WDCS

Whale and Dolphin Conservation Society

Orcinus orca a Species Complex

WDCS document providing information in support of the nomination of *Orcinus orca* as a species complex to Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals.

Prepared by:
WDCS, the Whale and Dolphin Conservation Society with contributions from (in alphabetical order):

Luciano Dalla Rosa
Museu Oceanográfico - FURG, Brazil

Erich Hoyt
Far East Russia Orca Project and WDCS, UK

Miguel Iñíguez
Fundación Cethus, Argentina

Mario Morcillo Moreno
Sociedad Oceanica de Cetaceos, Spain

Margie Morrice
Deakin University, Australia

Martin Taylor
Center for Biological Diversity, USA

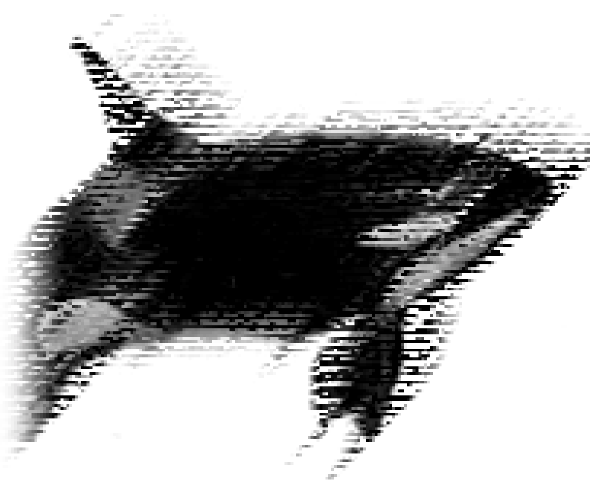
Vanesa Tossenberger
Fundación Cethus, Argentina

Ingrid Visser
Orca Research Trust, New Zealand

and

Margi Prideaux, Mark Simmonds and Sarah Dolman
WDCS, the Whale and Dolphin Conservation Society

WDCS, the Whale and Dolphin Conservation Society, is the global voice for the protection of cetaceans (whales, dolphins and porpoises) and their environment. Our objectives are to reduce, and ultimately, eliminate the continuing threats to cetaceans and their habitats, and to raise awareness of cetaceans and educate people about the need to address the continuing threats to their welfare and survival. WDCS achieves these objectives through a mix of campaigning, conservation, research, education and awareness, and representing the interest of whales and dolphins at appropriate national and international fora. WDCS is unique in combining concern for the welfare of animals with efforts to ensure the protection of whale species, unique populations and their habitats. WDCS has headquarters in the UK with offices in the US, Germany and Australia.



Executive Summary

This document shows that the species known as orca (*Orcinus orca*) is actually a widely spread species complex, divided into a number of defined and non-defined populations. Orcas are threatened by a range of factors and some populations – where data are available – are at risk of extinction. Specifically:

- Orca are a migratory species and in some cases are likely highly migratory species.
- Orca populations are likely small. Most known populations number fewer than 500 animals.
- Orca are a long-lived, slow breeding species and are therefore susceptible to a range of threats.
- Orca have high levels of bio-accumulation and are regarded as amongst the most vulnerable wildlife to chemical pollution.
- Orcas are effected by noise pollution which may also result in a displacement from habitat.
- Orca are increasingly threatened by directed takes, intentional killing and removal by the captivity industry.
- Orca are equally susceptible to climate change as other high order predators in the ocean.
- Orca will benefit from international cooperation and conservation mechanisms to mitigate these threats.

Orcas are large, long-lived and slow to mature. They have few offspring and a high parental investment in young. Orcas are apex predators, that have a low fecundity and a high rate of mortality for young calves. Hunting and habitat degradation pose a serious threat to the existence of these toothed whales. Indeed, orcas can be regarded as amongst the most vulnerable wildlife to chemical pollution. Orca habitats in populated coastlines are invariably polluted to varying degrees with persistent organic pollutants (POPs), and heavy metals as well as radionuclide contamination prevalent in the Arctic and sub-Arctic coastal regions. They are also impacted by raised levels of sediments and nutrients. The extent to which fecundity and survival have been impaired by POPs and heavy metals is still unknown, but much circumstantial evidence suggests that pollutants are a significant threat to existence for many populations.

There is also considerable evidence that orcas are affected by noise pollution, especially where they have to pass through narrow straits and sounds in the course of migration and have less room to manoeuvre and escape from loud noise and vessels. Seismic operations, such as the use of air guns in oil and gas surveys, may also disturb the natural movements of orcas, and their prey. Continuous noise pollution, especially if conducted in normal migration pathways, may lead to permanent avoidance of critical habitats.

While moving or migrating, orcas are exposed to ship strikes and fishing gear entanglements. There are an important series of interactions between orcas and various fisheries, including killing in response to predation on commercial longline and dropline fish catches, that requires urgent management.

Intentional killing by fishermen and marine mammal hunters have been historically widespread and orcas have been the subject of hunts in Greenland, Indonesia, Japan and the Lesser Antilles. Orcas have been hunted as recently as 2002 in Greenland and St Vincent and the Grenadines. The number of mortalities during captures for live trade has also been substantial, particularly in the early phase in most areas where captures have occurred.

Correlation between marine mammal die offs and climatic anomalies have been identified. Climate change affects ocean productivity and poor prey availability may trigger disease outbreaks in these mammals, also mobilising blubber stores and so releasing bio-accumulated immunotoxic pollutants. The global increase in harmful algal blooms may also affect orcas directly and indirectly. Orcas also appear to have distinct home ranges and so shifts in climate may bring about changes in distribution with unknown consequences.

The cumulative and synergistic effects of these threats are an important consideration for management decisions and for future research focus. They further intensify the case for the listing of all orcas on CMS Appendix II, to ensure a precautionary position is taken in the face of inconclusive, but compelling, information.

There are many small and distinct orca populations around the globe, although orca taxonomy is not yet fully understood, the term species complex seems to be appropriate. As more research is focused on orcas in regions beyond the northeast Pacific and northeast Atlantic, the status of the various populations and forms may become clearer and will likely develop to fully reflect the diversity of behaviours.

It is known that orca movements, including long distance movements or migrations, are strongly influenced by the distribution, movements and life history cycles of their preferred prey, although orcas, unlike baleen whales and some other large toothed cetaceans, appear to have less defined seasonal migration patterns. In many populations studied, however, it is clear that seasonal movements or migrations do take place. In some instances this migration occurs on the high seas and there is evidence that individuals occupy very large ranges and the proportion of time spent in different parts of their ranges may vary seasonally. Known migrations are extensive and probably typical, indicating that many populations can be expected to cross numerous national jurisdictions on a regular basis.

The success or decline of a population is usually judged by whether the population is increasing, decreasing or

stable. To be able to make this judgement requires that a discrete population unit can be identified and then monitored over time. This has been done for some orca populations, but they are the exception rather than the rule. Anecdotally we know that there are many regions where orcas are known to occur, but almost no documented survey work has been conducted.

Orcas are highly social animals and thus the loss of even one individual, especially from such small populations, may cause harm to others within its population.

Whitehead *et al*. (2000) has commented that *"it is increasingly recognized that our understanding of cetacean biology and population dynamics is going to remain inadequate in the foreseeable future. Thus following the precautionary principle, we need to be prepared to act …."*.

The fundamental principles of the CMS state that all the signatory parties acknowledge the importance of migratory species being conserved (Art II paragraph 1). In all conscience, with the evidence available, Parties to this agreement are bound by its fundamental principles to recognise the uncertain status of this species complex and the need for cooperative conservation and to afford them the protection of Appendix II listing on this convention, with the ultimate aim of concluding agreements to address the priority threats to these species.

This document will review what is known about the documented threats, the distinct populations and forms, population estimates and the migratory nature of populations of this species complex.

Short comments are also included about whale watching and its growing importance relating to orcas and about future research priorities and the relevance of Appendix II listing.

Margi Prideaux
WDCS, the Whale and Dolphin Conservation Society
August 2002

WDCS Recommendation:

That *Orcinus orca* (orca) be listed under Appendix II as a species complex in recognition of the precautionary principle and in response to the uncertain status of the many small and potentially threatened populations; and the value of cooperative management of the wide and complicated range of documented but little understood threats that they face.

Contents

Orcincus orca

Orcinus orca

Class	Mammalia	
Order	Cetacea	
Family	*Delphinidae*	
Genus and species		
	Orcinus orca complex (Linnaeus 1758)	

Common names

English	killer whale, orca
Russia	kosatka
France	épaulard, orque
Portugal	orca
Spain	orca
Norway	spekkhogger
Japan	Shachi, sakamata
Korea	innuata

Killer whales or orcas in the *Orcinus orca* complex have a black body with characteristic white markings, with a white region that extends from the tip of the lower jaw towards the flippers, where it constricts medially and then widens slightly towards the tail. A lateral white flank patch connects to a ventral white patch on each side of the animal in a trident-like design. The ventral side of the fluke is also white or a light gray and may be bordered in black. A conspicuous white patch is located slightly above and behind the eye, and a variable grey or white saddle is usually present behind the dorsal fin. The shape of the saddle varies among individuals, pods and from one side of an individual to the other (Baird and Stacey, 1988). The saddle patch is indistinct in young individuals, becoming more obvious as the individual matures. Orcas are the largest of the delphinids and one of the most strikingly pigmented cetaceans in the world.

