



Science Alone Won't Do It! South Africa's Endangered Humpback Dolphins *Sousa plumbea* Face Complex Conservation Challenges

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The Indian Ocean humpback dolphin (*Sousa plumbea*) is “endangered” with likely less than 500 animals remaining in South African waters. Established in 2016, the SouSA Consortium is a formalised network of scientists and conservationists to combine knowledge and research efforts, and make coordinated decisions with the aim of conserving the species. The first collaborative project collated available photo-identification data in an attempt to refine a national population estimate and investigate movements between research sites. This work was able to identify 250 uniquely marked individuals, with the population divided into the south-coast (Agulhas bioregion) and east-coast (Natal bioregion) populations. Environmental factors almost certainly play a role in the declining numbers of the species in South African waters. However, individual threats and solutions are challenging to identify as the South African marine environment is undergoing significant natural and anthropogenic changes with major shifts in the distribution and numbers of some prey, competitor and predator species. Therefore, we believe that a continued investigation of potential contributing factors and their interaction will take too long, inevitably resulting in another case of documenting extinction. With this in mind, we present the results of a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis in an effort to help us identify the next steps to take toward the conservation of humpback dolphins in South African waters. We unanimously conclude that no single cause for the rapid decline of humpback dolphins

in South African waters can be identified, and that the cumulative effects of multiple stressors, which are difficult to pinpoint and mitigate, are impacting population numbers. While highlighting the need for continued research, we suggest a shift toward more action-focused conservation efforts, the first concrete steps being the development of a Conservation Management Plan with input from other stakeholders.

Keywords: cetacean, coastal impacts, cumulative impacts, Indian Ocean humpback dolphin, SWOT analysis, consortium

INTRODUCTION

The rapid global decline in biodiversity is evident in marine ecosystems (Sala and Knowlton, 2006), with an associated loss in important ecosystem services (Worm et al., 2006). Small cetaceans are not exempt from this trend and an increasing number of species and populations are of conservation concern (Jefferson, 2019; Nelms et al., 2021).

In 2015/16, the Indian Ocean humpback dolphin (**Figure 1**) was listed as “Endangered” by both the International Union for the Conservation of Nature (IUCN; Braulik et al., 2015a) and the Red List of Mammals of South Africa (Plön et al., 2016). These assessments identified the species as the first, and to date only, endangered marine mammal resident in South African waters. Interestingly, humpback dolphins are one of the better studied cetaceans in southern Africa. Research since the late 1960s (Elwen et al., 2011) has covered a wide range of topics, including socio-ecology (Saayman et al., 1972; Saayman and Tayler, 1979; Cockcroft, 1999; Karczmarski and Cockcroft, 1999; Karczmarski, 1999; Karczmarski et al., 1999a,b; Koper and Plön, 2016), diet (Barros and Cockcroft, 1999), anatomy (Plön et al., 2012, 2018), distribution, habitat use, and movements (Atkins et al., 2004; Koper et al., 2016; Bouveroux et al., 2018; Vermeulen et al., 2018), population abundance estimates (Keith et al., 2002; James et al., 2015), vulnerability to direct human impacts such as bycatch in shark nets (Cockcroft, 1990, 1994; Atkins et al., 2013, 2016), vessel traffic (Karczmarski et al., 1997; Koper et al., 2016), health assessment, and pollutant loads (Cockcroft, 1999; Lane et al., 2014; Gui et al., 2016; Aznar-Alemany et al., 2019), acoustics (Frainer et al., 2019), and global population structure (Mendez et al., 2011, 2013). This species naturally occurs in small populations (Braulik et al., 2015a) and in the late 1990s, it was estimated that fewer than 1,000 individuals existed in South African waters (Karczmarski et al., 1999b). Although several abundance estimates for the species existed historically, these were geographically restricted, i.e., not obtained across the entire range of the species all from isolated study sites, making an overall assessment of the species within South African waters almost impossible (James et al., 2015).

Some of the early threats and concerns that led to the revised/updated conservation status were bycatch in shark nets (Cockcroft, 1990, 1994; Atkins et al., 2013, 2016), pollutant loads (Cockcroft, 1999), and observed changes in group sizes and behaviour (Koper et al., 2016). Recent publications have highlighted some additional key changes in the South African population, which have raised some concern. Notably Gui et al. (2016) and Aznar-Alemany et al. (2019) have shown that levels

of PCBs and flame retardants are above the likely effect threshold for impairment of immune function for the species, while several studies have suggested a declining population. Bouveroux et al. (2018) corroborated data from Koper et al. (2016), showing significant decreases in sighting rates, group sizes, the number of overall identified animals and an increase in the occurrence of solitary individuals in Algoa Bay. Similar trends have been reported from Plettenberg Bay (Greenwood, 2013) and Richard's Bay (Atkins et al., 2013, 2016).

Although these studies provided important baseline information and identified threats to the species, some key information is missing, such as a reliable national abundance estimate that would allow documentation of population trends. There was thus a recognised need for increased collaboration, cooperation, and data sharing between scientists and conservation groups working with humpback dolphins. Consequently, we formed a nationwide research collaboration, the SouSA Consortium, in 2016 to address the conservation biology of humpback dolphins at a national scale. The Consortium involves 18 individuals from 13 different institutions with the formulated common goal to create an improved understanding of the population and conservation status of the national Indian Ocean humpback dolphin population. Members come from different backgrounds, including academia, commercial whale-watching companies, and associated conservation groups.

