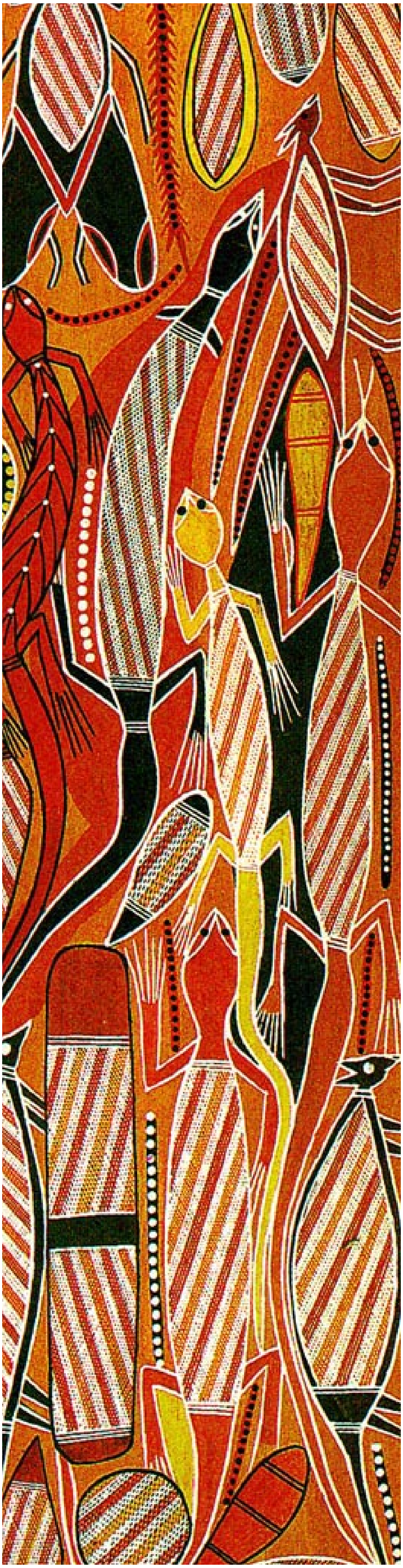

FAUNA *of* AUSTRALIA

48. ZIPHIIDAE

GRAHAM J.B. ROSS

DEFINITION AND GENERAL DESCRIPTION

This family comprises 18 living species of toothed whales in which the characteristic narrow and protruding snout gives rise to their collective name of beaked whales. Several features distinguish them from all other groups of whales. A pair of grooves, which converge anteriorly but do not meet, is present on the ventral surface of the throat. There is no median notch in the trailing edge of the flukes. In all but one species one or two teeth are present in the lower jaw; but these usually erupt only in adult males. The elongate, narrow rostrum of the skull is characteristic and the premaxillary bones extend posteriorly and dorsally to form, with the nasal bones, much of the vertex of the skull.

Humans rarely encounter beaked whales. Most species are known only from infrequent strandings. The resulting paucity in biological information is reflected in the following account.

HISTORY OF DISCOVERY

The pace at which beaked whale genera and species have been described reflects the opportunistic nature of the collection of material on which these descriptions have been based. In the century prior to 1870, seven of the 18 species currently recognised were described in four genera (*Berardius*, *Hyperoodon*, *Mesoplodon* and *Ziphius*). Between 1870 and 1920, a further seven species were added, and, subsequently, the remaining four species and two new genera were described (*Tasmacetus* and *Indopacetus*) (Hershkovitz 1966; Moore 1968).

With the exception of three species of *Mesoplodon*, Australia's contribution to these descriptive phases was limited. These species are *M. guntheri* Krefft 1871, *M. longirostris* Gray 1871 and *M. thomson*i Ogilby 1892 (Hershkovitz 1966). Based on study or description and illustrations of the skeleton of a Strap-toothed Beaked Whale (*M. layardii*) from Little Bay, New South Wales, presently held in the Australian Museum, Sydney (no. A 359), the former three names currently are included in the synonymy of the latter species.

Flower (1882) described the Southern Bottlenose Whale (*Hyperoodon planifrons*) based on a water worn cranium collected at Lewis Island, Dampier Archipelago, Western Australia [British Museum (Natural History) no. 1814a 82.3.2.4.1].

Of particular interest is Longman's Beaked Whale (*Indopacetus pacificus*) (Longman 1926) of which only two skulls are known. Originally described as *Mesoplodon pacificus* and based on a beach worn skull from Mackay, Queensland (Qld Museum no. J.2106) (Fig. 48.1), this specimen was assigned to *M. mirus* (Raven 1937) and *Hyperoodon planifrons* (McCann 1962) before Moore (1968) erected a new genus, *Indopacetus*.

Increased interest in stranded cetaceans in recent years has raised the number of beaked whale species on the Australian faunal list from eight to 11: Hector's Beaked Whale (*Mesoplodon hectori*) in 1966 (Guiler 1967), True's Beaked Whale (*M. mirus*) in 1974 (Ross 1984) and the Tasman Beaked Whale (*Tasmacetus sheperdi*) in 1976 (Ling & Aitken 1981). The inclusion of representatives of all six genera in the Australian fauna is unique.

