rare and where management has been implemented, as in Brazil through enacting a new fishing law, the effects of the actions are questionable. In other words, without much-needed protection, this species will suffer a fate similar to that of baiji and vaquita. Unlike the vaquita, there is an ex situ population in Mundo Marino, Argentina, a dolphinarium that has kept and successfully bred this species for decades (Loureiro et al., 2021). This means that this species is well suited for ex situ holding and an insurance population can therefore be created. Continued breeding success and the establishment of a self-sustaining ex situ population depend on factors such as individual demographic characteristics and adult sex ratio. In the case of Mundo Marino, this is not optimal, as there is a surplus of males and only two females. The fate of Lahille's bottlenose dolphin also prompted the EAZA to establish an ExSitu Programme (EEP) in 2022, with the aim of supporting conservation efforts for the species (EAZA Regional Collection Plan, 2022). Unlike the usual EEPs, it is not intended to keep the species in European zoos. A new campaign by the European Association for Aquatic Mammals (EAAM) will also be dedicated to the conservation of this species, providing expertise and funding to support in situ conservation projects. These examples clearly show the immense potential for zoos and dolphinaria to be active members of the conservation community.

Fig. 3: The Lahille Bottlenosed Dolphin in Southern Brazil. Photo © Rodrigo Genoves, KAOSA

A very important tool in zoo population management is the Zoological Information Management System (ZIMS) software package. This database houses records on more than 10 million individuals of more than 22,000 species, including medical histories and genetic tools for population analysis. The global web-based application is structured to facilitate cooperative animal management to achieve ex situ conservation goals. ZIMS will soon be used for the first time for a threatened dolphin population: a Lahille's dolphin population inhabiting the Lagoa dos Patos in Southern Brazil. A special feature of ZIMS is its application to analyse the demographic and genetic status of populations with a small number of individuals. It also enables the linking of data management processes for animals that spend part of their lives in human care and part of their natural environment and has great potential for use in managed wild populations (Schwartz et al., 2017). This first application of ZIMS to a threatened dolphin population will surely provide important information to better manage the species across the *in situ-ex situ* spectrum.

Perhaps the best example of how conservation breeding can contribute to the survival of a cetacean species is the case of the Yangtze finless porpoise or YFP (*Neophocaena asiaeorientalis* ssp. *asiaeorientalis*). When the steadily declining wild population reached a critical number of individuals, it was decided to capture animals and transfer them to remote riverine areas called oxbows. The first *ex situ* YFP population was established in 1990 in Tian-E-Zhou Oxbow in Hubei Province. The breeding programme that subsequently came into effect has resulted in the ex situ population now numbering more than 160 individuals (Wang, 2009; Hao et al., this volume). This population also provides research and training opportunities for local and regional scientists and is the subject of many regional education and public awareness programmes.

In summary, across the management continuum – from natural habitats in the wild to controlled environments in the dolphinarium or zoo – well-grounded practical knowledge has been

instrumental in achieving success. The expertise in cetacean management acquired in the ex situ community – mostly based on accumulated experience with just one species – has led to the development of effective management technique measures that can be applied to other species in need. This flow of knowledge will no doubt become even more relevant in the coming years due to the perilous conservation status of many species.

Research in support of conservation

There are few animal species of which we know as much about their general biology – from the performance of the sensory organs to cognition and behaviour – as we do about the bottlenose dolphin. It is particularly striking to appreciate the wealth of knowledge that ex situ-based research on these animals has provided. In particular, research on echolocation, which began in the 1950s, has provided many insights into the way dolphins perceive their environment (Au, 1993). Scientists working with animals in dolphinaria have also proven what dolphins perceive in terms of hearing (Ridgway & Au, 2009), communication (Caldwell & Caldwell, 1968; Janik & Sayigh, 2013) and other senses (Hüttner et al., 2022).

