

Prolific body scars and collapsing dorsal fins on killer whales (*Orcinus orca*) in New Zealand waters

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Summary

An account is given of adult male killer whales (*Orcinus orca*) in New Zealand waters, where two whales have prolific scars caused by conspecifics and seven whales have collapsing, collapsed or bent dorsal fins (23% of the observed New Zealand adult male killer whale population).

Introduction

Scars on the bodies of cetaceans have been reported for a wide range of species. In general, these scars are attributed to teeth marks from conspecifics, e.g., bottlenose dolphin *Tursiops truncatus* (Gunter, 1942), pygmy sperm whale *Kogia breviceps* (McCann, 1974), sperm whale *Physeter macrocephalus* (Kato, 1984), Risso's dolphin *Grampus griseus* (McCann, 1974), striped dolphin *Stenella coeruleoalba* (Mitchell, 1970), long finned pilot whale *Globicephala melas* (McCann, 1974) and narwhal *Monodon monoceros* (Sliverman & Dunbar, 1980), which have also been reported with tusks from conspecifics embedded in muscle tissue (Ford & Ford, 1986; Geist *et al.*, 1960). Scars have also been reported on various beaked whales; Baird's *Berardius bairdii* (Omura *et al.*, 1955), Hubb's *Mesoplodon carlhubbsi* (Heyning, 1984), Cuvier's *Ziphius cavirostris* (Heyning, 1989), True's *Mesoplodon mirus* T. Pusser, (pers. comm.), Bowdoin's *Mesoplodon bowdoini* (Hubbs, 1946), dense beaked *Mesoplodon densirostris* (Heyning, 1984), Arnoux's *Berardius arnouxii* (McCann, 1974), and Gray's *Mesoplodon grayi* (pers. obs). Limited literature refers to scars on killer whales (Ford *et al.*, 1994; Hoyt, 1984; Scheffer, 1969).

Collapsing, collapsed or bent dorsal fins of killer whales have only been reported in passing in the literature, although a few photographs have been published (Baird & Stacey, 1989; Ford *et al.*, 1994; Hoyt, 1984; Matkin, 1994). The purpose of this paper is to describe prolific body scars and collapsing, collapsed or bent dorsal fins on a number of

killer whales found in New Zealand waters. Few accounts of killer whales with body scars or abnormal dorsal fins have been reported worldwide, and these are the first from New Zealand.

Methods

The observations reported here were collected as part of a long term study of the killer whale population found in the waters around New Zealand. To date (September 1997) 125 individuals have been photoidentified, using methods developed by Bigg (1987). Data were collected in an opportunistic manner, including photographs of killer whales from the public. Killer whales were encountered after a report from fishermen, whale and dolphin watching boats, coastguard or the public and were followed until such constraints as fuel, weather conditions, or the animals' behaviour caused the encounter to be terminated. Where possible, photographs of killer whales were taken using a Nikon F90 camera with a 80–200 lens and Kodak 100 Select transparency film. A 4.3 m rigid hull inflatable with a 60 hp outboard engine was used as the observation platform and locations were recorded from nautical charts and/or a hand-held Global Positioning System (GPS).

Identified killer whales were assigned a category based on sex and/or age. All animals reported here fall into the category 'Adult Male'—categorised by having distinctively large dorsal fins (Bigg, 1982). For the purpose of this paper, 'prolific body scars' refers to scars on the killer whales that are extensive and numerous. These scars are generally parallel rows of three or four per group. The collapsing, collapsed or bent dorsal fins refer to a fin that is, or has begun to hang to one side of the animal's body, or is no longer upright. It may also have some form of malformation such as a bend or wave, or a combination of both hanging and bending. These dorsal fins are referred to as 'abnormal'.

Table 1. Sighting history of adult male killer whale NZ26 (Top Notch)

Sighting number	Date	Location	Comments	Photographer
1	5-Nov-89	Kaikoura	Notch clear in top of fin, fin upright	B. Todd
2	28-Nov-89	Kaikoura	Notch clear in top of fin, fin upright	B. Todd
3	18-Jun-90	Papamoa Beach	Notch clear in top of fin, fin upright	N. Ewing
4	Dec-90	Kaikoura	Notch clear in top of fin, fin upright	D. Buurman
5	8-Dec-91	Marlborough Sounds	Notch clear in top of fin, fin upright	M. Rowe
6	6-Feb-92	Kaikoura	Notch clear in top of fin, fin upright	D. Buurman
7	20-Dec-92	Marlborough Sounds	Notch clear in top of fin, fin upright	L. Battersby
8	Nov-93	Bay of Islands	Notch clear in top of fin, fin upright	L. Andrews
9	6-Feb-93	Kaikoura	Notch clear in top of fin, fin upright	D. Buurman
10	15-Jan-95	Marlborough Sounds	Notch clear in top of fin, fin upright	I. Visser
11	10-Mar-96	Bay of Islands	Notch top of fin, fin collapsing, prolific parallel scars all over body	J. Berghan, P & K Waller, I. Visser

Results

Prolific body scars

Two adult male killer whales have been photographed with prolific body scars. Catalogue numbers, names and details are given for each animal.