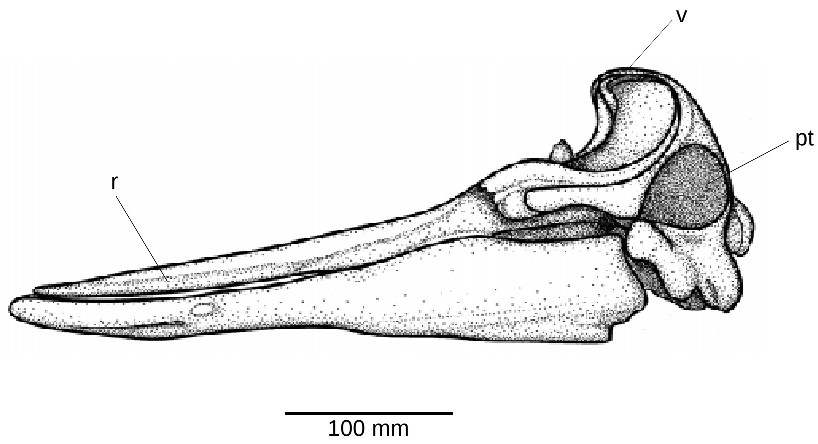

Figure 48.1 Lateral view of the skull of Longman's Beaked Whale (*Indopacetus pacificus*). Note the elongate rostrum (r), the elevated skull vertex (v) and ventrally, the broad, concave pterygoid bones (pt). (© ABRS) [S. Collin]

MORPHOLOGY AND PHYSIOLOGY

External characteristics

Beaked whales are streamlined, deep-bodied and laterally compressed. Body lengths in each genus are 4.3–6 m in *Mesoplodon*, 7 m in *Ziphius* and *Tasmacetus* and up to 9 m and 12 m in *Hyperoodon* and *Berardius*, respectively. The external form of Longman's Beaked Whale is entirely unknown. The beak is most attenuate and pointed in *Tasmacetus* and *Mesoplodon*, particularly Gray's Beaked Whale (*M. grayi*) (Fig. 48.2a), becoming progressively more robust with size in the other genera. Similarly, the fatty forehead or melon is smallest in the smaller genera, more developed in *Ziphius* and *Berardius* and largest in *Hyperoodon* (Bottlenose Whales) in which the melon is bulbous in adult males and overhangs the tip of the beak (Mead & Payne 1975; Ross 1984). In *Berardius*, the centre of the blowhole arches anteriorly rather than posteriorly, a feature unique to this genus (Leatherwood & Reeves 1983).

In all species the flippers are small (8–13% of body length) with subparallel leading and trailing edges, abruptly tapering to a bluntly rounded apex. In some species, the flipper lies in a shallow depression on the body. The dorsal fin is small, triangular or slightly hooked and set about two-thirds of body length from the snout. Its height varies from 4–6% of body length except in *Berardius* in which it may be as little as 2%. The flukes are broad and full (20–32% of body length) and resemble other toothed whales in their proportions (Ross 1984). A caudal notch is absent.

The number of erupted teeth varies with age and sex in beaked whale genera. In *Ziphius*, *Hyperoodon*, *Mesoplodon*, and probably *Tasmacetus*, a single pair of large teeth erupts only in adult males. In addition, in Tasmacetus there are 17 to 28 small functional teeth in both jaws of both sexes. Two pairs of teeth erupt in male and female *Berardius*. Teeth erupt at the tips of the mandibles in all genera except *Mesoplodon*, in which their position varies between species from the tip to midlength of the mandible, with tooth size tending to increase posteriorly (Moore 1968; Mead & Payne 1975). Such tooth development reaches its extreme in Blainville's Beaked Whale (*M. densirostris*) and the Strap-toothed

Beaked Whale. In the latter, the strap-like teeth meet over the upper jaw, restricting the gape to less than 150 mm at the jaw tips. In some species, such as Gray's Beaked Whale, a number of rudimentary teeth is present along the upper jaw.

The colour patterns of beaked whales are not well known, largely due to the rapid darkening of the skin on exposure to the sun when animals become stranded. Beaked whales are dark grey or greyish brown to black dorsally and usually paler ventrally in calves and immature animals. Adult *Berardius* species are entirely black with a few white splashes ventrally (Omura, Fujino & Kimura 1955). The head and beak of adult Cuvier's Beaked Whale (*Ziphius cavirostris*) may be whitish in colour (Fig. 48.2b) (Harmer 1927). Adult Bottlenose Whales become pale brown with age (Gray 1882). Patterns in *Mesoplodon* vary between species, mostly in the extent of various pale areas and the degree of scarring.