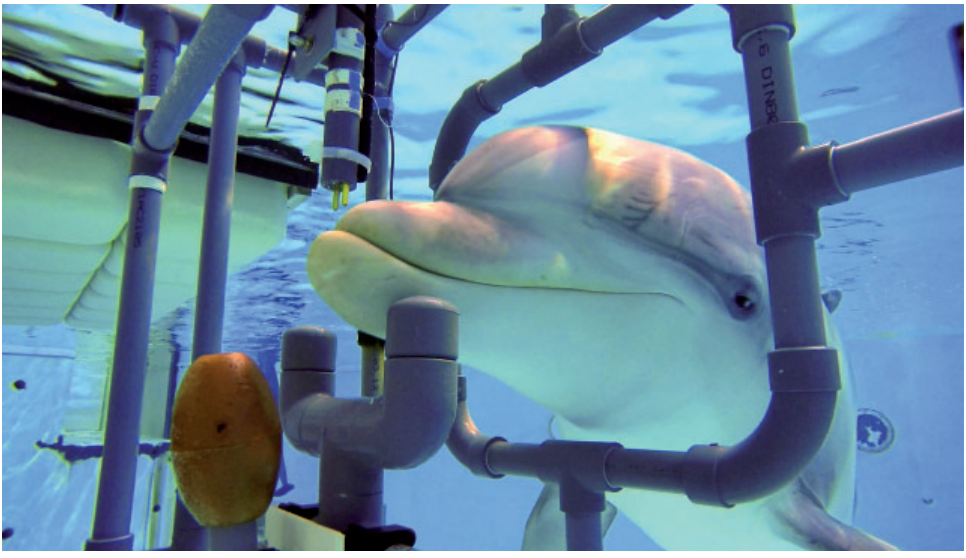

Fig. 4: Special electroreception test apparatus developed for dolphins. The dolphin touches the target with its rostrum. The electrodes are located approximately 10 cm directly above the dolphin's vibrissal crypts on the upper rostrum. After an electric signal was presented, the dolphin learned to leave the apparatus and return to its trainer. Each correct response was reinforced by the experimenter with a short continuous whistle sound and a food reward from the trainer. During stimulus-absent trials, the dolphin learned to stay in station for at least 12 s. Photo © Tim Hüttner, Nuremberg Zoo

The US Navy has conducted important research in Hawaii over the years in the area of dolphin echolocation (Au, 1993; Nachtigall & Pacini, in this volume). This work is now being continued and complemented by other topics in San Diego by the National Marine Mammal Foundation (NMMF). Hundreds of publications focusing on physiology, acoustics and advanced diagnostic

methods have been produced over the past decades thanks to the dolphins housed there (Houser et al., 2010). Overall, understanding the sensory systems of dolphins can help conservationists to better understand these animals in the first place, as well as to better assess the effects of different stressors, such as noise. Understanding how echolocation works may be important for developing bycatch mitigation methods.

Controlled conditions, such as those found in dolphinaria, are also critical environments for exploring other research fields that are becoming increasingly relevant. With the rapid development of new technologies in the field of biologging (animal-attached logging of biological variables with small electronic devices) and the increased demand for their use in the field, it is particularly important to conduct preliminary experiments with animals where detailed monitoring is possible (Tyack, 1985). Such non-invasive bio-logging tags, used in hundreds of studies ranging from basic ecology to the effects of human disturbance, are constantly being improved in ex situ facilities, while novel methods for sampling DNA (Frere et al., 2017) and hormones (Richard et al., 2017) from exhaled breath are being developed for health and genetic studies. Many of these studies have been designed to document the physiological and behavioural responses of dolphins to environmental stressors, such as sound and pollutants. The results of these studies help managers and scientists understand, for example, how entanglement and noise (e.g. from man-made sonar, oil and gas exploration) affect individual behaviour and survival (Houser et al., 2010).

Despite the intellectual advances summarised above, there are still many open questions about cetacean biology that dolphinaria can contribute to solving. The development of fishery gear deterrent devices is particularly urgent. Bycatch is and will certainly remain the greatest threat to the survival of many small cetaceans in the coming years. Pingers (active or passive) are seen as a solution, but there is still a lot of research to be done in this area, and answers to some of these questions can certainly be provided by projects with dolphins in human care. Another area relates to developing solutions using artificial intelligence. Be it behaviour or acoustics, animals from dolphinaria serve as good models to test a wide range of hypotheses.

In summary, close access to animals in human care has allowed scientists to study many aspects of cetacean biology and to gather information that would otherwise be inaccessible. This basic information from studies in facilities serves as a direct basis for scientists to interpret data from studies in the wild.

Veterinary medicine

Zoo veterinary medicine is certainly one of the fields that has developed most rapidly, and it has ultimately contributed greatly to the good health of bottlenose dolphins in ex situ facilities. This is echoed not only in breeding success and life expectancy but also in evidence of good animal welfare (Baumgartner et al. in this volume). In the meantime, the field of zoo veterinary medicine has now expanded to include the study of wild populations. One product of this work that reflects the exponential growth of knowledge is The Handbook of Marine Mammal Medicine. While the first editions focus mainly on diagnosis and treatment methods, the content in the last edition looks at the bigger picture by adding animal welfare, tagging and tracking rehabilitated animals, and a holistic concept of health, now known as One Health (Dierauf & Gulland, 2001). The term conservation medicine (Aguirre et al., 2002 and Smith et al., in this volume) covers this new field of veterinary medicine, addressing inter alia species conservation issues. Conservation medicine plays a vital role in preserving biodiversity by promoting the health of wildlife populations and their eco-

systems. It incorporates the One Health Approach, which recognises the strong connections between the health of humans, animals and the environment. Conservation medicine takes a one-health approach to promoting health and well-being across all three domains. By monitoring the health of animal populations, conservation medicine can help prevent the spread of these diseases and protect public and environmental health. By investigating the impact of environmental factors on health, conservation medicine can help promote a healthy environment for all.

