Southern right whale (*Eubalaena australis*) mortalities and human interactions in Australia, 1950-2006

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ABSTRACT

A total of 44 records of southern right whale mortalities and non-fatal anthropogenic interactions have been documented in Australia by museums, wildlife agencies and researchers since 1950. Sixteen of the events involved whales that apparently survived. Events were recorded in all months except January and 65% occurred in the period July to October. Mortalities were more numerous in the western half of the continent where southern right whales are more frequently observed. Events were classified according to their outcome and nature: carcasses (with no evidence of human interaction) *n*=25, fatal entanglements *n*=1, non-fatal entanglements *n*=12, fatal vessel collisions *n*=2, non-fatal vessel collisions *n*=3, non-fatal shooting *n*=1. No live strandings were recorded. The number of both mortalities and non-fatal anthropogenic incidents has increased 4-fold since the mid 1970s. More calves than 'non-calf' whales were present in the carcass category, whereas the opposite was the case for events involving human interaction. Lines, nets and buoys used in fishing crustaceans (rock-lobster, crab) were associated with several entanglements (*n*=5). A longline entanglement of a 14m female resulted in a chronic injury, debilitation and death. As a proportion of the total records for each region, there were fewer vessel collisions of right whales in Australia (11%) than in South Africa (16%) or the North Atlantic (35%).

KEYWORDS: SOUTHERN RIGHT WHALE; NORTH ATLANTIC RIGHT WHALE; AUSTRALASIA; STRANDINGS; INCIDENTAL CATCHES; VESSEL COLLISIONS; SOUTHERN HEMISPHERE

INTRODUCTION

Southern right whales (*Eubalaena australis*) frequent the southern coast of Australia, ranging from Cape Byron, New South Wales to Exmouth, Western Australia generally during early winter to mid spring (Bannister, 2001) but with occasional records outside this period (Kemper *et al*., 1997). Major concentrations of whales are found along the coast of southwestern Western Australia to Head of Bight, South Australia (Bannister, 2001; Burnell and Bryden, 1997). Smaller groups congregate in southeastern Australia (Bannister, 2001).

Records of southern right whales were rare in the Australian region until about 1970 and became much more frequent from the early 1980s onwards (Bannister, 1986; Kemper *et al*., 1997). The number of whales found in the Australian region was estimated in 2006 at about 2,000 with an annual increase rate of about 7% (Bannister, 2007). Most calves are born between late May/early June and late August/early September (Burnell and Bryden, 1997). Migrations between Antarctic and sub-Antarctic feeding grounds, and coastal calving and mating grounds have been documented (Bannister, 2001) as have east to west movements along the southern coast of Australia (Burnell, 2001; Hart *et al*., 1842).

In the absence of whaling, vessel collisions and entanglements may be the most significant conservation issues for small and endangered mysticete populations (e.g. Clapham *et al*., 1999). It is therefore important to document these events and, if possible, establish mitigation measures. Mortalities (not including directed catches) and entanglements of southern right whales have been summarised for South Africa (Best *et al*., 2001), Brazil (Greig *et al*., 2001) and for the sub-Antarctic region of South America and the Antarctic Peninsula (Goodall and Galeazzi, 1986). Best *et al*. (2001) concluded that anthropogenic factors did not appear to be impacting the conservation status of the rapidly recovering southern right whale population in South Africa.

North Atlantic (*E. glacialis*) and North Pacific (*E. japonica*) right whales include some of the most threatened populations/species of baleen whales (Clapham *et al*., 1999). Anthropogenic factors are believed to be contributing to reduced population growth of the North Atlantic right whale (Caswell *et al*., 1999; IWC, 2001a) where vessel collisions and entanglements comprise a significant proportion of documented mortalities (Knowlton and Kraus, 2001; Kraus, 1990). Brownell *et al*. (2001) summarised stranding and entanglement events for the North Pacific right whale but did not comment on whether anthropogenic mortalities were limiting population growth.

Reviews of cetacean interactions with fisheries (Shaughnessy *et al*., 2003) and aquaculture (Kemper *et al*., 2003) in Australian waters have recorded several gear types (droplines, longlines, finfish farms and traps) in incidents involving large cetaceans, including sperm whales (*Physeter macrocephalus*), southern right whales and minke whales (*Balaenoptera bonaerensis*, *B. acutorostrata*). Gribble *et al*. (1998) briefly discussed entanglements of humpback whales (*Megaptera novaeangliae*) in anti-shark netting off the Queensland coast. There are also unpublished records of humpback whales entangled off Western Australia.

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This paper reviews the available records of mortalities, entanglements and other human-induced injuries involving southern right whales in Australian waters, including the sub-Antarctic territories. Results are compared with those for right whales in other regions of the world. Health assessments and extent of injuries are documented for some live whales that were entangled or involved in collisions with vessels.

METHODS

Records were obtained from state museums and wildlife agencies, published and unpublished literature and records held by researchers. Museum records were included only when the skeletons could be related to a carcass having washed up. Reliability of the species identification was coded as follows: 1=certain (skeleton or genetic verification, photographic evidence or experienced observer); 2=probable (description of southern right whale features); and 3=uncertain (no description of features, observer reliability not known).