Body scarring of two main types is a prominent feature in many beaked whales. Single or parallel linear scars are attributed to intraspecific fighting, such as those of *Berardius* (Fig. 48.2c). Round or oval scars also occur frequently over the back, sides and genital area (Fig. 48.2b) and are thought to result from wounds inflicted by the small pelagic cookie-cutter shark, *Isistius brasiliensis* (Jones 1971).

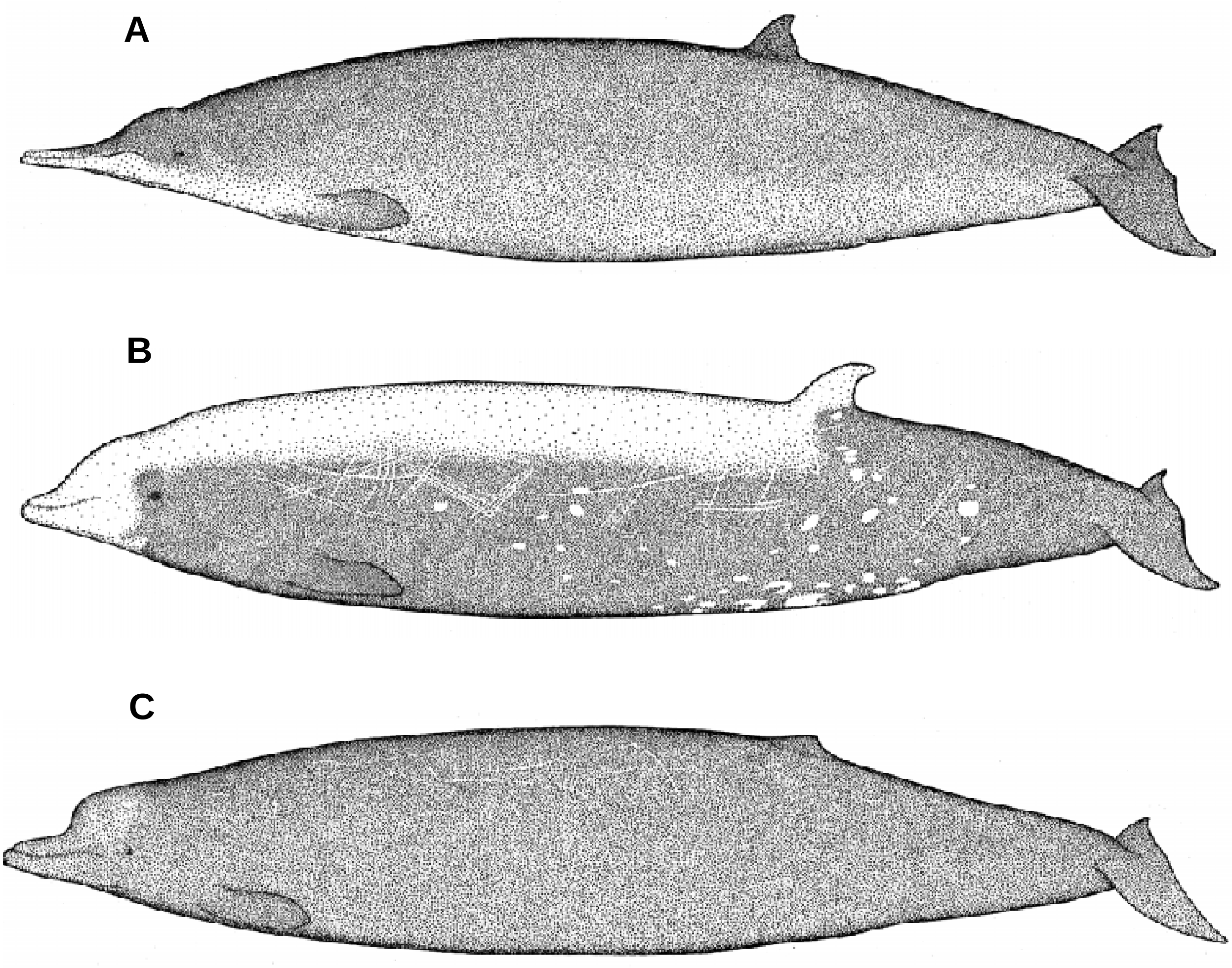

Figure 48.2 Three species of adult beaked whales: **A**, female Gray's Beaked Whale (*Mesoplodon grayi*); **B**, male Cuvier's Beaked Whale (*Ziphius cavirostris*); **C**, male *Berardius arnouxi*. Scale lines represent 0.5 m. (After Ross, 1984) [G. Ross]

Body wall

The epidermis of beaked whales resembles that of other cetaceans. It is about 3-5 mm thick, lacks sweat glands and hair except for a few rudimentary vibrissae on the upper beak of late-term foetuses. The bulk of the body wall is formed by the sub-epidermal blubber layer which covers the entire body, becoming thinner or disappearing over the appendages. It may be up to 80 mm thick mid-dorsally and weighs about 20% of total body mass in *Mesoplodon* (Ross 1984). The blubber consists of fat tissue supported by a fibrous matrix and insulates the body against heat loss, smooths the body contours and provides some buoyancy. Beneath the blubber, the body is sheathed by a thin muscle sheet (panniculus carnosus).