Body size, flipper size and height of the dorsal fin is different between males and females. Females attain a body length of up to 7.7 meters, while males reach 9.0 meters, although the maximum size of some populations can be considerably less. In adult males, the dorsal fin is erect and may be from 1.0 to 1.8 meters tall, whereas the dorsal fins of females are less than 0.7 meters and curve to a point. The head is somewhat rounded with a slight demarcation of a beak. Although few animals have been weighed, weights of 3810kg for a 6.7m female and 5568kg for a 6.75m male have been obtained (Dahlheim and Heyning 1999). Juvenile males can only be distinguished from adult females once their dorsal fins take on a straighter/less falcate shape.

The life cycle of the most studied populations of orcas in the northeastern Pacific begins with a gestation period of approximately 17 months (Walker *et al* 1988). The first six months of infancy is marked by an estimated mortality rate of 43%, although a lower estimate of annual calf mortality of 11.5% has been reported for resident orcas in the northeastern Pacific (Olesiuk *et al* 1990; Taylor and Plater 2001). Nursing occurs throughout the first and second year of rearing, although there is evidence that calves will also eat some solid foods shortly after birth (Heyning and Dahlheim 1988). A juvenile period of up to 10 years follows, extending into an adolescent period of 3-5 years (Olesiuk *et al* 1990).

Sexual maturity for males is evident when defined as the time that the male's dorsal fin can be distinguished from a female's dorsal fin (Baird and Stacey, 1988; Bigg *et al*., 1987). This occurs between 11 and 17 years of age, with an average of 15 (Olesiuk *et al* 1990). Female sexual maturity generally occurs between the ages of 12 and 16 years, with an average of 14 (Taylor and Plater 2001). Calving intervals average 5 years, indicating that an average female orca can theoretically produce between four and five calves during her lifetime (Olesiuk *et a*, 1990). In practice most females give birth to fewer offspring and cease reproduction at 40 years of age (Taylor and Plater 2001) but live on average 10 more years. The life cycle of other populations is poorly studied

The well studies populations of orcas are polygamous. These females come into oestrus or "heat" several times during the year. Observations of females in aquaria indicate that orcas undergo periods of multiple oestrus cycling, interspersed with periods of non-cycling. This period is highly variable, as is the period of non-cycling, both for one whale over time and between whales. Although breeding may occur in any season, in the northeastern Pacific it is most common in the summer (Dahlheim and Heyning 1999). It is unknown if this can be generalized to other populations and other regions. A small calf with its pod has been sited well inside the Antarctic sea ice during the austral winter (Gill and Thiele 1997).

Early data suggest that orca live an estimated 25 years. The maximum longevity may be 35-40 years (Dahlheim and Heyning 1999). However, average life expectancy for the well studied Vancouver Island residents has been calculated at approximately 29 years for males and 50 years for females, with an expected maximum longevity of 50-60 years for males and 80-90 for females (Olesiuk *et a*, 1990). An adult male off Patagonia is known to be approximately 42 years old (M. Iñíguez, *pers. comm*., 2002). An adult female in New Zealand waters is known to be at least 30 years old (Visser 2000). Southern residents of the northeast Pacific population had an average age at female death of 50 and maximum 68. The average age at death for males was 27.6, with a maximum of 43 (Taylor and Plater 2001).

If orcas are considered as a single species, their prey is extensive: including many marine mammals (including other cetaceans), many fishes, sharks, cephalopods, birds (including penguins), seabirds and sea turtles. Orcas attack and kill whales, including mature blue whales (Cotton 1943; George *et al* 1994; Hoyt, 1990; Jefferson *et al* 1991; Shaughnessy 2000; Pitman *et al* 2001). Some authors have suggested that the migrations of some baleen whales are an adaptive response to avoid orca predation on their young (Corkeron and Connor 1999). The wide-ranging movements of orcas may be in turn a further adaptive response to baleen whale migrations. Such has been suggested for humpback whale migrations along the east and west coasts of Australia (Anderson and Prince 1985; Janetzki and Paterson 2001; Paterson and Paterson 2001). Orcas are highly social and display differentiation into distinct cultures and language groups, similar to that found for humans (Rendell and Whitehead, 2001).

Orcas are large, long-lived and slow to mature, they have few, offspring and a high parental investment in young. As orcas have a low fecundity and a high rate of mortality for young calves, hunting and habitat degradation pose a serious threat to the existence of these whales.

Causes of natural mortality are rarely determined. There are no scientific records of orcas being attacked by any other predators, although predation on infants and/or sick individuals cannot be ruled out. Parasitism and disease have been recorded for orcas, but no severe infestations or epidemics have been recorded (Calambokidis and Baird 1994; Baird 1999). There is a documented case of an orca killed by stingray barbs. (Duignan, *et al* 2000).

Autopsies on stranded whales in Australia have found a stomach filled with plastic bags and fishing line, and another with pieces of dolphin flesh that had been cut with a blade. Although it could be assumed that these played a major role in the death of the animal, no direct cause of death could be determined (Morrice unpublished data; Gibbs 2001).

Populations have been reduced through direct culls, hunts and live captures for the aquaria trade. Indirect human impacts from pollution, habitat degradation, and over-fishing are also factors in current orca mortality.

Documented threats to orcas

The IUCN has not currently listed orcas as Endangered or Vulnerable, however this is based on a monolithic view of orcas that is not in accord with evidence put forward in this document. The data presented in Appendix 1 suggest that, with the possible exception of Antarctica (where the populations may be sympatric, yet still distinct) orcas are distributed into small distinct populations around the coastal and shelf waters of the globe. Some of these populations are subjected to interaction with fisheries and hunting, prey depletion by fisheries, vessel strikes, fishing gear entanglement, noise pollution and oil spills. As apex predators, depending on dietary specialisation, they are especially subject to bioaccumulation of organic pollutants.

After much discussion on this, during the 50th meeting of the IWC, the Scientific Committee confirmed “environmental change” as a looming threat to whale populations and their critical habitats. The meeting discussed the impacts of climate change, chemical pollution, physical and biological habitat degradation, effects of fisheries, ozone depletion and UV-B radiation, Arctic issues, disease and mortality events and the impact of noise (IWC, 1998) and resolved an ongoing work program for continued investigation.

The large scale travel and migration routes and even primary feeding areas of many orca populations lie across international boundaries making it difficult, in many areas of the world, for individual countries to develop effective conservation instruments. Conservation instruments available to address these threats are often discrete and often not well applied nationally or internationally (Prideaux, 2002). For example, although Canada has listed the southern resident population as endangered, the United States recently declined to do so (Stiffler and McClure 2002). The geographical range of many orca populations and the overlay of State and international jurisdictions they inhabit further complicate single State management (Prideaux, 2002).

Contaminants

Orca habitats in populated coastlines are invariably polluted to varying degrees with persistent organic pollutants (POPs), heavy metals and raised levels of sediments and nutrients. This is particularly an issue for the coastlines of industrialised countries. The extent to which fecundity and survival has been impaired by POPs and heavy metals is unknown, but much circumstantial evidence suggests that pollutants are a significant threat to existence for many populations.

Orcas that eat mammals accumulate extreme body burdens of organochlorines many times the levels at which reproductive impairment has been observed in pinnipeds (Calambokidis and Baird 1994; Jarman *et al* 1996; Law *et al* 1997a; Ono *et al* 1987; Ross *et al* 2000; Watanabe *et al* 1999; Ylitalo *et al* 2001). A transient orca found dead in early 2002 on the Olympic Peninsula of Oregon, USA had the highest level of PCBs ever found for an orca, and among the highest recorded for any cetacean (McClure 2002b). Populations that have a close proximity to industrial sources within their intracoastal habitat appear to have higher body burdens of PCBs (Ross *et al*., 2000). Higher body burdens of PCBs have been associated with higher stranding rates in striped dolphins in the Mediterranean (Marsili *et al* 1997; Marsili and Focardi 1997). Simmonds and Mayer (1997) presented the case for synergistic effect of starvation on POP mobilisation, immune dysfunction and disease outbreaks.

Contamination of marine life with immunotoxic organochlorines and heavy metals is known from many locations throughout the world. Aerial, water and biological transport can carry pollutants far outside the locality of contamination (Dalcourt *et al* 1992; deSwart *et al* 1996; Focardi *et al* 1996; Hargrave *et al* 1992; Harzen and Jbrunnick, 1997; Hernandez *et al* 2000; Law *et al* 1997a; Law *et al* 1998; Law *et al* 1997b; Marsili *et al* 1997; McCain *et al* 2000; Minh *et al* 1999; Moessner and Ballschmiter 1997; Muir *et al* 1996; Muir and Norstrom 1991; Ross *et al* 2000; Tanabe *et al* 1998; Watanabe *et al* 1999; Ylitalo *et al* 2001).

Another little studied threat is the radionuclide contamination prevalent in the Arctic and subArctic coastal regions, the scale of which has only recently become apparent (Crane *et al*., 2000).

