The Welfare of Bottlenose Dolphins and Killer Whales in Captivity

Välfärden hos flasknosdelfin och späckhuggare i fångenskap

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I denna serie publiceras olika typer av studentarbeten, bl.a. examensarbeten, vanligtvis omfattande 7,5-30 hp. Studentarbeten ingår som en obligatorisk del i olika program och syftar till att under handledning ge den studerande träning i att självständigt och på ett vetenskapligt sätt lösa en uppgift. Arbetenas innehåll, resultat och slutsatser bör således bedömas mot denna bakgrund.

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Summary

The aim of this paper was to investigate whether or not it is possible to keep bottlenose dolphins and killer whales in captivity while maintaining good animal welfare. Today, many zoos and aquariums claim that their primary function is to conserve species and educate people about conservation and threatened species. The keeping of wild animals is justified by conservation programs and by the information spread to the zoo visitors. This does however not seem to be the case for marine mammals such as bottlenose dolphins (*Tursiops* sp.) and killer whales (*Oricnus orca*) since these species are not threatened in the wild and neither of them are listed as threatened in IUCN's Red List.

Bottlenose dolphins and killer whales are entirely aquatic carnivores and are distributed in all coastal and pelagic waters from the Arctic ice in the north to the Antarctic ice in the south. They are highly social animals that living in complex social structures forming tight bonds to other individuals. Social stressors such as changes within the group, aggression, competition for resources and unstable dominance hierarchies etc, can be very stressful to cetaceans and have a negative impact on their health. It is impossible for animals kept in the same pools to affect their social grouping, being limited to the group that park management has chosen for them, and individuals that would not associate in the wild are forced to do so.

Both species have shown self-awareness through mirror self-recognition tests. Animals that are self-aware can learn that different outcomes can be produced or influenced by their behavior and that they have some control over certain parts of their environment. Their self-awareness and examples of tool-use in the wild should mean that a variety of environmental enrichments could be used successfully with these animals to improve their welfare.

In 2005 there were at least 199 facilities that kept cetaceans for research or public display. Their enclosures are usually larger than the minimum size requirements but are often made of slick concrete without much variation. Even though more and more parks rely on captive breeding there are still animals being captured from the wild and sold to the display industry. In the whaling season of 2003/ 2004, 78 cetaceans were captured and sold to marine parks by hunters from Taiji, Japan. The live-captures of cetaceans impacts not only the animals being caught, but also the groups they are taken from that have to deal with the loss of a group member.

There is little scientific literature on the welfare of bottlenose dolphins and killer whales in captivity and more research should be done on the subject. It is my conclusion that it is very difficult to keep these species and maintain animal welfare at a satisfactory level.

Sammanfattning

Syftet med denna uppsats var att undersöka om det är möjligt att hålla flasknosdelfiner och späckhuggare men ändå upprätthålla en god djurvälfärd. Idag hävdar många djurparker och akvarier att de i första hand arbetar med bevarande av arter samt att sprida kunskap om bevarandearbete och hotade arter. Hållandet av vilda djur rättfärdigas av bevarandeprojekt och av informationen som sprids till parkernas besökare. Detta verkar dock inte gälla marina däggdjur såsom flasknosdelfin (*Tursiops* sp.) och späckhuggare (*Oricnus orca*). Dessa arter är inte hotade i vilt tillstånd och ingen av dem är listade som hotade i IUCN:s röda lista.

Flasknosdelfiner och späckhuggare är helakvatiska karnivorer och lever i alla kustnära och pelagiska vatten, från de arktiska isarna i norr, till de antarktiska isarna i söder. De är mycket sociala djur som har komplexa sociala strukturer och bildar starka band till andra individer. Social stress i form av förändringar inom gruppen, aggressioner, konkurrens om resurser och instabila hierarkier kan vara väldigt stressande för valar och påverka deras hälsa negativt. Det är omöjligt för djur som hålls i samma bassänger att påverka sin sociala gruppering eftersom de är begränsade till gruppen som djurskötarna bestämt och individer som aldrig skulle interagera i det vilda tvingas att leva tillsammans.

Bägge arter har visat tecken på självmedvetande genom tester med speglar. Djur som är självmedvetna kan lära sig att de kan frambringa eller påverka olika utfall beroende på hur de beter sig och att de har viss kontroll över vissa delar av deras miljö. Självmedvetandet och exempel på verktygsanvändning i det vilda borde innebära att man framgångsrikt kan använda en mängd olika miljöberikningar för att förbättra välfärden hos dessa djur.

År 2005 fanns det minst 199 anläggningar som höll valar och delfiner för allmän förevisning. Bassängerna de hålls i är oftast större än ländernas minimikrav men är ofta gjorda av slät betong som inte erbjuder variation i miljön. Även om alltfler parker förlitar sig på avel för att få nya djur så fångas vilda individer fortfarande för att säljas till djurparker och akvarier. Under valfångstsäsongen 2003/ 2004 fångades 78 valar och delfiner av jägare från Taiji, Japan, och såldes vidare till parker. Att fånga in vilda individer påverkar inte bara djuret som fångas, utan även flocken djuret tas ifrån som behöver hantera förlusten av en flockmedlem.

Det finns väldigt lite vetenskaplig litteratur om flasknosdelfiners och späckhuggares välfärd i fångenskap och mer forskning behövs i ämnet. Min slutsats är att det är mycket svårt att hålla dessa arter och samtidigt upprätthålla djurvälfärden på en tillfredsställande nivå.

Introduction

Background

Today, many zoos and aquariums claim that their primary function is to conserve species and educate people about conservation and threatened species. Zoos no longer want to be menageries, but instead show animals in enclosures resembling their natural habitats. The keeping of wild animals is justified by conservation programs and by the information spread to the zoo visitors (Hutchins *et al*., 2003). However this does not seem to be the case for marine mammals such as bottlenose dolphins (*Tursiops* sp.) and killer whales (*Oricnus orca*) since these species are not threatened in the wild and neither of them are listed as threatened in IUCN's Red List. There are at least 600 000 wild bottlenose dolphins and from the samples provided it is estimated there are at least 50 000 wild killer whales, but the number is probably a lot higher (Hammond *et al*., 2008; Taylor *et al*., 2008). Threats to these species are mainly disturbance of their habitats, reduction of prey due to fishing or climate change, pollution, oil spills and the hunting and capture of animals by whaling industries and drive fisheries (Hammond *et al*., 2008; Taylor *et al.*, 2008).

