

ODONTOCETI (TOOTHED WHALES)

Review of Sperm Whales (*Physeter macrocephalus*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Across the entire north Pacific, occasionally including the Yellow and East China Seas and the Sea of Japan, from the equator up to the Gulf of AK and Bering Sea; northern boundary for males runs from Cape Navarin (62°N) to the Pribilof Islands and to Bristol Bay; females are rarely north of 45°N

For management purposes, north Pacific sperms are divided into two stocks by the IWC: eastern and western (Consiglieri et al, 1982; Bannister and Mitchell, 1980; Goshō et al, 1984). These two stocks are divided by a zig zag line that starts at 150°W at the equator, becomes 160°W between 40°N and 50°N, and ends up at 180°W north of 50°N (Barlow et al, 1997). However, the stock boundaries for sperms have not been reviewed recently, and there may be more than two stocks (Goshō et al, 1984; Hill et al, 1997; Barlow et al, 1997). According to Ivashin (1983), the stocks may intermingle in the Aleutian Islands, but Kasuya (1991) reports that adult males summering outside breeding grounds do not intermix. Kasuya (1991) states that there may be three stocks: eastern, which breeds in the AK gyre; northwestern, which breeds in the western north Pacific gyre; and southwestern, which breeds in the subtropical gyre. Shimadzu (1981) reports that differences in pregnancy rates support the idea of two separate western north Pacific stocks. Bannister and Mitchell (1980) suggest that sperms can be separated into an American stock, and central stock, and an Asian stock. However, Wada (1980) found that electrophoretic studies of genetic loci indicate the lower central Pacific population is heterogeneous. Sperms rarely occur in the Yellow and East China Seas and the Sea of Japan (Goshō et al, 1984). The U.S. separates sperms in its waters into three stocks: CA/OR/WA, HI, and AK (Hill et al, 1997; Barlow et al, 1997).

Population of the of the CA/OR/WA stock was 1,231 in CA in summer/fall and 892 in winter/spring, 1991 to 1993 (Barlow and Gerrodette, 1996; Forney et al, 1995; Barlow et al, 1997). N_{min} of this stock is 896 and PBR is 1.8 (This does not including OR and WA and sperms farther offshore.) (Barlow et al, 1997).

No data are available for estimating population or trends for the AK and HI stocks (Barlow et al, 1997; Hill et al, 1997). N_{min} and PBR are unknown (Barlow et al, 1997; Hill et al, 1997). Hill et al (1997) indicate that the AK stock is unlikely to be in danger of extinction.

Population in the western stock designated by the IWC was 104,700 males and 145,600 females in 1910 (IWC, 1980). Population was 35,100 males and 110,200 females in 1979 (IWC, 1980). In the eastern stock, population was 121,000 males and 168,300 females in 1910 (IWC, 1980). Population was 89,000 males and 162,600 females in 1979 (IWC, 1980). Barlow et al (1997) report that sperms are at 88% of historical carrying capacity in the eastern north Pacific and at 64% in the western north Pacific.

Pre-exploitation population of mature sperms in the eastern stock was 311,000 (Brueggeman et al, 1990; McCrary and Pierson, 1990) and in the western stock, was 912,200 (Shirakihara and Tanaka, 1982). However, definitions of maturity and exploitability seem to differ among sources. Total pre-exploitation population of mature sperms was estimated to be 516,000 (Consiglieri et al, 1982), and total pre-exploitation population of all sperms was

estimated to be 1,260,000 (Hill et al, 1997). Total population was reduced to 930,000 by the late 1970's (Hill et al, 1997).

Sperm population in the Galapagos Islands has been heavily studied (Hope and Whitehead, 1994; Waters and Whitehead, 1990b; Whitehead, 1989; Whitehead et al, 1991; Whitehead et al, 1992; Whitehead and Waters, 1990). Population was 12,000 in 1830 and 3,900 in 1985 to 1989 (Hope and Whitehead, 1991), with 200 in the islands at any given time (Whitehead et al, 1992). Adult males were ten times more abundant in the Galapagos Islands in 1830 to 1850 than in 1985 to 1989 (Hope and Whitehead, 1991).

Sperms in the eastern north Pacific stock received protection in 1980 from the IWC; sperms in the western north Pacific stock received protection in 1988 (McCrary and Pierson, 1990). Sperms are considered endangered under the ESA and depleted and strategic under the MMPA (Balsiger, 1995; Barlow et al, 1997; Hill et al, 1997; Swartzman and Hogman, 1991). In the late 1980's, Ecuador established a cetacean sanctuary over its entire 200 mile zone of control, including the Galapagos Islands, where sperms were practically extirpated in the last century (Evans and Persson, 1991).

Sperm migration is segregated by sex (Perez, 1990; Brueggeman et al, 1987; Goshō et al, 1984). Mature males range into higher latitudes than females and immature males (Brueggeman et al, 1987; Goshō et al, 1984; McCrary and Pierson, 1990). Females and immature sperms display little seasonal movement and are generally found south of 45°N year-round (Brueggeman et al, 1990; Hill et al, 1997; McCrary and Pierson, 1990). Kajimura and Loughlin (1988) suggest 50°N as their northern limit. Ohsumi (1980b) observed that females in late pregnancy tend to segregate in higher latitudinal water. Adult males may move as far north as the Gulf of AK, Bering Sea, and Aleutian Islands in the summer (Brueggeman et al, 1990; Hill et al, 1997; McCrary and Pierson, 1990). All sperms are usually found below 40°N in the winter (Brueggeman et al, 1990; Consiglieri et al, 1982; Hill et al, 1997; McCrary and Pierson, 1990). Goshō et al (1984) state that in the western north Pacific, mature males migrate in the spring from the Philippines to southern Japan along to the Kuril Islands and up to Kamchatka, many continuing on to the Aleutian Islands, the Bering Sea, and the Gulf of AK. They state that in the eastern north Pacific, mature males migrate in the spring from central CA north as far as the Gulf of AK, Aleutian Islands and southeastern Bering Sea. However, discovery tags have revealed a great deal of east-west movement between AK and the western north Pacific with little evidence of north-south movement in the eastern north Pacific (Hill et al, 1997). For example, several hundred sperms were tagged off San Francisco, CA, but none were recovered in the Gulf of AK (Hill et al, 1997). Breeding aggregations are frequently seen off CA and less frequently seen off Baja CA and Mexico and probably occur farther south (Leatherwood et al, 1972); however, in summer, feeding sperms are rarely found south of San Diego, CA (Leatherwood et al, 1972). Consiglieri et al, (1982) report that sperm distribution may be shifted farther east in the summer than in the spring. In the Galapagos Islands, abundance of mature males peaks in spring (Hope and Whitehead, 1991; Whitehead et al, 1989); however, logbooks indicate mature males were reasonably abundant year-round in 1830 to 1850 (Hope and Whitehead, 1991).

Sperms are pelagic and tend to be found far offshore (Brueggeman et al, 1990; Consiglieri et al, 1982; Kajimura and Loughlin, 1988; McCrary and Pierson, 1990; Goshō et al, 1984). They show preferences for continental shelf margins and sea mounts (Brueggeman et al, 1990).

Sizes of sperms and sizes of sperms at maturity have changed throughout their exploitation (Gosho et al, 1984). Males as large as 20 m were recorded in the past, but by the mid-1980's, males larger than 18 m were rare (Gosho et al, 1984). Kasuya (1991) states that the average length of males was 15.5 m in 1963 and 16.2 m in 1975. Gosho et al (1984) report the maximum size of females to be 12 m, and Kasuya (1991) reports the maximum size to be 11.6-12.8 m, rarely exceeding 12.2 m. Hope and Whitehead (1991) also state that sperms in the Galapagos Islands were generally about 2 m longer in 1830 to 1850 than in 1985 to 1989. Waters and Whitehead (1990b) report that the length of females at maturity in the Galapagos Islands was smaller in 1985 to 1987 than in the past. Kasuya (1991) suggests that growth changes are density dependent.

There is debate about the phylogeny of sperms. Analyses of mitochondrial DNA indicate that sperms are more closely related to mysticetes than to odontocetes (Milinkovitch et al, 1993; 1994; 1995; Milinkovitch, 1995). Milinkovitch et al, (1993) suggest that the common ancestor of sperms and mysticetes lived only 10-15 million years ago. Klima (1995) also states that embryological finding and molecular phylogenetic analyses indicate that sperms are more closely related to mysticetes than to odontocetes. However, Heyning (1997) asserts that morphological data provide unambiguous support for the monophyly of odontocetes, including sperms. He states that there are no morphological characters that support a mysticete/physeterid clade.

Food and Feeding

Sperms prey largely on squid and also on deep water fish (Brueggeman et al, 1987; 1990; Gosho et al, 1984; Hill et al, 1997; Kajimura and Loughlin, 1988; McCrary and Pierson, 1990). Fish are generally less important than cephalopds in the diet, but they may be locally important in some areas (Perez, 1990). Prey may more frequently be fish in the northeastern Pacific and squid in the northwestern Pacific (Consiglieri et al, 1982), or Gosho et al (1984) indicate that prey may more frequently be medium to large mesopelagic squid in lower latitudes and large demersal mesopelagic fish in higher latitudes.

Sperms feed from mid-water to the ocean floor (Consiglieri et al, 1982). Consiglieri et al (1982) suggest that sperms may plow the bottom sediment for food with their lower jaw while swimming. Jaquet and Whitehead (1996) state that 77% of prey is obtained by swimming through schools of luminescent, slow, neutrally buoyant cephalopods and 23% is obtained by chasing faster, larger prey. Whitehead (1989) observed sperms in the Galapagos Islands foraging about 40 m apart in ranks along a length of 550 m. Short term associations are probably used for foraging (Whitehead et al, 1991). The benefits of foraging in ranks may be to gather prey density information, to avoid interference, and/or to catch prey that eludes others (Whitehead, 1989; Whitehead et al, 1991). Sperms use echolocation to detect prey (Whitehead, 1987).

Sperms feed primarily from the continental slope seaward (Kajimura and Loughlin, 1988). Dive duration for feeding is usually 40-60 min. with 8-10 min. surface intervals in the Galapagos Islands (Christal and Whitehead, 1997). Whitehead (1987) found feeding dives to be an average of 410 m deep in the Galapagos Islands in 1985. Christal and Whitehead (1997) state that feeding success in the Galapagos Islands was low for males in 1995 and high for mixed schools. Feeding success may be reduced by El Niño (Waters and Whitehead, 1990a; Whitehead et al, 1991).

The following prey species have been determined for sperms:

Category
Cephalopoda

Scientific Name

Common Name

Abraliopsis felis
Allopsus mollis
Architeuthis japonica
Architeuthis sp.
Berryteuthis magister
Chroteuthidae
Chroteuthis calyx
Chroteuthis veranyi
Cranchiidae
Cycloteuthis akimushkini
Cycloteuthis sp.
Decapoda
Dosidicus gigas
Galiteuthis phyllura
Galiteuthis pacifica
Galeteuthis sp.
Gonatidae
Gonatopsis borealis
Gonatus berri
Gonatus fabricii
Gonatus magister
Gonatus pyros
Gonatus sp.
Histoteuthidae
Histoteuthis dofleini
Histoteuthis heteropsis
Histoteuthis hoylei
Histoteuthis sp.
Loligo opalescens
Mastigoteuthis sp.
Megalocranchia sp.
Mesonychoteuthis hamiltoni
Mroteuthis robusta
Mroteuthis sp.
Octopoda
Octopodidae
Octopoteuthidae
Octopoteuthis deletron
Octopoteuthis sp.
Octopus dofleini
Octopus sp.
Ocythoetuberculata rafinesque

Enope squid
Allopsid octopus
Giant squid
Giant squid
Magistrate armhook squid
Whiplash squid
Whiplash squid
Whiplash squid
Cranch squid
Cycloteuthid squid
Cycloteuthid squid
Squid
Giant squid
Cranch squid
Cranch squid
Cranch squid
Gonata squid
Gonata squid
Gonata squid
Gonata squid
Gonata squid
Gonata squid
Gonata squid
Gonata squid
Umbrella or jewel squid
Umbrella or jewel squid
Umbrella or jewel squid
Umbrella or jewel squid
Umbrella or jewel squid
Market squid
Whiplash squid
Cranch squid
Cranch squid
Giant squid
Giant squid
Octopus
Octopodid octopus
Octopus squid
Octopus squid
Octopus squid
Octopodid octopus
Octopodid octopus
Ocythoid octopus

	<u>Ommastrephes bartrami</u>	Arrow squid
	Ommastrephidae	Arrow squid
	Onychoteuthidae	Hooked squid
	<u>Onychoteuthis borealijaponicus</u>	Nail squid
	<u>Onychoteuthis</u> sp.	Hooked squid
	<u>Taningia danae</u>	Giant squid
	<u>Taningia</u> sp.	Giant squid
	<u>Taonis megalops</u>	Cranch squid
	<u>Taonis pavo</u>	Cranch squid
	<u>Taonis</u> sp.	Cranch squid
	<u>Vampyroteuthis infernalis</u>	Vampire squid
	<u>Vampyroteuthis</u> sp.	Vampire squid
Crustacea		
	Euphausiidae	Euphausiids, krill
Agnatha		
	Petromyzontidae	Lamprey
Chondrichthys		
	<u>Apristurus brunneus</u>	Brown cat shark
	Elasmobranch	Sharks
	Elasmobranch	Skates
	Macrouridae	Rattails
	<u>Raja rhina</u>	Longnose skate
	Rajidae	Rays
	<u>Squatina californica</u>	Pacific angel shark
Osteichthys		
	Agonidae	Poachers
	Alepisauridae	Lancetfish
	<u>Anoplopoma fimbria</u>	Sablefish
	<u>Aptocyclus ventricosus</u>	Smooth lumpsucker
	Cottidae	Sculpins
	Cyclopteridae	Lumpsuckers
	<u>Eleginus gracilis</u>	Saffron cod
	<u>Gadus macrocephalus</u>	Pacific cod
	<u>Hippoglossus stenolepis</u>	Halibut
	<u>Icosteus aenigmaticus</u>	Ragfish
	Macruidae	
	<u>Merluccius productus</u>	Pacific whiting
	Myctophidae	Lanternfish
	<u>Oncorhynchus</u> sp.	Salmon
	<u>Ophiodon elongatus</u>	Lingcod
	Plagyodontidae	
	<u>Pleurogrammus monopterygius</u>	Atka mackerel
	<u>Sardinops sagax</u>	Sardine

	Scorpaenidae	
	<u>Sebastes</u> sp.	Rockfish
	<u>Sebastodes</u> sp.	Ocean perch
	<u>Theragra chalcogramma</u>	Walleye pollock
	<u>Trachipterus altivelis</u>	King-of-the-salmon
Mammalia		
		Mammals

Habits

Sperms can dive down to 2,500 m (Brueggeman et al, 1987) and prefer water greater than 1,000 m deep (Brueggeman et al, 1990; McCrary and Pierson, 1990). Dive duration is usually 15-90 min. with 4-10 min. surface intervals (Forney and Barlow, 1998). Long dive times, ranging up to 138 min. have been documented (Forney and Barlow, 1998). Males tend to dive longer than females with calves (Forney and Barlow, 1998). Whitehead (1989) found that groups of females and offspring traveled an average of 3.7 km/hr. in the Galapagos Islands. He also found that individuals were not more likely to be at particular positions in the ranks of a group based upon age or sex.