The melon contains a body of fat within a fibrous capsule to which slips of facial muscle are attached. The fat closely resembles the waxy spermaceti of sperm whales in its properties. In large male Bottlenose Whales the melon may contain some 200 kg of spermaceti (Arvy & Pilleri 1983). The distribution of different fats within the melon suggests that it may function as a wave guide for sounds, as has been suggested for other toothed whales (Litchfield & Greenberg 1974).

Skeletal system

Several features of beaked whale skulls are typical, in addition to the structure of the vertex noted above. The elongate rostrum is comprised of the premaxillae, maxillae and the vomer which ossifies on its dorsal surface in older animals of most genera, replacing the cartilage which usually fills the mesorostral canal. Subsequent fusion of these elements produces a strong and very dense structure. The remainder of the skull consists almost entirely of porous bone filled with oil. In some genera the prenarial area becomes basin-shaped with age (Mead 1975a). In *Hyperoodon*, the maxillary prominences are greatly expanded dorsally, forming characteristic crests. Each pterygoid is expanded ventrally, is concave and supports a large, simple pterygoid sinus (Fraser & Purves 1960). As in all odontocetes, the skull is asymmetrical in dorsal view, least so in *Berardius* and most asymmetrical in *Mesoplodon*.

The number of vertebrae ranges from 44 to 49. There are seven cervical, 8 to 11 thoracic, 10 to 13 lumbar and 17 to 21 caudal vertebrae. The cervical vertebrae are compressed. In adults the anterior three (*Mesoplodon*, *Berardius*) to seven (*Hyperoodon*) of these vertebrae fuse. *Hyperoodon* may have as few as eight thoracic vertebrae, the least recorded for any mammal (Fraser 1945). The neural processes of the thoracic and lumbar vertebrae are typically broad and elongate for the attachment of the large dorsal muscle mass.

The scapula is small, in keeping with the small flipper. The sternum consists of three to five sternebrae, each typically notched on its anterior and posterior margins. Pelvic bones are recorded in *Berardius*, *Hyperoodon* and *Mesoplodon* (Arvy 1979) and probably are present in the other genera.

Locomotion

Beaked whales swim using vertical strokes of their tail flukes and anatomically appear to be powerful swimmers. Though they are slender and streamlined in dorsal view, in profile the body is deep, primarily reflecting the massive dorsal and ventral muscles which drive the tail. Together these muscles weighed 41-47% of body mass in four *Mesoplodon* and two *Hyperoodon* of various ages (Ross 1984). This mode of motion requires resilience anteriorly, seen in the compression of the cervical vertebrae and the short thorax. Elongation of the lumbar vertebrae increases the amplitude of the power stroke and the area for muscle attachment. In dolphins, this is achieved by an increase in the number of

vertebrae. Limited evidence from a captive juvenile *Mesoplodon* species suggests that the small flippers are of little use in steering during turns and are held against the body (Dudok van Heel 1974).

Feeding and digestion

Beaked whales prey primarily on oceanic squids. As in other whales specialised for eating squid, these animals have a reduced dentition which is of little or no value in the capture of food, with perhaps the exception of Tasmacetus. Instead, the prey is pincered between a longitudinal ridge on each mandible and on the palate before it is swallowed whole.

The stomach consists of the glandular or main stomach and the pyloric portion which is subdivided into 10 to 12 compartments. The soft squid diet of beaked whales may explain the absence of a forestomach, which in other cetaceans breaks down food by muscular action prior to digestion (Slijper 1979).

The length of intestines is 4.5 to 6 times body length, considerably shorter than other toothed whales (Slijper 1979; Ross 1984), but comparable to those of whalebone whales and some terrestrial carnivores.

Circulatory system

The circulatory system appears to be very similar in most respects to that of other cetacean groups and to terrestrial mammals.

The heart of Bottlenose Whales is broad, with a rounded apex and is flattened dorso-ventrally, features thought to be associated with depth and duration of diving (Rowlatt 1981). A network of muscular cords on the internal walls of the ventricles may prolong the ventricular flow, thus maintaining a smooth flow in the long circulatory column, as in other whales (Rowlatt 1981). The large proportion of elastic tissue in major arteries, particularly the aorta, assists in this process.

Retia mirabilia, in which the arteries and veins divide into innumerable intertwined branches embedded in fatty tissue, are less developed than in other whales and occur primarily in the cervical region and the upper half of the thorax. Smaller retia occur within and beneath the cranium and in the genital region (Arvy & Pilleri 1983). Retia regulate blood pressure changes by storing and releasing blood as needed (Slijper 1979), as do the large dilation of the base of the aorta, the large sinus formed by dilation of the hepatic veins and inferior vena cava beneath the diaphragm and the intravertebral spinal veins, by which much of the blood from the brain returns to the heart.

