

Review of Risso's Dolphins (*Grampus griseus*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Tropical and warm temperate, mostly pelagic waters; rarely as far north as the Gulf of AK and Kuril Islands; British Columbia, WA, OR, CA, commonly from central CA south to at least Acapulco, Mexico into the Gulf of CA and to Isla de Guadalupe, Baja, CA and Clipperton Island, Costa Rica in the eastern north Pacific; off the Pacific coast of Japan, East and South China Seas, and Sea of Japan in the western north Pacific; rarely in HI

For management purposes, Risso's are separated into two stocks: CA/OR/WA and HI (Barlow et al, 1997). Population of the CA/OR/WA stock was 32,376 in 1991 and 1992 (Barlow et al, 1997; Forney and Barlow, 1998). Abundance of Risso's off the U.S. west coast may have increased recently (Barlow et al, 1997). N_{\min} of the CA/OR/WA stock is 22,388, and PBR is 224 (Barlow et al, 1997). Population of the HI stock is unknown (Barlow et al, 1997). Risso's are known in HI from four reported sightings and four strandings (Barlow et al, 1997). There are no population data for this stock (Barlow et al, 1997).

Risso's may have extended their range to the north in the eastern north Pacific in recent decades, probably in response to long-term warming of oceanic waters (Brueggeman et al, 1990). Warm water events, such as El Niño, may shift distribution of Risso's into an area (Shane, 1995; Leatherwood et al, 1980). In surveys in 1958, 1959, and 1961, Risso's were not observed north of 42°N (Brueggeman et al, 1990). However, a group of over 2,000 Risso's was observed off WA in August, 1981 (Brueggeman et al, 1990), and a group of 14 Risso's was reported off the northwestern tip of Queen Charlotte Islands, British Columbia in the 1970's (Kajimura and Loughlin, 1988). Two Risso's were seen in the Gulf of AK, 450 km north of their reported summer range, on March 12, 1976 (Braham, 1983; Consigliieri et al, 1982), and a stranded Risso's was found in the central Gulf of AK (Kajimura and Loughlin, 1988). Reports of Risso's near the Commander and Aleutian Islands are regarded as unsubstantiated (Brueggeman et al, 1990; Leatherwood et al, 1980). Leatherwood et al (1980) report a distributional gap from 38°N to 45°N.

Degree of movement into Mexico is unknown, but a large gap in distribution of sightings occurs between 29°N and the tip of Baja CA (22°N) (Forney and Barlow, 1998). Leatherwood et al (1980) describes the gap as extending from 14°N to 29°N. Barlow et al (1997) also report a 500 nautical mile gap between Risso's sighted off northern Baja CA and those sighted south of Baja CA and in the Gulf of CA. Risso's off the U.S. west coast and northern Baja CA may be a separate stock from Risso's found farther south in the Gulf of CA and the eastern tropical Pacific (Forney and Barlow, 1998).

In the western north Pacific, the northern limit seems to be about 40°N in summer and fall (Miyashita, 1993). There is a density gap between 145°E and 148°E that may represent a boundary between offshore and coastal stocks (Kishiro and Kasuya, 1993; Miyashita, 1993). The coastal stock generally ranges south of 30°N and west of 145°E (Kishiro and Kasuya, 1993). Population of the coastal stock was 31,012 in 1983 to 1991 (Kishiro and Kasuya, 1993; Miyashita, 1993). Population of the eastern offshore stock was 45,223 in 1983 to 1991

(Miyashita, 1993). This population was divided by a density hiatus into 24,205 in the area from 145°E to 160°E and 21,028 in the area from 160°E to 180°E (Miyashita, 1993). Population of the southern offshore stock was 7,044 in 1983 to 1991 (Miyashita, 1993). Total population of these stocks was 83,289 in 1983 to 1991 (Miyashita, 1993).

Abundance in central and northern CA is 13,000 in summer and 30,000 in winter (Brueggeman et al, 1990). Forney and Barlow (1998) also found that abundance of Risso's was substantially higher in winter (32,376) than summer (3,980) in 1991 and 1992. In addition, all observations of Risso's north of 42°N have occurred between March and October (Brueggeman et al, 1990). This suggests that Risso's may migrate north to OR, WA, and British Columbia in summer and south to CA in winter (Brueggeman et al, 1990; Forney and Barlow, 1998).