The first collaborative project aimed to generate an estimate of the number of humpback dolphins in South African waters. The population structure and movements between study sites was investigated using data from 13 sites collected between 2000 and 2017, spanning almost the entire species range within South Africa, from False Bay in the West to Richards Bay in the East. The results confirmed earlier work (see James et al., 2015) that humpback dolphins in South Africa are split into two populations, one on the northern KwaZulu-Natal coast centred on Richards Bay, subject to bycatch in shark nets and high levels of pesticides and from which the majority of biological samples for the species in South Africa originate, and the other along the Cape south coast from False Bay to approximately Algoa Bay. Movements between sites along the Cape south coast were substantial, with regular travel distances up to 200 km and a maximum of 500 km, suggesting a single south coast population (Vermeulen et al., 2018). Although a national abundance estimate could not be calculated, only 247 unique, well-marked individuals were identified, suggesting a total population of fewer than 500 individuals in South African waters (Vermeulen et al., 2018).



FIGURE 1 | Indian Ocean Humpback dolphins are very coastal, exposing them to a number of anthropogenic threats (Photo credit: S. Plön).

This indicates a more dire situation than previously estimated (Plön et al., 2016).

This poor conservation status is largely a function of their coastal habitat, reflecting large-scale environmental degradation as shown by recent studies on other delphinids off South Africa (Lane et al., 2014; Gui et al., 2016; Aznar-Alemany et al., 2019). The situation of the species is alarming, but not unique. Globally, several small cetacean species inhabiting coastal and riverine areas have been identified as being at risk of imminent extinction (Jefferson, 2019), including the vaquita (*Phocoena sinus*; Brownell et al., 2019; Rojas-Bracho et al., 2019; Gulland et al., 2020), the North Island Hector's or Māui dolphin (*Cephalorhynchus hectori maui*; Hamner et al., 2014; Brownell et al., 2019), the Indo-Pacific finless porpoise (*Neophocaena phocaenoides*; Mei et al., 2014), the Indus River dolphin (*Platanista minor*; Braulik et al., 2015b), the Atlantic humpback dolphin (*Sousa teuszii*; Collins, 2015), and the Taiwanese humpback dolphin (*Sousa chinensis taiwanensis*; Wang et al., 2007).

While many of these species face a clearly identifiable dominant threat, the most prevalent being bycatch from fishing gear (Brownell et al., 2019; Anderson et al., 2020), no single dominant threat has yet been identified for the Indian Ocean humpback dolphin off South Africa. Rather, factors causing the decline include, but are not necessarily limited to, the following (Plön et al., 2016):

- continued bycatch in shark nets (limited to Richards Bay/KZN; Cockcroft, 1990; Atkins et al., 2013; Atkins et al., 2016);
- depletion of food source due to overfishing/climate change/indirect habitat degradation and noise (Driver et al., 2012; Koper and Plön, 2012; Plön et al., 2015; Koper et al., 2016);
- direct habitat degradation due to coastal development and human use of the coastal zone (building of harbours, tourism, including marine sporting events (such as boat racing, triathlons, and sea kayaking), whale watching vessels, etc. (Driver et al., 2012; Koper et al., 2016);
- increased noise pollution (from recreational use of watercraft, e.g., small boats, jet skis; fishing vessels; commercial

shipping, construction, and dredging, etc. (Koper and Plön, 2012); and

- increased levels of chemical pollutants [from agriculture, industry, etc. (Cockcroft, 1999; Gui et al., 2016; Aznar-Alemany et al., 2019)].

