

Mortalities of southern right whales (*Eubalaena australis*) and related anthropogenic factors in South African waters, 1999–2019

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ABSTRACT

The southern right whale (*Eubalaena australis*; SRW) population in South Africa's coastal waters has experienced marked changes since 2009, including altered feeding and migration behaviour, and decreased calving success. At the same time, anthropogenic activities in the area have increased. Based on this, an update on SRW mortalities and related anthropogenic factors is warranted. Building on the published information of Best *et al.* (2001a), data were collated on all SRW mortalities as well as non-fatal ship-strikes and entanglements along the South African coast between 1999 and 2019.

A total of 97 SRW mortalities were recorded, including three that did not result in a stranding, of which the majority were classified as calves of the year. Most of these occurred on the Western Cape coast between the months of July to November, coinciding with the seasonal presence of the species in South African coastal waters. Eleven of these mortalities could be attributed to ship-strikes whereas three mortalities related to entanglements. A total of 98 non-fatal incidents, including 16 ship-strikes and 82 entanglements with SRWs, were recorded in South Africa between 1999 and 2019. Ship-strikes occurred mainly around the area of Cape Town harbour. Entanglements occurred mainly in rock-lobster gear and bather-protection nets in the Western Cape and KwaZulu-Natal provinces respectively, although the latter did not occur between 2015–2019 attributable to the replacement of over 70% of the nets by drumlines, and the removal of the remaining nets during whale season.

In general, the incidence of SRW mortalities and entanglements decreased post-2007, coinciding with the decreased presence of SRWs along the South African coast. Available data show a relatively low rate of fatal entanglements and ship-strikes, although this may be underestimated due to the opportunistic nature of the collated data. In view of the population growth rate and the increased anthropogenic activities in South African coastal waters, continued and improved monitoring (e.g. through a more systematic reporting system) of these incidents is crucial to ensure accurate knowledge-based management decisions in the future. Possible mitigation measures aimed at reducing anthropogenic interactions are mooted.

KEYWORDS: BREEDING GROUND; ENTANGLEMENT; FISHERIES; SHIP-STRIKE; STRANDINGS

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INTRODUCTION

Each year during the austral winter months, southern right whales (*Eubalaena australis*; SRWs) migrate from their offshore summer feeding grounds at high latitudes towards the coastal waters at lower latitudes, including those of southern Africa, where they calve and nurse their young (Best, 1990a). When on the South African calving ground, SRWs mainly frequent the southern Cape coast, especially the area between Walker Bay and Plettenberg Bay (Best, 1990a; see fig. 5). Within this 500km-long stretch of coastline, they distribute non-randomly, in particular females with calves preferring those sections of the coast that provide protection from swell and seasonal winds, and have sandy seafloors with gentle slopes (Elwen and Best, 2004a). To a lesser extent, SRWs also frequent the South African west coast (between Cape Point and St Helena Bay; see Fig. 5), and although there appears to be a near year-round presence, the area seems mainly used for feeding during the spring and summer months (Barendse and Best, 2014; Best, 1990a). Though it remains unclear where the west coast whales originate from, it was suggested that substantial exchange takes place between the west and south coast in late spring/early summer, although the ingress of SRWs from further north (e.g. Namibia; Roux *et al.*, 2015) cannot be excluded (Barendse and Best, 2014).

When on their winter calving ground on the southern Cape coast, the South African population of SRWs has been studied extensively through annual aerial surveys conducted between Muizenberg and Plettenberg Bay since 1969, in order to monitor population recovery post-whaling (Best, 1970). From 1979 onwards, these annual aerial surveys have incorporated photo-identification of all females with associated calves, and individuals of a brindle or grey blaze colouration (Best, 1981; Best, 1990b; Best *et al.*, 2001b). Results of these surveys indicate a post-whaling population recovery rate of approx. 6.5% per annum, and an estimated population size of some 6,100 individuals in 2018 (Brandão *et al.*, 2018), comprising the largest breeding southern right whale stock of the global population (IWC, 2013). However, results from the past decade have shown some unusual and concerning trends, including a dramatically decreased coastal presence of unaccompanied adults (adults not associated with a calf), enormous fluctuations in annual coastal prevalence of cow-calf pairs, and an increase in calving intervals (Vermeulen *et al.*, 2020). These changes suggest a shift in the population may be in progress, caused by a decreased reproductive success and altered distribution, rather than an increased mortality (Brandão *et al.*, 2018). This, in turn, may be related to an observed shift in foraging strategy (van den Berg *et al.*, 2021) and a reduced body condition (Thavar *et al.*, 2021) of this capital breeder, although exact links still need to be determined.

South Africa's marine and maritime domain is one of the greatest contributors of ecosystem services to human well-being in the country. In this regard, the South African Government initiated 'Operation Phakisa' in 2014 to unlock the economic potential of South Africa's oceans. Whilst such expansions are often justified through the availability of untapped marine and maritime resources or ocean extent, many of these activities are concentrated in coastal or shallow continental shelf waters or waters within the country's EEZs. There is consequently considerable potential for conflict with the environment as oceans economies expand. Although a parallel Marine Spatial Planning (MSP) initiative was initiated to mitigate possible conflicts (DFFE, 2021; Harris *et al.*, 2022), the recovery of previously impacted SRWs in coastal South Africa alongside expanding oceans economies may lead to an increase in human-whale conflict. This may include an increase in ship-strikes and entanglements in fishing gear.

In light of the above, it is clear that continuous monitoring of the SRW population in South Africa, and possible human impacts, remains critical for meaningful contributions to conservation, policy development and mitigations. Therefore, this study aims to provide data on SRW mortalities along the South African coast for the past 20 years, as well as incidences of ship-strikes and entanglements, building on the work of Best *et al.* (2001a), Best *et al.* (2011) and Meyer *et al.* (2011).

MATERIALS AND METHODS

Stranding data

Data on SRW strandings presented herein were collected between Lambert's Bay and Mossel Bay by the Mammal Research Institute Whale Unit (MRIWU) of the University of Pretoria since 1985, and between Strandfontein and

the Groot Brak River (Mossel Bay) by the Department of Forestry, Fisheries and the Environment (DFFE) since 1988. However, through the recent development of technology resulting in improved communication (e.g. smart phones with built-in cameras), more formal stranding networks (e.g. in the form of WhatsApp groups) have developed along different sections of the coast with various stakeholders involved in reporting marine mammal strandings. As a result, also the area of data collection has increased to cover the entire South African coast where mortalities were reported (either through direct reports, or (social) media channels). When made aware of a cetacean stranding, every attempt was made to attend the stranding to collect, at minimum, Level A data, which includes reporting source, species ID, date, location, number of animals, length, sex and condition (see Geraci and Lounsbury, 2005). Due to provincial and/or municipal by-law limitations, large whales such as the SRWs are rarely necropsied on site; teams therefore assessed carcasses visually for possible external signs of cause of death (large scars, evidence of entanglement, ship-strike, etc). When the stranding was in an area too distant to attend, or team members were unavailable, the stranding was termed ‘unattended stranding-MRIWU’ or ‘incidental record-DFFE’. Collectively, this effort has led to the collection of 550 cetacean strandings recorded between 1999 and 2019 along the entire South African coast, from which strandings of confirmed SRWs were extracted.

Data on whale entanglements

Between 1998 and 2005, incidental records of whale entanglements from around the country were kept by DFFE and the Dolphin Action and Protection Group (DAPG). Since 2006, the record keeping was formalised with the establishment of the South African Whale Disentanglement Network (SAWDN). This organisation was formed to safely manage the release of entangled whales using specialised equipment. It is comprised of trained volunteers from the National Sea Rescue Institute (NSRI), KwaZulu-Natal Sharks Board (KZNSB), DFFE, Centre for Sustainable Oceans (Cape Peninsula University of Technology), CapeNature, MRIWU, South African National Parks, South African Police Service, Bayworld, DAPG, various Boat Based Whale Watching and Shark Cage Diving Operators, and the Rock Lobster and Octopus Fishing Industry. Country-wide recognition, with improved reporting from (currently) 21 disentanglement stations with trained volunteers along the South African coastline. Reports of entangled whales usually come in from the public or fishing vessels to the SAWDN, NSRI or DFFE. When possible, a vessel responds with trained SAWDN volunteers on board, and every effort is made to document and disentangle the animal in the safest way possible for both the animals as well as the personnel involved. These efforts are guided by international accepted best practices (IWC, 2018) and adapted for South African practical consideration. Data are collected on location, date, species ID, sex (when possible), type of gear involved, entanglement configuration, degree of injury (fatal, severe, minor) and age class based on size. Sizes of whales were estimated against the length of the responding vessel when up close. However, not all reported whales were sighted by responding vessels. In such cases, information was collated from reporting individuals, including any photographs they could provide to confirm species, gear identification and entanglement configuration. Since human effort in disentanglements have only been formally recorded since 2006 with the formation of the SAWDN, their dataset is confined to the period 2006–2019.

The KZNSB is responsible for the deployment and maintenance of the bather-protection nets deployed along the coast of the KwaZulu-Natal (KZN) province to provide protection against shark attacks. Records of accidental entanglement of cetaceans are regarded as accurate since 1981. These nets are set at or near the surface in water 10–14m deep, parallel to the shore and 300–500m offshore. Most nets used in KZN are 213.5m long by 6.3m deep and constructed from black flat braid polyethylene with a breaking strain of 160kg. Nets used at Durban are 304.8m long by 6.3m deep and constructed from yellow braid. Anchorage is provided by four or six 35 kg stockless naval-type or Danforth sand anchors. The stretched mesh size of all nets is 51cm and the hang-in coefficient (excess webbing/total stretched webbing \times 100) is 40% (Dudley, 1997, 1995; Meÿer *et al.*, 2011). During the study period, there were changes in numbers and length of net installations deployed along the KZN coast, with a 70% reduction in the total length of netting, from 45km in the mid-1990s to 13km currently. At the same time baited drumlines were introduced as a second mode of reducing bather risk by fishing for dangerous sharks, as they are less likely to catch non-target species including cetaceans. The bather-protection nets are

serviced approximately 20 times per month by KZNSB personnel. When whales are entangled, species ID, location, date and condition (dead or alive) are recorded, and length is estimated using the servicing craft as a reference.

Between the different groups, a total of 1,274 baleen whale entanglements were recorded between 1999–2019, the vast majority in the province of KZN ($n = 1,076$). From these, data on confirmed SRWs were extracted.

Data on cetacean ship strikes

Records of ship-strikes with cetaceans in South African waters have been kept by DFFE since 1983, and later also by SAWDN. Most of these data records related to the visual assessment of stranded individuals (or detailed photographs of carcasses) for possible external signs of cause of death (as detailed above), or reports of crew on board the vessels involved. In the latter case, the type of vessel involved and degree of injury to the whale (fatal, severe, minor) were reported. This database included 81 records from which data on confirmed SRWs were extracted for further analyses.