Females and their dependent offspring form highly social, permanent groups (Christal and Whitehead, 1997; Whitehead et al, 1991), sometimes called maternity schools (Consiglieri et al, 1982) or breeding schools (McCrary and Pierson, 1990). Maternity schools are generally made up of 20-40 individuals (Gosho et al, 1984). Females may form stable units within schools (Whitehead et al, 1991; Whitehead and Kahn, 1992). These units may travel together in schools with an average half-life of 6.5 days, and schools may come together to form larger aggregations (Whitehead et al, 1991; Whitehead and Kahn, 1992). DNA analyses indicate that sperms are more related within than between maternity schools and maternity schools are matrilineal (Richard et al, 1996). DNA analyses also suggest long-term associations between matrilineal (Richard et al, 1996). Social groups serve two functions: cooperative foraging and communal care of calves (Whitehead et al, 1991).

Males disperse from natal groups at about age 5-6 and form bachelor schools (Christal and Whitehead, 1997; Richard et al, 1996; Whitehead et al, 1991). Bachelor schools are generally made up of about 40 individuals (Gosho et al, 1984). Larger males tend to be found in increasingly smaller groups and the largest males tend to be solitary and farthest north (Christal and Whitehead, 1997; Gosho et al, 1984; Whitehead et al, 1991). At about 27 years old, males begin to migrate back to warmer waters to approach maternity schools to breed (Christal and Whitehead, 1997; Whitehead et al, 1991).

Mature and maturing males have much less durable relationships than females and immature sperms (Christal and Whitehead, 1997). Loose associations among young, adult males have been reported off CA, but such behavior has not been previously reported in a known breeding area (Christal and Whitehead, 1997). Adult males on breeding grounds rove between maternity schools, spending short periods of time with each (Christal and Whitehead, 1997). More than one male may be seen at one time with a maternity school, but there is no evidence of consistent coalitions between males (Christal and Whitehead, 1997; Whitehead, 1987); evidence, including acoustic recordings, suggests they avoid each other when around maternity schools (Christal and Whitehead, 1997). Mass strandings of males together suggest some form of social

organization among males (Christal and Whitehead, 1997). Breeding males may form dominance hierarchies (Christal and Whitehead, 1997). Direct observation, head scarring, and broken teeth all provide evidence for fights between mature males (Christal and Whitehead, 1997). Heading synchrony has been observed among males, but whether it is a result of social cohesion within aggregations or individual responses to environmental factors is unknown (Christal and Whitehead, 1997).

Aerial activity tends to be exhibited by maternity schools more often than by mature males (Waters and Whitehead, 1990a). Bouts of breaching and lobtailing can last several hours (Waters and Whitehead, 1990a). Waters and Whitehead (1990a) found that breaching and lobtailing rates were highest in late afternoon but both behaviors occurred at all times of the day and night. Sperms have been observed associating with Risso's dolphins (Shelden et al, 1995).

Reproduction

Breeding season:	Mate April to August; calve June to November
Calving season:	Late December to early March, peaks December to February
Sexual maturity	
Female:	9-10 yrs. old, 9 m
Male:	9-10 yrs. old, 9-12 m; begin to mate 25-27 yrs. old, 12-14 m
Gestation:	14-16.4 months
Lactation:	12-24 months
Cycle:	Calve every 3-6 yrs.
Neonate length:	4 m

Sperms are polygynous (Kasuya, 1991). Solitary, adult males search for schools of females and stay with them for characteristic periods of time (May and Beddington, 1980). Males leave the social group of females and immature sperms at about 4-5 years old and return to breed at about 25-27 years old (Christal and Whitehead, 1997; Whitehead et al, 1991). Sperms communally care for their young (Richard et al, 1996; Whitehead and Kahn, 1992) and may communally nurse calves (Whitehead et al, 1991). Females in late pregnancy tend to segregate in higher latitudinal water (Ohsumi, 1980b). Kasuya and Miyashita (1988) report that small scale interbreeding may occur between stocks of sperms. Age of sexual maturity has changed for sperms over time (Kasuya, 1991). Reproductive life of sperms lasts about 30 years (Kasuya, 1991).

Pregnancy rate was 25-31% in 1966 to 1967 (Ohsumi, 1980b) and was 20.6-27.1% (Masaki, 1980) in the mid-1970's in the western stock. Tillman and Breiwick (1983) report the pregnancy rate is 20-25% and recruitment rate is 4-6% for sperms. There are differences in pregnancy rate between sperms in the northwestern and southwestern north Pacific (Shimadzu, 1981). Pregnancy rate in the Galapagos Islands was reduced to 2-4% in 1985 and 1987 (Waters and Whitehead, 1990b). Ohsumi (1981b) states that pregnancy rate increased from the 1930's to the beginning of the 1960's.

Mortality and Economics

Natural Mortality

Sperm adults and calves are preyed upon by orcas (Anonymous, 1997; Consiglieri et al, 1982; Tsukagoshi, 1983; Whitehead et al, 1991). They have been observed being attacked by false killer whales in the Galapagos Islands (Palacios and Mate, 1996). The principal function of cooperative care for young is protection from predators (Whitehead et al, 1991).

At least 22 parasites and 6 viruses have been found in or on sperms:

Viruses

Caliciviruses

SMSV

SMSV 5

VESV

VESV A

VESV I

Parasites

Trematoda

Zalophotrema curilensis

Gubanov, 1952; Delyamure, 1955

Cestoda

Dipogonoporus sp.

Delyamure, 1955

Hexagonoporus physeteris

Gubanov, 1952; Delyamure, 1955

Phyllobothrium delphini

Bosc, 1802; Baylis, 1932

Priapocephalus grandis

Nybelin, 1922; Rees, 1953

Tetrabothrius curilensis

Gubanov, 1952; Delyamure, 1955

Tetrabothrium wilsoni

Leiper and Atkinson, 1914; Rees, 1953

Trigonocotyle sp.

Delyamure, 1955

Nematoda

Anisakis ivanizkii

Mozgovoi, 1949; Delyamure, 1955

Anisakis physeteris

Baylis, 1923; Baylis, 1932

Anisakis simplex

Rudolphi, 1809; Baylis, 1932

Anisakis skrjabini

Mozgovoi, 1949; Delyamure, 1955

Placentonema gigantissima

Gubanov, 1951; Delyamure, 1955

Acanthocephala

Bolbosoma brevicolle

Malm, 1867; Baylis, 1932

Bolbosoma captiatum

Linstow, 1880; Baylis, 1932

Bolbosoma physeteris

Gubanov, 1952; Delyamure, 1955

Corynosoma curilensis

Gubanov, 1952; Delyamure, 1955

Sperms also have ectoparasites. The diatom genus Plumosigma may be obligately associated with sperms (Nagasawa et al, 1990). Coronuline barnacles Coronula diadema, C. reginae, and Conchoderma auritum are found on sperms on rare occasions (Scarff, 1986). Cookiecutter shark

(*Isistius brasiliensis*) bites have been found on sperms (Gallo-Reynoso and Figueroa-Carranza, 1992; Kasuya and Miyashita, 1988).

Another source of natural mortality for sperms may be El Niño (Whitehead et al, 1991).

According to Tillman and Breiwick (1983), the mortality rate of sperms is 0.06, with a juvenile mortality rate of 0.09. Ohsumi (1980c) reports a natural mortality rate of 0.05. Male mortality rate is higher than female mortality rate (Ralls et al, 1980). Waters and Whitehead (1990b) found that mean mortality of females in the Galapagos Islands in 1985 and 1987 was low. Sperms may live for more than 60 years (Kajimura and Loughlin, 1988).

Mass strandings of sperms occur occasionally: 41 sperms (13 males and 28 females) mass stranded in Florence, OR in June, 1979 (McCrary and Pierson, 1990; Rice et al, 1986). Five mass strandings have been documented in the Gulf of CA: 9 males in Apr., 1953; 22 males in Jan., 1954; 17 in Sept., 1973; 38 males, 9 females, 3 aborted fetuses, and 9 unknown in Jan., 1979; and 3 males in Feb., 1983 (Vidal and Findley, 1986).

Anthropogenic Interactions and Mortality

Pollution may affect sperms. Wagemann and Muir (1984) report that DDT was found in the liver and blubber of sperms in CA in 1968. Ship strikes and entanglement can also be detrimental to sperms (Barlow et al, 1997). Sperms may purposely ram ships (Schmidt, 1979). Also, anthropogenic noise may be a concern for sperms (Barlow et al, 1997).

Sperms were commercially harvested until the 1980's (Barlow et al, 1997). The North Pacific Commissioners Meeting reduced pelagic catches starting in 1970 and set a size limit of 35 ft. (Ohsumi, 1980a). The International Whaling Treaty set size limits of 30 ft. for coastal whaling in 1938 and of 35 ft. in 1949 (Ohsumi, 1980a). The International Convention for the Regulation of Whaling set size limits of 38 ft. for pelagic whaling in 1952 and of 30 ft. with catch limits by sex in 1949 (Ohsumi, 1980a). The IWC limited the season to eight successive months starting in 1952 and changed the season limit to any eight months in 1975 (Ohsumi, 1980a). In 1980, the eastern north Pacific stock was given protection by the IWC, and quotas were established to limit catches to under 1,000 in the western north Pacific stock (Brueggeman et al, 1990). A prohibition on taking sperms in the north Pacific was enacted by the IWC in 1988 (Barlow et al, 1997; Takahashi, 1991).

American whalers harvested 24,500-34,000 sperms in Japan from 1822 to 1868 (Bannister et al, 1983; Tillman and Breiwick, 1983). 60,840 were harvested in the north Pacific from 1800 to 1909 (Ohsumi, 1980a; 1980c). It is estimated that 258,000 sperms were harvested by commercial whalers from 1947 to 1987, but the estimate is probably low due to under-reported kills by the Soviet Union (Barlow et al, 1997; Hill et al, 1997). 10,000 were harvested in the Galapagos Islands from 1830 to 1850 (Hope and Whitehead, 1991).

Fisheries are also an anthropogenic source of mortality for sperms. Most fisheries mortality is likely to be only in offshore drift gillnets (Barlow et al, 1997). In the CA/OR/WA stock, the CA/OR thresher shark/swordfish drift gillnet fishery takes a minimum of 4.5/yr. (CV=0.54) with another 4.5/yr. receiving serious injuries (Barlow et al, 1997). Minimum annual fisheries mortality for this stock is 4.5/yr. (Barlow et al, 1997). Fisheries that incidentally take sperms from the HI stock include pelagic, bottomfish, and lobster troll, handline, longline, and local inshore gillnet (Barlow et al, 1997). Minimum annual fisheries mortality for this stock is unknown (Barlow et al, 1997). Six commercial fisheries in the area of the AK stock were

monitored for incidental take from 1990 to 1995: Bering Sea (and Aleutian Islands) and Gulf of AK groundfish trawl, longline, and pot (Hill et al, 1997). No fisheries mortalities were observed, and none were reported in logbooks (Hill et al, 1997). Minimum annual fisheries mortality for the AK stock is 0/yr. (Hill et al, 1997). However, sperms have been observed feeding off of longline gear in the sablefish (Anoplopoma fimbria) and halibut (Hippoglossus stenolepis) fisheries in the Gulf of AK, and sperm interactions with Gulf of AK fisheries may be increasing in frequency (Hill et al, 1997). Sperms have never been reported to be taken by subsistence hunters (Hill et al, 1997).

Minimum total human-caused mortality is 4.5/yr. for the CA/OR/WA stock, unknown for the HI stock, and 0/yr. for the AK stock (Barlow et al, 1997; Hill et al, 1997). 4.5/yr. is more than PBR (1.8) for the CA/OR/WA stock and is considered significant (Barlow et al, 1997). PBR of the HI stock is unknown, so human-caused mortality is considered significant for this stock as well (Barlow et al, 1997). PBR is unknown for the AK stock, but since human-caused mortality is 0/yr., the mortality is considered insignificant (Hill et al, 1997).

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Review of Pygmy Sperm Whales (Kogia breviceps) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Warm-temperate and tropical waters; Japan to New Zealand in the western Pacific; WA, CA, Baja CA, the Gulf of CA, and Central America to Peru and Chile in the eastern Pacific; possibly British Columbia; HI in the central north Pacific

Before 1966, pygmies were lumped with dwarf sperm whales (Kogia simus), so some information overlaps for the two species (Baird et al, 1996). Pygmies are distributed throughout deep waters and along the continental slopes of the north Pacific (Barlow et al, 1997). They are rare on the U.S. west coast; this is probably a reflection of their pelagic distribution (Barlow et al, 1997). Strandings are known from the Gulf of CA, CA, OR, WA, HI, and Japan (Barlow et al, 1997; Brueggeman et al, 1990; Vidal et al, 1987; Baird et al, 1996; Thomas et al, 1990).

For management purposes, pygmies are separated into two stocks: CA/OR/WA and HI (Barlow et al, 1997). Population was 3,145 in CA in 1993-1995 (Barlow and Gerrodette, 1996; Barlow et al, 1997). Pygmies have also been sighted in the Gulf of CA (Vidal et al, 1987). Population in OR and WA is unknown (Barlow et al, 1997). No information exists regarding population trends for the CA/OR/WA stock (Barlow et al, 1997). N_{min} of this stock is 2,059, and PBR is 19 (Barlow et al, 1997). In HI, at least nine strandings were reported from 1949 to 1982 (Barlow et al, 1997). Three sightings have been reported off Oahu and Maui (Barlow et al, 1997). There are no data to estimate population of the HI stock, and no information exists regarding population trends (Barlow et al, 1997). N_{min} of this stock is unknown, and PBR is unknown (Barlow et al, 1997).

Pygmies are rarely seen at sea (Thomas et al, 1990), and Leatherwood et al (1972) states that they are probably not very numerous. Pygmies are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997).

Food and Feeding

Pygmies feed primarily on cephalopods, as well as on crustaceans and fish (Baird et al, 1996). Sargassum seaweed was found in the stomach of one stranded pygmy (Baird et al, 1997). Pygmies use echolocation (Karol et al, 1978).