In major oil-producing areas, oil spills are a serious threat to existence for orca populations. Orcas spend a large portion of time at or near the surface. Oil can poison orcas directly or though inhalation toxicity and can contaminate the food web upon which they rely (Volkman *et al* 1994)

The Exxon Valdez oil spill in Prince William Sound, Alaska provides the only well documented instance of oil spills killing and impairing orcas. The AB resident and the AT1 transient pods were observed swimming through oil. In the following two years, 14 whales were reported dead (Ford 2002). The dorsal fins of two adult males folded after the oil spill and both males died in 1991. The pod has had poor recruitment since then. The AT1 transient pod lost half its members after the oil spill, and have not successfully recruited any calves since then. Some synergy with organochlorine contamination is suspected but not proven (Matkin and Saulitis 1997; Matkin *et al* 1998). Oil spills may also have indirect effects on orcas by reducing prey abundance (Ford 2002; Volkman *et al* 1994).

As apex predators orcas are amongst the most vulnerable wildlife to chemical pollution. Management and mitigation of this threat will require State and international action as well as the appropriate identification and cooperative protection of critical habitat.

Noise and harassment

It has been shown that orcas use complex communication systems (Miller and Bain, 2000; Moore *et al.* 1988; Thomsen *et al* 2001; Deecke *et al* 2000; 1999). Sound is also used by cetaceans for navigation, as well as for other important biological activities including breeding and feeding. Interference with this ability is a potential threat to survival.

Whales that have to pass through narrow straits and sounds in the course of migration have less room to manoeuvre and escape from loud noise, fishing gear, vessels and pollutant discharges. Seismic operations, such as the use of air guns in oil and gas surveys, may also disturb the natural movements of orcas, and their prey, if conducted in normal migration pathways. Stone (2001) has reported that orcas were seen more often when airguns were not firing in UK waters

Military exercises can also interrupt whales' critical migratory, feeding and breeding patterns. A mass stranding of beaked whales in the Bahamas in March 2000, during U.S. Navy operations, confirmed that cetaceans are extremely susceptible to interference and injury by loud sonar signals (Balcomb and Claridge, 2001). Studies of noise relating to orcas are largely focused on boating impacts on the residents of the northeastern Pacific. Harassment and noise from whale watching boats is an increasing concern in areas such as Puget Sound where whale watching has become popular in recent years (Erbe, 2000). The potential of disturbance from whale watching will need ongoing assessment as it is an increasingly popular activity in all of the industrialised countries and tourist destinations of the world.

A variety of concerns have been raised about the potential of whale watching to harm orcas (Kruse 1991; Osborne 1991; Duffus and Dearden 1993; Phillips and Baird 1993; Williams *et al* 1998). The vessels used for whale watching can produce high levels of underwater sound in close proximity to the animals. The factors most affecting the noise levels are the distance from the cetacean and vessel speed and, to a lesser extent, vessel type (McCauley *et al* 1996).

Bain (2002) states that a shift from primarily large, low RPM vessels to small, high RPM vessels that may have resulted in an increase in the average noise exposure experienced by whales in the southern resident northeast Pacific population.

In the Bay of Islands, New Zealand, there has been an increase in the number of boats looking for and targeting cetaceans (based on the number of boats with marine mammal permits) Coinciding with this increase in permits from 1992 to 1994, there was an apparent increase in the number of reports of orcas in the Bay of Islands. However, after 1994, the number of orca sightings has apparently declined, in spite of more boats targeting and reporting sightings. (Visser, 2000)

Numerous behavioural changes have been reported in response to close approaches by boats, although some studies have methodological problems (Duffus and Dearden, 1993). The implications of such changes in behaviour on reproduction or mortality are unknown. Southern residents seem to engage in less resting behaviour coincident with the large increase in whale watching activity (Osborne, 1986) and also expend significantly more energy evading boats as measured by respiration rates (Kriete 1995). The noise level of boats circling orcas is already considered to be very close to the critical level assumed to cause permanent hearing loss over prolonged exposure (Erbe, 2000). Masking of orcas calls has been recorded over 14km (Erbe, 2001). This could reduce detectability of prey (Trites and Bain, 2000).

Bain and Dahlheim (1994) found that noise could mask echolocation and impair communication required for cooperative foraging. Bain (2002) calculated that above ambient noise levels, the noise from whale watching vessels will increase masking and reduce echolocation range. Therefore prey must be closer to the whale for it to be detected. Bain (2002) calculated that a reduction in prey of 80% or more was possible off San Juan Islands.

Simmonds and Dolman (2000) list the physical, behavioural and perceptual impacts that may be associated with acoustic pollution. Continuous noise pollution can lead to permanent avoidance of critical habitat (Erbe, 2000). Some populations may be much more dependent on clicks and echolocation than others and communication is likely to be impaired by vessel or other industrial noise such as seismic testing, drilling, pile-driving and dredging (Barrett Lennard *et al*., 1996). Erbe (2000) indicates that the cumulative effect of multiple vessels would be expected to cause interference and potentially even hearing damage to orcas. Further, in Juan de Fuca and Haro Straits, the orcas live in a commercial shipping lane, which means they are subjected to constant and increased background noise levels.

A more recent source of noise pollution is the noisemakers used to repel marine mammals from aquaculture farms. Noise pollution from these devices results in extensive exclusion of orcas from otherwise suitable habitat (Morton and Symonds, 2002).

Williams *et al* (2002) view boat traffic as one factor that can influence the 'cost of living' for whales. Low levels of disturbance may not be problematic in a thriving population, but when coupled with reduced prey availability and increased contaminant load, short term behavioural responses should not be dismissed lightly.

There is considerable evidence that orcas can be, and in many cases are, significantly affected by noise pollution and when coupled with other threats such as chemical pollution, the cumulative impact may be considerably higher than noise pollution considered in isolation.

Vessel strikes

While moving or migrating, orcas are exposed to ship strikes and fishing gear entanglements. The increase in oceanic shipping, inshore boat traffic and fishing activities increases the likelihood of collision and entanglement with whales.

Ship and boat strikes appear to be uncommon, although there is evidence for multiple boat strikes in New Zealand waters (Visser 1999b; Visser and Fertl, 2000) as well as incidences in British Columbia (Baird, 1999). Much depends on the number and density of fast boats in critical habitat areas as well as the lack of speed and range regulation.

The number of fast moving vessels is increasing and although data is not available at present to enable a thorough assessment of this threats, a precautionary position should be taken in light of increasing vessel speed and traffic.

Fisheries Interaction

A direct threat to orcas is killing in response to predation on commercial fish catches, in particular the long-line tuna fishery in the Indian Ocean (UNEP/CMS 1991) and possibly the South Pacific (Young 2000). Orcas are known to feed off the longlines before the catch has been hauled in by the vessel. This places the orcas in direct conflict with the fishing industry who try to deter and often kill orcas in the vicinity of the boats, in an effort to protect their catch. This threat remains as much a concern as it was during the original CMS listing of the northeastern Atlantic population of orcas.

In southern Brazil, a female orca was incidentally caught on a monofilament longline, but escaped alive (Dalla Rosa, 1995). Harpooning and shooting have also been reported by fishermen in this region (Dalla Rosa, pers. comm; Secchi and Vasque Jr., 1998).

Near the islands of South Georgia, interactions between longlining operations for Patagonian toothfish (*Dissostichus eleginoides*), orcas and sperm whales (*Physeter macrocephalus*) have been reported. Orca feeding on long line fisheries is also known from the southern coast of South America and the Falkland Island/Islas Malvinas (Ashford *et al.,* 1996).

There is also a reported interaction with the fisheries that use trap net to catch tuna, between April and June, off the Cadiz coast, Spain and also in the Atlantic waters off Morocco and Spain on. This continues between July and August in the trap net fisheries in Spain, Morocco and the Spanish colony of Ceuta, Africa, in the Mediterranean Sea. Moroccan and Spanish fishermen have reported a high incidence of predation by orcas and indicate the problem is increasing (Morcillo Moreno, pers. comm.)

Interactions between orcas and fishers in Australian waters are documented for longline and dropline fisheries that target deep sea trevalla and southern bluefin tuna in South-east Australia (Tasmanian Fisheries Development Authority 1981, McManus *et al* 1984; Bell *et al* in prep; Morrice *et al* in prep). Australian observers aboard Japanese longline fishing boats in the Australian Fishing Zone between 1987 and 1997 recorded interactions between marine mammals, including orcas, and the fishery. Bell *et al* (in prep) describes over six direct interactions with orcas including one that was hooked and released alive, whales chasing and/or eating fish and sharks from lines, and damage to fish gear. One report of a dead whale caught on the line that was cut and discarded is suspected to have been an orca. A survey and assessment of drop-line fishers operating off south-east Tasmania estimated that over a ten day period in 1980, during August to September, orcas took 10 percent of the landed catch (Tasmanian Fisheries Development Authority 1981). Other surveys and accounts indicate that orcas can be sighted near the fishery all year round, the whales target some vessels more than others and shooting of whales is said to occur. Fishers responses to minimise interactions with orcas in this region have included changing fish gear, temporarily moving away from the target area, and in more dramatic cases in Tasmania, they have permanently shifted from the region or have changed their target fish species (Morrice *et al* in prep; Gales pers. comm.). It is clear this issue needs to be quantified for this region, and that the implications for orca populations needs to be considered when moving any fishery to longline or dropline eg. Patagonian toothfish fishery in the Southern Ocean (Morrice pers. comm.).