NZ26 (Top Notch). NZ26 was first recorded in November 1989 off Kaikoura. His sighting history is given (Table 1). He had no noticeable scarring during the first ten encounters (1989-1995). When resighted on the eleventh encounter (10 March 1996) he had pink, fresh tooth rake marks, similar in pattern to those seen healed on NZ85 (see below). These rake marks were seen on most of the visible areas of the body, and were particularly obvious on the eye patch area, where pieces of skin could be seen hanging from the edges of the rakes, (Fig. 1a). The prolific scarring was raised into 'welts' (Fig. 1b). Scarring was not heavy on the dorsal fin, with the exception of the trailing edge of the fin, which was heavily lacerated, and had loose skin hanging from it. NZ26 surfaced several times alongside the research vessel, within 1/4 of a metre, allowing for close examination of the rake marks. From these examinations it was determined that the rake marks were 3-4 cm apart. No other killer whales seen in this group had prolific scarring, either fresh or healed.

NZ85 (Outlaw). NZ85 was photographed off Kaikoura (Fig. 2), on the 6 February 1993 by Dennis Buurman. This animal has not been recorded since this date. The scarring on this animal was extensive, and was prolific over all the dorso-lateral surfaces. The dorsal fin had a noticeable lack of scarring in comparison to the rest of the body.

With the exception of the peduncle area, the scarring appeared to be healed, and on the eye patch showed a contrasting colour (i.e., black on white). Some of the scarring on the peduncle area was fresh, appeared pink, and there was some loose skin on the ridge of the spinal area. From comparisons to the photos of NZ26, the rake marks on NZ85 appeared to be of similar length and spacing. No other animals seen in this group had prolific scarring, either fresh or healed.

Collapsing and twisted dorsal fins

In New Zealand seven adult male killer whales have been photographed with abnormal dorsal fins. Of the 125 killer whales catalogued for the New Zealand population, 30 are adult males. Twenty-three percent of the adult males show some form of collapsing, collapsed or twisted dorsal fins. Catalogue numbers, names and details are given for each animal below.

NZ15 (Corkscrew). NZ15 was first recorded on the 31 January 1985 (Table 2 lists sighting history). He has been seen ten times over a 13 year period. During all this time his dorsal fin has been bent into a loose concertina shape, with a wavy trailing edge, and the whole dorsal fin has a lean to the animal's right of approximately 15° (Fig. 3a). It has a large notch out of the front of the dorsal fin, at the first bend (Fig. 3b). The dorsal fin remains rigid during surfacing, and does not 'wobble' (D. Buurman, pers. comm.).

NZ26 (Top Notch). NZ26 was first photographed on 5 November 1989 at which time he had an upright and rigid dorsal fin. He had a large notch out of the top of his dorsal fin and a slight wave

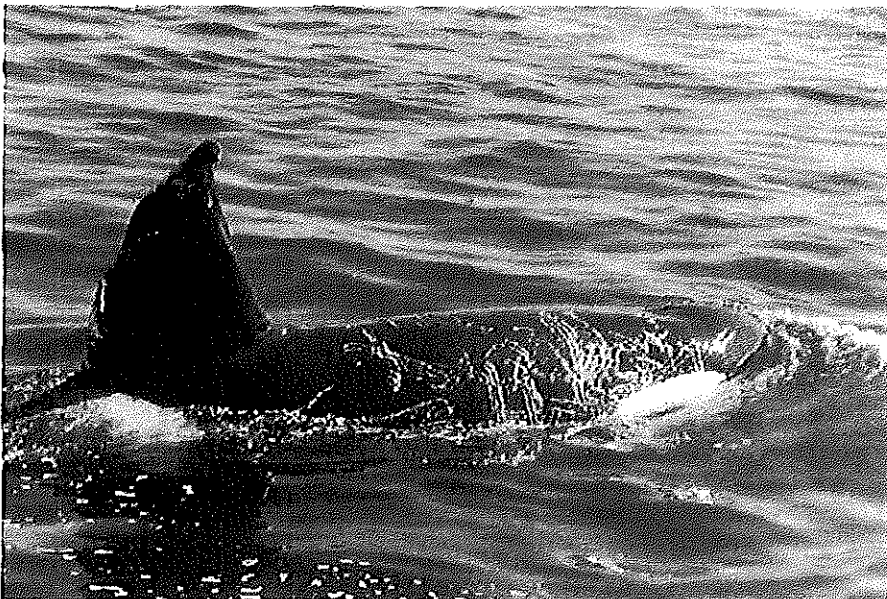
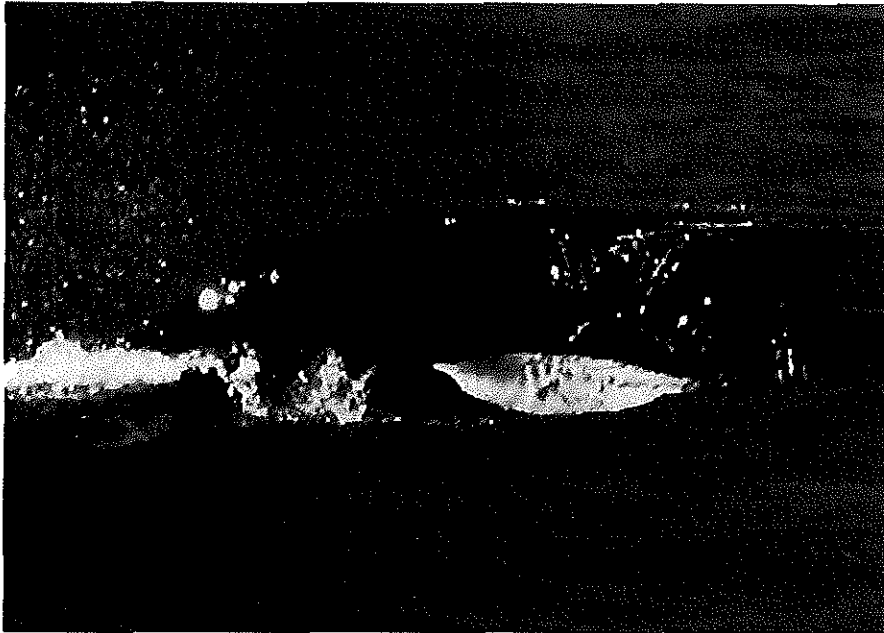