The following prey species have been determined for pygmies:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	<u>Abralia</u> sp.	Enope squid
	<u>Abraliopsis</u> sp.	Enope squid
	<u>Ancistrocheirus</u> sp.	
	<u>Galiteuthis</u> sp.	Cranch squid
	<u>Histioteuthis</u> sp.	Umbrella or jewel squid
	<u>Loligo vulgaris</u>	Common squid
	<u>Lycoteuthis diadema</u>	

	<u>Moroteuthis</u> sp.	Giant squid
	<u>Octopoteuthis cyeletron</u>	Octopus squid
	<u>Ommastrephes</u> sp.	Arrow squid
	<u>Onychoteuthis borealijaponicus</u>	Nail squid
	<u>Phasmatopsis</u> sp.	Squid
	<u>Pygropsis</u> sp.	
	<u>Pyroteuthis</u> sp.	Pyroteuthid squid
	<u>Sepioteuthis australis</u>	Squid
	<u>Taningia</u> sp.	Octopus squid
	<u>Taonius pavo</u>	Giant squid
	<u>Todarodes</u> sp.	Flying squid
	<u>Tuethomenia pellucida</u>	
Crustacea	<u>Vampyroteuthis</u> sp.	Vampire squid
	<u>Aristaeomorpha foliacea</u>	Giant red shrimp
	<u>Carcinides maenas</u>	Green crab
	<u>Gnathophausia ingens</u>	Deep sea mysid
	<u>Goneplax angulata</u>	
	<u>Hymenbodora</u> sp.	
	<u>Pandalopsis</u> sp.	Shrimp
	<u>Pandalus</u> sp.	Shrimp
	<u>Pasiphaea pacifica</u>	
Osteichthys	<u>Penaeus californiensis</u>	Brown shrimp
	<u>Lampanyctus</u> sp.	Lampfish
	<u>Maurollicus muelleri</u>	Lanternfish
	<u>Nexea solandri</u>	
	<u>Photichthys argenteus</u>	Lightfish
	<u>Pyrosoma</u> sp.	
	<u>Scopelopsis multipunctatus</u>	Lanternfish
	<u>Symbolophorus</u> sp.	Lanternfish
Other	<u>Sargassum</u> sp.	Seaweed

Habits

Pygmies have been seen singly or in groups of up to about 6 (Baird et al, 1996). Thomas et al (1990) also state that pygmies are most commonly seen as individuals or in small groups. Pygmies are not notably soniferous (Thomas et al, 1990). They will release feces when startled (Baird et al, 1996).

Reproduction

Breeding season: May be fall to spring

Calving season:	May be fall to spring
Sexual maturity	
Males:	2.7-3.0 m
Females:	2 yrs. old; 2.7-2.8 m
Gestation:	7-11 months
Cycle:	Some may calve annually
Neonate length:	1.2-1.25 m

Mortality and Economics

Natural Mortality

White sharks (Carcharodon carcharius) prey on pygmies (Baird et al, 1996; Long, 1991). Pygmies are mostly known from strandings (Baird et al, 1996). They most commonly strand from WA to the Gulf of CA and in Japan (Thomas et al, 1990). Most strandings in the eastern north Pacific occur in fall and winter (Baird et al, 1996). Pygmies are the fourth most stranded cetacean in HI (Baird et al, 1996). Two strandings have been recorded in WA (Brueggeman et al, 1990). At least 15 parasites and 6 bacteria have been found in or on pygmies:

Bacteria

<u>Bacillus</u> sp.	Baird et al, 1996
<u>Enterobacter agglomerans</u>	Baird et al, 1996
<u>Enterobacter cloacae</u>	Baird et al, 1996
<u>Flavobacterium</u> sp.	Baird et al, 1996
<u>Pseudomonas cepacia</u>	Baird et al, 1996
<u>Pseudomonas maltophilia</u>	Baird et al, 1996

Parasites

Cestoda

<u>Monorygma grimaldii</u>	Moniez, 1889; Baylis, 1932
<u>Phyllobothrium delphini</u>	Bosc, 1802; Delyamure, 1955; Baird et al, 1996

Nematoda

<u>Anisakis physeteris</u>	Baird et al, 1996
<u>Anisakis simplex</u>	Rudolphi, 1809; Van Thiel, 1966
<u>Anisakis</u> sp.	Vidal et al, 1987
<u>Anisakis typica</u>	Baird et al, 1996
<u>Crassicauda magna</u>	Johnston and Mawson, 1939; Delyamure, 1955
<u>Crassicauda duguyi</u>	Dollfus, 1966
<u>Crassicauda</u> sp.	Baird et al, 1996
<u>Phocanema kogiae</u>	Baird et al, 1996
<u>Psedoterranova kogiae</u>	Johnston and Mawson, 1939; Delyamure, 1955

Stenurus sp.
Terranova sp.

Baird et al, 1996
Baird et al, 1996; Vidal et al, 1987

Yeasts, Rhodotorula pallida, R. rubra, Touloopsis sp., and Aurcobasidium sp., have also been found in pygmies (Baird et al, 1996).

Anthropogenic Interactions and Mortality

No specific studies on the effects of pollution on north Pacific pygmies were found. Boat collisions and ingestion of foreign objects kills pygmies (Baird et al, 1996). Anthropogenic noise may also negatively affect pygmies (Barlow et al, 1997). Small numbers of pygmies have been taken directly in fisheries (Baird et al, 1996).

Fisheries are also an anthropogenic source of mortality for pygmies (Barlow et al, 1994; 1997; Hobbs and Jones, 1993). At least 24 pygmies were incidentally taken in the Japanese squid and Japanese and Taiwanese large-mesh fisheries in 1990 (Hobbs and Jones, 1993). The CA/OR thresher shark/swordfish drift gillnet fishery incidentally takes pygmies from the CA/OR/WA stock (Barlow et al, 1997). Similar drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja CA and may also take pygmies from this stock (Barlow et al, 1997). Minimum total annual fisheries mortality for the CA/OR/WA stock is 2.8/yr.; this exceeds 10% PBR (1.9) and is considered significant (Barlow et al, 1997). There are no reports of direct or incidental takes of pygmies in HI (Barlow et al, 1997). However, bottomfish, lobster, and pelagic fisheries, including commercial troll, handline, longline, local inshore gillnet, charter, and recreational troll could potentially incidentally take pygmies (Barlow et al, 1997). Minimum total annual fisheries mortality for the HI stock is 0/yr; this level of mortality cannot be considered insignificant because PBR is unknown (Barlow et al, 1997).

Minimum total annual human-caused mortality for the CA/OR/WA stock is 2.8/yr.; this is less than PBR (19) and is considered insignificant (Barlow et al, 1997). Minimum total annual human-caused mortality for the HI stock is 0/yr.; this level of mortality cannot be considered insignificant because PBR is unknown (Barlow et al, 1997).

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Review of Orcas (Orcinus orca) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Along the west coast of North America including the entire AK coast, British Columbia and WA inland waterways, and along the outer coasts of WA, OR, and CA; in AK, range along the entire AK coast from the Chukchi Sea and Beaufort Sea into the Bering Sea along the Aleutian Islands, Gulf of AK, and southeastern AK; also occur rarely in HI

There are two forms of orcas found in the north Pacific: residents and transients (Baird and Dill, 1996; Baird et al, 1992; Barlow et al, 1997; Hill et al, 1997; Brueggeman et al, 1990; Consiglieri et al, 1982; Heimlich-Boran, 1988; Jacobsen, 1986; Matkin and Dahlheim, 1995; Hoelzel and Dover, 1991). A third form, offshores, has been described in WA and British Columbia (Matkin, 1997; Matkin and Dahlheim, 1995). Residents and transients differ in morphology, ecology, and behavior (Barlow et al, 1997; Brueggeman et al, 1990; Heimlich-Boran, 1988; Hill et al, 1997; Hoelzel and Dover, 1991). Resident and transient pods are genetically distinct (Barlow et al, 1997; Brueggeman et al, 1990; Felleman et al, 1991; Hill et al, 1997; Matkin et al, 1997; Hoelzel and Dover, 1991). In fact, Hoelzel and Dover (1991) found that a resident pod and a transient pod off Vancouver Island, British Columbia were as genetically distinct as a Pacific pod and an Atlantic pod. Generally, resident pods are made up of 1-4 generations of one or more matriline, and transient pods are made up of 1-2 generations of a single matriline (Baird and Dill, 1996). Transients tend to have a larger range than residents (Bigg, 1982). Transients occur throughout the ranges of residents but do not socially interact with them (Felleman et al, 1991). Resident pods in British Columbia and WA are divided into two communities: northern, ranging from northern Georgia Strait to Queen Charlotte Sound, and southern, ranging from southern Puget Sound to northern Georgia Strait (Heimlich-Boran, 1986a; 1986b; 1988). Center of abundance for the northern community is the Johnstone Strait and for the southern community, is the San Juan Islands (Heimlich-Boran, 1986a). Genetic differences have been found between northern, southern, and AK residents (Baird and Stacey, 1988). However, Hoelzel (1991) states that mtDNA of the northern and southern resident communities is similar, and Matkin et al (1997) suggests that either genetic mixing occurs between Prince William Sound residents and northern and southern residents in British Columbia or that these groups recently diverged from a common ancestor. Matkin (1997) divides orcas into three groups: residents, transients, and offshores.

For management purposes, north Pacific orcas are divided into five stocks: eastern north Pacific northern resident, ranging from British Columbia through AK; eastern north Pacific southern resident, ranging within the inland waters of WA and southern British Columbia; eastern north Pacific transient, ranging from AK to Cape Flattery, WA; CA/OR/WA Pacific coast, ranging from Cape Flattery, WA through CA; and HI (Barlow et al, 1997; Hill et al, 1997). The eastern north Pacific transient stock may be further separated into three relatively distinct groups: British Columbia transients (including southeastern AK), Gulf of AK transients, and Prince William Sound transients (Hill et al, 1997).

Felleman et al (1991) and Hoelzel (1991) report that the population of the northern resident community in British Columbia is 172 in 16 pods. Matkin et al (1997) state that there

were 13 resident pods totaling 278 orcas in southeastern AK and Prince William Sound in 1993. Recruitment rates indicate a 2% annual increase for portions of the eastern north Pacific northern resident stock; however, trends for the entire stock are unknown (Hill et al, 1997). N_{min} of this stock is 764 and PBR is 7.6 (Hill et al, 1997).

Felleman et al (1991) report that the population of the southern resident community in British Columbia and WA is 81 in 3 pods. Hoelzel (1991) reports that the population is 81 in 5 pods. Population of the eastern north Pacific southern resident stock increased 35% from 71 in 1974 to 96 in 1993, for an annual growth rate of 1.8% (Barlow et al, 1997). N_{min} of this stock is 96 and PBR is 1.9 (Barlow et al, 1997).

Felleman et al (1991) report that the population of transients in British Columbia and WA is 79 in 30 pods. Hoelzel (1991) also states that there are 30 transient pods in the area. Population trends of the eastern north Pacific transient stock are unknown (Hill et al, 1997). N_{min} of this stock is 314 and PBR is 3.1.

Population of the CA/OR/WA Pacific coast stock was 747 in 1993 (Barlow et al, 1997; Barlow and Gerrodette, 1996). Population trends of this stock are unknown (Barlow et al, 1997). Barlow et al (1997) state that orca sightings off CA, OR, and the Pacific coast of WA have been relatively infrequent and dispersed. Forney and Barlow (1998) also report that orcas are infrequently observed off CA, without any apparent centers of concentration or seasonal patterns. N_{min} of the CA/OR/WA Pacific coast stock is 436 and PBR is 3.5 (Barlow et al, 1997).

Population of the HI stock is unknown (Barlow et al, 1997). Orcas are rare in HI (Barlow et al, 1997; Leatherwood et al, 1972). One orca stranded in HI in 1950, and two orca sightings were reported in HI in January, 1978 and December, 1979 (Barlow et al, 1997). N_{min} and PBR of the HI stock are unknown (Barlow et al, 1997).

Shuntov (1993) reports that the population of orcas in what was formerly the Soviet Union economic zone was 12,500 in 1984-1991. Sobolevsky and Mathisen (1996) report the population of the Bering Sea to be 3,000-5,000. Population has remained relatively stable over time in the Bering, Chukchi and Okhotsk Seas (Sobolevsky and Mathisen, 1996; Vladimirov, 1994).

Orcas are not listed as endangered or threatened under the ESA, nor are they listed as depleted or strategic under the MMPA (Barlow et al, 1997; Hill et al, 1997).

Orcas do not migrate but travel in cohesive social groups and forage on prey that may be available seasonally, episodically, or serendipitously (Brueggeman et al, 1990). Perez (1990) states that orcas in the Chukchi and northern Bering Seas move south with the advancing pack ice. Seasonal and year-round abundances of orcas have been noted throughout their range (Barlow et al, 1997; Consiglieri et al, 1982; Forney and Barlow, 1998; Nichol and Shackleton, 1996). Seasonal abundances of orcas have been found to correspond with abundances of prey species, such as salmon, in some areas (Felleman et al, 1991; Heimlich-Boran, 1986a).

Residents and transients have not been seen traveling together (Matkin et al, 1997). Heimlich-Boran (1988) suggests that, in British Columbia and WA, residents have movement patterns that correspond to the distribution of migrating salmon and transients have movement patterns that correspond to the distribution of harbor seals. Heimlich-Boran (1986a) states that residents typically travel continuously from headland to headland in a predictable manner, while transients follow the shoreline and enter dead-end bays in a random fashion.

Orcas may travel long distances. For example, orcas sighted in Prince William Sound have also been sighted near Kodiak Island; orcas sighted in southeastern AK have also been

sighted in Prince William Sound, British Columbia, and Puget Sound; and movements have even been documented between southeastern AK and central CA (Barlow et al, 1997; Hill et al, 1997; Forney and Barlow, 1998; Goley and Straley, 1994). Transients have been known to travel about 550 km in 6 days (Felleman et al, 1991). Orcas tend to be distributed over the continental shelf less than 200 m deep (Braham and Dahlheim, 1982; Perez, 1990) and generally have a range of about 300 nautical miles (Bigg, 1982).

Food and Feeding

Orcas prey on fish, marine mammals, birds, other vertebrates, invertebrates, and sea turtles (Brueggeman et al, 1990; Heimlich-Boran, 1988; Perez, 1990; Matkin and Dahlheim, 1995; Vidal and Pechter, 1989; Jefferson et al, 1991). They are opportunistic feeders, with the flexibility to follow fluctuations in their preferred prey and seasonal movements that are responsive to prey distribution (Felleman et al, 1991; Heimlich-Boran, 1988; Perez, 1990; Yano and Dahlheim, 1995a). Prey choice varies between age and sex classes, with larger individuals eating a greater percentage of marine mammals (Felleman et al, 1991). Orcas may feed preferentially on fish or marine mammals depending on the abundance of each type of prey (Braham and Dahlheim, 1982; Consiglieri et al, 1982). However, it is thought that generally, transient orcas tend to prey on marine mammals and resident orcas tend to prey on fish (Baird and Dill, 1996; Baird et al, 1992; Brueggeman et al, 1990; Heimlich-Boran, 1988; Jacobsen, 1986; Matkin, 1997; Matkin et al, 1997; Miller, 1996; Matkin and Dahlheim, 1995; George and Suydam, 1998). Matkin and Dahlheim (1995) found that, of identified transient predation in their study in northern southeastern AK, 5% was on salmon, 35% was on harbor seals, 15% was on Steller sea lions, 25% was on harbor porpoises, and 20% was on seabirds. They also report orcas preying on Pacific white-sided dolphins, humpback whales, and moose. In addition to moose, other terrestrial animals have been reported as prey, including deer and pigs (Jacobsen, 1986).

