

Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1998

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ABSTRACT

Between 1963 and 1998, 55 mortalities of southern right whales and a further three 'possible right whale' mortalities were recorded on the South African coastline. Of the known right whale mortalities, 31 could be classified as 'calves of the year', 8 as juveniles and 14 as adults. Relatively few (6.5-16.1%) of the calf mortalities could be attributed to anthropogenic factors, compared to juveniles (25-50%) and adults (35.7-57.1%). Apparent causes of death included ship strikes (4 definite, 7 possible) and entanglement (4 definite, 1 possible), with one harpooning incident. Five non-fatal ship strikes and 16 instances of non-fatal entanglement were also recorded. Whilst the gear most commonly involved in non-fatal entanglement was crayfish trap lines, three of the four entanglement fatalities involved longline gear. The incidence of scars attributable to previous entanglement remained constant amongst mature females from 1979-1997, at 3-4%. Recorded mortalities increased over the period 1963-1997 at a rate no different from that of population growth over the same period. The current level of anthropogenic mortality does not seem to be affecting population recovery.

KEYWORDS: RIGHT WHALE; FISHERIES; INCIDENTAL CAPTURE; STRANDINGS; SHIP STRIKES; SOUTHERN HEMISPHERE

INTRODUCTION

The population of southern right whales (*Eubalaena australis*) that visits the coast of southern Africa in winter was severely overexploited in the first half of the nineteenth century, received official international protection in 1935, and since 1969 has been staging a recovery on the South African coast (Best, 1990b; Best *et al.*, 2001). The current population, however, is still almost an order of magnitude smaller than some estimates of its unexploited size (Richards and du Pasquier, 1989).

While on the coast, right whales are usually found within 10km (and most often within 2km) of the shore (Best, 1990b) and tend to congregate in sheltered bays with flat, sandy bottoms. These habitat preferences bring them into juxtaposition with human activities, including commercial and recreational fishing and boating. Right whales are slow moving, do not show strong boat-avoidance behaviour and appear attracted to drifting or anchored objects (including naturally occurring components of the ecosystem such as kelp), possibly for the tactile experience. These behavioural traits make the species vulnerable to collisions with vessels ('ship strikes') and entanglement in a variety of floating and fixed gear. Some such interactions can prove fatal for the whale.

In the North Atlantic, anthropogenic sources of mortality such as ship strikes and entanglement have been suggested as a significant factor inhibiting the growth of the right whale population (Kraus, 1990; IWC, 2001). This paper attempts to document existing levels of right whale mortality, both natural and anthropogenic, off South Africa, both as a baseline against which to evaluate future trends and as an indication of where potential problems may arise.

MATERIALS AND METHODS

From 1963, the senior author kept records of all cetaceans stranded (or killed as a result of fishing activities, etc.) that came to his attention in the Western Cape (roughly from Lamberts Bay on the west coast to Mossel Bay on the south coast). Most of these have been inspected, and measurements, photographs and samples have been taken and deposited in the South African Museum. Up to and including 1998, this represented some 776 mortalities. In addition, there have been some 165 strandings not visited by the senior author but for which supporting data (photographs, measurements, etc.) were available; these have been termed 'unattended strandings'. Within this total database of 941 mortalities there are records of 51 right whales. An additional four right whale mortalities from the Eastern Cape have also been recorded (Table 1).

Some of the unattended strandings have involved instances where species identification was uncertain, although the descriptions of three suggest they were right whales. These have, therefore, been listed separately as 'possible right whale' mortalities (Table 2).

From 1981-1998, all incidents of non-fatal entanglement and ship strikes involving right whales on the South African coast that came to the authors' notice, either through the media or from members of the public, were recorded; these amounted to some 21 incidents over 17 years (Tables 3 and 4). Seven instances where the species identity was uncertain have been recorded as 'possible right whales' (Table 5).

From 1979-1997, annual aerial surveys of the right whale population along the southern coast of South Africa have been flown by helicopter, in which all cow-calf pairs seen were photographed for individual identification purposes.

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Table 1
Known mortalities of right whales in South African waters, 1963-98.

