

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 Meÿer *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 × 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) | Calf | 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) | Calf | Unknown | Unknown – found dead |
| UA0615 | 2006 | 10 | - | Unknown | 34°29'S | 20°31'E | Western Cape (south coast) | Calf | Unknown | Unknown – found dead |
| UA0616 | 2006 | 10 | - | Unknown | 34°29'S | 20°31'E | Western Cape (south coast) | Calf | 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) | Calf | 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) | Calf | 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 |

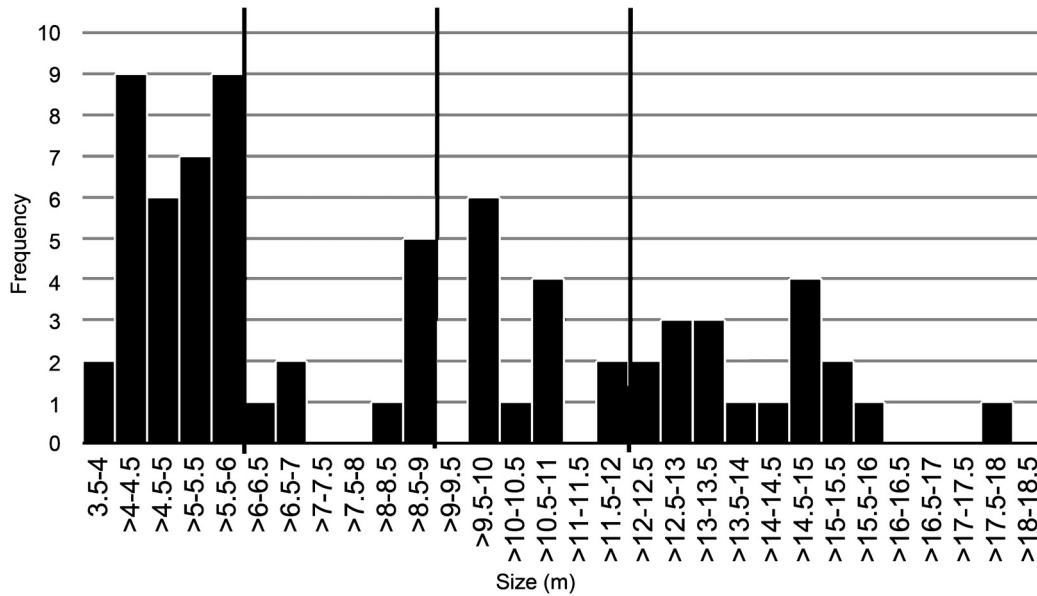


Fig. 1: Size distribution of stranded southern right whales in South African waters between 1999 and 2019, for which accurate length measurements were available (n = 73). Lines indicate the separation of age classes (newborn (< 6m), calves (6–8.9m), juveniles (9–11.9m), adults (≥ 12m)).