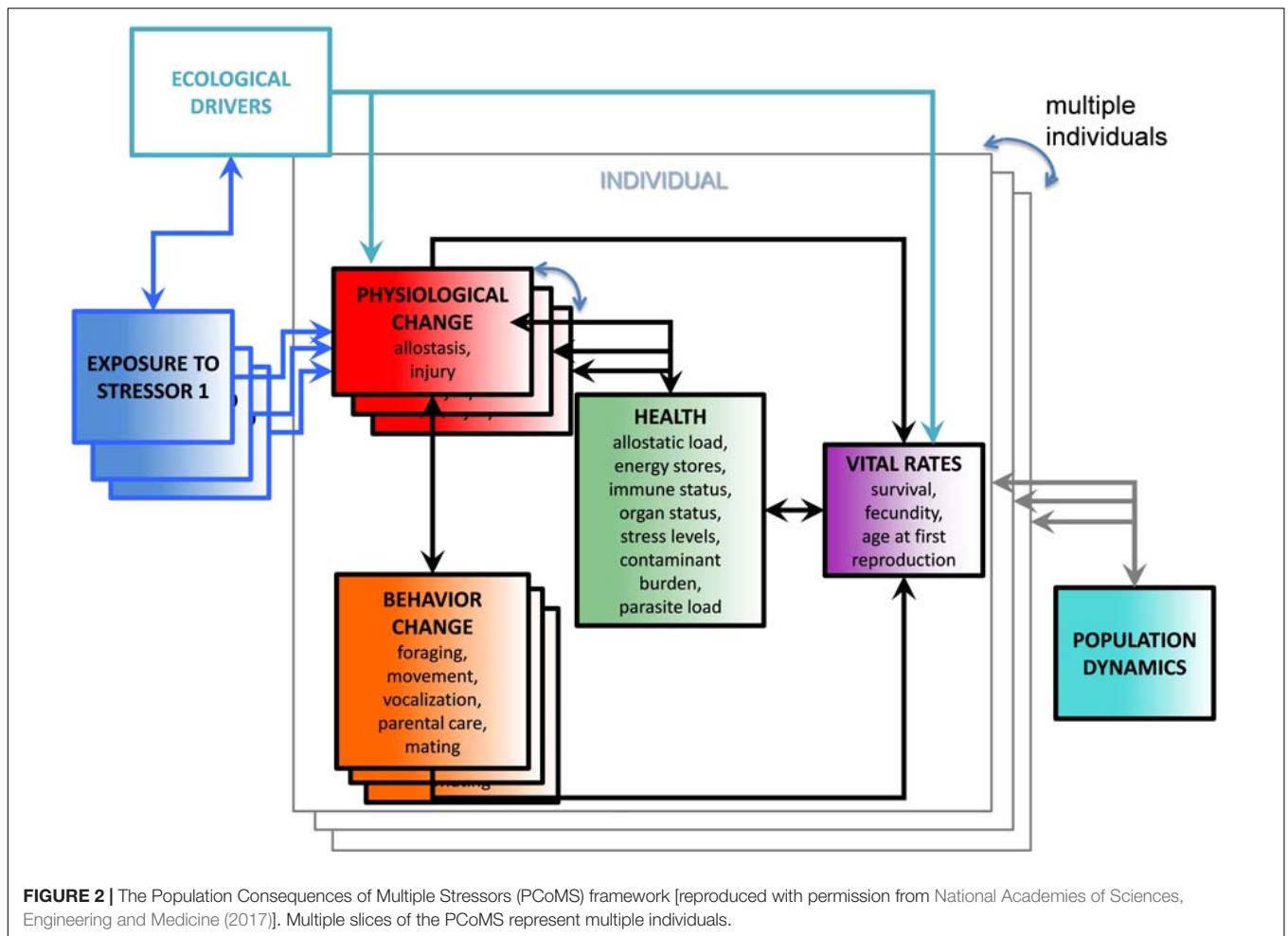
This situation of several cumulative impacts driving the rapid decline of a small cetacean species is reflected in the recent extinction scenario of the baiji, China's Yangtze river dolphin (*Lipotes vexillifer*). This species was declared likely to be extinct in 2006 (Turvey et al., 2007) and its extinction was likely a consequence of "the progressive ecological deterioration of the Yangtze region" (Turvey et al., 2007). The major contributing factors identified were habitat loss, entanglement in fishery gear, and ship strikes (Turvey et al., 2007).

Evaluating risks to marine mammal populations often requires an understanding of the full array of stressors as well as the complex interactions between anthropogenic and natural stressors, such as changing climatic conditions, prey, competitors, predators, pathogens, and pollutants, that alter ecological drivers (Figure 2; National Academies of Sciences, Engineering and Medicine, 2017; Pirodda et al., 2018). In this context, increasing levels of complexity must be taken into account as individual stressors may interact in a synergistic or antagonistic manner, where the resulting response is larger or smaller, respectively, than the total of the individual responses to various stressors (Figure 2; National Academies of Sciences, Engineering and Medicine, 2017).

As the range, relative strength and interplay of the threats impacting humpback dolphins in South African waters remain poorly understood, setting clear priority actions is extremely challenging. To address this and determine a way forward for the conservation of the species in South African waters, we conducted a SWOT (strengths, weaknesses, opportunities, and threats) analysis in an attempt to clarify the complexities of the situation and to assist us in focussing our actions as a Consortium, in the short- and long-term, to improve the conservation of the species. Here we present the results of the SWOT analysis, some insights of working as a Consortium, and discuss them within the framework of small cetacean conservation globally.

MATERIALS AND METHODS

A SWOT analysis is a process that can be used to develop a strategy in which an organisation considers its Strengths, Weaknesses, Opportunities, and Threats relative to a desired outcome. SWOT analyses are commonly used in strategic management across all disciplines (though rarely for species conservation) to identify the driving factors of change (Bull et al., 2016). It considers both internal factors (Strengths and Weaknesses that are within the control of the organisation) and external factors (Opportunities and Threats that are outside of the organisation's control) to identify those factors that can be exploited to foster performance (positive factors) and those factors that inhibit performance and should be minimised (negative factors; Martín-Collado et al., 2013; Bull et al., 2016).



We conducted a SWOT analysis with the desired outcome of advancing humpback dolphin conservation. We followed the method employed by Martín-Collado et al.'s (2013): (1) defining the system, (2) identifying and grouping the driving factors, and (3) ranking the driving factors.

(1) Defining the system.

We defined the system from our perspective and considered “internal factors” to be within our control to advance the conservation of humpback dolphins in South African waters.

(2) Identifying and grouping the factors.