Field no.	Date	Length (m)	Sex	Locality	Comments
63/6	14 Aug. 1963	13.11	M	30°25'S, 31°50'E	Harpooned in error
68/16	24 Aug. 1968	15.19	F	Plettenberg Bay	Stranded live, after calf
-	24 Aug. 1968	Calf	-	Plettenberg Bay	Stranded live
71/8	24 Oct. 1971	7.09	M	Springmount, Algoa Bay	Stranded live
77/6	12 Aug. 1977	4.01	M	Die Mond, Bredasdorp	Found dead
78/39	14 Sep. 1978	10.06	M	Mossel River, Hermanus	Stranded live
82/17	6 Aug. 1982	4.78	M	Blythesdale, KwaZulu-Natal	Caught in anti-shark nets
82/22	28 Sep. 1982	>11.97	-	Arniston	Blubber and appendages
82/31	3 Nov. 1982	5.17	-	Arniston	Stranded dead
82/32	22 Oct. 1982	5.82+	F	5.6km E of Skipskop	Found dead, tail eaten by sharks
	2 Dec. 1982	-	-	Thysbaai, Cape St Francis	Decomposed, fragments of skeleton
	27 Jul. 1983	14.3	F	Beachview, Port Elizabeth	Died at sea - shark bites. Five apparent propeller marks
84/2	8 Feb. 1984	Adult	-	Jakkalsfontein	Seen from air - ship strike?
84/27	8 Sep. 1984	9.25	M	Voorsteklip, Walker Bay	Found dead, entangled in longline
UA69	16 Oct. 1984	~7.2	-	East London harbour	Struck by dredger
86/29	16 Aug. 1986	~4.60	F	De Kelders, Walker Bay	Found dead
86/32	~1 Sep. 1986	4.85	M	Skipskop, De Hoop	Found dead
87/16	22 Aug. 1987	5.36	M	Silverstroomstrand	Stranded live
87/27	27 Aug. 1987	13.76	F	Sedgefield	Washed ashore dead, entangled in longline
87/31	15 Oct. 1987	5.76	M	Die Plaat, Walker Bay	Found dead
88/30	~10 Sep. 1988	14.1	M	25km E of Sundays River	Washed ashore dead - ship strike
88/31	~10 Sep. 1988	14.0	M	25km E of Sundays River	Washed ashore dead - ship strike
89/23	31 Jul. 1989	4.63	M	7.3km N of Dwarskersbos	Found dead
89/30	5 Dec. 1989	14.7	M	Romans Bay, Gansbaai	Found dead
UA133	7 Oct. 1989	12-15	-	20km N of Hondeklip Bay	Washed ashore dead
UA134	30 Oct. 1989	14.8	M	Kings Beach, Algoa Bay	Stranded dead
90/28	8 Aug. 1990	10.31	M	De Kelders, Gansbaai	Washed ashore dead - entangled in line with float
90/29	14 Aug. 1990	4.80	F	Grotto Beach, Hermanus	Stranded live
91/15	29 Aug. 1991	4.85	F	4km E of Koppie Alleen	Found dead
91/18	12 Sep. 1991	6.65	M	1km W of Koppie Alleen	Found dead
91/22	<20 Sep. 1991	~5.50	-	1.4km N of Dwarskersbos	Found decomposed
92/13	<9 Aug. 1992	5.32	M	5km W of Koppie Alleen	Found dead, not fresh
92/16	<5 Nov. 1992	~6.42	M	1km E of lagoon, Hermanus	Washed ashore decomposed
93/13	<16 Aug. 1993	3.9+	-	Between Long Beach and Koppie Alleen	Blubber and appendages, tail missing
93/17	10 Sep. 1993	5.89	F	Infanta, St Sebastian Bay	Found dead
93/18	<10 Oct. 1993	4.7+	F	Lekkerwater, De Hoop	Found decomposing, tail cut off
94/5	8 Mar. 1994	11.76	M	Matroosklip, Cape Point	Found dead
94/12	22 Sep. 1994	11.23	F	Kabeljoubank, Breede River	Found dead, possible ship strike?
	23 Sep. 1994	4.7	-	Kabeljou River mouth, Jeffrey's Bay	
	28 Oct. 1994	~11.0	-	Plettenberg Bay	Washed ashore dead
94/16	10 Nov. 1994	10.66	M	Shell Bay, St Helena Bay	Found dead - possible ship strike
95/12	8 Oct. 1995	~15.5	F	Moonlight Bay, Hangklip	Washed ashore dead - possible entanglement
UA157	25 Jul. 1996	~5.5	-	Witsand, St Sebastian Bay	Found dead
UA158	30 Aug. 1996	Calf	-	Voelklip, Hermanus	Tail only washed ashore
UA159	1 Sep. 1996	4.9	-	Glentana, Mossel Bay	Found dead
96/21	28 Jul. 1996	14.61	F	Scarborough, Cape Peninsula	Washed ashore dead - possible ship strike
96/25	23 Sep. 1996	~14.0	F	Witsand, St Sebastian Bay	Found dead
	- Jun. 1997	Adult	-	Mpeckweni River mouth	Washed ashore decomposed
97/07	11 Jul. 1997	5.5	M?	St Sebastian Point	Found dead
UA166	25 Sep. 1997	Adult	F	Vaalkrans-Hamerkop	Washed ashore decomposing
97/11	16 Oct. 1997	~5-6	-	Stoney Point, Betty's Bay	Washed ashore dead
98/08	<30 Jul. 1998	~7.1	?	Boggemsbaai, Mossel Bay	Found decomposing
98/10	18 Aug. 1998	4.95	?	Rhyspunt, De Hoop	Died at sea
98/09	19 Aug. 1998	3.9	F	Koppie Alleen, De Hoop	Found dead, fresh
UA165	<7 Oct. 1998	5.4+	?	Die Dam, Quoin Point	Found decomposing, tail cut off

