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4 Whales – individuals, societies and cultures

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The mammalian Order Cetacea encompasses all the species of whales, dolphins and porpoises. There are two main groups of living cetacean: Mysticeti (baleen whales) and Odontoceti (toothed whales).

Mysticeti (baleen whales)

The Mysticeti includes all the 'filter feeding' whales, which use baleen plates hanging from the roofs of their mouths to filter small prey species from mouthfuls of ocean water, or to skim planktonic species near the sea surface. Mysticete whales range in size from the blue whale (*Balaenoptera musculus*) to the pygmy right whale (*Caperea marginata*), which grow up to 27 metres and 6.5 metres, respectively, although the longest blue whale (and indeed the largest living creature ever recorded) measured over 33 metres (Jefferson *et al.* 1993). There are currently ten (or 13) species of baleen whale according to which particular author or organisation is referenced. For example, Rice (1998) and the Society for Marine Mammalogy consider there to be at least two species of Bryde's whale: the 'true' Bryde's whale (*Balaenoptera brydei*) and Eden's whale (*Balaenoptera edeni*). However, the International Whaling Commission currently only recognises one species of Bryde's whale, referring to all such whales as *Balaenoptera edeni*.

In addition, minke whales have recently been split into two species by most (but not all) authorities: the Antarctic minke whale (*Balaenoptera bonaerensis*) and the 'common' or 'northern' minke whale (*Balaenoptera acutorostrata*). There may actually be a third minke whale species, the 'pygmy' minke whale, which is found in the southern hemisphere, but is genetically distinct from the Antarctic minke whale (Best 1985; Arnold *et al.* 1987; Wada *et al.* 1991). This latter whale is the target of a substantial and economically valuable whale-watching industry off the coast of western Australia (Hoyt, 2001), and although animals have been seen carrying harpoon scars (IWC, 2003), probably caused by 'scientific whaling' operations for Antarctic minke whales, it is not yet known whether, indeed, these whales constitute a new species of minke whale.

The term 'great whales' was used for the large species listed on the schedule of the 1946 International Convention for the Regulation of Whaling (ICRW), which established the International Whaling Commission (IWC). All species of the Mysticeti, except the pygmy right whale, are considered to be 'great whales'.

Toothed whales (Odontoceti)

Toothed whales range in size from the sperm whale (*Physeter macrocephalus*) to the vaquita (*Phocoena sinus*), which grow up to 18 metres and 1.5 metres, respectively (Jefferson *et al.* 1993). There are currently between 69 and 73 species of toothed whale, again depending on the author or authority referenced.

Several species of toothed whale have been the target of historical commercial whaling activities, notably the sperm whale and several beaked whale species, e.g. the northern bottlenose whale (*Hyperoodon ampullatus*) and the Baird's beaked whale (*Berardius bairdii*), which is still hunted in Japan. Many of the smaller toothed whale species are the subject of commercial hunts today, notably the Dall's porpoise (*Phocoenoides dalli*); over 10,000 are harpooned every year off the coast of Japan (EIA 1999).

The sperm whale is considered to be a 'great whale' and is, therefore, the only toothed whale listed in the schedule of the ICRW. The remaining toothed whales are termed 'small cetaceans' which is rather misleading, as several toothed whales are actually larger than some of the mysticete 'great whales'. For example, minke whales rarely grow larger than 9 metres (the maximum being 10.7 metres; Jefferson *et al.* 1993). In comparison, northern bottlenose whales (*Hyperoodon ampullatus*), Arnoux's beaked whale (*Berardius arnuxii*) and killer whales (*Orcinus orca*) grow to similar sizes (up to 9.8 metres; Jefferson *et al.* 1993), whilst Baird's beaked whales can grow even larger (up to 12.8 metres; Jefferson *et al.* 1993).