Photographic evidence of entanglements and ship strikes in live SRW

Since 1979, annual photographic SRW aerial surveys have been conducted by MRIWU between Plettenberg Bay and Muizenberg. Details on the survey techniques are given in Best (1990a). Photographs of all individuals sighted between 1999 and 2019 were assessed for the presence of scars related to entanglement and/or ship-strikes following Best *et al.* (2001a).

Data processing

All data used in this study included at least confirmed information on date, location and species involved (SRW). In all cases, confirmation of species ID as a SRW was based on either photographs, expert opinion or detailed description. When possible, information was also collated on size (from accurate measurements of stranded individuals), age class, and sex. Age class was determined based on the findings of Best and Ruther (1992) and following Best *et al.* (2001a); individuals $< 6\text{m}$ were classified as new-born, between $> 6\text{--}8.9\text{m}$ as calves, individuals between $> 9\text{--}11.9\text{m}$ as juveniles or sexually immature animals, and those $\geq 12\text{m}$ as adults or sexually mature animals. When accurate measurements were not possible (mainly when the animal did not strand or the stranding could not be attended by experts), age class was estimated based on an expert visual assessment (of photographs or of the animal on-site (e.g. from vessel responding to an entanglement at sea)) of rostrum vs body length, and colour of whale lice on the head; adults have heads forming approximately 30% of the body length (Best, 2007), whereas this proportion in juveniles is smaller, and calves are small in size and often exhibit large patches of the reddish-orange *Cyamus erraticus* on the head (Rowntree, 1996).

Data were analysed in Excel to reflect the frequency of all events (mortalities (including fatal ship-strikes and entanglements separately) and non-fatal ship-strikes and entanglements) per year, sex, length and age class. To assess temporal trends in SRW mortalities, raw data from Best *et al.* (2001) and Best *et al.* (2011), held at MRIWU, were incorporated to gain a time-series spanning 1963–2019. To assess the geographical distribution of all reported events, QGIS (2.14.22) was used to map all SRW mortalities (including fatal entanglements and ship-strikes), and all non-fatal entanglements and ship-strikes recorded between 1999 and 2019. Tables are provided to make all raw data available.

RESULTS

Recorded mortalities

A total of 97 SRW mortalities were recorded along the South African coast between 1999 and 2019, including 94 strandings and 3 mortalities which did not result in a stranding on a beach (see Table 1).

Size compositions and sex

Accurate measurements were taken from 73 individual SRWs. Based on these measurements, 24.6% were classified as adults, 23.3% as juveniles, 12.3% as calves and 39.7% as new-born, measuring $< 6\text{m}$. (Fig. 1; Table 1).

Table 1
Known mortalities of southern right whales in South African waters, 1999–2019.
*Marks those individuals which died but did not strand on a beach, and were therefore not counted as ‘strandings’.

Field Nr	Year	Month	Day	Gender	Lat	Long	Province	Age class	Size (m)	Comment
UA	1999	9	14	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Newborn	4.95	Unknown – found dead
99/05	1999	9	16	Male	34°25'S	19°17'E	Western Cape (south coast)	Newborn	4.84	Unknown – found dead
UA	1999	10	30	Unknown	33°19'S	18°08'E	Western Cape (west coast)	Unknown	Unknown	Unknown – found dead
99/07	1999	12	3	Male	32°57'S	17°53'E	Western Cape (west coast)	Adult	12.60	Unknown – found dead
00/09	2000	7	24	Male	34°28'S	20°50'E	Western Cape (south coast)	Newborn	5.91	Unknown – stranded alive
00/10	2000	7	29	Male	32°19'S	18°20'E	Western Cape (west coast)	Newborn	4.42	Unknown – found dead
H_ANS00997*	2000	7	31	Unknown	29°56'S	31°02'E	KwaZulu-Natal	Newborn	4.50	Fatal entanglement – bathing-protection net KZNSB
00/11	2000	9	6	Female	33°55'S	18°23'E	Western Cape (west coast)	Juvenile	9.85	Fatal ship strike – unidentified vessel
00/12	2000	9	18	Male	32°40'S	18°15'E	Western Cape (west coast)	Newborn	4.43	Unknown – found dead
00/14	2000	10	12	Male	34°02'S	18°28'E	Western Cape (south coast)	Adult	15.70	Unknown – found dead
00/15	2000	10	12	Female	34°32'S	20°25'E	Western Cape (south coast)	Newborn	4.55	Unknown – found dead
01/04	2001	6	28	Male	34°10'S	18°20'E	Western Cape (west coast)	Adult	12.80	Unknown – found dead
01/06	2001	8	22	Female	32°41'S	18°14'E	Western Cape (west coast)	Newborn	5.44	Unknown – found dead
01/09	2001	9	10	Female?	34°02'S	20°51'E	Western Cape (south coast)	Newborn	5.43	Unknown – found dead
UA	2001	9	26	Male	31°49'S	18°14'E	Western Cape (west coast)	Adult	Unknown	Unknown – found dead
01/18	2001	10	12	Unknown	34°05'S	20°04'E	Western Cape (south coast)	Unknown	Unknown	Unknown – found dead
01/11	2001	10	19	Male	34°43'S	20°07'E	Western Cape (south coast)	Calf	6.00	Unknown – found dead
01/12	2001	10	29	Female	32°44'S	18°02'E	Western Cape (west coast)	Adult	14.37	Unknown – found dead
02/07	2002	7	9	Female	34°14'S	18°51'E	Western Cape (south coast)	Newborn	4.70	Unknown – found dead
02/09	2002	7	10	Female	34°03'S	20°28'E	Western Cape (south coast)	Newborn	5.20	Unknown – found dead
02/12	2002	8	15	Male	34°14'S	18°29'E	Western Cape (south coast)	Juvenile	9.00	Unknown – found dead
02/13	2002	8	15	Female?	34°05'S	22°11'E	Western Cape (south coast)	Calf	6.00	Unknown – found dead
SFRI 2002/8	2002	7 or 8	-	Male?	31°49'S	18°14'E	Western Cape (west coast)	Adult	18.00	Unknown – found dead
02/15	2002	9	7	Female	34°49'S	20°02'E	Western Cape (south coast)	Adult	12.90	Unknown – found dead
02/16	2002	9	12	Male	32°43'S	17°57'E	Western Cape (west coast)	Adult	15.00	Unknown – found dead
Poss same as 02/16	2002	9	18	Unknown	33°10'S	18°01'E	Western Cape (west coast)	Unknown	Unknown	Unknown – found dead
02/17	2002	9	24	Unknown	34°46'S	20°03'E	Western Cape (south coast)	Calf	6.29	Unknown – found dead
02/19	2002	10	16	Unknown	34°02'S	20°51'E	Western Cape (south coast)	Juvenile	9.75	Unknown – found dead
02/20	2002	10	20	Unknown	34°46'S	19°41'E	Western Cape (south coast)	Calf	6.00	Unknown – found dead
03/17	2003	6	27	Unknown	34°25'S	19°12'E	Western Cape (south coast)	Juvenile	11.00	Unknown – found dead
UA	2003	8	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Calf	6.00	Unknown – found dead
UA	2003	9	2	Female	34°04'S	22°13'E	Western Cape (south coast)	Adult	12.15	Unknown – found dead
UA	2003	9	25	Female	34°11'S	22°09'E	Western Cape (south coast)	Newborn	4.20	Unknown – found dead
UA*	2003	9	26	Female	34°06'S	18°35'E	Western Cape (south coast)	Juvenile	10.00	Fatal ship-strike – unidentified vessel
04/03	2004	7	14	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Newborn	4.50	Unknown – stranded alive
04/05	2004	8	24	Unknown	34°23'S	20°53'E	Western Cape (south coast)	Newborn	5.50	Unknown – found dead
04/06	2004	9	17	Female	33°26'S	18°16'E	Western Cape (west coast)	Adult	14.60	Fatal ship strike – unidentified vessel. Historically had been satellite tagged