Like many other people I have always been intrigued by dolphins and whales. Since my first visit to Sea World San Diego, California, I have been fascinated by their beauty, playfulness and intelligence, but I also always had a feeling something was not quite right. The drooping dorsal fins of killer whales, the small dolphin petting pools and movies like "Free Willy" made me wonder if it was appropriate to keep these animals in our care. I did however enjoy the shows I saw and wanted to believe the parks when they said their dolphins and whales live a very good life.

Because of the marine environment that whales and dolphins live in, it is difficult for us to observe them and study them in their natural habitat. Therefore, a lot of their natural behaviors are unknown to us and a great deal of information we have about land living species is not attainable for these species. This lack of information makes it hard to determine what aspects are most important for their well being.

Captive bottlenose dolphins and killer whales are often part of shows that do not offer a correct image of the animals' lives in the wild. The use of killer whales and dolphins in spectacular shows may in fact be used by the parks to attract paying visitors instead of keeping these animals for any conservation purposes.

Aim

The aim of this study is to investigate if it is possible to keep bottlenose dolphins and killer whales in captivity while maintaining good animal welfare.

My objective is to answer the following questions:
How do bottlenose dolphins and killer whales live in the wild?
How are bottlenose dolphins and killer whales kept in marine parks and aquariums?
Is the welfare of these species in captivity satisfying?

Material and Method
I searched for scientific literature through the databases Web of Knowledge and Google Scholar. The search terms I used were: marine mammals, bottlenose dolphin, killer whale, captivity, welfare, stereotypic behavior, social behavior, foraging behavior, enrichment etc. I also searched the web for marine mammal and cetacean societies and organizations and looked at what information these organizations provided.

I visited Kolmården Wildlife Park on April 5th 2010 to see how they keep their dolphins and experience what their zoo visitors see when visiting the dolphinarium and watch the dolphin show. I wanted to know how big their tanks are, how many dolphins they have and what information they provide to the visitors, both in form of signs around the exhibit and what the dolphin trainers say during their show. I photographed the information signs and took notes during the show.

Cetaceans

General description
Cetacea, the order both bottlenose dolphins and killer whales belong to, is divided into two suborders; *Mysticeti* (baleen whales) and *Odontoceti* (toothed whales) (Couquiaud, 2005). Bottlenose dolphins and killer whales are toothed whales of the *Delphinidae* family, which is the most diverse and largest group of cetaceans with about 37 species, and also the cetacean family most commonly seen in marine parks and aquariums (Couquiaud, 2005). All species in the dolphin family are of medium to large size and entirely aquatic carnivores. They are distributed in all coastal and pelagic waters from the Arctic ice in the north to the Antarctic ice in the south and are highly social animals (Wells, 2003).

According to Wells (2003) all dolphins basically have the same streamlined body shape, an adaptation to moving through their aquatic medium. However there are variations in body size, robustness, beak size, the size and number of teeth, and whether or not they have a dorsal fin (Wells, 2003). These differences in appearance are due to adaptations to different habitats and what type of prey they feed on (Wells, 2003). Wells (2003) states that dolphins' cone-like teeth are homodont and are not used for chewing but for grasping or tearing prey apart.

The dense water medium that cetaceans live in requires adaptations not found among land-living mammals (Fordyce & Gill, 1998). The environment in which these animals live also makes it hard for us to study and fully understand what senses cetaceans rely on and how these senses work. Fordyce and Gill (1998) state that sight, sound and touch seem to be important for functioning in navigation, feeding and breeding behaviors, communication and for monitoring the animals' environment. According to Couquiaud (2005) whales and dolphins are highly tactile animals and their skin is very sensitive to touch. Other senses that could also be important for cetaceans are detection of temperature, pressure, gravity, acceleration and magnetic fields (Fordyce & Gill, 1998).

The evolution of odontocetes has given them the ability to echolocate which facilitates navigation and foraging under water. Odontocetes have complex soft tissues in their nasal passages between their blowhole and forehead where the sounds used in echolocation are produced (Fordyce & Gill, 1998). The sounds are concentrated and transmitted forward as

a narrow beam out into the water by the melon, a large and fatty internal structure in their forehead (Fordyce & Gill, 1998). When echolocating, an animal can determine the distance, position and size of an object in the water by sending an intense beam of sound that bounces off the object and returns to the sender as an echo (Fordyce & Gill, 1998).

Many toothed whales, including bottlenose dolphins and killer whales, show altruistic behaviors rarely seen in other parts of the animal kingdom through defending and staying with sick or threatened members of their groups (Fordyce & Gill, 1998).

Cognition

Species within the dolphin family have shown high cognitive skills. They can form and generalize concept rules and they have proven that they can learn by observation (Couquiaud, 2005). Bottlenose dolphins' high levels of encephalization suggest that their intelligence and cognitive processing ranges closer to humans than even the primates that are our closest relatives (Reiss *et al.,* 1997). One very important element of social cognition is "joint attention", which is described by Pack and Herman (2006) as ranging from following the gaze of another individual, to selecting objects or locations from another's pointing or gazing cues. There are indications from comparative studies that some of the joint attention abilities dolphins possess also exceed the abilities shown by apes (Pack & Herman, 2006). Dolphins can be both the receiver and informant in tasks regarding joint attention and are one of few non-domesticated species that understand human pointing cues without being taught what the cues mean (Pack & Herman, 2006).

Recognizing oneself in a mirror is considered to show high levels of self- awareness and is a rare ability in the animal kingdom (Reiss & Marino, 2001). Before conducting their study, Reiss and Marino (2001) claim that there was no convincing evidence that any animals but humans and great apes had the skill of mirror self-recognition. Reiss and Marino (2001) tested two dolphins by giving them access to reflective surfaces after being marked or sham-marked with a black ink marker. Both dolphins showed investigative behaviors by inspecting themselves in mirrors or reflective surfaces after the marking or sham- marking (Reiss & Marino, 2001). The dolphins also spent more time exploring the marked area of their body when they actually had been marked than if they were sham-marked (Reiss & Marino, 2001).