Table 2
Mortalities of 'possible right whales' on the South African coast, 1963-98.

Field no.	Date	Length (m)	Sex	Locality	Comments
UA49	19 Jul. 1983	~4.6	-	5km S of Elands Bay	Found dead
UA?	26 Oct. 1996	15-20	-	Vermont	Found dead in kelp - towed out to sea
UA160	18 Nov. 1996	~6	-	Pearly Beach	Found dead

Details of the survey techniques and subsequent photographic matching procedures used are given in Best (1990a). The survey was timed each year to occur around 15 October, by which date most calves have been born (Best, 1994). After the 1997 survey, the photographic catalogue

contained some 521 adult females (unadjusted for natural mortality). Photographs of each female sighted were assessed for the presence of entanglement scars (recognising that the ease of detecting such scars from the air is less than from vessels; A. Knowlton, pers. comm.).

Table 3
Reported instances of ship strikes on right whales in South African waters that did not result in known mortality.

Date	Locality	Vessel involved	Outcome
21 Nov. 1986	False Bay	Fisheries protection vessel <i>Protector I</i>	Damage to screw and bracket - vessel abandoned but later towed in - whale cut but apparently OK
6 Jan. 1995	Table Bay	Launch <i>Condor</i>	Propeller and shaft damaged
6 Sep. 1997	Hout Bay	[Launch]	Damage to prop and bracket estimated at R20,000, whale apparently survived
28 Aug. 1998	St Sebastian Bay	6m inflatable <i>Balaena</i>	Submerged whale hit by skeg on outboard motor - no apparent damage to boat or whale
14 Oct. 1998	False Bay	Catamaran <i>Cape of Good Hope Ferry</i>	Whale hit pontoons, not propeller - no apparent damage to boat or whale

Table 4
Reported instances of non-fatal gear entanglement of southern right whales on the South African coast.