Orcas hunt in groups, particularly when feeding on marine mammals (Consiglieri et al, 1982; Felleman et al, 1991; Heimlich-Boran, 1988; Kajimura and Loughlin, 1988; Reed, 1997). They use echolocation to detect prey (Yano and Dahlheim, 1995a). Temporary absence of adult male orcas during the initial stages of predation has been observed in British Columbia and AK (Dahlheim and Towell, 1994). Orcas forage and feed at all hours (Jacobsen, 1986).

Two behavior categories have been defined for the feeding strategies of residents: foraging and milling (Heimlich-Boran, 1986a). Foraging involves orcas spread out in a broad flank across a large stretch of water, presumably to locate any fish in the vicinity (Heimlich-Boran, 1986a). Once a school of fish is located or herded into a confined area, the orcas are likely to break ranks and begin non-directional activity called milling; milling is indicative of individuals feeding independently (Heimlich-Boran, 1986a).

Northern and southern residents and transients were observed in Greater Puget Sound from 1976 to 1983 (Felleman et al, 1991). Feeding behaviors included foraging, percussive foraging, milling, and marine mammal predation (Felleman et al, 1991). Residents typically had a basic foraging pattern extended over a 3-10 km range with pod members traveling abreast in flank formations, oriented at right angles to the shoreline or to underwater ridges (Felleman et al, 1991). Females and calves often traveled together in loose or tight subgroups, while adult males and females without calves traveled individually or in pairs (Felleman et al, 1991; Osborne,

1986). During foraging, adult female and calf groups commonly engaged in percussive splashing just prior to milling; percussive behaviors included slapping tails, dorsal fins, or pectoral fins on the water and breaching (Felleman et al, 1991). Individuals or subgroups often exhibited foraging peripheral to the pod (Felleman et al, 1991). Adult males typically foraged individually as much as 3 km from the nearest individual, though still traveling in the same direction as the pod (Felleman et al, 1991; Osborne, 1986). Adult females foraging at a distance from the pod were normally in pairs (Felleman et al, 1991). Peripheral individuals often exhibited rapid sharp turns at the surface (Felleman et al, 1991). Pairs of peripheral females frequently oriented toward each other as they dove, which may have enabled them to herd fish (Felleman et al, 1991). Females with calves traveling close inshore remained parallel to each other and rarely changed direction sharply (Felleman et al, 1991). Northern residents were not observed preying on marine mammals, and less than 1% of observed predation by southern residents was on marine mammals (Felleman et al, 1991). Between feeding bouts, young orcas are likely to engage in play (Jacobsen, 1986).

Fish foraging behavior of transients was similar to the peripheral adult foraging among residents (Felleman et al, 1991). However, transients exhibited a greater tendency to follow coastlines and spend long periods milling in one area, often in bays, before moving on (Felleman et al, 1991). Percussive behavior was observed only rarely during foraging of transients (Felleman et al, 1991). Transients preying on marine mammals tended to envoke a cooperative foraging strategy, surrounding the individual prey and taking turns attacking it (Felleman et al, 1991). Fewer vocalizations were made by foraging transients than foraging residents (Felleman et al, 1991). Ljungblad and Moore (1983) did not detect sounds from orcas chasing gray whales. Sounds may be used during fish predation, but marine mammal prey are likely to flee from orca sounds (Felleman et al, 1991).

The following prey species have been determined for orcas:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	Decabrachia	Squid
	Decapoda	Squid
	Gonatidae	Gonata squid
	Octobrachia	Octopus
Crustacea	Amphipoda	Amphipods
	Copepoda	Copepods
	Euphausiidae	Euphausids, krill
Chondrichthys	<u>Carcharodon carcharias</u>	White shark
	Carcharinidae	Carcharinid sharks
	<u>Cetorhinus maximus</u>	Basking shark
	<u>Prionace glauca</u>	Blue shark
	Rajidae	Skates
	Squaliformes	Sharks
	<u>Torpedo californica</u>	Electric ray

Osteichthys

Anoplopoma fimbria
Atheresthes stomias
Bathymaster signatus
Boreogadus saida
Clupea pallasii
Coregonus sp.
Eleginus gracilis
Gadus macrocephalus
Heterosomata sp.
Hexagrammidae
Hippoglossus stenolepis
Lampris regius
Mallotus villosus
Oncorhynchus clarki
Oncorhynchus gorbuscha
Oncorhynchus keta
Oncorhynchus kisutch
Oncorhynchus mykiss
Oncorhynchus nerka
Oncorhynchus sp.
Oncorhynchus tshawytscha
Ophiodon elongatus
Osmeridae
Pleurogrammus monopterygius
Pleuronectiformes
Reinhardtius hippoglossoides
Sarda orientalis
Sardinops melanosticta
Scombridae
Sebastes sp.

Sablefish/blackcod
Arrowtooth flounder
Searcher
Arctic cod
Pacific herring
Whitefish
Saffron cod
Pacific cod
Flatfish
Greenlings
Pacific halibut
Opah/moonfish
Capelin
Cutthroat trout
Pink salmon
Chum salmon
Coho salmon
Steelhead trout
Sockeye salmon
Salmon
Chinook salmon
Lingcod
Smelts
Atka mackerel
Flatfish
Greenland turbot
Bonito
Sardine
Mackerel
Rockfish

Reptilia

Dermochelys coriacea

Leatherback sea turtle

Aves

Brachyramphus mormoratus
Branta bernicla nigricans
Cepphus columba
Gavia immer
Melanitta deglandi
Melanitta fusca
Melanitta nigra
Melanitta perspicillata
Mergus merganser
Mergus serrator
Phalacrocorax pelagicus

Marbled murrelet
Black brant
Pigeon guillemot
Common loon
White-winged scoter
White-winged scoter
Black scoter
Surf scoter
Common merganser
Red-breasted merganser
Pelagic comorant

Mammalia

Rissa tridactyla
Phalacrocoracidae

Alces alces
Balaena mysticetus
Balaenoptera acutorostrata
Balaenoptera borealis
Balaenoptera edeni
Balaenoptera musculus
Balaenoptera physalus
Berardius bairdii
Cetacea
Callorhinus ursinus
Delphinidae
Delphinus delphis
Delphinapterus leucas
Enhydra lutris
Erignathus barbatus
Eschrichtius robustus
Eubalaena glacialis
Eumetopias jubatus
Globicephala macrorhynchus
Grampus griseus
Kogia breviceps
Lagenorhynchus obliquidens
Lissodelphis borealis
Megaptera novaeangliae
Mirounga angustirostris
Mysticeti
Neophocaena phocaenoides
Odobenus rosemarus
Odocoileus sp.
Otariidae
Phoca hispida
Phoca sp.
Phoca vitulina
Phocoena phocoena
Phocoenidae
Phocoenoides dalli
Physeter macrocephalus
Pinnipedia
Stenella coeruleoalba
Sus sp.
Zalophus californianus
Ziphius cavirostris

Black-legged kittiwake
Comorant

Moose
Bowhead whale
Minke whale
Sei whale
Byrde's whale
Blue whale
Fin whale
Baird's beaked whale
Whales, dolphins, and porpoises
Northern fur seal
Dolphins
Common dolphin
Beluga
Sea otter
Bearded seal
Gray whale
Northern right whale
Steller sea lion
Short-finned pilot whale
Risso's dolphin
Pygmy sperm whale
Pacific white-sided dolphin
Northern right whale dolphin
Humpback whale
Northern elephant seal
Baleen whales
Finless porpoise
Walrus
Deer
Sea lions
Ringed seal
Seal
Harbor seal
Harbor porpoise
Porpoises
Dall's porpoise
Sperm whale
Seals, sea lions, and walruses
Striped dolphin
Pig
California sea lion
Cuvier's beaked whale

Habits

Pods of orcas are almost always made up of the same individuals (Balcomb and Bigg, 1986; Jacobsen, 1986). Pods consist of mixed ages and sexes, strongly suggesting that they are long-term fundamental social units of breeding populations (Balcomb and Bigg, 1986; Bigg, 1982). Pods frequently join with one another, but when they split, individuals return, with few exceptions, to their own pods (Balcomb and Bigg, 1986; Balcomb et al, 1982; Heimlich-Boran, 1986b; Jacobsen, 1986). Association between individuals have been found to be selective rather than random (Heimlich-Boran, 1986a; Jacobsen, 1986). Associations within a pod result in distinct subgroups (Jacobsen, 1986). Subgroups are recognized as assemblages of orcas that swim close together and coordinate respirations (Jacobsen, 1986). The most stable subunits are mother-calf associations, which may last into adulthood and appear to be the basic structure in orca social organization (Jacobsen, 1986). The degree to which various members of the same or different pods synchronize their movements indicates their social affinity (Jacobsen, 1986). Some individual associations observed in resident pods have lasted at least 13 years (Balcomb and Bigg, 1986).

Pod formation is matrilineal (Bigg, 1982; Bigg et al, 1990; Felleman et al, 1991; Matkin 1997), and female hierarchies may exist (Heimlich-Boran, 1986b). Both sexes spend their entire lives in maternal subgroups, remaining within their natal pods (Felleman et al, 1991; Matkin et al, 1997). Transients have a more fluid social structure than residents (Matkin et al, 1997; Matkin and Dahlheim, 1995). The lack of dispersal among residents appears to be unique among mammalian social systems (Bigg et al, 1990). Pods within the northern and southern resident communities have never been observed interacting with each other, but pods from the same community are frequently seen in association (Heimlich-Boran, 1986b).

Pod sizes range from 1-100 (Braham and Dahlheim, 1982; Brueggeman et al, 1990; Consiglieri et al, 1982; Yano and Dahlheim, 1995a). Only 1% of pods have more than 20 orcas (Braham and Dahlheim, 1982; Yano and Dahlheim, 1995a). Resident pods tend to have more than five orcas, while transient pods tend to have less than five orcas (Bigg, 1982; Felleman et al, 1991). Brueggeman et al (1990) state that residents generally travel in pods of 5-50 whereas transients generally travel in pods of 1-7. Matkin and Dahlheim (1995) report that residents usually are in pods of 10-50 but transients usually are in pods of 1-15. Average pod size is 6 in Japan (Yano and Dahlheim, 1995a). Orca groups often dive synchronously (Forney and Barlow, 1998). Stable repertoires of stereotyped vocalizations and the presence of dialects have been reported for orca pods (Jacobsen, 1986).

Residents and transients have shown distinct behavioral differences (Heimlich-Boran, 1988). Heimlich-Boran (1988) found that residents in WA and British Columbia from 1976 to 1983 spent 47% of their time feeding, 25% traveling, 13% resting, and 15% socializing. He found that transients spent 81% of their time feeding, 12% traveling, 7% resting, and 0% socializing. Osborne (1986) found that resident orcas in Greater Puget Sound spent 27% of their time traveling, 13% playing, 12% sleeping/resting, and 46% foraging. Residents tend to vocalize more than transients (Matkin and Dahlheim, 1995). Also, northern resident orcas have been observed rubbing their bodies on shallow pebble substrate for up to 1.5 hours (Heimlich-Boran, 1988). Many of the differences between resident and transient behaviors may be learned (Heimlich-Boran, 1988).

There seems to be evidence for agonistic behavior (Jacobsen, 1986). However, it has not been documented (Jacobsen, 1986). Infliction of wounds may arise during parent-young interactions, sexual aggression, and play rather than during agonistic interactions (Jacobsen, 1986).

Resident pods follow a predictable strait line course while traveling (Jacobsen, 1986). The three travel speeds, slow, medium, and fast, each have a characteristic respiratory pattern (Jacobsen, 1986). Slow travel is 2-4 knots, typically with synchronous diving for 2-5 minutes, surfacing, then diving for 10-30 second intervals several times before another long dive (Jacobsen, 1986). Slow travel often includes periods of play and brief rest (Jacobsen, 1986). Medium travel is 4-6 knots, and the soundings are more regular with intervals of 15-60 seconds and fewer longer dives in between, as well as more efficient surfacing (Jacobsen, 1986). Fast travel has been observed to be up to 11 knots, with orcas rising higher out of the water when surfacing and 10-60 second dive intervals with occasional 1.5-2.5 minute soundings (Jacobsen, 1986). Matkin et al (1997) found that a resident orca in AK traveled 740 km, with a minimum average speed of 5.1 km/hr. Transients have been known to travel 550 km in 6 days (Felleman et al, 1991). Once inshore, transients tend to move quickly across major straits and then to remain in restricted areas for extended periods (Felleman et al, 1991).

Orcas engage in a resting pattern that has been observed for up to 8 hours (Jacobsen, 1986). In this pattern, they travel at less than 2 knots, physical and vocal activity is minimal, and orcas sometimes float for up to 3 minutes (Jacobsen, 1986). Respirations of the entire pod are highly coordinated and orcas are close together, in a line perpendicular to the direction of travel (Jacobsen, 1986). The line is organized into maternal subgroups, generally with an adult male on each end (Jacobsen, 1986). This resting pattern has been observed at all times of day (Jacobsen, 1986).

Play is most likely to occur when a pod is in transition between more goal-oriented activities (Jacobsen, 1986). Play is also common during short periods between long dives (Jacobsen, 1986). Orcas have been observed playing with kelp (Nereocystis luetkeana) (Jacobsen, 1986).

Sometimes, orcas will engage in a greeting ceremony when two resident pods come together after being separated for more than a day or two (Osborne, 1986). The pods will form two tight lines and approach each other head on (Osborne, 1986). When the groups are within 10-20 m of each other, they stop motionless at the surface and hover, facing each other for 10-30 seconds (Osborne, 1986). The two groups then submerge and swim toward each other (Osborne, 1986). They resurface in mixed tight swarms characteristic of intermingling (Osborne, 1986).

Orcas have been observed interacting with minke whales, porpoises, dolphins, Steller sea lions, Dall's porpoises, fin whales, humpback whales, false killer whales, Risso's dolphins, common dolphins, spinner dolphins, Pacific white-sided dolphins, harbor porpoises, walruses, California sea lions, sea otters, and harbor seals without showing a predator response (Felleman et al, 1991; Jacobsen, 1986; Jefferson et al, 1991).

Reproduction

Breeding season: Year-round; generally late summer and fall for northern and southern residents; peaks in May-July in eastern north Pacific

Calving season:	Year-round; generally October to March for northern and southern residents
Sexual maturity	
Female:	3 yrs. old; many as late as 6-14.9 yrs. old; 4.9 m
Male:	15.0 yrs. old; 6.7 m
Gestation:	12-17 months
Lactation:	at least 1 yr.
Cycle:	Minimum calving interval is 3 yrs.
Neonate length:	246-276 cm

In courtship, the 2-3 orcas involved chase one another with a great deal of physical contact (Jacobsen, 1986). The male may slide over the female anterior to her dorsal fin and impede her forward progress (Jacobsen, 1986). Fluke and pectoral slaps may be oriented toward one another (Jacobsen, 1986). The female or male may alternately swim in an inverted position below the other with its head oriented toward the other's genital region (Jacobsen, 1986). The female may perform an inverted fluke lift, possibly to avoid copulation (Jacobsen, 1986).