Delfour and Marten (2001) state that killer whales, like bottlenose dolphins, are self aware which has been proven through a variety of tests with mirrors. They saw evidence of self-recognition when killer whales were marked and the killer whales also showed that they anticipated their image would look different after being marked and one female would rub off her marking on the sides of the pool (Delfour & Marten, 2001).

According to Gallup (1998), animals showing mirror self- recognition can also conceive of themselves. Through interacting and experimenting with living and non-living aspects of their environment these animals also develop a sense of personal agency, or in other words, the exercise of free will (Gallup, 1998). Animals that can conceive of themselves learn that different outcomes can be produced or influenced by their behavior: what, how and when they do something (Gallup, 1998). Gallup (1998) states that personal agency emerges from response contingent experiences since the animals then realize that they have some control over certain parts of their environment.

Bottlenose dolphins

Distribution, depth & size
According to Wells (2003) bottlenose dolphins (*Tursiops* sp.) are found in temperate and tropical waters worldwide (i.e. all non-arctic waters), with the highest population densities close to shorelines and in estuaries and bays.

Not much is known about the diving behaviors of bottlenose dolphins but off the coast of Florida they are often seen diving to the ocean bottom at 7 – 13 meters depth (Stewart, 2002). Williams *et al.* (1999) used bottlenose dolphins that had been taught to dive to depths of 210 meters to conduct open water studies on diving physiology. This in combination with the knowledge of other dolphin species' diving behaviors suggests that wild bottlenose dolphins dive to these depths too.

They grow to a total length of 2.5 – 3.8 m, weigh 230 – 500 kg (Wells, 2003) and can live for 50 years (Couquiaud, 2005). The variation in size depends on where they live, dolphins living in warmer waters are smaller than the ones living in colder temperatures (Connor *et al.*, 2000). It is difficult to tell males and females apart since there is no obvious dimorphism between the sexes (Connor *et al.*, 2000).

Diet & foraging
Bottlenose dolphins feed on both solitary and schooling fish, squid and other invertebrates (Wells, 2003), using many different foraging and hunting behaviors (Connor *et al.*, 2000). They can feed individually or hunt cooperatively and it is also common for them to take advantage of human fishing activities while foraging (Wells, 2003). The same source states that a common method of pursuing schools of fish is that part of the dolphin group circles the school to keep the fish together while others take turns darting into the school to grab fish easily. Bottlenose dolphins can also find prey hidden in the sand on the sea floor or follow prey that jumps out of the water, grabbing them in the air (Connor *et al.*, 2000).

Tool use
Bottlenose dolphins in Shark Bay, Australia, have since 1984 been observed carrying sponges on their beaks (Smolker *et al.*, 1997). Smolker *et al.* (1997) claim that the sponges used are often so large that they interfere with the use of echolocation and the mouth, and cause hydrodynamic drag. Therefore, functional advantages must compensate for what seems like a very costly behavior (Smolker *et al.*, 1997). According to Smolker *et al.* (1997), it is only a small number of relatively solitary female dolphins that have specialized in the sponge carrying behavior but it is unknown exactly what the sponges are used for. It seems like sponge use is not a playful behavior, nor do the dolphins appear to eat the sponge (Smolker *et al.*, 1997). Therefore, Smolker *et al.* (1997) conclude that sponges are used as a foraging aid with several purposes, the main one probably being to protect the rather sensitive rostrum from sharp rocks, shells or coral and from the spines and stingers of dangerous fish and other organisms. They also state that there is some evidence supporting that this foraging specialization is taught by mothers to their daughters.

Social structure
According to Connor *et al.* (2000) bottlenose dolphins have a complicated social structure living in fission/ fusion societies varying in size. In a fission/ fusion society individuals within the same society form smaller groups that can change in size and composition on a

daily or even hourly basis (Connor *et al.*, 2000). The social structure shown in this type of society is regarded to be more complex than that found in chimpanzee societies (Reiss *et al.*, 1997) and is possible due to dolphins' high social cognitive skills (Pack & Herman, 2006).

The average group size is difficult to determine due to the constantly changing groupings but anything from 5 – 140 individuals is considered normal (Connor *et al.*, 2000). The same source states that bottlenose dolphins living in pelagic waters (water not close to the bottom of the sea or near the shore), tend to form larger groups (probably resulting from a fusion of several smaller groups) than dolphins living in more shallow coastal habitats. This difference in group size can probably be explained by the predation risk being higher in deeper waters and prey changing from individual prey animals in shallower waters close to the shore, to schooling prey in pelagic waters (Connor *et al*., 2000).

Not much is known about how large home ranges bottlenose dolphins have and the range sizes also vary between populations (Connor *et al.*, 2000). In Sarasota, Florida, the dolphins are practically permanent residents while other populations are considered migratory (Connor *et al.*, 2000).

Male bottlenose dolphins form alliances at two levels (Connor *et al.*, 2001). They form pairs and trios that cooperate to protect their individual partnerships with females, keeping other males from mating with them. The pairs and trios also form larger alliances that attack other male alliances to gain access to more females or defend themselves from attacks by other alliances (Connor *et al.*, 2001). Connor *et al.* (2001) claims that the bonds between males in pairs and trios are strong and that these stable alliances can last for many years. The members of the larger alliances are not as strongly bonded to each other and these alliances change more often (Connor *et al.*, 2001).

Reproduction & juveniles

The females have a 12 month gestation period before they give birth to a single calf (Wells, 2003). Females start breeding at 5 – 13 years of age and the variation in age is probably due to health differences (Connor *et al.*, 2000). The same source states that the birth interval in Sarasota bottlenose dolphins is 3 – 6 years and in Shark Bay 4 – 6 years. The calves stay with their mother for several years and it is not uncommon for young to keep nursing until the age of 5 (Connor *et al.*, 2000). Mann and Smuts (1999) claim infants start to practice foraging at about one month of age, although they do not actually forage while they are newborns (the first 10 weeks of life). In captivity however calves only nurse for 18 – 20 months and females give birth every 2 – 3 years, probably since food is readily available and the calves not having to learn different foraging methods (Connor *et al.*, 2000).