Food and Feeding

Risso's feed mainly on cephalopods (Baird and Stacey, 1991; Consiglieri et al, 1982; Jones, 1981; Kajimura and Loughlin, 1988; Kim et al, 1996; Shane, 1995). Jones (1981) states that Risso's lack teeth in the upper jaw and may feed solely on invertebrates. However, Baird and Stacey (1991) and Kajimura and Loughlin (1988) report that Risso's also feed on some fish. Leatherwood et al (1979) state that Risso's were observed feeding on a school of mullet in the Gulf of CA just prior to stranding. Jones (1981) reports that goose-neck barnacles and a single hydroid were found in the stomach of a Risso's found on southeast Farallon Island May 20, 1973, but these items were probably accidentally ingested. Kajimura and Loughlin (1988) describe a behavior in which Risso's swim in echelon formation, lined abreast at evenly spaced intervals. This tactic is thought to be used in search of prey (Kajimura and Loughlin, 1988). The following prey species have been determined for Risso's:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cnidaria	<u>Aglaophenia latirostris</u>	Hydroid
Cephalopoda	<u>Chiroteuthis calyx</u>	Whiplash squid
	<u>Chiroteuthis sp.</u>	Whiplash squid
	Decapoda	Squid
	<u>Dosidicus gigas</u>	Giant squid
	Gonatidae	Gonata squid
	<u>Gonatus pyros</u>	Gonata squid
	<u>Gonatus sp.</u>	Gonata squid
	<u>Loligo opalescens</u>	Market squid
	<u>Octopoteuthis deletron</u>	Octopus squid
	<u>Octopoteuthis sp.</u>	Octopus squid
	<u>Ommastrephes bartrami</u>	Neon flying squid
	<u>Onychoteuthis borealijaponicus</u>	Nail squid
	<u>Onychoteuthis sp.</u>	Hooked squid
	<u>Sthenoteuthis oualaniensis</u>	Purpleback flying squid
	<u>Taonius pavo</u>	Giant squid

Crustacea	<u>Todarodes pacificus</u>	Japanese flying squid
Osteichthys	<u>Pollicipes polymerus</u>	Goose-neck barnacle
	Mugilidae	Mulletts

Habits

Risso's are generally gregarious, traveling in groups of up to several hundred (Kajimura and Loughlin, 1988). Group size usually ranges from 11-45 in the eastern north Pacific (Baird and Stacey, 1991). The largest group size reported was more than 2,000 in WA (Barid and Stacey, 1991; Brueggeman et al, 1990). Miyashita (1993) found that group size ranged from 1-200, with an average of 32, in the western north Pacific from 1983 to 1991. Risso's typically segregate by age and sex in larger groups (greater than 60) (Shelden et al, 1995). Distinctive groups of calfless adults, juveniles, and females with calves are formed (Shelden et al, 1995).

Risso's are also highly gregarious with other small cetaceans (Shelde et al, 1995; Baird and Stacey, 1991). They have been seen associating with bottlenose dolphins (Tursiops truncatus), short-finned pilot whales (Globicephala macrorhynchus), Pacific white-sided dolphins, northern right whale dolphins, and Dall's porpoises (Shane, 1995; Shelden et al, 1995). They have also been observed associating with larger whales, such as sperm whales, fin whales, and gray whales (Shelden et al, 1995). Risso's may ride the "bow wave" of gray whales (Shelden et al, 1995). Some Risso's may try to chase and encircle gray whales until the rest of the group is at a safe distance, and young Risso's may attempt to play with gray whales (Shelden et al, 1995). In two cases in 1993, Risso's were observed striking the rostrum of a gray whale (Shelden et al, 1995).

Risso's ride the bow waves of boats (Shelden et al, 1995; Baird and Stacey, 1991). Males have been observed to approach and place themselves between the group and a potential intruder, such as a vessel (Shelden et al, 1995).

Reproduction

Calving season:	Winter
Sexual maturity	
Males:	9-10 yrs. old; 3 m
Females:	9-10 yrs. old; 3 m
Gestation:	13-14 months
Neonate length:	110-150 cm

Risso's have hybridized with bottlenose dolphins (Tursiops truncatus) in the wild (Baird and Stacey, 1991). Perrin and Reilly (1984) report that pregnancy rate is 30.8% in the western north Pacific, and Baird and Stacey (1991) state that reproductive rate is 6-7% in Japan.