Mating orcas have been observed to align their genital areas in at least four copulatory positions that may be held for as long as 30 seconds (Jacobsen, 1986). Jacobsen (1986) observed three occasions in which a third orca was involved in mating activity. In these cases, the male lay on his side next to the horizontal female with his pectoral fin on her back (Jacobsen, 1986). The other orca positioned itself on the other side of the female, apparently holding her in place during copulation (Jacobsen, 1986). When only two orcas are involved in mating activity, the orcas converge and glide against each other for a brief moment (Jacobsen, 1986). At the surface, they simultaneously roll onto their sides with ventral surfaces together, their pectoral fins sometimes locked (Jacobsen, 1986). Underwater, the female swims upside down, presenting to the diving male (Jacobsen, 1986). If both orcas are underwater they swim obliquely toward each other while turning and gliding together in a mutually spiraling motion (Jacobsen, 1986).

There is a high degree of nurturant behavior in orca family groups (Jacobsen, 1986). Although calves and juveniles form subgroups, there is always an adult in the immediate vicinity (Jacobsen, 1986). Mothers have been observed to swim off by themselves, leaving their calves with an adult bull (Jacobsen, 1986). The calves are generally playful when left with a bull, who sometimes participates in the calves' activities (Jacobsen, 1986). After a period of up to an hour, mothers rejoin their calves (Jacobsen, 1986).

Calves may nurse several times during a dive (Jacobsen, 1986). Calves maintain swimming positions alongside the flank and behind the dorsal fin of cows (Jacobsen, 1986). This position may help them keep up with the cows (Jacobsen, 1986).

An orca birth was observed in the Juan de Fuca Strait, British Columbia in 1990 (Stacey and Baird, 1997). A pod of orcas milled for 2 minutes in a 20 m² area with occasional high-speed movements and splashing (Stacey and Baird, 1997). Several times over a period of about 30 seconds, an orca rotated quickly at the surface (Stacey and Baird, 1997). About 5 seconds after the last rotation, three orcas spyhopped with a neonate jointly held on their rostrums (Stacey and Baird, 1997). The neonate remained motionless while held about 1 m above the surface for 2-3

seconds (Stacey and Baird, 1997). The orcas swam clockwise in circles about 50 m in diameter (Stacey and Baird, 1997). The neonate was resighted about 10 minutes later swimming between two adult females that were circling with the rest of the group about 1 m apart (Stacey and Baird, 1997). Some of the orcas departed to the south, but eight orcas remained including the neonate (Stacey and Baird, 1997). The orcas engaged in considerable percussive activities (Stacey and Baird, 1997). On several occasions the neonate was thrown partway into the air and once, one or more orcas in the group tail lobbed on top of, or very close to, the neonate (Stacey and Baird, 1997). There were sustained bouts of high speed swimming, and the neonate was pushed out of the water several times (Stacey and Baird, 1997). Most of the identified orcas were closely related to the mother, and many of these orcas were in direct physical contact with the neonate within minutes of birth (Stacey and Baird, 1997).

Resident and transient orcas are probably reproductively isolated (Baird and Dill, 1995; 1996; Baird et al, 1992; Felleman et al, 1991; Heimlich-Boran, 1988). Hoelzel (1991) found that mtDNA of residents and transients in British Columbia and WA is genetically different, but the mtDNA of the two resident communities is similar. A recent division between the two resident populations following a founder event and extensive breeding has been suggested (Hoelzel, 1991). Preliminary genetic analysis indicates that either genetic mixing occurs between Prince William Sound residents and northern and southern residents in British Columbia or that these groups have recently diverged from a common ancestor (Matkin et al, 1997).

Balcomb and Bigg (1986) found that the average reproductive rate for resident pods in Puget Sound, WA and off southern Vancouver Island, British Columbia from 1974 to 1981 was 0.081 calves/cow/yr., with the highest rate for individuals being 0.333 calves/cow/yr. and the lowest being 0 calves/cow/yr. Matkin and Dahlheim (1995) report that orcas have a normally low reproductive rate. Some females may not breed for social reasons (Balcomb and Bigg, 1986). Consiglieri et al (1982) suggest that two females in a pod produce most of the calves over several years. Average age of primipary for residents is 15 yrs. old (Stacey and Baird, 1997). Female orcas produce an average of 5.35 viable calves over a reproductive lifetime of 25.2 years (Olesiuk et al, 1990).

Mortality and Economics

Natural Mortality

Orcas have no known natural predators (Consiglieri et al, 1982). At least 7 parasites have been found in or on orcas:

Trematoda

Fasciola skiriabini

Delyamure, 1955

Cestoda

Diphyllbothrium sp

Hatsushika et al, 1987

Phyllobothrium sp.

Dailey and Brownell, 1972

Trigonocotyle spasskyi

Gubanov, 1952; Delyamure, 1955

Nematoda

Anisakis simplex

Rudolphi, 1809; Delyamure, 1955

Ectoparasitic barnacles, Xenobalanus globicipitis and Cryptolepas rhachianecti were found on a female orca stranded in CA in 1984 (Samaras, 1989). C. rhachianecti is generally thought to be host specific to gray whales (Samaras, 1989).

Balcomb and Bigg (1986) found that the average natural mortality rate was 0.015 orcas/yr. and the average life span was 69 years for resident pods in Puget Sound, WA and southern Vancouver Island, British Columbia from 1974 to 1980. Balcomb et al (1982) found that the average natural mortality rate was 0.010 orcas/yr. for resident pods in Greater Puget Sound from 1974 to 1980. Bigg (1982) observed that the average natural mortality rate for males was 0.0280 orcas/yr. and for juveniles was 0.0230 orcas/yr. on Vancouver Island from 1973 to 1981. Olesiuk et al (1990) state that neonate mortality was 43% for residents in British Columbia and WA from 1973 to 1987.

Female orcas live an average of 50 years but can live up to 80-90 years (Anonymous, 1997b; Olesiuk et al, 1990). Males live an average of 29 years but can live up to 50-60 years (Anonymous, 1997b; Olesiuk et al, 1990). Bigg (1982) states that 0.70% of females live to 143 yrs. old.

Anthropogenic Interactions Mortality

Pollution may affect orcas. In particular, the Exxon Valdez oil spill in Prince William Sound in 1989 may have had detrimental effects (Braham, 1992; Hill et al, 1997; Loughlin et al, 1996; Matkin and Dahlheim, 1995). By seven days after the oil spill, seven orcas were missing and six more disappeared by June, 1990 (Braham, 1992; Loughlin et al, 1996). One more disappeared from 1990 to 1991, but none disappeared from 1991 to 1992 (Loughlin et al, 1996). Also, PCBs and DDT have been detected in orca blubber (Varanasi et al, 1994; Matkin and Dahlheim, 1995). Dioxins have been detected in orca blubber from British Columbia (Jarman et al, 1996). Jarman et al (1996) found relatively high levels of OCs and PCBs in British Columbia orcas. Kannan et al (1989) and Ono et al (1987) detected PCBs and PCDFs in the blubber of orcas caught on the Pacific coast of Japan in 1986. Ono et al (1987) found that there was no obvious loss of PCDFs and PCBs to lactation and parturition in pregnant or resting females that they analyzed. Orcas may have a weaker metabolic capacity for PCDFs than some other marine mammals (Ono et al, 1987). Toxic heavy metals have been detected in orcas as well (Matkin and Dahlheim, 1995).

In terms of vessel interaction with orcas, transients seem distinctly less habituated to close approaches than residents, which are surprisingly tolerant of multiple observation vessels (Felleman et al, 1991). Small boats in Johnstone Strait were observed to cause orcas to become active and change their direction to avoid the boats (Jacobsen, 1986). Noise from boats may adversely affect orca acoustical behavior (Jacobsen, 1986).

At least 134 orcas were taken into captivity between 1961 and 1996 (Anonymous, 1997b). Of those 134, 98 have died (Anonymous, 1997b). One orca was captured and kept in CA in 1961; of 223 orcas captured in WA from 1962 to 1976, 10 died, 31 were kept, and 182 or more escaped or were released; of 52 orcas captured in British Columbia from 1964 to 1977, 1 died, 25 were kept, and 26 escaped or were released; 12 orcas were captured and kept in Japan from 1972 to 1982 (Hoyt, 1984). Some captures were intentional, some were accidental, and some were rehabilitation (Hoyt, 1984). Average survival time of a captive orca is just over 5 years, and most in captivity die before they reach their early twenties (Anonymous, 1997b).

Balcomb and Bigg (1986) indicate that orcas were significantly harvested in Puget Sound, WA and off southern Vancouver Island, British Columbia to be used for public display and research from 1962 to 1977. In whaling, 78 orcas were caught in Kamchatka from 1948 to 1964; 223 were caught in the Kuril Islands from 1949 to 1963; two were caught in Korea in 1981; 1,534 were caught in Japan from 1946 to 1981; one was caught in British Columbia in 1955; and three were caught in CA from 1963 to 1967 (Hoyt, 1984).

Fisheries are also an anthropogenic source of mortality for orcas. Orcas have been found drowned in fishing nets (Balcomb and Bigg, 1986) and entangled and drowned in sablefish longlines (Barlow et al, 1994). Orcas have been taken incidentally in the British Columbia driftnet fishery for salmon, the western Canadian driftnet fishery for neon flying squid (discontinued), the Prince William Sound driftnet and setnet fisheries for salmon, and the AK trawl fishery for pollock and other groundfish (Barlow et al, 1994). The only fishery in which mortality was observed for the CA/OR/WA Pacific coast stock from 1991 to 1995 was the CA/OR thresher shark/swordfish drift gillnet (Barlow et al, 1997). The minimum average annual fisheries mortality for this stock is 1.2/yr. (Barlow et al, 1997). No fisheries mortality was observed for the eastern north Pacific southern resident stock from 1988 to 1995 (Barlow et al, 1997). Orcas from the eastern north Pacific northern resident stock and from the eastern north Pacific transient stock were taken in the Bering Sea and Aleutian Islands groundfish trawl and longline fisheries from 1990 to 1995 (Hill et al, 1997). The minimum average annual fisheries mortality for each of these stocks is 1.4/yr. (Hill et al, 1997). Fisheries that have the potential to incidentally take orcas are as follows (Hill et al, 1997; Barlow et al, 1994; 1997):

Eastern north Pacific northern resident stock:

- British Columbia driftnet for salmon
- AK trawl for pollock and other groundfish
- Bering Sea and Aleutian Islands groundfish trawl
- Bering Sea and Aleutian Islands groundfish longline
- Bering Sea and Aleutian Islands groundfish pot
- Gulf of AK groundfish trawl
- Gulf of AK groundfish longline
- Gulf of AK groundfish pot

Eastern north Pacific southern resident stock:

- British Columbia driftnet for salmon
- Prince William Sound driftnet and setnet for salmon
- Northern WA marine set gillnet
- WA Puget Sound Region salmon set/drift gillnet
- Puget Sound non-treaty salmon gillnet
- Puget Sound treaty and non-treaty chum salmon gillnet
- Puget Sound treaty chum and sockeye salmon gillnet
- Puget Sound treaty and non-treaty sockeye salmon gillnet

Eastern north Pacific transient stock:

- British Columbia driftnet for salmon
- Prince William Sound driftnet and setnet for salmon
- AK trawl for pollock and other groundfish
- Bering Sea and Aleutian Islands groundfish trawl
- Bering Sea and Aleutian Islands groundfish longline

- Bering Sea and Aleutian Islands groundfish pot
- Gulf of AK groundfish trawl
- Gulf of AK groundfish longline
- Gulf of AK groundfish pot
- CA/OR/WA Pacific coast stock:
 - CA/OR thresher shark/swordfish drift gillnet
 - Large mesh (>3.5") set gillnet for halibut and angel sharks
- HI stock:
 - Pelagic troll
 - Pelagic handline
 - Pelagic longline
 - Pelagic local inshore gillnet
 - Bottomfish
 - Lobster

Orcas have been observed feeding on sablefish caught on longline gear in the Aleutian Islands (Barlow et al, 1997). Yano and Dahlheim (1995a; 1995b) report that orcas in the southeastern Bering Sea and Prince William Sound, AK depredate longline catches of bottomfish, such as sablefish, Greenland turbot, and arrowtooth flounder. They estimate depredation rates in the southeastern Bering Sea and adjacent waters to be 14-60% of sablefish, 39-69% of Greenland turbot, and 6-42% of arrowtooth flounder. Orcas also depredate longline catches of halibut in northern southeastern AK (Matkin and Dahlheim, 1995). Deterrents to depredation have been unsuccessful (Yano and Dahlheim, 1995a). Orcas are shot by fisherpeople protecting their catch (Yano and Dahlheim, 1995a; Hill et al, 1997). Heimlich-Boran (1986a) estimates that resident orcas in WA have a maximum consumption rate of 4-7% of the salmon fishery.

Orcas have been caught commercially in Japan (Miyazaki, 1983). Miyazaki (1983) reports that 12 were caught commercially (harpoon, drive, and longline fisheries or small-type whaling) in Japan from 1976-81.

Minimum total human-caused mortality is 1.2/yr. for the CA/OR/WA Pacific coast stock, 0/yr. for the eastern north Pacific southern resident stock, unknown for the HI stock, 1.4/yr. for the eastern north Pacific northern resident stock, and 1.4/yr. for the eastern north Pacific transient stock (Barlow et al, 1997; Hill et al, 1997). 1.2/yr. is less than 10% of PBR (3.5) for the CA/OR/WA Pacific coast stock and is considered insignificant (Barlow et al, 1997). 0/yr. is less than 10% of PBR (0.19) for the eastern north Pacific southern resident stock, but because of uncertainty in estimates, human-caused mortality is still considered significant for the stock (Barlow et al, 1997). Because minimum population and human-caused mortality are unknown for the HI stock, mortality cannot be considered insignificant (Barlow et al, 1997). 1.4/yr. is more than 10% of PBR for the eastern north Pacific northern resident stock (0.76) and for the eastern north Pacific transient stock (0.31) and is considered significant for both stocks (Hill et al, 1997).