Date	Locality	Gear involved	Outcome
18 Oct. 1981	Kommetjie	Orange rope round tail stock snared on sea floor, then around middle of body when whale broke free	Whale free-swimming
17 Nov. 1990	3 n.miles S of Vondeling Island	Crayfish trap line	Whale (large adult) cut free
21 Feb. 1991	Off Yserfontein	Yellow and blue ropes plus float - crayfish trap line?	Whale (adult) free-swimming
6 Nov. 1991	Off Olifantsbos	Crayfish trap line	Whale (12-15m) cut free
17 Nov. 1992	Between Stony Head and Vondeling Island	Crayfish trap line	Whale (4-4.5m) cut free
29 Aug. 1994	Durban, KwaZulu-Natal	Anti-shark net	~6m - free-swimming
15 Sep. 1994	Zinkwazi, KwaZulu-Natal	Anti-shark net	~15m - cut free
26 Sep. 1994	Blythesdale, KwaZulu-Natal	Anti-shark net	~6.5m - free-swimming
22 Dec. 1994	Yserfontein	Rope plus 2 buoys round tail - crayfish trap line?	Whale free-swimming
20 Sep. 1995	False Bay	Fishing net	Whale free-swimming - later died? See Table 1
18 May 1996	Lamberts Bay	Yellow rope round tail stock and rear half of body	Whale free-swimming
4 Dec. 1997	5-6km N of Dassen Island	Rope and floats - crayfish trap line, possibly through mouth	Whale free-swimming
14 Aug. 1998	Rhyspunt, De Hoop	3 loops of green rope and red buoy	Whale free-swimming
23 Aug. 1998	Kalk Bay, False Bay	Rope and buoy behind head	Whale free-swimming
Undated	Smitswinkel Bay	Diver's float line	Whale swam off with line plus speargun
Undated	False Bay	Diver's float line	Line removed from one flipper but whale swam off still attached to gear

Table 5
Recorded instances of non-fatal gear entanglement on the South African coast possibly involving southern right whales.

Date	Locality	Gear involved	Outcome
7 Aug. 1990	Hermanus	Anchor line of ski-boat	Rope cut, whale swam off
24 Nov. 1990	Jutten Island/South Head	Entangled in rope	Small adult, free-swimming
7 Dec. 1990	3km N of Vondeling Is.	Crayfish nets, ropes and buoys	Adult (15-18m), cut free except for one small buoy and some rope round tail
10 Dec. 1991	1 n.mile off Stompneus Light	Crayfish trap line plus buoy	Free-swimming
13 Jan. 1995	12 n.miles SW of Dassen Is.	Crayfish trap lines plus a number of buoys	About 14m long, cut free ¹
2 Nov. 1996	Brighton Beach, KwaZulu-Natal	Anti-shark net	Calf, freed itself
15 Sep. 1997	Betty's Bay	Anchor line of inflatable	Rope cut, whale later freed of line

¹ Whale identified as a humpback but described as lacking a dorsal fin.

RESULTS

Recorded mortalities

Size and sex composition

The 33 dead whales that were accurately measured fell into three groups, the first from 3.90-7.09m ($n = 18$), the second from 9.25-11.76m ($n = 6$) and the third from 13.11-15.19m ($n = 9$) according to length (Fig. 1). The first group consisted entirely of calves of the year, judging from the short baleen and (in most cases) unhealed or healing navel regions. Given that 12.37m was the size of the smallest mature female measured photogrammetrically by Best and R  ther (1992), the other two groups are assumed to represent juvenile (i.e. sexually immature) and adult (i.e. sexually mature) animals, respectively. The ages of the six juveniles were adjudged to be between one and four years, based on stable isotope patterns in their baleen (Best and Schell, 1996). If the inaccurately measured animals are assigned to these

groupings, there were 31 calves of the year, 8 juveniles and 14 adults amongst the 55 known mortalities (the remaining two animals were unmeasured and could not be assigned).

In a review of Soviet catch data, the sex ratio amongst 213 southern right whale foetuses was 1.03 male to 1 female (Tormosov *et al.*, 1998). Of the sexed calves in this study, 11 were male and 7 female, while of the sexed juveniles, 5 were male and 1 female. The apparent predominance of males amongst stranded calves and juveniles combined (16 males to 8 females) is not, however, statistically significant (chi-square = 2.67, $0.25 < p < 0.10$). Amongst the sexed adults there were 5 males and 7 females.