A particularly striking phenomenon that has recently increased among dolphins is strandings (Alvarado-Rybak et al., 2020). In the case of dead animals, a well-considered and conducted necropsy is crucial for determining the cause of death. Good protocols, such as those designed and applied in zoological institutions, often serve as models and are the basis for scientific work. A good example of how zoo-acquired marine mammal medicine can be directly and effectively implemented in the field is given with live strandings. Starting with the transport to the Rehabilitation Centre, the initial care and the entire rehabilitation process up to the release, all depends on veterinary knowledge from zoological institutions. For live strandings, zoo veterinarians' participation is of great importance due to their long experience with these animals. Dolphinaria as institutions play a crucial role here as they provide staff, first aid, logistics, space, medicine and professional care. An excellent example of this type of collaboration is the Alliance for Franciscana-Dolphin Conservation, Research, Rescue and Rehabilitation (AFCR3), composed of veterinarians, biologists, animal managers and rehabilitation experts from different countries. The aim of this alliance is to help protect the endangered Franciscana dolphin by not only better understanding the phenomenon of live strandings but also identifying ways to keep these animals alive. For that purpose, the Alliance has developed rehabilitation protocols that are not only based on scientifically valid findings but also consider the specific circumstances of the places/countries (Meegan et al., 2022).

Conservation translocation, the deliberate movement of organisms from one site for release to another, is also a phenomenon that is becoming more and more common. River dolphins in particular are more frequently affected (Aliaga-Rossel & Escobar, 2020). Habitat changes result in the animals' habitat becoming restricted and often requiring the translocation of single individuals. Again, zoo veterinarians, as well as trained staff (i.e. keepers) who are familiar with the handling of these animals, can be extremely important for ensuring successful translocation.

Another important achievement of dolphinaria relates to artificial insemination (AI). AI is considered a very important tool in species conservation. Assisted reproductive technologies (ART) are a critical component of management tools and include semen cryopreservation, AI and sex pre-selection using sperm sorting. Some dolphinaria have already had some success with the application of ART tools and techniques (O'Brien & Robeck, 2006). AI with sex-selected sperm is a potentially effective tool for restoring small animal populations, as it shifts the sex ratio in favour of females and ultimately increases recruitment rates (Robeck et al., 2013). Although the applicability of bottlenose dolphin successes to other species has been debated (Curry et al., 2013), it is undeniable that many of the fundamentals that have been created here facilitate the application of AI to a host of endangered cetacean species. Finally, it is important to emphasise that AI can help maintain genetic diversity in endangered species by allowing the mixing of genetic material between individuals that are geographically separated, have a low reproductive rate or have difficulty reproducing in controlled environments.

Capacity building

Much of the collective knowledge regarding animal husbandry in ex situ facilities is scientifically valid and published, but much of it is based on many years of experience and

is referred to as management-based expertise (MBE). The Animal Care Manuals (ACMs) of the Association of Zoos and Aquariums (AZA), the EAAM Standard and Guidelines, and the EAZA Best Practice Guidelines (BPG) are certainly very valuable sources of knowledge, as they contain practical information relevant to the management of animals. This knowledge is not only used for the continuous improvement of their animal management efforts but also serves as a good foundation for the management of wild populations. In this context, capacity building in wildlife management means applying and transferring the knowledge, skills and resources learned in an ex situ-facility to effectively manage wildlife populations, protect habitats and address the challenges facing wildlife in different contexts.

Training is an important activity for capacity building in wildlife management. Providing targeted training for wildlife veterinarians, biologists, conservationists and community members can help build their knowledge and skills in different areas of husbandry, capture, veterinary care and animal handling. Another important capacity-building area is research and monitoring. Many dolphinaria/zoos have in-house scientists who work with animals to answer different research questions. Capacity building can involve developing the skills and resources needed to carry out research in the wild as well as the ability to analyse and interpret the resulting data.

Engaging local communities in wildlife management can also build capacity by empowering them to take an active role in conservation efforts, fostering a sense of ownership and stewardship and building local capacity to manage wildlife resources sustainably. Methods for this can be partly derived from the work that zoos/dolphinaria do in environmental education and training.

Overall, capacity building requires, above all, knowledge and this is abundant in zoos/dolphinaria. It is rooted in a multi-layered approach that includes expertise and knowledge but also education, research, training, collaboration, innovation and community engagement. By building capacity, we can improve the living conditions of kept animals, and we can better protect and conserve wildlife populations and their habitats for future generations.

Networking

An important prerequisite for maximising the chances of success in species conservation is networking. Building partnerships and collaboration between scientists, wildlife managers, government agencies, NGOs, community organisations and other stakeholders can help build capacity by pooling resources, expertise and knowledge. This can involve sharing best practices, coordinating efforts and leveraging each other's strengths.