Field Nr	Year	Month	Day	Gender	Lat	Long	Province	Age class	Size (m)	Comment
04/08	2004	10	-	Unknown	33°08'S	17°58'E	Western Cape (west coast)	Juvenile	11.58	Unknown – found dead
05/13	2005	7	25	Female	34°28'S	20°34'E	Western Cape (south coast)	Newborn	5.70	Unknown – found dead
SFRI 2005/9	2005	8	8	Unknown	34°26'S	19°19'E	Western Cape (south coast)	Unknown	Unknown	Unknown – found dead
05/15	2005	9	13	Female	34°05'S	18°37'E	Western Cape (south coast)	Juvenile	10.78	Unknown – stranded alive
05/16	2005	9	21	Female	34°40'S	19°28'E	Western Cape (south coast)	Adult	13.18	Fatal ship strike – unidentified vessel
2005/07	2005	9	25	Unknown	33°44'S	18°26'E	Western Cape (west coast)	Juvenile	10.80	Fatal entanglement – Rock lobster gear
UA0603	2005	9	-	Female	34°46'S	19°52'E	Western Cape (south coast)	Adult	15.20	Unknown – found dead
06/06	2006	4	5	Female	33°05'S	18°23'E	Western Cape (west coast)	Juvenile	10.00	Fatal ship strike – unidentified vessel
06/13	2006	7	21	Female	34°09'S	18°19'E	Western Cape (west coast)	Adult	14.65	Unknown – found dead
UA0607	2006	7	27	Female	33°47'S	18°22'E	Western Cape (west coast)	Unknown	Unknown	Unknown – found dead
06/15	2006	7	30	Unknown	34°23'S	20°52'E	Western Cape (south coast)	Newborn	5.00	Unknown – found dead
06/16	2006	7	30	Unknown	34°23'S	20°53'E	Western Cape (south coast)	Newborn	5.50	Unknown – found dead
06/17	2006	8	14	Male	34°37'S	20°19'E	Western Cape (south coast)	Calves	7.00	Unknown – found dead
06/22	2006	8	28	Male	34°02'S	20°51'E	Western Cape (south coast)	Newborn	4.15	Unknown – found dead
06/20	2006	9	7	Unknown	32°04'S	18°02'E	Western Cape (west coast)	Newborn	5.05	Unknown – found dead
06/21	2006	10	10	Unknown	34°28'S	20°34'E	Western Cape (south coast)	Adult	Unknown	Unknown – found dead
SFRI 2006/19	2006	10	26	Unknown	34°29'S	20°29'E	Western Cape (south coast)	Adult	~15.00	Unknown – found dead
UA0612	2006	10	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Adult	Unknown	Unknown – found dead
UA0613	2006	10	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Adult	Unknown	Unknown – found dead
UA0614	2006	10	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Calves	Unknown	Unknown – found dead
UA0615	2006	10	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Calves	Unknown	Unknown – found dead
UA0616	2006	10	-	Unknown	34°29'S	20°31'E	Western Cape (south coast)	Calves	Unknown	Unknown – found dead
07/06	2007	6	10	Unknown	32°01'S	18°17'E	Western Cape (west coast)	Adult	12.50	Fatal ship strike – unidentified vessel
07/07	2007	7	4	Unknown	32°40'S	18°16'E	Western Cape (west coast)	Adult	13.70	Unknown – found dead
SFRI 2007/7	2007	7	12	Female	34°25'S	20°52'E	Western Cape (south coast)	Newborn	4.50	Unknown – stranded alive
07/08	2007	7	20	Male	34°22'S	20°55'E	Western Cape (south coast)	Newborn	5.98	Unknown – found dead
07/09	2007	8	22	Male	32°44'S	18°11'E	Western Cape (west coast)	Newborn	4.33	Unknown – found dead
07/10	2007	8	26	Male	32°47'S	17°05'E	Western Cape (west coast)	Newborn	3.94	Unknown – stranded alive
07/11	2007	9	1	Unknown	34°25'S	21°01'E	Western Cape (south coast)	Adult	Unknown	Unknown – found dead
SFRI 2008/5	2008	3	23	Female	32°56'S	17°49'E	Western Cape (west coast)	Juvenile	~10.00	Unknown – found dead
UA	2008	8	13 or 14	Unknown	34°44'S	20°05'E	Western Cape (south coast)	Newborn	5.60	Unknown – no info provided
08/07	2008	10	23	Unknown	34°40'S	19°29'E	Western Cape (south coast)	Unknown	Unknown	Unknown – no info provided
SFRI 2009/21	2009	10	7	Male	34°02'S	20°51'E	Western Cape (south coast)	Newborn	5.00	Unknown – stranded alive
SFRI 2009/28	2009	11	9	Unknown	34°37'S	19°20'E	Western Cape (south coast)	Calves	8.06	Unknown – found dead
SFRI 2010/36	2010	11	23	Unknown	33°05'S	18°23'E	Western Cape (south coast)	Juvenile	10.30	Unknown – no info provided
SFRI 2011/08	2011	3	18	Unknown	33°49'S	18°22'E	Western Cape (west coast)	Juvenile	9.00	Unknown – found dead
SFRI 2011/09	2011	3	25	Female	33°47'S	18°22'E	Western Cape (west coast)	Adult	~15.00	Unknown – found dead
PEM N4549	2011	7	12	Unknown	33°49'S	25°40'E	Eastern Cape	Juvenile	10.60	Unknown – found dead
SFRI 2011/24	2011	8	17	Female	34°07'S	18°27'E	Western Cape (south coast)	Calves	8.28	Unknown – stranded alive
SFRI 2011/26	2011	8	27	Male	34°22'S	21°28'E	Western Cape (south coast)	Newborn	4.00	Unknown – stranded alive
SFRI 2011/27	2011	8	29	Female	34°37'S	19°19'E	Western Cape (south coast)	Juvenile	11.90	Unknown – found dead
SFRI 2012/05	2012	2	29	Male	34°23'S	21°26'E	Western Cape (south coast)	Adult	13.48	Unknown – found dead

Field Nr	Year	Month	Day	Gender	Lat	Long	Province	Age class	Size (m)	Comment
SFRI 2012/19	2012	8	13	Unknown	33°53'S	18°29'E	Western Cape (west coast)	Newborn	5.20	Unknown – found dead
SFRI 2012/21	2012	10	7	Female	34°01'S	18°29'E	Western Cape (south coast)	Adult	13.40	Fatal ship strike – ski boat
SFRI 2012/22	2012	10	9	Female	34°31'S	19°22'E	Western Cape (south coast)	Calf	6.55	Unknown – stranded alive
CET 2013/11	2013	6	28	Female	34°41'S	20°14'E	Western Cape (south coast)	Adult	13.30	Unknown – found dead
CET 2013/27	2013	11	17	Unknown	32°29'S	18°20'E	Western Cape (west coast)	Unknown	Unknown	Unknown – no information provided
CET 2014/12	2014	5	10	Male	33°51'S	18°29'E	Western Cape (west coast)	Juvenile	10.00	Fatal entanglement – octopus gear on 15/03/2014 – stranding on 10/05/2014
CET 2016/05*	2016	2	12 or 17	Male	33°49'S	18°23'E	Western Cape (west coast)	Juvenile	10.00	Fatal ship strike – unidentified vessel
CET 2016/06	2016	2	14	Female	33°56'S	18°22'E	Western Cape (west coast)	Juvenile	8.90	Fatal ship strike – unidentified vessel
CET 2016/11	2016	3	3	Female	33°45'S	18°26'E	Western Cape (west coast)	Adult	12.57	Fatal ship strike – I&J Stern Trawler Avro Warrior (701t)
WU_UA 18/09	2018	6	26	Unknown	34°08'S	18°19'E	Western Cape (west coast)	Adult	Unknown	Unknown – found dead
WU_UA18/10	2018	7	1	Unknown	34°43'S	20°07'E	Western Cape (south coast)	Calf	Unknown	Unknown – found dead
WU_UA18/11	2018	7	12	Unknown	34°01'S	24°50'E	Eastern Cape	Newborn	Unknown	Unknown – found dead
PEM N5749	2018	8	11	Unknown	33°59'S	25°16'E	Eastern Cape	Newborn	4.22	Unknown – found dead
PEM N5752	2018	8	30	Unknown	33°04'S	25°05'E	Eastern Cape	Calf	Unknown	Unknown – found dead
WU_UA18/17	2018	9	18	Unknown	34°03'S	19°22'E	Western Cape (south coast)	Calf	Unknown	Unknown – found dead
WU_AT 18/01	2018	11	7	Unknown	34°25'S	19°15'E	Western Cape (south coast)	Newborn	5.85	Unknown – found dead
WU_UA19/05	2019	3	18	Male	33°56'S	18°23'E	Western Cape (west coast)	Juvenile	9.10	Fatal ship strike – unidentified vessel
WU_AT 19/04	2019	9	30	Unknown	34°40'S	19°03'E	Western Cape (south coast)	Calf	Unknown	Unknown – stranded alive

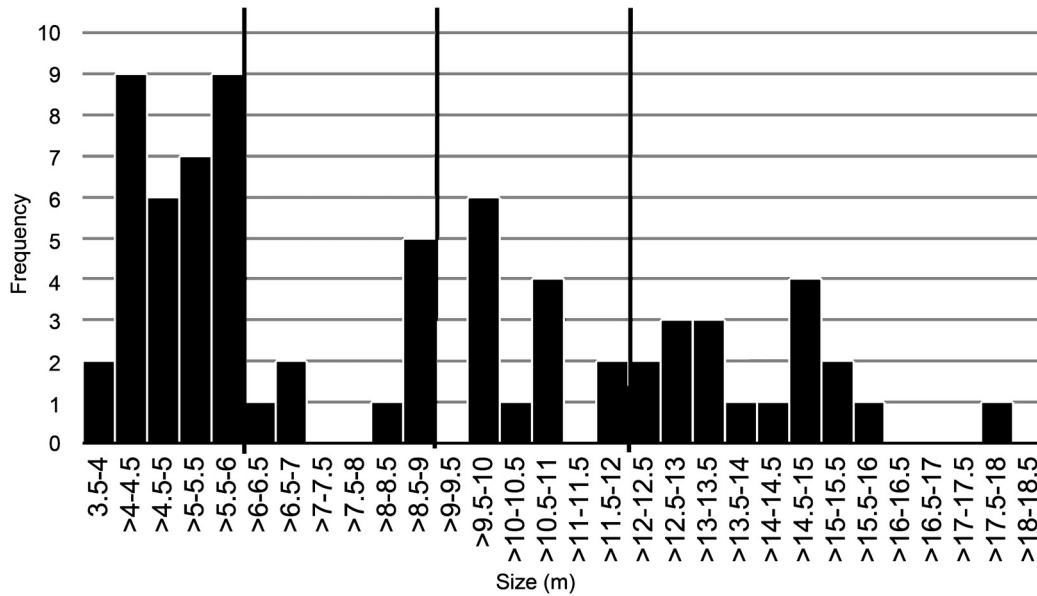


Fig. 1: Size distribution of stranded southern right whales in South African waters between 1999 and 2019, for which accurate length measurements were available (n = 73). Lines indicate the separation of age classes (newborn (< 6m), calves (6–8.9m), juveniles (9–11.9m), adults (≥ 12m)).

The age class of a further 17 individuals was recorded based on a visual assessment, and included 8 adults, 1 juvenile, 7 calves and 1 new-born.

Sex was recorded for 53 individuals based on the visual inspection of the whale’s genital area, and included 28 confirmed females, 2 likely females, 22 confirmed males and 1 likely male.

Temporal trends

The annual number of recorded SRW mortalities has decreased overall since 2007 (Fig. 2). Data showed substantial interannual variation but included two years where no mortalities were recorded (in 2015 and 2017). In order to account for the interannual variation, a three-year moving average was calculated which confirmed a reduction in SRW mortalities recorded after 2007.

When considering only mortalities on the coast between Plettenberg Bay and Muizenberg, where the annual aerial survey is undertaken each year (Best, 1990a; Best *et al.*, 2001b), and assessing them as a proportion of

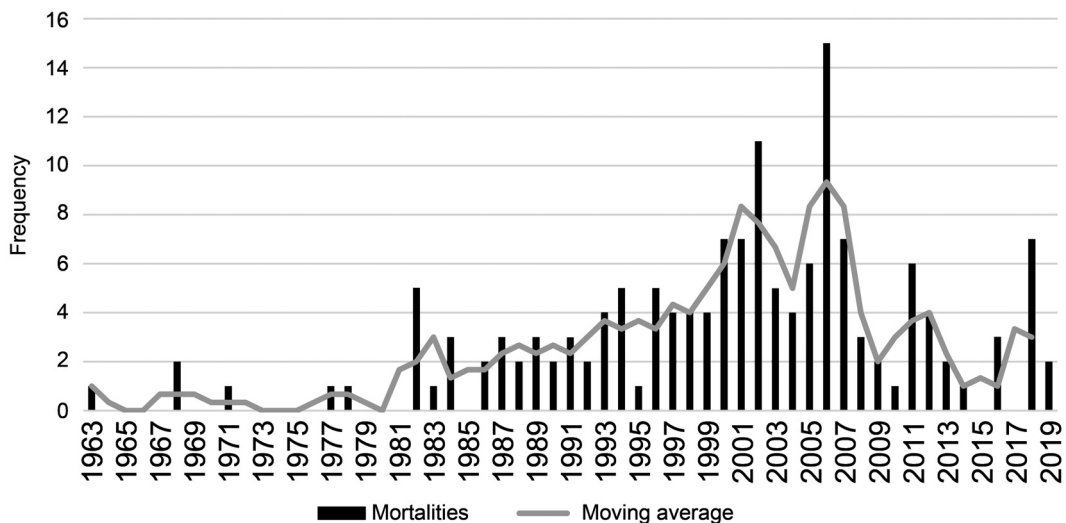


Fig. 2: Absolute frequency and three-year moving average of southern right whale mortalities per year, between 1963 and 2019, incl. data published in Best *et al.* (2001a) and reported in Best *et al.* (2011) for the period 1963–1998.