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

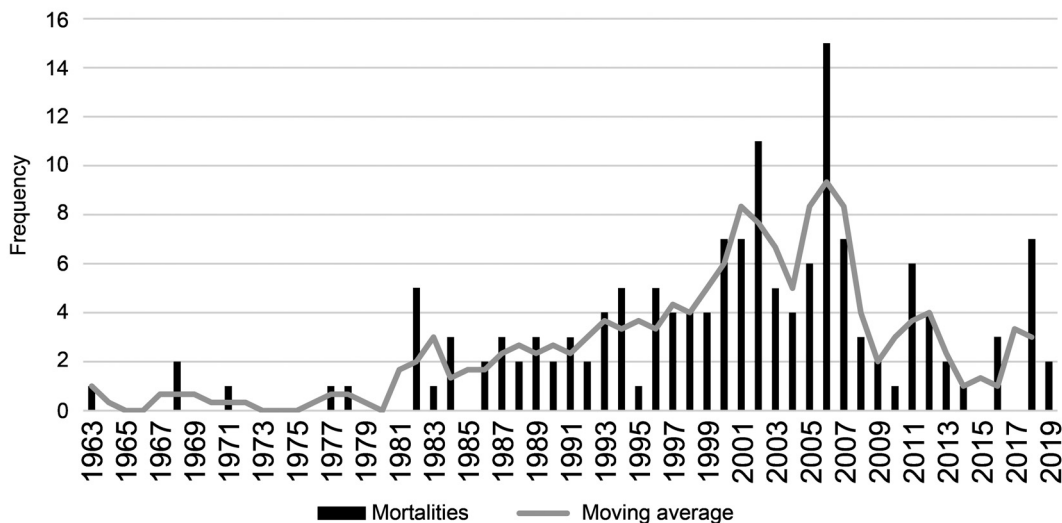


Fig. 2: Absolute frequency and three-year moving average of southern right whale mortalities per year, between 1963 and 2019, incl. data published in Best *et al.* (2001a) and reported in Best *et al.* (2011) for the period 1963–1998.

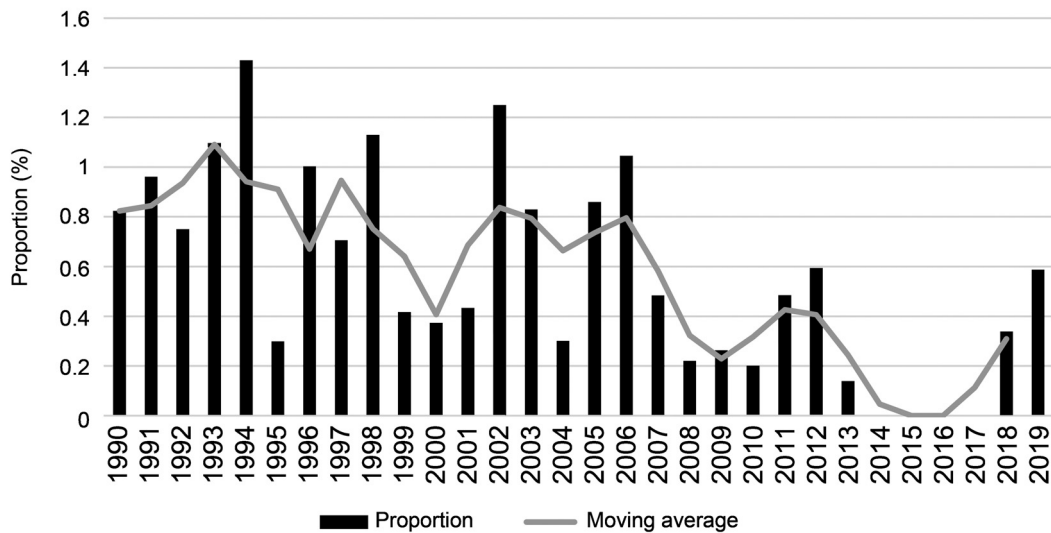


Fig. 3: Proportion and three-year moving average of southern right whale mortalities on the coastal area between Plettenberg Bay and Muizenberg in relation to the total number of southern right whales counted on the annual aerial survey over the same area (incl. cows, calves and unaccompanied adults; 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).

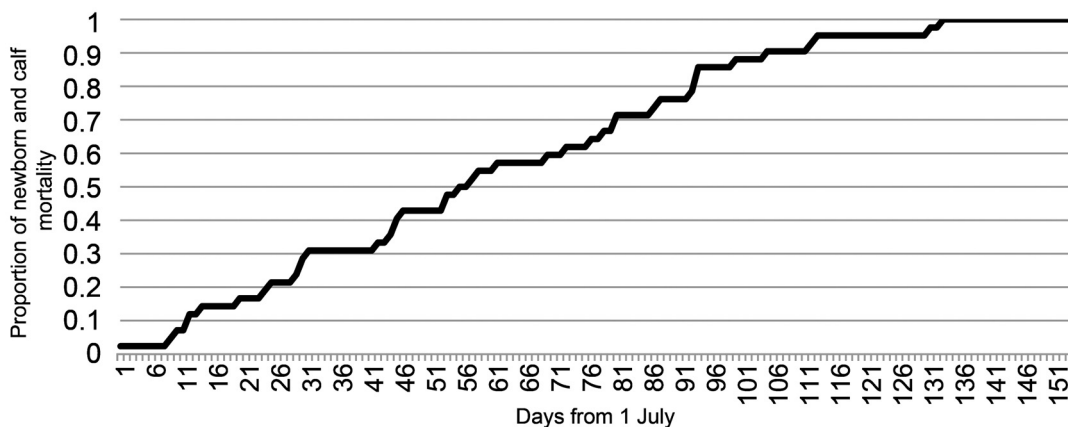


Fig. 4: Cumulative distribution of mortalities of southern right whale new-borns and calves in South African waters, against time of year (1999–2019).