The total length of some carcasses was measured (tip of the upper jaw to fluke notch) while in others it was estimated by the observer. Gender was determined by examining the anogenital region (or photographs of it), the reproductive organs themselves or by using genetic methods (i.e. SAMA M22965, N. Patenaude, pers. comm. 2002; Nanga, WA carcass 5 December 2005, P. Spencer, pers. comm., 2006)

Relative age classes were assigned, based on a knowledge of the life history and growth patterns of southern right whales (Best and Rüther, 1992): calves grow to about 11m by December, when they are about 3 to 6 months old. In the present paper, whales >11m were classified as 'non-calf'.

Health assessment criteria developed by Pettis *et al*. (2004) for the North Atlantic right whale were applied to photographs of five whales. These criteria are summarised as follows (higher numbers mean poorer whale condition): body condition (1=back flat or rounded behind head, 2=slight to moderate concavity, 3=marked concavity); skin condition (1=good i.e. smooth, black, no epidermal lesions, few cyamids away from callosities, 2=poor i.e. numerous epidermal lesions, skin rough looking, cyamids found away from callosities.); rake marks forward of blowholes (1=zero to few rake marks, 2=several radiating lines, 3=many radiating lines that appeared to be deeply furrowed and/or bright white in colour); cyamids around blowholes (1=zero to few cyamids, 2=largely or completely covered with cyamids).

RESULTS

Records of 44 southern right whale mortalities and/or events involving human interactions were reported in Australian waters between 1950 and 2006 (Appendices 1 and 2). The relative frequencies were: South Australia (14); Western Australia (12); Tasmania (10); Victoria (5); Macquarie Island (2); and New South Wales (1) (Fig. 1). The number of known mortalities was 28 and for apparently non-fatal events was 16. Of the 43 records where the month of event was known, 28 (65%) occurred during July to October.

Events were categorised according to whether or not there was evidence of the nature of the interaction or cause of death (Table 1). The category 'carcass' included all events involving dead animals for which there was no evidence of human interaction. No live strandings were recorded although several of the whales were found in a state of minimal decomposition, suggesting that they had either live stranded or died shortly before washing up. Six whales were found floating dead, some in an advanced state of decomposition, suggesting that they had died at sea and floated inshore, where they were then detected. Thorough necropsies were not carried out on any carcasses and for many there was little information on external signs that might indicate whether human activities were involved in the whales' death. Of the carcasses that could be assigned a relative biological age, many more were calves than 'non-calves' (Table 1). Fewer calves than 'non-calves' were involved in anthropogenic incidents (χ^2=8.702; critical value=6.635, p=0.01, 1 d.f.). Five were $\leq$5.5m body length and therefore likely to have been neonates. These died in June (1), July (2), September (1) and October (1). Gender was known for 11 carcasses (6 males, 5 females).

Anthropogenic incidents involving southern right whales included shooting (1), vessel collisions (5, including a likely but unconfirmed case in 1981) and entanglements (13). The only confirmed large-vessel collision occurred when a 400 to 500 tonne passenger/car ferry, travelling at a speed of 15kts during darkness between the Australian mainland and Kangaroo Island in South Australia, hit a 14.5m whale (Appendix 1). The whale was found floating dead within 10km of the incident and still very fresh a day and a half later. A large, swollen injury (possible subcutaneous haemorrhage) on the back towards the rear of the animal confirmed that the whale was probably alive when it was struck by the ferry.

Entanglements were first recorded during the late 1980s and appear to be increasing relative to the number of carcasses reported (Fig. 2). For entanglement records that include fishing gear, there were at least five cases involving lines or nets associated with traps and pots set to catch crustaceans. Floats/buoys were reported to have been associated with eight of the entanglements. In the majority of cases, gear was entangled around the caudal peduncle. However, in one case, many wraps of crab pot line were also observed on the whale's body (Fig. 3) and in another, rope was entangled through the mouth of the whale. Other noteworthy records were an interaction during which a whale damaged a floating fish cage, a whale that died after being entangled in an offshore longline and a whale caught up in a boat mooring line. Human intervention resulted in two whales being released from the lines/nets in which they were entangled. There were more 'non-calf' than calves involved in entanglements and vessel collisions (Table 1).

Condition indices were calculated for five live whales that were involved in interactions with human activities and for which adequate photographs were available (Table 2). Full assessments were made on three whales and all were in good condition. There is documentation to show that at least one of these three whales was a recent entanglement (Cockburn Sound, WA, 12 August 1992, Appendix 1). The Cape Jervis whale that was struck by a ferry was observed a day and a half later by N. Patenaude (pers. comm. 2001), who noted an obvious fat roll behind the head and thus the whale was likely to be in good condition.

The 14m female with longline and buoy around the caudal peduncle (SAMA M22080) was assessed by viewing a video recorded from a light aircraft just prior to death. Observers noted that the whale appeared unable to dive deeply and that swimming was laboured during the several days it was observed alive. Subsequent assessment of the whale's condition (Table 2) scored maximum values for the three available categories, thus rating it in very poor

