THE OCCURRENCE OF TWO FORMS OF MINKE WHALES IN EAST AUSTRALIAN WATERS WITH A DESCRIPTION OF EXTERNAL CHARACTERS AND SKELETON OF THE DIMINUTIVE OR DWARF FORM

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ABSTRACT

Two forms of minke whales occur in eastern Australian and adjacent southwest Pacific waters: a dark shouldered form previously widely reported from southern hemisphere temperate to Antarctic waters, and a cold temperate to tropical diminutive form, referred to in this paper as the dwarf minke whale. We have examined in detail a 7.1 m sexually mature female dwarf minke whale and photographs of 15 other individuals for external characters. Skeletal features were examined on the 7.1 m female and two juveniles.

Dwarf minke whales had a light rostral saddle, blowhole streaks, dark throat patch, white shoulder patch containing a dark flipper oval, grey shoulder blaze, white flipper base and light peduncle patch. This characteristic colour pattern varied only slightly over a wide geographic range (Australia, New Zealand, New Caledonia, South Africa). Dwarf minke whales appeared to differ from southern hemisphere dark shoulder minke whales in size, position and shape of the dorsal fin. Previously reported characters of the baleen plates of dwarf minke whales were generally confirmed. Skeletal features of the dwarf minke whale are described for the first time, and compared with descriptions of other forms from both hemispheres. The majority of features suggested a greater affinity with the northern hemisphere forms than with the southern hemisphere dark shoulder form. Within Australia, the dwarf minke whale has been recorded from Victoria (lat. 38° S) to northern Queensland (lat. 11°55′ S) during May to December.

Our observations generally confirmed previously reported colour patterns for the southern hemisphere dark shoulder form. Examination of skulls in Australian museums also confirmed previous information, especially concerning the form of the vertex. Records of dark shoulder minke whales within Australia ranged from Tasmania (42°50′ S, identification tentative) to central Queensland (23°08′ S), overlapping with the dwarf form at the latter locality.

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INTRODUCTION

The occurrence of a southern hemisphere minke whale which lacks the white flipper band of the northern hemisphere *Balaenoptera acutorostrata* Lacépède 1804 has been recognized since the last century. The species *B. bonaerensis* Burmeister 1867 and *B. huttoni* Gray 1874 were erected for specimens of this form collected near Belgrano, Argentina and Otago Head, New Zealand respectively. There have also been scattered reports of a white-flippered form from the southern hemisphere (Lillie, 1910; Taylor, 1957; Kasuya and Ichihara, 1965; Gaskin, 1976; Wada and Numachi, 1979; Best, 1982; Wada, 1983; Singarajah, 1984) but it has only recently been well illustrated (Baker, 1983) and clearly documented (Best, 1985). In addition to differences in colour pattern, Best showed that this second form of minke whale was reproductively mature at a smaller size than the form having flippers with a single or two tones of grey. He thus called it the "diminutive" form. In this paper we will refer to this form as the dwarf minke whale, and to the other southern hemisphere form as the southern hemisphere dark shoulder minke whale.

The taxonomic status of the various forms of minke whales in both hemispheres is still unclear, despite studies on colour pattern, morphometrics, osteology and electrophoretic patterns (Kasuya and Ichihara, 1965; Omura, 1975; Omura and Kasuya, 1976; Doroshenko, 1979; Wada and Numachi, 1979; Best, 1982, 1985; Wada, 1983; Singarajah, 1984). In the case of the dwarf minke whale documented by Best (1985), this is partly a function of limited material. Morphometrics, for instance, were available for only two very small individuals (1.9, 2.5 m long) and detailed information on colour pattern of the animal and baleen plates was primarily from one locality (South Africa). There is also little information on the distribution of the dwarf minke whale, which to date has been reported from South Africa (Best, 1985), Australia (Best, 1985; Marsh, 1985), New Zealand (Baker, 1983) and Brazil (Best, 1985).

In this paper, we describe the colour pattern of the body and baleen plates, external morphometrics, and skeletal morphology of the dwarf minke whale based primarily on material from eastern Australia. Limited data are also given on colour pattern and skeletal morphology of the dark shoulder form from Australia. Both forms are compared with minke whales from other areas, based on a review of the literature.

Finally, we give preliminary information on the distribution of both forms in eastern Australia and the seasonality of their occurrence.

MATERIALS AND METHODS

Detailed information is available for a 7.1 m female dwarf minke whale which was first reported in a lagoon at Hook Reef, Qld (19°52′ S) on August 31, 1982. It was observed and photographed, both from the surface and underwater, between September 6 and November 28, 1982 when it died. A necropsy was carried out on the 29–30 November, allowing detailed measurements and further observations of colour pattern. Measurements were as recommended by Norris (1961). All ventral grooves were counted, in line with the eye. All characters identified as of potential systematic value by Doroshenko (1979) and Wada and Numachi (1979) were examined. An attempt to recover ear plugs was unsuccessful; Sergeant (1963) has noted that ear plugs of minke whales decompose unless removed within about six hours of death. A liver sample was taken for electrophoresis but the specimen was subsequently lost due to a freezer breakdown.

Data on the reproductive status of the animal are in Marsh (1985), who also included a preliminary account of the necropsy, with observations on pathology by R. Speares (School of Tropical Veterinary Science, James Cook University).

The complete skeleton was recovered and is registered with the Queensland Museum (JM 3861). Measurements of the skeleton generally follow Omura (1975) and Omura and Kasuya (1976). A skull discussed by Omura (1975) was re-measured by Marsh to ensure consistency when taking similar measurements on the Hook Reef specimen. Additional measurements were taken on the hyoid bones as recommended by Satake and Omura (1974).

The entire baleen plate series from each side of the animal was kept dry. Following Williamson (1973), we counted anterior hairs and baleen plates, but ignored posterior hairs (*sensu* Williamson). We had difficulty in determining the number of posterior plates, and our figures may be underestimates (but only by one or two plates). The longest baleen plate in the series was measured as outlined by Omura and Fujino (1954). A length of string was placed along the outer edge of the plate to follow its contour and the length marked off, to be measured with a ruler. There was difficulty in determining the level of the base of the bristles, which may introduce some error. Breadth of the plate was a straight line measurement taken with vernier calipers across the baleen plate series. There was some warping of the baleen plates in series and the breadth will be somewhat lower than if the plates were pressed flat and measured. Further, the measure could include some dried gum. Thickness of the dried gum was measured with vernier calipers and this value subtracted from the breadth of the baleen plate series. The breadth of the dark lateral border of baleen plates was measured with vernier calipers. Measurements for breadth/length ratios and width of dark border (just above the gum) were taken on the longest plates, to be comparable with data in Best (1985).

Information is also available for a 4.0 metre female dwarf minke whale stranded at Wonga Beach, Qld (16°28′ S) on August 24, 1982. This animal was not examined by us, however 29 colour photographs were taken, mostly of the left side but also including ventral and oblique dorsal views. The carcass was buried and the skeleton recovered approximately a year later. The skull was disarticulated and partially damaged in recovery. Mandibles and

TABLE 1. SIGHTINGS OF MINKE WHALES IN EASTERN AUSTRALIA

Record location number	Coordinates	Date D.M.Yr.	Number of whales	Sighting circumstances	Lengh (m)	Sex	Colour pattern: Flipper	Colour pattern: Shoulder patch	Colour pattern: Baleen	Observer	Documentation
1. QUEENSLAND											
*1. Lizard Island	14°40′S 145°28′E	7.80	4	seen and photographed underwater	–	–	white	white	–	–	xerox of photo of one at JCU, original at Museum of Victoria
*2. Crispins Reef	16°05′S 145°44′E[1)]	5. 8.81	1	seen underwater	–	–	white	–	–	Prettejohn	drawing + description at JCU[2)]
3. Point Lookout	27°24′S 153°27′E	18. 6.82	1	at sea, surfacing	–	–	–	–	–	Bryden	–
4. Point Lookout	27°24′S 153°27′E	13. 7.82	2	at sea, surfacing	–	–	–	–	–	Bryden	–
5. Point Lookout	27°24′S 153°27′E	13. 7.82	1	at sea, surfacing	–	–	–	–	–	Bryden	–
*6. Milne(?Milln)Reef	16°47′S 146°16′E[3)]	16. 7.82	3	seen and photographed underwater	"15,15–20,20ft" (4.5,4.5–6.1,6.1m)	–	white	white	–	Waugh	photos at JCU of one of the three whales
*7. Wonga Beach	16°28′S 145°23′E	24. 8.82	1	stranding	4.04	♀	white	white	cream	Wall	photos at JCU
*8. Hook Reef	19°52′S 149°10′E	31. 8.82	1	trapped in reef lagoon, seen and photographed underwater; necropsied	7.1	♀	white	white	cream	Heinsohn, Marsh, Arnold	photos, measurements and skeleton at JCU
*9. Kelso Reef	18°24′S 147°00′E	15. 9.82	1	seen and photographed underwater	"about 18ft" (5.5m)	–	white	white	–	Ward, Springett, Johnson	photos at JCU
10. 12 miles NWW North Reef	23°11′S 151°54′E	4-18. 9.82	3	at sea, surfacing	–	–	–	–	–	Titmarsh	–

+11.	Yeppoon	23°08′S 150°45′E	11. 8.83	1	stranding	–	–	dark base, distally grey, with thin white transverse line separating two tones	no patch	apparently dark posteriorly on right side	Simmons	photos at JCU
*12.	Yeppoon	23°08′S 150°45′E	~30. 8. 83	1	stranding	4m	–	white	white	apparently light	–	photo in Rockhampton Morning Bulletin, held at JCU
*13.	One Tree Island	23°31′S 152°03′E	5. 6.85	2	aerial survey sighting	–	–	white	white	–	Simmons	photo at Q.NPWS
*14.	Ribbon Reef No.8	15°05′S 145°44′E	18. 6.85	1	seen and underwater	"8–10m" photographed	–	white	white	–	Oke	photos at JCU
?*15.	Ashmore Banks, near Star Reef	11°55′S 143°50′E	19.11.85	4(5?), separated	aerial survey sighting	–	–	–	–		Marsh	–
?*16.	Between Ross Reef and Hewitt Reef	19°50′S 149°35′E	3.12.85	1	aerial survey sighting	–	–	–	–	–	Marsh	–
*17.	Marion Reef	19°10′S 152°17′E	.85	8	seen and photographed underwater	–	–	white	white	–	Rockman (1986a,b)	article at JCU
*18.	Lizard Island region	14°40′S 145°28′E	seen "often" May–July	–	seen and photographed underwater	–	–	white	white	–	Gladstone (1984)	article at JCU
*19.	Grub Reef	14°02′S 143°51′E	4. 7.86 5. 7.86	1 2–3	seen and photographed underwater	"15ft" (4.5m)	–	white	white	–	Zann	photo at GBRMPA
?*20.	Hope Reef	16°32′S 146°08′E	13. 7.86	2	at sea, surfacing	"20ft" (6.1m)	–	–	white	–	Alderson	sighting sheet at JCU
					2. NEW SOUTH WALES							
+1.	Minnie Waters near Grafton	29°47′S 153°18′E	8.81	1	stranding	4.0	–	see text	no patch	–	Goodall	photos at JCU

TABLE 1 (Cont.)

*2.	Terrigal	33°27′S 151°27′E	7. 9.82	1	stranding	4.1	–	white	white	–	Ted Smith	photo at JCU
3.	Ocean opposite Ulladulla	36°22′S 150°23′E	–	1	at sea	7.6	–	white	–	–	Tuna spotter, via Bryden	–
					3. VICTORIA							
+1.	Portland Bay	38°21′S 141°38′E	13.10.46	1	stranding	"6–7ft" (1.8–2.1m)	–	dark	no patch	from photos appears light	Wakefield (1967)	2 photos in article at JCU
*2.	Reeves Channel, Lakes Entrance	37°53′S 147°55′E	3. 6.66	1	stranding	2.2m	♀	white	white	light	Warnecke	xerox of photo (lateral & ventral view) at JCU, originals at Mus. of Victoria; skull C24936
*3.	Point Leo, Westernport Bay	38°25′S 145°04′E	26. 6.76	1	stranded	4.54m	♀	–	–	light anteriorly	Dixon	xerox of photos at JCU
					4. SOUTH AUSTRALIA							
+1.	Brownlow Beach Kangaroo Island	35°50′S 137°06′E	29. 9.75	1	stranding	–	♀	dark	no patch	dark posteriorly	Aitken	photo in Ling & Aitken[4)]
+2.	Tulka, Eyre Peninsula (Port Lincoln)	34°44′S 135°52′E	19. 9.78	1	stranding	10′10″ (3.3m)	♂	dark	no patch	–	Aitken	photo in Ling & Aitken; photo of skull at JCU
					5. TASMANIA							

?1. Lenasham	42°50′S 147°37′E	7. 6.57	1	stranding, thought to have been dead 4–6 wks	2.16	?	light band about half way along flipper; much decomposed specimen	–	–	Davies, Guiler	Davies & Guiler (1958), article at JCU
?2. Tomahawk	40°50′S 147°45′E	8.72	1	stranding	5.48	♀	–	–	–	Guiler	identification by Guiler from photograph; Guiler (1978)
?3. Fortescue Bay	43°08′S 147°57′E	6. 8.73	1	stranding, thought to have been dead over a month	3.65	♂	–	–	–	Guiler (1978)	Guiler (1978), article at JCU

* dwarf minke whale
\+ southern hemisphere dark shoulder form
1) position for St. Crispins Reef, Roberts (1978)
2) JCU = School of Biological Sciences, James Cook University of North Queensland
3) position for Milln Reef, Roberts (1978)
4) identified as Bryde's whale; 3 additional photos seen and returned to South Australian Museum
GBRMPA = Great Barrier Reef Marine Park Authority
Q.NPWS = Queensland National Parks and Wildlife Service

most of the post-cranial skeleton were also recovered. A portion of the left hand baleen plate series was also available for examination. Although incomplete, the additional skeleton has allowed confirmation of certain features noted in the Hook Reef specimen.