Adaptations to a marine environment

Sperm whales can dive more than 2 kilometres deep (Heezen 1957; Watkins *et al.* 1993) and can hold their breath for up to two hours (Watkins *et al.* 1985; Kooyman 2002). Baleen whales can also hold their breath for long periods; whilst normal dive times rarely exceed 7 to 14 minutes for the two species, blue whales and bowhead whales being pursued by whalers have dived for up to 50 minutes and 80 minutes, respectively (Stewart 2002). Being air breathing mammals, diving to such depths and for such durations require considerable anatomical and physiological adaptations.

Cetaceans have the ability to utilise 90 per cent of the inhaled oxygen in their lungs, compared to 4-20 per cent in terrestrial mammals. This means that, when resting, cetaceans need to respire less often: only one to three breaths per minute, compared to 15 breaths per minute in humans. This extraction of oxygen is assisted by cetacean blood volume, which is two to three times that of terrestrial mammals (Ponganis 2002). Therefore, more oxygen can be taken up by the haemoglobin contained in red blood cells. This extra blood volume is partially distributed by a supplementary blood circulation system, the *retia mirabilia*. One part of this network, the thoracic rete, supplies the cetacean brain with a regular flow of blood – it should be noted that this blood supply to the brain in cetaceans has no measurable pulse, unlike in humans, where the pulse in the carotid artery is frequently measured as a sign of life (Ponganis 2002).

Cetaceans also have as much as nine times the amount of myoglobin (a substance similar to haemoglobin, but which has a greater capacity for binding with oxygen and is found in muscles) than terrestrial mammals, allowing for a much greater uptake and storage of oxygen in muscle tissue (Ridgway and Johnston 1966; Ridgway *et al.* 1984). In fact, up to fifty per cent of the oxygen required by cetaceans during dives may be stored in muscle tissue (Schlolar 1940). Cetacean

lungs actually collapse due to increasing pressure during a dive, meaning they do not rely on air in the lungs for the required oxygen (Kooyman 2002). In addition, muscle and other marine mammal tissues can withstand much higher concentrations of the by-products of cellular respiration (carbon dioxide and lactic acid), with some vessels closing off to prevent or restrict these waste products from being circulated in the animal's body until the dive is terminated (Elsner 1999).

Moreover, marine mammals have the ability to divert their blood flow away from non-essential organs during dives, while maintaining a blood flow to essential organs such as the brain (Elsner 1999). Other organs slow down, requiring less oxygen to function. One such organ is the heart, which can be reduced to 20 to 50 per cent of the normal rate (a process called *bradycardia*), to as few as four or five beats per minute (Slijper 1962).

These various adaptations have implications for whaling activities. For example, for species adapted for extended dives, harpoon wounds to the thoracic cavity and lungs, which might be lethal in a terrestrial mammal, may allow the brain and other vital organs to continue functioning in the absence of inspired oxygen (Wills and Bob 1995). Also, a reduction in metabolism, a reduction in blood flow to all but essential organs such as the brain, and a virtual cessation of breathing might erroneously be taken as indicators of death, when in fact brain function may continue (Wills and Bob 1995) (chapter 11).

Age and reproduction

Most baleen whales breed every two to three years. The minke whale species are an exception and may give birth annually. Baleen whales give birth to a single calf after a long gestation period, typically around 12 months in duration. Many do this in warm water breeding grounds (although tropics-dwelling Bryde's and Eden's whales and resident humpback whales (*Megaptera novaeangliae*) in the Indian Ocean have different breeding patterns due to their non-migration). The young can be nursed from six months to a year before weaning. Most species reach sexual maturity at eight to ten years of age, although the minke whales reach maturity about two years earlier, and bowhead whales (*Balaena mysticetus*) five years later. Information on total longevity in baleen whales is sparse, but blue whales can live up to 80 or 90 years (Sears 2002) and evidence is mounting that bowhead whales may live well over 150 years (e.g. Rugh and Shelden 2002).

While the reproductive rates of the toothed whales vary between species, or are largely unknown (as in many beaked whale species) reproduction in sperm whales is relatively well documented: females reach sexual maturity at about nine years of age and give birth to a single calf every five years and reach physical maturity at approximately age 30; males become sexually mature between ten and 20 years of age, although it should be noted that the young of the sperm whale can suckle for up to 13 to 15 years, showing a long period of dependency; males do not usually breed until their late twenties, and reach physical maturity at approximately 50 years of age (Whitehead 2002a).