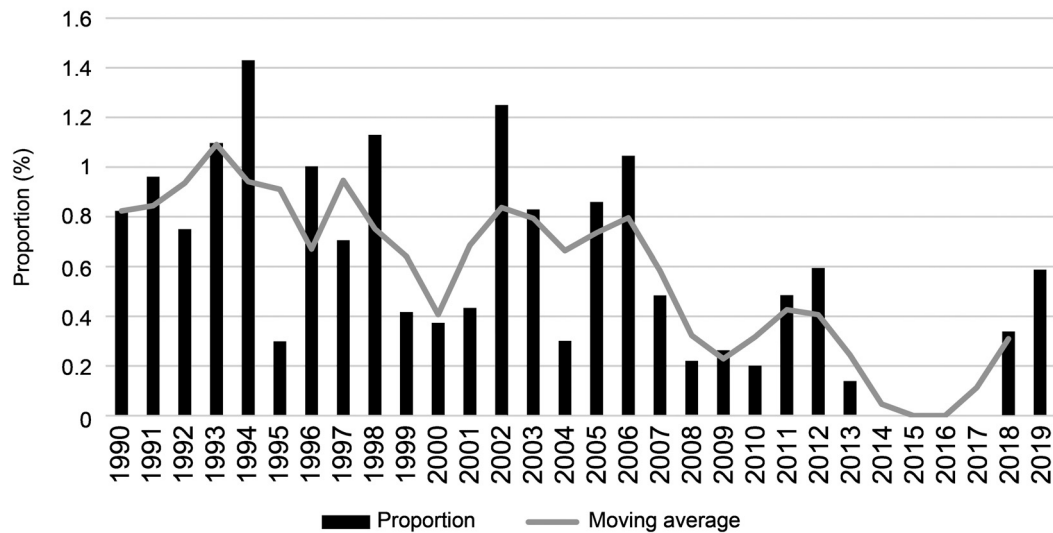


Fig. 3: Proportion and three-year moving average of southern right whale mortalities on the coastal area between Plettenberg Bay and Muizenberg in relation to the total number of southern right whales counted on the annual aerial survey over the same area (incl. cows, calves and unaccompanied adults; Best 1990a), including data published in Best *et al.* (2001a) and reported in Best *et al.* (2011) for the period 1990–1999 (the time period in which both cow-calf pairs and unaccompanied adults were consistently counted).

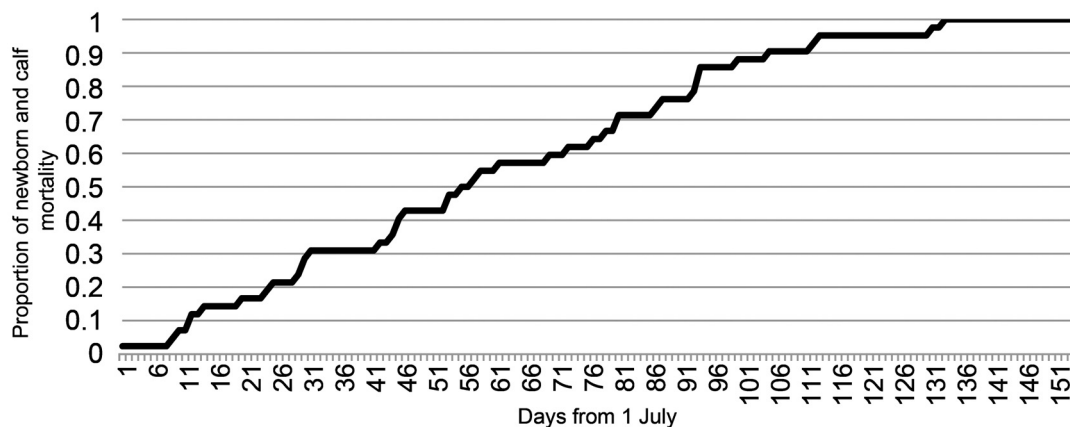


Fig. 4: Cumulative distribution of mortalities of southern right whale new-borns and calves in South African waters, against time of year (1999–2019).

the annual count of SRWs from these aerial surveys, a similar decrease can be observed post 2006 (Fig. 3). Again, to account for interannual variation, a three-year moving average was calculated, also showing a decrease since 2007.

The vast majority of mortalities (85.5%) occurred between the months July to December, coinciding with the seasonal presence of the species in South African coastal waters. All new-born and calf mortalities were recorded between July and November, with 90% of these incidents occurring by 12th October (Day 104, Fig. 4).

Causes of death

Due to by-law limitations, carcasses are usually not subjected to standard necropsy protocols. Therefore apparent causes of death could only be assessed through visual assessment of the carcass. Due to this limitation, cause of death was only reported for 14 (14.4%) SRW mortalities, and included only ship-strikes and entanglements (due to clear external cues).

Ship-strikes: In total, 11 SRWs were recorded having been fatally hit by a vessel between 1999 and 2019 (Table 1; Fig. 6). These included 5 adults and 6 juveniles, or 19.2% and 33.3% of the confirmed adult ($n = 26$) and juvenile ($n = 18$) mortality respectively, and comprised 2 males, 8 females and 1 unsexed individual. The type of

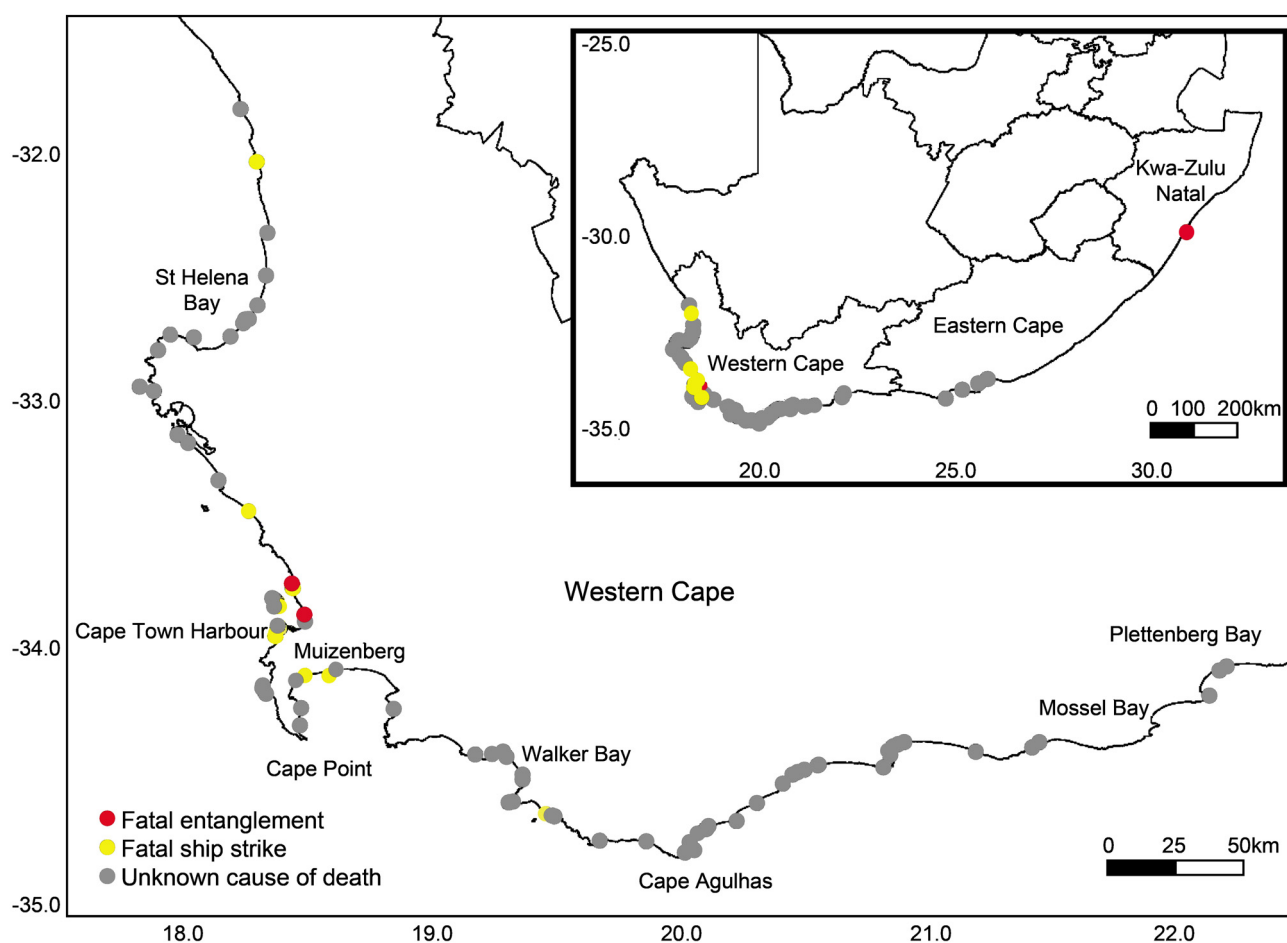


Fig. 5: Location of recorded mortalities of southern right whales off South Africa between 1999 and 2019, plus detailed map of the Western Cape province.

vessels involved could rarely be determined, but included at least one ski-boat and one trawler. Most ship-strikes occurred in the vicinity of Cape Town Harbour (Fig. 5).

Entanglements: Three SRW mortalities were attributed to entanglement in ropes and/or nets (Table 1; Fig. 7). One newborn (sex unknown) was entangled in a bather-protection net in July 2000 on the KZN coastline, one juvenile (sex unknown) in (presumed) rock lobster gear in September 2005, and one male juvenile entangled in octopus gear in March 2014, both on the Western Cape coastline.