Figure 1 (a) Scarring on the eye patch area of NZ26, where loose pieces of skin can be seen (photo author), (b) Prolific scarring on the dorso-lateral area of NZ26, which is raised into 'welts' (photo P. & K. Waller).

to the trailing edge. On the 15 January 1995 his dorsal fin was still upright (Fig. 4a), however on 10 March 1996, (the eleventh resighting) his dorsal fin was beginning to collapse. As NZ26 surfaced his dorsal fin would remain upright for a

short time, then collapse to the animal's right, (Fig. 4b), at times bending nearly 60°. Photographs taken whilst the dorsal fin was upright allowed matches to be made with previous records (Fig. 4c).

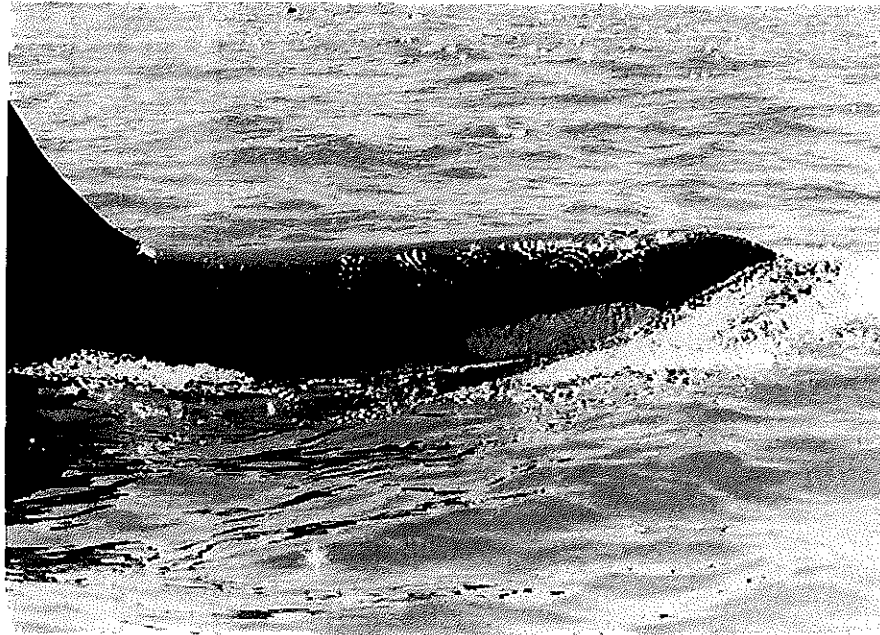


Figure 2. Prolific scarring on the dorso-lateral area of NZ85, showing contrasting colour on eye patch area (photo D. Buurman).

Table 2. Sighting history of adult male killer whale NZ15 (Corkscrew)

Sighting number	Date	Location	Comments	Photographer
1	31-Jan-85	Auckland Harbour	Twisted fin, large notch in front of fin	S. Whitehouse
2	23-Mar-89	Kaikoura	Twisted fin, large notch in front of fin	B. Todd
3	11-Jan-92	Kaikoura	Twisted fin, large notch in front of fin	B. McFadden
4	30-Nov-92	Kaikoura	Twisted fin, large notch in front of fin	D. Buurman
5	1-May-94	Kaikoura	Twisted fin, large notch in front of fin	S. Yin
6	25-Dec-95	Marlborough Sounds	Twisted fin, large notch in front of fin	R. Gross, L. & Z. Battersby
7	3-Jan-96	Kaikoura	Twisted fin, large notch in front of fin	D. Buurman
8	8-Feb-96	Kaikoura	Twisted fin, large notch in front of fin	D. Buurman, R. Constantine
9	9-Dec-96	Marlborough Sounds	Twisted fin, large notch in front of fin	D. Mayson
10	29-Jan-97	Westport	Twisted fin, large notch in front of fin	S. Bräger

NZ66 (Captain Hook). NZ66 was first photographed on 19 October 1994. The top 1/3 of his dorsal fin was bent over into a 'hook', and the trailing edge had a 'wavy' appearance. The dorsal fin has maintained that shape for at least two years, (1994–1996), neither folding over further, nor straightening (Fig. 5).