Generally speaking, cetaceans are among the longest lived and most slow breeding of animals, meaning that they are poorly adapted to replenishing their populations.

Social behaviour

Mother-calf pairs

One of the most important social bonds in cetaceans is that between a mother and her calf. A cetacean calf may stay with its mother for up to a decade, or throughout its life in some species, and learns important life skills, such as foraging and social behaviour, during this period. Dolphin mother-calf pairs communicate with unique whistles, which they use particularly if the animals become separated (Sayigh *et al.* 1990; Smolker *et al.* 1993).

Male parenting

Baird's beaked whale males live longer than females, resulting in an excess of mature males in the population. It has been suggested that this has led to a social system where males provide significant parental care, looking after calves once they have been weaned, protecting them from predators and possibly teaching them foraging skills (Acevedo-Gutiérrez 2002). This type of paternal care is very unusual in mammalian species, including cetaceans. For most cetacean species, paternal care is absent, although kin-selected male care-giving behaviour (known as alloparental care) has been observed in some small cetaceans (e.g., killer whales: Heimlich-Boran and Heimlich-Boran 1994; Baird 2002).

Co-operative foraging

Cetaceans frequently form groups and co-operate and co-ordinate, for example, when foraging. Co-ordinated herding of prey allows cetaceans to catch larger, and greater quantities of, prey. In humpback whales in the North Pacific, groups of up to 22 whales will simultaneously swim to the surface from beneath a school of shoaling fish – the individual whales maintain specific locations and orientations with respect to the prey and one another. This action is usually led by one whale and is preceded by a vocal signal when the co-ordinated behaviour initiates, with another call issued just prior to simultaneously surfacing (D'Vincent *et al.* 1985). In addition, humpbacks will also swim around a school of fish, releasing a stream of bubbles from their blowholes. The targeted fish will not pass through this curtain of bubbles, which effectively becomes a net trapping the fish.

These behaviours are complex, requiring considerable awareness of other animals and their locations and actions, as well as requiring learning to perfect the techniques involved – all indices of intelligence. In addition, the use of non-living objects, such as bubbles, as an aid to capture prey could be considered tool-use (another indicator of intelligence), which is defined as “*the external employment of an unattached environmental object to alter efficiently the form, position or condition of another object, another organism, or the user itself*” (Beck 1990).

Although less well-studied, other baleen whale species demonstrate some co-ordinated feeding behaviour, e.g. pairs of blue whales lunging at prey and right whales swimming in staggered formations, side by side (Würsig 1988). Female and immature sperm whales also form co-ordinated feeding groups, with animals spread out in a line, perpendicular to their direction of travel (Whitehead 2002a).

Defending and supporting

In addition to co-operating while foraging, cetacean groups may also co-operate in response to predators. For example, sperm whale calves are typically found in groups of approximately ten females. The adults stagger their foraging dives so that the young whales are constantly attended by

an adult (Whitehead and Weilgart 1991). When a predator is encountered (such as a killer whale), the group adopts what is called the marguerite or wagon-wheel formation (Whitehead 2002a). This formation consists of females in a circle, aligned like the spokes of a wheel, with their tail flukes forming the rim and the calves in the centre, or hub, of the wheel (Whitehead 2002a). The females put themselves at risk to protect the other members of the group, in particular wounded animals and calves. The whales will slash their tail flukes at predators (including humans, whom they perceive as predators) who try to attack individuals in the group. An alternative protective arrangement is the 'heads out' formation wherein the animals arrange themselves in a tight rank, with their heads (and, therefore, their teeth) facing towards the predator, with calves, again, in the centre of the formation (Whitehead 2002a).

Although these defensive formations assist the sperm whale to defend itself against natural predators, such as sharks and killer whales, humans unfortunately have used the whale's defensive behaviour to their advantage during whaling activities. Whalers have killed group members one by one, knowing that their fellows would stand by and not leave the sides of injured or stricken animals (Tyack 2002a). Exploiting the bond between mother cetaceans and calves, whalers in St Vincent and the Grenadines have traditionally targeted a humpback calf in order to lure its mother closer to the whaling boat (see chapter 6).