Interactions between tuna longlines and orcas (and other “black fish”) have been reported by fishers in the Indian Ocean Tuna fishery (Prideaux pers. comm.)

In Alaska, fishers have been known to shoot orcas that were taking sablefish from long-lines, and a survey of the Bering Sea in 1990 documented five of twelve pods encountered had evidence of bullet wounds (Read, 1996). Similarly fishers in Iceland have believed orcas to be in competition as well as damaging fishing gear (Earle, 1996; Reeves and Leatherwood, 1994).

Countries with protective legislation, whale watching operations or public education programs have seen reductions in such killings, but illegal killings are likely to be continuing particularly for longline fisheries which are highly attractive to orcas (Heide- Jorgensen, 1988; Secchi and Vaske, 1998; Visser, 2000; Yano and Dahlheim, 1995). Entanglements have been reported in British Columbia, though few have resulted in death (Barrett-Lennard, 2000) and orcas are known to be taken as bycatch in gillnets in some parts of the Indian Ocean (Leatherwood *et al* 1991) and probably elsewhere (Reeves and Leatherwood, 1994).

Penalty provision in many jurisdictions, low level of independent observer coverage and de-centralised data collection suggest that incidences of interaction and bycatch are either poorly, or possibly under, reported.

There is sufficient evidence, and cause to suspect a wider incidence of interactions that require urgent management.

Direct take

Intentional killings by fishermen and marine mammal hunters have been widespread. The 1994-1996 Action Plan for the Conservation of Cetacean states that orcas have been the subject of hunts in Greenland, Indonesia, Japan and the Lesser Antilles (Reeves and Leatherwood 1994).

Commercial whalers have taken large numbers orcas - particularly in Norway where total estimated takes are as high as 2500, in Japan where total estimated takes are as high as 1500 and the former Soviet Union where total estimated takes are as high as 2000 (of which 1,644 were killed by Russian whalers in the Antarctic, and 300 in waters of the former Soviet Union) (Dahlheim and Heyning, 1999). Blubber-Oil formerly taken from orcas is of inferior quality, low yield and is now completely substituted by other superior synthetic products. With the ban imposed by the International Whaling Commission (IWC) on factory ship whaling of species, including orcas, this intensity of hunting has diminished, although orca hunts continue.

The most recent hunts have taken place in Greenland and St Vincent and the Grenadines (IWC 2002). Greenland hunters killed over 30 orcas as recently as early 2002. It was claimed this hunt was to remove orcas competing for the same resource, rather than as a food source, although the products are believed to have been distributed. The killing in Greenland has been encouraged by Government policy and hunting mortality is known to be under-reported (Reeves and Leatherwood 1994).

It is known that orcas may still be hunted in Indonesia and Japan (Barnes 1991; Reeves and Leatherwood, 1994). In 2001 and again in 2002, the Russian Government issued capture permits for orcas in the Eastern Sakhalinskaya sub-zone (Government of the Russian Federation 2001; Hoyt *et al* 2002). The IWC Scientific Committee noted that the Russian Central Committee had issued permits for the live capture of 10 orcas (IWC 2002b).

While not a direct net removal in numerical parallel with lethal hunts, the number of mortalities during captures for live trade has also been substantial in the past. During a 1967 capture from the southern resident K pod, three animals died during capture and five were taken into captivity. The same pod, along with the resident J and L pods, which together comprise the entire southern Vancouver Island community population, was once again targeted in 1970 and at least four animals (including 3 calves) drowned in nets during capture and eight animals were taken into captivity (Hoyt 1990, Hoyt 1992). Between 1974-1989, 55 orcas were taken from the waters around Iceland and sent to world aquaria (Hoyt, 1992). A more recent capture in February 1997 off near Taiji, Wakayama prefecture, Japan resulted in five animals being captured and transported to three different Japanese facilities. Two animals, a male and a female, died within four months of being captured, and the surviving orcas have all suffered health problems. Since 1983, the captivity industry has sought to capture orcas off Alaska, Argentina, Norway and Eastern Russia.

Russia's Marine Mammal Council advised in November 2001 that up to 10 could be taken for the year 2002 and then in Sakhalin a permit was granted to take 2 orcas in the waters off northeast Sakhalin. It is not known at present if more permits will be granted for this or future years. These permits were granted in the face of considerable opposition from Russian and worldwide orca scientists who contended on a precautionary basis that no orcas should be captured until at minimum that detailed studies had been undertaken (Hoyt *et al.*, 2002).

While there is documented evidence of removals (and associated mortalities) of orca from their populations by the captivity trade, there is very little documented data on the removals by direct hunts, with many regions either under or not reporting these hunts. However there is sufficient reason to presume that directed hunts are ongoing, and that deliberate killing through fisheries interactions are likely widespread. The combined nett removal from various populations should be considered a concern and further reinforces the appropriateness for CMS Appendix II listing.

Climate change

Anthropogenic global environmental change poses a severe threat to orcas. Springer (1998) concluded that fluctuations in marine mammal populations in the north Pacific are related to climate variations and change. Sherman (2000) found a correlation between marine mammal die offs and strandings, and climatic anomalies. Some of these fluctuations could be due to long term cycles in ocean productivity driven by oscillations in atmospheric circulation (Klyashtorin, 1998). However, it is clear that downward trends in productivity and prey abundance suitable for marine mammals have already been detected and are expected from climate models, particularly in the Arctic (IPCC Working group II, 2001; MacGarvin and Simmonds 1996; Tynan and Demaster 1997). In a related finding, Whitehead (1997) observed that sperm whales suffered reduced fertility in warmer waters during El Niño events.

As evidence of this downward trend, an anomalous collapse in productivity of the Bering Sea ecosystem that led to mass dieoffs of shearwaters and fish was tied to an El Niño event of 1997-1998. Jellyfish have also been increasing in the Bering Sea since 1990 (Brodeur *et al* 1999). El Niño events are expected to increase in frequency with global warming (Baduini *et al* 2001; Napp and Hunt, 2001; Napp *et al* 2000) and northeast Pacific gray whales have suffered mass dieoffs due to starvation and lack of prey in their Bering Sea feeding grounds (Le Boeuf *et al* 2000). Schell (2000) inferred declining productivity of the Bering Sea from a 25 year decline in Carbon isotope signatures in bowhead whale baleen.

The Bering Sea anomaly also highlights a disturbing global increase in harmful algal blooms that have been observed worldwide in recent decades (Sherman, 2000). Algal blooms have many causes, including iron deposition, shifts in upwelling, stratification and coastal eutrophication. Global warming is expected to exacerbate harmful algal blooms (Burkholder, 1998), perhaps leading to increased risk of toxic poisonings of apex predators such as orcas, as has been observed in humpback whales and manatees (Geraci *et al* 1989; Hokama *et al* 1990; Imai *et al* 2001).

Ability to forecast these trends remains poor, however. Some authors argue that warming will intensify upwellings and enhance productivity (Bakun, 1990). Lehtonen, (1996) argues that while gross productivity may increase, the shift in species distributions toward less favoured species will be disruptive for fisheries (and make local marine productivity more variable), making fish a less reliable as a source of food.

Declines in salmon are expected from global warming and have already been observed, although it remains uncertain to what extent the declines may be primarily due to climatic oscillations (Beamish *et al* 1999; Chatters-Chatters *et al* 1995; Keleher and Rahel, 1996; Welch *et al* 1998) or to what extent this may also affect other fish stocks.

Another indirect route by which global warming might elevate mortality for orcas is that food supply failures might force whales to forage more widely that they previously had to. This could have energetic consequences and might result in increased accidents, conflict with other populations, or contact with diseased animals (Simmonds and Mayer 1997). Conversely, degradation of habitat of other cetaceans caused by warming could bring them into orca habitats where they would compete for food or bring in infectious diseases.

Simmonds and Mayer (1997) present models of how starvation may trigger disease outbreaks by mobilising blubber stores and so release bio-accumulating immunotoxic pollutants. Immune depression in turn leaves the population vulnerable to epidemics such as the various distemper viruses that have significantly impacted a number of marine mammal species in recent years. Starvation induced by climate change could also trigger such disease events in stressed orcas.

Low salinity has been connected to increased skin infections of dolphins. Salinity in nearshore habitats and in Arctic habitats is likely to decrease substantially with loss of sea ice and higher precipitation predicted under global warming (Wilson *et al*. 1999). The ultimate impact on survival and fecundity is however, unclear.

The well studies orcas appear to have distinct home ranges. If this also translates to other lesser studies populations, so shifts in climate may bring about increased migration and conflict. In the past year one southern resident juvenile has been found lost and separated from his pod on the northwest coast of Vancouver Island, while a northern resident juvenile was found in poor health in southern resident territory in Puget Sound (McClure 2002a).