Mortality and Economics

Natural Mortality

Orcas, false killer whales, and sharks prey on Risso's (Baird and Stacey, 1991). Risso's occasionally mass strand (Leatherwood et al, 1979; Morimitsu et al, 1992; Baird and Stacey, 1991). 582 mass stranded on the Goto Islands, Japan on November 2, 1990. Five were observed as they mass stranded in the Gulf of CA on June 18, 1973 (Leatherwood et al, 1979). Parasitism may be a factor in mass strandings (Leatherwood et al, 1979; Morimitsu et al, 1992). At least 7 parasites have been found in or on Risso's:

Cestoda

Monorygma grimaldii

Dailey and Stroud, 1978

Phyllobothrium delphini

Rudolphi, 1819; Baylis, 1932

Nematoda

Crassicauda grampicola

Johnston and Mawson, 1941; Dailey and Stroud, 1978

Stenurus minor

Tomilin, 1957

Trematoda

Nasitrema gondo

Morimitsu et al, 1992

Dailey and Stroud (1978) also report finding Penella sp. on the skin of one stranded Risso's in OR. Ectoparasitic barnacle, Xenobalanus globicipitis has also been found on Risso's (Samaras, 1989). Risso's can live to at least 20 years old (Baird and Stacey, 1991). Risso's brought into captivity in Japan have survived more than five years (Baird and Stacey, 1991).

Anthropogenic Interactions and Mortality

Pollution may affect Risso's. Risso's collected off Taiji, Japan in 1991 contained PCBs, DDTs, CHLs, HCHs, and BTs (Kim et al, 1996). PCBs>DDTs>CHLs>HCHs in the Risso's analyzed (Kim et al, 1996). PCB and DDT levels increase with age in males and decrease with age in females (Kim et al, 1996). This decrease occurs due to transfer of pollutant burden to offspring via gestation and lactation (Kim et al, 1996). BT levels increase with age until maturity and then stabilize (Kim et al, 1996). There are no significant differences in the residue patterns of BTs between the sexes (Kim et al, 1996). BTs are less transferable from mother to fetus and infant than other OCs (Kim et al, 1996). Proportions of α -HCH and p,p'-DDT increase with age in females after maturity (Kim et al, 1996).

Another source of anthropogenic mortality is fisheries. 110 Risso's were incidentally taken in the CA drift gillnet fishery for swordfish and sharks from 1990 to 1993 (Barlow et al, 1994). Similar drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja CA and probably take Risso's as well (Barlow et al, 1997). Risso's were incidentally taken in the experimental gillnet fishery for thresher shark in OR and WA, which operated from 1986 to 1988 (Barlow et al, 1997). Risso's may also be taken in the CA squid purse seine fishery (Barlow et al, 1997). There are no reports of incidental takes of Risso's in HI (Barlow et al,

1997). However, pelagic, bottomfish, and lobster fisheries, including troll, handline, longline, local inshore gillnet, commercial charter, and recreational troll fishing, may take Risso's (Barlow et al, 1997). 75 Risso's were caught incidentally in seine, set, and gillnet fisheries in Japan from 1976 to 1981 (Miyazaki, 1983). Risso's were also taken incidentally in the Japanese high seas squid and large-mesh fisheries (Hobbs and Jones, 1993). Minimum total annual fisheries mortality for the CA/OR/WA stock is 37/yr.; this exceeds 10% of PBR (22.4) and is considered significant (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).

There are no reports of direct takes of Risso's in HI or CA/OR/WA (Barlow et al, 1997). Minimum total annual human-caused mortality for the CA/OR/WA stock is 37/yr.; this is less than PBR (224) 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).

Small numbers of Risso's are harvested commercially in whale fisheries, such as hand harpoon, drive, and small-type whaling fisheries, in Japan and the East China Sea (Baird and Stacey, 1991; Kishiro and Kasuya, 1993). 1,664 were harvested by drive fisheries and some other related fisheries off the Pacific coast of Japan from 1963 to 1991 (Kishiro and Kasuya, 1993). Risso's are also directly killed off Iki Island, Japan to reduce fisheries competition (Baird and Stacey, 1991).

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Review of Striped Dolphins (*Stenella coeruleoalba*) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Warm-temperate and tropical waters; along the coast of North America from British Columbia to the equator, including the Gulf of CA in the eastern north Pacific; seen rarely in HI; off Japan, with a few records north to the southern Okhotsk Sea, and possibly in the South and East China Seas in the western north Pacific

A hiatus in distribution in the eastern Pacific between 10°N and 15°N-17°N has caused eastern Pacific stripededs to be considered as at least two separate stocks in the past (Dizon et al, 1994; Baird et al, 1993; Perrin et al, 1985; NMFS 1991; 1992). However, no significant differences in lengths of stripededs was found north and south of the distributional gap, and interchange is quite possible between the two populations, so they are generally no longer considered separate stocks (Dizon et al, 1994; NMFS, 1993; Perrin et al, 1985).