Connor *et al.* (2000) states that mortality among young is high in wild populations, 44 – 46 % die before they are weaned or have left their mothers and most first born calves do not survive. Mann and Watson- Capps (2005) argue that predation is not the main cause of calf mortality. They say that it is the calf condition that determines if the calf survives and that factors influencing calf condition are maternal condition, maternal foraging success, the mother's age and maternal experience and social factors.

Mann and Smuts (1999) argue that newborn dolphins rapidly learn to stay close to their mothers which is probably a consequence of mothers not hiding their young from

predators. Over time the newborn calves get more independent, spending less time close to their mothers and travelling and socializing on their own (Mann & Smuts, 1999). Newborns associate with other calves, young and adult females but are rarely seen with sub-adult or adult males, who typically show no interest in the infants (Mann & Smuts, 1999).

Killer whales

Distribution, depth and size

Killer whales are considered cosmopolitan since they reside in all marine waters, although most of them are found at higher latitudes (Wells, 2003). They are concentrated to areas in pelagic and coastal habitats and along ice edges where prey is abundant (Wells, 2003).

Like bottlenose dolphins, killer whales around New Zealand have been observed diving to the ocean floor at about 12 meters depth, probably burrowing for stingrays (Stewart, 2002). Baird *et al.* (2005) conducted a study on resident killer whales that were tagged with time-depth recorders and/ or velocity meters. The killer whales probably dive deeper than the maximum dive depth that was recorded, 228 m, since that was the depth limit of the recording device. Most dives did not go below 30 m but since velocity spikes were observed when the whales did dive deeper than 30 m it is likely they forage at depths below 30 m (Baird *et al*., 2005).

Adult male killer whales are up to 9 m in length, can weigh over 5 600 kg and can live up to 50 – 60 years, adult females can reach a length of 7.7 m, weigh nearly 4000 kg and have a maximum life expectancy of 80 – 90 years (Ford, 2002). There is sexual dimorphism in body size and the size of pectoral fins and tail flukes (Ford, 2002). Wells (2003) states that the dorsal fins of large adult males can be 2 meters high and usually start growing when they reach sexual maturity.

Residents & transients

Currently there is only one species in the genus *Orcinus*, the killer whale *Orcinus orca*, but there is an ongoing debate if *Orcninus orca* should be divided into several species due to differences in size, coloration, diet, group size etc between different subpopulations (Baird, 2000). Regardless of the possible division of the present *Orcinus orca* into several species, two types of killer whales are commonly recognized: residents and transients (Baird, 2000). When killer whales were divided in transients and residents, whales living in large, stable groups that stayed in specific areas during the summer months were called residents (Ford *et al.*, 1998). The whales that were only seen sporadically, formed smaller groups and did not associate with the larger resident groups were considered to be in transit (migrating) and therefore got the name transients (Ford *et al.*, 1998).

According to Baird (2000) resident killer whales form long-term stable groups with several maternal lineages and there is practically no dispersal from these groups. Transients on the other hand stay in their natal range but almost all female and male offspring disperse from their maternal group (Baird, 2000). Ford *et al.* (1998) claim that research has proven that transients and residents are two distinct, socially isolated forms of killer whale. They differ in genetics, morphology, social organization, vocalization, pigmentation patterns, diving and movement patterns and diet (Ford *et al.*, 1998). Residents primarily feed on fish,

mainly salmon, while transients feed on marine mammals, such as pinnipeds, small cetaceans and sea birds (Ford *et al.,* 1998). Hoelzel (1993) found that resident killer whales search for prey cooperatively in subgroups of their pods but usually capture the prey independently and that males more often than females leave the subgroup for prey capture.

Echolocation

According to Barrett- Lennard *et al.* (1996) there are differences in resident and transient killer whales' sonar use. They say that residents use echolocation for both orientation and foraging purposes and produce trains of sonar clicks. Other vocalizations, like whistles or short clicks, seem to mainly have a social function, like gathering a scattered group. Transients on the other hand, use lower, isolated clicks or short, irregular and infrequent trains of clicks while echolocating. Barrett- Lennard *et al.* (1996) thought that transients ought to use echolocation more often than residents since they travel more near the shore where the risk of colliding with objects and the ocean floor, or stranding, is high. The finding that transients use echolocation far less than residents suggests that the costs of sonar use are higher than the benefits for these animals (Barret- Lennard *et al.,* 1996). Barret- Lennard *et al.* (1996) explain that fish do not change their behavior or respond to sonar clicks, and therefore residents can use echolocation for foraging purposes without alerting their prey. Unlike fish, marine mammals have acute hearing and can hear the sonar clicks of killer whales and thus are alerted to the presence of their predators making it costly for transients to use echolocation while hunting (Barret- Lennard *et al.,* 1996).

Social structure

The size of the groups or pods they form can vary from two to hundreds of animals, however the larger groups are most likely temporarily formed by smaller, more stable groups (Baird, 2000).

The basic social unit of resident killer whales is the matriline- a very stable group where the individuals are connected by maternal descent (Ford, 2002). Ford (2002) explains that a matriline typically consists of a female, her adult daughters and sub adult sons, and her daughters' offspring. Because of the longevity of female killer whales a matriline could contain up to four generations of individuals that are maternally related. Related matrilines that share a recent maternal ancestor form pods, a social unit that is less stable than the matriline (Ford, 2002). Above the pod comes the next level of social organization- the clan, which is composed of several pods that probably descend from the same ancestral pod and have similar vocal dialects (Ford, 2002). The highest level of social structure among resident killer whales is, according to Ford (2002), the community and is defined by the association patterns of pods. Pods that regularly associate with each other are part of the same community and pods from different communities do not associate or travel with one another (Ford, 2002).

The social organization of transient killer whales is not well documented (Ford, 2002). The same author writes that transients do seem to form matrilines, but smaller ones since offspring disperses from their original groups. The transient matrilines have dynamic association patterns and do not form stable pods equivalent to those of residents (Ford, 2002). In a transient community, all groups of whales can be linked through the network of associations of the matrilines, and all members of a community have a similar call repertoire (Ford, 2002).