The skull of a 2.23 m female dwarf minke whale from Lakes Entrance, Victoria (Museum of Victoria number C24936) was examined and photographed by Heinsohn.

Photographs of the vertex and posterior underside of two skulls of minke whales in the Australian Museum (S272 and S1396) were also examined. As indicated later (Dwarf minke whale Results: Skull) these showed the characters of the dwarf minke whale, but data on external appearance were not available for confirmation of the identification.

All known records have been collated, based on published and unpublished photographs of both forms of minke whales. Details of those records from eastern and southeastern Australia are given in Table 1. Coordinates of reefs along the Queensland shelf are from Roberts (1978). The account of variation in colour pattern of dwarf minke whales is based largely on photographs of 16 individuals, which are referred to in the text by site locality. The photographs are retained at James Cook University.

A southern hemisphere dark shoulder minke whale skull (not listed in Table 1) in the Queensland Museum (J2 1708) was examined by Marsh and photographs taken. An additional skull of this form in the South Australian Museum (M 11,375) was also examined for us by Museum staff, and photographs taken of the dorsal side.

DWARF MINKE WHALE

RESULTS

Colour pattern

The rostrum is predominantly dark slate grey, however there may be a rim of light grey just above the gum. In underwater photographs of animals from Hook Reef, Kelso Reef, Grub Reef, Ribbon Reef 8, Milne Reef, Marion Reef (Rockman, 1986a,b), apparently in an animal from New Caledonia (Laboute and Magnier, 1979), as well as a surfacing animal from the subantarctic (Kasamatsu, unpublished photograph) there is a saddle of lighter grey. This was of variable extent, but could cover most of the head, at least back to the level of the flipper base (Fig. 1a, rs; Fig. 3e). It was particularly obvious in photographs of the animal from Ribbon Reef 8, but the lighter pigment was not seen in photographs of stranded animals.

The lower jaw overlying the mandible is light slate grey in living animals, but may darken rapidly after death. On the Wonga Beach specimen the grey extended downward over about six ventral grooves, just in front of the downturn in the angle of the mouth. The extent of grey at the angle of the

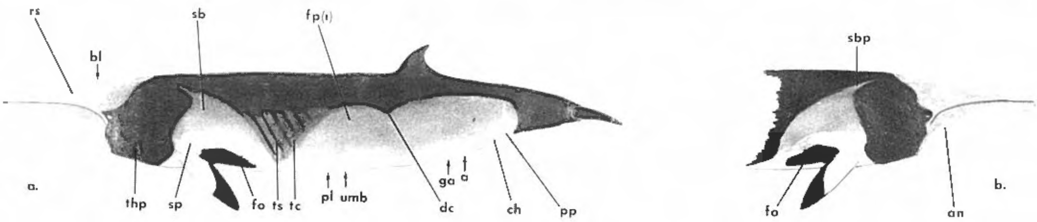

Fig. 1. Generalized colour pattern of the dwarf minke whale, incorporating terminology from Best (1985). Body proportions based on a 7.1 m female. a. View of left side. b. View of right anterior side. Abbreviations: a= anus, an= extension of white at angle of jaw, bl= position of blowhole, ch= chevron, dc= dorsal cape, fo= flipper oval, fp(1)= anterior of flank patch (thorax blaze of Best, 1985), ga= position of genital aperture, pl= posterior extent of plicae, pp= peduncle patch (Best, 1985), rs= rostral saddle, sb= shoulder blaze, sbp= anteriorly directed peak of shoulder blaze, sp= shoulder patch, tc= thorax cape, thp= dark throat patch (Best, 1985), ts= thorax streak, umb= position of umbilicus.

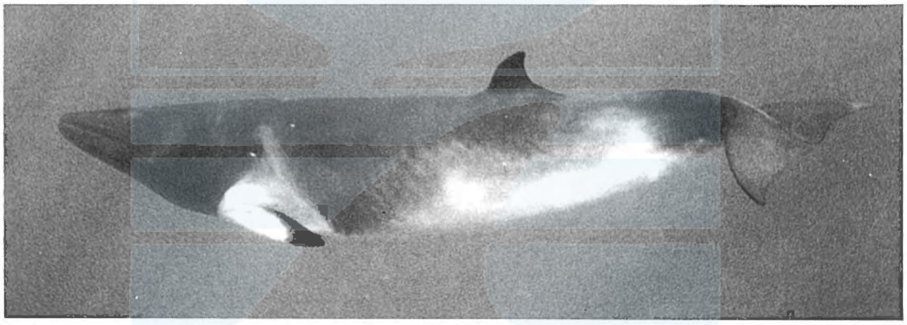

Fig. 2. Dwarf minke whale, approximately 4.5 m long, at Grub Reef. Note light rostral saddle, flipper colour, shoulder blaze shoulder patch, thorax cape and thorax streaks, peduncle patch and chevron. Photograph by Dr L. Zann, courtesy Great Barrier Reef Marine Park Authority.

mouth may be reduced by a pocket of white from the throat (Fig. 1b, an), but always rapidly extends ventrad between the gape and flipper as a broad throat patch (Fig. 1a, thp). On the Wonga Beach animal, this patch extended onto the left side, just behind the eye, to about the sixteenth ventral groove (Fig. 3a). In the animal figured by Gladstone (1984), the patch (apparently on the right side) extended to the twelfth ventral groove. We cannot say, however, whether the throat patch was asymmetrically developed on any individual animal. When seen from the side underwater, the throat appears predominantly dark grey, with only a narrow band of white along the lower edge (Fig. 2; Fig. 3e)

The throat patch extends to just in front of the flipper base. It forms the anterior margin of a white shoulder patch (Fig. 1a, sp) which contains the flipper base and extends along the side to completely surround the flipper

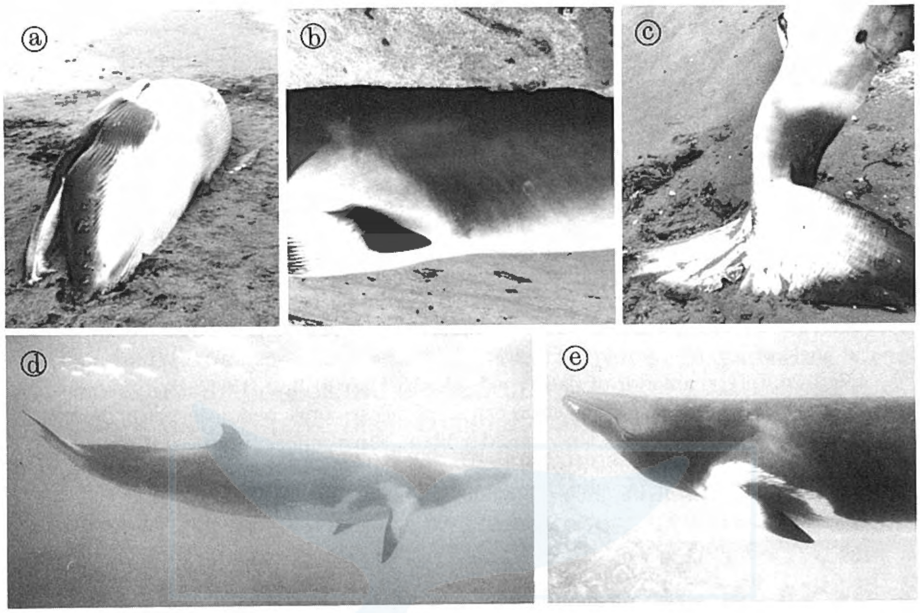

Fig. 3. Dwarf minke whale. a-c, 4.04 m female at Wonga Beach, photographed by D. Wall. a. Antero-lateral view showing throat patch and light baleen. b. Lateral view, showing flipper colour, shoulder patch, shoulder blaze and thorax streaks. c. Postero-ventral view showing chevron, peduncle patch and coloration of undersides of flukes. d-e, 7.1 m female at Hook Reef, photographed by L. Zell. d. View of right side showing flipper oval and anterior extension of margin of shoulder patch. e. View of left side showing more extensive white of shoulder patch, light rostral saddle and anteriorly directed peak of shoulder blaze. Photographs d and e courtesy of the Great Barrier Reef Marine Park Authority.

when it is held in against the body. The shoulder patches appeared to be of comparable size on both sides of animals from Hook and Kelso Reefs.

Within the shoulder patch, on both sides of the animal, is an elongate dark oval, about the size of the flipper and hidden by it when the flipper is held in against the body. This patch, which we call the 'flipper oval' (Fig. 1, fo), was evident in animals from Hook, Kelso and Grub Reefs, Wonga Beach, Lizard Island (Gladstone, 1984), Ribbon Reef 8, New Caledonia (Laboute and Magnier, 1979), and Marion Reef (Rockman, 1986a,b).

The shoulder patch is rimmed with a thin grey border, actually an extension of the light grey shoulder blaze (Fig. 1a, sb) which lies dorsal to the shoulder patch (see below). This grey rim extends in a band from the posterior edge of the shoulder patch to link with the flipper oval. On animals from Hook and Kelso Reefs, for which we have photos of both sides, this connection was narrow on the left side, but much broader on the right (Fig. 1; Figs 3d and 3e). On the Wonga Beach specimen, the flipper oval on the left side was connected with the posterior margin of the shoulder patch only by scattered dark grey streaks (Fig. 3b). The effect of this asymmetry was quite striking when the Hook Reef animal was observed underwater. On the left side, the connecting band was hardly visible and the flipper, when held against the body, seemed to be contained in a continuous band of white. On the right hand side, the broad connecting band merged with the distal dark portion of the flipper, so that the white was much less extensive.

Dorsal to the shoulder patch is a roughly triangular, light grey shoulder blaze. Its anterior margin extends obliquely backwards until level with the upper jaw, then is reflexed forward to a shoulder blaze peak (Fig. 1b, sbp). In the animals from Wonga Beach (Fig. 3b) and Marion Reef (Rockman, 1986a), this extension ran almost directly forward, while in other animals (e.g. from Ribbon Reef 8) it extended obliquely forward and dorsad. The posterior margin of the shoulder blaze runs in a broad arc from this reflexed peak back to a level just beyond the flipper when it is pressed in against the body (Fig. 2; Figs 3b and 3e). In an underwater photo of the top of the head and shoulder of the Hook Reef animal, the shoulder blazes appeared of comparable size on both sides of the animal. They could be seen to run forward in parallel, rather than extending onto the top of the shoulder region to link up as a white crescent *sensu* Best, 1985, for the southern hemisphere dark shoulder form: see Southern hemisphere dark shoulder form Results: colour pattern. However, in the animal from Grub Reef, the right shoulder blaze appeared to extend almost to the midline of the back, while the left shoulder blaze extended more anteriad and not onto the back of the neck.

A dorsal view of an animal from Marion Reef (Rockman, 1986a,b) clearly showed blowhole streaks running posteriad and curving to the left.

Behind the flipper, about half way to the dorsal fin, there is a dark grey cape which extends down almost to the belly (Fig. 1a, tc). This divides the sides into the shoulder patch and shoulder blaze anteriorly and the light grey flank patch posteriorly. Often it has a series of 6–10 oblique dark rib-like streaks (Fig. 1a, ts; Figs 2 and 3b; see also Gladstone, 1984). The flank patch (Fig. 1a, fp (1)) continues past the level of the dorsal fin and onto the caudal peduncle, the posterior half of which is again dark grey. In most animals from Australia for which we have photos, this flank patch seemed entire, however there were indications of a dorsal cape (Fig. 1a, dc; Fig. 2) on the animal from Grub Reef.

On the caudal peduncle, within the light grey flank patch, the white of the underside may continue as a narrow band at least half way up the tail stock. Dorsally it may continue further as a grey-white band (Fig. 1a, pp). This feature was very conspicuous on the left side of the Wonga Beach specimen (Fig. 3c) and evident on the right side of the Kelso Reef animal. The band appears to be present on the animals illustrated by Rockman (1986b), Laboute and Magnier (1979) and Baker (1983) from Marion Reef, New Caledonia and New Zealand respectively.

On the Wonga Beach specimen, the white peduncle band was separated

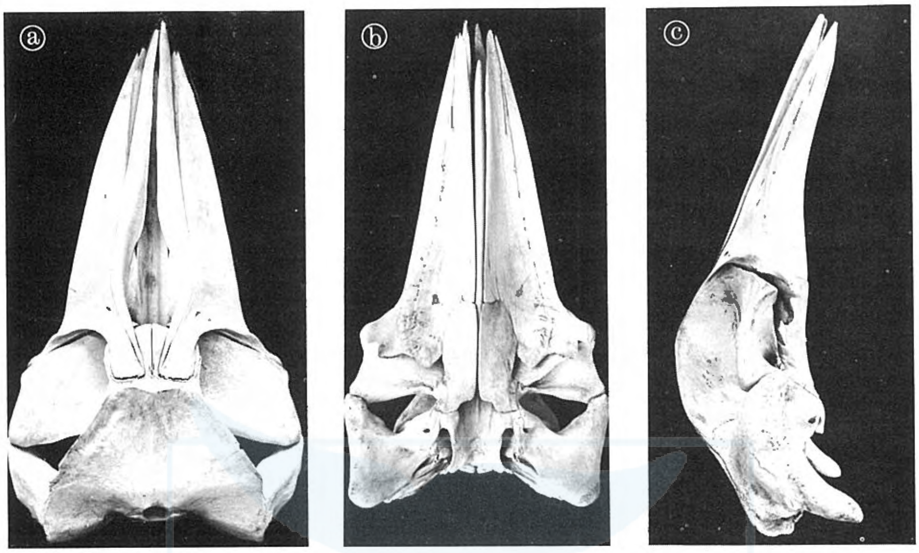

Fig. 4. Skull of 7.1 m female minke whale from Hook Reef. a. Dorsal view; b. Ventral view; c. Lateral view.

from the rest of the white belly by a thin grey streak, which was reflexed sharply forward at its base to form a reverse-L (Fig. 3c). The posterior border of the peduncle band was also reflexed forward (Fig. 3c; Fig. 1a, ch). A similar pattern was evident on photos of the Kelso and Grub Reef animals.