All core members contributed to a list of perceived strengths, weaknesses, opportunities, and threats. Then three of us (GP, SA, SP) standardised the terminology, made full sentences out of phrases, and identified the actors in the statements. The other core members reviewed and corrected any misinterpretations. Next, these SWOT statements were assigned to four themes: Governance, Logistics, Knowledge, and Ecology (Table 1). “Governance” included formal and informal structures that support future conservation efforts, e.g., national legislation, the SouSA Consortium and international organisations. “Logistics” included funding, physical needs (research equipment, access to areas), and human capacity. “Knowledge” included research, public knowledge and government awareness. “Ecology”

included species-specific and habitat-specific factors, e.g., the shy and elusive nature of humpback dolphins, habitat preference restrictions (working in surf zone, overlap with human activities, etc.). Some statements were assigned to multiple themes, e.g., some spoke to both Governance and Knowledge.

(3) Ranking the factors.

All core members independently ranked the statements within the four SWOT categories in order of importance, with 10 being the most important and 1 the least. In categories with more than 10 statements, we ranked the top 10 and allocated zeros to the remaining statements. Finally, we averaged the scores for each statement (Supplementary Table); a summary is presented in Table 2.

RESULTS

We were mostly in agreement about the main Strengths and Opportunities, with average ranking scores of 8.1 and 9.2 for the most important “Strength” (i.e., “We are aware of the fact that progress on conservation of humpback dolphins is needed and have taken the first steps by forming the SouSA Consortium”) and “Opportunity” (“Humpback dolphins’ endangered status

TABLE 1 | Definitions of the four categories that Strengths, Weaknesses, Opportunities, and Threats statements fell into/pertained to.

G = Governance: formal and informal structures in place, e.g., national government, legislation, consortium, international organisations

L = Logistics: financial, human capacity, physical (boats, access to areas)

K = Knowledge: includes research, public knowledge, and awareness

E = Ecological: inherent habitat and species-specific factors that influence progress

TABLE 2 | Factors of the SWOT with an average rank > 5.

Strengths	Weaknesses
<ol style="list-style-type: none"> 1) Consortium formation – awareness that conservation of humpback dolphins is needed, and have formed SouSA Consortium 2) Specialist skills – varied specialised research skills available within the Consortium 3) High profile research underway – current national-level research, and new scientific outputs will increase the profile of humpback dolphins and the SouSA Consortium, locally, and internationally 4) Available data – good biological data available for data mining to address gaps, e.g., calving rates and skin disease 	<ol style="list-style-type: none"> 1) Multiple threats – difficult to prioritise conservation actions 2) Funding – lack of large and long-term funding 3) Insufficient engagement with government – despite “in theory” support, in practice there has been less engagement with the government than we had hoped 4) Different benchmarks of success – SouSA Consortium is composed of biologists who use scientific measures of success (e.g., publications), which are different to those for conservation (e.g., engagement with non-scientists)
Opportunities	Threats
<ol style="list-style-type: none"> 1) Conservation status recognised – humpback dolphins' Endangered status formally recognised, nationally, and internationally 2) Government support – SouSA Consortium has some support from government (recognition of conservation status of species, offer to share equipment, comment on whale watching regulations, invitations to meetings, etc.) 3) Legislative support – some legislation that South Africa is committed to protecting humpback dolphins, e.g., Threatened or Protected Species regulations, and South Africa is party to CITES (<i>Sousa</i> spp. are listed in Appendix 1) 4) Flagship species – humpback dolphins can be considered a flagship and an indicator species, increasing possibilities for engagement with decision makers 5) Available learning opportunities – the South African National Biodiversity Institute (SANBI) published the National Biodiversity Assessment, SouSA Consortium can learn about government's perspective on biodiversity and conservation 	<ol style="list-style-type: none"> 1) Multiple threats – no single, clear, identifiable threat to humpback dolphins (combatting multiple threats is very difficult) 2) Conflicting government priorities – difficulty gaining support of government at different levels due to conflicting departmental mandates and priorities 3) “Wicked problems” – the threats to humpback dolphins constitute “wicked problems,” i.e., social problems that are difficult to solve because of incomplete or contradictory knowledge, the number of people and needs involved, the large economic burden, and the lack of boundaries with other problems 4) Impacts from all sides – humpback dolphins' coastal habitat is impacted by human activities in multiple environments: marine, terrestrial, and freshwater

is formally recognised, nationally, and internationally”), respectively (**Table 2** and **Supplementary Table**). There was a greater spread in opinions on what the main Weaknesses and Threats were, with average scores of 7.5 and 7.3, respectively (highest ranked Weakness: “Multiple threats to humpback dolphins make it difficult to prioritise conservation action”; highest ranked Threat: “There is no single, clearly identifiable threat to humpback dolphins (combatting multiple threats is very difficult).”

The identified Strengths mostly relate to our research skills and our research outputs; we know a substantial amount about the species, we know that they need action, and are in a good position as a group of scientists to keep adding to this knowledge and extracting more information from the data we have already collected.

The top Weaknesses were varied and pertained to a lack of resources: knowledge resources, financial and networking resources and the fact that, as scientists, our benchmarks of success may differ from those of conservationists.

The top-ranked Opportunities mostly relate to the fact the conservation and public profile of the species is on the rise,

and there are structures in place that we can use to keep making progress.