For management purposes, stripededs are separated into two stocks: CA/OR/WA and HI (Barlow et al, 1997). Stripededs have been sighted 100-300 nautical miles from the CA coast (Barlow et al, 1997). No sightings have been reported in OR or WA, but stripededs have stranded in both states (Barlow et al, 1997). Population of the CA/OR/WA stock was 24,910 in 1991 and 1993 (Barlow et al, 1997). Prior to 1991, stripededs were not thought to be common off CA (Barlow et al, 1997). It is possible that striped abundance off CA has increased over the last decade; however, no definitive statement can be made (Barlow et al, 1997). Oceanographic conditions may affect year-to-year abundance (Barlow and Gerrodette, 1996). N_{\min} of the CA/OR/WA stock is 19,248, and PBR is 154 (Barlow et al, 1997).

Only two sightings have been recorded at sea in HI (Barlow et al, 1997). However, more stripededs than any other cetaceans stranded in HI from 1936 to 1988 (Barlow et al, 1997). Population of the HI stock is unknown (Barlow et al, 1997). There are no data available on population trends (Barlow et al, 1997). N_{\min} of this stock is unknown, and PBR is also unknown (Barlow et al, 1997).

Three stocks are recognized in the western north Pacific (Barlow et al, 1997; Kishiro and Kasuya, 1993). Stock boundaries are based on the latitudinal gap observed in the summer distribution and the comparison of catch history and offshore-inshore density differences (Kishiro and Kasuya, 1993). One stock is found south of 30°N; one stock is found from 145°E to at least 180°E and north of 30°N; and one stock is found in Japanese coastal waters from 30°N to 42°N (Kishiro and Kasuya, 1993; Miyashita, 1993). Population of the southern offshore stock was 52,682; population of the northern offshore stock was 497,725; and population of the coastal stock was 19,631 in the early 1990's (Kishiro and Kasuya, 1993; Miyashita, 1993). The Japanese drive fishery has depleted the coastal stock to less than 10% of its post World War II level (Kishiro and Kasuya, 1993).

Population in the eastern north Pacific was 2,300,000 in the mid-1980's (Baird et al, 1993) and was 1,531,800-2,249,300 in 1992 (NMFS, 1993). Pre-exploitation population was more than 320,000 on the Pacific coast of Japan and was 218,000-255,000 in the late 1950's to early 1960's (Kasuya and Miyazaki, 1982). Population in Japan decreased from 1960 to 1967

and increased from 1968 to 1972 (Kasuya and Miyazaki, 1982). Population was 120,000 in Japan in 1974 (Kasuya and Mizazaki, 1982).

Stripeds are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997; NMFS, 1991; 1992; 1993). Cooperative management agreements exist between the U.S. and Mexico only in regard to the tuna purse seine fishery (Barlow et al, 1997).

No strong seasonal changes in distribution are evident for stripeds in the eastern north Pacific (Baird et al, 1993). Stripeds may migrate north to about 46°N in May-July and south to about 33°N in October-December on the Pacific coast of Japan (Baird et al, 1993; Honda and Tatsukawa, 1983). Stripeds usually migrate along the Pacific coast of the Kii peninsula to Hokkaido following the movement of the Kuroshio current (Itano et al, 1984b). Stripeds may migrate in part of the shallow waters of the South and East China Seas (Loganathan et al, 1990).

Food and Feeding

Stripeds prey on fish, squid and shrimp (Baird et al, 1993). In the western north Pacific, dominant prey are squid, myctophids, and shrimp (Honda and Tatsukawa). The following prey species have been determined for stripeds:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	Decapoda <u>Todarodes pacificus</u>	Squid Pacific flying squid
Crustacea	<u>Bentheogennema borealis</u> Decapoda	Shrimp Shrimp
Osteichthys	Mycotphidae	Lanternfish

Habits

Baird et al (1993) state that the average group size in the northeastern U.S. is 64.9, with a range of 1-500. Average group size ranged between 27.4 and 83.4 for the northern stock and between 52.8 and 70.5 for the southern stock from 1986 to 1990 (Wade and Gerrodette, 1992). Groups of up to 3,000 have been seen off the coast of Japan (Baird et al, 1993). However, Baird et al (1993) and Miyazaki and Nishiwaki (1978) report that 85.8% of groups observed in the Japanese drive fishery from 1963 to 1973 had less than 500 stripeds. Group size ranged from 8 to 2,136 (Baird et al, 1993). Average group size was 360 (Baird et al, 1993). Miyazaki (1977b) states that group size averages 415. Miyazaki and Nishiwaki (1978) found that southbound groups are larger than northbound groups in Japan. Nishiwaki (1982) estimates that southbound groups average 300 and northbound groups average 150-200 stripeds. Miyashita (1993) reported groups sizes ranging from 1 to 1,500, with an average of 121.