NZ83 (no name). In 1992, NZ83's dorsal fin was bent over for the top 1/3, similar to that seen for NZ66 and the trailing edge of the hooked over section had at least three tight bends in it. This

animal was sighted on seven occasions, over a two year period. He died on or about the 2 July 1994, and his dorsal fin remained bent in death (R Gross, pers. comm.).

NZ85 (Outlaw). On the only sighting of NZ85 (6 February 1993) the top 2/3 of his dorsal fin was collapsed to the animal's right at nearly 80° (Fig. 6). The dorsal fin was not rigid and 'wobbled' (D. Buurman, pers. comm.). The trailing edge of the dorsal fin was 'wavy' and the front had a large notch near the bending point.

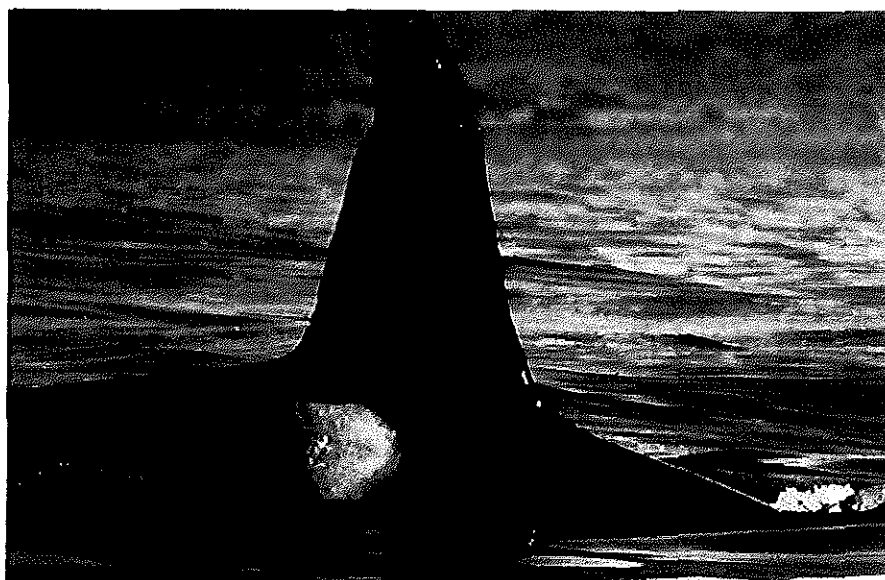
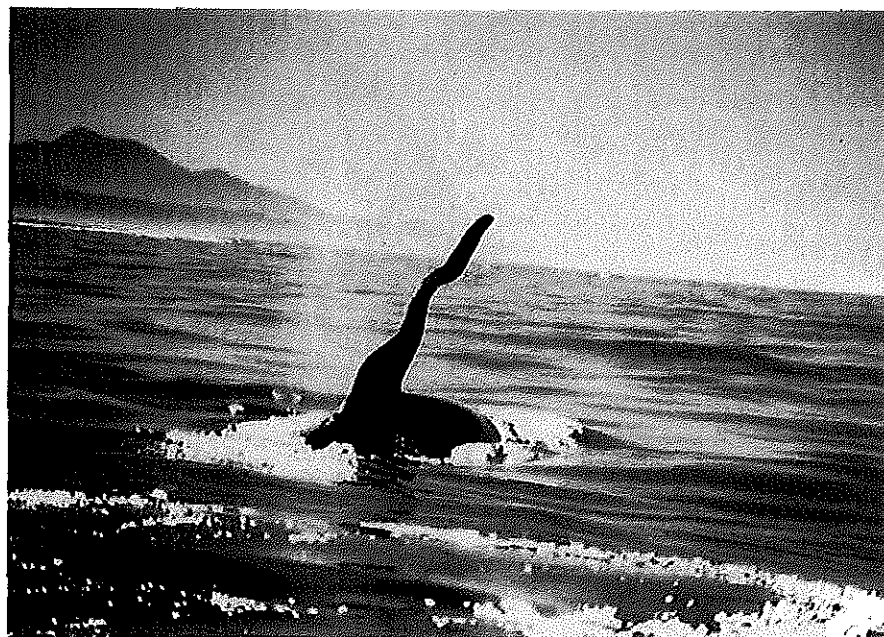


Figure 3. (a, b) NZ15 (Corkscrew) showing bend in dorsal fin in a loose concertina fashion, the wavy trailing edge, and a notch out of the front of the fin (photo S. Yin).

NZ86 (Wavy). On 8 December 1991, NZ86 had a wavy trailing edge to his dorsal fin. The waves began at the base of the dorsal fin, and had three folds. The whole dorsal fin appeared to 'wobble' about 10° to each side of centre during a surfacing (M. Rowe, pers. comm.). NZ86 had been observed

over a three year period (1991–1993) and during this time the wave had become progressively more pronounced.

NZ100 (Slater). NZ100 was photographed on one occasion, in September 1981. His dorsal fin was



Figure 4 (a) and (b).