The top four Threats were all related to the many and broad nature of threats to the species and the difficulties in combatting them.

When it came to assessing the themes that the highest ranked SWOT statements were assigned to, the clearest outcome was for the Opportunities, in which 64% of our statements related to Governance (**Table 3**). Governance is often associated as being an obstruction to conservation; however, it was identified here as being one of the strongest opportunities we have to raise the profile of the species and to gain support from official channels. This is reflected in the fact that almost all members who contributed to this SWOT analysis ranked the most important opportunity the fact that humpback dolphins are already formally assessed nationally and internationally as being “Endangered” (**Table 2** and **Supplementary Table**).

In summary, the results show that our Strengths relate to our “knowledge” (as a Consortium of scientists), Weaknesses are “logistics” and “knowledge,” and Opportunities are strongly related to “international governance” (international recognition

TABLE 3 | Percentage of statements that fell into each of the categories of Governance, Logistics, Knowledge, and Ecology and how these are distributed between the SWOTs.

	Governance	Logistics	Knowledge	Ecology
Strengths	35.29	23.53	41.18	0
Weaknesses	22.73	36.36	31.82	9.09
Opportunities	63.64	9.09	0	27.27
Threats	33.33	16.67	30	20.00

Green cells represent the highest, and pink cells are the lowest (i.e., least important).

of species' plight and the Consortiums reputation among national and international organisations). However, the Threats are mostly related to "national governance." "Ecology," i.e., the inherent nature of the species and its habitat, did not factor highly in the SWOT analysis and is therefore not seen as a major hurdle to making progress. It is encouraging that the scientists working on this species are optimistic that the challenges related to working with the species (which are quite substantial in some instances) are not insurmountable and that with the right support (i.e., governance and logistics) these can be overcome. However, all the anthropogenic pressures on the coastal region of South Africa occur, or are concentrated within, humpback dolphin habitat and threaten the species' survival in ways that are challenging to quantify. For example, pollutant loads are likely a result of pollution from rivers with multiple industrial, urban, and agricultural origins. Ranking these threats to the survival of the species is difficult and we lack an understanding of the effect of cumulative impacts (Plön et al., 2016).

Based on the best available knowledge, we were able to identify the following priority actions recommended as a starting point to address the poor conservation status of Indian Ocean humpback dolphins in South Africa. We hope that these can form the basis of a Conservation Management Plan (CMP):

- Critical areas: based on the best available data, the following coastal areas can be identified as critical areas for the species in South African waters, many of which are associated with estuarine environments and shallow rocky reefs: Uilkraal River Mouth, Pearly Beach, Struisbaai, Breede River estuary, Duiwenhoks estuary, Stilbaai, Vleesbaai, Mossel Bay (mainly Klein Brak estuary), Knysna Estuary, Buffels Bay, Plettenberg Bay, Algoa Bay, and Richards Bay.

However, humpback dolphins are highly mobile, covering distances up to 500 km (Vermeulen et al., 2018). Therefore, coastal areas between these critical areas are also vital to ensure healthy gene flow in the population and prevent population segregation.

- Improve habitat quality in critical areas, including (in no particular order):

- Prevent further habitat degradation (for example from harbour constructions) through engagement with developers, proper environmental impact assessments, and development of artificial reefs to help regenerate fish stocks.
- Reduce noise levels from both commercial sources and coastal construction, as well as sport and recreational boating.

- Further removal of shark-nets in KZN: a strategy to replace the current lethal methods of shark control with more modern, non-lethal methods should be developed to reduce the mortalities of humpback dolphins and other apex predators in the shark-nets at Richards Bay, KwaZulu-Natal.
- Prevent the further reduction of freshwater flow, especially in estuaries in KwaZulu-Natal.
- Strongly address riverine and estuarine chemical pollution levels through improved engagement with estuary forums, local and national government, and conservation authorities, etc. (waste discharge, runoffs, etc.).
- Establish no-take zones in critical areas to prevent the further decline in reef fish and other estuarine-dependent marine species. This can be achieved by combining a top-down and bottom-up approach, including local and national fishing clubs and competitions in the latter.
- Conduct a spatial analysis of the distribution and magnitude of individual threats where possible.

As a first step, we plan to convene a wider stakeholder meeting to address the above points with government regulators, shark control programme managers, conservation groups and additional stakeholders. In particular, experts to assist with spatial risk assessment will be engaged in these discussions with the aim to better quantify threats and their overlap with key habitat and to conduct further research/modelling into disentangling cumulative population level impacts of the multiple known stressors.

However, resulting from our discussions, the necessity to find financial support for dedicated personnel to drive the Consortium and the conservation of Indian Ocean humpback dolphins in South African waters has emerged as a priority recommendation.

DISCUSSION

The SWOT analysis, conducted to identify and direct efforts to improve the conservation of the species, highlighted that the multiple threats faced by Indian Ocean humpback dolphins in South African waters make it difficult to prioritise conservation action. In particular, a noteworthy, yet surprising outcome was that our top Strengths and Opportunities as well as our top ranked Weaknesses and Threats all lay within Knowledge and Governance. We recognise that although individual research projects about various aspects of Indian Ocean humpback dolphin biology need to continue, these will span longer time frames and precautionary/pre-emptive action is required in the interim.