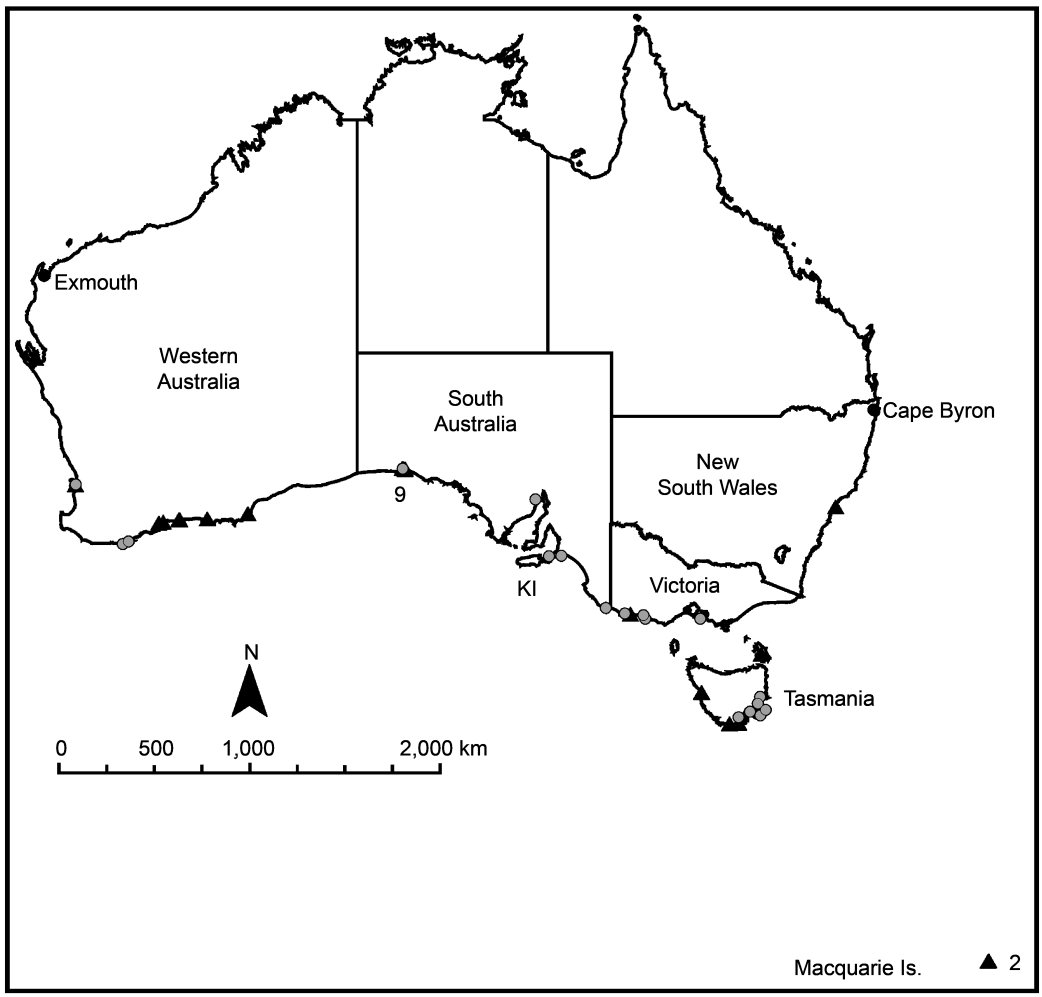

Fig. 1. Map of Australia depicting where southern right whale events have occurred. Triangle=carcass; grey circle=vessel collision, entanglement or shooting; black circle=towns at limits of southern right whale distribution. Number of records indicated when symbols represent multiple records. KI=Kangaroo Island.

Table 1

Number, relative age and gender of southern right whales from Australia. Animals listed under 'Carcasses' were found dead and no cause of death was noted. See Methods for definition of calf and 'non-calf'. Vessel collisions include small boats.

Event	No. records	Calf:'non-calf'
Carcasses	25	16:5
Non-fatal entanglements	12	4:7
Fatal entanglements	1	0:1
Non-fatal vessel collisions	3	0:1
Fatal vessel collisions	2	0:2
Non-fatal shooting	1	
Total	44	20:16

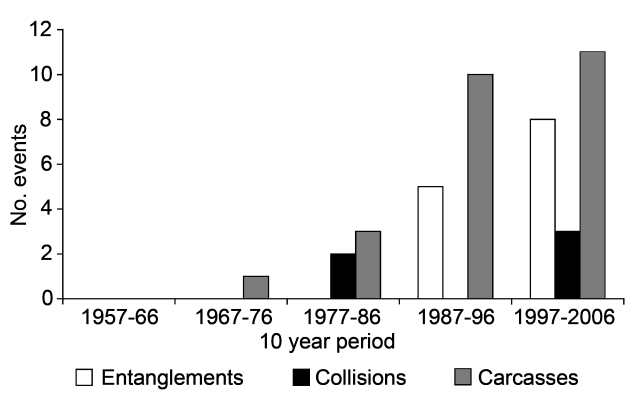

Fig. 2. Numbers of southern right whale entanglements, vessel collisions and carcasses in Australia from 1957.

condition. A deep concavity was apparent behind the head and later measurement of blubber thickness in that region was 15cm. The neural spines of the vertebrae showed as a distinct ridge along the back of the whale and many cyamids were present where the longline was attached to the peduncle. Many large sharks appeared at the scene and began to feed on the whale at about the time of death. Examination of the carcass after it washed up revealed that cyamid parasites were very abundant over much of the surface of the whale, particularly so on the head and the caudal peduncle. A 5mm braided nylon line was wrapped around the peduncle at least twice and was so deeply embedded in the flesh that in some places it was covered by scar tissue (Fig. 4). Subdermal tissue reaction was also severe, with extensive periosteal proliferation. Later maceration of the caudal peduncle revealed 18.5kg of this bony tissue.