In southern Australia, two single stranded juvenile orcas were both observed to be disorientated and one in poor condition prior to stranding (Morrice unpublished data). Perhaps these whales had become separated from their pod and did not have the skills to forage on their own.

Greater rainfall and river flow and a more energetic marine environment under global warming may result in mobilisation of greater amounts of pollutants from benthic sediments in orca habitats, further increasing dietary intake of pollutants (Calambokidis and Baird 1994).

Climate change is a significant challenge to all whales, including orcas and mitigation of this threat must be considered in the context of cumulative impacts.

Distinct orca populations and forms

The state of knowledge of differentiated populations and forms, population estimates, feeding, migration and threats are summarised in Appendix 1. In general, the state of knowledge is poor. However, there is much circumstantial evidence to suggest that there is a general pattern of orca differentiation into distinct cryptic species, subspecies, forms or populations, each one of which is likely a small size and consequently subject to risk of extinction. Therefore each may require distinct and separate conservation management.

Before the intensive studies into orca social structure of the past two decades, orcas have been considered a single, freely interbreeding species. CMS considerations initially focused on the two relatively well-studied populations of the northeastern Atlantic and northeastern Pacific. However, the species occurs in all oceans and seas of the world, although most research has been based in temperate and sub Arctic /Antarctic latitudes, and in shelf or coastal waters. Therefore available information is biased towards these habitats. Although tropical and offshore sightings are limited, there are records that attest to the species' widespread occurrence in these areas (Parker 1978; Stewardson and Child 1997; Chatto and Warneke 2000; Shaughnessy 2000; Ford 2002; Morrice *et al* in prep; Visser and Bonnocorso in press) and further research is needed to arrive at population estimates.

The northeastern Pacific population of orcas is subdivided into reproductively isolated, genetically, morphologically and behaviourally distinct forms: mammal hunting transients, fish eating residents and the recently discovered, lesser known, “offshore” pods. All three may warrant subspecies classification (Ford 2002; Taylor and Plater 2001; Center for Biological Diversity 2001; Baird and Whitehead 2000; Saulitis *et al* 2000; Hoelzel *et al* 1998; Ford *et al* 1998; Baird and Dill 1995; Hoelzel 1993; Heimlich-Boran 1988;). Northeastern Pacific residents show hierarchical differentiation, genetically and acoustically, into three geographically distinct neighbouring populations, the southern, the northern and the southern Alaska populations. Within populations there is further significant differentiation into clans, pods and matrilines. Genetic analysis by Barrett-Lennard (2000) show that resident mating tends to be 85% endogamous within populations, but exogamous for pods, suggesting an adaptive response to avoid inbreeding. Transients and offshores differed genetically as much from each other as from residents. Indeed the tiny transient AT1 pod, from Prince William Sound, which was decimated by the Exxon Valdez oilspill of 1989, is genetically distinct from Gulf of Alaska transients that surround and overlap the AT1 range.

Barrett-Lennard (2000) concludes that the divergence between transients and residents in the northeastern

Pacific occurred once. He also suggests that differentiation occurred in sympatry as a result of cultural divergence in dialects.

While the distinctions used in the northeastern Pacific of 'transients' and 'residents' do not necessarily correlate to other populations, they do illustrate distinct differences in population behaviour. There is also some evidence of resident/ transient type animals around south-east Kamchatka (in the northwest Pacific off Russia) with sympatric forms feeding on fish or marine mammals (Tarasyan *et. al* 2002; Burdin *et al* 2001).

Resident types show high fidelity to particular feeding areas and are specialised on fish. The residents of the northeastern Pacific feed primarily on salmon (Balcomb *et al* 1980; Bigg *et al* 1987). Ford *et al* (1998) estimated that chinook salmon comprises 38% of the diet of the average southern resident. Non-salmon fish species comprise a small portion. Transient type orcas have a much broader range than resident types, as their name suggests, and they prey on marine mammals and seabirds (Ford and Ellis 1999). In the northeastern Pacific the range of transients completely overlaps the more restricted range of residents. Baird (2000) has suggested that foraging specialisation appears to occur in orca populations elsewhere, although research efforts have not been sufficient to determine this conclusively.

Most orca populations are not yet well enough studied to draw broad conclusions about the 'transient types' and 'resident types' trends in feeding behaviour. (Hoyt, pers. comm; Morrice *et al* in prep) In other areas around the world some sympatric orca populations show different foraging strategies and prey preferences (foraging eco-types) (Visser pers. comm.)

Transient types and resident types also differ in morphology, group size, social organisation and acoustic repertoire some of which is clearly a result of their different dietary specialisation (Ford and Ellis, 1999; Bain, 1989; Baird, 1994). Transient types have smaller groups sizes than resident types and do not use echolocation as much for prey detection, due to their reliance on mammalian prey. (Baird and Whitehead, 2000; Barrett Lennard et al., 1996).

Norway coastal orcas have a unique tail-slap stunning technique to catch herring (*Clupea harengus*) (Domenici *et al.,* 2000). Yet another "loud-bang" stunning technique is suggested by Marten *et al* (2001). The highly coordinated pack hunting of orcas directed toward large cetaceans is briefly reviewed in Dahlheim and Heyning (1999). It is possible that orcas that hunt whales might be distinct even from other small mammal hunting populations.

Norway coast orcas are acoustically distinct from those in Iceland. There is no known migration between populations (Christensen 1988; Oien 1988; Strager, 1995), although this has yet to be explicitly investigated .

The east coast of the USA and Canada harbours at least two distinct populations, one that migrates seasonally north and south, and another that is resident type year round south of 35ºN (Katona *et al*., 1988). It is unknown if they have different dietary specialisations.

Prey specialisation seems to be typical for some orca populations while others are opportunistic feeders. Orcas also have a wide range of hunting techniques, including adapting their foraging to take advantage of human activities such as following icebreakers to areas of high concentrations of seals or penguins, removing fish from long-lines, or following whaling vessels to feed on injured prey.

Individuals of some southern ocean populations appear to feed almost exclusively on marine mammals (Baird 2000b; Hoelzel 1991), although directed studies will be required to confirm this.

Orcas have been recorded in the Pacific region of Southern Costa Rica, Panama and Northern Colombia (Fertl *et al* 1996; Florez-Gonzalez *et al* 1994; Iñíguez, pers. comm.). Fertl *et al* (1996) has documented a orca in this region feeding on Carcharinid shark. Florez-Gonzalez *et al* (1994) has described an attack of ten orcas on three humpback whales (2 adults and 1 calf) off Gorgona Island, Colombia.

In Northern Patagonia, orcas appear to be of a generalist transient type, in that they prey on marine mammals and seabirds. Although the transient term does not fully describe their behaviour because this populations have also been observed eating fish. Thirty orcas have been identified since 1975 but a core group of 17 return to the same area each year (Lopez and Lopez, 1985; Hoelzel, 1991; Iñíguez, 1991; Iñíguez, 1993; Iñíguez, 2001). Iñíguez (2001) reported a seasonal distribution of orcas largely associated with the movement of South American sea lions and southern elephant seals. North of Buenos Aires province, Argentina there is some evidence of a separate population of orcas that feed on fish. This population could migrate seasonally between Southern Brazil, Uruguay and Argentina (Iñíguez et al, 1994). In Brazil, orcas prey on cetaceans, bony fish, stingrays and cephalopods (Castello, 1977; Dalla Rosa, 1995; Ott and Danilewicz, 1996).

Orcas from Northern Patagonia and Crozet Archipelago have a hunting technique where they intentional strand to catch pinnipeds (Lopez and Lopez 1985; Guinet 1991; Hoelzel 1991; Iñíguez 1991; Guinet and Bouvier 1995; Iñíguez 2001).

Of the lesser studied populations, Antarctic whales differ from other orcas in pigmentation, showing a distinct cape and light dorsal surface coloration posterior to the dorsal fin (Visser, 2000). Antarctic mammal hunting orcas venture much further into sea-ice than do Arctic orcas (Finley 2001; Gill and Thiele 1997; Reeves and Mitchell, 1988a). Smaller, fish eating orcas have also been differentiated from among the proposed Antarctic mammal hunting orcas studied by Russian researchers in the early 1980s (Berzin and Vladimirov 1982; Mikhalev *et al* 1981) and were designated by these authors as two new species *O.glacialis* and *O. nanus* respectively. Further studies are needed to ascertain whether these small orcas deserve recognition as separate species or subspecies.

For Australian waters, including subantarctic Macquarie Island and the Australian Antarctic Territory, orcas have been observed to feed on humpback whales, blue whales, minke whales, fur seals, southern elephant seals, crabeater seals, dugongs, various penguins, and fish and sharks off longlines In many cases this corresponds to areas where these prey species aggregate for breeding or feeding (Cotton 1943; Anderson and Prince 1985; Copson 1994; Shaughnessy 2000; Janetzki and Paterson 2001, Paterson and Paterson 2001; Morrice and van den Hoff 2001; Morrice *et al* in prep). To what extent these orca populations specialise on prey or migrate is unknown, although it is suspected that these groups have their own variety of preferred prey and can adapt to some extent to changes in prey availability (Morrice pers. comm.).