Respiration

The lungs are elongate, triangular organs placed dorsally in the thorax, thus providing stability in the water. Their mass in *Hyperoodon* and *Mesoplodon* is about 0.9–1.7% of body mass (Slijper 1979; Ross 1984), comparable to that of baleen whales and sperm whales, less than that of dolphins and proportionately about half that of terrestrial mammals of similar mass. The reduced mass of the lungs allows for their complete collapse at depth with least stress. Other features assisting in this process are cartilaginous sternal ribs which increase the flexibility of the thorax and, in *Berardius*, the absence of bronchiolar cartilages beyond the end of the interlobular bronchioles, unlike other cetacean groups (Murata 1951).

Prior to a long dive Bottlenose Whales breath frequently, replenishing the oxygen stores in the myoglobin of the dark muscles and the haemoglobin of the blood. Like other cetaceans, beaked whales have a large blood volume and, during diving, circulation to the muscles and some organs is probably restricted

to conserve oxygen. The muscles respire anaerobically once their oxygen supply is depleted. These adaptations allow for dives of 70 minutes or more in *Hyperoodon*.

Excretion

The kidneys resemble those of other cetaceans. They are situated on the dorsal wall of the abdominal cavity, well protected by the dorsal musculature. They may be ovoid (*Hyperoodon*) or elongate (*Mesoplodon*) (Arvy 1973-74). In the latter genus, the renal artery and vein are attached to the kidney near the midlength of its inner edge. The ureter is attached to the kidney slightly anterior to these vessels (Arvy 1973-74).

The kidney is divided into numerous lobes, as in other whales, seals and some terrestrial animals. Structurally, each lobe or renculus is a complete, miniature kidney, though in *Hyperoodon* and *Mesoplodon* three or four renculi may be partially joined. The number of renculi varies with species and body size, examples being counts of 474 and 1912 in single specimens of *Mesoplodon* and *Ziphius*, respectively (Kamiya 1958; Arvy 1973-74). The connective tissue investing these renculi is more extensive in beaked whales than other whales, weighing up to one-third the total mass of the kidney in *Ziphius* (Kamiya 1958).

The slender, cylindrical bladder reaches nearly to the umbilicus in *Mesoplodon*. Unlike most cetaceans, the ureters are suspended posteriorly in a peritoneal fold from the dorsal wall of the abdominal cavity, effectively subdividing the latter into a median and two lateral compartments (de Smet 1977).

Sense organs and nervous system

The brain of Bottlenose Whales resembles that of dolphins and porpoises. It is highly compressed from front to back, with a large, very convoluted cerebrum. Of interest are the presence of rudimentary olfactory nerves, absent in other odontocetes except sperm whales, and a perforated ethmoidal plate. The olfactory centres of the brain, however, are absent (Slijper 1979). The pineal gland is also rudimentary (Arvy & Pilleri 1983). The brain of *Hyperoodon* weighs 3 kg, comparable to that in other whales of equal mass and proportionately larger than that of terrestrial mammals.

Almost nothing is known of sense organs or sensory perception in beaked whales. The gross anatomy of the eye in Bottlenose Whales resembles that of other odontocetes (Arvy & Pilleri 1983). Structures relating to hearing are well developed (Fraser & Purves 1960) and observations by whalers show that Bottlenose Whales have acute hearing (Tomilin 1967).

Reproduction

The reproductive organs are similar to those of other odontocetes. In *Mesoplodon* and *Hyperoodon* the internal surfaces of the vagina and bicornuate uterus are finely ridged longitudinally. The ovaries are paired and in *Mesoplodon* (McCann 1964) and possibly *Hyperoodon* (Arvy & Pilleri 1983) are hooded by a bursa ovarica, a membranous fold of peritoneum which may ensure the ovum reaches the oviduct. Each testis in *Mesoplodon* lies in a posterior extension of the lateral peritoneal cavity formed by each ureter in its peritoneal fold. As a result, each vas deferens extends forward, sweeping around the ureter before reaching the urethra, superficially suggesting in part the descent of the testes seen more prominently in other mammal groups (de Smet 1977).

Reproductive data are available for Baird's Beaked Whale (*Berardius bairdi*), Northern Bottlenose Whale (*Hyperoodon ampullatus*) and Cuvier's Beaked Whale (*Ziphius cavirostris*), which have been exploited commercially (Mead 1984). Female and male Baird's Beaked Whales reach sexual maturity at 8–10 years of age at a mean length of 10.5 m and 10 m, respectively (about 83% of maximum length). The single calf is usually born in spring at a length of 4.5 m after a gestation period of 17 months. Female and male Northern Bottlenose Whales mature sexually at 7–11 and 11 years and at mean lengths of 6.9 m and 7.5 m, respectively (about 78% of maximum length). The single calf is born in spring at a mean length of 3.6 m after 12 months gestation and is suckled for about 1 year. The mean calving interval is about 2 years. Sexual maturity in Cuvier's Beaked Whale occurs at mean lengths of 5.8 m and 5.5 m in females and males, respectively (about 78% of maximum length). Data for *Mesoplodon* are extremely scanty. The length at birth is about 40–48% of maximum length of the female, slightly longer than that in the three genera noted above (35–40% of maximum length of the female) (Mead 1984).