Fig. 3. Southern right whale entangled in crab pots and lines near Point Lowly, Spencer Gulf, South Australia in August 2002. Note the healthy body condition suggesting recent entanglement.

Fig. 4. Injury caused by probable long-term entanglement around the peduncle of southern right whale that died at Head of Bight, South Australia, July 2001 (SAMA M22080).

DISCUSSION

Large whale species that live in, or migrate through, coastal waters where there is much fishing activity and commercial vessel traffic are particularly vulnerable to accidental entanglements and vessel collisions (Clapham *et al*., 1999). For example, humpback whales made up the greatest proportion of Lien's (1994) summary of cetaceans entrapped in passive inshore fishing gear off Newfoundland and Labrador. Along the Pacific coast of North America Baird *et al*. (2002) and Heyning and Lewis (1990) reported that baleen whales (mostly the gray whale, *Eschrichtius robustus*) often became entangled and died in fishing gear.

Laist *et al*. (2001) analysed worldwide data involving vessel collisions and great whales. Fin whales (*B. physalus*) were hit most often and right, sperm, humpback and gray whales were commonly involved in vessel collisions. All vessel sizes were recorded, with vessels 80m or longer travelling at speeds of 14kts or greater being considered the most lethal. The bowhead whale (*Balaena mysticetus*) is rarely involved in vessel collisions (George *et al*., 1994) because it lives in the Arctic where at least at present there is little large vessel traffic.

Right whales are very vulnerable to entanglement and vessel collision because they spend about half of each year in coastal waters where human activities are often intense. The population size of the endangered North Atlantic right whale is estimated at only 300 and its distribution overlaps with one of the most intensely used marine habitats along the eastern seaboard of North America. As a result, fatal and non-fatal entanglements and vessel collisions are numerous (Table 3, 1.5 yr^{-1}) and are a major factor in limiting population growth (Knowlton and Kraus, 2001). Reducing mortality from anthropogenic sources is believed to be the most effective way to improve the prospects for the North Atlantic right whale (Caswell *et al*., 1999; IWC, 2001a).

In contrast, the southern right whale inhabits environments where human activities are not as intense and the rate of anthropogenic incidents is less than for the North Atlantic right whale (Table 3). However, differences in awareness and reporting effort must also be considered when comparing these data. Vessel collisions were lowest for southern right whales off Australia and highest for the North Atlantic right whale. The amount of shipping traffic is less off southern Australia than southern Africa and the eastern seaboard of North America, and the shipping lanes are generally further offshore especially in the Great Australian Bight where right whales are abundant inshore. In addition, vessel collisions beyond the extensive (up to 200km) continental shelf off southern Australia may go undetected because whales struck and killed there would probably sink and not refloat (Scarff, 2001) or if they did refloat, their carcasses would be less likely to drift the many hundreds of kilometres to the coast.

In all three regions there were more entanglements in lines and ropes (primarily those associated with trapping crustaceans) than in nets (Best *et al*., 2001; Knowlton and Kraus, 2001). Trap fishing is a large and important industry along the continental shelf and slope off southern Australia and is intense in some areas frequented by whales (Anon., 2006). Best *et al*. (2001) suggested that entanglements in longlines might be fatal more often than ropes used in association with crustacean pots and traps because the smaller diameter of the longlines would be more likely to cut deeply into the tail of the whale. In Australia, the only

Table 2

Body condition of southern right whales involved in entanglements and vessel collisions in Australian waters. See Methods for explanation of scores.

Date	Locality	Length	Body condition	Skin condition	Rake marks	Blowhole cyamids	Total score	Fate
12/08/92	Cockburn Sound, WA	~10m	1	1	1	1	4/10	Unsuccessful disentanglement
17/08/94	Shoalwater Bay, WA	~10m	-	-	1	1	2/5	Whale freed itself
2-7/07/01	Head of Bight, SA	14.0m	3	2	-	2	7/7	Died with long line around tail stock
21/07/01	Cape Jervis, SA	14.5m*	1	1	1	1	4/10	Died after being hit by a ferry
19/08/02	Point Lowly, SA	~13m	1	1	1	1	4/10	Successful disentanglement

*Body length estimated from skull size.

Table 3

Right whale mortalities and incidents involving human activities in three world regions. Vessel collisions include small boats. Total mortalities = from all causes, including those unknown. Sources: South Africa (Best *et al*., 2001), Northwest Atlantic (Knowlton and Kraus, 2001), Australia (this paper). Percentage is of total records for each region.

	Australia (1950-2006)	South Africa (1963-98)	NW Atlantic (1970-99)
	E. australis	*E. australis*	*E. glacialis*
Fatal and non-fatal entanglements	13 (30%)	21 (28%)	15 (24%)
Fatal and non-fatal vessel collisions	5 (11%)	12 (16%)	22 (35%)
Total anthropogenic incidents*	19 (43%)	33 (43%)	37 (59%)
Total mortalities	28	55	45
Total records	44	76	63

*Includes one non-fatal shooting.

confirmed longline entanglement of a southern right whale (SAMA M22080) was fatal and in that case the line was very deeply embedded in the tail, causing extensive tissue damage and periosteal proliferation. The chronic nature of this injury suggests that the whale had towed the longline and buoy for a considerable period before it died. The blubber thickness of this whale (15cm) was well below that predicted (Tormosov *et al*., 1998) for a 14m whale (>20cm), although measurements of the latter were made during November to April, the austral feeding season. Evidence from other species of whale lends support to the hypothesis of Best *et al*. (2001) that longline injuries can be fatal. In 1990, an adult sperm whale stranded alive in South Australia with a longline around its tail. The wound was so deep that the tail was almost severed (South Australian Museum, unpublished records). However, gray whales have survived fluke amputations presumed to have been caused by entanglements (Urbán-R *et al*., 2004).