Standing by injured group members is a behaviour that has been observed in many other cetacean species, particularly when attempting to keep a stricken animal's blowhole above the sea surface in order that it can still breathe (Caldwell and Caldwell 1966). There have been many records of cetaceans supporting dead companions, especially calves, long after the animals have died, sometimes for a period of several days. This type of behaviour has been reported in a variety of species, including common dolphins (*Delphinus delphis*), rough-toothed dolphins (*Steno bredanensis*), striped dolphins (*Stenella coeruleoalba*), Pacific humpback dolphins (*Sousa chinensis*) and bottlenose dolphins (*Tursiops truncatus*) (Moore 1955; Brown *et al.* 1966; Lodi 1992; Fertl and Schiro 1994; Parsons 1998).

These collaborative behaviours reflect not only intelligence, but also show that individuals within groups benefit from the presence of the other group members. In addition, individuals may have differing, but complementary, roles. Thus, the removal of any one animal may negatively affect the remainder.

Societies

A society is defined as “*an interacting group consisting of more individuals than parents and their immediate dependent offspring*” (Slobodchikoff and Shields 1988). Several species of cetacean form matrilineal societies, the best-studied being sperm whales, pilot whales (*Globicephala spp.*) and some killer whales. Within these societies, females spend their entire lives with their natal group (families). Male killer whales, and possibly male short-finned pilot whales (*G. macrorhynchus*), stay with these female groups (that is, they stay with their mothers, sisters, and aunts), but mate with unrelated females from other groups they encounter (thus avoiding inbreeding).

The matrilineal groups of pilot whales and killer whales are particularly interesting; female pilot whales and killer whales may live 20 years beyond the end of their reproductive years (that is, they experience menopause), living past 60 years of age. It has been suggested that this allows old females

to store and pass on information to other group members and perhaps provide alloparental care in the form of babysitting and/or wet nursing (Heimlich-Boran and Heimlich-Boran 1994; Acevedo-Gutiérrez 2002; Baird 2002). Pilot whales (and also sperm whales) suckle calves for 13 to 15 years, indicating a very long period of dependency and close association with their mothers.

Sperm whale females may also form associations that last for decades. These groups appear to assist in the care of young animals, with group members taking the role of babysitters, to allow mothers to take long, deep dives in search of food (Whitehead and Arnbohm 1987; Whitehead *et al.* 1991).

It has been suggested that the cultural transmission of learned behaviours to family members is conserved in matrilineal groups: these societies assist in the learning of complex skills essential for survival, as well as ensure these skills are passed onto future generations without being lost or forgotten. Although these societies aid in the transmission of information, they also have the effect of changing mating patterns and hence the genetic evolution of the populations and/or species (Whitehead 1998). Genetic modification as the result of 'culture', such as occurs in these cetacean societies, was previously believed to occur only in humans (Acevedo-Gutiérrez 2002).

Culture

Culture can be defined as behavioural variations between sets of animals that are maintained and transmitted by social learning (Whitehead 2002b) and typically involves components of both teaching and imitation by the animals concerned. It has been suggested that everything of importance in human behaviour is transmitted culturally (Manning and Dawkins 1992). Culture has been identified in several cetacean species, for example, in the eastern North Pacific, killer whale groups were discovered to possess distinct calls that are unique to their group members (Ford 1989, 1991, 2002). In short, like many populations of humans, these cetaceans had unique vocal dialects. Similar dialects have also been found in other species of cetacean (Ford 2002), including the codas of sperm whales (Weilgart and Whitehead 1997) and the songs of humpback whales (Payne and Guinee 1983). These dialects are learned from older members of the group in the matrilineal sperm whale and killer whale, and from other singing males on the breeding grounds of humpback whales; that is, cultural transmission of information rather than ecological or genetic differences account for the geographical differences in vocalisations (Rendell and Whitehead 2001).