NATURAL HISTORY

Life history

The maximum recorded ages, based on growth layers in teeth, in males and females, respectively, were 37 and 27 years in Northern Bottlenose Whales, 71 and 39 years in Baird's Beaked Whale and over 36 and 30 years in Cuvier's Beaked Whale, assuming that one layer is deposited per year (Mead 1984).

Ecology

Beaked whales inhabit oceanic waters beyond the continental shelf. Whaling catches suggest that some species concentrate along the edge of the continental slope over depths of 1000 m, probably in association with good feeding grounds. Off Labrador, Northern Bottlenose Whales feed on squids (particularly *Gonatus fabricii)* and some deep sea fish (Benjaminsen & Christensen 1979). Off Japan, Cuvier's Beaked Whale shows a similar preference for deep sea squids supplemented with deep sea fishes. Baird's Beaked Whale feeds primarily on deep sea and shoaling surface fishes and fewer squids (Nishiwaki & Oguro 1971).

The presence of indigestible squid mandibles in stomachs of stranded animals indicates that squids are important in the diets of other beaked whales, though differential digestion may have removed evidence of fish remains in these animals.

The Northern Bottlenose Whale is renowned for long and deep dives which may exceed one hour and depths of 1000 m (Benjaminsen & Christensen 1979). The presence of benthic food items in stomachs of *Berardius* and *Ziphius* indicates that they have similar capabilities.

External parasites include cyamid amphipods (whale lice) and the stalked barnacles of the genera *Conchoderma* and *Xenobalanus* (Gray 1882; Omura *et al*. 1955; Ross 1984). Genera of internal parasites of the stomach and intestines include nematodes (*Anisakis*), cestodes (*Strobilocephalus*, *Tetrabothrius* and *Diphyllobothrium*) and acanthocephalans (*Bolbosoma*). The nematodes *Crassicauda* species, and trematode *Oschmarinella* are recorded from the renal system and liver of beaked whales, respectively. Larval cestodes, *Phyllobothrium* species, occur in the blubber. Nothing is known concerning host/parasite interactions (Zam, Caldwell & Caldwell 1971; Dailey & Brownell 1972; Gibson & Harris 1979; Ross 1984).

Migratory patterns are poorly known. The Northern Bottlenose Whale moves into high Arctic latitudes in summer and there is evidence that Baird's Beaked Whale does the same (Nishiwaki & Oguro 1971; Benjaminsen & Christensen 1979). *Ziphius* does not appear to migrate. In the Southern Hemisphere, stranding records of Arnoux's Beaked Whale (*Berardius arnuxii*), Southern Bottlenose Whales, Strap-toothed and Gray's Beaked Whales are more numerous in summer and autumn suggesting an onshore movement of these species (Ross 1984).

Behaviour

Beaked whales occur singly or in small schools, usually less than 20 animals. Nothing is known of social interactions, though adult males, females and calves of Northern Bottlenose Whales may be grouped and all male groups occur. Most beaked whales are wary of ships though Northern Bottlenose Whales are curious and investigate them (Gray 1882). This species stands by a wounded companion until it is dead, unlike Baird's Beaked Whale which will desert (Tomilin 1967). Species of Hyperoodon, *Berardius* and *Ziphius* are known to breach clear of the water, producing a large surface splash on re-entry.

Various sounds have been reported from species of *Mesoplodon*, including roars, lowing and sobs and pulsed whistles (Caldwell & Caldwell 1971).

Economic significance

Only two species of beaked whales, the Northern Bottlenose Whale and Baird's Beaked Whale, have been hunted extensively in the North Atlantic and North Pacific Oceans, respectively. Between 1877 and 1930, some 50 000 Northern Bottlenose Whales were caught (Benjaminsen & Christensen 1979). In the second period of exploitation (1949 onwards), a further 5000 whales were caught (Mitchell 1975a). Baird's Beaked Whale has been hunted since 1934 using modern methods, with a total catch of about 3500 to the present (Mitchell 1975a). Small numbers of *Ziphius*, averaging about 30 animals per year, were taken incidentally in the fishery for *Berardius* (Nishiwaki & Oguro 1972).

BIOGEOGRAPHY AND PHYLOGENY

Distribution

The distribution of ziphiids along the Australian coast reflects the preference of this group for cool temperate or polar waters, though Blainville's Beaked Whale and probably Longman's Beaked Whale are essentially tropical in distribution. The occurrence, by State, of each of the eleven species recorded from Australia to date, based on museum specimens and records in the literature, is shown in Table 48.1. None of these species is endemic to Australia. Most of the Western Australian beaked whale records are from the cooler waters of the south-western or southern coast, in keeping with the preponderance of species and records from the other southern States (South Australia, Victoria, Tasmania). The single record from the Northern Territory probably results from a low density of beaked whales and interested observers.