Anti-shark nets were involved in one fatal and three non-fatal entanglements of southern right whales in South Africa (Best *et al*., 2001), but none in Australia. Large-scale anti-shark netting is used throughout the year in Queensland (north of the main range of the southern right whale) and seasonally in New South Wales. Small nets have been used to protect swimmers in South Australia in a few locations but apart from this, anti-shark netting is not used along the southern coast of the continent.

The number of southern right whale mortalities in Australia appears to be related to regional differences in whale abundance. The majority of mortalities occurred in the central and western part of the continent, where dense aggregations of whales are located (Bannister, 2001; Burnell and Bryden, 1997) and where numbers are known to be increasing. Whale aggregations in southeastern Australia are fewer in number and much smaller (Department for Environment and Heritage, 2005; Kemper *et al*., 1997) and there is no apparent increase in aggregation size.

Population estimates for southern right whales in 1997 (IWC, 2001b) are available for Australia (1,200) and South Africa (3,100) and the mortalities recorded in these regions are directly proportional to these (Australia=0.49 yr^{-1}, South Africa=1.53 yr^{-1}, Table 3). This implies that the mortality rate, at least that near the continents, is similar. Best *et al*. (2001) concluded that in South Africa the degree of anthropogenic mortality did not pose a threat to the conservation of southern right whales. On the available evidence, the same is likely to be true for the whales frequenting the Australian region.

Knowlton and Kraus (2001) noted that most North Atlantic right whale calves died of natural causes. Best *et al*. (2001) found that 56.4% of their 55 mortalities of southern right whales off South Africa were calves of the year and that, of these, few were anthropogenic in nature. A similar proportion (52.4%) was found in the present study and none was attributed to human activities. In Australia, the major calving aggregations are in remote locations, well distant from the major shipping routes that are located offshore, and generally where there is little fishing (Anon., 2006). Maternal vigilance may also be a factor in reducing calf entanglements and vessel collisions.

It is inevitable that Australian southern right whales will become increasingly involved in deleterious interactions with human activities in the future. Whale numbers are increasing, as are fishing, aquaculture, shipping and boating. Protection of whales from harmful interactions with human activities has been recommended at a federal level through the encouragement of best practice (Department for Environment and Heritage, 2005) and disentanglement procedures are in place in all southern states. Western Australia has introduced a code of practice for reducing entanglements in the West Coast Rock Lobster Managed Fishery (available at *http://www.western-rock-lobster.com/pdf/whaleCofP*). Marine protected areas can provide some protection in regularly used coastal aggregation areas, but designing effective measures for other areas is much more problematic, particularly without detailed knowledge of whale offshore movements and distribution (see Burnell, 2001).

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REFERENCES

Anon. 1991. Australia. Progress report on cetacean research, May 1989 to May 1990. *Rep. int. Whal. Commn* 41: 223-29.

Anon. 1995. Project Jonah Tasmania Newsletter No. 11 (October).

Anon. 2006. Bureau of Rural Sciences 2006. Available from *http://affaship.gov.au/PdfFiles/marine_matters_national.*

Baird, R.W., Stacey, P.J., Duffus, D.A. and Langelier, K.M. 2002. An evaluation of gray whale (*Eschrichtius robustus*) mortality incidental