Locality

Most mortalities ($n = 92$) occurred on the Western Cape coastline, of which 36 were on the west coast (from Cape Point northwards) and 56 on the south coast (from Cape Point eastward). Four occurred in the Eastern Cape and only one on the KZN coastline (Fig. 5).

Ship-strikes and entanglements that did not result in a recorded mortality

Ship-strikes: Sixteen ship-strikes with SRWs were recorded between 1999 and 2019 (Fig. 6; Table 2). Of these, eight did not result in a direct mortality, and the strike outcome was unknown for a further eight. These records came from three live SRWs observed with fresh propeller scars as well as 13 reports from the vessels involved. Based on a visual assessment, these included at least 3 adults and 3 juveniles. Most ($n = 10$) non-fatal ship-strikes occurred between July and December. Vessels involved included 3 ski-boats, 1 ferry, 1 water taxi, 1 commercial rock lobster vessel, 1 commercial dive vessel and 3 yachts. All these non-fatal collisions occurred in the Western Cape coastline, near the Cape Town Harbour or off the Cape Peninsula (Fig. 8).

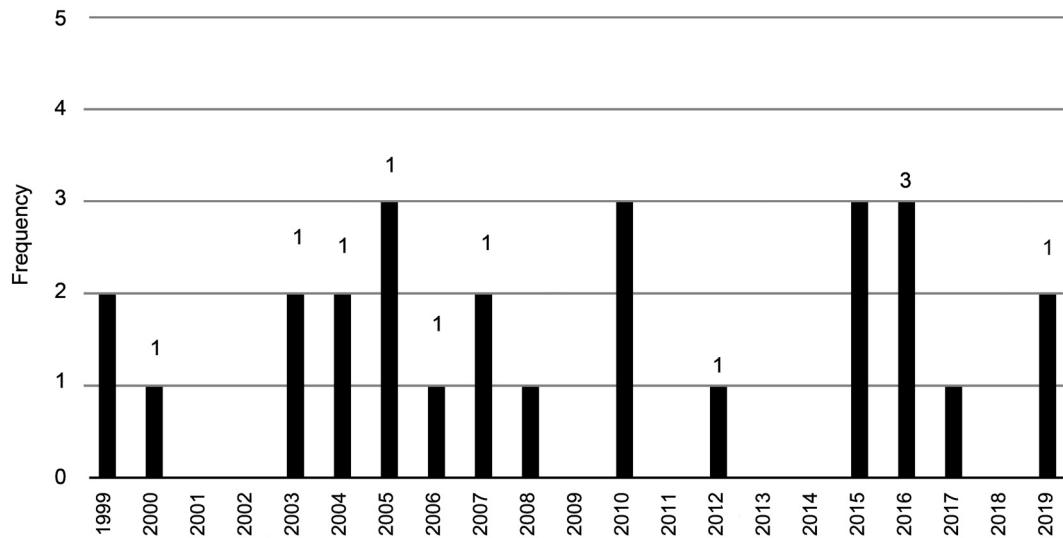


Fig. 6: Annual frequency of ship-strikes of southern right whales off South Africa from 1999 to 2019. The number of fatal collisions per year was annotated above the bars.

Entanglements: Between 1999 and 2019, 82 SRW entanglements were recorded which did not result in an observed mortality (Table 3; Fig. 7). Based on an assessment of the reported size of the individuals, these included at least 12 adults, 17 juveniles and 4 calves, while the age class of the remaining 49 whales was undetermined. In nearly all cases, the sex of the individuals involved remained undetermined, with only 6 confirmed females. Of all 82 entangled whales, at least 26 were partly or fully disentangled by human intervention, while 25 managed to break free from the gear. Of these latter, three animals were observed again at a later date including one which was then disentangled from the remaining gear. For 31 individuals, there was no intervention possible and their outcome remained unknown.

Most non-fatal entanglements (70%) occurred between July and October. In general, the annual frequency of reported SRW entanglements decreased after 2009 (Fig. 7).

The majority of non-fatal SRW entanglements involved rock lobster (*Jasus lalandii*) gear (40.2%; n = 33; Table 3) and bather-protection nets (26.8%; n = 22). Unidentified ropes (8.5%; n = 7), gear for octopus fishing (6.1%; n = 5), likely longline (3.7%; n = 3), unidentified nets (3.7%; n = 3), likely rocklobster gear (2.4%; n = 2), tuna-

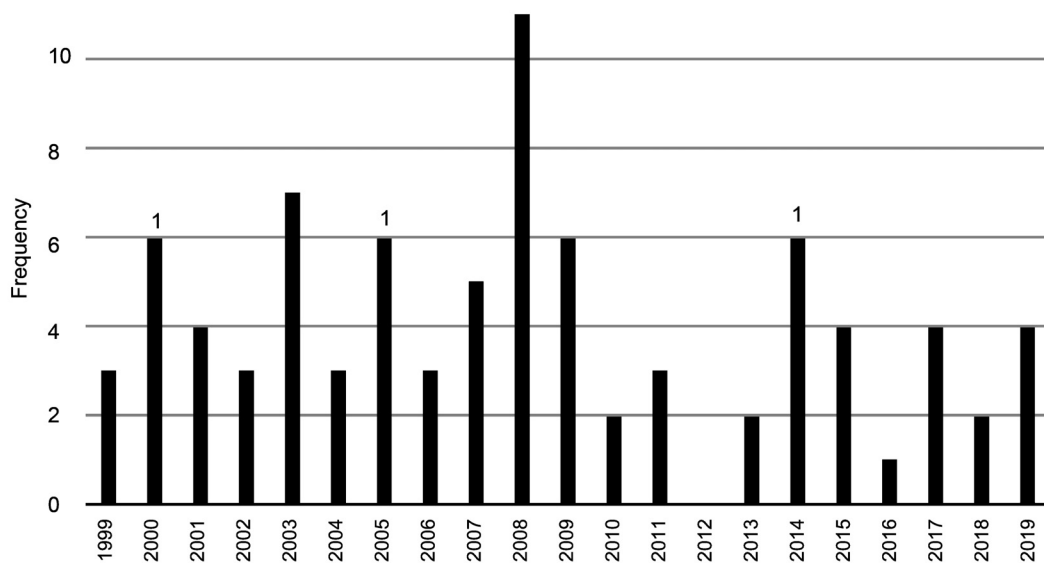


Fig. 7: Total frequency of entanglements of southern right whales off South Africa from 1999 to 2019. The number of entanglements resulting in a mortality was annotated above the bar.

Table 2
Reported ship–strikes with southern right whales in South African waters between 1999 and 2019, which did not result in an observed mortality.

Year	Month	Day	Gender	Lat	Long	Area	Location	Age class	Size (m)	Result	Relevant stranding nr	Vessel type	Comment
1999	9		Unknown	34°3'S	18°21'E	Western Cape	Hout Bay	Unknown	Unknown	Unknown	–	Ski-boat	Went over whale, skeg damaged
1999	12	3	Unknown	29°49'S	17°04'E	Western Cape	Jakkalsbaai	Adult	12.60	Unknown	–	Unidentified vessel	–
2003	Unknown	–	Unknown	–	–	Unknown	Unknown	Juvenile	Unknown	Serious but not fatal	–	Unidentified vessel	Struck by propellor of large ship
2004	7	–	Unknown	34°35'S	19°20'E	Western Cape	Gansbaai	Unknown	Unknown	Unknown	–	Ski-boat	People thrown overboard
2005	2	1	Unknown	33°53'S	18°28'E	Western Cape	Table Bay	Unknown	Unknown	Unknown	–	Yacht <i>Shoshalozza</i>	Vessel has damaged keel, two yachtsmen injured
2005	2	22	Unknown	33°53'S	18°26'E	Western Cape	Bell Buoy at CT Harbour	Unknown	Unknown	Minor	–	Robben Island ferry <i>Makana</i> at ~12h00	Divers could not find damage to vessel
2007	12		Female	34°32'S	19°22'E	Western Cape	Hermanus Die Plaat	Adult	Unknown	Minor	–	Unknown vessel	Cow/caif seen during aerial survey
2008	8	6	Unknown	34°12'S	18°22'E	Western Cape	Scarborough	Unknown	Unknown	Unknown	–	Commercial Rock lobster vessel	Struck whale not seen
2010	7	18	Unknown	33°53'S	18°25'E	Western Cape	Off Cape Town Harbour	Juvenile	Unknown	Unknown	–	Yacht – <i>Intrepid</i> SA3588	Whale breached onto yacht, broke mast, railing and coach house. Whale swam off. Damage to whale unknown
2010	9	9	Unknown	34°11'S	18°26'E	Western Cape	Within Simonstown port limits	Juvenile	9.00	Minor	–	Water taxi – semi-rigid duck <i>Mellow Yellow</i>	Craft had 4 passengers onboard and whale popped up – skipper was travelling slowly
2010	9	21	Unknown	31°45'S	18°13'E	Western Cape	Strandfontein	Unknown	Unknown	Serious but not fatal	–	Large vessel	Seen by BBWW operator
2015	8	19	Unknown	34°11'S	18°26'E	Western Cape	Simonstown	Unknown	Unknown	Serious but not fatal	–	Unidentified large vessel	–
2015	8	20	Unknown	34°11'S	18°28'E	Western Cape	Boulders Beach	Unknown	Unknown	Minor	–	Commercial dive vessel	Strike on body and prop/keel
2015	9	26	Unknown	34°08'S	18°27'E	Western Cape	Fish Hoek	Unknown	Unknown	Unknown	–	35ft yacht <i>Bad Habit</i>	Recreation yacht taking part in Spring Regatta, ripped off transom and rudder
2017	9	21	Unknown	34°07'S	18°29'E	Western Cape	Offshore Muizenberg Beach	Adult	14.00	Minor	–	Unidentified large vessel	Seen by D. Hurwitz BBWW at 15h00. Estimated strike may have occurred 9 months ago? On ventral area roughly between genital area and flippers
2019	5	29	Unknown	32°02'S	18°11'E	Western Cape	6.5nm NW Lamberts Bay	Unknown	Unknown	Unknown	–	5.3m catamaran fishing ski-boat (~11h00)	Five fishermen onboard, cracked left hull (600mm). Fishermen thrown around boat

Table 3
Reported southern right whale entanglements in South African waters between 1999 and 2019, which did not result in an observed mortality.