Affinities with other groups

Beaked whales show most affinities with living sperm whales, for example in the structure of the tympano-periotic region (Kasuya 1973) and similarities in the composition or properties of spermaceti. Though the karyotype of beaked whales (2n=42) also occurs in sperm whales but not in other cetaceans, the

Table 48.1 Numbers of Beaked Whale specimens recorded from each state of Australia.

SPECIES	WA	SA	VIC	TAS	NSW	QLD	NT
Hyperoodon planifrons	2	4		1			
Berardius arnuxii		1					
Tasmacetus sheperdi		2					
Indopacetus pacificus						1	
Ziphius cavirostris	3	2	1	3		1	1
Mesoplodon mirus	1		1				
Mesoplodon bowdoini	4	1	1		2		
Mesoplodon densirostris	1			1	1	4	
Mesoplodon grayi	6	8	2	6	2		
Mesoplodon layardii	2	7	2	5	5	1	
Mesoplodon hectori				1			

chromosomal structure of the two groups differs markedly, suggesting that beaked whales and sperm whales shared a common ancestry, but diverged from each other early in the evolution of toothed whales (Gaskin 1982).

Beaked whales are probably derived from the extinct shark-toothed dolphins (Family Squalodontidae) (Mead 1975a).

Fossil record

The fossil record extends back to the early Miocene period and, although fossils are comparatively numerous, the interrelationships within the group are sketchy (Mead 1975a; Fordyce 1982a).

Fordyce (1982a) has reviewed Australian fossil beaked whales. He indicated that the material for the nominal species *Ziphius geelongensis* McCoy 1882 and four species of Cetolites from Waurn Ponds, Victoria, was insufficient to diagnose family affinities. Five fossil beaked whale rostra, however, are known from Late Miocene-Early Pliocene formations of Victoria and Flinders Island. A post-cranial skeleton, apparently of a beaked whale, is known from Tasmania. This may be from the Early Miocene period. The relationships of these specimens with other fossil beaked whales have yet to be determined.

COLLECTION AND PRESERVATION

The scarcity of study material of this group emphasises the need to take advantage of opportunities offered by stranded specimens. Collectors are advised to collect/take as many of the following as possible: photographs showing dorsal, ventral and lateral views of the head, body, appendages and apertures; measurements from tip of upper jaw to eye, blowhole, dorsal fin, flipper, trailing edge of flukes and to genital and anal apertures; height and width of appendages; collect the skull, the entire skeleton, the ovaries, any foetus, a sample of mammary gland and the entire stomach contents. Weigh, measure and sample the testes.

If the animal is fresh, small samples (50 g) of blubber, liver and brain tissue should be stored frozen in aluminium foil for organochlorine analysis. Examine all organs for parasites and preserve the latter in 10% formalin. Whole body and organ mass data would be most valuable.

Macerate the bones in water for several weeks. Reproductive material should be preserved in 10% formalin. The stomach should be opened and rinsed into a tray. The entire contents should be preserved in 70% ethyl alcohol, though fish otoliths (earstones) can be separated and stored dry.

CLASSIFICATION

The genera *Ziphius*, *Tasmacetus* and *Indopacetus* are represented by one species. The genus *Hyperoodon* includes the North Atlantic *H. ampullatus* and the Southern Ocean *H. planifrons*. *Berardius baird*i and *B. arnuxii* occur in the North Pacific and Southern Ocean respectively, though these may represent a single species. The genus *Mesoplodon* includes 11 nominal species at present, though further research may reduce this number and improve current knowledge of their distributions.

KEY

Functional keys to the beaked whales are difficult to devise without reference to features of the skull, mandibles and teeth. The following key is derived from Moore (1968) and Ross (1984) to apply to the 11 species presently known from Australia. Features of the vertex are shown in Fig. 48.3.

1 On the vertex of the skull, a nasal bone extends farthest forward 2

On the vertex of the skull, a premaxillary bone extends farthest forward 3

2 Two compressed teeth at the tip of the mandible *Berardius arnuxi*i

One cylindrical tooth at tip of mandible *Ziphius cavirostris*

3 On the vertex of the skull, the nasal bones extend farthest forward laterally 5

On the vertex of the skull, the nasal bones extend farthest forward centrally 4

4 On the vertex of the skull, the area of the nasal bones exceeds that of the frontal bones *Tasmacetus sheperdi*

On the vertex of the skull, the area of the nasal bones is less than or equals that of the frontal bones *Indopacetus pacificus*

5 Tooth rounded in cross section. Maxillary prominences rise well above mesethmoid bone *Hyperoodon planifrons*

Tooth compressed laterally. Maxillary prominences may rise to level of mesethmoid bone 6