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

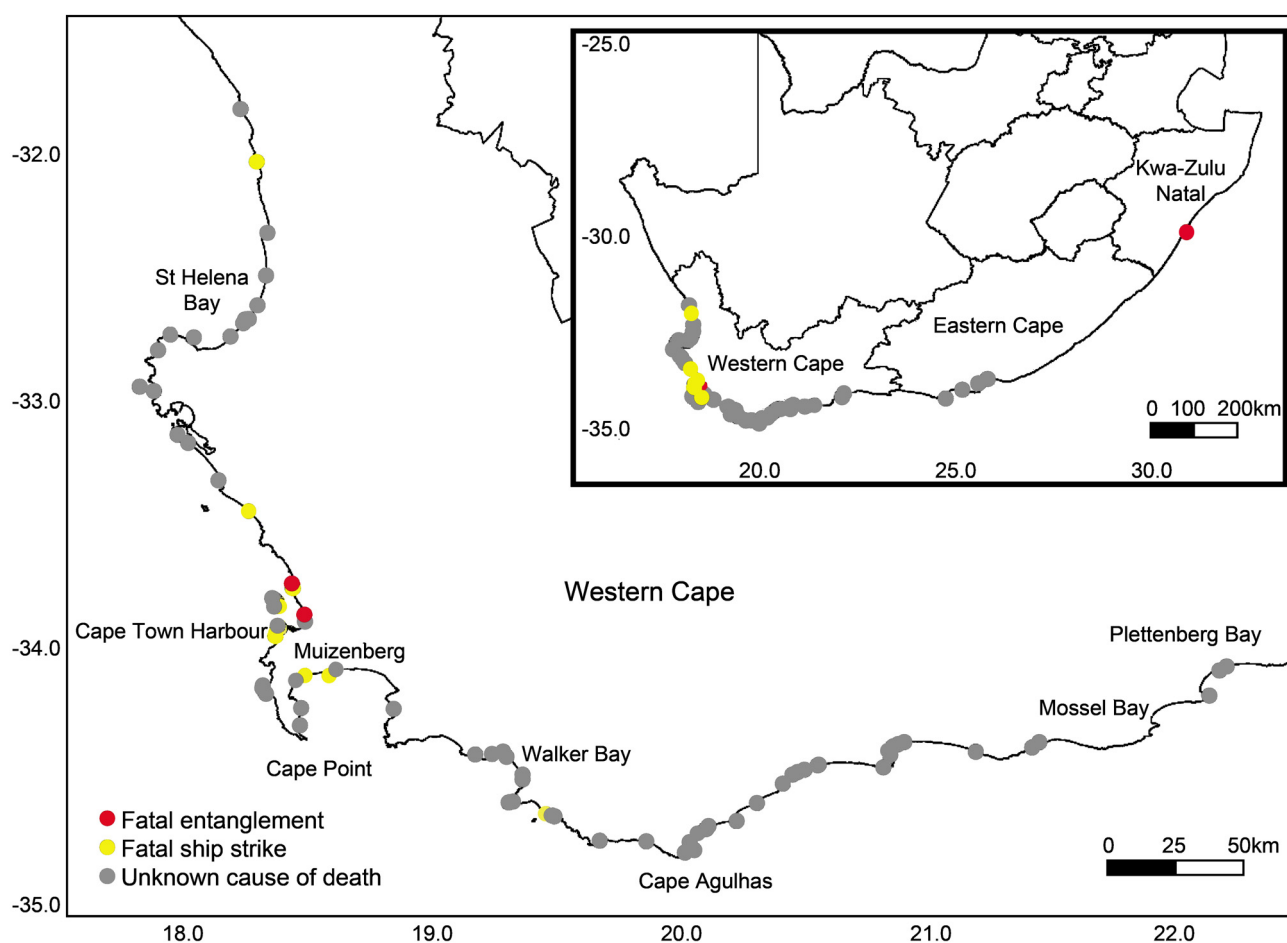


Fig. 5: Location of recorded mortalities of southern right whales off South Africa between 1999 and 2019, plus detailed map of the Western Cape province.

