3
Summary of present knowledge of beaked whales

Colin McLeod, University of Aberdeen, UK, supplied following general information on the family of *Ziphiidae* (Beaked whales), in particular *Ziphius cavirostris* (Cuvier's beaked whales).

3.1. Introduction

The family *Ziphiidae*, or beaked whales, is the second largest family in the order Cetacea behind the *Delphiniids*. With 20 species the *Ziphiidae* make up approximately a quarter of all cetacean species. However, they are also probably the least known family of cetaceans and almost all information comes from stranded animals or from a much smaller number of opportunistic sightings at sea. This limits the present knowledge to that which can be examined from dead animals or brief encounters, such as anatomy, morphology and distribution. As a result, little is known about social structure, behaviour, acoustics and to a lesser extent habitat requirements. Beaked whales are generally found in deep water far from shore and tend to be unobtrusive in their habits. This is one reason for the limited number of sightings of living animals at sea. In addition, different species may have very similar external appearances, so making definite identifications to species level very difficult.

However, some species are better known than others. Three species (Baird's beaked whale, *Berardius bairdii*, the northern bottlenose whales, *Hyperoodon ampullatus*, and Cuvier's beaked whale, *Ziphius cavirostris*) have been the subject of directed fisheries, which have provided a wealth of information on morphological and anatomical features and two species (*H. ampullatus* and the dense beaked whale, *Mesoplodon densirostris*) have been the subject of directed research, which has provided a great deal of information on behaviour and ecology. In comparison some other species, such *as Tasmacetus shepherdi* (Shepherds beaked whale) or *Mesoplodon bahamondi* (no common name) have only been recorded from a limited number of stranded animals, in the case of *Mesoplodon bahamondi* a single cranial remnant. In the past 10 years two new species of beaked whale have been described (*Mesoplodon peruvianus*, the pygmy beaked whale in 1991 and *M. bahamondi* in 1995), which emphasises how little is known about some member of this family.

This summary provides a brief outline of what is known about the biology of the family *Ziphiidae* at present, although it should be remembered that this is often based on a limited number of specimens from a limited number of species. It is not known how valid it is to transfer information from one species to another between or within genera.

However, one thing that is certain is that more research is needed to be able to fully understand the biology of the family *Ziphiidae.*

3.2. Number of species

The family *Ziphiidae*, or beaked whales, consists of 20 presently recognised species separated into six genera. These are *Berardius*, *Hyperoodon*, *Indopacetus*, *Mesoplodon*, *Tasmacetus* and *Ziphius*. As noted above, it is the second largest family of the order Cetacea. Both *Berardius* and *Hyperoodon* consist of two species, each restricted to higher latitudes of one hemisphere. *Indopacetus* consists of a single species about which little is known although it is thought to occur in the tropical Indopacific. *Tasmacetus* contains a single species apparently restricted to the cold temperate waters of the southern hemisphere. The genus *Ziphius* consists of a single species with a world-wide distribution in all oceans with the exception of polar waters. The genus *Mesoplodon* is by far the largest genus of beaked whales with 13 species. This genus is found in all the worlds oceans from the equator to polar waters of both hemispheres. However, each species has a smaller distribution and most are restricted to one or two oceanic basins.

3.3. Distribution

Beaked whales are found in all the worlds oceanic waters and at all latitudes from the equator to the edge of the ice, and sometimes beyond. For example Arnoux's beaked whale (*Berardius arnuxi*) has been recorded surfacing in open areas of water within the ice sheets in Antarctica. Individual species differ greatly in the size of their range. *Ziphius cavirostris* (Cuvier's beaked whale) has the largest range and is found in all oceans from the equator to the sub-polar regions. Other species may be restricted to one or two oceanic basins (e.g. Sowerby's beaked whale - *Mesoplodon bidens* - found only in the North Atlantic), or have even smaller ranges (e.g. *Mesoplodon bowdoini* - Andrew's beaked whale - recorded only from the coasts of New Zealand and Australia).

3.4 Body size

Beaked whales range in size from 3.72 m for the pygmy beaked whale (*Mesoplodon peruvianus*) to 12.8 m in Baird's beaked whale (*Berardius bairdii*). Animals are between 1/3 and 1/2 of adult size when born.

3.5. Morphology

Beaked whales are generally robust animals which taper at both ends. The dorsal fin is placed two-thirds of the distance between the tip of the rostrum and the flukes. The flukes are large and relatively broad in comparison to other cetaceans. The pectoral fins

are small and fit into recessed 'pockets' on the sides of the whale. These characteristics suggest that beaked whales may be capable of high swimming speeds.

All beaked whales have a well defined beak, with the exception of *Z. cavirostris* where the beak is less distinct, but still present. Most beaked whales only have one or two pairs of teeth and these are found in the lower jaw. With the exception of *Berardius* species, these teeth are sexually dimorphic and only erupt to become functional in adult males. In *Berardius* species erupted teeth are found in adults of both sexes. The only species which significantly differs from this basic pattern is *Tasmacetus shepherdi* (Shepherd's beaked whale). This is the only species of beaked whale to have functional teeth in the upper jaw and it has between 17 and 27 pairs in each jaw.