6 Tooth at tip of mandible *Mesoplodon mirus*

Tooth about 25 mm from tip of mandible *Mesoplodon hectori*

Tooth at or posterior to mandibular symphysis 7

7 Tooth directed dorsally*Mesoplodon grayi*

Tooth strap-like, directed posterio-dorsally *Mesoplodon layardii*

Tooth directed anterio-dorsally 8

8 Tooth at or near mandibular symphysis. Mandible not strongly arched at midlength *Mesoplodon bowdoini*

Tooth well behind symphysis. Mandible strongly arched dorsally at midlength *Mesoplodon densirostris*

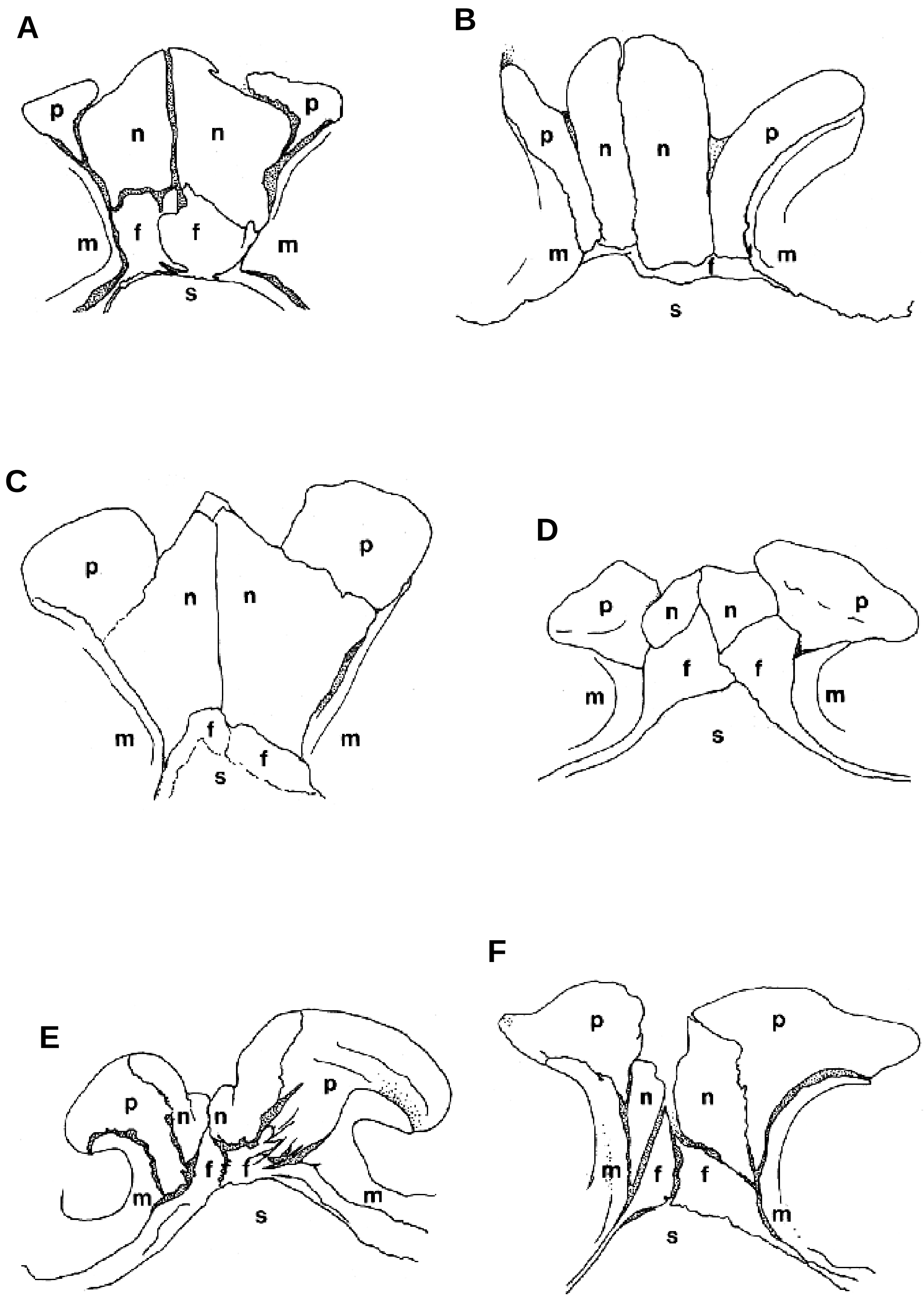

Figure 48.3 The form of the dorsal surface of the vertex in: (a) *Berardius*; (b) *Ziphius*; (c) *Tasmacetus*; (d) Indopacetus;(e) *Hyperoodon*; <NL>(f) *Mesoplodon*; p = premaxillary; n = nasal; m = maxillary; f = frontal; s = supraoccipital. (© ABRS) [G. Ross]

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