Zoos and aquaria are often members of many professional organisations (IUCN, WAZA, EAZA, EAAM), enjoy partnerships with universities and other research institutions, and develop contacts with local political institutions. As a result, these institutions are well suited to building effective conservation networks. These networks should serve to highlight the relevance of zoos/dolphinaria to ultimately be recognised as active and serious partners in species conservation. The efforts of the European Association for Aquatic Mammals as the umbrella organisation of European dolphinaria are worth mentioning in this respect. In particular, the political work done in France and other European countries to consolidate the status of dolphinaria as research and educational institutions was important in preventing further closures. Additionally, initiatives such as the ESOCC workshop described previously can be good examples of these networks. The ESOCC enabled the ex situ community to prove how deeply integrated species conservation is in its activities. The task is to continue this work.

Awareness and conservation education

Visiting a zoo/dolphinarium and seeing a live animal are probably the most effective ways to communicate animal-related content in an effective and sustainable way. These institutions use this phenomenon to make visitors aware of important issues. Through careful planning and implementation, these encounters and associated educational programmes can be powerful sources of information for the public.

Building awareness of wildlife in a zoo/dolphinarium is an important task that requires a multi-faceted approach and can take place in different ways. Many institutions offer educational programmes for visitors, especially children, to learn about animals and their habitats. These programmes can include guided tours, interactive exhibits and hands-on activities.

Especially in the case of dolphinaria, animal presentations can be a great way to showcase the magnificence and diversity of wildlife. These presentations are also used to communicate content, for example, from scientific research or species conservation. Some institutions show pure research presentations, which again shows that visitors can be attracted to these topics. At the same time, these research presentations are also a good opportunity to collect data for science.

Another important source of information for visitors are signs, posters and monitors. If well designed, they can hold other important content about the animals, their behaviours and the importance of conservation complementary to the presentations. Overall, building awareness of wildlife requires a holistic approach that prioritises education, animal welfare and conservation efforts. By engaging visitors and partnering with organisations, zoos/dolphinaria can play an important role in protecting and preserving wildlife. For example, in the Nuremberg Zoo, the zoo-based conservation organisation YAQU PACHA has conducted numerous campaigns to draw the attention of visitors to the conservation problems of small cetaceans and to raise awareness of them.

At this point, it should be mentioned that the reach of zoos/dolphinaria is immense. Each year, over 700 million people visit these institutions (WAZA, 2022). This figure illustrates the enormous potential as an awareness-raising and educational institution. Through the presentation of live animals, zoos/dolphinaria have a unique platform to direct the visitors' attention to biological topics but also to point out environmental problems.

Fundraising

If everything that was mentioned before is fulfilled – successful population management, animal welfare, expansion of knowledge through research, public awareness and education – then the conditions are given for visitors to donate money for conservation projects. Zoos/dolphinaria can generate revenue through a variety of fundraising opportunities. The best known are membership programmes, corporate partnerships, individual donations, special events, animal adoptions, merchandise sales and grant funding.

Overall, zoos/dolphinaria have many opportunities for fundraising, and these initiatives can help support important conservation efforts (in situ/ex situ), education programmes and research projects. Collectively, the global zoo/aquarium community invests more than US$ 350 million in in situ wildlife conservation, representing the third largest conservation organisation contributor globally (Gusset & Dick, 2011; EAZA Conservation Database). These in situ conservation activities are primarily funded by paying visitors and other sources, such as donations.

Without having exact figures, one has the impression that active participation in species conservation through financial support for projects in dolphinaria is unfortunately not yet as advanced as zoos. There is often a lack of creativity and ideas on how to get visitors to participate financially in species conservation. It should be clear to everyone that species protection is

not just a word but that it is about taking responsibility and setting a good example to ensure the survival of animal species. Thus, dolphinaria should take this task seriously and act accordingly.

Conclusions

The OPA is now a central paradigm within the IUCN's Species Survival Commission for the integrated conservation of endangered species. We argue here that this approach should become a similar organising principle for the cetacean conservation community. In adopting this principle for the conservation of a species group to which humans have such a deep emotional connection, it is crucial to understand that integrated conservation does not equate only with keeping animals in tanks for display and entertainment. As explained in the IUCN's Guidelines for the Use of Ex Situ Management for Species Conservation, dolphinaria can engage in a host of activities that can make meaningful contributions to the conservation of small cetacean species in their natural habitats. Where appropriate, maintaining healthy animals in ex situ environments comes with difficult scientific challenges. It is the responsibility of the ex situ community to accept this challenge and help create conditions in which ex situ management can ultimately play a key role in saving cetacean species from extinction.