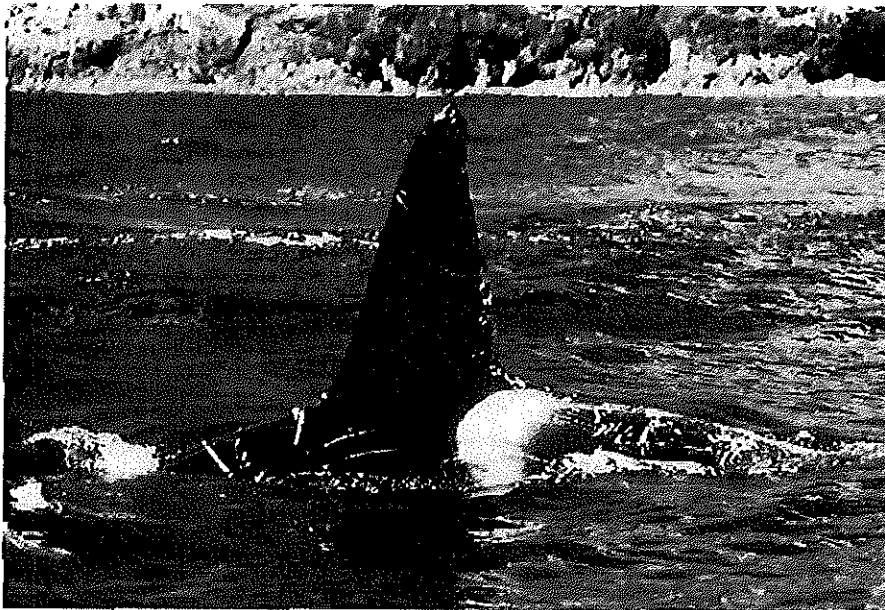


Figure 4(c).

Figure 4(a) NZ26 (Top Notch) showing his upright and rigid dorsal fin, photographed on 15 January 1995 (photo author). (b) NZ26 (Top Notch) as his fin begins to collapse on 10 March 1996. (c) NZ26 (Top Notch) photos taken whilst the dorsal fin was upright allowed matches to be made with previous records.

completely collapsed and folded over to the right (Fig. 7). This animal was travelling alone and appeared to be 'sluggish' (S. Whitehouse, pers. comm.). NZ100 had an indentation around the thorax area (arrow, Fig. 7).

Discussion

Prolific body scars

No reports in the literature refer to such prolific or extensive scarring on killer whales as those presented here. Lockyer (1979) reports some members of a group of killer whales had scars on the head and body, and proposed that they were caused by other killer whales. T. Similä and F. Ugarte (pers. comm.) have seen two young calves who appeared to be ill and were being carried by other killer whales, causing extensive scarring.

Scarring on cetaceans has been recorded for a wide range of species with many of these scars attributed to inter-male aggression (Heyning, 1984), but prolific scarring has also been reported on females of some species e.g., *Physeter macrocephalus* (S. Hooker, pers. comm.) and *Monodon monoceros* (Ford & Ford, 1986). The extensive scarring on the two adult male killer whales reported here cannot be positively attributed to one sex or the other, but it is highly probable that

conspecifics caused the parallel tooth rakes, due to the spacing of the rake marks. Scheffer (1969) reports a killer whale marked with regular lines suggesting scars made by the teeth of another killer whale. He measured the spacing of the alveoli of teeth in skulls of two adult male killer whales and found the mean distance to be 34.5 mm. My estimates of the distance between rake marks seen on the two adult male killer whales are between 3-4 cm. Measurements taken from tooth rake marks (also thought to be caused by conspecifics) on a stranded sub adult male killer whale were 3 cm apart.

Scheffer's figure 1 (1969) shows parallel rake marks with a group of five rakes. Most of the groups of rake marks on the two adult male killer whales reported here show groups of three or four. A clear photo in Morejohn (1979, their figure 3) shows rake marks attributed to a killer whale which are grouped in three and four, on each side of the peduncle of a Dall's porpoise *Phocoenoides dalli*.

The rake marks seen on NZ85 were mostly healed, and appear to be permanent scars, in particular the ones on the eye patch that show a contrasting colour (Lockyer & Morris, 1990). This killer whale also had an abnormal fin (see above).

It is likely that any other killer whale involved in a mutually aggressive interaction would also show

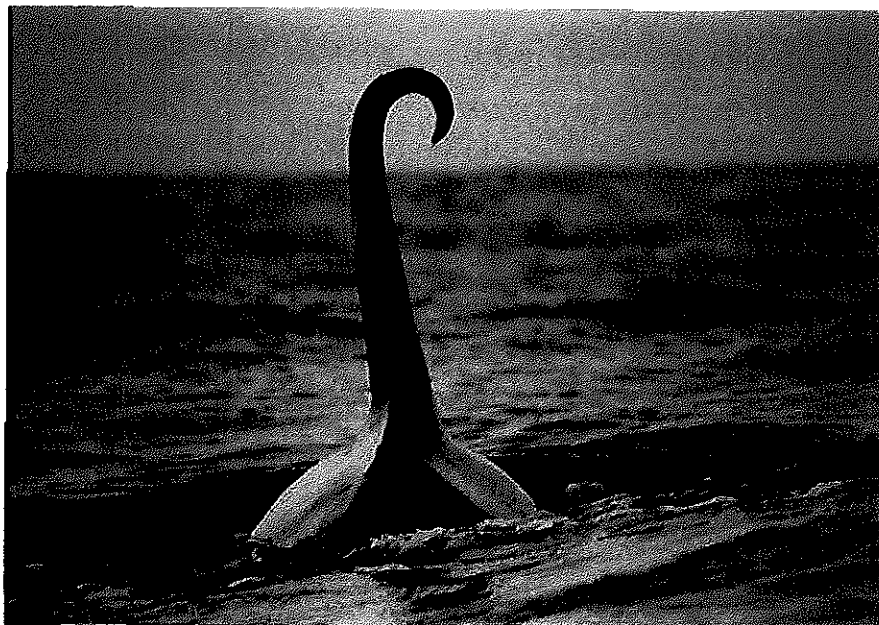


Figure 5. NZ66 (Captain Hook) showing the top 1/3 of the dorsal fin bent over into a 'hook', and the trailing edge with a 'wavy' appearance (photo S. Yin).