Rendell and Whitehead (2001) identified several different ways in which culture was transmitted in cetaceans. The first was a spread of novel and complex behaviours between members of the same generation (i.e. a 'horizontal' transmission of culture), which occurs in humpback and bowhead whales when learning songs from other males (e.g. Noad *et al.* 2000). The second type of cultural transmission was between mother and young (i.e. a 'vertical' transmission of culture); for example, female killer whales teaching offspring how to strand themselves in order to catch the pups of southern sea lions (*Otaria flavescens*) or elephant seals (*Mirounga leonina*) on haul-out beaches (Lopez and Lopez 1985; Guinet and Bouvier 1995). The final pattern of cultural transmission has been described above; a stable group transmission of culture that can be horizontal, vertical or 'oblique' (a non-parent from a previous generation transferring information), e.g. vocal dialects in killer whales (Deecke *et al.* 2000) or sperm whales (Weilgart and Whitehead 1997).

Other apparently culturally transmitted behaviours include bottlenose dolphins placing sponges on their beaks to avoid being punctured by urchins and spiny fish when foraging; bottlenose dolphins,

Atlantic humpback dolphins (*Sousa teuszii*) and Irrawaddy dolphins (*Orcaella brevirostris*) co-operating with humans to school and capture fish; group specific migration patterns and ‘greeting ceremonies’ in killer whales; and group-specific movement patterns and co-operative defence patterns in sperm whales (Rendell and Whitehead 2001).

Clearly, there is considerable evidence that culture exists in cetacean societies, even in great whale species. Culture was previously considered to be the province only of humans, or at best, higher primates. The exhibition of culture in cetaceans, therefore, adds to the argument that they are, indeed, highly intelligent animals.

Intelligence

At 7.8 kilograms, the sperm whale has the biggest brain of any living animal (Whitehead 2002a). The large brains of cetaceans have led to several studies, which have tried to assess cetacean intelligence by looking at the Encephalisation Quotient (EQ). The EQ is a ratio between the size of the brain and the mass of the animal, with a ratio of 1 meaning that the brain is the size expected for that animal’s body (Jerison 1973). Using this ratio, the smaller dolphins have EQs ranging from 3.24 to 4.56 (Jerison 1973), lower than modern humans with an EQ of 7.0. However, the dolphins’ EQ is similar to several hominid species beyond the earliest human ancestors (e.g. *Homo habilis* had an EQ of 4.4). However, two issues must be considered here: first, the structure of the cetacean brain is very different from that of humans, due to the cetacean’s evolution in, and adaptation to, an aquatic environment (Oelschläger and Oelschläger 2002). Second, these calculations do not take into account the high proportion of a cetacean’s mass that is blubber, a tissue that needs little neurological control and, therefore, needs little brain mass dedicated to it. An analogy might be to look at an obese human compared to a normal-weight human – the obese person would have a much lower EQ than the other, but this does not mean overweight people are less intelligent!

The sperm whale and baleen whales do not, however, fare well in terms of EQs. The sperm whale has an EQ of 0.58, the humpback whale 0.44 and the blue whale 0.21 (Jerison 1973). Pro-whalers have thus argued that great whales are not intelligent and should be given no more special status than creatures with similar EQs, such as domestic cows and sheep. However, these EQs do not take into account two important facts: first the weights used in the EQ calculations for the great whales are primarily based on animals caught in whaling activities, where the biggest and fattest would often be targeted, skewing the average body mass used in calculations and hence the EQs. Second, the EQ for the sperm whale does not take into account the large spermaceti organ, which, as a fatty substance like blubber does not require much in the way of neural control, or brain volume, allocated to it, but nonetheless accounts for a sizeable proportion of the animal’s mass. Third, the size of the great whales is disproportionably large, an adaptation to their ecological niches. The supportive, buoyant nature of water has allowed the achievement of excessive mass, which was not possible in terrestrial mammals. However, great whales have achieved this increased mass in ways that do not necessarily need an increase in accompanying brain size (Marino 2002). Therefore, in terms of measuring intelligence in the great whales, “EQ is not an appropriate measure” (Marino 2002).