Year	Month	Day	Gender	Latitude	Longitude	Area	Location	Age class	Size (m)	Result	Gear involved	Comment
1999	5	27	Unknown	34°13'S	18°38'E	Western Cape	Off St James, False Bay	Unknown	Unknown	No intervention	Rock lobster gear	Grey rope and buoy round tail stock
1999	6	27	Unknown	34°9'S	18°20'E	Western Cape	5 mi S Slangkop	Unknown	Unknown	No intervention	Rock lobster gear	Crayfish trappings implicated
1999	10	10	Unknown	34°13'S	18°38'E	Western Cape	Off Glencairm, False Bay	Unknown	Unknown	No intervention	Rock lobster gear	Trailing buoy
2000	8	12	Unknown	34°34'S	19°20'E	Western Cape	Walker Bay	Unknown	Unknown	Disentangled	Rock lobster gear	Rope and Orange buoy and current buoys round tail. Seen again on 16th August when it was disentangled
2000	8	22	Unknown	34°3'S	23°22'E	Western Cape	Plettenberg Bay	Juvenile	10.00	No intervention	Rock lobster gear	3 rope strands through mouth and over top jaw and head, has a knot, 1 buoy. Dubbed <i>Princess</i>
2000	8	24	Unknown	29°32'S	31°14'E	KZN	Ballito Bay	Unknown	Unknown	Broken free	Bather-protection net KZNSB	MRI aerial survey – net? Round tail – cow with calf
2000	10	13	Unknown	34°30'S	20°29'E	Western Cape	De Hoop	Adult + calf	Unknown	No intervention	Net	
2000	10	3	Unknown	29°32'S	31°14'E	KZN	Ballito Bay	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2001	9	15	Female	33°2'S	18°1'E	Western Cape	Saldanha Bay	Unknown	Unknown	Partly disentangled	Net	St Joseph's net round left flipper, tail, anchored. 10mm diameter yellow rope and net 2mm nylon mesh net
2001	10	4	Unknown	34°32'S	19°22'E	Western Cape	Walker Bay	Unknown	Unknown	No intervention	Likely Rock lobster gear	Rope 'lasso' round tail stock – loose
2001	10	18	Unknown	34°2'S	18°22'E	Western Cape	Hout Bay	Calf	Unknown	Disentangled	Rope	Rope entanglement of calf
2001	10	23	Unknown	34°40'S	19°30'E	Western Cape	Pearly Beach	Unknown	Unknown	No intervention	Rock lobster gear	Rope + 2 buoys round tail
2002	8	30	Unknown	30°52'S	30°23'E	KZN	Margate	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2002	10	9	Unknown	34°4'S	22°13'E	Western Cape	Mossel Bay	Unknown	Unknown	No intervention	Bather-protection net KZNSB	Net + 4–5 yellow buoys round tail
2002	10	29	Unknown	33°28'S	18°6'E	Western Cape	2km from Dassen Island	Unknown	Unknown	Broken free	Rope	Resighted on 16 December 2002 Anchor rope in mouth?
2003	7	30	Unknown	30°49'S	30°25'E	KZN	St Michaels-on-Sea	Unknown	Unknown	Broken free	Bather-protection net KZNSB	Resighted on 16 th of December 2003
2003	8	22	Unknown	29°56'S	31°1'E	KZN	Ansteys Beach	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2003	8	3	Female	30°40'S	30°31'E	KZN	Banana Beach	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2003	9	12	Unknown	34°13'S	18°38'E	Western Cape	Kalk Bay – Simons-town, False Bay	Unknown	Unknown	Broken free	Rock lobster gear	Rope 6 times round tail stock + buoy
2003	9	23	Unknown	29°44'S	31°5'E	KZN	Umhlanga Rocks	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2003	10	15	Female	31°2'S	30°14'E	KZN	Port Edward	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2003	10	5	Unknown	30°17'S	30°46'E	KZN	Scottburgh	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2004	7	14	Unknown	33°49'S	18°29'E	Western Cape	Off Blaauwbergstrand	Unknown	Unknown	No intervention	Rock lobster gear	2 buoys round tail
2004	7	19	Unknown	34°14'S	18°50'E	Western Cape	Gordons Bay – Kogelbaai	Unknown	Unknown	No intervention	Rock lobster gear	Rope and buoy on side
2004	9	14	Unknown	34°14'S	18°25'E	Western Cape	False Bay, nr Cape Point	Juvenile	Unknown	Disentangled	Rock lobster gear	Ropes and buoys round tail. Wrapped at least 15 times around caudal peduncle and tail.

Year	Month	Day	Gender	Latitude	Longitude	Area	Location	Age class	Size (m)	Result	Gear involved	Comment
2005	1	20	Unknown	33°25'S	18°5'E	Western Cape	Dassen Island	Unknown	Unknown	No intervention	Rock lobster gear	2 x ropes round tail + buoys, broke free of traps, only rope and buoys attached to tail
2005	2	23	Unknown	33°56'S	18°23'E	Western Cape	Clifton/Bantry Bay	Unknown	Unknown	No intervention	Rock lobster gear	6-9 loops yellow rope round head/body, pink buoy on back with cork floats
2005	7	14	Unknown	34°23'S	18°50'E	Western Cape	Off Cape Hangklip	Unknown	Unknown	No intervention	Rock lobster gear	Entangled in ropes
2005	9	15	Unknown	34°11'S	18°37'E	Western Cape	False Bay, near Rocky Bank	Adult	13.70	Disentangled	Rock lobster gear	Rope, buoys and current buoys + crayfish traps (7 traps removed) – entanglement. Indentations in tail stock but damage minimal
2005	10	3	Unknown	34°16'S	18°34'E	Western Cape	False Bay	Unknown	Unknown	No intervention	Rock lobster gear	12 mm rope and buoys on tail
2006	1	30	Unknown	33°25'S	18°5'E	Western Cape	SW of Dassen Island	Juvenile	Unknown	Partly disentangled	Rock lobster gear	Juvenile female rope around body, head and tail, one? Trap
2006	7	11	Unknown	32°57'S	17°35'E	Western Cape	St Helena Bay	Juvenile	8.00	Partly disentangled	Net	Entangled in mullet gill net – partial grey morph
2006	8	22	Unknown	34°13'S	23°21'E	Western Cape	Plettenberg Bay off Keurboom river mouth	Unknown	Unknown	No intervention	Rope	At least 5-6 rope turns on bonnet and through baleen – brindle animal
2007	7	16	Unknown	30°6'S	30°52'E	KZN	Winkelspruit	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2007	7	31	Unknown	34°14'S	23°11'E	Western Cape	Plettenberg Bay	Unknown	Unknown	No intervention	Rock lobster gear	Green rope + yellow float around tail stock and flukes. Twice around L. fluke + 2m trialling. Rock lobster current buoy
2007	8	15	Unknown	34°0'S	22°34'E	Western Cape	Wilderness	Unknown	Unknown	No intervention	Likely longline	Yellow rope around head, unconfirmed report, shore sighting
2007	8	15	Unknown	34°3'S	23°22'E	Western Cape	Plettenberg Bay, Robberg (just south)	Unknown	Unknown	No intervention	Likely longline	Rope around body close to DF. Rope is thick
2007	10	9	Unknown	34°7'S	18°29'E	Western Cape	Pringle Bay / Muizenberg (depth 9.75m)	Juvenile	10.00	Disentangled	Rock lobster gear	2 x red buoys + 6 x floats and 110m x 17mm + 50m x 10mm yellow rope
2008	1	5	Female	34°20'S	18°49'E	Western Cape	Pringle Bay, False Bay	Adult + calf	Unknown	No intervention	Rock lobster gear	11h10 reported, cow + calf. Cow trapped in recreational ring net rope around head, animal sped off
2008	2	20	Unknown	33°26'S	18°6'E	Western Cape	Dassen Island (depth 10m)	Juvenile	10.00	Disentangled	Rock lobster gear	Red buoy, yellow float, red cork and yellow rope – 10m
2008	4	3	Unknown	34°6'S	18°20'E	Western Cape	Chapmans Peak/Kommetjie	Juvenile	10.00	Partly disentangled	Rock lobster gear	Complete trap with yellow 12mm rope + red buoy, + yellow 12mm rope + red buoy from 2nd trap
2008	6	5	Unknown	34°4'S	22°19'E	Western Cape	Glentana + Plettenberg Bay	Unknown	Unknown	No intervention	Rope	Yellow + Green polypropylene 'mooring rope' around head and tail stalk
2008	8	6	Unknown	30°55'S	30°20'E	KZN	Southbroom	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2008	8	8	Unknown	34°5'S	22°58'E	Western Cape	Struisbay/Pearly Beach/Buffels Bay	Juvenile	8.00	No intervention	Rock lobster gear	Possibly three wraps around peduncle Green + yellow ropes, pink buoy + white float
2008	8	16	Unknown	34°47'S	20°4'E	Western Cape	Struisbaai	Unknown	Unknown	No intervention	Longline Tuna	Longline – LHS Fluke = 1 wrap, RHS fluke = 2 wraps and peduncle = 1 wrap