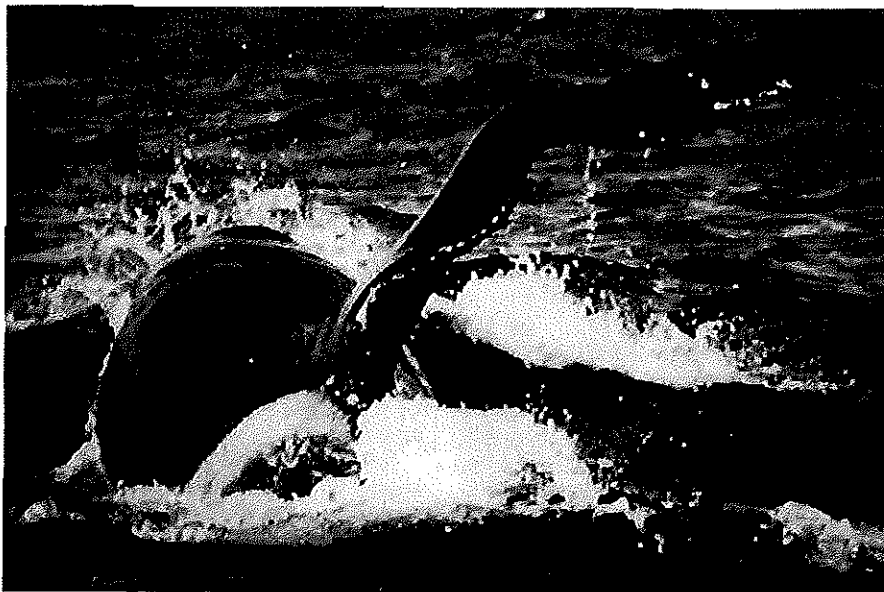


Figure 6. NZ85 (Outlaw) showing the top 2/3 of his dorsal fin was collapsed to the animal's right at nearly 90° (photo D. Buurman).

some scarring. However no other animals in either group (i.e., the animals found with NZ26 or NZ85) showed any extensive scarring.

Rake marks from killer whales are not uncommon on other species of cetaceans, e.g., *Physeter*

macrocephalus (Arnbom & Whitehead, 1989; Best *et al.*, 1984), humpback whales *Megaptera novaeangliae* (Katona & Whitehead, 1981), *Monodon monoceros* (Campbell *et al.*, 1988), Gray whales *Eschrichtius robustus* (Lowry *et al.*, 1987; Rice &

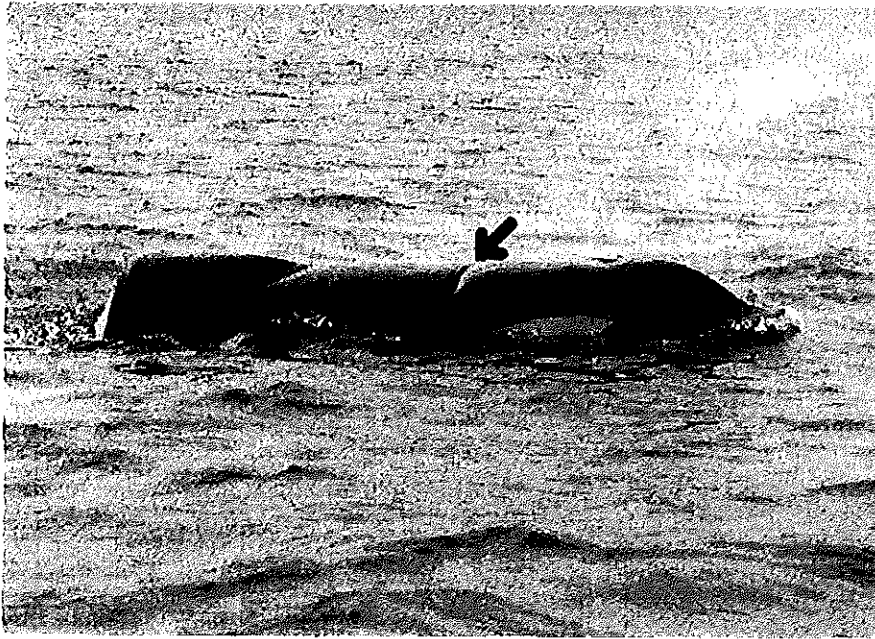


Figure 7. NZ100 (Slater), showing his dorsal fin was completely collapsed and folded over to the right. Arrow shows an indentation around the thorax area (photo S. Whitehouse).