to fishing operations in British Columbia, Canada. *J. Cetacean Res. Manage.* 4(3): 289-96.
Bannister, J.L. 1986. Notes on nineteenth century catches of southern right whales (*Eubalaena australis*) off the southern coasts of Western Australia. *Rep. int. Whal. Commn (special issue)* 10: 255-59.
Bannister, J.L. 1997. Aerial survey of southern right whales off Western and South Australia, 1995 and 1996 calving seasons: report on work undertaken to 1 March 1997. Unpublished report to Environment Australia, Canberra. Project No. SO-95-01. 27pp. [Available from: *www.environment.gov.au/library/pubs*].
Bannister, J.L. 2001. Status of southern right whales (*Eubalaena australis*) off Australia. *J. Cetacean Res. Manage. (special issue)* 2: 103-10.
Bannister, J.L. 2006. Southern right whale aerial survey and photo-identification, southern Australia, 2005. Final report to the Commonwealth of Australia, Canberra, (unpublished). 20pp. [Available from the author, Western Australian Museum, Locked Bag 49, Welshpool, WA 6986].
Bannister, J.L. 2007. Southern right whale aerial survey and photo-identification, southern Australia, 2006. Final report to the Commonwealth of Australia, Canberra, (unpublished). 20pp. [Available from the author, Western Australian Museum, Locked Bag 49, Welshpool, WA 6986].
Best, P.B., Peddemors, V.M., Cockcroft, V.G. and Rice, N. 2001. Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1998. *J. Cetacean Res. Manage. (special issue)* 2: 171-76.
Best, P.B. and Rüther, H. 1992. Aerial photogrammetry of southern right whales, *Eubalaena australis*. *J. Zool., (Lond.)* 228: 595-614.
Brownell, R.L., Clapham, P.J., Miyashita, T. and Kasuya, T. 2001. Conservation status of North Pacific right whales. *J. Cetacean Res. Manage. (special issue)* 2: 269-86.
Burnell, S.R. 2001. Aspects of the reproductive biology, movements and site fidelity of right whales off Australia. *J. Cetacean Res. Manage. (special issue)* 2: 89-102.
Burnell, S.R. and Bryden, M.M. 1997. Coastal residence periods and reproductive timing in southern right whales, *Eubalaena australis*. *J. Zool. (Lond.)* 241: 613-21.
Caswell, H., Fujiwara, M. and Brault, S. 1999. Declining survival probability threatens the North Atlantic right whale. *Proc. Natl Acad. Sci. USA* 96(6): 3,308-13.
Clapham, P.J., Young, S.B. and Brownell, R.L., Jr. 1999. Baleen whales: conservation issues and the status of the most endangered populations. *Mammal Rev.* 29(1): 35-60.
Copson, G.R. 1994. Cetacean sightings and strandings at subantarctic Macquarie Island, 1968 to 1990. *ANARE Research Notes* 91: 1-15.
Department for Environment and Heritage. 2005. *Southern right whale recovery plan 2005-2010*. Australian Government. Available from: *http://www.environment.gov.au/biodiversity/threatened/publications/recovery/e-australis*.
Dixon, J.M. and Frigo, L. 1994. *The Cetacean Collection of the Museum of Victoria. An Annotated Catalogue*. Australian Deer Foundation, Croydon, Victoria, Australia. 38pp.
George, J.C., Philo, L.M., Hazard, K., Withrow, D., Carroll, G.M. and Suydam, R. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring of bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. *Arctic* 47(3): 247-55.
Goodall, R.N.P. and Galeazzi, A.R. 1986. Recent sightings and strandings of southern right whales off subantarctic South America and the Antarctic Peninsula. *Rep. int. Whal. Commn (special issue)* 10: 173-76.
Greig, A.B., Secchi, E.R., Zerbini, A.N. and Dalla Rosa, L. 2001. Stranding events of southern right whales, *Eubalaena australis*, in southern Brazil. *J. Cetacean Res. Manage. (special issue)* 2: 157-60.
Gribble, N.A., McPherson, G. and Lane, B. 1998. Effect of the Queensland Shark Control Program on non-target species. Whale, dugong and dolphin: a review. *Mar. Freshw. Res.* 49: 645-51.
Guiler, E.R. 1978. Whale strandings in Tasmania since 1945 with notes on some seal reports. *Pap. Proc. R. Soc. Tasman.* 112: 189-213.
Hart, J.L., Hagan, J. and Baker, J. 1842. Report on whaling in South Australia. *Proc. Roy. Geog. Soc. Aust.* 22: 22-34.
Heyning, J.E. and Lewis, T.D. 1990. Entanglements of baleen whales in fishing gear off southern California. *Rep. int. Whal. Commn* 40: 427-31.
International Whaling Commission. 2001a. Report of the Workshop on Status and Trends of Western North Atlantic Right Whales. *J. Cetacean Res. Manage. (special issue)* 2: 61-87.
International Whaling Commission. 2001b. Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. *J. Cetacean Res. Manage. (special issue)* 2: 1-60.
Kemper, C.M. and Samson, C.R. 1999. Southern right whale remains from 19th century whaling at Fowler Bay, South Australia. *Rec. South Aust. Mus.* 32: 155-72.
Kemper, C.M., Mole, J., Warneke, R.M., Ling, J.K., Needham, D.J. and Wapstra, J.E. 1997. Southern right whales in south eastern Australia – aerial surveys during 1991-93 and incidental information from 1904. pp.40-45. *In*: Hindell, M. and Kemper, C. (eds). *Marine Mammal Research in the Southern Hemisphere*. Surrey Beatty and Sons Pty Ltd, Chipping Norton, New South Wales.
Kemper, C.M., Pemberton, D., Cawthorn, M., Heinrich, S., Mann, J., Wursig, B., Shaughnessy, P.D. and Gales, R. 2003. Aquaculture and marine mammals: co-existence or conflict? pp.208-25. *In*: Gales, N., Hindell, M. and Kirkwood, R. (eds). *Marine Mammals and Humans: Fisheries, Tourism and Management Issues*. CSIRO Publishing, Melbourne. 446pp.
Knowlton, A.R. and Kraus, S.D. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *J. Cetacean Res. Manage. (special issue)* 2: 193-208.
Kraus, S.D. 1990. Rates and potential causes of mortality in North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mammal Sci.* 6(4): 278-91.
Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. 2001. Collisions between ships and whales. *Mar. Mammal Sci.* 17(1): 35-75.
Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). *Rep. int. Whal. Commn (special issue)* 15: 149-57.
McManus, T.J., Wapstra, J.E., Guiler, E.R., Munday, B.L. and Obendorf, D.L. 1984. Cetacean strandings in Tasmania from February 1978 to May 1983. *Pap. Proc. R. Soc. Tasman.* 118: 117-35.
Nicol, D.J. 1987. A review and update for the Tasmanian cetacean stranding record to the end of February 1986. Environmental Studies Working Paper 21, University of Tasmania, Hobart. 97pp.
Pettis, H.M., Rolland, R.M., Hamilton, P.K., Knowlton, A.R., Brault, S. and Kraus, S.D. 2004. Visual health assessment of North Atlantic right whales (*Eubalaena glacialis*) using photographs. *Can. J. Zool.* 82: 8-19.
Scarff, J.E. 2001. Preliminary estimates of whaling-induced mortality in the 19th century North Pacific right whale (*Eubalaena japonicus*) fishery, adjusting for struck-but-lost whales and non-American whaling. *J. Cetacean Res. Manage. (special issue)* 2: 261-68.
Shaughnessy, P.D., Kirkwood, R., Cawthorn, M., Kemper, C. and Pemberton, D. 2003. Pinnipeds, cetaceans and fisheries in Australia: a review of operational interactions. pp.136-52. *In*: Gales, N., Hindell, M. and Kirkwood, R. (eds). *Marine Mammals and Humans: Fisheries, Tourism and Management Issues*. CSIRO Publishing, Melbourne. 446pp.
Tormosov, D.D., Mikhalev, Y.A., Best, P.B., Zemsky, V.A., Sekiguchi, K. and Brownell Jr, R.L. 1998. Soviet catches of southern right whales, *Eubalaena australis*, 1951-1971; biological data and conservation implications. *Biol. Conserv.* 86(2): 185-97.
Urbán-R, J., Flores de Sahagún, V., Jones, M.L., Swartz, S.L., Mate, B., Gömez-Gallardo, A. and Guerrero-Ruiz, M. 2004. Gray whales with loss of flukes adapt and survive. *Mar. Mammal Sci.* 20(2): 335-38.