Dolphinaria are a significant and largely untapped resource in the global cetacean conservation community. In this article, the term dolphinaria consistently refers to facilities that keep dolphins in their care. These institutions have proven to be successful over many years and have been markedly successful in raising people's awareness of dolphins and their role in nature. There have been institutions that, in parallel with their traditional focus on animal display, have also conducted biological research, developed educational programmes and supported species conservation. In this article, however, we want to clarify that the traditional vision of a dolphinarium is no longer sufficient if the goal is to be an active player in the protection of endangered species. In view of the catastrophic situation of many dolphin species, but also in view of current developments in species conservation, such as the OPA and IUCN Motion 079, there is a call for a new evaluation of these facilities. In this article, we have highlighted numerous opportunities for involvement in the broad conservation movement, and it would be negligent, at best, for dolphinaria to ignore this invitation. We would like to see dolphinaria follow the same path taken by zoos and aquaria over the past few decades, moving from mere exhibit institutions to active participants in global species conservation. With this in mind, we envision a future for dolphin facilities in which their primary goal is to educate and empower their visitors to appreciate the value of species conservation, to enable research and to actively participate in in situ species conservation. Without the active participation of our community, the likelihood of improving the conservation status of these animals decreases.

Zusammenfassung

Die Welt befindet sich in einer Phase des Verlusts der biologischen Vielfalt, die in absehbarer Zeit nicht aufzuhalten ist. In-situ-Artenschutz/Habitatschutz reichen nicht aus, um den weiteren Verlust von Arten zu stoppen. Daher ist der Ruf nach neuen Strategien unausweichlich. Eine dieser Strategien ist der One Plan Approach (OPA), der von der Conservation Planning Specialist Group (CPSG) ins Leben gerufen und später von der International Union for Conservation of Nature (IUCN) übernommen wurde. Im Gegen-

satz zu herkömmlichen Artenschutzstrategien, die sich in erster Linie auf den Schutz von Arten in ihrem natürlichen Lebensraum konzentrieren, umfasst OPA das gesamte Spektrum des Tiermanagements (von intensiv in zoologischen Einrichtungen bis zur weniger intensiven im Freiland). Mit OPA wurde den Zoos nicht nur eine weitere wichtige Aufgabe übertragen, sondern sie haben nun auch Verantwortung für den Erhalt der Artenvielfalt übernommen. Während bei den meisten bedrohten Pflanzen- und Tierarten ein Konsens über die Umsetzung integrierter Schutzmaßnahmen besteht, gehen die Meinungen bei den Kleinwalen auseinander. Dieser Artikel soll diese Diskrepanz aufzeigen und zeigen, dass für viele Kleinwalarten integrierte Artenschutzstrategien nicht nur dringend erforderlich sind, sondern dass bereits erste Schritte zur Umsetzung eines solchen integrierten Ansatzes unternommen wurden. Zoologische Einrichtungen, die Delfine halten, sollten sich der wichtigen Rolle, die sie jetzt spielen, bewusst sein und verantwortungsbewusst handeln.

References

Aguirre, A.A., Ostfeld, R.S., Tabor, G.M., House, C., & Pearl, M.C. (2002). Conservation Medicine: Ecological Health in Practice. New York, NY: Oxford University Press.

Aliaga-Rossel, E., & Escobar, M. (2020). Translocation of trapped Bolivian river dolphins (*Inia boliviensis*). IWC Report, 21(1), 17-23. https://journal.iwc.int/index.php/jcrm/article/view/96

Alvarado-Rybak, M., Toro, F., Escobar-Dodero, J., Kinsley, A.C., Sepúlveda, M.A., Capella, J., Azat, C., Cortés-Hinojosa, G., Zimin-Veselkoff, N., & Mardones, F.O. (2020). 50 years of cetacean strandings reveal a concerning rise in Chilean Patagonia. Sci Rep**,** 10, 9511.

Au, W.L. (1993). The Sonar of Dolphins. New York: Springer-Verlag.

Barratclough, A., Wells, R.S., Schwacke, L.H., Rowles, T.K., Gomez, F.M., Fauquier, D., Sweeney, J., Townsend, F.I., Hansen, L., Zolman, E.S., Balmer, B.C., & Smith, C.R. (2019). Health assessments of common bottlenose dolphins (*Tursiops truncatus*): past, present, and potential conservation applications. Frontiers in Veterinary Science, 6, 444.

Boede, E.O., Mujica Jorquera, E., Boede, F., & Varela, C. (2018). Reproductive management of the Orinoco river dolphin *Inia geoffrensis humboldtiana* in Venezuela. International Zoo Yearbook, 52, 1-13. https://doi.org/10.1111/izy.12195

Bossenecker, P.G. (1978). The capture and care of *Sotalia guianensis*. Aquatic Mammals, 6, 13-17.

Brownell, R.L., Reeves, R.R., Read, A.J., Smith, B.D., Thomas, P.O., Ralls, K., Amano, M., Berggren, P., Chit, A.M., Collins, T., Currey, R., Dolar, M.L.M., Genov, T., Hobbs, R.C., Kreb, D., Marsh, H., Zhigang, M., William F. Perrin12, Somany Phay18, Rojas-Bracho, L., Ryan, G.E., Shelden, K.E.W., Slooten, E., Taylor, B.L., Vidal, O., Ding, W., Whitty, T.S., & Wang, J.Y. (2019). Bycatch in gillnet fisheries threatens critically endangered small cetaceans and other aquatic megafauna. Endangered Species Research, 40, 285-296. https://doi.org/10.3354/esr00994

Byers, O., Lees, C., Wilcken, J., & Schwitzer, C. (2013). The One Plan Approach: the philosophy and implementation of CBSG's approach to integrated species conservation planning. WAZA Mag, 14, 2-5.