Wolman, 1971), bowhead whales *Balaena mysticetus* (George *et al.*, 1994), *Phocoenoides dalli* (Morejohn, 1979). These scars all resemble those reported on the two adult male killer whales in this paper.

It is likely that large social carnivorous animals such as killer whales, (like wolves or lions), have strong inhibition mechanisms against conspecific aggression (Lorenz, 1966). There have been very few reports of conspecific aggression in wild killer whales (Baird *et al.*, 1992; Hoyt, 1984; Shore, 1995). Accounts of cannibalism by killer whales are also low, with partial remains of killer whales found in the stomach of two conspecifics (Shevchenko, 1975). In these instances, however, it must be taken into account that scavenging may have occurred rather than conspecifics being attacked. There is one report of a group of killer whales attacking another, which had been injured by a bullet wound (Gaskin, 1972).

Collapsing and twisted dorsal fins

Currently the percentage of observed adult males with abnormal (i.e., collapsed, collapsing or bent) dorsal fins, in the New Zealand population of killer whales, is 23.3%. For the British Columbian population the rate is 4.7% and for the Norwegian population the rate is 0.57% (details are given in Table 3). It is not known why there appears to be such a high rate of abnormality in dorsal fins in the New Zealand population.

Bigg (1982) noted that in adult males the dorsal fins 'seem to develop structural weaknesses eventually, which result in curling at the tip, less rigidity of the dorsal fin and in three cases, complete collapse of the dorsal fin to lie flat along the side of the body'. This suggests that collapsing or collapsed fin may be attributed to age. No age estimates are known for any of the adult males reported here, but all would be considered to be at least 12 years old due to the large size of their fins (Bigg, 1982).

In captivity many adult male killer whales ($n=18$) have developed abnormal fins, in the form of collapsed or collapsing fins (Hoyt, 1992). The seven killer whales reported here are wild animals, and no killer whales are kept in captivity in New Zealand.

It is possible that the collapsing of the dorsal fin of NZ26 may have been caused by the same agent as the body scars (i.e., an attack by a conspecific), or the stress involved in such an interaction, but as the animal was not monitored immediately prior to the infliction of the wounds, the dorsal fin may have begun to collapse before the fresh wounds were inflicted. The dorsal fin of NZ15 has maintained its concertina shape for at least 13 years. There is a large notch at the forward edge of his dorsal fin that may have been one of the causative agents for the concertina shape. NZ85 shows both prolific body scars and an abnormal fin. It cannot be ascertained if one is linked to the other in terms of causative agents.

Table 3. The percentage of known adult males with abnormal (i.e., collapsed, collapsing or bent) dorsal fins, in different populations of killer whales

	New Zealand	British Columbia (resident population)	Norway
Source	Author	[Ford, 1994 #137]	T. Similä (pers. comm.)
Adult males	n=30	n=64	n=174
Adult males with abnormal fins	n=7	n=4	n=1
Percentage with abnormal fins	23%	6.25%	0.57%

Complete collapse of the dorsal fin of killer whales does not appear to be common in any population. Ford *et al.* (1994) report an adult male killer whale whose dorsal fin collapsed completely over several years, and Baird & Stacey (1989) report another animal whose dorsal fin 'bent over at its base to the left side, with the upper half dragging in the water'. Only one of the killer whales reported here had a completely collapsed dorsal fin, NZ100 (Slater). He was only photographed once so conclusions cannot be drawn about his collapsed dorsal fin, but an indentation around the thorax can be seen (Fig. 7, arrow). This may indicate entanglement at some stage. A similar indentation can be clearly seen on a killer whale in Greenwood (1974), (their figure 3), which is termed a 'pressure lesion', and was caused by slings during transportation to captivity.

Conclusions

The prolific body scars on the two adult male killer whales appear to be unusual and are the first of their type reported in the literature. They are almost certainly caused by conspecifics. The collapsing, collapsed and bent dorsal fins found on the New Zealand killer whales do not appear to be uncommon in this population, with 23% of the adult males having some form of abnormal fin.

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References

- Arnham, T. & Whitehead, H. (1989) Observations on the composition and behaviour of groups of female sperm whales near the Galápagos Islands. *Can. J. Zoo.* 67, 1-7.
- Baird, R. W., Abrams, P. A. & Dill, L. M. (1992) Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. *Oecologia* 89, 125-32.
- Baird, R. W. & Stacey, P. J. (1989) Observations on the reactions of sea lions, *Zalophus californianus* and *Eumetopias jubatus*, to killer whales, *Orcinus orca*; evidence of 'prey' having a 'search image' for predators. *Can. Field-Nat.* 103(3), 426-428.
- Best, P. B., Canham, P. A. S. & Macleod, N. (1984) Patterns of reproduction in sperm whales *Physeter macrocephalus*. *Reports of the International Whaling Commission*, Reproduction of whales, dolphins and porpoises (Special Issue 6), 51-78.
- Bigg, M. (1982) An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. *Rep. Int. Whal. Commn.* 32, 655-666.
- Bigg, M. A., Ellis, G. M., Ford, J. K. B. & Balcomb, K. C. (1987) *Killer whales: a study of their identification, genealogy and natural history in British Columbia and Washington State*, Phantom Press and Publishers, Nanaimo, B.C.
- Campbell, R. R., Yurick, D. B. & Snow, N. B. (1988) Predation on narwhals, *Monodon monoceros*, by killer whales, *Orcinus orca*, in the eastern Canadian Arctic. *Can. Field-Nat.* 102, 689-696.