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Appendix 1

Records of human-related events involving southern right whales in Australia. ID = reliability of identification (see Methods). *Body length estimated from skull size. SAMA = South Australian Museum Adelaide, AM = Australian Museum Sydney, DPIW = Department of Primary Industries and Water Tasmania, DEC = Department of Environment and Conservation, Western Australia, DSE = Department of Sustainability and Environment Victoria.

Date	Locality	Event	Description	Body length (m)	Gender	ID	Source
17/08/50	Victor Harbor, SA 35º35'S, 138º38'E	Shooting	Adult wounded, calf disappeared. Fate of both unknown.	'Adult and calf'	F?	3	SAMA
10/02/81	Orwell Rocks, SA 38º3'S, 140º44'E	Possible fatal vessel collision	Washed up dead after floating at sea. Observers noted that the incident may have been a vessel strike but gave no details to substantiate this.	11.5	M?	1	SAMA M14135
22/10/84	Cremorne, South Arm, Tas. 42º57'S, 147º33'E	Boat collision	Accidentally hit by fishing boat. Deep gash in blubber.	>10	-	2	Anon (1995); DPIW
30/05/89	Huon River, Tas. 43º13'S, 147º0'E	Entanglement	Whale damaged Atlantic Salmon fish pen and apparently freed itself.	Reported as 'adult'	-	3	Anon (1991)
07/10/90	King George Sound, Albany, WA 35º2'S, 117º56'E	Entanglement	Rock-lobster pot rope wrapped 2-3 times around body and peduncle, with orange float. Whale cut free.	~15	-	2	DEC
12/08/92	Cockburn Sound, WA 32º16'S, 115º41'E	Entanglement	Illegal crab tangle net around caudal peduncle. Whale photographed by DC on 1 August 1992, before entanglement.	~10	-	1	DEC, Bannister (pers. comm., 2005)
17/08/94	Shoalwater Bay, WA 32º19' 9"S, 115º42'38"E	Entanglement	Freed itself from octopus set line.	~10	-	1	DEC
26/08/95	Little Swanport, Tas. 42º15'S, 148º1'E	Entanglement	Monofilament net and rope attached to tail stock. Unsuccessful attempt to disentangle.	~15	-	3	Anon. (1995), DPIW
02/07/01	1.3 km ENE Twin Rocks, SA 31º28' 7"S, 131º8'55"E	Fatal entanglement	Longline and buoy around caudal peduncle. Died 7 July.	14.0	F	1	SAMA M22080
21/07/01	3 km WNW Cape Jervis, SA 35º36'17"S, 138º3'17"E	Fatal vessel collision	Hit by passenger ferry. Large welt on body.	14.5*	F	1	SAMA M22965
19/08/02	10 km N Point Lowly, SA 32º55'S, 137º25'E	Entanglement	Crab pot lines and eight pots around body (at least seven wraps) and caudal peduncle. Buoys attached to line. Lines cut and animal freed.	~13	-	1	SAMA S309
31/08/02	Shelly Point, Prosser Bay, Tas. 42º33'59"S, 147º54'30"E	Boat collision	Two whales disturbed by starting up outboard motor. Some skin lost.	-	-	3	DPIW
03/11/02	Cremorne, Tas. 43º8'S, 148º2'E	Boat collision	Whale lifted and rolled fishing boat. Blood on dorsal surface. Boat propeller damaged.	Reported as 'adult'	-	3	DPIW
24/10/03	Portland Harbour, Vic. 38º19'S, 141º38'E	Entanglement	Line and small white buoys around tail. Disentanglement not attempted as whale not located.	-	-	1	DSE
25/03/05	Betty's Beach, WA 34º55'5"S, 118º14'13"E	Entanglement	20m length of 50mm diameter rope with ruptured buoy left side mouth, right side of mouth four loops of heavy braided green rope trailing 2m. Disentanglement attempt unsuccessful. Travelled 90km over several days.	~9	-	1	DEC
08/08/05	Diamond Island, Bicheno, Tas. 42º52'S, 148º17'E	Entanglement	Whale entangled in boat mooring line attached to buoy. Later freed itself.	12.5	-	1	DPIW
27/08/05	Logans Beach, Vic. 38º19'S, 141º38'E	Entanglement	Rock-lobster pot rope and buoy. Disentanglement not attempted and report unconfirmed.	Reported as 'adult and calf'	-	3	DSE
09/09/05	Diamond Rock, Warrnambool, Vic. 38º28'36"S, 142º36'12"E	Entanglement	Line and crayfish pot around tail. Disentanglement not successful.	~14	-	1	DSE
31/12/06	Pyramid Rock, Phillip I., Vic. 38º33'48"S, 145º11'54"E	Entanglement	Lines and floats around head. Aerial search failed to relocate.	~10	-	1	DSE