Migration & home ranges
There is no clear evidence of seasonal migrations among killer whales but there are indications of some north – south seasonal movement among killer whales in polar areas due to the presence of pack ice (Baird, 2000). Baird (2000) also argues that evidence shows that killer whales have very large home ranges. According to Baird (2000) the actual sizes of home ranges are unknown although individual killer whales have been seen to move over very large areas, for example from central California to southeastern Alaska, a distance of 2 660 km. In British Colombia and Washington the largest home range documented for a single transient pod is 140 000 km^2 and for a resident pod 90 000 km^2 (Baird, 2000). There is also documentation of both types spending extended periods of time in very small areas, as well as records of individuals travelling up to 160 km in a 24-hour period (Baird, 2000).

Reproduction & juveniles
According to Wells (2003) killer whales give birth to a single calf after about 15 months of gestation. They have their first viable calf at 11 – 20 years of age, they can give birth to calves at younger ages but these calves seldom survive, and the birth intervals vary from 2 – 14 years (Baird, 2000).

Young killer whales are probably somewhat dependent on their mothers or other adults until around the age of 6, but their exact weaning age is not known (Baird, 2000). Mortality rates are high, 37 – 50 %, for calves up to 6 months but the rates decline steadily for older animals (Baird, 2000). Baird (2000) also claims that the reasons for the high mortality rates among calves are unclear and suggests that calf condition is more important than predation, as for bottlenose dolphins. Though killer whales are the only cetacean species not having any natural predators, they are actually themselves one of the predators that attack other cetaceans (Fordyce & Gill, 1998).

Dolphins and killer whales in aquariums and marine parks

History
Cetaceans have been held in captivity and displayed in exhibits since 1860 when two beluga whales where captured, but since they were kept in a freshwater tank they died only days later (Jiang *et al.,* 2008). The capture of five bottlenose dolphins by the New York Museum was somewhat more successful, the last individual surviving for 21 months (Jiang *et al.,* 2008). The first killer whale put on display was captured in 1961, but died only a few days later. The survival rates have gotten better since then and thousands of dolphins, beluga whales and killer whales have been captured and exhibited in marine parks and aquariums around the world (Jiang *et al.,* 2000).

Today
Couquiaud (2005) lists 199 facilities worldwide that keep dolphins and whales for research or public display. However, the same author believes there could be up to 20 facilities not recorded yet in their home countries at the time of the survey that therefore did not appear in the list. Bottlenose dolphins are the most common species displayed and the average group size of cetaceans in captivity is 5 – 7 animals, but not all cetacean groups consist of only one species (Couquiaud, 2005). According to the Orca Homepage there are 42 known

killer whale individuals kept in 11 aquariums or marine parks today, four of which keep only one killer whale.

There are mainly two types of enclosures used for cetaceans in captivity, natural and artificial environments (Couquiaud, 2005). The same author explains that natural facilities keep the animals in fenced sea enclosures and artificial facilities keep them in manmade pools or tanks. Even though natural enclosures are economical and often provide a dynamic environment for the animals kept in them, there are also disadvantages like the difficulty to protect the animals from harmful events like pollution, storms, oil spills etc (Couquiaud, 2005). According to Couquiaud (2005), artificial pools are more costly to both build and maintain, but make it possible to keep cetaceans far from their natural habitats and offer greater control of the animals' environment.

To solicit information from veterinarians, institutional directors and curators, and scientists experienced in the care of cetaceans, Couquiaud designed a questionnaire that included all aspects of cetacean maintenance. In 1996 the questionnaire was sent to 157 facilities all over the world, of which 44 responded. Out of these 44 facilities, the median water surface area available to each animal in artificial facilities was 90.5 m^2, the minimum being 14 m^2 and maximum 195 m^2. In natural facilities the median water surface area per animal was 400 m^2, the minimum 92 m^2 and maximum 1 633 m^2. The median volume of water per animal in artificial facilities was 344 m^3 with a minimum of 46 m^3 and maximum of 1 181 m^3 and in natural facilities the mean water volume / animal was 939.5 m^3 (306 m^3 minimum and 11 333 m^3 maximum) (Couquiaud, 2005).

Examples from San Diego and Kolmården

The Education Department at Sea World in San Diego, California (pers. comm., May 2010) informed me that the Dolphin Stadium is currently under reconstruction, but at the moment they have an interactive area with 10 – 12 bottlenose dolphins called Rocky Point, which is 938 m^2, holds 2.5 million liters of water and averages 3.7 m in depth. 7 adult and sub-adult killer whales, ranging from 5½ years to over 40 years old are kept in Sea World's Shamu Stadium, which has a total volume of 25.4 million liters and with a main pool of 27 x 55 m and 11 m deep.

According to information signs at the dolphin "lagoon" at Kolmården Wildlife Park, Sweden in May 2010 (pers. obs.) the dolphinarium has two main pools and several smaller holding pools. The total volume of water in the facility is 6 400 m^2 and they keep 8 bottlenose dolphins in the facility. Further, the pool used for shows holds 3 200 m^2 and is 4 m deep, while the other main pool, the lagoon, is 3 m deep but has a deeper part that is 6 m, and it contains 2 800 m^2 water (see Fig 1).

Fig. 1. Information sign at Kolmården's dolphinarium, 2010-04-05. Photo: L.Lundin.

Wild-borns, survival rates & longevity
Many cetaceans in captivity are wild-born animals caught for the display industry, although nowadays fewer animals are being captured and no dolphins have been caught for parks in the USA for 20 years (Corkeron, 2002). Even though many marine parks in the Western world try to rely on captive breeding to secure their captive populations, more and more parks are starting up in Asia where laws and regulations about capturing wild cetaceans are limited (Corkeron, 2002). In the whaling season of 2003/ 2004, 78 cetaceans were captured and sold to marine parks by hunters from Taiji, Japan (Rose *et al.*, 2009).

It is difficult to compare survival rates of captive and free-ranging cetaceans, mainly since the data available for free-ranging dolphins and whales is limited and often only includes populations from certain areas (Woodley *et al.*, 1997). Woodley *et al.* (1997) also explain that different methods have been used when calculating wild and captive cetaceans' survival rates, which adds to the difficulty of making a correct comparison. In Woodley *et al.* (1997) survival rates and longevity for both bottlenose dolphins and killer whales were higher for free-ranging animals than those held in captivity, the difference being greater for killer whales where wild whales were expected to live twice as long as captive ones (Woodley *et al.*, 1997). For individuals captured from the wild, survival rates are low and Small and DeMaster (1995) argue that the first 60 days of captivity should not be taken into account when calculating survival rates for wild-born individuals, since the mortality during this time is so high.