- Ford, J. & Ford, D. (1986) Narwhal: Unicorn of the Arctic Seas. *Nat. Geog.* March 1986, 354-363.
- Ford, J. K. B., Ellis, G. M. & Balcomb, K. C. (1994) *Killer whales: The natural history and genealogy of Orcinus orca in British Columbia and Washington State*, University of British Columbia Press, Vancouver.
- Gaskin, D. E. (1972) *Whales dolphins and seals, with special reference to the New Zealand region*, Heinemann Educational Books Ltd, London.
- Geist, O. W., Buckley, J. L. & Manville, R. H. (1960) Alaskan records of the Narwhal. *J. Mamm.* 41(2), 250-253.
- George, J. C., Philo, L. M., Hazard, K., Withrow, D., Carroll, G. M. & Suydam, R. (1994) Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort seas stock. *Arctic* 47(3), 247-255.
- Greenwood, A. G., Harrison, R. J. & Whitting, H. W. (1974) *Functional and pathological aspects of the skin of marine mammals*. Functional Anatomy of Marine Mammals, R. J. Harrison (ed.), Academic Press, London, 73-110.
- Gunter, G. (1942) Contributions to the natural history of the bottlenose dolphin, *Tursiops truncatus* (Montague), on the Texas coast, with particular reference to food habits. *J. Mamm.* 23(3), 267-276.
- Heyning, J. (1984) Functional morphology involved in intraspecific fighting of the beaked whale, *Mesoplodon carlhubbsi*. *Can. J. Zool.* 62, 1645-1654.
- Heyning, J. E. (1989) Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. In: S. H. Ridgway & R. Harrison (eds) *Handbook of Marine Mammals*. Academic Press, London, 289-308.
- Hoyt, E. (1984) *Orca the whale called killer*, Camden House Publishing Ltd, Ontario.
- Hoyt, E. (1992) *The performing orca---why the show must stop*. Whale and Dolphin Conservation Society, Bath, United Kingdom.
- Hubbs, C. L. (1946) First records of two beaked whales, *Mesoplodon bowdoini* and *Ziphius cavirostris*, from the Pacific coast of the United States. *J. Mamm.* 27(5), 242-255.
- Kato, H. (1984) Observation of tooth scars on the head of male sperm whale, as an indication of intra-sexual fightings. *Sci. Rep. Whal. Res. Inst., Tokyo* 35, 39-46.
- Katona, S. K. & Whitehead, H. P. (1981) Identifying humpback whales using their natural markings. *Polar Record* 20(128), 439-444.
- Lockyer, C. (1979) Response of orcas to tagging. *Carnivore* 2(3), 19-21.
- Lockyer, C. H. & Morris, R. J. (1990) Some observations on wound healing and persistence of scars in *Tursiops truncatus*. *Rep. Int. Whal. Comm.*(12), 113-118.
- Lorenz, K. (1966) *On Aggression*, Harcourt, Brace & World, New York.
- Lowry, L. F., Nelson, R. R. & Frost, K. J. (1987) Observations of killer whales, *Orcinus orca*, in western Alaska: sightings, strandings and predation on other marine mammals. *Can. Field-Nat.* 101, 6-12.
- Matkin, C. O. (1994) *An observer's guide to the killer whales of Prince William Sound, Alaska*, Prince William Sound Books.
- McCann, C. (1974) Body scarring on Cetacea-Odontocetes. *Sci. Rep. Whal. Res. Inst.* 26, 145-155+8 plates.
- Mitchell, E. (1970) Pigmentation pattern evolution in delphinid cetaceans: an essay in adaptive coloration. *Can. J. Zool.* 48, 717-740.
- Morejohn, V. G. (1979) The natural history of Dall's porpoise in the North Pacific Ocean. In: H. F. Winn & B. L. Olla (eds) *Behavior of Marine Animals*, Plenum Press, New York, NY, 45-83.
- Omura, H., Fujino, K. & Kimura, S. (1955) Beaked whale *Barardius bairdi* of Japan, with notes on *Ziphius cavirostris*. *Sci. Rep. Whal. Res. Inst., Tokyo* 10, 89-132.
- Rice, D. W. & Wolman, A. A. (1971) The life history and ecology of the Gray whale (*Eschrichtius robustus*). *Am. Soc. Mamm.* (Special Publication No. 3), 142.
- Scheffer, V. B. (1969) Marks on the skin of a killer whale. *J. Mamm.* 50, 151.
- Shevchenko, V. I. (1975) Kharakter vzaimootnoshenii dastok i drugikh kitoobranznykh (The nature of the interrelationships between killer whales and other cetaceans). *Morskije Mlekopitayuchchie Chast* 2, 173-174.
- Shore, V. (1995) Close encounter of Nannaimo. *The Black-fish Sounder* 3, 1.
- Silverman, H. B. & Dunbar, M. J. (1980) Aggressive tusk use by the narwhal (*Monodon monoceros* L.). *Nature* 284(6 March), 57-58.