Appendix 2

Records of carcasses of southern right whales in Australia. ID = reliability of identification (see Methods), M = male, F = female. SAMA = South Australian Museum Adelaide, MV = Museum of Victoria, DEC = Department of Environment and Conservation, Western Australia. DSE = Department of Sustainability and Environment Victoria, DPIW = Department of Primary Industries and Water Tasmania. The length of SAMA M22965 was estimated by comparing greatest skull width with skulls from known-length whales (Kemper and Samson, 1999).

Date	Locality	Length (m)	Sex	ID	Comments	Source
17/04/74	Prion Beach, Tas., 43º32'S, 136º34'E	-	-	3	Seen from air being attacked and driven ashore by large shark.	Guiler (1978), Nicol (1987)
06/03/77	Caroline Cove, Macquarie Island, 54º45'S, 158º47'E	-	-	3	Found dead. Fresh.	Copson (1994)
April 1980	Henty River, Tas., 42º3'S, 145º15'E	-	-	3	Found dead and decomposing.	McManus *et al.* (1984), Nicol (1987)
01/11/80	Actaeon Island, Tas., 43º30'S, 147º0'E	7	-	3	Found dead and decomposing.	McManus *et al*. (1984), Nicol (1987)
04/10/88	12km ESE Twin Rocks, SA, 31º29'S, 131º15'E	5.52	M	1	Found dead and decomposing.	SAMA M15596
26/07/90	4km E Twin Rocks, SA, 31º28'0"S, 131º10'40"E	~5.3	M	1	Found dead on beach.	SAMA M16470
05/11/91	4km E Fitzroy River mouth, Vic., 38º15'S, 141º54'E	9.30	-	1	Washed up in advanced state of decomposition (mandible missing).	MV C28603 (Dixon and Frigo, 1994)
1992	Head of Bight, SA, 31º28'S, 131º8'E	Calf	-	1	Found dead. Calf of known female.	S. Burnell (pers. comm., 2006)
1993	Head of Bight, SA, 31º28'S, 131º8'E	Calf	-	1	Found dead. Calf of known female.	S. Burnell (pers. comm., 2006)
07/09/92	30km W Hopetoun, WA, 34º00'S, 119º50'E	5.2	M	1	Found dead and fresh?	WAM M40552
17/07/93	Norah Head, NSW, 33º17'S, 151º35'E	4.88	M	1	Found floating dead in channel. Decomposing.	AM M28973
09/08/94	4km SE Twin Rocks, SA, 31º28'0"S, 131º10'30"E	Calf	-	1	Went missing from mother then carcass found on beach, stripped of flesh.	SAMA M17766
21/10/95	20km E Hopetoun, WA, 33º54'S, 120º34'E	A?	-	1	Seen floating dead with shark bites.	WAM M54175, Bannister (1997)
08/10/96	Dempster Inlet, WA, 34º3'S, 119º38'E	7.8	-	1	Floating dead just off beach.	DEC, Bannister (1997)
24/07/01	1km W Twin Rocks, SA, 31º28'10"S, 131º7'40"E	-	-	2	Floating dead near shore.	SAMA
10/07/02	0.8km NE Twin Rocks, SA, 31º27'55"S, 131º8'27"E	6.83	F	1	Found dead on beach. Fresh.	SAMA M23661
19/08/02	North Precarious Bay, Macquarie Island, 54º44'S, 158º49'E	10.6	F	1	Found dead and decomposing.	Hindell and Evans (pers. comm., 2005)
11/07/03	Broun Bay, Garden Island, WA, 32º14'34"S, 115º41'31"E	13.4	F	1	Found dead and reasonably fresh.	DEC
22/12/03	Buffalo's Beach, Flinders I., Tas., 40º15'S, 148º4'E	11.5	-	1	Found dead and decomposed.	DPIW
14/07/04	15km SE Twin Rocks, SA, 31º31'S, 131º15'E	Calf	-	1	Floating dead. Carcass being eaten by sharks.	SAMA
09/10/05	Point Dempster, Israelite Bay, WA, 33º38'S, 123º52'E	Calf	M	1	Found dead on beach. Fresh.	Bannister (2006)
16/06/05	Esperance, WA, 33º51'S, 121º55'E	~6	M	1	Found dead on beach. Fresh.	DEC
18/08/05	Munglinup Beach, WA, 33º53'24"S, 120º36'54"E	15	-	1	Washed up dead and decomposing.	DEC
05/12/05	Nanga, Peron Peninsula, WA, 26º15'S, 113º48'E	12.7	F	1	Found dead. Early decomposition.	DEC
08/07/06	5km E Twin Rocks, SA, 31º28'30"S, 131º11'0"E	Calf	F	1	Found dead. Fresh.	SAMA