In summary, the body, when seen underwater, appears subtly banded in alternate shades of light and dark grey. Dark bands are (1) at the level of the throat patch and onto the back of the neck, (2) between the shoulder patch-shoulder blaze and the flank patch, and (3) at the base of the caudal peduncle. Lighter grey occurs on the rostrum, head and border of lower jaw; triangular blaze dorsal to white shoulder patch; and over most of the flanks.

The flippers are tri-tone. The distal portion is a dark slate grey, with a thin light grey band separating this portion from the white base. The line of separation is oblique, beginning about two-thirds of the way along the anterior margin. The edge of dark grey curves inward over the top of the flipper so that only about the basal third of the flipper along the posterior margin is white (Fig. 1). A variable number of dark grey streaks may run over the white basal portion of the flipper (Fig. 3b). The underside of the flipper is white at the base and along the anterior edge, but otherwise dark.

The dorsal fin appeared uniformly dark grey in all animals examined.

The upper surface of the flukes are dark grey. The trailing edge of the undersides of the flukes and a variable amount of the apices are also dark. (Compare Fig. 3c and Fig. 3d, showing undersides of flukes of Wonga Beach and Hook Reef animals respectively).

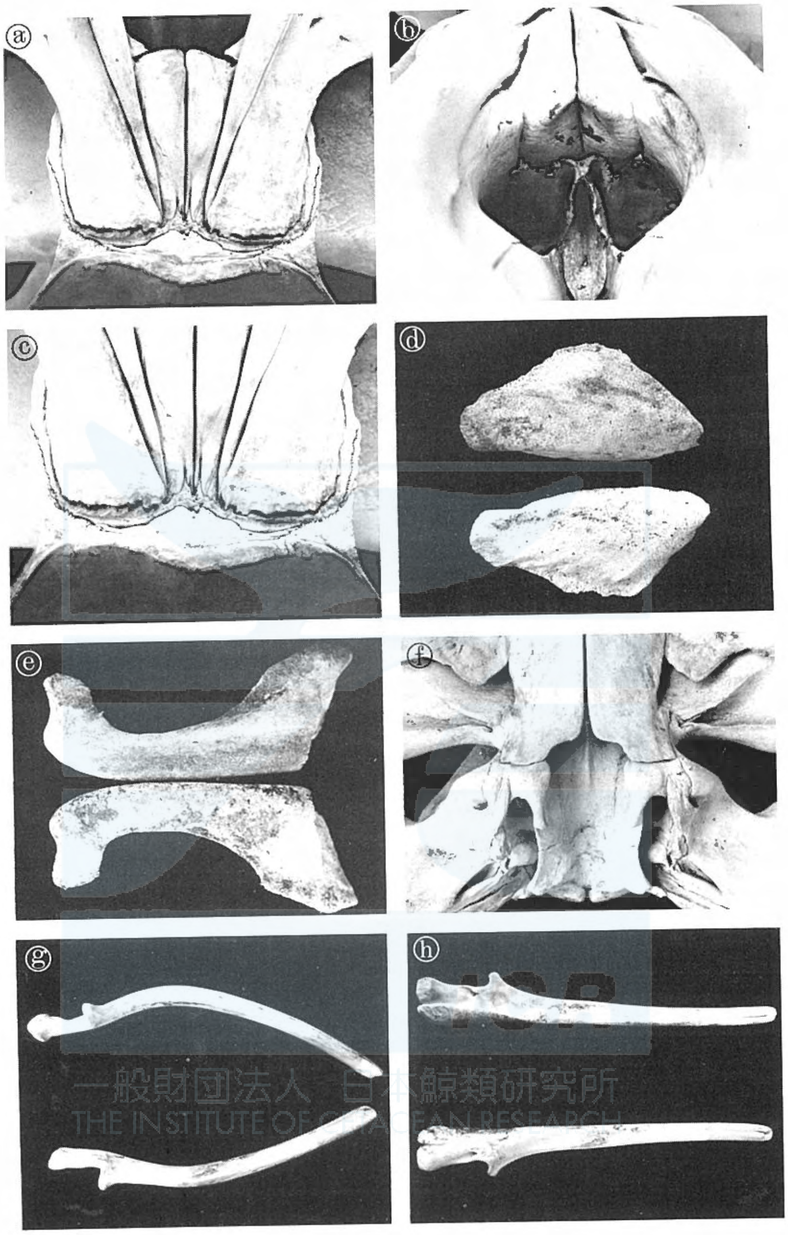

Fig. 5. Skeleton of 7.1 m female dwarf minke whale from Hook Reef. a. Detail of the vertex and nasal bones, dorsal view. b. Detail of nasal bones, showing inferior pit or groove, antero-ventral view. c. Detail of vertex showing relative positions of nasals, premaxillaries and maxillaries; frontal bone, inter-parietal and parietals, dorsal view. d. Lachrymal bones. e. Malar bones. f. Detail of posterior underside of skull showing angulate posterior margin of palatine bones and elongate hamular processes of the pterygoid bones. g. Mandibles, dorsal view. h. Mandibles, medial view.

TABLE 2. EXTERNAL MORPHOMETRICS OF MINKE WHALES

	Dwarf[1] (Australia)		Dwarf[2] (South Africa)	Dark shoulder southern hemisphere[3] (Antarctic)	North Pacific[4] (Japan)	North Atlantic[5] (Norway)
	absolute (metres)	% total length	% total length (mean, range)	% total length (mean, range)	% total length (mean, range)	% total length (mean, range)
Total length	7.10	100.0	100.0 1.9m, 2.5m absolute sizes	100.0	100.0	100.0
Snout to centre anus	5.40	76.0	72.5, 72.8	73.0 (68.7–76.4)	73.5 (70.7–76.1)	74.0 (69.9–81.3)
to centre genital aperture	5.18	72.9	64.9, 65.6	68.1 (n=2)	70.7 (68.8–72.1)[6]	–
to tip dorsal fin	4.94	69.6	71.5, 71.3	–	–	–
to centre umbilicus	3.96	55.8	54.3, 52.4	53.7 (47.5–62.4)	53.8 (51.6–57.7)	54.0 (48.0–62.7)
to posterior extremity of ventral grooves	3.76	52.9	51.5, 48.6	48.0 (43.5–54.8)	46.2 (39.5–54.4)	48.5 (41.3–56.5)
to anterior insertion of flipper	2.05	28.9	31.5, 28.9	29.3 (24.0–32.0)	30.8 (28.1–32.7)[7]	–
to external auditory meatus	1.69	23.8	25.2, 24.2	25.1 (23.4–27.0)	21.6 (19.9–23.0)[8]	–
to angle gape	1.21	17.0	18.2, 17.9	18.7 (17.1–20.5)	16.1 (13.3–18.7, n=10)	17.8[9]
to centre eye	1.27	17.9	19.2, 18.3	20.0 (18.3–22.0)	15.8 (13.3–18.6)	18.0 (15.7–19.3)
to centre blowhole	1.10	15.5	13.2, 14.0	14.3 (12.2–16.0)	13.3 (11.7–14.9)	13.2 (11.0–14.8)
Girth at axilla	3.06	43.1	46.5			
at anus	1.54	21.7	28.5, 27.0			
Projection lower jaw	0.07	0.98	1.0, 1.0			
Centre eye to external auditory meatus	0.36	5.1	6.1			
Centre eye to centre blowhole	0.68	9.6	10.8			
Blowhole length	0.20, 0.20 (R, L)	2.8, 2.7	4.0, 3.9			
Eye length	0.06 slit 0.11	0.8 slit 1.5	1.5, 1.4			
Eye height	0.08	1.1	0.3			
Length genital slit	0.46	6.5	4.6, 4.8			
Length anal opening	0.05	0.7	1.3, 1.4			
Flipper: anterior insertion to tip	1.02	14.3	19.2, 16.5	15.8 (12.5–17.5)	12.1 (9.4–15.8,)	–
: axilla to tip	0.75	10.6	12.6, 11.7	–	8.9 (7.3–11.4, 14)	10.0 (8.8–12.4)
: maximum width	0.26	3.7	5.3, 4.0	3.7 (2.8– 4.1)	3.8 (3.5– 4.0, 12)	3.6 (3.2– 3.9)
Dorsal fin height	0.34	4.8	5.6, 4.8	3.7 (3.0, 4.2)	4.2 (3.1– 5.0, 10)	3.6 (2.9–4.4, 72)

Dorsal fin length base	0.6	8.4	8.3, 8.9	5.5 (3.7– 7.7)	7.4 (5.9– 8.8, 11	) 5.6[9]
Flukes: width tip to tip	1.75[10] 0.94	24.6[11] 26.4	24.2, 23.0	29.0 (25.1–35.8)	30.6 (27.6–33.8)[12]	27.8 (24.0–30.8)[13]
: nearest point on anterior : margin to notch	0.48	6.8	8.3, 7.5	–	–	6.8 (5.8– 7.5)
: depth notch	0.07	0.9	1.7, 1.2	–	–	–
Centre eye to angle gape	0.13	1.8				
Girth half way from axilla to umbilicus	2.94	41.4				
Length mammary slit	0.29, 0.30 (R, L)	4.1, 4.2				
Diameter auditory meatus	9.5 × 4.5mm					
Blubber thickness: anterior to dorsal fin	38 mm					
: mid lateral, mid length	34.5mm					
: mid ventral, mid length	22 mm					
: anterior to flippers	48 mm					

1) this paper, 1 ♀. 2) Best 1985, (specimens = 2). 3) Ohsumi, in Best 1985 (10♂♂, 2 ♀♀). 4) Omura & Sakiura 1956 (15 ♀♀). 5) Jonsgård 1951 (75 ♀♀). 6) n = 6 ♀♀ 6.58–7.97m, measures 100%−(10+13). 7) n = 5♀♀ 6.58–7.97m, measures 6−17. 8) n = 6♀♀ 6.58–7.97m, measures 5+ 7. 9)1 ♀, Turner (1892). 10) left fluke damaged, second figure length of right fluke. 11) second % right fluke × 2. 12) 13 ♀♀, measure 23 × 2. 13)74♀♀, measure 12 × 2.

Morphometrics

Measurements of the Hook Reef specimen are given in Table 2.

Baleen plates

The longest baleen plates of the Hook Reef animal were 18.3 and 18.5 cm long for the right and left series respectively. The breadth of the right and left baleen plate series was 8.2 and 8.6 cm (7.9 and 8.3 cm with width of dried gum excluded). This gives a breadth/length ratio of 0.45–0.46 for both sides (0.43–0.45 with gum excluded).

There were 235+ baleen plates on the right side and 225+ on the left. It was impossible to separate consistently the most posterior plates. Using Williamson's (1973) criteria there were eight and nine anterior hairs in the right and left series.

The outer border of a baleen plate was considered dark if over a third of the length was darkly pigmented. On the right side, 5 plates had a dark grey to black border, while 24 plates had a dusky grey border. On the left side, 18 plates had a dark grey to black border, while 29 had a dusky grey border. Plates with only a lingual band or median strip were not counted, following Best (1985). The percentage of white baleen plates is thus 87.7 and 79.1 for right and left sides (see Figs 6g and 6h).

The outer dark border of baleen plates was most extensive on posterior plates, which were entirely dark except for the bristles. In order to be comparable with measurements by Best (1985), the width of the dark border was taken on the longest plates, about two-thirds of the way back in the series. Width of the border was 2.5 mm on both sides, (3.0% and 2.9% of total breadth of right and left plates respectively).

Skeleton

Unless otherwise noted, the description is based on the Hook Reef specimen.

Skull

Measurements of the skull are given in Table 3 (measurements 1–32, 41–54). These were compared with specimens from the Antarctic (Omura, 1975; Omura and Kasuya, 1976), N. Pacific (Omura, 1957, 1975) and N. Atlantic (Table 4). The features in which the dwarf minke whale differed from previously described forms included proportional lengths of both premaxillaries; median length of nasals; breadth of rostrum at the base; breadth of frontal across the nasals; breadth between the maxillaries at nares; and median length from the tip of the premaxillaries to the anterior end of the vomer. These and other differences will be considered in detail in the discussion.