In New Zealand, twenty-four different species of prey have been recorded, consisting of four main types; rays, sharks, fin-fish and cetaceans. Although other prey types (birds, cephalopods and coelenterates) are occasionally taken, of note is that pinnipeds have not been identified as prey. Ten prey species have been recorded for the first time from New Zealand waters (elasmobranchs: short tailed stingray, *Dasyatis brevicaudatu*s; long tailed stingray, *Dasyatis thetidi*s; eagle ray, *Myliobatis tenuicaudatu*s; torpedo ray, *Torpedo fairchild*i; mako shark, *Isurus oxyrinchu*s; school shark, *Galeorhinus galeu*s; fin-fish: bluenose, *Hyperoglyphe antarchi*a; kahawai, *Arripis trutta*; cetaceans: dusky dolphin, *Lagenorhynchus obscuru*s; birds: blue penguin, *Eudyptula mino*r). Records of other prey include the blue shark, *Prionace glauc*a; basking shark, *Cetorhinus maximu*s; sunfish, *Mola mol*a; pilot whale, *Globicephala mela*s; southern right whale, *Eubalaena australi*s, and unidentified species of octopus and salp. Foraging strategies were different for each prey type, but food sharing was observed for all four main prey types. Rays were the most common food type, by number of individual orcas foraging and by the number of prey taken. One of the three proposed New Zealand sub-populations of orcas appears to be generalist or opportunistic foragers, feeding on all four prey types; another sub-population slightly less so, feeding on three prey types.The third sub-population appears to be a specialist forager, taking only one prey type (cetaceans). In New Zealand, foraging eco-types may help to define the proposed sub-populations and suggest areas where management should focus. (Visser, 2001)

In the Western Mediterranean Sea orcas were recorded between March and September 2001 feeding on Bluefin tuna (*Thunnus thynnus*) and Ocean sunfish (*Mola mola*). In the Western Mediterranean sea orcas were resighted between Spanish and Morocco waters was observed (Morcillo Moreno, pers. comm.2002.).

The orcas of Crozet Archipelago in the southwestern Indian Ocean feed on both marine mammals and fish.(Barrett-Lennard 2000; Guinet 1991). In the same region, orca observed off Marion Island in appear to feed on southern elephant seals colonies. (Kieth *et al* 2001; Pistorius *et al* 2002)

Orcas have also been reported in Mauritania, Senegal, the Ivory Coast and Cape Verde Archipelago in Africa (Reiner *et al* 1996) although no further information on the populations are available at this point..

New research into a previously-unstudied population in south-east Kamchatka (northwest Pacific off Far-eastern Russia) suggests that this population is a resident type form, bearing several similarities in terms of pod size, travelling, foraging and social behaviour to the well-studied residents of the northeastern Pacific. At least 151 animals have been photographically-identified off south-east Kamchatka. In 2001, at least 45 individuals (33.3%) were re-sighted from 1999/2000. Acoustic analysis of some 900 calls (1999-2001) provides evidence that each pod has a limited repertoire of discrete call types, and that this repertoire differs from group to group (Filatova *et al* 2002). This further suggests that this eastern Russian population has a system of pod specific dialects as do the northeastern Pacific populations. Also, off Kamchatka, there is some evidence of a separate population of transient-type orcas feeding on larga (or spotted) seals, *Phoca largha*, and other marine mammals. Photo-Ids have been obtained from the Kuril Islands and Sakhalin Island, also off eastern Russia but hundreds of miles away from Kamchata, but to date there are no matches indicating that these may well represent separate populations (Burdin *et al* 2001) Based on sightings collected mainly by Russia’s Kamchatrybvod from all over Kamchatka and the Komander Islands from 1992-2001, a total of at least 700-800 orcas can be found off the east coast of Kamchatka and the Komander Islands, but it is not known how many populations this may represent (Mironova *et al* 2002)

Although some authors suggest that most orcas are concentrated in higher latitudes, orcas are also recorded from the relatively shallow and warm Gulf of Mexico (Aurioles-Gamboa 1993, Black *et al* 1997; Guerrero-Ruiz and Urban 2000; Katona *et al* 1988, Mitchell and Reeves 1988; O'Sullivan and Mullin 1997; Roden *et al* 1993; Sarti *et al* 1994) However it is unknown if Gulf of Mexico populations are distinct from other neighboring populations. Orcas are also known to be hunted around Indonesia (Barns 1991) and are also found in tropical waters around Papua New Guinea. (Visser and Bonnocorso in press)

As this review suggests, there are clear and distinct orca populations around the globe and while the species complex is not yet fully understood.

The Conservation of Small Cetaceans Report prepared for the CMS Secretariat, based on data collected by the IWC, suggests at least six separate populations are possible for the southern hemisphere, including a dwarf form (CMS 1991). Based on the number of populations found in known areas of the northern hemisphere, there could well be many more in the southern hemisphere. A priority for conservation must be to determine the boundaries and population sizes of the distinct populations, forms or subspecies throughout the world, including Antarctica, and to conduct a thorough overhaul of the present monospecific taxonomy of the orcas as suggested by Dahlheim and Heyning (1999).

The case for listing as a species complex on CMS Appendix II is strong. As more research is focused on orcas in other regions the forms may become clearer and will likely develop to fully reflect the diversity of behaviours within the species complex.

Population estimates for orcas

It is not yet possible to give a global population estimate for orcas, nor is it meaningful to derive such a figure if orcas constitute a complex of highly distinctive and unique populations, forms subspecies or new species, as suggested by the evidence of the previous section.

Reliable population estimates are critical to conservation decisions, as the smaller a population is, the greater the probability of it becoming extinct (Caughley 1994; Hunter 1996). Soulé (1987) described a population (of any species) of fewer than 500 individuals as small. Most known distinct populations of orcas may number fewer than 500. It is also important to know how many animals within the population are viable breeding stock and if they are under threat from any source. Large organisms such as orcas require more resources than smaller ones and therefore a low population density may be normal (Hunter, 1996).

Ford (2002) suggests that orca habitat is primarily determined by their prey distribution. In terms of habitat preference relating to prey, heavy sea-ice does not appear to present the same barrier to Antarctic orcas as it does for Arctic orcas.

There are also likely to be other reasons for habitat preference. Special features like “rubbing” beaches are also a habitat requirement for some populations. There are no known special habitat requirements for birthing and nursing. Southern Vancouver Island residents in the northeast Pacific seem to prefer high relief sea-floor areas perhaps related to the preferred corridors of salmon migration (Heimlich-Boran 1988).

Known distinct populations in the northeastern Pacific, each number fewer than 300, and each is at high risk of extinction due to habitat degradation, take and stochastic demographic and environmental processes. Loss of any of these populations would be a significant gap in the global range of the orca complex.

Current population data for some populations of orcas are in poor agreement except for the few well-studied populations in the northeastern Pacific. A rough estimate of 2,500 individuals for all forms and in all populations from the South-east Bering Sea down to the Gulf of California, is derived from the data in Appendix 1 of this document. This is dwarfed by the estimate of 70,000 for all populations and species in Antarctica obtained by sighting vessel transects (Kasamatsu and Joyce 1995). Either the Antarctic ecosystem is dramatically more productive or one or both of the estimates are biased. The northeastern Pacific estimate of 2,500 is plausible based on photo-ID surveys indicating 1,500 animals ‘from the Aleutians to California’, 1,000 for the area of the southeast Bering Sea and Mexican outer coast and Gulf of California. However the real number for the Antarctic could be considerably lower than 70,000 (Hoyt pers comm, 2002;

Simmonds pers comm, 2002). Off the Antarctic Peninsula, during the summer seasons of 1997/98, orcas were the third most frequently sighted cetacean species, after humpback and minke whales, with an encounter rate of 0.03 whale/nautical mile (Secchi *et al* 2001). However, as orcas are known to be attracted to fishing vessels in other contexts, these estimates from sighting vessels may well be inflated.

Population estimation and differentiation is also confounded by the migratory habits of orcas (Forney 2000). Without individual identification it is difficult to determine if animals seen, for example, off the coast of Labrador in summer belong to the east coast migratory population or to a resident type population in the northwest Atlantic. Migration can occur at low frequency across long distances (Visser 1999a; Dahlheim 1997). For instance around northern Patagonia some individuals use a 1000 km stretch of coastline (400.000 km^2 area) and the seasonal distribution of orcas is correlated to the distribution of pinnipeds (Iñíguez, 2001).

The orca species complex appears to comprise of many small and disparate populations, which increases their vulnerability to anthropogenic stressors. This is exacerbated by the widespread distribution of orca, and further reinforces the case for CMS Appendix II listing as a species complex to ensure a precautionary position is taken in the face of inconclusive but compelling information.

Orcas are migratory

The case for orca as a globally spread potentially highly migratory species complex is building. It is known that orca movements, including long distance movements, which are sometimes termed migrations, are strongly influenced by the distribution, movements and life history cycles of their preferred prey (Mikhalev *et al* 1981; Christensen 1988; Iñíguez 2001).