The South African Scenario: Cumulative Impacts and "Operation Phakisa" in a Changing Environment

The cumulative anthropogenic impacts that Indian Ocean humpback dolphins currently experience in South African waters emerged in our SWOT analysis as both the main Weakness and Threat to our ability to progress with the species' conservation

efforts. In both instances, the difficulty of dealing with a multitude of stressors that are difficult to quantify, rather than a single dominant threat, were highlighted. In addition to the already existing cumulative impacts from large-scale degradation of the marine environment, the South African government implemented “Operation Phakisa” (meaning “hurry up” in Sesotho) in 2014, an initiative established to stimulate economic growth in the marine environment and develop the Oceans Economy (Findlay, 2018). The “Oceans Economy Lab” in this initiative consists of five workstreams, four of which are expected to result in increased anthropogenic noise levels in the oceans through growth in marine tourism, shipping, harbour and port development, and oil and gas exploration. The fifth workstream focuses on protected area expansion. The environmental impacts of the proposed growth in these sectors are poorly understood, but are likely to pose additional threats to the already endangered Indian Ocean humpback dolphin population off South Africa, particularly as they live in small groups and exhibit high levels of site fidelity (James et al., 2015; Atkins et al., 2016; Vermeulen et al., 2018) and thus are vulnerable as they may not be able to avoid or escape from stressors (Forney et al., 2017; Wisniewska et al., 2018).

The main Strength that emerged from the SWOT analysis is our knowledge about the species and our experience in working together as a Consortium. In particular, the diversity of specialist skills that individual Consortium members contribute presents valuable expert opinion, such as bioacoustics, population modelling, spatial analyses, and health assessments (Colson and Cooke, 2018). However, interestingly our SWOT analysis indicated that all knowledge is internal within the Consortium and that external knowledge is lacking. Therefore, we need to engage more with other groups and increase involvement in governance and policy. Although as a Consortium we have made substantial advances in our understanding of this species locally and successfully raised the profile of the species on international platforms [e.g., International Whaling Commission (IWC), Western Indian Ocean Marine Science Association (WIOMSA), Society for Marine Mammalogy (SMM), IUCN, Important Marine Mammal Areas (IMMA)], there is a lack of engagement with local and national stakeholders outside of the cetacean research field that could greatly assist with mitigating the threats to the species. For example, engagement with organisations, such as government departments working in, e.g., tourism, fisheries, and agriculture, as well as regional Estuarine Forums, could accelerate a shift toward more action-focused conservation efforts.

The main Opportunity that emerged from the SWOT analysis was that the “endangered” status of Indian Ocean humpback dolphins facilitates action in regard to governance. In particular, a number of recent developments present important mechanisms that may help facilitate a shift for the conservation of Indian Ocean humpback dolphins in South African waters:

- In late 2019, one of the newly declared IMMA's off South Africa, the “Southern Coastal and Shelf waters of South Africa IMMA,” was primarily based on Indian Ocean