Year	Month	Day	Gender	Latitude	Longitude	Area	Location	Age class	Size (m)	Result	Gear involved	Comment
2008	8	23	Unknown	34°13'S	22°2'E	Western Cape	Dana Bay (Mossel Bay) (depth 8–10m)	Juvenile	9.00	Partly disentangled	Longline Tuna	8–10m brindle. Tuna longline through mouth, over body both sides, trailing float
2008	9	5	Unknown	34°13'S	18°40'E	Western Cape	False Bay	Unknown	Unknown	Broken free	Unknown	Fresh entanglement scars on tail stalk – no entanglement present
2008	9	26	Unknown	29°16'S	31°27'E	KZN	Zinkwazi	Unknown	Unknown	Broken free	Bather-protection net KZNSB	–
2008	12	5	Unknown	34°26'S	19°14'E	Western Cape	Hermanus	Unknown	Unknown	Disentangled	Rock lobster gear	Ring net. 12mm blue/white ski-rope and yellow + red floats
2009	1	21	Unknown	33°55'S	18°23'E	Western Cape	Sea Point	Unknown	Unknown	No intervention	Rope + rope and buoy	Thick Yellow rope around head to flukes + large Orange buoy trailing behind flukes
2009	8	15	Unknown	34°41'S	19°30'E	Western Cape	Pearly Beach	Juvenile	8.00	No intervention	Rock lobster gear	Yellow rope + 2x white floats, whale estimated at 8m. Rope through mouth, down length and wrapped around caudal peduncle, some damage
2009	9	17	Unknown	30°3'S	30°55'E	KZN	Amanzimtoti	Calf	6.00	Disentangled	Bather-protection net KZNSB	Bather-protection nets badly entangled with panel over its back and large amount netting on tail
2009	9	19	Unknown	34°10'S	24°52'E	Eastern Cape	Keurbooms river mouth	Adult	Unknown	Broken free	Rope	Yellow nylon rope around body + tail
2009	9	20	Unknown	34°10'S	18°26'E	Western Cape	Glencairn	Unknown	Unknown	Broken free	Octopus gear	Flagged buoy
2009	10	5	Unknown	30°4'S	30°53'E	KZN	Amanzimtoti	Unknown	Unknown	Broken free	Bather-protection net KZNSB	Net #2 whale released safely
2010	7	13	Unknown	34°11'S	22°10'E	Western Cape	Glentana, Mossel Bay	Unknown	Unknown	No intervention	Rope	Red anchor rope
2010	8	14	Unknown	34°22'S	18°49'E	Western Cape	Hangklip	Juvenile	9.00	Disentangled	Rock lobster gear	Yellow rope – two wraps around each fluke + red buoy + 11m rope behind
2011	1	7	Unknown	33°26'S	18°6'E	Western Cape	Dassen Island	Adult	12.00	Disentangled	Rock lobster gear	Yellow 12mm rope (length 81.5m) orange buoy and white cork
2011	5	22	Unknown	30°8'S	30°52'E	KZN	Karridene	Juvenile	9.00	Disentangled	Bather-protection net KZNSB	Bather-protection nets top rope (14mm 7 keg floats) – 5–6 wraps caudal peduncle
2011	10	3	Female	30°4'S	30°54'E	KZN	Amanzimtoti	Adult	Unknown	Broken free	Bather-protection net KZNSB	Believed bather-protection net around caudal peduncle of cow which had a calf. Broke free
2013	1	16	Unknown	33°54'S	18°27'E	Western Cape	Bell buoy Table Bay Harbour	Adult	15.00	Partly disentangled	Rock lobster gear	Entangled in 12 mm rope and buoy, around peduncle and flukes
2013	8	12	Female	30°55'S	30°20'E	KZN	Southbroom	Adult	Unknown	Partly disentangled	Bather-protection net KZNSB	Bather-protection net around peduncle/grapnel and two keggings buoys on 30m rope
2014	4	9	Unknown	32°43'S	18°4'E	Western Cape	Sandy Point Harbour	Unknown	Unknown	No intervention	Likely longline	Had a large white buoy (with black numbers) trailing behind flukes
2014	6	4	Unknown	29°31'S	31°14'E	KZN	Thompsons Bay	Adult	10.00	Disentangled	Bather-protection net KZNSB	Bather-protection net, initially covering only the head but later fully covered in net except tail
2014	7	20	Unknown	29°41'S	31°8'E	KZN	Umdloti	Calf	8.00	Disentangled	Bather-protection net KZNSB	Bather-protection net released by lifeguards had rope and net around the tail
2014	7	21	Unknown	29°41'S	31°7'E	KZN	Umdloti	Unknown	Unknown	Broken free	Shark drumline	–
2014	9	30	Unknown	34°10'S	24°51'E	Eastern Cape	St Francis Bay	Unknown	Unknown	No intervention	Rock lobster gear	Buoy marked Regal

Year	Month	Day	Gender	Latitude	Longitude	Area	Location	Age class	Size (m)	Result	Gear involved	Comment
2015	1	29	Unknown	33°26'S	18°5'E	Western Cape	5.7nm south of Dassen Island	Juvenile	8.00	No intervention	Rock lobster gear	Reported to be ensnared on bottom. It had three wraps of 18mm rope around the body (posterior to the flippers) and had three wraps on the caudal peduncle with a tight rope joining the two areas, restricting the body to the shape of a bow. The trap had 120m of rope and it was unable to move
2015	7	29	Unknown	30°52'S	30°23'E	KZN	Margate	Adult	13.00	Disentangled	Shark drumline	Drumline around tail stock and flukes
2015	9	21	Unknown	29°1'S	32°31'E	KZN	Thompson Bay	Calf	7.00	Disentangled	Bather-protection net	Bather-protection net – net panel destroyed with head and bottom ropes were twisted together running over the animal around the left flipper then back over the head
2015	9	21	Unknown	29°31'S	31°14'E	KZN	Thompson Bay	Unknown	Unknown	Broken free	Bather-protection net	–
2016	3	2	Unknown	33°54'S	18°24'E	Western Cape	300m off Rocklands Beach CT	Juvenile	9.00	Partly disentangled	Rock lobster gear	4 ropes on back @ LHS entering cluster with current buoy and 3 ropes leaving on LHS
2017	6	20	Unknown	34°13'S	18°28'E	Western Cape	~150m off Rocklands Bay, False B	Unknown	Unknown	Broken free	Octopus gear	Seen by observer to be thrashing with yellow octopus rope crossing body
2017	8	20	Unknown	34°21'S	19°1'E	Western Cape	Between Palmiet and Kleinmond	Adult	12.00	Disentangled	Rope and buoy	The whale was dragging 20m of rope behind it with a small buoy attached. Three rope wraps were around caudal peduncle
2017	8	22	Unknown	34°9'S	18°26'E	Western Cape	Sunny Cove (False Bay)	Juvenile	10.50	Disentangled	Octopus gear	8 ropes on the flukes (including grey sinking rope and yellow floating rope, as well as concrete tyre and chain around caudal peduncle and fluke
2017	9	9	Unknown	34°16'S	18°29'E	Western Cape	Millers Point (False Bay)	Unknown	Unknown	Broken free	Octopus gear	Temporarily entangled – seen to be thrashing
2018	5	30	Unknown	34°11'S	22°10'E	Western Cape	Santos Beach Mossel Bay	Juvenile	Unknown	Broken free	Rope	Swimming safety rope. Photograph indicated whale temporarily caught on callosities
2018	8	20	Unknown	34°25'S	19°15'E	Western Cape	300m off Gearing's Point	Unknown	Unknown	No intervention	Likely rock lobster gear	Rope wrapped at least three times around caudal peduncle – no rope or buoy seen trailing behind
2019	2	21	Unknown	33°55'S	18°23'E	Western Cape	Originally 2.3nm off Sea Point	Juvenile	10.00	Disentangled	Rock lobster gear	Had 6 wraps around caudal peduncle and 3 wraps around left fluke. Has a red float with white cross on tail and attached 93m rope (14mm). Seen first on 15 February 2019
2019	4	16	Unknown	34°6'S	18°21'E	Western Cape	~1nm offshore Noordhoek	Unknown	Unknown	No intervention	Rock lobster gear	SRW in group of 6 whales feeding, yellow buoy attached to flukes and whale was dragging it down
2019	5	23	Unknown	34°22'S	18°49'E	Western Cape	18.09nm offshore Hangklip	Unknown	Unknown	Broken free	Rock lobster gear	Rope and buoy around caudal peduncle. Freed itself – rope broke
2019	6	30	Unknown	34°10'S	18°26'E	Western Cape	Clovelly Corner (False Bay)	Adult + calf	Unknown	Broken free	Octopus gear	Whale was seen to be struggling to get to surface. Adult cow had rope and a grey box on back

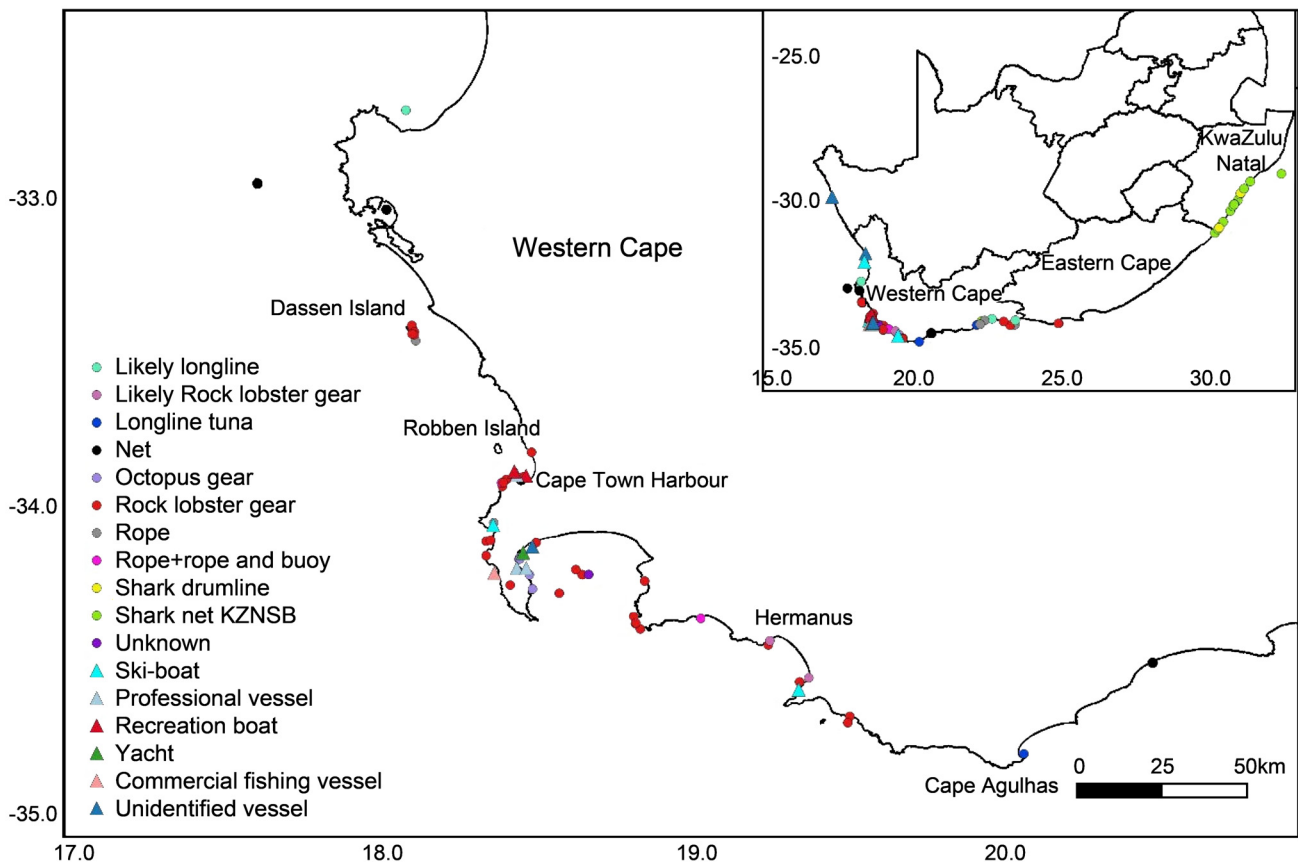


Fig. 8: Location of anthropogenic incidents that did not result in confirmed mortalities of southern right whales off South Africa between 1999 and 2019, including a more detailed map of the area around Cape Town.

longlines (2.4%; $n = 2$), ropes and buoys (2.4%; $n = 2$), shark drumlines (1.2%; $n = 1$) and unknown gear (1.2%; $n = 1$) were less involved.