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).

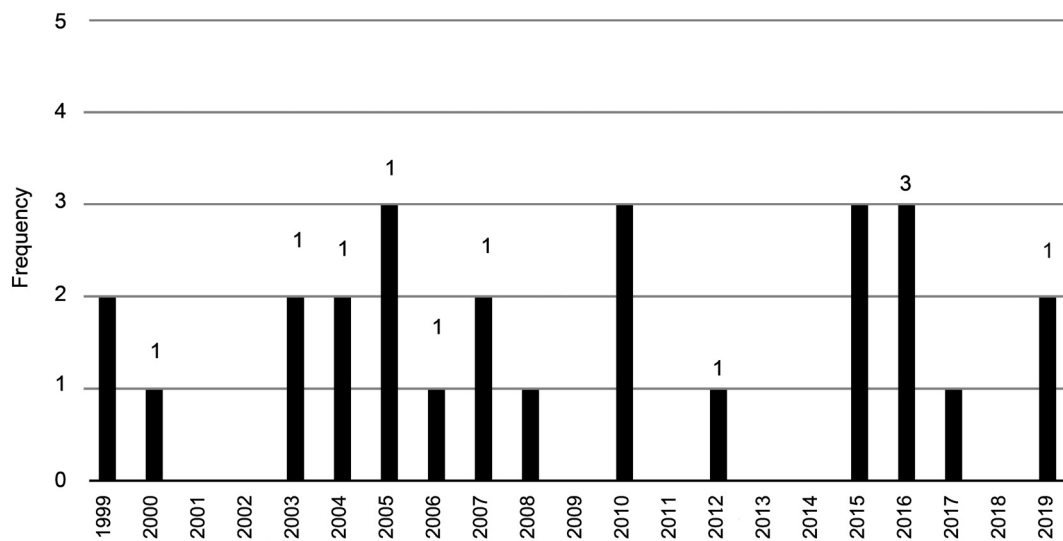


Fig. 6: Annual frequency of ship-strikes of southern right whales off South Africa from 1999 to 2019. The number of fatal collisions per year was annotated above the bars.

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-

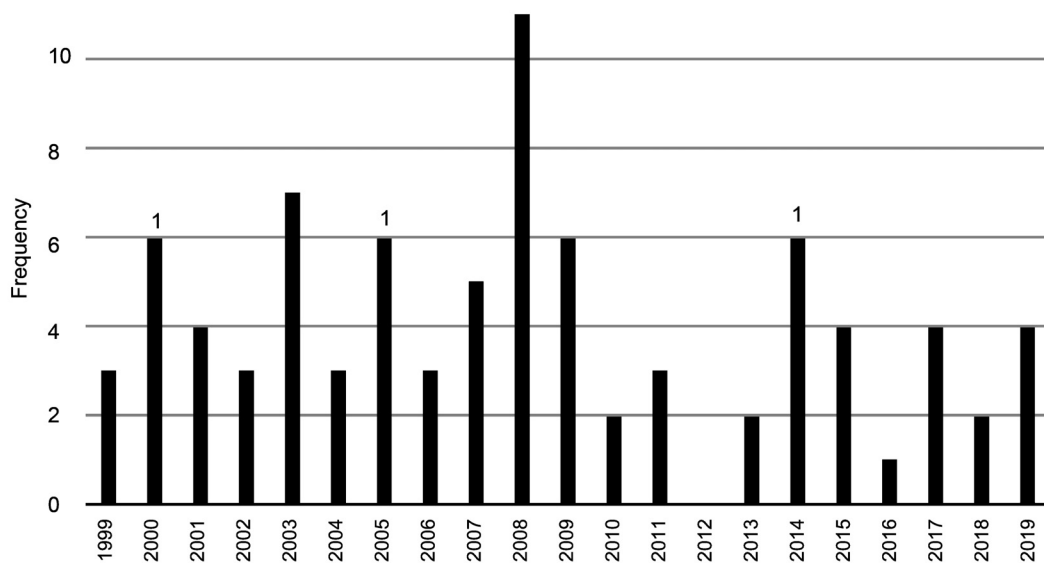


Fig. 7: Total frequency of entanglements of southern right whales off South Africa from 1999 to 2019. The number of entanglements resulting in a mortality was annotated above the bar.