Caldwell, M.C., & Caldwell, D.K. (1968). Vocalization of naive captive dolphins in small groups. Science 159, 1121-1123.

Conde, D.A., Flesness, N.R., Colchero, F., Jones, O.R., & Scheuerlein, A. (2011). An emerging role of zoos to conserve biodiversity. Science, 331, 1390-1391. doi: 10.1126/science.1200674

Curry, B.E., Ralls, K., & Brownell Jr., R.L. (2013). Prospects for captive breeding of poorly known small cetacean species. Endangered Species Research, 19, 223-243. https://doi.org/10.3354/esr00461

Defran, R.H., & Pryor, K. (1980). The behavior and training of cetaceans in captivity. In L.M. Herman (Ed.), Cetacean Behavior: Mechanisms and Functions (pp. 319-362). New York: John Wiley & Sons.

Dierauf, L., Gulland, F.M.D. (2001). CRC Handbook of Marine Mammal Medicine. Boca Raton, Florida: CRC Press.

European Association for Zoo and Aquaria – Marine Mammal TAG. (2022). Regional Collection Plan.

Frère, C.H., Krzyszczyk, E., Patterson, E.M., Hunter, S., Ginsburg, A., & Mann, J. (2010). Thar she blows! A novel method for DNA collection from cetacean blow. PloSone, 5(8), e12299.

Fruet, P.F., Daura-Jorge, F.G., Möller, L.M.L.M., Genoves, R.C., & Secchi, E.R.E.R. (2015). Abundance and demography of bottlenose dolphins inhabiting a subtropical estuary in the Southwestern Atlantic Ocean. Journal of Mammalogy, 96(2), 332-343. https://doi.org/10.1093/jmammal/gyv035