The margin of the rostrum was slightly convex in dorsal view. An approximate measure of maximum curvature, taken at right angles to a ruler

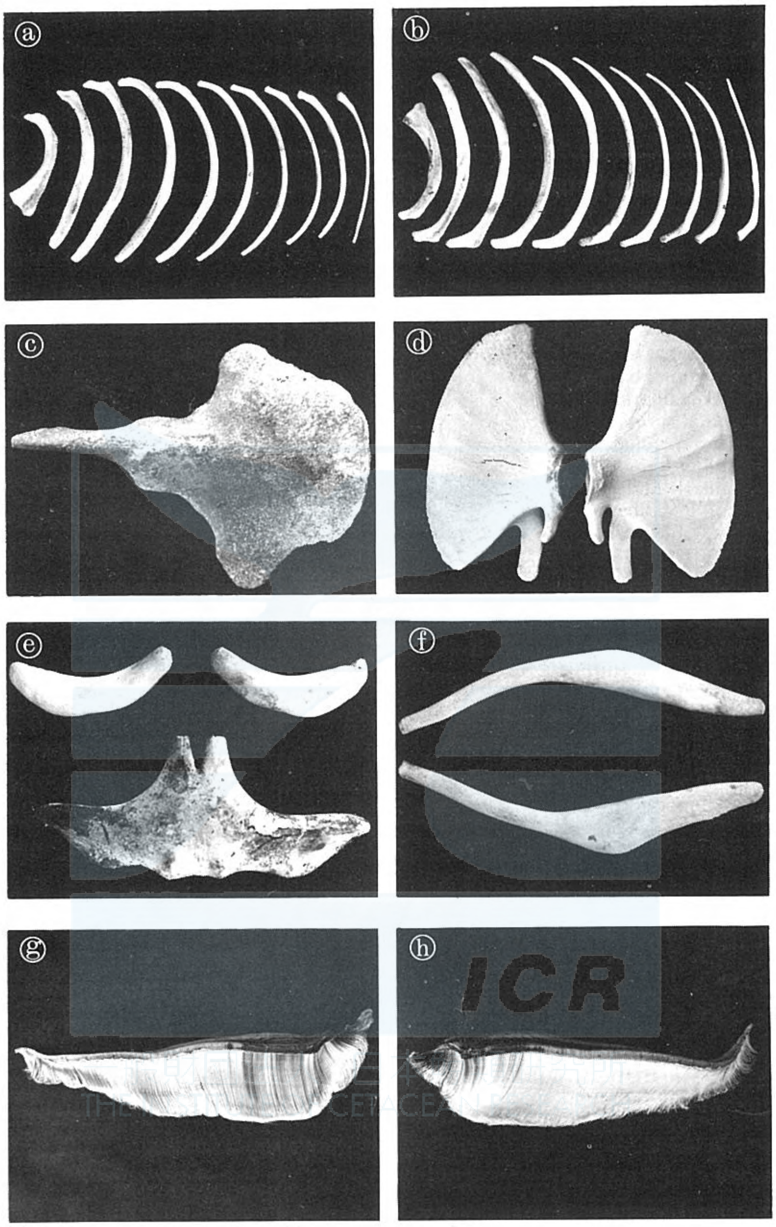

Fig. 6. Skeleton and baleen of 7.1 m female dwarf minke whale from Hook Reef. a. Ribs, left series, lateral view. b. Ribs, right series, lateral view. c. Sternum. d. Scapulae, medial view. e. Stylohyals (above) and fused basihyal-thyrohyals. f. Pelvic bones. g. Baleen plates, left series, lateral view. h. Baleen plates, right series, lateral view.

TABLE 3. OSTEOLOGICAL MEASUREMENTS OF HOOK REEF DWARF MINKE WHALE

Measurements*	Absolute measure (mm)	% of total length of skull
1. Condylo-premaxillary length	1640.0	100.0
2. Length of premaxillary, right[1)]	1252.0	76.3
3. Length of premaxillary, left[1)]	1248.0	76.1
4. Length of maxillary, superior, right	1182.0	72.1
5. Length of maxillary, superior, left	1191.0	72.6
6. Tip of premaxillary to vertex	1222.0	74.5
7. Tip of premaxillary to nasals	1038.0	63.3
8. Length of nasals, median	178.0	10.8
9. Breadth of nasals, anterior[2)]	105.8	6.4
10. Length of rostrum	1145.0	69.8
11. Breadth of rostrum at middle[3)]	381.3	23.2
12. Breadth of rostrum at base	604.1	36.8
13. Breadth across maxillaries at vertex	221.9	13.5
14. Breadth of frontal across nasals	257.8	15.7
15. Breadth between maxillaries at nares	244.2	14.9
16. Breadth of skull, squamosal	905.0	55.2
17. Breadth of skull, frontal	880.0	53.7
18. Breadth of skull, maxillaries	808.0	49.3
19. Length of orbit, frontal, right	167.3	10.2
20. Length of orbit, frontal, left	164.1	10.1
21. Breadth of occipital bone	647.0	39.4
22. Breadth across occipital condyles[4)]	174.9	10.7
23. Height of occipital condyle, right	98.3	6.0
24. Height of occipital condyle, left	101.5	6.2
25. Breadth of foramen magnum aperture	70.5	4.3
26. Height of foramen magnum aperture	65.7	4.0
27. Length from foramen magnum to vertex[5)]	427.0	26.0
28. Tip of premaxillary to ant. vomer, median	177.8	10.8
29. Tip of premaxillary to ant. palatine, median	1012.0	61.7
30. Tip of premaxillary to post. palatine, median	1314.0	80.1
31. Tip of premaxillary to post. pterygoid	1432.0	87.3
32. Breadth across hamular process of pterygoid	160.3	9.8
33. Length of mandible, straight, right	1602.0	97.7
34. Length of mandible, straight, left	1630.0	99.4
35. Length of mandible, curved, right	1756.0	107.1[6)]
	1686.0	102.8[7)]
36. Length of mandible, curved, left	1788.0	109.0[6)]
	1719.0	104.8[7)]
37. Height of mandible at coronoid, right	218.8	13.3
38. Height of mandible at coronoid, left	219.2	13.4
39. Height of mandible at condyle, right	179.5	10.9
40. Height of mandible at condyle, left	178.8	10.9
41. Tympanic bulla, length, right	79.5	4.8
42. Tympanic bulla, length, left	77.3	4.7
43. Tympanic bulla, greatest breadth, right[8)]	62.0	3.8
44. Tympanic bulla, greatest breadth, left[9)]	58.8	3.6
45. Tympanic bulla, thickness at middle, right	42.2	2.6
46. Tympanic bulla, thickness at middle, left	41.9	2.5
47. Malar length, right	202.1	12.3
48. Malar length, left	213.0	13.0
49. Malar breadth, right[10)]	71.6	4.4
50. Malar breadth, left[10)]	72.0	4.4
51. Lachrymal length, right	118.5	7.2
52. Lachrymal length, left	118.0	7.2
53. Lachrymal breadth, right	58.5	3.6
54. Lachrymal breadth, left	54.5	3.3
55. Scapula, greatest breadth, right	630.5	
56. Scapula, greatest breadth, left	631.5	
57. Scapula, greatest height, right	369.5	

TABLE 3 (Cont.)

58. Scapula, greatest height, left		376.5	
59. Length of acromion, inferior[11)]	R 195.5		L 195.5
60. Breadth of acromion, distal end	R 57.9		L 49.3
61. Length of coracoid, inferior [12)]	R 99.1		L 88.5
62. Breadth of coracoid, distal end	R 33.0		L 31.1
63. Length of glenoid fossa[13)]	R 121.5[14)]		L 140.5
64. Breadth of glenoid fossa	R 91.9		L 90.3
65. Scapula, ratio breadth/height	R 1.7		L 1.7
66. Stylohyal, length	R 244.8		L 252.2
67. Stylohyal, maximum width	R 64.8		L 63.3
68. Basihyal length, straight		452.2	
69. Pelvis, length	R 258.2		L 259.5
70. Pelvis, width	R 28.8		L 36.5
71. Pelvis, degree of curvature[15)]	R 31.8 (12.3)		L 29.5 (11.4)
72. Pelvis, point of maximum width from wider end	R 101.8		L 102.3
73. Sternum, length		329.5	
74. Sternum, maximum breadth		233.9	
75. Sternum, point of max. width, from wider end		116.0	
76. Sternum, point of base to wider end		143.9	
77. Sternum, shaft length		185.6	

1) broken at tip. 2) between premaxillaries at anterior end of nasals. 3) at 572.5mm from tip of premaxillae. 4) to base of spongy bone. 5) measured at posterior parietals. 6) outside curve. 7) inside curve. 8) on to process. 9) process broken. 10) max. ant. end obliquely across. 11) lateral tip to centre of base. 12) to base of glenoid fossa. 13) smooth bone to smooth bone. 14) cartilage present. 15) percentage of length in parentheses. *) After item 55, only absolute measure indicated.

laid along the edge of the maxillaries, ranged from 7–12 mm.

The anterior margin of each nasal bone was convex (Fig. 5a), with a groove (*sensu* Omura, 1975) ventrad (Fig. 5b).

Details of the vertex are shown in Fig. 5c. The supraoccipital curved gently posteriorly in the mid-line. Its anterior edge was bordered laterally by the parietals and antero-medially was fused with the inter-parietal. The inter-parietal was angulato-ovate (Stearn, 1973; Fig. 19) and was bordered along its entire anterior margin by the frontal. The frontal extended across the vertex of the skull and inter-locked with the posterior margin of the nasals. Laterally it was over-ridden by the premaxillaries and ascending processes of the maxillaries. The posterior margins of the nasals, premaxillaries and maxillaries were approximately in a straight line.

The vertex of skull S1396 agreed in all details with that of the Hook Reef animal. The nasal bones had a convex anterior margin, and were elongate, the posterior tip reaching the posterior borders of the ascending processes of the maxillaries. The nasals were widely separated from the interparietal by exposed frontal bone. Skull S272 also had the parietals and inter-parietal incorporated in the vertex and the anterior of the nasal bones convex. However, the posterior of the nasals appeared to be well in front of the posterior borders of the ascending processes of the maxillaries.

The skull of the Lakes Entrance specimen had elongate nasal bones with

TABLE 4. MEASUREMENTS OF SKULLS FOR THE VARIOUS FORMS OF MINKE WHALE AS PERCENTAGE OF SKULL LENGTH

	Dwarf[1]	Antarctic[2]	N. Atlantic[3]	N. Pacific[4]	N. Pacific[6]
Length rostrum	69.8	64.0– 69.4	60.8– 67.8	61.8– 64.0	57.4– 62.9
Breadth rostrum (mid length)	23.2	18.9– 22.7	20.7– 24.3	17.9– 20.7	18.0– 19.1
Breadth rostrum (base)	36.8	29.8– 32.8	32.9– 36.5	32.7– 35.0	30.9– 32.6
Breadth skull (at squamosal)	55.2	50.8– 53.4	54.6– 57.2	54.7– 57.3[7]	50.9– 53.9
Length pre-maxillaries	76.1, 76.3[5]	70.4– 72.8	73.8– 75.7	73.6– 75.9	69.3– 73.0
Length mandibles (straight line)	97.7, 99.4[5]	96.4– 98.1	100.0–101.4	–	88.2– 97.3
Length mandibles (outer curve)	107.1, 109.2[5]	102.8–106.9	105.0–109.3	109.8	91.7–101.8
Height mandibles (at condyle)	10.9	8.8– 9.9	9.3, 10.5	–	9.4– 10.2
Height mandibles (at coronoid)	13.3	11.8– 14.3	12.8– 13.1	12.7	12.3– 13.2

1) this paper. 2) Omura (1975); Omura and Kasuya (1976). 3) Turner (1892); True (1904); Allen (1916). 4) Tomilin 1967, table 64. 5) right and left sides. 6) Omura (1957; 1975). 7) Zygomatic width.

convex anterior margins and an inferior anterior groove (J. Dixon, personal communication to Heinsohn). The posterior margin of the nasals was in line with the posterior of the premaxillaries, however the ascending process of the maxillary extended further posteriad for about one-third the length of the nasals (0.35–0.37, based on measurements from three photographs). The maxillary processes were bordered on their posterior edges by frontal bone which formed a medial triangular area bounded laterally by maxillary, anteriorly by nasals and posteriorly by parietals and inter-parietal. The parietals and inter-parietal were similar to those of the Hook Reef specimen; the inter-parietal was clearly separated by a suture from the left parietal.

The skull of the Wonga beach specimen was damaged and disarticulated, with the nasals missing. However, the form of the vertex was similar to that just described. The anterior margin of the supraoccipital was somewhat more irregular but also curved posteriorly in the mid-line. The inter-parietal appeared to be partially fused to the right parietal, but was clearly separate on the left side and could be seen as a distinct bone on the inner roof of the skull. The frontal was oriented as described for the Hook Reef specimen.

Lachrymal and malar bones are shown in Figs 5d and 5e respectively; dimensions are given in Table 3 (measurements 47–54).

The posterior margin of the palatine was sharply angulate (Fig. 5f) in specimens from Hook Reef and Lakes Entrance, and possibly skull S1396, although that skull was damaged. The shape of the palatines could not be determined in skull S272 or the Wonga Beach specimen.

In the Hook Reef specimen, the hamular process of the pterygoid (Fig. 5f) was long (41% and 44% of the length between the tip of the process and the intersection of pterygoid and palatine bones on the medial side). The ratio of basal width/length of the hamular process was 0.68 for both right and left sides. Skulls of the Wonga Beach animal, S272 and S1396 were all broken on the underside so that details of the pterygoids could not be seen. The hamular processes were elongate in the Lakes Entrance specimen.

Mandibles are shown in Figs 5g and 5h. Measurements are included in Table 3 (measurements 33–40).

Axial skeleton

The epiphyses were completely fused to the posterior caudal and first two cervical vertebrae only; they were unfused to thoracic vertebrae.

The main feature previously identified as of potential systematic value is the presence or absence of the parapophysis on the seventh cervical vertebra. It was present as a tubercle in the Hook Reef specimen.

Ribs

There were ten pairs of ribs, with one possible pair of much reduced ribs (18.2 and 25.8 cm long). Proportions can be seen from Figs 6a and 6b (reduced ribs not shown). The Wonga Beach specimen had eleven pairs of ribs.