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Review of False Killer Whales (*Pseudorca crassidens*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Mainly in tropical and warm-temperate waters; AK, British Columbia, WA, CA and the eastern tropical Pacific to Mexico, the Galapagos Islands, and Peru in the eastern north Pacific; Sea of Japan, South and East China Seas, and Pacific coast of Japan in the western north Pacific; HI; rare north of 30°N

False killers are generally considered pelagic and are usually sighted offshore (Acevedo-Gutiérrez et al, 1987; Stacey and Baird, 1991; Leatherwood et al, 1972). False killers are well known from southern Japan, HI, and the eastern tropical Pacific (Barlow et al, 1997). There are four stranding records from HI (Barlow et al, 1997). A false killer was killed in Puget Sound, WA in May, 1937, and 14-17 false killers were observed from May to July in southern Puget Sound in 1987 (Brueggeman et al, 1990). There are 23 records of solitary false killers seen in British Columbia since 1987 (NOAA, 1995). There is one record of a false killer sighted in Prince William Sound, AK (Stacey and Baird, 1991). False killers have been sighted in Golfo Dulce and Isla del Coco, Costa Rica (Acevedo-Gutiérrez et al, 1987). Two individuals were resighted in Golfo Dulce and 22 were resighted 1-4 times at Isla del Coco over a two year study period; however, no resightings were made between study areas (Acevedo-Gutiérrez et al, 1987).

For management purposes, false killers are considered one stock: HI (Barlow et al, 1997). The population of the HI stock is unknown, and there are no data available on population trends (Barlow et al, 1997). N_{min} of this stock is unknown, and PBR is unknown (Barlow et al, 1997).

In the western north Pacific, false killers summering in the Sea of Japan may belong to a different stock from those summering off the Pacific coast of Japan (Kishiro and Kasuya, 1993). Population of the western north Pacific between 25°N and 39°N and west to 180°E was 16,668 in the early 1990's (Kishiro and Kasuya, 1993; Miyashita, 1993). A density gap occurs near 141°E to 146°E (Kishiro and Kasuya, 1993; Miyashita, 1993). Using this boundary, the population nearshore north of 30°N and west of 145°E was 2,029 (Kishiro and Kasuya, 1993; Miyashita, 1993), population in the eastern offshore waters from 145°E to 160°E was 8,569, and population in the southern offshore waters south of 30°N was 6,070. Population wintering in the Iki Island waters and in part of the East China Sea was 3,259 (Kishiro and Kasuya, 1993).

False killers are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997). Migrations have not been documented (Stacey and Baird, 1991).

Food and Feeding

False killers are opportunistic feeders that consume a wide variety of prey, including fish, squid, and marine mammals (Acevedo-Gutiérrez et al, 1997; Barid et al, 1989; Palacios and Mate, 1996; Stacey and Baird, 1991). In observations in Golfo Dulce and Isla del Coco, Costa Rica, Acevedo-Gutiérrez et al, 1997 noted that during foraging, there were large distances between subgroups, asynchronous dives, leaps, and the number of associated seabirds increased.

They state that directional feeding at the surface is characterized by high-speed activity, leaps, and absence of dives, directional feeding at depth is characterized by remaining in one place or slowly heading in one direction while diving in large subgroups, and non-directional feeding is characterized by back and forth movement of individuals heading in different directions and diving asynchronously. They observed false killers feeding on fish and chasing bottlenose dolphins. Palacios and Mate (1996) report an attack by false killer whales on sperm whales in the Galapagos Islands. They and Stacey and Baird (1991) also mention an attack by false killers on a humpback whale calf in HI.

The following prey species have been determined for false killers:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	<u>Berryteuthis magister</u>	Magistrate armhook squid
	Decapoda	Squid
	<u>Gonatopsis borealis</u>	Gonata squid
	<u>Oregoniateuthis</u> sp.	Squid
	<u>Phasmatopsis</u> sp.	Squid
	<u>Todarodes</u> sp.	Flying squid
Osteichthys	<u>Coryphaena hippurus</u>	Mahimahi
	<u>Lateolabrax japonicus</u>	Perch
	<u>Oncorhynchus</u> sp.	Salmon
	<u>Pseudosciaena</u> sp.	Yellowtail
	<u>Sarda</u> sp.	Bonito
	Scombridae	Mackerel
	<u>Thunnus albacares</u>	Yellowfin tuna
Mammalia	<u>Delphinus delphis</u>	Short-beaked common dolphin
	<u>Delphinus</u> sp.	Common dolphins
	<u>Megaptera noveaengliae</u>	Humpback whale
	<u>Physeter macrocephalus</u>	Sperm whale
	<u>Stenella coeruleoalba</u>	Striped dolphin
	<u>Stenella</u> sp.	Dolphins
	<u>Tursiops truncatus</u>	Bottlenose dolphin

Habits

False killers are gregarious and may form strong social bonds (Acevedo-Gutiérrez et al, 1997). False killers resighted in Golfo Dulce and Isla del Coco, Costa Rica were always observed with previous associates (Acevedo-Gutiérrez et al, 1997). NOAA (1995) states that false killers generally travel in large pods, often exceeding 100 individuals, but Stacey and Baird (1991) report that false killers are usually in pods of 20-50 individuals. Acevedo-Gutiérrez et al (1997) found that average group size was 16.0 in Golfo Dulce and Isla del Coco, Costa Rica. Miyashita (1993) found that average groups size was also 16 in the western north Pacific.

However, one exceptionally large group of 500 individuals, comprised of several smaller pods was observed by Miyashita (1993).

False killers frequently swim in broad formations (NOAA, 1995). Acevedo-Gutiérrez et al (1997) report that traveling false killers move in the same direction in relatively tight groups that dive synchronously. False killers will ride the bow waves of boats (Leatherwood et al, 1972; Stacey and Baird, 1991).

Reproduction

Breeding season:	May be year-round
Calving season:	May be year-round
Sexual maturity	
Males:	8-14 yrs. old
Females:	8-14 yrs. old; 360-399 cm
Gestation:	15.5-15.7 months
Lactation:	18-24 months
Neonate length:	120-210 cm

False killers are probably polygynous (Stacey and Baird, 1991). Calving may last several months or be year-round (Stacey and Baird, 1991; Leatherwood et al, 1972). Reproductive senescence may occur (Stacey and Baird, 1991), and females in the East China Sea are known to have a significant post-reproductive lifetime (Kishiro and Kasuya, 1993).

Reproductive rate off Japan is 5-6%/yr. (Stacey and Baird, 1991). Pregnancy rate is 21.1%/yr. in the western north Pacific (Perrin and Reilly, 1984). Pregnancy rate is 14.5%/yr. and gross reproductive rate is 6.7%/yr. in the East China Sea (Kishiro and Kasuya, 1993). Kishiro and Kasuya (1993) state that net reproductive rate is probably low.

Mortality and Economics

Natural Mortality

No specific studies were found on predation of false killers in the north Pacific. False killers frequently strand in large numbers (Stacey and Baird, 1991; Leatherwood et al, 1972). Parasites may have a role in causing mass strandings (Stacey and Baird, 1991). At least eight parasites have been found in or on false killers:

Trematoda

<u>Nastrema attenuata</u>	Neiland et al, 1970
<u>Nasitrema globicephalae</u>	Neiland et al, 1970
<u>Nasitrema gondo</u>	Stacey and Baird, 1991
<u>Orthosplanchus elongatus</u>	Stacey and Baird, 1991

Nematoda

Anisakis simplex

Delyamure, 1955; Stacey and Baird, 1991

Anisakis sp.

Baird et al, 1989

Stenus auditivus

Stacey and Baird, 1991

Stenus globicephalus

Stacey and Baird, 1991

Acanthocephala

Bolbosoma capitatum

Linstow, 1880; Baylis, 1932;
Kikuchi and Nakajima, 1993; Stacey
and Baird, 1991

Individuals over 41 years old have been recorded (Stacey and Baird, 1991). Kishiro and Kasuya (1993) state that false killers may live 62 years. Females in the East China Sea are known to have a significant post-reproductive lifetime (Kishiro and Kasuya, 1993).

Anthropogenic Interactions and Mortality

Pollution may negatively affect false killers. Heavy metals and pesticides, including high levels of Hg and DDE were detected in tissues of an adult male stranded on Denman Island, British Columbia on May 3, 1987 (Baird et al, 1989). PCBs were detected in blubber and liver of a false killer found dead near Denman Island, British Columbia in May, 1988 (Bergman et al, 1994). Levels of 4,4'-DDE detected in the same false killer were among the highest reported in a marine mammal (Bergman et al, 1994). Stacey and Baird (1991) report that tissues from false killers in British Columbia had the highest level of Hg recorded for cetaceans, as well as high DDE levels. Jarman et al (1996) also report dioxins and high levels of OCs and PCBs in false killers in British Columbia.

Large numbers of false killers have been taken in direct fisheries in southern Japan (Barlow et al, 1997). Kishiro and Kasuya (1993) report that 495 false killers were taken by drive fisheries and some other related fisheries, such as the Nago crossbow fishery, the hand-harpoon fishery off Taiji, and the small-type whaling fishery off Taiji and Chiba, from 1963 to 1991. Miyazaki (1983) states that 1,375 false killers were caught commercially in Japan from 1976 to 1981. Also, at least 12 false killers have been live-captured for aquaria or the Navy since the early 1960's (Barlow et al, 1997).

Fisheries are also a source of mortality for false killers (Barlow et al, 1997; Hobbs and Jones, 1993; Perrin and Oliver, 1982; Stacey and Baird, 1991). Small numbers have been taken incidental to fishing operations in the eastern tropical Pacific, including tuna purse seine fisheries (Perrin and Oliver, 1982; Barlow et al, 1997). There are no reports of direct or incidental takes in HI, but bottomfish, lobster, and pelagic fisheries, including commercial troll, handline, longline, local inshore gillnet, charter, and recreational troll could potentially incidentally take false killers (Barlow et al, 1997). Two false killers were observed incidentally taken in the Japanese squid fishery in 1990, and seven were observed taken in the Japanese large-mesh fishery in 1990 (Hobbs and Jones, 1993). False killers have also been taken incidentally in Chinese fisheries (Stacey and Baird, 1991). False killers are purposely killed in Iki Island, Japan to reduce fisheries conflicts (Stacey and Baird, 1991). They have been reported stealing fish from longlines in the Japanese tuna longline fishery (Stacey and Baird, 1991) and stealing from

pelagic longlines and trolling lines of commercial and recreational fisherpeople in HI (Barlow et al, 1997). Minimum total annual fisheries mortality and minimum total annual human-caused mortality for the HI stock is 0/yr.; this level of mortality cannot be considered insignificant since PBR is unknown (Barlow et al, 1997).

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Review of Cuvier's Beaked Whales (*Ziphius cavirostris*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Southern Bering Sea, Commander Islands, Aleutian Islands, and AK south to at least the tip of Baja CA in the eastern north Pacific; at least Japan in the western north Pacific; HI in the central north Pacific

Cuvier's are distributed widely in deep waters (Barlow et al, 1997; Brueggeman et al, 1990). They generally occur seaward of the 1,000 m contour (Brueggeman et al, 1990; Consiglieri et al, 1982; Houston, 1991) and are non-existent or rare on the continental shelf regions of CA and Baja CA (Kajimura and Loughlin, 1988). Cuvier's is the most frequently sighted north Pacific Ziphiid (Brueggeman et al, 1990; Houston, 1991; Barlow et al, 1997), and may be the most abundant beaked whale in the eastern north Pacific (Kajimura and Loughlin, 1988; Leatherwood et al, 1972). Distribution in the eastern north Pacific is based on more than 40 strandings and a few reliable pelagic sightings (Kajimura and Loughlin, 1988; Brueggeman et al, 1990). Cuvier's have stranded in Japan, the Midway Islands, HI, CA, Mexico, Canada, and AK (Houston, 1991).

Houston (1991) states that the Pacific population represents a single, widespread, morphologically variable stock. Morphological evidence is consistent with the existence of a single eastern north Pacific population from AK to Baja CA (Barlow et al, 1997). For management purposes, eastern north Pacific Cuvier's are separated into three stocks: CA/OR/WA, HI, and AK (Barlow et al, 1997; Hill et al, 1997). In general, sightings have been too rare to produce reliable population estimates (Barlow et al, 1997). However, population was estimated to be 9,163 in CA in 1991 and 1993 (Barlow et al, 1997; Barlow and Gerrodette, 1996). No information exists regarding population trends for the CA/OR/WA stock (Barlow et al, 1997). N_{min} of this stock is 6,070, and PBR is 61 (Barlow et al, 1997). In HI, strandings have been reported from the Midway Islands, Pearl and Hermes Reef, Oahu, and the HI Islands (Barlow et al, 1997). Sightings have been reported off Lanai and Maui (Barlow et al, 1997). Population of the HI stock is unknown, and no data are available on population trends (Barlow et al, 1997). N_{min} of this stock is unknown, and PBR is unknown (Barlow et al, 1997). In AK, six Cuvier's were seen southeast of Kodiak Island, one was seen in the Gulf of AK, and a group of two was seen in the Shumagin planning area (Brueggeman et al, 1987). Population of the AK stock is unknown, and there are no reliable data on population trends (Hill et al, 1997). N_{min} of the stock is unknown, and PBR is unknown (Hill et al, 1997).

Cuvier's are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997; Hill et al, 1997). There are no international agreements for cooperative management of Cuvier's (Barlow et al, 1997).

Houston (1991) states that there is no evidence of migration, but there may be some north-south movement of Cuvier's. Brueggeman et al (1990) also mentions that there is some evidence that Cuvier's migrate to higher latitudes in summer but report that the few sightings and strandings show no convincing trends in seasonality. Hill et al (1997) and Barlow et al (1997) also state that there is no obvious pattern of seasonality to strandings in the eastern north Pacific.

Food and Feeding

Cuvier's feed mainly on squid and deepsea fish (Balsiger, 1995); Brueggeman et al, 1987; Consiglieri et al, 1982; Houston, 1991; Kajimura and Loughlin, 1988). They also feed on crabs and sea stars (Houston, 1991). Houston (1991) reports that only the males have teeth. Cuvier's feed from the continental slope and seaward (Kajimura and Loughlin, 1988). Preferred prey varies by location (Kajimura and Loughlin, 1988). In some areas, deepsea fish are mainly eaten, and in other areas, squid are the primary prey (Kajimura and Loughlin, 1988; Consiglieri et al, 1982).

The following prey species have been determined for Cuvier's:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	<u>Berryteuthis</u> sp.	Armhook squid
	<u>Chroteuthis</u> sp.	Whiplash squid
	Decapoda	Squid
	<u>Eogonatus tinro</u>	Gonata squid
	<u>Galiteuthis</u> sp.	Cranch squid
	<u>Gonatopsis makko</u>	Gonata squid
	<u>Gonatus berryi</u>	Gonata squid
	<u>Gonatus madokai</u>	Gonata squid
	<u>Gonatus middendorffi</u>	Gonata squid
	<u>Gonatus pyros</u>	Gonata squid
	<u>Gonatus</u> sp.	Gonata squid
	<u>Japetella</u> sp.	Bolitaenid octopus
	<u>Histioteuthis dofleini</u>	Umbrella or jewel squid
	<u>Taonius</u> sp.	Cranch squid
	<u>Vampyroteuthis infernalis</u>	Vampire squid
Crustacea		
	Decapoda	Crabs
Echinodermata		
	Asteroidea	Sea stars
Osteichthys		
		Deepsea fish

Habits

Cuvier's are generally seen in small groups of 2-7 (Kajimura and Loughlin, 1988; Houston, 1991; Brueggeman et al, 1987), but can occur in groups up to 25 (Leatherwood et al, 1972). Older males are sometimes solitary (Kajimura and Loughlin, 1988). Cuvier's swim at about 5-6 km/hr. (Houston, 1991). They stay submerged in excess of 30 minutes (Houston, 1991; Leatherwood et al, 1972). They will occasionally breach (Houston, 1991).