humpback dolphin habitat importance for feeding and reproduction.¹

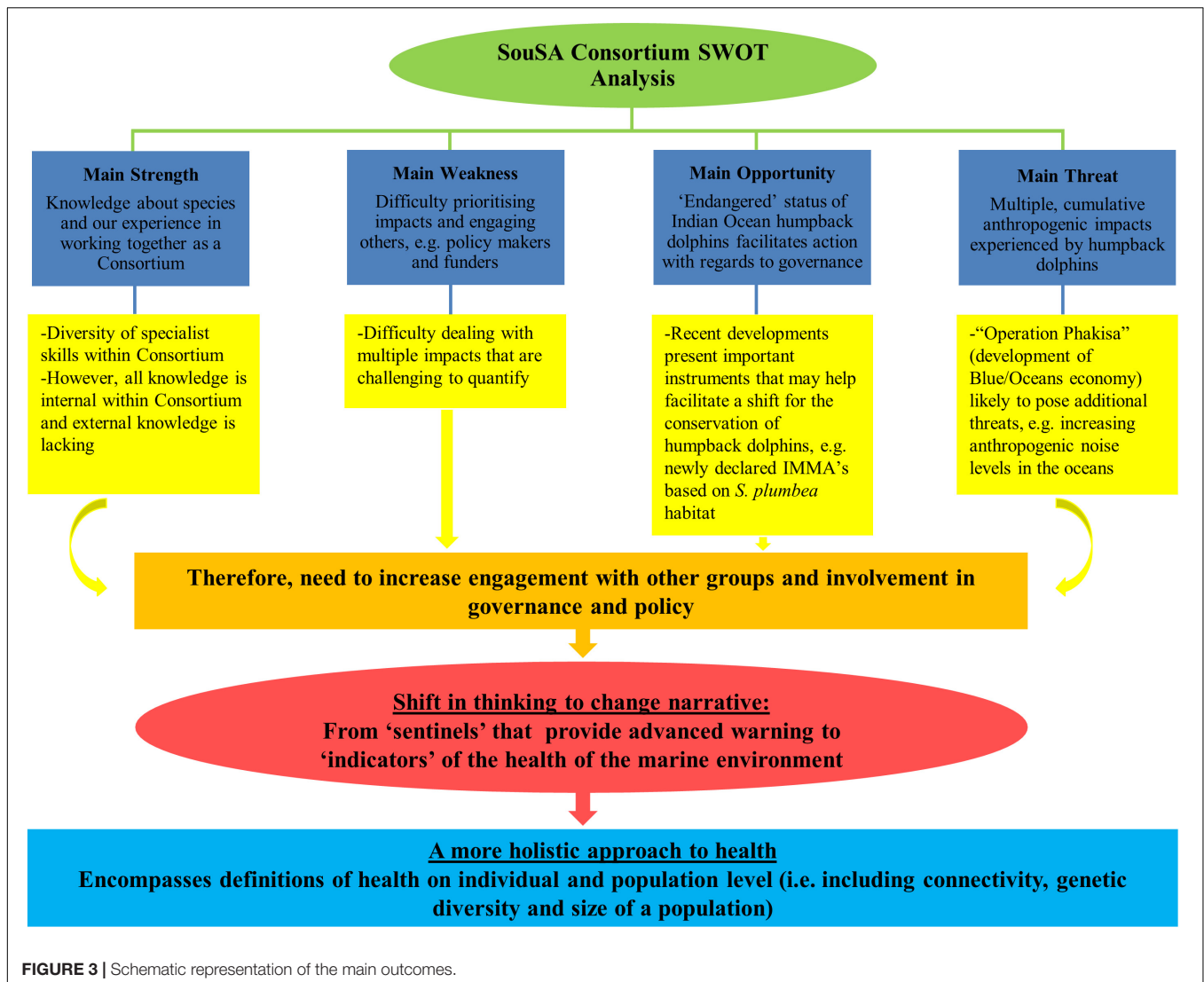
- In May 2019, 17 new marine protected areas (MPAs) and expansions to three existing coastal MPAs were formally promulgated and management regulations were defined (Government Gazettes No's 42478 and 42479 of 2019).
- In 2019, the Africa-focused *Sousa* task team of the IWC was formed with the aim to facilitate and coordinate the work recommended by the IWC. Its main goal is to start working toward developing a comprehensive framework of conservation actions as it has become increasingly clear that populations of *Sousa* spp. across Africa are in precipitous decline and that some populations may have already disappeared (IWC, 2019).
- At the World Marine Mammal Conference (WMMC) in Barcelona, December 2019, the “Judges Discretionary Award” went to Sasha Dines (Ph.D. candidate) in representation of the Consortium as “a way of recognising or highlighting something exceptional” and “an outstanding contribution to science and conservation through collaborative research.” The award recognised the impressive scope of the Consortium and its outputs. This assisted in raising the profile of Indian Ocean humpback dolphin conservation in South Africa and internationally, thus allowing further expansion of the research, and highlighted the value of science communication.
- In the past 15 years, two of the six shark nets that used to catch the most humpback dolphins in KwaZulu-Natal have been replaced with baited hooks (drumlines), which has significantly reduced the number of humpback dolphins caught (Atkins et al., 2019).

Since Ocean Economy developments are also planned in other parts of the range of Indian Ocean humpback dolphins, namely the western Indian Ocean, some of these mechanisms also provide opportunities for better ocean governance in these regions. In addition, a shift in thinking may be facilitated by changing the narrative from “sentinels,” originally used to detect risks to humans and providing advance warning of a danger (e.g., canaries in a coalmine; National Research Council (US), 1991; Bonde et al., 2004; Bossart, 2006) to “indicators” of the health of the marine environment (i.e., ocean health; Carignan and Villard, 2002; De Cáceres et al., 2010), highlighting the urgency of the situation.

Indian Ocean Humpback Dolphins as an Indicator Species for Ocean Health

The overall health of the individual is an indicator of the effects of multiple stressors, which may influence vital rates of individuals (Figure 2); the resulting effects on multiple individuals can lead to population level consequences (National Academies of Sciences, Engineering and Medicine, 2017; Pirota et al., 2018). The health of an individual therefore essentially reflects the cumulative effects of multiple stressors in this scenario, and consequently marine mammals can be viewed as indicators of the overall health of our oceans. Estimating the population-level consequences of

¹<https://www.marinemammalhabitat.org/immas/imma-eatlas/>



the responses of individuals to disturbance requires information on the proportion of the overall population that is exposed to the stressor as well as the aggregate exposure of each individual (i.e., the total duration and intensity of exposure to the stressor during a given period). In the current context, the stressor corresponds to an anthropogenic source of disturbance. However, as an individual’s health encompasses many aspects of its physiology (for example, immune status, stress levels, and contaminant and parasite load; Pettis et al., 2017), even when such assessments are possible, pinpointing the cause of observed changes in health as well as assessing interaction factors remains a challenge.

The decline noted over the last ~20 years of Indian Ocean humpback dolphins off South Africa due to cumulative impacts as a result of widespread environmental degradation is alarming. With likely fewer than 500 animals left in South African waters (Vermeulen et al., 2018), we are running out of time to research various contributing factors and halt the decline of the species, i.e., we are dealing with another case of documenting extinction. While we, as the SouSA Consortium, are making a joint effort

to address this rapid decline, the current poor and continuously deteriorating economic situation in South Africa (even pre-COVID-19) is hindering such efforts. A recent article, which highlighted the plight of all the species in the genus *Sousa*, suggested that dolphin populations in poor, developing countries receive little study and management attention (Li, 2020). While that is not necessarily the case in South Africa, financial support for the efforts of local scientists has been lacking.