Sternum

The sternum was roughly T-shaped, with the point of maximum breadth 71.0% of the total length (Fig. 6c). The point of maximum breadth was reached 35.2% from the wider end, while the shaft of the sternum was 56.3% of the total length. Measurements of the sternum are given in Table 3 (measurements 73–77).

Scapula and flipper bones

The scapulae are shown in Fig. 6d. Measurements are given in Table 3 (measurements 55–65). The maximum breadth/length ratio was 1.71 and 1.68 for the right and left scapulae.

The phalangeal formula for both flippers (based on X-radiographs) was 4,7,7,4. In the left flipper, the terminal phalanges of II and III (numbering system from Omura, 1975) were minute.

Hyoid bones

The hyoid bones are shown in Fig. 6e. The posterior margin of each wing of the fused basihyal-thyrohyals curved posteriad sub-medially but then ran obliquely forward toward the anterior margin which was almost at right angles to the mid-line.

Measurements are given in Table 5. The tips of the right and left wings

TABLE 5. MEASUREMENTS OF HYOID BONES OF HOOK REEF DWARF MINKE WHALE[1]

	Absolute measure (mm)	% total length
Fused basihyal and thyrohyals		
Total length	533.0	100.0
Straight length	452.2	84.8
Greatest height	152.0	28.5
Height at centre	118.9	22.3
Forward notch, depth	32.3	6.1
Height at middle of right wing	70.5	13.2
Height at middle of left wing	72.1	13.5
Thickness at middle of right wing	33.2	6.2
Thickness at middle of left wing	38.5	7.2
Height at distal end, right	33.8	6.3
Height at distal end, left	34.5	6.5
Stylohyal		
Total length, right	244.8	100.0
Height at middle, right	58.0	23.7
Thickness at middle, right	23.8	9.7
Degree of curvature, right	34.5	14.1
Total length, left	252.2	100.0
Height at middle, left	56.3	22.3
Thickness at middle, left	23.3	9.2
Degree of curvature, left	35.3	14.0

1) See Satake and Omura (1974) for definitions of measurements.

of the fused basihyal-thyrohyals and the tips of the anterior projections of the basihyal were eroded so that proportions based on overall lengh (Table 5) will be over-estimates. Nonetheless, the stylohyals were proportionately short (length of the right and left stylohyal was 45.9 and 47.3% of the overall length of the fused basihyal-thyrohyals). The stylohyals were strongly curved (degree of curvature 14.1 and 14.0% of total length of the right and left stylohyal).

Pelvic bones

The pelvic bones are shown in Fig. 6f. They were long (258.2 and 259.5 mm for right and left bones) and knife-like. The maximum width (11.2 and 14.1% total length) was reached 39.4% of the distance from the wider end. The bones were strongly curved (maximum curvature 12.3 and 11.4% of total (straight line) length of right and left bone). Further measurements are given in Table 3 (measurements 70–72).

Other features

Unless otherwise noted, the following observations are for the Hook Reef speciman.

The longest ventral groove did not reach to the umbilicus; this corresponds to the type B animals of Wada and Numachi (1979).

The flukes had a deep median notch, corresponding to type 2 of Doroshenko (1979).

The palate was uniformly cream coloured.

Jacobsen's organ was represented by two pairs of pits. The anterior and posterior pairs were 28 and 52 mm from the tip of the snout, while the anterior fringe of baleen was 50 mm from the tip.

The lateral edge of the left liver lobe was even.

The animal was reproductively mature. Further details were given by Marsh (1985).

Healed skin lesions were evident on the Hook Reef specimen and at least one open, circular lesion was noted on the Wonga Beach specimen.

Distribution

Known records of dwarf minke whales are given in Table 1. Sight records from Queensland with a question mark lacked detailed notes on colour pattern or photographs, but were made by observers familiar with the appearance of dwarf minke whales at sea. The record from Point Leo, Victoria was based primarily on the dark throat patch visible in one photograph, but other colour features could not be determined from material available. The stranded animals were 4.04 m (Wonga Beach), 4.1 m (Terrigal), 4 m (Yeppoon, length estimated), 2.23 m (Lakes Entrance) and 4.5 m long (Point Leo, Victoria). The Hook Reef specimen was 7.1 m, while estimates of animals observed at sea ranged from 15 ft (4.5 m) to 10 m. The fourteen records from central and northern Queensland (11°55′–23°08′S) were from July to December, with most sightings from July (5) and August (4).

The stranding at Terrigal, N.S.W. (33°27′ S) occurred in early September, while the two records from Victoria (about 38° S) occurred in June.

Six of the records were of single animals (including three single strandings). Five sightings were of pairs, one of three animals and two of four animals. A sight record west of Barrow Island, Western Australia (20°28′ S) of four animals seen on June 23, 1983 (Pattenden, pers. comm.) appears to have been of dwarf minke whales.

Sight records on the northern Queensland shelf are from the mid- to outer shelf.

DISCUSSION

Colour pattern

The colour patterns of the various forms of minke whales are compared in Table 6.

Our observations confirm Best's (1985) description of the dark throat patch, flipper pigmentation, and presence of a white shoulder patch and shoulder blaze. These, in combination, separate the dwarf minke whale from all other forms.

TABLE 6. COMPARISON OF COLOUR PATTERNS OF MINKE WHALE FORMS

Colour pattern	Dwarf minke whale				Southern hemisphere dark shoulder minke	North Pacific	North Atlantic
	Best (1985)	Baker (1983)	Magnier Laboute (1979)	Present Study[1]			
1. Rostral saddle	–	–	×	×	–	–	–
2. Dark throat patch	×	×	×	×	–	×	×
3. White shoulder patch	×	×	×	×	–	–	–
4. White flipper base	×	×	×	×	–	–	–
5. Thorax blaze	×	×	×	×	–	–	–
6. Gray crescent dorsad	×	?	?	×	×	×[2]	?
7. Blowhole streaks	×	?	?	×	×	?	?
8. Flank patch	×	×	×	×	×	×	×
9. Dorsal cape	–	× (indistinct)	–	× (indistinct)	×	×	?
10. Caudal chevron	×?	×	×	×	×	×	×[3]
11. Peduncle patch	×	×	×	×	–	×?[4]	?
12. Dorsal fin flare	–	–	–	–	×	×?[2]	?
13. Speckling	–	–	–	–	×	×?[5]	?

1) including photos from Gladstone (1984); Rockman (1986a,b). 2) Leatherwood *et al.* (1982). 3) Blake, in Allen (1916). 4) Norris and Prescott (1961). 5) Stern, unpublished photograph.

TABLE 7. AVERAGE SEA SURFACE TEMPERATURES (°C) ON QUEENSLAND SHELF AT TIMES OF REGULAR SIGHTINGS OF MINKE WHALES. DATA FROM BRANDON

Month	Latitude					
	25°	23°	20°	18°	16°	14°
June	21.3	21.7	22.3	23.0	23.5	23.8
July	19.4	20.9	21.2	22.2	22.7	23.7
Aug.	21.5	20.5	20.5	22.8	22.8	24.3
Sept.	22.7	21.3	22.7	23.3	24.5	24.8

The dark throat patch contrasts sharply with the light lower jaw of the southern hemisphere dark shoulder form but is similar to the pigment in specimens from the North Pacific and North Atlantic (see figures in Omura and Sakiura, 1956; Sergeant, 1963).

Best (1985) did not report what we have called the flipper oval within the shoulder patch, nor did he comment on the asymmetrical development of dark pigment running into the shoulder patch from its posterior margin. This asymmetry was confirmed on two of the animals for which we have photos of both sides and is suggested by photographs of other animals taken from different angles. The asymmetry also seems to be present in South African material, based on a comparison of Best's (1985) Fig. 1c (right side) and Fig. 8 (left side).

Best (1985) reported that one of the stranded dwarf minke whales had a crescent-shaped mark running towards the mid-dorsum. This statement is supported by his Fig. 8 in which the pigment does run onto the back. He considered this analagous to the crescent marks extending onto the back of dark shoulder minke whales and further noted that there were indications of a similar pattern in the dwarf minke whale from New Zealand illustrated by Baker (1983). On our material, this streak ran more anteriad and did not appear to meet on the back. This feature was seen especially clearly in specimens from Hook Reef and Wonga Beach, although in other animals it appeared to run obliquely dorsad. The animal from Grub Reef seemed to be asymmetrically coloured with the right shoulder blaze extending further onto the back. The orientation and extent of the blaze thus may be variable.

Dorsal views of animals from South Africa (Best, 1985) and Marion Reef (Rockman, 1986b) showed a medial patch of light pigment between the blowhole and level of the flipper insertion.

Best (1985) reported blowhole streaks in a dwarf minke whale from South Africa. We did not see these in the Hook Reef animal, nor are they apparent in any photographs of this or other dwarf minke whales from the Barrier Reef region. However, Rockman (1986a,b) has a dorsal view of a dwarf minke whale from Marion Reef, Coral Sea, which clearly shows these streaks.

The light head and rostral saddle may be apparent only in living or recently dead animals; it has not been previously noted in the dwarf minke or other forms.

Neither we nor Best (1985) have seen a dorsal fin flare (such as he reported in the southern hemisphere dark shoulder form) in the dwarf minke whale.

Best (1985) described a flank patch reaching to the level of the dorsal fin and a peduncle patch, or extension of white up the side of the tail stock. On animals of which we have photographs or have examined, the flank patch extends past the dorsal fin, onto the latter half of the tail stock. In most cases, it appears to be entire, but in the animal from Grub Reef and the one illustrated by Baker (1983) there is an obscure dorsal cape (Fig. 1a, dc), just in front of the dorsal fin, dividing the flank patch into two parts. On our animals, the extension of white up the tail stock, which appears to be the peduncle patch of Best, occurred within the flank patch, and was bordered on either side by light grey. The tail stock darkened just behind the peduncle patch. These features can also been seen in the photograph of the New Zealand specimen (Baker, 1983).

The shoulder blaze is a consistent feature which may not be found in other forms. In a dwarf minke whale from New Zealand illustrated by Baker (1983) there is a clear shoulder blaze dorsal to the flipper, plus a dusky dorsal cape just in front of the dorsal fin, which divides the flank patch into two parts. The anterior part of this flank patch is of similar form and overlaps in position the 'thorax blaze' described in the southern hemisphere dark shoulder form by Best (1985), and seen in other minke whales from the North Pacific (Leatherwood, Reeves, Perrin and Evans, 1982; Figs 104 and 105). We thus distinguish between the shoulder blaze, above the flipper and reported only from the dwarf minke whale, and the flank patch, which may be divided into two parts, the anterior of which has been called a "thorax blaze".

In our specimens of dwarf minke whale, the light grey either side of the peduncle patch continued ventrad, then turned sharply anteriad, forming a chevron. Best (1985) noted 'indications' of a chevron on a stranded specimen from South Africa and the chevron can be seen in the specimen illustrated by Baker (1983).

Both the chevron and peduncle patch appear to be variably developed in the east Australian specimens, both being very clear on the Wonga Beach and Kelso Reef animals but poorly developed (peduncle patch) or absent (chevron) in the Hook Reef specimen.

The caudal chevron appears to occur in the North Pacific and both southern hemisphere forms, based on photographs of animals from those regions. A caudal chevron is shown in the illustration by Blake of a minke whale from Massachusetts (Allen, 1916), so that it appears to be a general feature of all forms.

The peduncle patch may be a characteristic feature of the dwarf minke, as suggested by Best (1985). However, an eastern North Pacific minke whale illustrated in Norris and Prescott (1961) shows an extension of white and grey on the peduncle, similar to the patch we have seen in eastern Australian dwarf minke whales.

Speckling of the sides was not noted in the east Australian dwarf minke whales, nor has it been reported by Best (1985).

The dorsal fin flare has been documented only in the southern hemisphere dark shoulder form but may occur in the North Pacific from (Leatherwood *et al.* 1982; Fig. 104).

Comparison of morphometrics with other dwarf minke whales

Best (1985) included a full set of measurements for two specimens of dwarf minke whale 1.9 and 2.5 metres long. The Hook Reef specimen differed from these in: (1) greater distance from snout to anus (76% versus 72.5, 72.8%); (2) more anterior position of dorsal fin (69.6% versus 71.5, 71.3%); (3) shorter mouth (17% to angle of gape, versus 17.9, 18.2%); (4) greater breadth of flukes (26.4% versus 23.0, 24.2%); (5) shorter (14.3% versus 16.5, 19.2% – insertion to tip) and narrower (3.7% versus 4.0, 5.3%) flippers.

The height and basal length of the dorsal fin of the Hook Reef specimen (4.8 and 8.4% of total length) agreed well with the figures given by Best (1985; 5.6, 4.8% and 8.3, 8.9% respectively).

Comparison with other forms

We have no measurements of Australian dark shoulder minke whales. Best (1985) compiled data on proportions of southern hemisphere minke whales, including data of Ohsumi, Masaki and Kawamura (1970) on 10 males and two females from the Antarctic. We also have examined data compiled from Omura and Sakiura (1956), Jonsgård (1951) and Turner (1892) for North Pacific and North Atlantic animals. It should be considered that not all the measurements were taken in the same manner, especially in those studies published before Norris (1961).

The distance from snout to anus (76%) was greater than the values for dwarf minke whale in Best (1985: 72.5, 72.8%). The difference may simply reflect the varying sizes of the specimens and is within the range of variation noted for other forms of minke whales.