Reproduction

Calving season: Appears to be year-round

Sexual maturity

Males: 5.3-5.5 m

Females: 5.5-6.1 m

Neonate length: 2-3 m

Mortality and Economics

Natural Mortality

Orcas prey on Cuvier's (Hoyt, 1984). Cuvier's is the most frequently stranded Ziphiid (Houston, 1991). At least five parasites have been found in or on Cuvier's:

Cestoda

Phyllobothrium sp.

Tomilin, 1957

Nematoda

Crassicauda boopis

Baylis, 1920; 1932

Crassicauda crassicauda

Creplin, 1829; Delyamure, 1955

Crassicauda giliakiana

Kikuchi et al, 1995

Parasitic crustacean Livoneca ravnaudi has also been found on Cuvier's and may cause oval, white patches on the skin (Houston, 1991). The maximum recorded age for a female is 30 years old and for a male is 36 years old (Houston, 1991).

Anthropogenic Interactions and Mortality

No specific studies of the effects of pollution on north Pacific Cuvier's were found. Anthropogenic noise may negatively affect Cuvier's (Barlow et al, 1997).

Cuvier's are harvested in Japan (Houston, 1991; Consiglieri et al, 1982). 85 were harvested from 1948 to 1952, and 189 were harvested from 1965 to 1970 (Consiglieri et al, 1982). 13-60 Cuvier's are taken annually by Japanese coastal whaling (Houston, 1991).

Fisheries are also a source of anthropogenic mortality for Cuvier's (Barlow et al, 1994; 1997; Dept. of Comm., 1996). At least one Cuvier's was incidentally taken in the western Canadian driftnet fishery for neon flying squid, which operated from 1983 to 1987 (Barlow et al, 1994). At least two Cuvier's were incidentally taken in the Japanese squid fishery and at least six were incidentally taken in the Japanese large-mesh fishery in 1990 (Hobbs and Jones, 1993).

28 Cuvier's in the CA/OR/WA stock are incidentally taken annually in the CA/OR thresher shark/swordfish drift gillnet fishery (Barlow et al, 1997). Minimum total annual fisheries mortality for this stock is 28/yr.; this exceeds 10% PBR (6.1) and is considered significant (Barlow et al, 1997). There are no reports of direct or incidental takes of Cuvier's in HI (Barlow et al, 1997). However, bottomfish, lobster, and pelagic fisheries, including commercial troll, handline, longline, local inshore gillnet, charter, and recreational troll could potentially incidentally take Cuvier's in this stock (Barlow et al, 1997). Minimum total annual

fisheries mortality for the HI stock is 0/yr.; this level of mortality cannot be considered insignificant because PBR is unknown (Barlow et al, 1997). No fisheries mortalities for the AK stock have been observed or recorded in logbooks (Hill et al, 1997). Fisheries that could potentially incidentally take Cuvier's in this stock include Bering Sea and Aleutian Islands and Gulf of AK groundfish trawl, longline, and pot (Hill et al, 1997). There is no known subsistence harvest of Cuvier's in AK (Hill et al, 1997). Minimum total annual fisheries mortality for the AK stock is 0/yr.; this level of mortality is considered insignificant even though PBR is unknown (Hill et al, 1997).

Minimum total annual human-caused mortality for the CA/OR/WA stock is 28/yr.; this is less than PBR and is considered insignificant (Barlow et al, 1997). Minimum total annual human-caused mortality for the HI stock is 0/yr.; this level of mortality cannot be considered insignificant because PBR is unknown (Barlow et al, 1997). Minimum total annual human-caused mortality for the AK stock is 0/yr.; this level of mortality is considered insignificant even though PBR is unknown (Hill et al, 1997).

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Review of Common Dolphins (Delphinus delphis and Delphinus capensis) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

About 10°S-42°N and 83°W-132°W; strandings have been reported in OR, WA, and British Columbia; most are below 36°N

Eastern north Pacific commons are considered to belong to two distinct species: short-beaked (Delphinus delphis) and long-beaked (Delphinus capensis) (Barlow et al, 1997; Forney and Barlow, 1998; Rosel et al, 1994). Rosel et al (1994) analyzed DNA from skin samples of short- and long-beaked commons in CA. They found that short- and long-beaked commons were monophyletic clades, suggesting that they may have been genetically separated for some time. Short-beaked and long-beaked commons are sympatric and range from CA south into Mexico and Central America (Barlow et al, 1997; Rosel et al, 1994). Strandings have been reported as far north as OR, WA, and British Columbia (Barlow et al, 1997; Evans, 1982; Leatherwood et al, 1972).

For management purposes, commons are separated into three stocks which are considered in determining mortality in the tuna fishery: northern, which ranges from 15°N-28°N; central, which ranges from 3°N-15°N; and southern, which ranges from 10°S-3°N (Perrin et al, 1985; Balazs et al, 1991). Evans (1982) suggests a Baja CA neritic stock, which consists of long-beaked, long-bodied commons north of 20°N, but that stock is not generally considered separate from the northern stock for management (Anganuzzi and Buckland, 1994; Anganuzzi et al, 1991; Perrin et al, 1985; Balazs et al, 1991; Perrin, 1984). There are hiatuses in distribution from 15°N-20°N and from 27°N-32°N (Evans, 1982). However, Perrin et al (1985) states that no evidence exists to support dividing short-beaked commons at 28°N. They and Balazs et al (1991) report that northern and central commons are separated by an 800 nautical mile wide zone in which sightings are rare. They also report that central and southern commons are fairly well separated by a zone between 0°N and 5°N. Northern stock commons, on average, have shorter beaks than central stock commons (Balazs et al (1991). The two stocks also have other differing skull characteristics (Balazs et al, 1991). Southern commons are longer than northern commons, and the two stocks have skull and possibly color pattern differences as well (Perrin et al, 1985).

According to Anganuzzi and Buckland (1994) relative abundance of the northern stock, central stock, and southern stock were 144,000, 210,000, and 257,000 respectively in 1992. However, NMFS (1993) reports the abundance of the three stocks to be 476,300, 406,100, and 2,210,900 respectively in 1992. Basically, abundance appears to be difficult to determine and to fluctuate considerably from year to year (NMFS, 1991; 1992; 1993; Anganuzzi et al, 1991; 1992; Anganuzzi and Buckland, 1994; Wade and Gerrodette, 1992). Forney and Barlow (1998) report that abundance in CA has increased dramatically since the late 1970's, with a concomitant decrease in the eastern tropical Pacific, suggesting a large-scale shift in distribution. Findings of Anganuzzi and Buckland (1994) support this conclusion. Distribution appears to vary interannually and with changing oceanographic conditions (Forney and Barlow, 1998). Abundance of the central stock may be stable but at lower levels than in the 1970's (Anganuzzi and Buckland, 1994; Anganuzzi et al, 1991; 1992). Abundance of the southern stock may also

be stable but at lower levels than in the mid-1970's (Anganuzzi et al, 1991). Overall, there is little evidence of recent trends in abundance, although there is strong evidence of a decline from 1979 to 1982 (Anganuzzi et al, 1992).

For management purposes in the U.S., commons are separated into two stocks: CA long-beaked and CA/OR/WA short-beaked (Barlow et al, 1997). Short-beaked commons are smaller and more pelagic than long-beaked commons (Rosel et al, 1994). The two types also differ in color pattern, external morphology, and cranial characters (Rosel et al, 1994). Short-beaked commons are the most abundant cetacean off CA and are widely distributed between the coast and up to thousands of kilometers offshore (Barlow et al, 1997; Rosel et al, 1994). In 1991 and 1993, they were commonly sighted as far north as 42°N (Barlow et al, 1997). Population of the CA/OR/WA short-beaked stock was 372,425 in 1991 and 1993 (Barlow et al, 1997). N_{min} of this stock is 309,717, and PBR is 3,097.

Long-beaked commons are generally found within 150 km of the coast from Baja CA, including the Gulf of CA, north to central CA (Barlow et al, 1997; Rosel et al, 1994). Population of the CA long-beaked stock was 8,980 in 1991 and 1993 (Barlow et al, 1997). N_{min} of this stock is 5,504, and PBR is 53 (Barlow et al, 1997).

Abundance estimates for both the CA long-beaked and CA/OR/WA short-beaked stocks in 1991 and 1992 were considerably greater than historical estimates (Barlow et al, 1997). Declines in abundance of commons in the eastern tropical Pacific and along the Pacific coast of Mexico suggest a northward shift in distribution (Barlow et al, 1997; Forney and Barlow, 1998). Commons are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997).

Abundance varies by season (Barlow et al, 1997; Dohl et al, 1986). Generally, abundance increases in CA during warm water months (Barlow et al, 1997). Dohl et al (1986) report that common distribution expands from the southeast into the central and western parts of the Southern CA Bight in late spring and early summer and recedes toward the east and south in late fall and early winter. They also report that the western summer-fall population in the Bight is augmented by an influx of "pelagic" commons from far offshore. However, Forney and Barlow (1998) report that winter abundance was greater than summer abundance in the Bight in 1991. They found that commons exhibited offshore and northward movement out of the Bight in summer. Barlow et al (1997) suggest that short-beaked commons may make seasonal movements north in summer and fall and south in winter and spring.

Food and Feeding

Jones (1981) reports that commons are thought to feed on mesopelagic fish at depths exceeding 120 m. However, commons have been observed feeding at the surface and surface dwelling species have been found in stomachs of commons (Jones, 1981). Commons appear to often feed on Myctophids (Chou et al, 1995; Jones, 1981; Leatherwood et al, 1972). Commons also feed on various species of squid (Chou et al, 1995; Jones, 1981; Leatherwood et al, 1972).

The following prey species have been determined for commons:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	<u>Abraliopsis felis</u>	Enope squid

Berryteuthis anonychus
 Decapoda
Eucleoteuthis slumina
Galiteuthis phyllura
Gonatopsis borealis
Gonatus sp.
Loligo opalescens
Mastigoteuthis sp.
 Onychoteuthidae
Onychoteuthis borealijaponicus
Onychoteuthis sp.
Opishoteuthis sp.
Taningia danae

Gonata squid
 Squid
 Eucleoteuthid squid
 Cranch squid
 Gonata squid
 Gonata squid
 Market squid
 Whiplash squid
 Hooked squid
 Nail squid
 Hooked squid
 Opishoteuthid squid
 Octopus squid

Osteichthys

Alepocephalidae
 Bathylagidae
Bathylagus sp.
Ceratoscopelas warmingi
Chauliodus sp.
Cololabis saira
Diaphus gigas
Diaphus parri
Diaphus sp.
Diaphus theta
Electrona risso
Engraulis mordax
Gonostoma sp.
Howella brodei
Ichthyococcus sp.
Ichthyos lockingtoni
Lampanyctus jordani
Lampanyctus regalis
Lampanyctus sp.
Lestidops ringens
Microstoma sp.
 Myctophidae
Myctophum asperum
Myctophum sp.
Nansenia sp.
Notoscopelas resplendens
Notoscopelas sp.
 Osmeridae
Paralepis atlantica
Paralepis sp.

Slickheads
 Deepsea smelts
 Blacksmelt
 Lampfish
 Viperfish
 Pacific saury
 Headlightfish
 Headlightfish
 Headlightfish
 California headlightfish
 Chubby flashlightfish
 Northern anchovy
 Fangjaw
 Pelagic basslet
 Bristlemouth
 Medusafish
 Brokenline lampfish
 Pinpoint lampfish
 Lampfish
 Slender barracudina
 Pencilsnail
 Lanternfish
 Lanternfish
 Lanternfish
 Argentine
 Patchwork lampfish
 Lampfish
 Smelts
 Duckbill barracudina
 Barracudina

<u>Protomyctophum</u> sp.	Flashlightfish
<u>Sarda chiliensis</u>	Bonito
<u>Sardinops sagax</u>	Sardine
<u>Stenobrachius</u> sp.	Lampfish
<u>Symbolophorus</u> sp.	Lanternfish
<u>Tactostoma macropus</u>	Longfin dragonfish
<u>Trachipterus altivelis</u>	King-of-the-salmon

Habits

Commons are often seen in groups numbering in the hundreds, or even thousands (Anganuzzi and Buckland, 1994; Anganuzzi et al, 1991; 1992; Forney and Barlow, 1998; Leatherwood et al, 1972; Wade and Gerrodette, 1992). Commons ride the bow waves of boats (Christmann, 1983; Leatherwood et al, 1972). They have been seen associating with gray whales by riding the gray whales' "bow waves" (Shelden et al, 1995).

Reproduction

Breeding season: Evenly throughout the year in the central stock; throughout the year with a peak in Jan.-July in the northern and southern stocks; peak is particularly evident in the southern stock

Sexual maturity

Female: 8-14 yrs. old
Male: 6-12 yrs. old; 200 cm

Gestation: 11.1 months
Cycle: Calve every 2.6 yrs.

Neonate length: 79.0-81.3 cm

Pregnancy rate is 36.2% in the eastern tropical Pacific (Perrin and Reilly, 1984). Birth rate is 9.6% in the eastern tropical Pacific: 8.7% in the northern stock and 6.6% in the southern stock (Perrin and Reilly, 1984).

Mortality and Economics

Natural Mortality

Commons are preyed upon by orcas and false killer whales (Hoyt, 1984; Stacey and Baird, 1991). An adult common from the Gulf of CA was found with a sting ray (*Dasyatis* sp.) spine wound; however, this was not the cause of death (Reynoso and Aguilar, 1989). At least 18 parasites have been found in or on commons:

Parasites

Trematoda

Braunina cordiformis
Campula delphini
Campula palliata
Campula rochebruni
Galactosomum erinaceum
Nasitrema delphini

Delyamure, 1955
Poirier, 1886; Baylis, 1932
Looss, 1885; Baylis, 1932
Poirier, 1886; Baylis, 1932
Poirier, 1886; Baylis, 1932
Neiland et al, 1970

Cestoda

Diphylobothrium stemmacephalum
Monorygma delphini
Monorygma grimaldii

Phyllobothrium delphini
Strobilocephalus triangularis
Tetrabothrius forsteri

Cobbold, 1858; Baylis, 1932
Gervais, 1847; Baylis, 1932
Moniez, 1889; Delyamure, 1955; Dailey and Stroud, 1978
Dailey and Stroud, 1978
Diesing, 1850; Baylis, 1932
Kreff, 1871; Baylis, 1932

Nematoda

Anisakis simplex
Halocercus delphini
Halocercus kleinenbergi
Skrijabinalius cryptocephalus

Rudolphi, 1809; Baylis, 1932
Baylis and Daubney, 1925; Baylis, 1932
Delyamure, 1951; Delyamure, 1955
Delyamure, 1942; Delyamure, 1955

Acanthocephala

Bolbosoma vasculosum
Corynosoma cetaceum

Corynosoma sp.