Seasonality

All but two of the mortalities occurred over the five-month period from early July to early December, matching the seasonality of right whales in South African coastal waters.

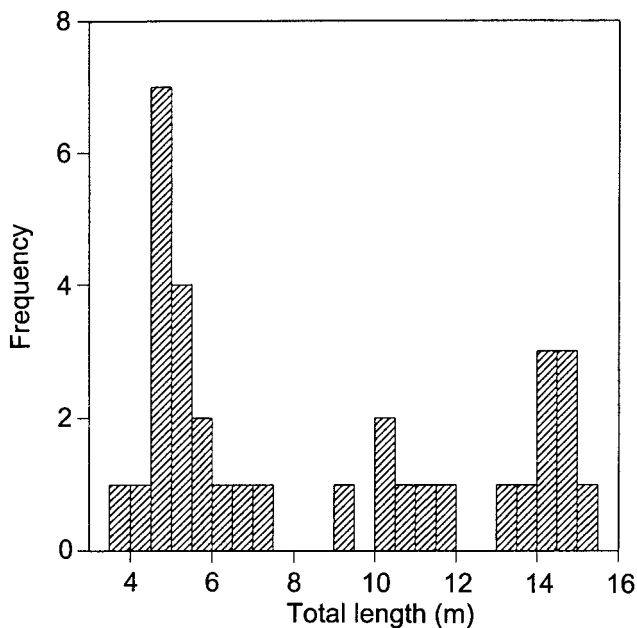


Fig. 1. Size composition of southern right whale mortalities in South African waters, 1963-1998.

The two exceptions were an adult from early February and a juvenile from early March. The seasonal occurrence of non-anthropogenic mortalities amongst 21 calves of the year (that were not decomposed when found) indicated that most (~86%) occurred by 15 October, or the mean date of the annual photographic surveys (Fig. 2).

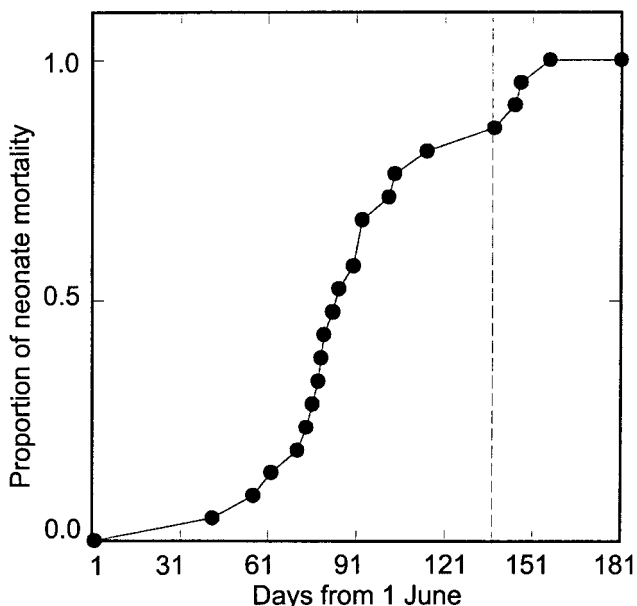


Fig. 2. Cumulative distribution of mortalities of right whale calves from natural causes in South African waters, against time of year (dotted line = mean date of aerial surveys).

Causes of death

CALVES

The deaths of only two of the 31 calves could definitely be attributed to anthropogenic factors, one being entangled in anti-shark nets at a bathing beach off Natal, and the other being struck by a dredger in East London harbour (Best, 1984). A press report of the latter incident stated that the

strike occurred at about 0730hrs as the 4,541 ton suction dredger *D E Paterson* was making its way towards the river-mouth entrance of East London harbour. Crew of a cargo ship had earlier reported to port staff the presence of a cow-calf pair at the harbour entrance, so the *D E Paterson* had been warned to be on the lookout. Despite this, the captain reported that as the dredger was coming up to pass the breakwall the pair suddenly surfaced directly in front of the ship's bow. The calf took the full brunt of the impact and had the full length of the vessel pass over it before the propeller caught it. After attempts by the mother to support the bleeding calf, it made its way across the river to a small sandy beach in front of the East London yacht club where it stranded and died shortly afterwards. Photographs of the dead calf show at least three separate curved incisions through the dorsal blubber, one just anterior to the coaming, one mid-dorsally and one in the lower back at about the level of the genital aperture. No photographs of the ventral region were available. The mother stayed in the area for several hours, and a large crowd of workers had to 'shout and do everything they could' to stop the cow from beaching herself (*Daily Dispatch*, 17 October 1984).