The tip of the dorsal fin was further forward on the Hook Reef animal (snout to tip 69.6%, versus 71.5, 71.3% for Best's specimens). Best (1985) noted that the dorsal fin was placed more anteriorly in his two specimens of juvenile dwarf minke whales, than in six southern hemisphere dark shoulder minke whales of comparable size. The even more anterior position of the fin on the mature Hook Reef specimen supports this difference, and suggests that it is maintained, if not augmented, with growth. Exact comparison with larger specimens of other forms of minke whales is impossible as most authors have measured to the posterior emargination of the dorsal fin. However given that the tip of the dorsal fin is more posterior than the posterior emargination of the fin, the fact that the fin tip of the Hook Reef animal was more anterior than the posterior emargination of the fin in dark shoulder southern hemisphere (Best, 1985) and North Pacific (Omura and Sakiura, 1956) minke whales indicates that the fin was more anterior than in those forms. From data summarized by Omura and Sakiura (1956), the dorsal fin is situated further forward in northern hemisphere Atlantic minke whales than in those from the North Pacific, and may be similar in position to that of the dwarf minke whale.

The broad dorsal fin with strongly convex anterior margin and shallowly emarginate posterior border (Fig. 3d, Laboute and Magnier, 1979; Rockman, 1986a) may be characteristic of the dwarf minke whale. Photographs of animals from the North Atlantic (True, 1904; Plate 28.4), North Pacific (Leatherwood *et al.*, 1982; Figs 108 and 110) show a tall, more slender fin with deeply emarginate posterior margin. A similar form of fin may occur in the southern hemisphere dark shoulder form (Lillie, 1910; Plate 5.2).

The mouth of the Hook Reef animal was short (17.0% to angle of gape, which is below the figures given by Best (1985) for the dwarf minke whale and outside the range of the figures given for dark shoulder minke whales quoted from Ohsumi, Masaki and Kawamura (1970). Doroshenko (1979) figured marked differences in the length of mouth in southern hemisphere dark shoulder minke whales from different sectors of the Antarctic. A similar range of proportions could be expected for the dwarf minke whale. The value for our specimen is lower than in animals from the North Atlantic measured by Turner (1892) and Allen (1916): 17.4–22.6%, but within the range of specimens from the North Pacific. The wide variability in gape measurements may reflect different measuring techniques and the character seems of limited value.

The height and basal length of the dorsal fin of the Hook Reef specimen (4.8 and 8.9%) agree well with figures for dwarf minke whales by Best (1985) (5.6, 4.8% and 8.3, 8.9% respectively). They are outside the range reported in dark shoulder minke whales by Ohsumi *et al.* (1970) ($\bar{x}$ =3.7% (3.0–4.2) and $\bar{x}$ =5.5% (3.7–7.7) respectively) and for height, outside the range for North Atlantic animals given by Jonsgård (1951; n = 72 females). Both dorsal fin height and basal length are within the range given for North Pacific animals by Omura and Sakiura (1956).

The left fluke of the Hook Reef animal was damaged and the relative total width (24.6%) is thus suspect. Doubling the value of the right fluke gives a value of 26.4%, which is within the range reported for southern hemisphere dark shoulder (Ohsumi *et al.* (1970) cited in Best (1985) and North Atlantic minke whales (Jonsgård, n = 74 females), but outside the range of the North Pacific animals (Omura and Sakiura, 1956). The width of flukes is greater than that reported for the juvenile dwarf minke whales. That this may simply be a function of growth can be seen by comparing the figures in Best (1985;

Table 5) which shows that the proportional width of flukes in six small southern hemisphere dark shoulder minke whales was smaller than in the larger specimens quoted from Ohsumi *et al.* (1970).

The flippers of the dwarf minke whales described in Best (1985) were proportionately longer and broader than those of the Hook Reef animal. However, our figures for the mature specimen agree well with those for southern hemisphere dark shoulder minke whales (Ohsumi *et al.*, 1970) of comparable size. The discrepancy with Best's specimens may again simply reflect the markedly different ages of his and our specimens.

The number of ventral grooves (67) of the Hook Reef specimen is between the values for the two dwarf minke whales given by Best (1985) (76, 54 respectively), and does not differ from his figures for the dark shoulder minke whale juveniles ($\bar{x}$ =65.6 (44–76)). The summary of reported values for number of ventral grooves by Best suggest that the feature is either very variable or subject to large differences in counting by different observers. In this respect, we counted grooves at the level of the eye, which is anterior to the position recommended by Williamson (1973), and now apparently in general use.

In summary, the differences in measurements between our specimen and those documented in Best (1985) fall within the range of variation reported from other forms of minke whales. The greater size and more anterior position of the dorsal fin, compared with the dark shoulder southern hemisphere form, has been confirmed.

Baleen plates

The number of baleen plates is within the range reported for both the dwarf minke whales by Best and other workers on dark shoulder minke whales as summarized by Best (1985). We counted only anterior hairs and baleen plates so that our estimates may be lower than others given in the literature, but only by a few baleen plates. Doroshenko (1979) noted that in the southern hemisphere dark shoulder minke whale, there was a direct relationship between length of jaw and number of baleen plates. The relatively low numbers of plates thus may reflect the shorter mouth of the Hook Reef specimen (see Dwarf Minke Whale Discussion; Comparison of morphometrics with other dwarf minke whales and Table 2).

Although the method of measuring breadth of baleen plates differed from that given by Omura and Fujino (1954) and that used by Best (1985), the differences seem slight. Subtracting the width of the gum made little difference to the values. A greater potential error arises from the variability in the breadth of plates in the series even in the section with longest baleen plates. However, the ratio reported here (0.43–0.45) agrees well with the value given by Best (1985; $\bar{x}$ = 0.43, n = 5) for the dwarf minke whale.

The length of the longest baleen plates of the Hook Reef animal is in agreement with Best's (1985)report that plates of the dwarf minke whale are relatively shorter than those of the dark shoulder form, not exceeding 20 cm. The values of 18.3 and 18.5 cm for right and left side agree well with the mean of 18 cm reported by Best. Baleen length also appears to be shorter than in North Atlantic minke whales as reported by Jonsgård (1951), although that author noted a wide range of values and indicated that baleen plates of females were shorter than those of males, at least for specimens from the Lofoten area.

The colour pattern of the baleen plates is similar to that described by Best (1985) for the dwarf minke whale. However, Best (1985) noted that animals with predominantly white plates, with a few plates bearing a thin (about 0.3 cm wide) black border, as shown in his Fig. 1f, were scored as having all white baleen. The Hook Reef animal (Figs 6g and 6h) had a similar colour pattern to Best's Fig. 1f, and would probably be scored as having 100% white plates. This might explain the discrepancy between our value for the right hand series (87.7% white) and the figures in Table 4 of Best (1985), which showed completely white plates in the right series of all but one animal.

The width of the dark border of mid-series plates found in the Hook Reef animal also fits the pattern described by Best (1985). However, the posterior plates on both sides were increasingly dark and the most posterior plates were all dark, except for the bristles. This feature was not commented on by Best (1985), who extracted baleen plates more from mid-series, nor can it be seen in his Fig. 1f of the baleen series of a "Type 3" whale.

Skeleton

Our present observations represent the only available data on the skeletal features of the dwarf minke whale.

The Hook Reef animal was sexually mature (although physically immature) and should be comparable with specimens of the southern hemisphere dark shouldered form, as documented by Omura (1975) and Omura and Kasuya (1976). The two forms overlapped only in proportional breadth of the occipital bone, height of right occipital condyle and height of both mandibles at the coronoid. The disarticulated skull of the Wonga Beach specimen could not be measured. Clearly, more specimens (especially of the dwarf form) must be measured to establish if there are consistent differences in the proportions of the skulls.

Omura (1975) and Omura and Kasuya (1976) have indicated skeletal features of apparent systematic value in separating North Pacific and the southern hemisphere dark shoulder form. They noted, however, that the small number of animals from both localities, and their discrepancy in size (the North Pacific animals being much smaller) made comparisons difficult. In Table 4 we present data on the dwarf minke whale, the southern hemisphere dark shoulder form (Omura, 1975; Omura and Kasuya, 1976), small North Pacific minke whales (specimens with skulls less than 1.5m, from Omura, 1957), large North Pacific minke whales (from Tomilin, 1967), and large

North Atlantic animals (Turner, 1892; True, 1904; Lilljeberg in True, 1904; Allen, 1916; Tomilin, 1967). An examination of Table 4 (and Fig. 6 in Omura, 1975) shows that two features used by Omura (1975) to separate the North Pacific and Antarctic forms (breadth of skull, breadth of rostrum at base) differed only in the largest animals, listed by Tomilin (1967). The smaller North Pacific animals listed by Omura differed as much from the large North Pacific specimens listed by Tomilin (1967) as they did from the Antarctic specimens. Similarly, the large North Atlantic specimens agreed more closely with the large North Pacific specimens listed by Tomilin (1967) than they did with the smaller animals listed by Omura (1957). It would clearly be misleading to compare measurements of the dwarf minke with data on North Pacific animals measured by Omura (1957). Unfortunately, only the relatively few measurements given in Table 4 seem to be available for mature northern hemisphere specimens.

Of the nine measurements in Table 4, four refer to the mandible. The Hook Reef specimen overlapped in two and one of the four measurements with specimens from the Antarctic and North Atlantic respectively, while there was no overlap with specimens from the North Pacific.

The dwarf minke whale was closest to the southern hemisphere dark shouldered form in length of rostrum, although still outside the range for that form (69.8 vs 64.0–69.4%). True (1904) and M'Intosh (1917) noted that the rostrum was proportionately more elongate in the largest skulls of North Atlantic minke whale; their values overlap those of the dark shouldered form and approach that of the dwarf minke whale. However, even including the data from Tomilin (1967) North Pacific minke whales appear to have a shorter rostrum than either southern hemisphere form.

The basal breadth of the rostrum (36.8%) was larger in the dwarf minke than in all the Antarctic and North Pacific forms. Northeast Atlantic minke whales also seem to have a narrower rostrum ($\bar{x}$=34.2 (32.9–36.5) %, n = 5), although one specimen from Norway had a broad rostrum (Allen, 1916). More data are needed, but the basal breadth of the rostrum may be a distinctive feature of the dwarf form.

The dwarf minke whale overlapped the North Atlantic specimens in breadth of rostrum at mid-length and was close to Antarctic specimens in this value. Again it was the North Pacific animals which had a narrower rostrum at mid-length.

In breadth of skull at the squamosal, the dwarf minke whale differed from the dark shouldered form but overlapped with the Atlantic and possibly larger North Pacific animals, based on zygomatic widths from Tomilin (1967).

In length of premaxillaries, the dwarf minke whale was much closer to the North Atlantic and large North Pacific specimens than to those from the Antarctic.

Omura (1975) and Omura and Kasuya (1976) also noted several qualitative differences in skulls from North Pacific and Antarctic animals. Of these, the profile of the skull and margin of the rostrum as seen in dorsal view seem particularly subject to variable interpretation, and are difficult to measure consistently. Moreover, M'Intosh (1917) noted a prominent flattening of the premaxillary region of a large (1.83 m) skull, compared with a small (0.81 m) skull of a North Atlantic minke whale. The difference between young North Pacific whales compared with mature Antarctic specimens noted by Omura (1957) may thus simply reflect the different ages of the animals. However, the skull of the mature dwarf minke whale did more closely resemble in profile the North Pacific than the Antarctic specimens (compare Fig. 4c of the present study with Omura, 1975; Plate 3).

The anterior margins of the nasal bones in the dwarf minke whales from Hook Reef and Lakes Entrance were convex and had an antero-ventral groove. Skulls in the Australian Museum had nasal bones of similar shape, but the presence of an inferior groove has not been confirmed. This contrasts with the southern hemisphere dark shoulder minke but agrees with specimens from the North Pacific (Omura, 1975). Minke whales from the North Atlantic also have nasal bones with convex anterior margins (Flower, 1864; True, 1904) but the antero-ventral groove has not been recorded.

The vertex of the skull of the dwarf minke differed from previously described forms. The inclusion of parietals in the vertex and presence of an inter-parietal were as in specimens from the North Pacific (Omura, 1975) and North Atlantic (Carte and MacAlister, 1868; True, 1904), but differed from the dark shoulder form as described by Omura (1975). The configuration of the inter-parietal in the dwarf minke whale was rhomboidal, rather than triangular as in the northern hemisphere specimens. Moreover, the posterior margins of the nasals, premaxillaries and maxillaries all appeared at the same level in the mature dwarf minke whale. This agreed with southern hemisphere dark shoulder minke whales but differed from the northern hemisphere forms (Carte and MacAlister, 1868; True, 1904; Omura, 1975). In the juvenile specimen from Wonga Beach and skull S1396 both frontals and parietals were an obvious feature of the vertex. Moreover, in skull S272, there appeared to be a forward extension of the frontal bone between the ascending processes of the maxillaries, similar to the triangular region of inter-parietal and frontal bones described in the vertex of North Pacific minke whales. This was clearly the case in the 2.2 m specimen from Victoria. Thus the position of nasals, maxillaries and premaxillaries may be age dependent; this would fit with information in Miller (1923) on telescoping of the baleen whale skull (see Southern hemisphere dark shoulder form Discussion: Skeleton).

The Hook Reef and Lakes Entrance dwarf minke whales had angulate palatines and elongate hamular processes unlike the southern hemisphere dark shoulder form but as in the North Pacific specimens (Cowan, 1939; Omura, 1975). The angulate palatine is not a general feature of northern hemisphere minke whales, however, as can be seen from Plate 24 of True

(1904) which shows North Atlantic minke whales from Massachusetts and Norway with elongate hamular processes but curved, rather than angulate posterior margins of the palatine.