The shape and position of the teeth is one of the main characteristics used to separate sympatric species. However, as these teeth generally only erupt in adult males it is often hard to identify females to species level, especially when observed at sea. This is particularly true of the genus *Mesoplodon* which has a very conservative body plan and species differ very little in their external appearance, with the exception of the teeth of adult males. This difficulty in identifying beaked whales at sea has undoubtedly contributed to our lack of knowledge of this family

3.6 Life history

Beaked whales are born at between 33 and 50% of adult size. Animals mature at around 10 years and live for up to 30 years or more. A single calf is produced at a time and there may be a gap of several years between calves if the calf survives. Little is known about how long calves are dependant on their mothers or the number of calves a female may produce in a lifetime.

3.7. Habitat use

Beaked whales generally occur in non-continental shelf waters greater than 200 m in depth. In areas where there is no continental shelf they may occur close to shore, however most sightings occur far from land. This is another feature of their biology which has limited research into beaked whales in the past.

Most records of beaked whales come from the continental shelf edge and slope and around oceanic islands where the seabed shelves rapidly. Such areas appear to be important habitats for beaked whales. Beaked whale distribution is often recorded as being in association with areas of complex seabed topography, such as seamounts, escarpments, drop-offs and gullies. A prime example of this is the gully area off Nova Scotia, Canada. This area, as its name suggests, is a deep gully in the edge of the Scotian shelf and descends to depths of over 1000 m, in comparison to the 200 m or less water depth of the surrounding shelf. This area is home to one of the very few populations of beaked whales which have been the subject of a directed research programme and it has

been found to be inhabited by a relatively small (around 230 animals) population of northern bottlenose whales, *Hyperoodon ampullatus*. The range used by this population is very restricted and covers an area of approximately 8 by 12 km within this marine canyon. The distribution of beaked whales is presumably related to the distribution of their prey species, which are thought to be mostly deepwater squid and fish species.

Photo-identification studies have shown that in some species (most notably *Z. cavirostris* in the Mediterranean, *H. ampullatus* in the Gully, off Nova Scotia and *M. densirostris* in The Bahamas) individuals show a degree of site fidelity both within and between years and some populations may be resident within an area. However, other populations, for example *H. ampullatus* in the eastern Atlantic and *H. planifrons* (the southern bottlenose whale) off South Africa may be migratory. Both these populations may migrate to higher latitudes in summer months.

3.8. Diet

Beaked whales feed on deepwater squid, fish and possibly on a variety of invertebrates. These species are generally thought to live at or close to the seabed and in water depths of greater than 200 m. However, as many of the prey items are only known from the stomach contents of beaked whales and other deep-diving cetaceans, very little is known about their ecology or biology.

3.9. Diving abilities

Beaked whales can make prolonged and deep dives and possibly have a greater diving capacity than any other group of cetaceans. They can stay underwater for up to 70 min, although shorter dives of around 30 to 60 minutes are more common. During this time they may dive to the seabed in water depths of 1000 m or more to forage. In *Hyperoodon ampullatus* (the northern bottlenose whale) the length of a dive is correlated to the depth of the water. This may well be true for other species. Between long dives beaked whales may stay at the surface for less than 2 min. However, sometimes longer periods of time are spent at the surface between dives. Not all dives will be to great depth or for long periods of time. Such long, deep dives probably only occur when an animal is feeding. If an animal is travelling or socialising dives may be shallower and of shorter duration (for less than 15 min). During longer foraging dives there may be little or no horizontal movement and the animal may resurface in the same area where it went down.

3.10. Acoustic and hearing abilities

Little is known about the acoustic abilities of free-swimming beaked whales and much less is known about their hearing abilities. Information on acoustic abilities is available for four of the twenty species of beaked whale at present and only two of these consist of

recordings made from free-swimming individuals (Baird's beaked whale - *B. bairdii* and the northern bottlenose whale - *H. ampullatus*). Information on the remaining two species comes from recordings made from stranded animals held in a captive environment (Hubb's beaked whale - *Mesoplodon carlhubbsi* and the dense beaked whale - *Mesoplodon densirostris*). These species of beaked whales have been recorded producing pulsed (presumably echolocation) and unpulsed (presumably for social communication) sounds.

B. bairdii off the west coast of North America have been recorded as producing frequency modulated whistles with fundamental frequencies of 4 to 8 kHz. In addition, clicks, irregular pulsed sequences and click bursts have been recorded. In most cases the largest spectral peak of such clicks was between 22 and 25 kHz, with the second largest peak typically occurring between 35 and 45 kHz. Only rarely was one of the largest spectral peaks over 80 kHz. The maximum recorded peak was at 129.5 kHz.