A further three strandings of calves in which the tails were cut off may represent ship strikes; three such instances involving northern right whales are reported by Kraus (1990).

JUVENILES

Two of the eight juveniles came ashore dead with longline entangled around their caudal peduncle and tail. One of these (84/27) carried 182m of longline, comprising 121m of brown braided nylon, 18m of green cable-lay rope and 43m of monofilament nylon tracer: metal quick-release clips were also present (Best, 1984). The opinion of fishing experts consulted was that this gear originated from the local longline fishery for hake (*Merluccius* spp.). When first seen, the second juvenile (90/28) was floating dead with longline and a red plastic buoy wrapped around its peduncle. By the time the senior author reached the stranding, however, all the gear had been removed; a sample of the line examined later showed that it was identical to the brown braided nylon in which the first juvenile had been entangled.

Two other juveniles may have been the victims of ship strikes. In the case of one of these (94/16), there was a diagonal slash through the blubber near the genital aperture, through which the viscera protruded: this might indicate that the whale was floating dead when struck (Kraus, 1990), although the animal was not heavily decomposed (skin still intact). In the other instance (94/12), bystanders claimed that there had been a boat strike in the adjoining bay two to three days previously, and that the animal bore cuts across the back (however these cuts were not seen by the senior author on the side of the animal that was visible). A fifth animal (78/39) was noticeably emaciated, with the back hollowed so much that the dorsal ridge of the scapula could be clearly seen; on dissection, 189 cestodes weighing 3,475g were collected from the intestines. This was the only mortality for which a possible natural cause of death could be established.

ADULTS

Two adult females died possibly as a result of entanglement. The first (87/27) came ashore dead and was beginning to decompose, with longline entangled around the base of the left flipper and the body at about the level of the anus. The

base of the right flipper was also badly scarred, and the body surface bore numerous weals that were most prominent where the epidermis was missing. A portion of the line recovered weighed 7kg, and consisted mainly of the same 8mm braided nylon line described previously. This was accompanied by some 5mm braided line, 4mm cable-lay line, 2mm monofilament nylon tracer, 4 metal quick-release clips, 1 plastic squid lure, 3 small aluminium reflectors and a conical lead weight. This description most closely resembled gear from a pelagic longline fishery for tuna or swordfish (B. Rose, pers. comm.).

The second adult (95/12) may also have been the victim of entanglement; four days after it washed ashore (clearly having died at sea some time previously), 12m of chain and a buoy were recovered *ca* 200m from the carcass. The links of the chain were covered with buttery whale fat, despite the surrounding rocks having no oil on them. Eighteen days previously a right whale had been seen and photographed entangled in a fishing net about 18 n.miles from the site of the stranding.

A total of five adult whales appear to have died as a result of ship strikes, two of which (the adult males 88/30, 88/31) were linked to an actual incident. The roll-on, roll-off ferry MV *Barrier* (11,000 tons) was getting up speed on leaving Port Elizabeth harbour at 16:53hrs on 7 September 1988, when nine whales were spotted ahead of the vessel, crossing the bows. Although not stated, it seems possible that the whales were engaged in courtship activity. They failed to dive to avoid the vessel, which was travelling at 12-13 knots, about 4.4 n.miles from the harbour entrance. No avoidance action was taken because it was anticipated that the animals would dive. Impact with at least one animal was felt. On looking aft into the setting sun all that could be seen was blood in the water (Capt I.D. Chown, pers. comm.). Three days later, the two whales were found on the beach 5km apart and about 15 n.miles from the site of impact. The damage to one whale was described as 'propeller shaved off flipper, cut flipper bone, cut through gape below eye and above eye, taking off rostrum (some of which came up on beach nearby)'. The other whale appeared superficially undamaged.