Unlike baleen whales and some other large cetaceans, orcas have less defined and less studied seasonal migration patterns. In most populations studied, however, it is clear that seasonal movements or migration takes place. In some instances migration takes place on the high seas (i.e. all marine areas outside of State jurisdiction). Evidence suggests that individuals occupy very large ranges and the proportion of time spent in different parts of their ranges may vary seasonally (Baird 2000b). Therefore orcas are migratory as defined under CMS:

> *"the entire population or any geographically separate part of the population of any species or low taxa of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries"* (CMS 1979, art I (1)(a))

Further, Perrin (2001) has stated that:

> "*… the cetacean agreements developed under CMS to date have not stipulated that the cetacean species included be known to be migratory in the sense of the CMS definition …The assumption is that all or most of them will eventually be proven to be migratory, wholly or in part."*

Individuals have been documented to move over very large areas. Two of the widest geopolitical migrations documented have occurred in the northeast pacific and also around New Zealand. Baird (2000b) has reported that a number of individuals seen both in central California and south eastern Alaska, passing through Canadian waters, traversed a linear distance of 2660km. Visser's research of the New Zealand population of orcas has documented longer geographical migrations of between 2100 and 4000 km and 3900 km. The animal identified as NZ1 has the widest distribution of any identified individual, and has been recorded in four regions within New Zealand's Exclusive Economic Zone over a 20 year period, with the minimum distance travelled between the northern and southernmost sightings of 4200 km (Visser, pers. comm. 2002).

The orcas found around northern Hokkaido and the southern Kuril Islands regularly cross the Japanese-Russian border (Hoyt, pers. comm. 2002)

Gill and Thiele's (1997) research indicates that some Antarctic orcas may associate with sea ice in winter and seasonal movements in the Antarctic, Arctic, subantarctic and subarctic are necessary to some extent as they are forced to move with the ice.

There is circumstantial evidence that Antarctic populations migrate vast distances, over many thousands of miles, both north-south and east-west following their two major prey groups (Mikhalev *et al* 1981; Brown pers comm 2002). Soviet research has concluded that orcas are found throughout the southern hemisphere and, although their distribution is not uniform, they migrate from higher latitude warmer waters (up to 60 degrees) in winter to as far as the ice edge for the Antarctic summer (Mikhalev *et al* 1981). Mikhalev *et al* (1981) alternatively identified six populations, classified by their winter distribution as western American, eastern American, western African, eastern African, western Australian and eastern Australian.

Visser (1999) reported a sighting of orcas off New Zealand waters with the lighter coloration pattern typical of animals from the Antarctic, suggesting long range migration.

Migration is also recorded between Chilean and Argentine waters at the southern tip of South America (Iñíguez pers. comm. 2002). The population inhabiting southern Brazil, Uruguay and northern Argentina may be a single distinct migrating population (Iñíguez *et al* 1994).

In the Western Mediterranean Sea a movement between Spanish and Morocco waters is recorded (Morcillo Moreno pers. comm. 2002) At least one northwestern Atlantic population migrates seasonally between US and Canadian waters, while Norwegian resident types migrate north and south (and east and west to some extent) following herring.

Much closer study of orcas movements using individual identification is needed to resolve the multiple uncertainties of which distinct population is being observed, and what is each population's distinct range. It is certain however, that most populations cross international boundaries at some point in their wide-ranging travels and that the species complex qualifies as a migratory species.

The available migratory information supports Appendix II listing. Where populations migrate within jurisdictions such as Antarctica (high seas) and the New Zealand Exclusive Economic Zone, the distance travelled are so great as to substantiate that other populations are likely travel similar distances over multiple jurisdictional boundaries.

Whale watching and its growing importance relating to orcas

Orcas and humpback whales are two of the biggest draws to whale watchers around the world (Hoyt 2001). They have a value for wider marine management, environmental awareness raising and education. The most common focal species for whale watching industries are humpback whales, gray whales, northern and southern right whales, blue whales, minke whales, sperm whales, short-finned pilot whales, orcas, and bottlenose dolphins. The percentage of whale watchers who focus on smaller cetaceans including orcas is increasing (Hoyt 2001).

Whale watching of orcas is now offered in such geographically diverse locations as Iceland, the Shetland Islands (UK), Norway, New Zealand, western Canada and Newfoundland, northwestern USA (Washington State and Alaska), Argentina, and in the Antarctic (Hoyt 2001). In addition, orcas are sometimes seen as part of other whale, dolphin or marine nature trips out of Chile (central coast), Faroe Islands, Falkland Islands, Gibraltar, Greenland (northwest), Iceland, Japan (Muroran-shi, Shibetsu-cho, Nemuro-shi, Rausu-cho, Shari-cho), Mauritainia Russia (northeast Siberia and Kamchatka), South Africa, Spain (southwest Cadiz & Tarifa and Bay of Biscay).

Around Vancouver Island alone, in US and Canadian waters, approximately 400,000 people a year watch orcas from boats or shore-based parks, spending $75 million USD in total revenues (Hoyt 2001; Hoyt, *et al* 2002).

However, whilst public awareness of the negatives associated with captivity has undoubtedly been achieved through education (and many ex-capture locations such as BC, WA State, Iceland and Argentina have now banned further captures), there are still countries and facilities seeking to secure new orcas for public display (Hoyt 1992).

In the Tysfjord area of Norway there are approximately eight operators at present, several of which are from Sweden and bring large numbers of Swedes and other Europeans to Norway for orca watching. (Hoyt 2001)

A study at Punta Norte, Peninsula Valdes, Argentina in March 1997 during the orca peak season, showed that approximately 80% of 1646 visitors interviewed were Argentine. The 20% were foreigners from Germany, Italy, America, Israel, France and New Zealand. At Punta Norte, orca watching activity is from land. Only one small company advertises orca-watching trips at Punta Norte (Iñíguez *et al* 1998).

Iceland's extraordinary average annual growth rate of 250.9% from the mid-to late 1990s is one of the highest ever growth rates in whale watching. In 1994, some 200 people went whale watching from one community; by

1998, there were 30,330 taking trips from eight communities. Iceland offers close-up encounters with minke, blue and humpback whales, as well as orcas and Atlantic white-sided and white-beaked dolphins. There is some evidence from visitor surveys that the whale watch growth in Iceland might not have been so rapid if the country had resumed whaling (Hoyt 2001). There are concerns about the future of this industry as Iceland furthers its pro-whaling campaign.

Protection of orca habitat off northern Vancouver Island at Robson Bight Michael A. Bigg Ecological Reserve, as well as the estalishment of land-based orca-watching facilities at Lime Kiln Park on San Juan Island, Washington, USA, have had the effect of increasing whale watcher numbers, while providing some framework for local management of the species (pers. comm. Hoyt 2002).

Appendix I: *Orcinus orca* populations, distribution, diet, migration, abundance and threats, where known

Pacific

Region	Populations	Diet	Migration	Pop.	Threats	Cite
Tropical Pacific	Galapagos Islands	Unknown.	Unknown.	>135	Unknown.	Merlen, 1999
	Costa Rica	Shark	Unknown.	Unknown.	Unknown.	Fertl *et al.*, 1996
	Hawaii	Unknown.	Unknown.	~5, rarely sighted	Unknown.	Mobley *et al.*, 2001
	Australasia Papua New Guinea	Unknown. elasmobranchs	Unknown.	14 individuals have been recorded in PNG	Unknown.	Chatto and Warneke, 2000; Yang Shih *et al.*, 1999; Eldredge, 1991; Visser pers. comm..
Southeast Pacific	Chilean coast- probably heterogeneous (varied populations)	Unknown.	Unknown.	Low sighting rate	Unknown.	Aguayo *et al.*, 1998; Capella *et al*., 1999
Southwest Pacific	Southern Australia, Tasmania, Macquarie Island - likely heterogeneous (varied populations)	Unknown.	Unknown.	>50	Unknown. Poss. heavy metals, fisheries.	Anderson and Prince 1985; Bell *et al*. in prep; Chatto and Warneke 2000; Copson 1994; Cotton 1943; Gibbs 2001; Janetzki and Paterson 2001, Ling, 1991; McManus *et al.*, 1984; Morrice and van den Hoff 2001; Morrice *et al*. in prep; Paterson and Paterson 2001; Tasmanian Fisheries Development Authority 1981; R. Gales pers. comm
	New Zealand- likely to be three separate populations	Primary prey rays, sharks, fin-fish and cetaceans. Other prey types including birds, cephalopods and coelenterates) are occasionally taken, of note is that pinnipeds have not been identified as prey	Wide migration – document over 4000km	Approximately 200 in New Zealand waters.	Shipstrikes, bycatch, shooting and pollution	Visser *et al.*, 2000; Visser, 1998; Visser, 1999b; Visser, 2000; Visser and Fertl, 2000; Visser *et al.*, 2000, Visser, 2001
Northwest Pacific	Many sightings from all coasts and seas – likely heterogeneous	Nishiwaki and Handa 1958 have a list that includes Japan and waters north; plus Tomilin 1957.	Unknown	Unknown	Unknown. Probably as for NE Pacific	Dahlheim and Heyning, 1999; Sobolevskii, 2000; Hoyt 1990; See also extensive referenced Appendix on orca diet in Hoyt - Orca: The Whale Called Killer, 1990
Northwest Pacific: SE Kamchatka	Evidence for separate populations ; possibly separate Kuril Islands and Sakhalin Island populations (no matches from limited photo-IDs to date)	Resident types eat Atka mackerels and salmon; supposed Transient types eat largha, or spotted seals	Seen in nearly all months of the year but coming in close to land from May-Oct. and to rivermouths for fish corresponding to salmon runs and mackerel presence	Southeast Kamchatka resident types only [=151 photo-Ided] Rough estimate for all eastern Kamchatka and Kommander Islands is 700-800	Capture (2-10 permits granted for far eastern Russia)	Burdin *et al*, 2001; Burdin *et al* 2002 Mironova *et al*, 2002; Hoyt, *et al*., 2002; Filatova, *et al.*, 2002; Tarasyan *et al.*, 2002; Jikiya, *et al.*, 2002; Hoyt pers.comm.