Gusset, M., & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. Zoo Biol, 30, 566-569.
Houser, D.S., Finneran, J.J., & Ridgway, S.H. (2010). Research with Navy marine mammals benefits animal care, conservation and biology. International Journal of Comparative Psychology, 23(3), 249-268.
Hüttner, T., von Fersen, L., Miersch, L., Czech, N.U., & Dehnhardt, G. (2022). Behavioral and anatomical evidence for electroreception in the bottlenose dolphin (*Tursiops truncatus*). The Anatomical Record, 305(3), 592-608. https://doi.org/10.1002/ar.24773
IUCN-CSG (2022). https://iucn-csg.org/update-on-cetacean-red-list-assessments-published-in-2022.
IUCN-SSC (2014). https://www.eaza.net/assets/Uploads/Position-statements/IUCN-Guidelines-on-the-Use-of-ex-situ-management-for-species.pdf
Irwin, M.D., Stoner, J.B., & Cobaugh, A.M. (eds) (2013). Zookeeping. Chicago: The University of Chicago Press.
Jachowski, D.S., & Lockhart, J.M. (2009). Reintroducing the Black-footed Ferret *Mustela nigripes* to the Great Plains of North America.
Jaakkola, K., & Willis, K. (2019). How long do dolphins live? Survival rates and life expectancies for bottlenose dolphins in zoological facilities vs. wild populations. Mar Mam Sci, 35:1418–1437. https://doi.org/10.1111/mms.12601
Janik, V.M., & Sayigh, L.S. (2013). Communication in bottlenose dolphins: 50 years of signature whistle research. Journal of Comparative Physiology A, 199, 479-489. https://doi.org/10.1007/s00359-013-0817-7
Kierulff, M.C.M., Ruiz-Miranda, C.R., Oliveira, P.P., Beck, B.B., Martins, A., & Dietz, J.M. (2012). The Golden lion tamarin *Leontopithecus rosalia*: a conservation success story. International Zoo Yearbook, 46:36–45. https://doi.org/10.1111/j.1748-1090.2012.00170.x
Kleiman, D.G., Thompson, K.V., & Baer, C.K. (2010). Wild Mammals in Captivity. Principles and Techniques for Zoo Management. 2nd edition. Chicago: The University of Chicago Press.
Lee, G. (1992). Recovery Plan for the Puerto Rican Crested Toad (*Peltophryne lemur*). Boqueron, Puerto Rico: USDI, Fish and Wildlife Service, Caribbean Field Office.
Loureiro, J.D., Migliorisi, A.L., Loureiro, J.P., Rodríguez Heredia, S., Rebollo, J., Álvarez, K.C., Morón, S., & Nuñez Favre, R. (2021). Breeding program in rehabilitated bottlenose dolphins (*Tursiops truncatus gephyreus*) from the Southwestern Atlantic Ocean. Zoo Biology, 40(3), 208-217. doi: 10.1002/zoo.21592. Epub 2021 Feb 19. PMID: 33606298.
McBain, J. (1999). Captive breeding of marine mammals: feasibility and success. Report of the Workshop Marine Mammal Reproduction: Morphology & Physiology. P. 417 in: European Research on Cetaceans Vol. 12 (P.G.H. Evans & E.C.M. Parsons, eds). Liége, Belgium: European Cetacean Society.
McBride, A.F., & Hebb, D.O. (1948). Behavior of the captive bottle-nose dolphin, *Tursiops truncatus*. Journal of Comparative Physiology and Psychology, 41, 111-123.
McBride, A.F., & Kritzler, H. (1951). Observations on pregnancy, parturition, and post-natal behavior in the bottlenose dolphin. Journal of Mammalogy, 32, 251-266.
McBride, A.F. (1956). Evidence for echolocation by cetaceans. Deep Sea Research, 3, 153-154.
Meegan, J., Gomez, F., Barratclough, A., Smith, C., Sweeney, J., Ruoppolo, V., Kolesnikovas, C., Pinho da Silva Filho, R., Lima Canabarro, P., Laporta, P., Loureiro, J.P., Alvarez, K., Rodriguez Heredia, S.A., Cabrera, A., Faiella, A., Saubidet, A., & von Fersen, L. (2022). Rescue and rehabilitation of neonatal Franciscana dolphins, care and hand-rearing protocol, AFCR3 – Publication Nr. 01 – 2022.
Mickelberg, J., & Balou, J. (2013). The Golden Lion tamarin conservation programme's One Plan Approach. WAZA Magazine, 14, 24-27.
O'Brien, J.K., & Robeck, T.R. (2006). Development of sperm sexing and associated assisted reproductive technology for sex pre-selection of captive bottlenose dolphins (*Tursiops truncatus*). Reproduction Fertility and Development, 18, 319-329.
Pryor, K. (1975). Lads Before the Wind: Adventures in Porpoise Training. New York: Harper & Row.
Pucek, Z. (1991). History of the European bison and problems of its protection and management. Global Trends in Wildlife Management, 39, 19.
Reeves, R.R., & Mead, J.M. (1999). Marine mammals in captivity. In J.R. Twiss, & R.R. Reeves (Eds), Conservation and Management of Marine Mammals (pp. 412-436). Washington, D.C.: Smithsonian Institute Press.
Richard, J.T., Robeck, T.R., Osborn, S.D., Naples, L., McDermott, A., LaForge, R., Romano, T. & Sartini, B.L. (2017). Testosterone and progesterone concentrations in blow samples are biologically relevant in belugas (*Delphinapterus leucas*). General and Comparative Endocrinology, 246, 183-193.
Ridgway, S.H., & Au, W.W.L. (2009). Hearing and echolocation in dolphins. Encyclopedia of Neuroscience, 4, 1031-1039. https://doi.org/10.1016/B978-008045046-9.00263-1
Robeck, T., Montano, G., Steinman, K, Smolensky, P., Sweeney, J., Osborn, S., & O'Brien, J. (2013). Development and evaluation of deep intra-uterine artificial insemination using cryopreserved sexed spermatozoa in bottlenose dolphins (*Tursiops truncatus*). Animal Reproduction Science, 139(1-4), 168-181. https://doi.org/10.1016/j.anireprosci.2013.04.004

Rojas-Bracho, L., Gulland, F.M.D., Smith, C.R., Taylor, B., Wells, R.S., Thomas, P.O. Bauer, B., Heide-Jørgensen, M.P., Teilmann, J., Dietz, R., Balle, J.D., Jensen, M.V., Sinding, M.H.S., Jaramillo-Legorreta, A., Abel, G., Read, A.J., Westgate, A.J., Colegrove, K., Gomez, F., Martz, K., Rebolledo, R., Ridgway, S., Rowles, T., van Elk, C.E., Boehm, J., Cardenas-Hinojosa, G., Constandse, R., Nieto-Garcia, E., Phillips, W., Sabio, D, Sanchez, R., Sweeney, J., Townsend, F., Vivanco, J., Vivanco, J.C., & Walker, S. (2019). A field effort to capture critically endangered vaquitas *Phocoena sinus* for protection from entanglement in illegal gillnets. Endangered Species Research 38, 11-27. https://doi.org/10.3354/esr00931

Rojas-Bracho, L., Booth, C., Taylor, B., Thomas, L., Jaramillo-Legorreta, A., Mesnick, S., Gerrodette, T., & Henry, H. (2021). Report using expert elicitation to estimate total unique vaquitas and calves seen in the Zero Tolerance Area during the 2021 survey. Paper submitted to the IWC.