The other three mortalities attributed to ship strikes all bore evidence of contact with motorised vessels. One of these (84/2) was originally seen on the beach from the air, and although quite fresh appeared to have suffered major damage at its mid-length, the whale being 'bent' at an unnatural angle. Two days later all that could be found on the beach was a section of intestine 25m long, although the body later washed ashore further to the south. The second whale (96/21) washed ashore dead and was starting to decompose. Although no external marks could be seen, when the skeleton was later prepared for display it was found that the rostrum was broken right across and some of the skull bones were missing. It cannot be discounted that this damage was inflicted post-mortem. The third whale came ashore dead bearing five apparent propeller marks, plus several shark bites, suggesting that it had died at sea some time before. The whole body was twisted as it lay, as if it had been crushed, and there was a vertical split in the body across the thorax; it was assumed that the damage was due to a ship striking it (G.J.B. Ross, pers. comm.).

One adult male (63/6) was harpooned in error by a catcher-boat from the Durban whaling station. At the time the right whale was swimming with a group of sperm whales, of which four (all males) were also shot by the same catcher-boat, three 39ft (11.9m) and one 40ft (12.2m) in length.

Ship strike and entanglement incidents that did not result in a recorded death

Only five non-fatal ship strikes on right whales were recorded (Table 3), all involving relatively 'high-profile' ships (a Government fisheries patrol vessel, a whalewatching catamaran, the senior author's own inflatable and two launches carrying tourists). In three of these collisions considerable damage was inflicted to the vessel. Other incidents that may have occurred with less public vessels and/or in which relatively minor damage was incurred most probably went unreported.

There were 16 instances of non-fatal entanglements involving right whales (Table 4) and a further seven that may have involved right whales (Table 5). Apart from five animals entangled in nets (one in a fishing net and the others in beach protection nets against sharks), all the incidents reported involved entanglement in ropes. Nine of these were associated with crayfish trap lines (6 positively and 3 tentatively), 2 involved anchor ropes of small boats, 2 involved float lines of spearfishermen, while 5 could not be attributed to a particular source. Five of the animals entangled in crayfish trap lines, one entanglement in anti-shark nets and both animals entangled in anchor lines, were cut free and all or part of the gear removed. Both animals entangled in diver's floatlines escaped with the line still attached. The remaining 13 whales were all free-swimming when first seen, and were not disentangled.

Incidence of scarring in the population attributable to entanglement and ship strikes

Within the photographic catalogue of identified mature females, there are 15 individuals with scarring that is attributable to entanglement. In 14 of these cases the scarring appears as white lines on the peduncle at the base of the flukes, while in the 15th instance the scars appear as raised ridges (weals) that run irregularly over the back and head of the animal. No animals have lost such scars during the periods they have been monitored (up to 16 years). After being smoothed by threes, it can be seen that the incidence of such individuals, expressed as a proportion of the number photographed on annual surveys, has remained more or less constant throughout the time series at between 3-4% (Fig. 3). Only one animal has been photographed both with and without scars, suggesting that whales usually acquire the scars before they are first photographed, i.e. while they are young, sexually immature animals.

Only one animal in the photographic catalogue (or 0.2% of the total) exhibits scars that could be reasonably attributed to ship strikes. These appear as a set of four parallel lines an estimated 15-50cm in length and about 25cm apart, situated diagonally across the right flank, and so presumably inflicted by a relatively small vessel. They were present when the cow was first photographed (in 1995), and so far have persisted for three years.

DISCUSSION

Most (56.4%) of the 55 recorded right whale mortalities in South African waters involved calves of the year. Relatively few (6.5-16.1%) of these mortalities could be attributed to anthropogenic factors. Although recorded mortalities of juveniles and adults were fewer, the proportions that could be attributed to anthropogenic factors were much higher, 25-50% and 35.7-57.1% respectively. Causes of mortality were divided between entanglement or possible entanglement (5 cases) and ship strikes or possible ship strikes (11 cases), with one harpooning incident.