Region	Populations	Diet	Migration	Pop.	Threats	Cite
	Northern residents: US and Canadian waters N Vancouver Is to Q. Charlotte Is.	Salmon, fish	Some members of the orca northern resident community are seen in winter months but they certainly range over wider areas in winter, especially North and out to sea	200	Fishing, bycatch, ship strikes, oil spills, noise, global warming.	Ford and Ellis 1999; Balcomb *et al* 1980
	Alaska residents: Kodiak Is to SE Alaska.	Salmon, fish	Winter movements unknown	360	As above	
	Offshores: West coast US and Canadian offshore waters.	Fish, little studied	Unknown	Unknown.	As above	
	West Coast Transients: West coast US and Canadian offshore waters.	Pinnipeds, porpoises, otters seabirds	Unknown	219	As above	
	Gulf of Alaska Transients	Pinnipeds, porpoises, otters seabirds	Unknown	>60	As above	
	AT1 Transients: Prince William Sound, Alaska	Pinnipeds, porpoises, otters seabirds	Unknown	11	As above	
	Bering Chukchi Beaufort seas – probably heterogeneous	Marine mammals and fish	Unknown. Only summer locations. Minor immigration from other west coast populations	>289	Unknown. Fishing impacts likely	George *et al.*, 1994; Lowry, Nelson and Frost, 1987; Frost, *et al.*, 1992; Yano and Dahlheim, 1995; Dahlheim, 1997
	California coast – probably heterogeneous	Unknown. ~ Sperm whale	No significant seasonal shifts Could include migrants from north.	184	Unknown. Fishing, pollution impacts likely	Pitman et al., 2001; Dahlheim, 1997; Forney and Barlow, 1998
	Gulf of California at least 4 “communities”	Unknown. Bryde’s whale	Mexican waters. Movement in and out of Gulf. Full range unknown.	850	Unknown. Fishing, pollution impacts likely	Silber *et al.*, 1994; Guerrero Ruiz *et al.*, 1998; Silber *et al.*, 1990
	Mexican Coast	Unknown.	Unknown.	65	Unknown	Dahlheim, 1997

Indian Ocean

Region	Populations	Diet	Migration	Pop.	Threats	Cite
Indian Ocean	Tropics –rare, transitory from south?	Unknown.	Unknown.	Unknown	Unknown.	Ilangakoon et al., 1992
	St Paul and Amsterdam Is	Unknown.	Migration to subantartic islands	Unknown.	Unknown.	Roux, 1986; Kasamatsu and Joyce, 1995; Visser, 1999a; Roux, 1986 Gill and Thiele 1997; Parker 1978; Shaughnessy 2000; Stewardson and Child 1997; Kieth *et al* 2001; Pistorius *et al* 2002
	Crozet Islands	Mammals-intentional stranding technique	Unknown.	Unknown.	Unknown.	Guinet, 1991; Guinet and Bouvier, 1995

Atlantic

Region	Populations	Diet	Migration	Pop.	Threats	Cite

Region	Populations	Diet	Migration	Pop.	Threats	Cite
North Atlantic	Norway coast: 9 pods with distinct calls	Stun fishing of herring	Follow herring northward spring migration to Barents Sea	100s in 1960s >483 based on questionnaire 26 Similä 1997 identified 445 orcas off Norway using photo-ID	Fishing, persecution by fishermen; also as for northeast Pacific	Christensen, 1988; Oien, 1988; Oien, 1988; Strager, 1995; Domenici *et al.*, 2000; Lyrholm, 1988; Dahlheim and Heyning, 1999
	British Isles - summer only, not in Channel	Salmon, herring	Offshore southward movement in winter	Unknown.	Probably as for northeast Pacific	Evans, 1988; Hammond and Lockyer, 1988
	Iceland: distinct from Norway pop.		Unknown.	143	Unknown.	Lyrholm et al., 1987; Moore *et al*., 1988
	Canadian Arctic probably heterogeneous	Bowhead, other marine mammals, fish cephalopods	Move north follow sea ice retreat into Hudson Bay, Davis Strait	Unknown. Probably >100	Persecution by hunters, fishermen	Heide- Jorgensen, 1988; Finley, 2001; Reeves and Mitchell, 1988a
	Newfoundland/Labrador	Unknown. Probably St Lawrence belugas	Portion may be summer migrants from south see below, or Davis Strait migrants	Small only 68 sightings in 7 years	Persecution by hunters, fishermen	Mitchell and Reeves, 1988
	Eastern US/Canada coast Historically common in Central Atlantic as well	Cetaceans, marine mammals . Other prey inconclusive	Seasonal migration north in summer	Unknown.	Probably as for northeast Pacific, bycatch entanglement and shipstrikes likely more severe	Reeves and Mitchell, 1988b; Katona *et al.*, 1988; Mitchell and Reeves, 1988
Central west Atlantic/ Caribbean	Resident type population S of 35ºN Uncommon in Gulf of Mexico	Large fish, squid, turtles only	Possibly resident type	Unknown.	As above; directed hunts	Mitchell and Reeves, 1988; Dahlheim, 1997; Katona et al., 1988; IWC 2001
Central east Atlantic	Sightings and bycatch from west Africa, Spain and Morocco – likely heterogenous or transitory Rare around Azores	Bluefin tuna	Migrants from North Atlantic	Sparse	Bycatch entanglement, noise, pollution, persecution by fishermen.	Bayed and Beaubrun, 1987; Cendrero, 1993; Concepcion Prez et al., 1990; Dahlheim and Heyning, 1999; Martin, 1988; Hammond and Lockyer, 1988; Morcillo Moreno, pers. comm.
Mediterranean	Sparse sightings. Sightings and bycatch from Spain and Morocco	Bluefin tuna and Ocean sunfish	Unknown..	Unknown.	Probably as for northeast Pacific	Dahlheim and Heyning, 1999; Notarbartolo Di Sciara, 1987; Hammond and Lockyer, 1988; Morcillo Moreno, pers. comm.; M. Iñíguez, pers. comm.
South Atlantic	Northern Patagonian coast 1000km (400,00km square)	Mammals- food sharing, intentional stranding. Seabirds and fish	Follow pinniped prey south in summer	30	Unknown.	Hoelzel, 1991; Lopez and Lopez, 1985; Iñiguez, 2001
	Brazilian coast. There may be a common population inhabiting southern Brazil, Uruguay and northern Argentina	Cephalopods , fish, cetaceans	Unknown. Occurrence is seasonal off Rio de Janeiro state.	Unknown.	Incidental capture.	Dalla Rosa et al., 1994; Dalla Rosa, 1995; dos Santos and Haimovici, 2001; Iñiguez et al. 1994; Ott and Danilewicz, 1996; Siciliano et al. 1999; Secchi and Vaske, 1998
	Namibia-S Africa-Mozambique	Seals, dolphins, penguins, cormorants	Unknown.	Unknown. Large pods up to 50	Illegal killing	Rice and Saayman, 1987

Antarctic/Southern Ocean

Region	Populations	Diet	Migration	Pop.	Threats	Cite
Antarctic	Distinct from other KWs, certainly heterogenous with distinct new fish-specialist species (*O.nanus* and/or *O.glacialis*). Other subdivisions likely.	Mar. mammals, cetaceans (minke whale), penguins, fish.	Unknown, poss. migration to north of some populations Poss. migration from Indian Ocean. to sub Antarctic	>70,000 est. of heterogeneous, possible bias.	Unknown.	Kasamatsu and Joyce, 1995; Visser, 1999a; Roux, 1986 Gill and Thiele 1997; Parker 1978; Shaughnessy 2000; Stewardson and Child 1997

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WDCS UK – Head Office

Brookfield House
38 St Paul Street
Chippenham, Wiltshire
SN15 1LY
Tel +44 (0)1249 449500
Fax +44 (0)1249 449501

WDCS Deutschland
Goerdelerstr. 41
D-82008
Unterhaching
Tel +49 89 6100 2393
Fax +49 89 6100 2394

WDCS Australia
PO Box 720 Port Adelaide Business Centre
Port Adelaide, South Australia
Australia 5015
Tel +61 (0) 8 8242 5842
Fax + 61 (0) 8 8242 1595

www.wdcs.org

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