Rudolphi, 1819; Delyamure, 1955
Johnston and Best, 1942; Delyamure, 1955
Delyamure, 1955

Anthropogenic Interactions and Other Mortality

Pollution may affect commons. DDT and PCBs have been detected in muscle and blubber of commons in CA (Wagemann and Muir, 1984), and α -HCH, β -HCH, and γ -HCH have been detected in the blubber of commons (Tanabe et al, 1996).

Fisheries are an anthropogenic source of mortality for commons (Balazs et al, 1991; Barlow et al, 1994; 1997; Chou et al, 1995; Evans, 1982; Ferrero and Walker, 1995; U.S. Dept. of Comm., 1996). The yellowfin tuna purse seine fishery incidentally took at least 2,221,290 commons from 1971 to 1990 (Balazs et al, 1991). Commons have been taken in the tuna purse seine fishery since the late 1950's (Barlow et al, 1997). Incidental mortality in this fishery averaged 426/yr. from 1991 to 1995 (Barlow et al, 1997). Miyazaki (1983) reports that 299 were incidentally taken in seine, set, and gillnet fisheries in Japan from 1976-81. Commons have been taken in the Taiwanese, Korean, and Japanese driftnet fisheries, but a moratorium was placed on driftnet gear in the early 1990's (Chou et al, 1995; Ferrero and Walker, 1995). An estimated 4,210 were taken incidentally in the Japanese, Taiwanese, and Korean high seas squid fisheries and the Japanese and Taiwanese high seas large-mesh fisheries in 1990 (Hobbs and Jones, 1993). Other fisheries that incidentally take commons and average annual mortality are as follows (Barlow et al, 1994; 1997):

CA/OR/WA short-beaked stock:

CA/OR thresher shark/swordfish drift gillnet	271 (CV=0.19)
CA angel shark/halibut and other species large mesh (>3.5") set gillnet	>1
Yellowfin tuna purse seine	
Mexican swordfish drift gillnet	

CA long beaked-stock:

CA/OR thresher shark/swordfish drift gillnet	14 (CV=0.48)
CA angel shark/halibut and other species large mesh (>3.5") set gillnet	0
Yellowfin tuna purse seine	
Mexican swordfish drift gillnet	

Minimum total annual fisheries mortality for the CA/OR/WA short-beaked stock is 272/yr., which is less than 10% of PBR (309.7) and is considered insignificant (Barlow et al, 1997).

Minimum total annual fisheries mortality for the CA long-beaked stock is 14/yr., which exceeds 10% of PBR (5.3) and is considered significant (Barlow et al, 1997).

Commons are harvested commercially in Japan (Miyazaki, 1983). Miyazaki (1983) reports that 452 were caught commercially (harpoon, drive, and longline fisheries or small-type whaling) in Japan from 1976-81. 153 commons were harvested in the hand harpoon in 1988 (Hobbs and Jones, 1993).

Minimum total annual human-caused mortality for the CA/OR/WA short-beaked stock is 272/yr., which is less than PBR (3,097) and is considered insignificant (Barlow et al, 1997). Minimum total annual human-caused mortality for the CA long-beaked stock is 14/yr., which is less than PBR (53) and is considered insignificant (Barlow et al, 1997).

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Review of Northern Right Whale Dolphins (*Lissodelphis borealis*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Commonly in temperate, offshore waters; at least from San Clemente Island (32°N) to AK in the eastern Pacific; reported as far north as the southern Bering Sea, but probably range between 30°N and 50°N; sighted in the Gulf of AK at 55°N; Japan to the Kuril and Aleutian Islands in the western Pacific

Genetic analyses have not found statistically significant differences between right whale dolphins in the north Pacific (Dizon et al, 1994; Barlow et al, 1997). Therefore, north Pacific right whale dolphins are considered a single stock (Barlow et al, 1997). For management purposes, a CA/OR/WA stock is recognized along the west coast of the U.S. (Barlow et al, 1997). Population of this stock was 21,332 in 1991 and 1992, but no information is available regarding population trends (Kajimura and Loughlin, 1988; Barlow et al, 1997). Barlow and Gerrodette (1996) report that right whale dolphin abundance decreased in CA from 1991 to 1993. Few right whale dolphins are reported from OR, WA, and British Columbia (Brueggeman et al, 1990; Kajimura and Loughlin, 1988; Leatherwood et al, 1972). Right whale dolphins probably range into Baja CA during cold-water periods (Barlow et al, 1997). Minimum population of the CA/OR/WA stock is 15,080, and PBR is 151 (Barlow et al, 1997).

Population in the north Pacific was estimated to be 400,000 in the late 1980's (Hobbs and Jones, 1993; Hiramatsu, 1993; Tanaka, 1993). However, average estimates ranged from 68,000-988,000 (Mangel, 1993; Tanaka, 1993; Hobbs and Jones, 1993; Hiramatsu, 1993; Buckland et al, 1993; Miyashita, 1993).

Right whale dolphins are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997). There are no international agreements for cooperative management of right whale dolphins (Barlow et al, 1997).

Right whale dolphins appear to move south and inshore in fall and winter and north and offshore in spring and summer in the eastern north Pacific (Baird and Stacey, 1991; Barlow et al, 1997; Brueggeman et al, 1990; Forney and Barlow, 1998; Hobbs and Jones, 1993). However, Brueggeman et al (1990) report that movements may simply be inshore and offshore rather than north and south. Forney and Barlow (1998) describe an influx of right whale dolphins into the continental shelf of the Southern CA Bight in winter, with abundance being 5,377 in summer and 21,332 in winter.

Food and Feeding

Right whale dolphins feed on a variety of cephalopods and fish (Baird and Stacey, 1991; Chou et al, 1995; Walker and Jones, 1993). The majority of fish prey are myctophids (Chou et al, 1995; Consiglieri et al, 1982; Kajimura and Loughlin, 1988; Walker and Jones, 1993).

The following prey species have been determined for right whale dolphins:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
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Cephalopoda

<u>Abraliopsis felis</u>	Enope squid
<u>Abraliopsis</u> sp.	Enope squid
<u>Berryteuthis anonychus</u>	Armhook squid
<u>Chroteuthis</u> sp.	Whiplash squid
<u>Cranchia</u> sp.	Cranch squid
Decapoda	Squid
Enoploteuthidae	Enope squid
<u>Enoploteuthis chuni</u>	Enope squid
<u>Galiteuthis phyllura</u>	Cranch squid
<u>Gonatus</u> sp.	Gonata squid
<u>Loligo opalescens</u>	Market squid
<u>Mastigoteuthis</u> sp.	Whiplash squid
<u>Octopoteuthis deletron</u>	Octopus squid
<u>Ommastrephes bartrami</u>	Neon flying squid
Onychoteuthidae	Hooked squid
<u>Onychoteuthis borealijaponica</u>	Nail squid
<u>Taningia danae</u>	Octopus squid

Osteichthys

<u>Alepocephalus tenebrosus</u>	California slickhead
<u>Argentina</u> sp.	Argentines
Argentinidae	Argentines
Bathylagidae	Deep sea smelts
<u>Bathylagus</u> sp.	Blacksmelts
<u>Benthalbella dentata</u>	Northern pearleye
<u>Ceratoscopelas</u> sp.	Lampfish
<u>Ceratoscopelas warmingi</u>	Lampfish
<u>Cololabis saira</u>	Pacific saury
<u>Diaphus gigas</u>	Headlightfish
<u>Diaphus</u> sp.	Headlightfish
<u>Diaphus theta</u>	California headlightfish
<u>Gempylus serpens</u>	Gempylidid
Gonostomatidae	Bristlemouths
<u>Ichthyococcus</u> sp.	Lightfish
<u>Icichthys lockingtoni</u>	Medusafish
<u>Lampadena urophaos</u>	Sunbeam lampfish
<u>Lampanyctus jordani</u>	Brokenline lampfish
<u>Lampanyctus regalis</u>	Pinpoint lampfish
<u>Lampanyctus ritteri</u>	Broadfin lampfish
<u>Lampanyctus</u> sp.	Lampfish
<u>Lestidiops ringens</u>	Slender barracudina
<u>Leuroglossus schmidti</u>	Northern smoothtongue
<u>Melamphaes</u> sp.	Bigscales
Melamphiadae	Bigscales
Melanostomiidae	Scaleless dragonfish

<u>Merluccius productus</u>	Pacific hake
Myctophidae	Lanternfish
<u>Myctophum asperum</u>	Lanternfish
<u>Nansenia candida</u>	Argentine
<u>Notoscopelas japonica</u>	Lampfish
<u>Notoscopelas resplendens</u>	Patchwork lampfish
Paradeipidae	Paradeipids
Paralepididae	Barracudinas
<u>Paralepis atlantica</u>	Duckbill barracudina
<u>Pentaceros richardsoni</u>	Longfin armorhead/southern boarfish
<u>Protomyctophum</u> sp.	Flashlightfish
Scopelarchidae	Pearleyes
<u>Scopelogadus bispinosus</u>	Bigscale
Scopelosauridae	Paperbones
<u>Scopelosaurus harryi</u>	Scaly paperbone
<u>Stenobranchius leucopsarus</u>	Northern lampfish
<u>Stenobranchius</u> sp.	Lampfish
<u>Symbolophorus</u> sp.	Lanternfish
<u>Tarletonbeania</u> sp.	Lanternfish
<u>Tetragonurus cuvieri</u>	Tetragonurid
<u>Trachipterus altivelis</u>	King-of-the-salmon
Trichiuridae	Cutlassfish and Scabbordfish
<u>Triphoturus mexicanus</u>	Mexican lampfish

Habits

Right whale dolphins appear to favor deeper water and are generally considered a pelagic species (Baird and Stacey, 1991; Brueggeman et al, 1990). Seasonal depth averages range between 867 m and 1,479 m and are shallowest in winter and spring (Brueggeman et al, 1990). Right whale dolphins tend to avoid boats but do occasionally bow ride (Baird and Stacey, 1991; Hobbs and Jones, 1993; Leatherwood et al, 1972).

Group size varies widely, including small, inconspicuous, synchronously diving groups and large, active schools (Forney and Barlow, 1998). Right whale dolphins are gregarious, and groups of up to several thousand are often seen (Baird and Stacey, 1991; Brueggeman et al, 1990; Hobbs and Jones, 1993; Kajimura and Loughlin, 1988; Leatherwood et al, 1972). Groups are often observed associating with other marine mammals, such as Pacific white-sided dolphins, common dolphins, Risso's dolphins, and Dall's porpoises (Baird and Stacey, 1991; Brueggeman et al, 1990; Hobbs and Jones, 1993; Kajimura and Loughlin, 1988; Leatherwood et al, 1972; Shelden et al, 1995). Right whale dolphins have also been seen associating with copulating gray whales and riding the "bow waves" of gray whales (Shelden et al, 1995).

Reproduction

Calving season: Early spring and summer, with a peak in July and August

Sexual maturity	
Males:	9.0-10.3 yrs. old; 210-223 cm
Females:	6-10.4 yrs. old; 180-220 cm
Gestation:	12.1-12.3 months
Cycle:	Minimum calving interval of 2 yrs.
Neonate length:	60-115 cm

Mortality and Economics

Natural Mortality

Orcas and large sharks may prey on right whale dolphins (Baird and Stacey, 1991). Strandings are uncommon and no mass strandings have been reported (Baird and Stacey, 1991). Males have a higher natural mortality rate than females (Ferrero and Walker, 1993). At least 4 parasites have been found in or on right whale dolphins:

Trematoda	
<u>Nastrema globicephalae</u>	Neiland et al, 1970
<u>Nasitrema</u> sp.	Baird and Stacey, 1991
Nematoda	
<u>Anisakis</u> sp.	Baird and Stacey, 1991
<u>Crassicauda</u> sp.	Baird and Stacey, 1991
Cestoda	
<u>Phyllobothrium delphini</u>	Moser and Rhinehart, 1993
<u>Phyllobothrium</u> sp.	Baird and Stacey, 1991; Dailey and Brownell, 1972

The oldest male found in incidental catch in Japanese squid driftnets in 1990 was 22.5 years old, and the oldest female was 41.6 years old (Ferrero et al, 1993).

Anthropogenic Interactions and Mortality

Pollution may affect right whale dolphins (Tanabe et al, 1996). HCHs were detected in the blubber of right whale dolphins analyzed in 1991 (Tanabe et al, 1996).

Fisheries are a source of anthropogenic mortality. At least 13 right whale dolphins were incidentally taken in the Canadian experimental neon flying squid driftnet fishery which operated from 1983 to 1987 (Baird and Stacey, 1991; Barlow et al, 1994). Right whale dolphins were also taken in the experimental gillnet fishery for thresher shark off OR and WA which operated from 1986 to 1989 (Barlow et al, 1997). Logbooks indicate that right whale dolphins are occasionally killed in the Bristol Bay set net and driftnet fisheries for salmon (Barlow et al, 1994). Right whale dolphins were the most common cetacean species in bycatch of the high seas large scale driftnet fisheries which operated in the north Pacific until the early 1990's (Dizon et al, 1994; Hiramatsu, 1993; Hobbs and Jones, 1993). More than 40/yr. were taken incidentally in Japanese

fisheries up to 1985, and the number increased thereafter (Baird and Stacey, 1991). Total incidental mortality of right whale dolphins was 10,961-11,587 in the Japanese squid driftnet fishery in 1989 (Hobbs and Jones, 1993). About 107,270, 17,874, 2,088, and 7,474 were incidentally taken from 1978 to 1990 in the Japanese squid, Korean squid, Taiwanese squid, and Taiwanese large mesh fisheries respectively, for a total of 134,707 taken (Tanaka, 1993). Depletion by high seas driftnet fisheries was 24-73% of the population in 1978 (Mangel, 1993).

The CA/OR/WA stock of right whale dolphins is taken incidentally in the CA/OR thresher shark/swordfish drift gillnet fishery (Barlow et al, 1997). Similar drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja CA and may take right whale dolphins from this stock during cold-water periods (Barlow et al, 1997). Minimum total annual fisheries mortality for this stock is 47/yr.; this exceeds 10% PBR (15.1) and is considered significant (Barlow et al, 1997). Minimum total annual human-caused mortality for this stock is 47/yr.; this is less than PBR (151) and is considered insignificant (Barlow et al, 1997).

Only one of five right whale dolphins taken into captivity lived more than three weeks, with the one living 15 months (Baird and Stacey, 1991). Right whale dolphins were taken sporadically by whalers in the 19th century (Baird and Stacey, 1991), and are still taken in Japanese drive fisheries (Hobbs and Jones, 1993). 109 were taken in drive fisheries in 1988 (Hobbs and Jones, 1993).

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