The urgency of the situation of Indian Ocean humpback dolphins off South Africa – and in fact with many other cetacean populations around the globe (e.g., Desforges et al., 2018; Nelms et al., 2021) highlights the need to abandon the “sentinel” concept (Fox, 2001; Reddy et al., 2001; Wells et al., 2004) and rather recognise cetaceans as “indicators” of ocean health, encompassing definitions of health on the individual level as well as at the population level (i.e., including connectivity, genetic diversity, and population size), thus reflecting a more holistic approach to health (Figure 3). While cetaceans have been used as indicator species when examining the potential impact of noise

(Merchant et al., 2018), further studies considering cetaceans as indicators of cumulative impacts and thus the overall state of ocean health are needed.

Applying this concept to Indian Ocean humpback dolphins off South Africa in an effort to elucidate different aspects of the cumulative impacts for the species, various members of the Consortium are conducting ongoing investigations into various health aspects (Lane et al., 2014; Van Bressemer et al., 2020), molecular ecology, trophic biology, and life history (Plön et al., 2015), acoustic research as well as the behaviour and ecology of interactions with shark nets at Richards Bay, KwaZulu-Natal, where mortality risk is high (Atkins et al., 2004, 2013, 2016; Keith et al., 2013).

Lessons From Working Together as a Consortium Trying to Conserve a Species

Working as a Consortium with a common goal has allowed us, as a national community of cetacean researchers, to draw closer together, benefit from being part of a network, listen to our colleagues' varied experiences, and learn from one another. Recognising that we hold very different individual expertise has allowed us to engage on a different level and move forward together. The collaborative nature of the group has enabled the strong output to date and this in turn has aided conservation efforts across southern Africa. For students working within the Consortium, the experience of benefiting from existing study sites, and working relationships has been invaluable in feeling supported and getting new projects started. Furthermore, being a member of the Consortium has secured a high level of trust, which in turn enabled data and resource compilation and sharing. Ultimately, the formalisation of the Consortium and the members' willingness to collaborate achieved one of the core aims of the Consortium: *"to work together in an effort to make a substantial contribution to the conservation of the species"*; this has facilitated progress that would not have been achieved otherwise by individual researchers or groups. In addition, working with Consortium collaborators has led to the formation of satellite research groups for long-term data collection. As the Consortium has become better known throughout South Africa, this has helped to drive various projects forward. Being able to draw on our joint experience has been particularly beneficial when working with various communities and differing attitudes toward humpback dolphin conservation.

Going forward, we recognise that one of our strengths lies in our research skills, and that individual research projects on South Africa's Indian Ocean humpback dolphins need to be continued. However, it is clear that scientific research alone will not ensure the survival of the species and that our work needs to go beyond that, i.e., it may be more important and cost-effective to implement direct conservation actions (such as a reduction in shark nets, spatial analysis of threats, etc.) than to use resources to obtain a more robust abundance

estimate (Chades et al., 2008; Williams and Thomas, 2009) – a lesson that was also communicated early on about the vaquita (Jaramillo-Legoretta et al., 2007). We recognise that we will need to engage with other groups, such as both provincial and national conservation authorities, policy makers and experts, fundraisers, education/conservation marketing experts, as well as groups that can assist in addressing multiple, cumulative impacts (Roux et al., 2017) to access the skills we are lacking. Education and awareness plays a big part in this, particularly as the challenge of addressing cumulative impacts is to find a single focal point to highlight. The main challenge in regard to governance is that it has to be addressed at multiple levels (e.g., from fishing clubs and estuary management forums to national government), which may pose complications due to differing interests.

Conclusion and Recommendations

In conclusion, we developed a list of priority recommendations going forward. As a result of our exercise, the necessity to find financial support for dedicated personnel to drive the Consortium and the conservation of Indian Ocean humpback dolphins in South African waters has emerged as a priority recommendation. Furthermore, collaboration is imperative due to the complex nature of addressing cumulative impacts on the species. We agree that effective conservation measures would require a staged approach, starting in one location and expanding to other areas from there, recognising that threats and legislative barriers differ substantially between areas/sub-populations. For such an approach, we need to examine the individual threats to Indian Ocean humpback dolphins in more detail, especially their sources and any existing policy, followed by engagement with relevant stakeholders. We also recognise that increased awareness and education at various levels presents a vital part of conservation efforts for the species and that effective processes (e.g., Fisher et al., 2020) should be followed. In particular, increased engagement with government to declare Indian Ocean humpback dolphins a priority species for conservation should be pursued. We plan to engage more with stakeholders (public, government, legislators, etc.) through increased outreach and education and have a stakeholder meeting with invited conservation experts as well as experts from the sectors that are a threat to the species, e.g., tourism, coastal development, etc. Ultimately, we intend to develop a multi-pronged CMP for Indian Ocean humpback dolphins that defines conservation objectives and includes the required conservation actions, lead agencies, indicators of progress as well as the required resources.

Some African wisdom:

"If you want to go fast, go alone.
If you want to go far, go together."

African Proverb

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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SUPPLEMENTARY MATERIAL

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