Ruiz-Miranda, C.R., de Morais Jr., M.M., Dietz, L.A., Rocha Alexandre, B., Martins, A.F., & Ferraz, L.P. (2019). Estimating population sizes to evaluate progress in conservation of endangered golden lion tamarins (*Leontopithecus rosalia*). PLoS ONE, 14(6), e0216664. https://doi.org/10.1371/journal.pone.0216664

Schroeder, J.P. (1990). Breeding bottlenose dolphins in captivity. In S. Leatherwood, & R.R. Reeves (Eds), The Bottlenose Dolphin (pp. 435-460). San Diego, California: Academic Press.

Schwartz, K.R., Christien, E., Rockwood, L., Wood, T.C. (2017). Integrating in-situ and ex-situ data management processes for biodiversity conservation. Front Ecol Evol, 5. https://doi.org/10.3389/fevo.2017.00120

Smith, D., Abeli, T., Bruns, E.B., Dalrymple, S.E., Foster, J., Gilbert, T.C., Hogg, C.J., Lloyd, N.A., Meyer, A., Moehrenschlager, A., Murrell, O., Rodriguez, J.P., Smith, P.P., Terry, A., & Ewen, J.G. (2023). Extinct in the wild: the precarious state of Earth's most threatened group of species. Science, 379, eadd2889. https://doi.org/10.1126/science.add2889

Spalton, A. (1993). A brief history of the reintroduction of the Arabian oryx *Oryx leucoryx* into Oman 1980–1992. Int Zoo Yearb, 32, 81-90. https://doi.org/10.1111/j.1748-1090.1993.tb03519.x

Stanley-Price, M. (2016). Reintroduction as an antelope conservation solution. In J.B. Jørgensen, & D. Mallon (Eds), Antelope Conservation: From Diagnosis to Action, First Edition (pp. 125-132). New York: John Wiley & Sons.

Taylor, B.L., Abel, G., Miller, P., Gomez, F., von Fersen, L., DeMaster, D.P., Reeves, R.R., Rojas Bracho, L., Wang, D., & Cipriano, F. (eds) (2020). Ex situ Options for Cetacean Conservation: December 2018 workshop. Nuremberg, Germany: IUCN. Gland, Switzerland. https://doi.org/10.2305/IUCN.CH.2020.SSC-OP.66.en

Ternes, K. (2022). Ex situ management of the Amazon River dolphin (*Inia geoffrensis humboldtiana*): previous experiences, successes, and constraints. Der Zoologische Garten Neue Folge, 90, 183-218 .

Tokarska, M., Pertoldi, C., Kowalczyk, R., & Perzanowski, K. (2011). Genetic status of the European bison *Bison bonasus* after extinction in the wild and subsequent recovery. Mammal Review, 41, 151-162. https://doi.org/10.1111/j.1365-2907.2010.00178.x

Turvey, S.T., Pitman, R.L., Taylor, B.L., Barlow, J., Akamatsu, T., Barrett, L.A., Zhao, X., Reeves, R.R., Stewart, B.S., Wang, K., Wei, Z., Zhang, X., Pusser, L.T., Richlen, M., Brandon, J.R., & Wang, D. (2007). First human-caused extinction of a cetacean species? Biology Letters, 3, 537-540. https://doi.org/10.1098/rsbl.2007.0292

Tyack, P. (1985). An optical telemetry device to identify which dolphin produces a sound. Journal of the Acoustic Society of America, 1892-1895.

Vermeulen, E., Fruet, P., Costa, A., Coscarella, M., & Laporta, P. (2019). *Tursiops truncatus* ssp. *gephyreus*. The IUCN Red List of Threatened Species, 2019, e.T134822416A135190824. https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T134822416A135190824.en

Wakefield, S., Knowles, J., Zimmermann, W., & van Dierendonck, M. (2002). Status and Action Plan for the Przewalski's Horse (*Equus ferus przewalskii*). In P. Moehlmann (Ed.), Equids: Zebras, Asses and Horses (pp. 82-92). Cambridge, UK: IUNC/SSC Equid Specialist Group, IUCN Publications Services Unit.

Walters, J.R., Derrickson, S.R., Fry, D.M.D., Haig, S.M., Marzluff, J.M., & Wunderle Jr., J.M. (2010). Status of the California condor (*Gymnogyps californianus*) and efforts to achieve its recovery. Auk, 127, 969-1001. https://doi.org/10.1525/auk.2010.127.4.969

Wang, D. (2009). Population status, threats and conservation of the Yangtze finless porpoise. Chinese Science Bulletin 54, 3473–3484. https://doi.org/10.1007/s11434-009-0522-7

Wood, F.G., Jr. (1977). Births of porpoises at Marineland, Florida, 1939 to 1969, and comments on problems involved in captive breeding of small cetacea. In S.H. Ridgway, & K. Benirschke, K. (Eds), Breeding Dolphins: Present Status, Suggestions for the Future (pp. 47-69). Washington, DC: Marine Mammal Commission.