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 | Southbrook | 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 <i>Regal</i> |

| 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 |

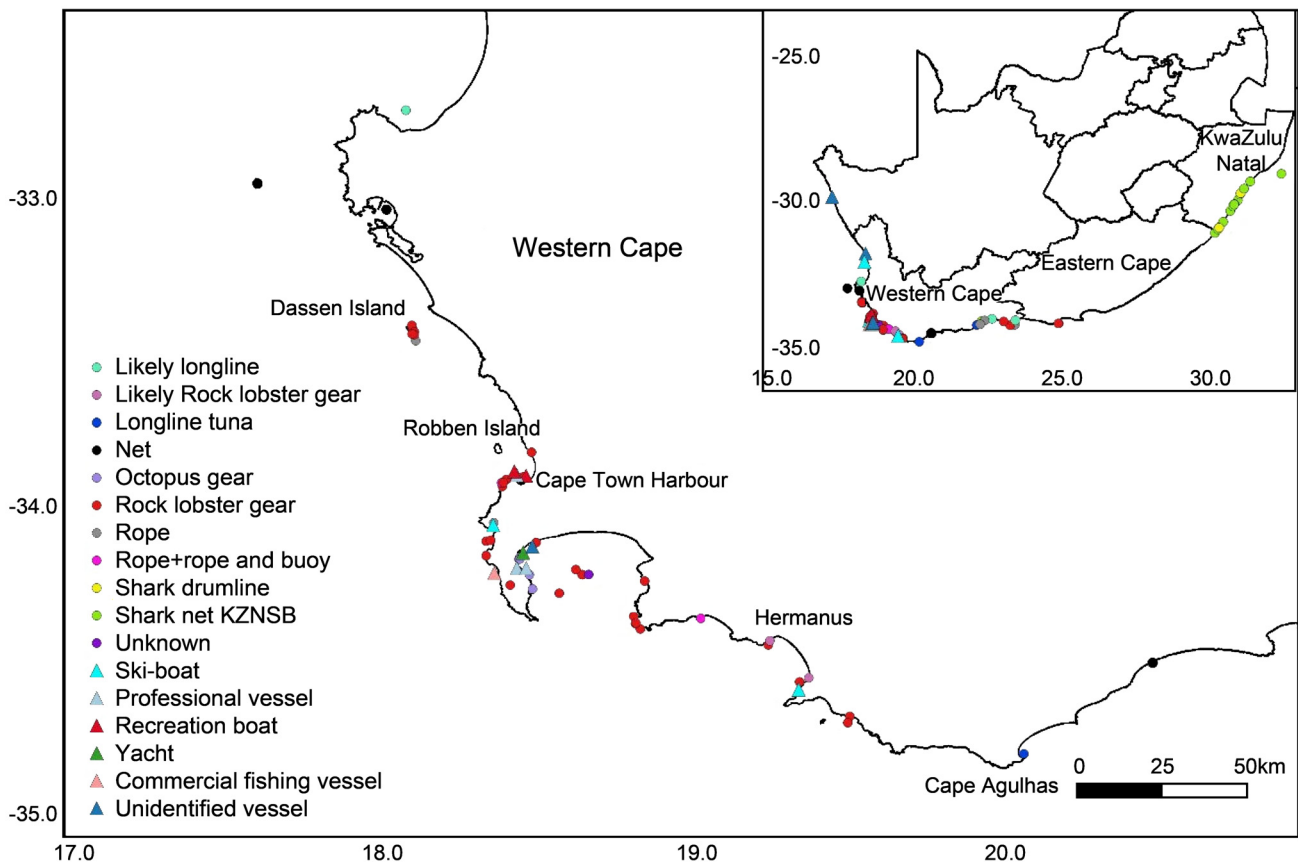


Fig. 8: Location of anthropogenic incidents that did not result in confirmed mortalities of southern right whales off South Africa between 1999 and 2019, including a more detailed map of the area around Cape Town.

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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