The malars appear to be similar to those in other forms of minke whale as illustrated by Omura (1975). The lachrymals, however, appear to be closer to those of the North Pacific specimen than to the Antarctic specimen (Omura, 1975).

The presence of a tuberculate parapophysis on cervical vertebra 7 of the dwarf minke is a feature shared with northern hemisphere forms but not southern hemisphere dark shoulder minke whales.

The presence of ten pairs of ribs (plus one possible very reduced pair) in the Hook Reef animal was anomalous, but seems of no systematic value given that the Wonga Beach animal had the usual complement of eleven.

The sternum differed in shape only slightly from some of the many variants illustrated by Tomilin (1967). The fused basihyal-thyrohyals, and pelvic bones were not closely similar to any of these bones figured in Omura (1957, 1975), Omura and Kasuya (1976), or Satake and Omura (1974). All are subject to considerable variation as indicated in the articles just quoted. The proportional length of the stylohyals was outside the range given by Satake and Omura (1974) for the southern hemisphere dark shoulder form. It was closer to the short stylohyals of animals from the North Pacific (Satake and Omura, 1974) and North Atlantic (Turner, 1892; M'Intosh, 1917). The significance, if any, of differences in these bones, based solely on the Hook Reef animal, must await examination of further material.

The breadth/length ratio of the scapula was lower than for mature southern hemisphere dark shoulder minke whales but within the range for North Pacific animals (Omura, 1975). However, Tomilin (1967) has shown that this ratio is size dependent, with relatively greater growth in breadth in larger animals. This, with the small sample size and slight proportional differences (1.68–1.71 versus 1.76–1.81) make conclusions tentative.

The phalangeal formula of the Hook Reef specimen fell within the values for southern hemisphere dark shoulder minke whales (Omura, 1975) except for digit II and within the ranges compiled for northern hemisphere minke whales by Tomilin (1967).

Geographical range

Tomilin (1967) and Watson (1981) reported the minke whale to be rare in the tropics. Morzer-Bruyns (1971), while giving various sightings from tropical locations, especially in the Indian Ocean, noted that minke whales were "relatively rare" in the south-west Pacific. Stewart and Leatherwood (1985; Fig. 2) showed no records of minke whales around Australia, north of Tasmania. Clearly these impressions are misleading.

Within Australia, the dwarf minke whale extends into low latitudes (at least 11°55′ S on the east coast, and possibly 20°38′ S on the west). Although there are two records from Victoria, most sightings have been from northern New South Wales to northern Queensland; all confirmed records north of 23°08′ S have been dwarf minke whales.

Records of both forms of minke along the Queensland coast and off northern New South Wales have been in June to December, with most in July and August. Temperature data (Table 7) from Brandon (1973) show the expected decrease in temperature with increasing latitude, so that in August sea surface temperatures were 22.8°C. at latitudes 16°–18°, compared with 20.5°C at 23° S. Lowest temperatures at all latitudes occurred in July and August, which is the time of peak sightings.

Gladstone (1984) reported minke whales (apparently all dwarf form) near Lizard Island (14°40′ S) from May to July. This is somewhat earlier than our records. According to Brandon's (1973) data, animals near Lizard Island in May would experience much warmer water, with a mean surface temperature of 27.8°C, versus a June average of 23.8°.

Within New Zealand, the two forms overlap in the Cook Strait region (records in Baker, 1983; W.H. Dawbin, personal communication). Unpublished photographs of an animal stranded at Timaru, N.Z. (44°S) and referred to as a white flipper form by Gaskin (1976) show an extensive throat patch; the animal was almost certainly a dwarf minke whale. Miyashita (personal communication to Marsh) reported a possible dwarf minke whale with a "white flipper band" from the Tasman Sea (39°05′ S, 160°35′ E) – about half way between Australia and New Zealand – on Novembr 24, 1983. Otherwise, the most southerly record is Plimmerton, N.Z. (about 41°05′S) (Cawthorn, in Best, 1985). Baker (1983) described the dwarf minke whale as 'rare' in New Zealand. Given its predominance in warm waters along the east Australian coast, it may be at the edge of its range in New Zealand. Against this argument are records from Timaru and even further south in the sub-Antarctic (see below).

The minke whale from near the Isle of Pines, New Caledonia illustrated in Laboute and Magnier (1979) is clearly the dwarf form. Further details are unavailable (Laboute, personal communication to Arnold).

Best (1985) summarized records of dwarf minke whales from South Africa. The animals seem to be in low numbers at Durban (30°S), forming only 3–4% of the catch there. However, a stranding was reported at 34°09′S, close to the southern extremity of the Cape Province and Best noted that the low percentage of dwarf minke whales in the Durban catch could reflect selectivity by the gunners.

Best (1985) considered some of the records from Brazil tentative, but listed the occurrence of dwarf minke whales there, based on a specimen with a dark throat patch, reported by Williamson (1973). Singarajah (personal communication to Marsh) has not seen the dwarf form in the Brazilian fishery, however other Brazilian scientists have reported that the "diminutive form" of Best was regularly sighted but rarely captured off Brazil because of its small size (Anon, 1985). While the dwarf minke whale clearly occurs in the Brazilian region, more information on its distribution and abundance there is needed.

No specimens of dwarf minke were noted by Best (1985) in the Antarctic, nor have they been seen by Japanese workers (Wada, pers. comm. to Marsh). None of the 1179 photographs of minke whales from the Antarctic taken by Japanese scientists and examined by Marsh were of the dwarf form (Marsh, 1985). Best (1985) has already pointed out the difficulty in assessing the colour of the flipper at sea and one must question some of the sight records of white-flipper forms from the Antarctic (e.g. Lillie, 1910; Taylor, 1957). The most southerly records of dwarf minke whales, supported by photographs, appear to be at 52°57′ S, 112°32′ E and 53°08′ S 112°30′ E both on Dec. 26, 1984 (Kasamatsu, personal communication to Marsh). While this could suggest latitudinal migration, we also have records of dwarf minke whales at 11°55′ and 19°50′ S in late November and early December respectively. Thus nothing can be said about long distance movements of this form in the southwest Pacific.

Records in the literature of minke whales from the tropical Indo- Pacific are generally inconclusive. Deranyigala (1948, 1960) reported the southern hemisphere dark shoulder form from Sri Lanka, but with no details to support the identification. In 1963 he then described a new subspecies from Sri Lanka, *B. acutorostrata thalmaha*. This was based on differences in the colour of the baleen plates, with black and white plates anteriorly, but entirely black plates (except for bristles) posteriorly. There are some discrepancies in the description. Figures of "two feet, six inches" and "two feet, five inches" were given for the height and length of the dorsal fin respectively (about 8.6% total length). This is nearly twice the height reported for any form of minke whale, but is comparable to the length of the base of the dwarf form. The fluke width listed was 17.2% of the total body length. Deranyigala (1963) noted that this was narrower than reported in the southern hemisphere dark shoulder form. In fact, it is much smaller than for any form from either hemisphere. The length of the baleen plates (17 cm) suggests the dwarf minke whale, but only parts of the baleen series were available and the longest plates may not have been collected. The colour of the baleen, if it was as described, would seem to rule out the dwarf form. No information was given on diagnostic colour patterns of the body, while the illustrations and description of the skull are insufficient to establish the identity of the animal. The total body length of 28ft (8.5m) would suggest that it was not a dwarf minke whale, of which the largest specimen measured was a 7.8 m female (Best, 1985).

Lekagul and McNeely (1977) recorded minke whales from Thailand. They described the animals as having white flipper bands, but the account seems to be a compilation from the literature and the colour pattern may be based on descriptions of animals from higher latitudes of the northern hemisphere.

Harrison (1974) noted that records of *B. edeni* from Malaysia and Singapore "appear to be the local representative of the Lesser Rorqual *B. acutorostrata*". No description or other support for this statement is given. One of the records of minke, "Pulau Sugi in 1950" is suspiciously like the record of *B. edeni* from Pulu Sugi described fully by Junge (1950). Harrison stated that the colour of the minke whale in Malaysian waters is still unknown.

Herre (1925) reported a minke whale from the Philippines, but with no description which could confirm his identification.

On the basis of present records, confirmed sightings of the dwarf minke whale appear confined to the west Indian Ocean (South Africa), southwest Pacific (Australia, New Zealand, New Caledonia) and in the Atlantic, off South Africa and Brazil. Accounts of the minke whale in the Philippines, Thailand, Malaysia, Singapore and Sri Lanka need to be confirmed.

School size and distribution from shore

Most of the records of dwarf minke whales in northern Queensland were of single animals, with one sighting of three animals '15–20 ft' long. Gladstone (1984) reported diving with five dwarf minke whales off Lizard Island (14°40′ S). Rockman (1986a,b) reported a group of eight dwarf minke whales from Marion Reef (19°10′ S, 152°17′ E).

The predominance of sight records from the mid and outer Queensland shelf probably partly results from the concentration of reefs in those areas. Thus sport divers, fishermen and research scientists are more likely to spend time anchored in such spots, where they can be approached closely by minke whales. It is usually only under such circumstances that sufficient detail can be observed and/or photographed to allow positive identification of the dwarf minke whale. In the only systematic aerial survey of the region (111 cross-shelf transects between 11°30′ S and 20°30′ S during November–December 1985) dwarf minke whales were recorded only twice, both from the mid to outer shelf (Marsh, unpublished data). In contrast, Best (1985) showed that dwarf minke whales off Durban occurred closer inshore than other minke whales.

The length of sightings (up to several hours) and the high proportion of sightings supported by underwater observations and photographs suggests a behaviour similar to other forms of minke whale which have been reported to closely approach vessels (e.g. Leatherwood *et al.*, 1982).

SOUTHERN HEMISPHERE DARK SHOULDER FORM

RESULTS

Colour pattern

We have less extensive information on the dark shoulder form. Unless otherwise noted, the following notes are based on a 4 m minke whale stranded near Coff's Harbour, N.S.W. (29°47′ S) in August 1981, and photographed alive at the Pet Porpoise Pool, Coff's Harbour. Photographs (see Figs

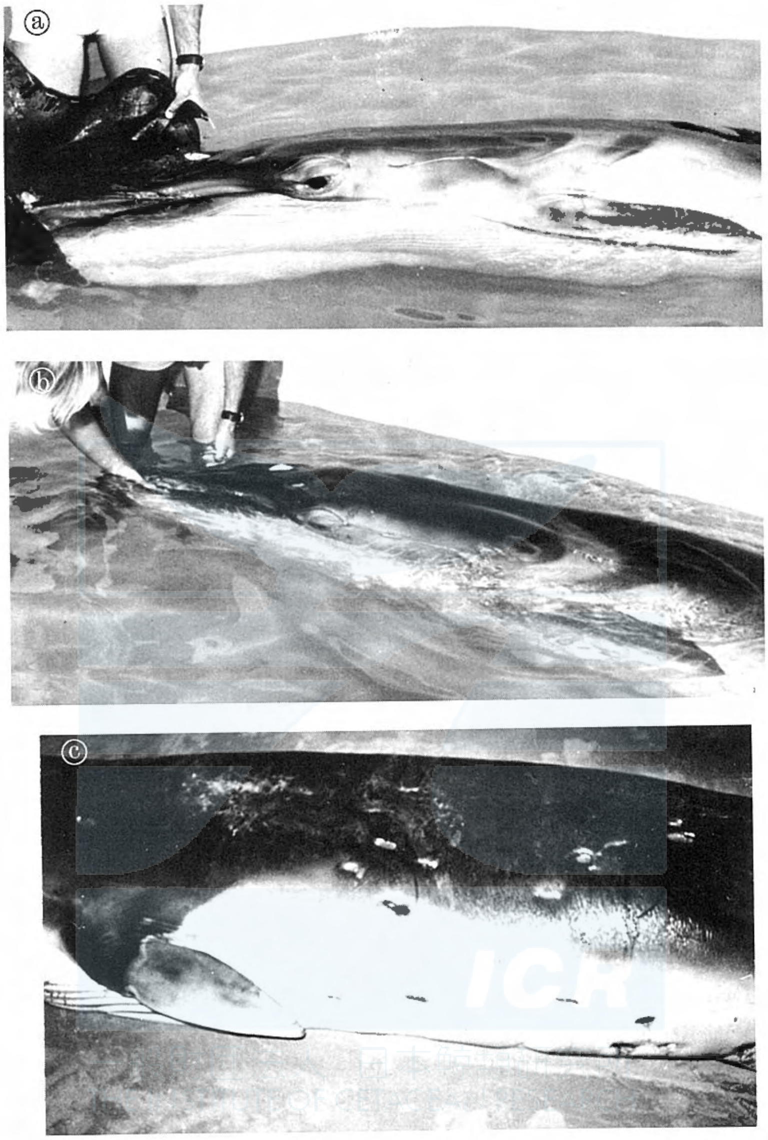

Fig. 7. Southern hemisphere dark shoulder minke whale. a,b 4.0 m individual, stranded near Grafton, New South Wales. a. Note light lower jaw, white ear stripe, light anterior edge of flipper with fine transverse dark band near flipper base. b. Note light crescent extending onto the neck region and circular deep lesions on rostrum. Photographs a and b courtesy of Pet Porpoise Pool, Coffs Harbour, N.S.W. c. Four metre individual stranded near Yeppoon, Queensland. Note dark base and light leading edge of flipper, light narrow transverse band near base of flipper, and numerous deep circular to elliptical lesions. Photograph courtesy of M. Simmons, Queensland National Parks and Wildlife Service.

7a, 7b) were taken of the left side only.

The rostrum was slate grey, with a margin of light grey to white along the gum.