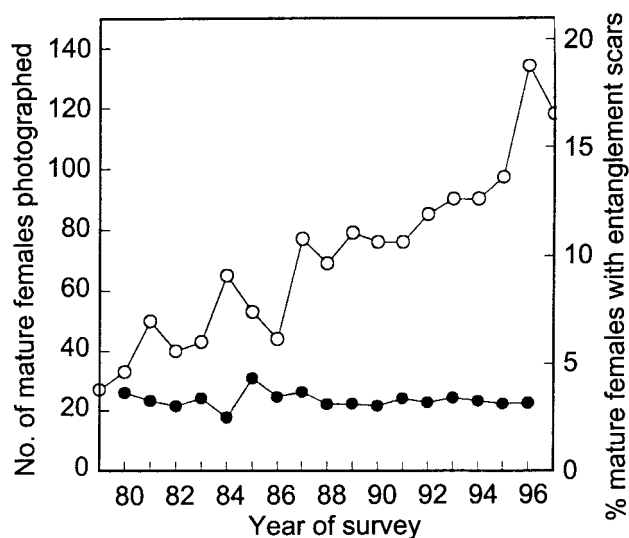


Fig. 3. Number of mature female right whales photographed annually on the South African coast, 1979-1997 (open circles), and the proportion of these carrying entanglement scars, after smoothing by threes (solid circles).

The incidence of recorded mortalities by five-year period in the senior author's dataset has shown a steady increase, from 1 in 1963-67 to 3, 1, 5, 8, 12 and 16 in succeeding five-year periods. This rate of increase (on average an exponential value of $9.4 \pm 2.0\%$ per year) is compatible with the estimated rate of population increase between 1982 and 1998 (7.1%, 95% CI = 5.9, 8.2%, Best *et al.*, 2001). This suggests that there has not been a marked increase in the recorded *per capita* mortality rate over the 30-year time span. Such a conclusion depends, of course, on there being a constant efficiency of reporting of mortalities over the time period, an assumption that is difficult to prove.

There is also an interesting contrast between the apparently frequent observation of live animals entangled in crayfish trap lines, and the finding that the three recorded right whale mortalities in which entanglement was a factor involved gear from a longline, not crayfish operation. Crayfish traplines are usually constructed of cable-laid polypropylene rope with a minimum diameter of 12-14mm, whereas the longline gear has mainly been a braided nylon rope with a maximum diameter of 8mm (and including monofilament line as thin as 2mm in diameter in at least two cases). It is possible that the thinner the line, the deeper it cuts into the whale's integument and the more it tends to bind in on itself. These factors would, firstly, make it more difficult for the gear to come off naturally, and, secondly, increase the degree to which the whale might become physically disabled through the destruction of underlying muscles or tendons. Alternatively, the relative degree of mortality inflicted may be associated with the weight of gear involved.

The finding that the incidence of entanglement scars in the photographic catalogue of mature females has remained constant over the period 1979-1996 is somewhat surprising, given that these scars presumably remain throughout life. If the population was constantly exposed to the risk of entanglement, one would expect the incidence of scarred animals to increase naturally over time. The failure to do so

suggests that the animals pass through a 'window of exposure' to entanglement, possibly when they are young (as indicated by the rarity with which mature females pick up such scars). The closure of this window could be related to changes in the distribution/migration of the animals with age, or to a behavioural change (increased gear avoidance) as the animals get older.

The scarcity of scars attributable to boat strikes in the photographic catalogue suggests either that such strikes occur less frequently than entanglement amongst adult females, or that when they do, they are more likely to be fatal.

As the South African right whale population is increasing at a rate that must be close to the maximum biologically possible (Best *et al.*, 2001), the current degree of anthropogenic mortality does not seem to pose a major conservation concern for this population. This is not to say that the situation could not change; an increasing whale population and an increasing human use of coastal waters for commercial and recreational pursuits, would seem to make an acceleration of interactions between them inevitable.

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