Legislation

The laws and regulations regarding bottlenose dolphins and killer whales can differ greatly between different countries. Pool size requirements in USA are that the minimum horizontal dimension (MHD) must be 7.32 m or 2x the average length in adults of the longest species held in the facility and the minimum depth should be no less than ½ the average adult length or 1.83 m, whichever is larger (Williamson, 2006). The pool volume will be sufficient for two individuals if MHD and depth requirements are met. The facility should provide temporary holding pools for isolation, medication, transfer etc, but these pools may be smaller than the minimum requirements but cannot be e used for permanent housing or for longer periods than prescribed by a veterinarian (Williamson, 2006).

In Sweden, the pool size for bottlenose dolphins is regulated by the water surface that shall be at least 800 m^2 (Chapter 7 Section 4 of the Swedish Board of Agriculture´s administrative provisions (SJVFS 2009:92) on the keeping of animals in zoos etc., act L108). If there are smaller pool compartments in the facility, these may not be smaller than 100 m^2. The depth of the pool should be at least the average length of the species housed but one part of the pool must be at least twice the average body length (SJVFS 2009:92). As with the American regulations, water volume will be sufficient if the water surface and depth requirements are met.

Animal welfare

Definition

Duncan and Fraser (1997) write that the term "animal welfare" refers to the moral concern we have for animals based on their ability to have subjective experiences. An animal's welfare refers to its quality of life and many different factors are included, such as contentment, longevity, health and breeding success (Duncan & Fraser, 1997). To be able to address the society's concerns, animal welfare has become a subject of scientific research and public, medial and political discussion (Duncan & Fraser, 1997). However, according to the same authors, it has been difficult to define the term as it does not only involve physical information about the animals, but also human values. A conventional definition does not suffice and to be able to define the term we need to understand the underlying values as well.

Three approaches

In the discussions about what factors are important for animals' welfare and quality of life, three approaches to the subject have emerged. The first is a feelings-based approach, where the feelings and emotions of an animal define its welfare, which means it is important to reduce negative feelings (like suffering and pain) and to promote positive feelings (such as comfort and pleasure) (Duncan & Fraser, 1997). According to Duncan and Fraser (1997) the second approach is functional and refers to that the biological functioning of an animal should be normal or satisfactory if the animal's welfare is to be considered good. Health, longevity and disturbances in behavior or physiology are important measures to this approach (Duncan & Fraser, 1997). The third and final approach looks to the nature of the species and calls for animals to be kept in such ways that they can perform all of their natural behaviors, according to the same authors.

Duncan and Fraser (1997) claim that all three of these approaches to assessing animal welfare have their strengths and weaknesses and that an animal's feelings, biological functioning and natural behavior often affects each other making it difficult to measure just one of these parameters. Their conclusion is that a broad information base gives the best grounds for assessing welfare of animals. Hewson (2003) agrees with this, saying there are limitations to using just one of the approaches, giving the example that an increased heart rate can be a response to both positive and negative experiences. She also states that just because an animal is in good physical condition does not mean the animal feels content.

Discussion

The way in which cetaceans are kept in zoos is very different from how they live in the wild. It is difficult, if not impossible, to keep them in tanks that are similar to their natural environment. For sanitary reasons the water in the tanks is usually chemically treated, making it impossible to add live plants or fish to enrich the tank environment (Rose *et al.*, 2009). The walls of the tanks are often smooth concrete to make cleaning easier, but do not promote the animals' acoustic behaviors, or provide a varying environment.

Pool size and legislation

Pool size is an important issue to address when discussing the welfare of cetaceans in captivity. In the US, the minimum pool size requirements are not much larger than the

animals themselves. Swedish legislation regarding cetaceans does call for larger pools but is otherwise inadequate since only a few sentences concern these species. Wild bottlenose dolphins and killer whales have access to vast volumes of water with endless opportunities to roam freely. According to the Sea World San Diego Education Department (personal communication) the shape and size of their Shamu Stadium are based on the typical length of a nursing bout for a female killer whale and her calf. It is questionable if this is a good method of calculating an appropriate pool size, considering that killer whales can travel as far as 160 km in 24 hours (Baird, 2000). Also, according to Clark and Odell (1999), there have not been many observations of killer whales' nursing behaviors and the information available is brief and the data insufficient. They claim that the difficulties of observing and collecting accurate data from wild killer whales are the reasons for the lack of literature on the subject. Therefore one can wonder what information about nursing bouts Sea World used to base their pool size on.

Hoyt (1992) calculated that the absolute minimum volume of water traversed by a typical pod of resident killer whales in a normal day (24 hours) would be nearly 170 000 million liters, an amount difficult to even grasp. The Shamu Stadium at Sea World San Diego contains 25.4 million liters, a volume almost 7000 times smaller than the minimum requirement calculated by Hoyt.

In the US the minimum size requirements are quite small, not much larger than the animals themselves, but there is a restriction of two animals and if more animals are kept in the pool there is a formula for calculating how much larger the pool has to be. In Sweden, the pools are required to be much larger, but there are no restrictions on how many animals are allowed to be held in the same pool. The pool size requirements cannot be sufficient for an infinite number of animals and how many individuals a facility is allowed to keep in the same pool should be regulated.

The drooping dorsal fins frequently seen in captive killer whales are often brought up when discussing the welfare of these animals. Sea World explains the phenomenon in their FAQ on their website, writing that the drooping fins could be a consequence of the affected individual spending more time at the water surface, leading to the fin not getting any support from surrounding water. They also note that another reason for drooping fins could be that the collagen in the fin becomes more flexible when heated, which could happen through exposure to sunlight. Both of these explanations have to do with the whales swimming close to the water surface, with their fins protruding out of the water, which could be a consequence of pools not being large enough or deep enough. Since the dorsal fin of killer whales can be up to 2 m high (Wells, 2003) it is not improbable that the depth requirement in the US of ½ the average adult length is inadequate, forcing the animals to spend more time at the water surface than they do in the wild.