The lower jaw overlying the mandible was light grey, but there was no dark throat patch. The head appeared light grey in colour. The area around the eye was light grey, but merged posteriorly with a darker grey band running posteriorly towards the base of the flipper. There was no white shoulder patch. Dorsal to the flipper the side was light grey, with a thin dark grey streak running obliquely forward and ventrad from the back, dividing the light grey into two parts. The anterior of these continued dorsally to form a distinct light crescent on the back of the neck (Fig. 7b). There was a dark streak, apparently level with the ear, which merged posteriad with a white stripe. This stripe ran dorsally, increasing in width, and merged with the anterior light grey patch above the flipper (Fig. 7a).

The flipper was light grey to white along the anterior edge, but was darker grey over most of the upper surface. A small oval patch of light grey to white extended onto the upper surface of the flipper base from the axilla. A fine dark line crossed the flipper at its base, gently curving outwards toward the tip of the flipper (Fig. 7a). A similar thin dark line continued across the light grey of the side towards the dark grey back. The underside of the flukes were white, except for a thin dusky margin.

Unpublished photos of a dark shoulder minke whale stranded on Kangaroo Island, South Australia (record in Ling and Aitken, 1981; 35°50′ S) also show the distinctly light grey to white leading edge of the flipper but with an otherwise dark upper surface (there appeared to be some white at the axilla as well, but no transverse band was seen). The thorax was light grey with two dark grey bands originating at the axilla and running upwards toward the back, becoming somewhat wider dorsally.

An animal stranded at Yeppoon (23°08′ S) had a light grey flipper, in which the anterior margin and most of the tip appeared lighter, almost white. The base of the flipper was much darker, contrasting sharply with the flipper itself. The two grades of grey were separated by a thin white line, the central portion of which curved sharply outwards toward the tip of the flipper (Fig. 7c). This white line occurred on both flippers.

Skeleton

The anterior margin of the nasal bones in skulls from Queensland and South Australia were flattened or concave; the nasals in the Queensland specimen definitely lacked an inferior elliptical groove. The South Australian skull definitely had the parietals excluded from the vertex. The parietals also seemed to be excluded from the vertex of the specimen from Queensland, however it was difficult to interpret the formation of the vertex due to a strong supraoccipital crest overhanging the peak.

The posterior margin of the palatines was curved and the hamular processes of the pterygoid bones were short and stout in the South Australian specimen. The hamular processes appeared to be stout in the Queensland specimen as well, but both pterygoids were damaged.

Finally, the nasals, premaxillaries and maxillaries all appeared at about the same level in both the skulls. This was obvious even in the South Australian skull, from a young animal only 3.3 m long.

Other features

A conspicuous feature of the southern hemisphere dark shoulder minke whales stranded near Coff's Harbour and Yeppoon was numerous circular to oval lesions, in which plugs of blubber were missing. At least 26 open lesions were present in a photograph of the one side of the Coff's Harbour animal. Over thirty open lesions were counted in photos of the Yeppoon animal.

Distribution

Animals from Tasmania reported by Davies and Guiler (1958) and Guiler (1978) are tentatively considered the dark shoulder form, but insufficient information was given to allow positive identification.

The smallest animals were recorded from Tasmania and Victoria, based on the reports in Davies and Guiler (1958) and Wakefield (1967). Estimated lengths of these animals were 2.2 m and 6–7 ft (1.8–2.1 m) respectively.

With the exception of a neonate (or late fetus) stranded in Tasmania (42°50′ S), probably in May, all records of dark shoulder minke whales from southeastern Australia and the central Queensland coast are from August to October. The most northerly record of a dark shoulder minke whale was the animal stranded near Yeppoon (23°08′ S); it stranded around August 11, 1983 while a dwarf minke whale was found nearby in the last week of August 1983. Sight records from southern Queensland (27°24′ S) of unidentified forms of minke whale were in June and July.

Records of the dark shoulder form are based on strandings and thus give no information on distribution of the animals offshore.

DISCUSSION

Colour pattern

Our material of the southern hemisphere dark shoulder minke whale confirms features such as the light grey to white lower jaw and absence of throat patch, which have been described previously. The white line behind the eye, noted in the Coff's Harbour specimen, is similar to that reported by Kasuya and Ichihara (1965). However, in their figure and in photographs of dark shoulder minke whales from the Antarctic which we have seen, the line was curved ventrally toward the flipper rather than dorsally as in the Australian specimen. The alternating light and dark grey of the body above the flippers and the dorsal extension of light pigment onto the back as a crescent agrees with previous descriptions of this form.

The specimens from Yeppoon and northern New South Wales both had a thin transverse band on the flipper, although one was dark and the other light coloured. The light coloured band separated a dark grey base from the lighter flipper. Both forms would fit Doroshenko's (1979) flipper type 2, which he reported from 75.2% of specimens taken in the New Zealand sector of the Antarctic. van Beek and van Biesen (1982) found that the differences in banding of the flipper between areas reported by Doroshenko were statistically significant but noted that his categories did not encompass the full variation in colour pattern reported from the Antarctic. Best (1985) documented asymmetry of colour pattern, in which on one side, the flipper was banded while on the other it was not. He found that bands occurred more frequently on the left side. The animal from Coff's Harbour, N.S.W. was only photographed from the left side, but the Yeppoon specimen was photographed from both sides and had bands on both flippers.

Skeleton

Observations of Australian material generally confirms previous reports based on specimens from the Antarctic (e.g. Omura, 1975). The frontals appeared to be proportionately more exposed in the skull of an immature dark shoulder minke whale (J2 1708), when compared with the larger skulls of this form illustrated by Omura (1975) and Omura and Kasuya (1976). However, there was no triangular region of parietal and frontal bone separating the nasals from the supraoccipital. In the South Australian skull, from an immature animal, the nasals, premaxillaries and maxillaries were at the same level as illustrated for Antarctic specimens by Omura (1975). Thus, although telescoping of the skull may be less developed in juveniles (see Miller, 1923), the differences noted between the southern hemisphere dark shoulder minke whale and other forms can not be simply attributed to differences in the ages of the specimens examined.

Other features

Shevchenko (1977) has used frequency of 'white scars' to separate stocks of sei whales from the southeast Atlantic and Indian Oceans. Such lesions have been for a long time associated with movement of baleen whales into tropical waters and have been attributed either to a deep-water squaloid shark, *Isistius* (Jones, 1971) or to shedding of parasitic copepods of the family Penellidae (Ivashin and Golubovsky, 1978). Neither the dwarf minke whales nor the dark shoulder minke whales which we have seen have the intensity of scars shown for sei whales by Shevchenko, although the few specimens of dark shoulder minke whales seem to be the more heavily scarred (Note, however, what appear to be numerous scars on the specimen of dwarf minke whale from New Caledonia figured by Laboute and Magnier (1979) and obvious lesions on Marion reef specimen in Rockman (1986a,b)). Shevchenko

(1977) suggested that intensity of scarring might be used to separate stocks of baleen whales from the east Indian Ocean and Tasman Sea. More material is needed to assess its use for minke whales.

Distribution

The few records of the dark shoulder form in Table 1 do not adequately reflect its distribution. Published records of minke whales from southern Australia usually contained inadequate information to identify the form or sometimes even the species. We have been unable, except in a few cases, to examine the skeletal material in Australian museums and have had to rely on photographs of animals and skulls (or even photocopies of these). It has been impossible to identify some of these records positively and they were not included in Table 1. A detailed examination of skeletal material in Australian museums would provide useful information on the distribution of minke whales, especially around the southern half of the continent and off Tasmania.

STATUS OF THE DWARF MINKE WHALE

Wada (1983) analyzed electrophoretic patterns of North Pacific, Antarctic and Brazilian southern hemisphere dark shoulder minke whales and one dwarf minke whale from South Africa. He suggested an uniformity of the southern hemisphere forms, which were considered to differ subspecifically from the North Pacific animals. His conclusions regarding the dwarf minke whale must be considered tentative given the single sample available.

Moreover, there are a range of osteological, morphometric and pigmentation differences between the dwarf minke whale and the southern hemisphere dark shoulder form. Some of these features (e.g. skull breadth, length of rostrum, profile of skull) are age dependent and must be compared between animals of similar size. Other features such as length of mouth and number of baleen plates appear to be inter-related and may be variable irrespective of age. Features such as size and form of baleen plates may be subject to short-term selection, possibly associated with diet. In this respect, Best (1977) has documented two forms of Bryde's whale which have different forms of baleen, different distributions off the South African coast, and different diets.

The differences in morphometrics and osteology which remain when comparing the two southern hemisphere forms of similar size are still impressive. Our examination of skulls of young dark shoulder minke whales (previously described on the basis of skulls from large animals) and morphometrics and the skull of a sexually mature dwarf minke whale (in which morphometrics were previously based on immature animals and osteology was previously undocumented) helps resolve problems of comparing forms of widely different sizes and thus ages. Some of the previously reported differences in the dwarf minke whale have been confirmed while we have been able to document further differences. There are also differences in size at reproductive maturity (Best, 1985, Marsh, 1985) and apparently in distribution (see Dwarf minke whale Discussion: geographical range) between the two southern hemisphere forms.

Differences in colour pattern between the two southern hemisphere forms further support a degree of genetic isolation. Although many variants in colour pattern have been described for the dark shoulder form (e.g. Doroshenko, 1979; Wada and Numachi, 1979), none approaches the flipper and shoulder colouration of the dwarf form. Throughout its wide range, the dwarf minke whale appears to have a remarkably consistent colour pattern. The lack of intermediates, despite known areas of overlap with the dark shoulder form in South Africa, Australia, and New Zealand, argues for a greater degree of genetic isolation than suggested by Wada (1983). A similar argument was used by Kasuya (1978) for genetic isolation between colour forms of Dall's porpoise in the North Pacific. However, unlike the Dall's porpoise (Kasuya, 1978), the dwarf minke whale appears to be separated from the southern hemisphere dark shoulder form by characters other than colour pattern, e.g. morphometrics, skull characters and size at reproductive maturity. In this respect, it is closer to the apparently isolated population of Commerson's dolphin, *Cephalorhynchus commersonii*, from the Kerguelin Islands which shows a range of character differences from the main South American population (Robineau and de Buffrenil (1985), in addition to retention of juvenile pigment pattern (Leatherwood and Cornell, 1985)).

Present data on skeleton and morphometrics strongly suggest a closer affinity of the dwarf minke whale with either of the northern hemisphere forms than with the southern hemisphere dark shoulder form. Omura (1975: fig. 14) identified 17 characters differentiating the geographical "populations" of minke whale. Three of these (dorsal view of rostrum, profile of skull, pelvic bone shape) we consider difficult to evaluate or too variable, while one (flipper colour) is unique to the dwarf minke whale. Of the remaining 13 characters, 11 differed between the two southern hemisphere forms but were shared between the dwarf minke and at least one of the northern hemisphere "populations". Of the two characters shared by the two southern hemisphere forms, only one (position of bones in vertex) was not also shared with one of the northern hemisphere forms. Moreover, that feature may be variable, especially with age. There appears to be sufficient grounds to recognize the two southern hemisphere forms as taxonomic entities, at least as subspecies. If the relative resemblances of the dwarf minke with the northern hemisphere forms are supported by examination of more material and the differences between the two southern hemisphere forms are maintained, then it could be argued that the dark shoulder form deserves full specific status, in which case *Balaenoptera bonaerensis* would have priority. Final resolution of these questions will require examination of more material from all oceans. However, it is easy to separate the two southern hemisphere forms on the following combination of features:

External morphology

Lower jaw overlying mandible grey, extending over ventral grooves as a dark throat patch; base of flipper white; thorax around flipper white, containing a dark patch (flipper oval, Fig. 1) and bordered dorsally by a triangular light grey shoulder blaze which may run obliquely anteriad onto the back; light grey flank patch extending past dorsal fin and containing an extension of white from the underside of the tail stock (peduncle patch, Fig. 1a); living animals with light grey on upper surface of rostrum and head; baleen plates predominantly light, with black at most as narrow band along lateral margin, except for most posterior plates which may be almost entirely black; dorsal fin well forward (69.6–71.5% total length to tip of fin), tall (4.8–5.6% total length) and long at base (8.3–8.4% total length)......dwarf or diminutive form

Lower jaw light grey with no dark grey pigment over throat; flippers with single or two tones of grey, especially light along the leading edge but never white at base; thorax in region of flipper insertion light grey, extending as forwardly directed crescent onto the back; light flank patch extending high on sides just in front of the dorsal fin, without peduncle patch; living animals with dark grey upper surface of rostrum and head; baleen plates asymmetrically coloured with light plates occupying $\bar{x}$=34–37% and 12–16% of the length of right and left baleen plate series respectively in specimens from the Antarctic and South Africa; dorsal fin further posterior (72.9–76.1% total length of juveniles to tip of fin); low (3.0–4.2% total length of adults) and short at base (3.7–7.7% total length of adults; Best, 1985) .... dark shoulder form

Skull

Anterior of nasal bones convex, with inferior elliptical groove; parietals incorporated into vertex with angulato-ovate inter-parietal; ascending processes of maxillary may extend posteriad to level of nasals and premaxillaries in juvenile specimens but are at about same level in mature specimens; posterior of palatine bones angulate; hamular process of pterygoid elongate (Fig. 5f) .... dwarf or diminutive form

Anterior of nasal bones straight or concave, extending forward laterally and with no inferior elliptical groove; parietals and inter-parietal excluded from vertex; posterior borders of ascending processes of maxillary, nasals and premaxillaries at about same level in both juvenile and mature specimens; posterior of palatine bones smoothly curving; hamular process of pterygoid bones stout (Omura, 1975; Fig. 5) .... dark shoulder form

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