H. ampullatus in the Gully have been found to produce two types of clicks (pulsed sounds). The first has a constant inter-click interval of approximately 0.51 s and is mostly recorded during deep dives. Frequencies ranged from 6 - 8 kHz to 16 - 20 kHz. The second type of click had a more variable inter-click interval of around 0.07 s and was recorded predominantly when animals were apparently echolocating at the research vessel. Frequencies ranged from 2 - 4 kHz to 10 - 12 kHz. They have also been recorded producing discrete frequency whistles of around 4 kHz.

A single stranded juvenile *M. carlhubbsi* while being held in captivity produced sounds similar to echolocation signals of other odontocetes, and whistles. Two types of pulsed signals were recorded, a lower frequency type with most of the energy in a narrow bandwidth between 300 Hz and 2 kHz and a broader band type with energy from 300 Hz to beyond 40 kHz. Whistles had frequencies of 2.6 to 10.7 kHz and had dynamic ranges of 1 to 7 kHz. However, how characteristic these sounds are of adult, free-swimming animals is unknown.

The final species for which acoustic information is available is *M. densirostris*. Again this comes from a single stranded individual. The sounds produced were reported as chirps and whistles by human listeners, although analysis showed some were pulsed. Fundamental frequencies ranged from slightly below 1 kHz to 6 kHz. Again, how representative this is of the acoustics produced by free-swimming animals is unknown.

In summary beaked whales have been recorded producing sounds in the frequency range of 300 Hz to over 80 kHz. Both pulsed and unpulsed sounds have been recorded. Pulsed sounds generally have a greater range of frequencies and presumably function for echolocation. Unpulsed sounds generally take the form of whistles and have frequencies in the range of approximately 1 to 10 kHz. Nothing is known about the function of these sounds.

Nothing is known about the hearing abilities of beaked whales as no audiograms have been produced for any species of beaked whales. However, presumably beaked whales can hear sounds they produce and may be most sensitive at these frequencies. If

comparisons can be made from other odontocete species it may be expected that beaked whales hearing will be somewhere in the range from approximately 100 Hz to over 80 kHz. Odontocetes are most sensitive at frequencies approximately in the middle of this range and below the optimal frequencies sensitivity decreases with decreasing frequency. Whether such comparisons with other odontocetes are valid is unknown.

3.11. Social structure

Beaked whales occur in groups of up to 80 or more in some species. However groups of 4 to 10 are most commonly recorded in those species where information is available. There may be some age or sexual segregation between groups in some species. How stable these groups are is unknown, although evidence of long-term associations between individual animals has been found in male *H. ampullatus* and possibly in female dense beaked whales (*M. densirostris*). Other than this little is known about the social structure of beaked whales.

The presence of large sexually dimorphic teeth suggests that most beaked whales are probably polygamous and some species, most notably those of the genus *Mesoplodon*, may have a social structure similar to sperm whales where females form long-term stable associations and males move between female groups looking for receptive females. Scarring on adult males indicates that they compete aggressively, using their teeth as weapons, and this competition is almost certainly for access to receptive females.

3.12. Population sizes and status

Very little is known about the population dynamics of beaked whales and about the size of global or local populations. In some areas, such as Antarctica and the southern oceans beaked whales may be one of the most common groups of cetaceans, however due to the difficulty in identifying animals to species level the species composition of such populations estimates is unknown. The only population of beaked whales which is well enough known at present to provide adequate information on population biology is a population of northern bottlenose whales in the Gully, off the east coast of Canada. Here there is a relatively small and isolated population which has a very limited geographic range, with little exchange with other populations of the same species. Whether this applies to other populations of this species or other species is unknown, but it does suggest that global populations of beaked whale species may be split into a number of smaller populations which may be to a greater or lesser extent genetically isolated from each other. As a result disturbances in an area may have a greater effect on the local population due to it’s small size and isolation than would be expected if the global population formed a single breeding group.

The IUCN lists the status of all beaked whale species as insufficiently known. Before any judgements to the status of local populations can be made baseline information needs to first be gathered to allow examination of future changes.

Possible threats to beaked whale species include bycatch in fishing gear, directed hunting (for a very limited number of species), direct competition with man for food with the increasing level of deepwater fisheries, noise pollution from oil and gas exploration and extraction, noise pollution from shipping and other forms of pollution. In addition military activities, such as SWAC research, has been implicated in the strandings of a number of beaked whales. However, evidence to support a direct link between such activities and beaked whale strandings is at present limited.

3.13. Summary

The present knowledge of beaked whales varies considerably both between individual species and between different aspects of their biology. Some species, such as *H. ampullatus*, the northern bottlenose whale, are well known due to information gathered from directed hunting and from dedicated research, while others, such as *T. shepherdi*, Shepherd's beaked whale, are only known from stranded specimens. Most of the current information on beaked whales comes from stranded animals and this has limited the possible information which was available. As a result little is known about behaviour, social structure, habitat use, hearing abilities or acoustics, all of which require the study of living animals. If anthropogenic impacts on beaked whales are to be properly assessed it is these aspects of biology which will need to be clearly understood. It is therefore essential to carry out suitable research into these aspects of beaked whale biology which can only be done through long-term research projects directed at individual species in their natural environment.