My suggestion is that pool size requirements should be larger and also that legislation should require a more complex pool environment, such as a varying topography. This would offer a more stimulating environment for the animals, which has proven important to their welfare (Wemelsfelder & Birke, 1997; Couquiaud, 2005). In addition, it could also have a positive effect on the social structures of the groups by providing visual barriers as well as giving individuals places to hide, allowing them to get away from dominant individuals.

Social structure in captivity

The social life of bottlenose dolphins and killer whales plays a large role when assessing the welfare of these species in captivity. Social stressors such as changes within the group, aggression, competition for resources and unstable dominance hierarchies etc, can be very stressful to cetaceans and have a negative impact on their health (Waples & Gales, 2002). Waples and Gales (2002) state that a decline in fitness, reproductive and physiological problems or even death can be the result of an animal being subjected to stress. There are several cases where stress, social stress in particular, was the probable cause of illness and death in captive bottlenose dolphins (Waples & Gales, 2002). To get past the difficulties of proving stress was the cause, Waples and Gales (2002) had a very clear method for their study and included both physiological data and behavioral studies. For all social animals it is important to maintain group structures that are as much alike the species natural group structures as possible.

The social structure of bottlenose dolphins in captivity is far from how they live in the wild since fission/ fusion societies, or any other fluid social networks, are not possible due to confinement in pools. In fission/ fusion societies individuals form small groups that can change in size and composition on an hourly basis (Connor *et al.*, 2000), which is not possible in captivity since the dolphins cannot leave their enclosures to associate with other individuals or groups. It is impossible for animals kept in the same pools to affect their social grouping, being limited to the group that park management has chosen for them, and individuals that would not associate in the wild are forced to do so. Adult bottlenose males are kept within the social unit and cannot disperse to form their own alliances like they would in the wild (Connor *et al.*, 2001). They are also seldom seen interacting with newborns in the wild (Mann & Smuts, 1999), but in captivity the only way to avoid this is to separate the group in different pools, giving them less space to move in compared to if all animals have access to the whole facility.

Neither individuals nor pods from different populations of killer whales have been seen associating in the wild (Ford, 2002), but in captivity wild-born whales from different parts of the world are kept with each other and with captive-born individuals. Since individuals from different populations, or from different communities within the same population do not have the same call repertoires (Ford, 2002) they do not speak the same dialect or language. The killer whales might not use the same foraging techniques or eat the same types of prey (Hoelzel, 1993; Ford *et al.*, 1998). How well do they adapt to living together? And while learning to communicate with one another, it is not farfetched to suppose that they experience a great deal of social stress.

The social life of killer whales has mainly been studied in killer whales outside the coast of Washington and British Colombia (Baird, 2000; Ford, 2002). The information available from this population might not be applicable to other populations of killer whales from other parts of the world. To gain more general knowledge of the social structures of killer whales, other populations must also be observed.

Some facilities keep single dolphins or killer whales as the sole individual of their species. According to the Orca Homepage, 4 killer whale individuals are currently kept alone in facilities in Japan, USA and Buenos Aires. Both killer whales and dolphins are highly social animals that live in groups (Baird, 2000; Connor *et al.*, 2000; Wells, 2003), and it is likely that not being able to interact with conspecifics is very stressful for these individuals.

Therefore, keeping a single individual of one of these species should not be allowed, except under certain circumstances, such as temporarily separating an animal from its group due to health reasons. This would ensure they get their basic needs of social interactions fulfilled and eliminate unnecessary stress caused by solitude.

Captive breeding

According to Connor *et al.* (2000) wild bottlenose dolphins give birth every 3 – 6 years, but every 2 – 3 years in captivity. Giving birth more often than they would in the wild could be strenuous on the females and have a negative impact on their health. Also, some parks breed hybrids of different dolphin species and killer whales from populations with genetic differences (Rose *et al.*, 2009). These hybrids have no conservation value and if the hybrids themselves are used for breeding there will be a growing number of animals with questionable genetic backgrounds. Even if we disregard the fact that neither bottlenose dolphins nor killer whales are threatened, this type of breeding is counter to the claim of aiding conservation made by marine parks and aquariums. Justifying the keeping of these species for conservation reasons could therefore be considered preposterous.

Wild-caught animals

One problem with wild-caught animals (other than the ethical concerns) is that they are often very young and still dependant on their mothers when they are caught. As of 2010, most of the 13 captive killer whales known to be wild-born, were captured at 1 – 3 years of age, and none were older than 4 (The Orca Homepage, 2010-05-16). Killer whales stay with their mothers for several years, probably depending on them until at least the age of 6 (Baird, 2000), and some never leave their maternal group. One can wonder how being separated from their mothers at such an early age affects these individuals, and also how their young age affects their adaptation to captivity and a new social group.

Taking wild individuals from their families has a great impact not only on the captured animals but also disrupts the pod that they are taken from, which has to deal with the loss of a group member. The knowledge that many cetacean species stand by and defend sick or threatened group members (Fordyce & Gill, 1998) shows that the loss of a member is probably a stressful event for the group. The wild-caught animals have to deal with both losing their family and all previous social bonds and have to adjust to a new social environment where they, not being able to leave the area, cannot avoid stressful social situations like aggression from other individuals.

According to Small and DeMaster (1995) the first 60 days of captivity should not be taken into account when calculating survival rates for wild-born individuals, since the mortality during this time is so high. In my opinion the high mortality rates during this time is a strong indicator that being caught is extremely stressful for the animals and that the welfare of these newly captured individuals is far from sufficient. However, if the stress of being caught is not considered relevant, Small and DeMaster (1995) were right to not count the first period of captivity. Also, Woodley *et al.* (1997) note that it is difficult to compare the survival rates of wild and captive cetaceans due to differences in calculation methods. Standardizing a method for calculating the survival rates would be beneficial for both researchers and animals.

Because of the negative impacts live captures have on both the captured individual and its former group, these captures should be banned worldwide. The current practice of

capturing wild individuals to obtain more animals cannot be justified and therefore marine parks and aquariums should establish and follow captive breeding programs eliminating these live captures.