If EQs are an inappropriate way to assess intelligence in the great whales, then, perhaps, a better way to assess intelligence is to look at communication: if animals can communicate in sophisticated and novel ways, this implies intelligence (Würsig 2002).

Communication in great whales

The most elaborate and probably best-studied form of cetacean communication in the great whales is the song of the humpback whale. Although other baleen whales also produce complex songs, notably the bowhead and right whales (*Eubalaena spp.*) (Clark 1990), the vocalisations of the humpback whale have received the most scientific, and public, attention. To date, the song of the humpback whale is the most complicated animal song studied and is believed to have a role in competition between males, or in determining mate selection (Tyack 1999). Each humpback whale population has its own specific song; at the beginning of the breeding season all humpback whales in a population sing approximately the same song. As the breeding season progresses the songs of each population change in structure (Payne *et al.* 1983). At the end of the breeding season males stop singing until the following mating season and when they resume singing, their song has the same structure as at the end of the previous breeding season (Payne *et al.* 1983), i.e. the song has been 'memorised' over the intervening period.

As the song evolves through the season it is apparent that each whale is actively learning and incorporating new aspects of the song structure as they are introduced. Although it is at present impossible to assess whether these changes in the song structure are due to 'inventiveness' by the whales, this is a possibility. Certainly the way in which the songs are learnt shows an ability to learn and memorize complex behaviours, and throughout over 30 years of recording these songs they have been shown not to revert to, or repeat, old songs, which suggests that the whales can mentally 'keep track' of a song's evolution (Tyack 2002b); an impressive mental feat.

Sperm whales also have sophisticated calls, in particular 'codas': rhythmic sets of 3-20 clicks in bursts of 0.2-2 seconds. It has been found that groups of sperm whales have group-specific codas (Weilgart and Whitehead 1997), and possibly individually distinct codas (Watkins and Schevill 1977). These codas are learnt within family units and are commonly heard when members of a group rejoin after foraging. It is possible that these codas may help to strengthen social bonds, aid in-group identification or possibly act as a 'greeting' call. It has been suggested that verbal recognition of individuals was a prerequisite for the development of human language (Janik 2000). Sperm whales may have the building blocks for the development of a language as complex as our own.

Communication has also been studied at length in certain small cetaceans, notably bottlenose dolphins and killer whales (e.g. summaries in Tyack 1999 and Dudzinski *et al.* 2002). Some of the most notable types of cetacean communication include the production of alarm and greeting calls (see below). In addition, it has been shown that cetaceans can communicate their individual identity (see below) which, for all intents and purposes, is effectively communicating their individual 'names'. Various researchers have proposed that the complexity of cetacean communication suggests that these animals do indeed possess language and several studies have been conducted to determine whether, in fact, cetaceans possess sufficient linguistic skills to understand or potentially develop language (see below). Sophisticated communication mechanisms have evolved in these species and similar systems may exist in less well-studied species, including some of the other great whale species.

Greeting calls

Clark (1982) analysed the calls of the southern right whale (*Eubalaena australis*) and identified a loud, low frequency (0.2-0.3 kHz) call, which he subsequently identified as a call used to contact other whale groups (Clark 1983). The call was produced while one group of whales was swimming towards another, and the contacted group would then return the call. The frequency of the calls would then increase, as the groups swam together, until they eventually met (Clark, 1983). This 'hello' call between whale groups is interesting and demonstrates an awareness of, and socialising between, whale groups. It is also possible that other calls produced by baleen whales serve as greeting signals (Gordon and Tyack 2002), although this is as yet unsubstantiated.

Alarm calls

A number of vertebrate species, especially primates, produce alarm calls. Many of these calls provide information as to the type of threat, so that group members can respond appropriately (e.g. Seyfarth *et al.* 1980; Cheney and Seyfarth 1985). Alarm calling is often seen as a sophisticated social behaviour, and often an altruistic one. Giving an alarm call could, for example, draw the attention of a predator to the individual giving a call. It appears that cetaceans can be added to the list of animals that produce these signals, as several studies have documented increases in certain odontocete calls, believed to be 'alarm' calls, in response to boat traffic (Findley *et al.* 1990; Lesage *et al.* 1999).