Reported entanglements involving rock lobster gear have occurred annually since 1999, mainly between July and February (82%). Entanglements with bather-protection nets were mainly reported between July and October (86%), however there have been no reports of entanglements in bather-protection nets between 2015 and 2019. Entanglements in other type of gear was reported sporadically throughout the year. Entanglements in octopus gear was only reported after 2009 when experimental fishing became more prolific, while other gears such as unidentified nets and tuna-longlines have not been registered in entanglements since 2006 and 2008 respectively.

Most non-fatal entanglements occurred in the Western Cape province, especially around Cape Town, while nearly all entanglements in bather-protection nets were reported on the KZN coastline (Fig. 8).

Incidence of scarring observed during annual aerial surveys

In total, 15 identified animals were photographed between 1999 and 2019 with scarring on the peduncle, likely caused by ropes and/or entanglement. In one case a rope/net was still visible around the whale's peduncle (in 2000). Most of these whales presented such scars upon first identification, with only three previously identified individuals presenting such scarring for the first time in a photographic recapture. At least four animals in the photographic catalogue, all identified post-1998, presented scars that could be attributed to propellers (set of parallel lines at regular intervals), and are thus most likely the result of a ship-strike.

DISCUSSION

Southern right whale mortalities

Recorded mortalities of SRWs along the South African coast generally increased between 1999 and 2006, likely associated with their positive population growth rate in this region (Best *et al.*, 2001a; 2011). However, this

general trend reversed after 2006, when the incidence of recorded mortalities decreased, as already reported by Best *et al.* (2011). Despite possible bias from fluctuations in effort, environmental awareness, reporting technology and the development of a stranding and disentanglement network around the South African coast has substantially improved in the past decade. As a result, we hypothesise that this decline is related to the notable decrease in SRW prevalence along the South African coast since 2009 and the apparent reduced residency time of cow-calf pairs on this calving ground (Vermeulen *et al.*, 2020). Indeed, data from 40 years of SRW aerial surveys indicate that sightings of unaccompanied adults (i.e. males as well as non-calving females) along the South African coast have decreased dramatically since 2009, from about 250–430 on the 2006–2008 surveys to about 12–34 on the 2017–2019 surveys (Vermeulen *et al.*, 2020). Additionally, since 2015, the number of cow-calf pairs along the South African coast has fluctuated enormously, with the lowest sighting density over the last 30 years in 2016 (55 cow-calf pairs) while an all-time record of > 400 cow-calf pairs was observed in 2018 (Vermeulen *et al.*, 2020). Recent research into these observed changes revealed a dramatic shift in foraging strategy in the past few decades (van den Berg *et al.*, 2021), while Thavar *et al.* (2021) reported a severe reduction in physical body condition of lactating females in the population over the same period. Combined, these data point towards an adverse effect of large-scale environmental changes in the Southern Ocean feeding grounds on the population, leading to altered migration behaviour.

The majority of reported SRW mortalities between 1999 and 2019 were calves of the year (53%). This is in line with the findings of Best *et al.* (2001a) and Best *et al.* (2011). In the past decade alone (2011–2019), this proportion increased further to 64.7%, again likely related to the notable decrease in the number of unaccompanied adults and consequent increase in the proportion of calves present along the South African coast (from an average of 32% between 1991 and 2010 to 44% between 2011–2019 on the annual photographic aerial surveys; MRIWU, unpublished data).

It is not surprising that the majority of recorded mortalities coincided with the seasonal presence of the species in the South African calving ground, and accordingly, occurred in their main concentration area (southern Cape coast; Best, 1990a). Notably, outside of this main calving area, strandings were more prevalent along the South African west coast rather than east coast, in line with the reported increased use of this area for feeding (Barendse and Best, 2014; Mate *et al.*, 2011; Shabangu *et al.*, 2020).

Anthropogenic impacts

Due to restrictions in South Africa's legal framework, full necropsies are seldomly performed on deceased baleen whales. Diagnosing cause of death is therefore often limited to an external visual inspection of the carcass. This was noticeable in the database, in which only 14.4% of the SRW mortalities were assigned a cause of death. Unsurprisingly, these were all due to entanglement or ship-strikes, as they both usually present clear external cues (e.g. rope attached, severe scarring on the peduncle, propeller cuts, etc). Nonetheless, the frequency with which these two causes of death were recorded seems rather low, although due to the opportunistic nature of the data it needs to be acknowledged that this frequency can be an underestimation. Severe scarring in the extensive and long-term photo-identification catalogue (Best *et al.*, 2001a; Best *et al.*, 2011) also appears to be low, although it is recognised that this could also be underestimated as the photographic focus during the surveys concentrates on the head of the whales for identification purposes (Best, 1990b). Therefore, all presented numbers should be regarded as a minimum value. To what degree anthropogenic impacts on the SRW population may be underestimated remains unknown.

The proportions of adult and juvenile mortality attributable to entanglements or ship-strikes seem to have decreased since the period 1963–1998 (54% in Best *et al.* (2001a) vs 13.4% in this study). However, the absolute number of reported fatal (13 reported in Best *et al.* (2001a) vs 14 in this study) and especially non-fatal ship-strikes and entanglements (21 reported in Best *et al.* (2001a) vs 98 in this study) has increased since 2 decades ago. Although data collection may not be fully comparable as they are both opportunistic in nature, a positive trend is expected either due to an improved reporting system, the formation of a comprehensive disentanglement network, the positive growth rate of the SRW population and increasing anthropogenic activities, or a combination of all. Furthermore, precisely due to the opportunistic nature of the data, ship-strikes

and entanglements are expected to often go undetected and/or unreported, and the fate of the whale often remains undetermined. Therefore, the actual number of mortalities related to such events is likely underestimated. Improved monitoring (e.g. through a systematic reporting system) of these incidences is therefore highly recommended to ensure that accurate evidence-based conclusions can be drawn for effective management decisions in the future.

The vast majority of ship-strikes and entanglements recorded between 1999 and 2019 occurred in the area between Cape Town Harbour (west coast) and Cape Agulhas (south coast). Although it could be argued that this can be an artefact of the opportunistic data collection effort, the geographical overlap between the occurrence of these risks and SRW distribution along the South African coast cannot be ignored. Shipping lanes in the Western Cape are closely linked to the location of Cape Town Harbour, and fishing and recreational boating activities most dense along the south coast and southernmost region of the west coast, overlapping with the core distribution area of SRWs. Although the presence of SRWs along the southern Cape coast is well known and documented (e.g. Best 1990a; Elwen and Best, 2004a,b), the use of the South African west coast as a breeding and/or feeding ground remains poorly understood (Best, 2006). Nonetheless, a few dozen right whales use the South African west coast as a foraging ground during austral summer months (e.g. Mate *et al.*, 2011; Barendse and Best, 2014), leaving the whales vulnerable to anthropogenic impacts. A better understanding of the whales' use of this highly navigated area would therefore be beneficial in any attempt to mitigate human-whale conflicts. Considering > 10% of known SRW mortality and 25% of the confirmed combined adult and juvenile mortality in South Africa is caused by fatal collisions with vessels (mainly females), and the area use by other baleen whales species including dense super-group aggregations of humpback whales (*Megaptera novaeangliae*; Findlay *et al.*, 2017), a reduction of vessel speed for incoming and departing ship traffic, as well as the deployment of dedicated lookout observers on board vessels to spot whales is recommended. Additionally, a mandatory ship reporting system could be established, as occurs in the main distribution areas of the North Atlantic right whale (*Eubalaena glacialis*) (Silber *et al.*, 2012), to inform vessels on whale presence and the necessary precautionary measures. Furthermore, in the event of a collision, user-friendly reporting systems should be developed to increase reporting and therefore data collection.

Nearly 70% of all recorded entanglement cases involved rock lobster gear or bather-protection nets, occurring in the Western Cape and KZN provinces respectively, although the opportunistic nature may lead to an underreporting of entanglement in other types of gear. In general, fishing effort for west coast rock lobster commences in November near Dassen Island (see Fig. 8) and progresses southwards towards the area of the Cape Peninsula up to October (Meÿer *et al.*, 2011). However, recent reductions in the west coast rock lobster biomass have resulted in permit changes, with fishing starting much further north in Port Nolloth in October (ring nets) and fishing effort moving south during the season and involving traps from November to July. This creates a temporal and spatial overlap with SRWs, resulting in entanglements in rock lobster gear peaking on the west coast from November to April (coinciding with SRW foraging in the area; Barendse and Best, 2014), and subsequently on the southwest and south coast from July to October (coinciding with calving season; Best, 1994). In general, south coast rock lobster fishing efforts begins in October and ends on the 30th September of the following year. However this industry is mostly offshore and may have limited effect on SRWs. Therefore, time and area restrictions in west coast rock lobster fishing in SRW hot spots could reduce entanglement incidents significantly (Meÿer *et al.*, 2011). Recent developments with regards to North Atlantic right whales have proposed that ropeless fishing should be introduced since it removes the vertical buoy lines extending up to the surface, used to mark traps on the sea floor, and vessels can acoustically release them on demand which would significantly reduce or eliminate entanglements in rock lobster gear and the need to have closed areas (Myers *et al.*, 2019).

Bather-protection nets caused 22 entanglements with SRWs in the period 1999–2019, with only one known fatality. However, between 2015 and 2019, no such entanglements have been recorded, possibly due to the extensive replacement of bather-protection nets with drumlines to reduce all bycatch (Cliff and Dudley, 2011). Furthermore, since 2019 the KZNSB has removed nets at most of its protected beaches during times of intense whale activity (mostly humpback whales) between June and November, to reduce the risk of whale entanglement.

In summary, the rate of entanglement seemed to decrease post-2009, coinciding temporally with the decreased rate of SRW mortalities and the observed altered migration behaviour of the population discussed above (Vermeulen *et al.*, 2020). No such trend could be observed in relation to ship-strikes, which may be linked to the geographical distribution of this risk around the southern part of the west coast and the recent increase in SRWs foraging in that area.

CONCLUSION

The presented data compilation reveals a decreasing trend in SRW mortality in South Africa's coastal waters over the past decade which we hypothesise is related to the decreased presence of SRWs on their South African calving ground in recent years (Vermeulen *et al.*, 2020). In general, available data show a relatively low rate of fatal entanglements and ship-strikes. However, strong conclusions from this dataset are hampered by the opportunistic nature of the collated data. Regardless, in light of the expected increased anthropogenic pressures on South Africa's coastal waters under 'Operation Phakisa', and the observed increases in the South African population of SRWs, continued and ideally improved monitoring of SRW mortalities and associated anthropogenic factors is highly recommended going forward. Additionally, improved data collection, necropsies and reporting systems (including non-fatal incidents) are strongly advised to improve data quality and monitoring abilities.

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