Temperature and communication

Another problem with combining animals from different wild populations for dolphins are that bottlenose dolphins are widely spread throughout our oceans and consequently are used to very different water temperatures depending on where they live. Even though dolphins and killer whales can tolerate and adapt to other temperatures, Couquiaud (2005) states that it is critical to the animals' health that the water temperature in their tanks is the same as in their original habitats. Therefore, when keeping individuals from different parts of the world in the same pool, at least some of them will be forced to adapt to new temperatures, which could be stressful and have a negative impact on their health.

Because of the way tanks and pools are built, captive dolphins and whales cannot escape acoustical interference. Sounds, both made by the animals themselves and by humans, bounce off the walls and produce unnatural echoes in the pools. This can cause aggression, endocrine changes, loss of appetite and even irreversible hearing loss (Couquiaud, 2005). The acoustical environment is a very important part of these animals' lives, but at the same time an aspect that is often neglected in captivity. It is critical to reduce and avoid excess noise so that the animals do not need to suffer health problems from such acoustical disturbances.

Stereotypic behaviors

Stereotypies in bottlenose dolphins and killer whales has not been the focus of much research and therefore it is not clear what behaviors should be considered stereotypic. But according to Couquiaud (2005) certain behaviors, such as swimming in small circles, do tend to occur when individuals are held in environments without diverse stimuli, are kept alone or subjected to other environmental stressors. More research needs to be done on stereotypic behaviors of these species to ensure we do not keep them in environments they cannot cope with and which frustrate them. It is also important to not only look at the size of the pools and enclosures dolphins and whales are kept in, but also the shape and complexity. This is in agreement with Couquiaud (2005) who states that offering an enriched and complex environment to captive cetaceans affects the prevalence of behaviors that could be considered stereotypic.

One reason for the lack of research in the area could be that most captive dolphins and killer whales are owned by marine parks and aquariums who want the public to believe there are no welfare issues with keeping these species. If stereotypic behaviors were to be documented this would be evidence that there are at least some shortcomings in their environment. It is important to establish a good relationship with these facilities so research opportunities can be provided and welfare improvements made based on this research. This would be beneficial not only to the animals but to the parks themselves.

Cognitive issues

The fact that bottlenose dolphins and killer whales show high cognitive skills (Reiss *et al.*, 1997; Gallup, 1998; Delfour & Marten, 2001; Pack & Herman, 2006) further emphasizes the importance of the welfare of these species. If these species indeed are self-aware, they understand that what and how they do something will affect their situation and produce

different outcomes, and could possibly also mean they want to have some control over their situation and environment. If they are kept in slick pools without any enrichment they have no way of controlling or manipulating their environment or situation, which could prove to be stressful for them. On the other hand, their tool use in the wild (Smolker *et al.,* 1997) and their self-awareness should mean that a variety of environmental enrichments could be used successfully with these animals to improve their welfare.

Most research of these species' cognitive abilities is conducted on dolphins and on very few individuals. For example, even though their method was very clear, Reiss and Marino (2001) only used two dolphins in their study, which makes it questionable if their results can be applied to all dolphins or just the two individuals tested. More research is needed on a larger number of animals, especially killer whales, so that we can truly understand their level of intelligence. More knowledge on these species' cognitive abilities can help us comprehend how they perceive their environment and to asses if the keeping and displaying of them is justifiable.

Enrichment

In captivity animals' environments tend to be highly predictable and structured with no or infrequent challenges and not being challenged enough also has a negative impact on welfare (Wemelsfelder & Birke, 1997). Many marine parks and aquariums say they use a variety of environmental enrichments to make their animals' lives more complex. When searching for literature on enrichment for cetaceans, there was not much to be found. One would think that the water medium these species live in could offer valuable research opportunities in this field. For example, how would adding currents or using jets to shoot out fish into the pool, offering hunting possibilities, affect the animals? Many zoos today want to display their animals in enclosures resembling the animals' natural habitats. This in itself offers a more complex environment and should be adapted by parks keeping marine mammals. Even though parks and aquariums cannot replicate ocean habitats, they could at least, as I have mentioned earlier, offer a varying topography in their pools.

Future studies

There is a need for more scientific literature on both bottlenose dolphins and killer whales. The lack of several studies on the same subjects leads to uncertainty that the results found are accurate or generally applicable. Without more research on both wild and captive bottlenose dolphins and killer whales, it will continue to be very difficult to assess the welfare of these animals. If I had limited myself to one of the two species studied, that would have allowed a more thorough investigation of the species and a more in-depth discussion. This paper should be considered a basic investigation into the welfare of bottlenose dolphins and killer whales in captivity, as well as what impact their biology and how they are kept has on their welfare. As it brings up many areas of concern and offers a broad view of what needs to be researched more thoroughly, this paper could be used as basic information and an introduction into the subject.

Conclusions

I have drawn the following conclusions from my research for this paper:

In the wild, bottlenose dolphins and killer whales inhabit waters all over the world and there are large variations in diet, foraging techniques, communication etc. They are highly social animals that live in complex social societies.

Bottlenose dolphins and killer whales are kept in a variety of different ways in parks all over the world. In 2005 there were at least 199 facilities that kept cetaceans for research or public display and currently there are 11 parks that keep killer whales. They are usually kept in pools larger than the minimum size requirements but are made of slick concrete without much variation. Legislation should require a more complex pool environment. Even though more and more parks rely on captive breeding there are still animals being captured from the wild and sold to the display industry. Live-captures should be banned worldwide due to the negative impacts it has on the animals affected.

There is little research on the welfare of bottlenose dolphins and killer whales in captivity. It is not clear what parameters are important or what indicators could be used when assessing their welfare. Valuable research opportunities could be provided if good working relationships are established with facilities keeping these species. It is difficult to keep bottlenose dolphins and killer whales in a way that resembles their natural life and captivity has great impact on many of their natural behaviors like foraging, redproduction, social interactions and communication. Keeping the animals in well-functioning social groups similar to how they live in wild is essential. To make this evaluation of captive bottlenose dolphins and killer whales easier, I should have limited myself to one of these species. However, it is my conclusion that it is very difficult to keep these species and maintain a satisfactory animal welfare.

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