Individual identities

It was Caldwell and Caldwell (1965) who first reported that dolphins produced whistles that were unique to individual animals. These whistles are believed to play an important role in recognition of individual animals, and for all intents and purposes could be considered the 'names' of individuals. These whistles can, among other things, allow individual dolphins to distinguish closely related animals from others (Sayigh *et al.* 1999), much like last or family names in humans. Individual recognition plays an important role in the behaviour of social animals such as cetaceans (Tyack 1986), as it allows animals to identify relatives, form alliances, and aid co-ordinated behaviours such as foraging and repelling competitors or predators. This leads to a much more sophisticated social structure.

Language

Several researchers have investigated the linguistic skills of cetaceans. One of the first studies tried to teach bottlenose dolphins (*Tursiops truncatus*) how to mimic human speech, the idea being that this would be a sign of intelligence (Lilly, 1961). That particular study was a failure, although subsequently beluga whales (*Delphinapterus leucas*) were found to be able to imitate human speech (Würsig 2002) and bottlenose dolphins have been taught to imitate computer-generated sounds (Richards *et al.* 1984).

One of the most well-known, and successful, cetacean linguistic studies was conducted by Herman (1986), who taught bottlenose dolphins a simple sign language and a computer-generated sound language, and using these constructed simple sentences, structured with subject-verb-object. This study determined that, using these artificial symbolic languages, dolphins could understand simple sentences and novel combinations of words but, most importantly, it demonstrated a comprehension of sentence structure (syntax) – an extremely advanced linguistic concept (Herman 1986).

Self-awareness

One of the most compelling pieces of evidence for cetacean intelligence is the demonstration that cetaceans have self-awareness. Several studies in recent years have used a modified test of self-awareness developed for chimpanzees (Gallup 1970). This test involves animals recognising their image in a mirror and, moreover, using that image to investigate their body. The experiments involved marking captive bottlenose dolphins on their bodies with zinc oxide cream (Marten and Psarakos 1995) or non-toxic marker pens (Reiss and Marino 2001). The dolphins would then inspect themselves in a mirror that was placed in their pool. The experiments demonstrated that the dolphins not only paid attention to the information in the mirror, but also they were able to interpret the images as themselves, and not simply another dolphin. Finally, the dolphins used the mirrors as tools to view themselves. These are all indicators of self-awareness.

Using mirror recognition studies, only the great apes had previously demonstrated self-recognition (Gallup 1970, 1982; Lethmate and Dücker 1973; Suarez and Gallup 1981; Anderson 1984). In humans, the ability to recognise one's self in a mirror does not appear until about 24 months of age (Amsterdam 1972). Therefore, bottlenose dolphins have a level of awareness at least as developed as a two-year old child. It should also be stressed that hearing is the primary sense of bottlenose dolphins; therefore, being able to identify visual images as one's self using a secondary sense, is doubly remarkable.

Although self-recognition tests have only been conducted on bottlenose dolphins so far and not on other odontocetes or baleen whales, the experiments demonstrate that at least one species of cetacean is indisputably self-aware and can, therefore, be considered to be at least as intelligent as our nearest relative, the great apes, and human children. Cetaceans, therefore, cannot be dismissed as 'dumb animals', bringing the ethical and welfare issues of whaling into sharp focus.

Conclusions

This short review of cetacean biology raises a number of issues with respect to killing these animals for profit:

- from a cruelty perspective, the diving adaptations of the animals may make it difficult to determine whether they are dead;
- their sheer mass, complex blood systems and adaptations to marine life will also be complicating factors in trying to kill them swiftly and humanely;
- the intelligence, self awareness and family and other social bonds known from some of the better-studied species raise ethical dilemmas for those that wish to kill, or otherwise, exploit these animals;
- consideration of the dimension of 'culture' should exacerbate these concerns because we, as the human species, now need to consider whether we are in danger of destroying other cultures, as well as destroying individuals, populations and species by our actions.

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