There are three types of groups in Japan: juvenile, adult, and mixed, to which stripeds belong at different times according to their age and reproductive condition (Baird et al, 1993; Miyazaki, 1977b; Miyazaki and Nishiwaki, 1978; Nishiwaki, 1982; Perryman and Lynn, 1994).

Adult and mixed groups are further divided into mating and non-mating groups (Miyazaki and Nishiwaki, 1978). Striped calves are found in adult groups and move to juvenile groups at about 1-2 years old (Miyazaki, 1977b; Miyazaki and Nishiwaki, 1978). Males return to adult mating groups at about 8.7 years old, and females return at about 9 years old (Miyazaki, 1977b).

Stripeds are among the most acrobatic of dolphins (Baird et al, 1993). They frequently perform aerial behaviors (Leatherwood et al, 1972). They will ride the bow wave of boats and have been recorded swimming at speeds up to 32 knots (Baird et al, 1993). Stripeds have been seen associating with common dolphins, long-finned pilot whales (Globicephala melaena), Risso's dolphins, bottlenose dolphins (Tursiops truncatus), other Stenella, sperm whales, and minke whales (Baird et al, 1993).

Reproduction

Breeding season: 3 seasons: February-May, July-September, and December

Sexual maturity

Males: 7-12 yrs. old; 195-220 cm

Females: 5-13 yrs. old; 211.5-216 cm

Gestation: 12 months

Lactation: 15-18 months, some up to 2-3 yrs.

Cycle: Calve every 1.4-6.5 yrs.

Neonate length: 100 cm

Neonate weight: 12 kg

Stripeds form mating groups (Miyazaki, 1977b; Miyazaki and Nishiwaki, 1978). Males enter adult mating groups at about 8.7 years old, and females enter at about 9 years old (Miyazaki, 1977b). Estrous occurs every four months (Nishiwaki, 1982). Average calving cycle and lactation period increase with age (Kasuya and Miyazaki, 1982). Average age of sexual maturity decreased from 9.7 years old in the 1950's to 7.2 years old in the 1970's in Japan (Kasuya, 1985). Average reproductive cycle shortened from 4.00 years to 2.76 years from 1955 to 1977 in Japan (Kasuya, 1985; Kishiro and Kasuya, 1993). Lactation period decreased 46% from 1952 to 1973 in Japan (Kasuya and Miyazaki, 1982). These reproductive changes are likely due to exploitation (Baird et al, 1993; Kasuya, 1985). Generally, stripeds give birth to one calf at a time, but one pair of twin fetuses was found in a sample of about 30,000 stripeds examined in Japan (Baird et al, 1993).

Birth rate is 10.9% in the eastern tropical Pacific and 10.3-11% in Japan (Perrin and Reilly, 1984). Pregnancy rate is 30.4% in the eastern tropical Pacific and ranged from 29.9-70.9% in the western north Pacific from 1968 to 1975 (Perrin and Reilly, 1984). Net annual reproductive rate is 2.3-4.4% in Japan (Perrin and Reilly, 1984).

Mortality and Economics

Natural Mortality

Sharks, orcas, and false killer whales prey on stripededs (Baird et al, 1993; Hoyt, 1984). Female stripededs have lower natural mortality than male stripededs (Kasuya and Miyazaki, 1982; Miyazaki, 1977a). At least 15 parasites have been found in or on stripededs:

Nematoda

<u>Anisakis simplex</u>	Baird et al, 1993
<u>Anisakis sp.</u>	Kagel et al, 1967
<u>Anisakis typica</u>	Baird et al, 1993
<u>Halocercus delphini</u>	Baird et al, 1993
<u>Halocercus lagenorhynchi</u>	Baird et al, 1993

Trematoda

<u>Campula delphini</u>	Baird et al, 1993
<u>Campula rochebruni</u>	Baird et al, 1993
<u>Nasitrema sp.</u>	Baird et al, 1993
<u>Pholetes gastrophilus</u>	Baird et al, 1993

Cestoda

<u>Monorygma grimaldii</u>	Dailey and Stroud, 1978
<u>Monorygma sp.</u>	Baird et al, 1993; Dailey and Brownell, 1972
<u>Phyllobothrium delphini</u>	Baird et al, 1993; Dailey and Stroud, 1978
<u>Phyllobothrium sp.</u>	Dailey and Brownell, 1972
<u>Strobilocephalus triangularis</u>	Baird et al, 1993; Dailey and Stroud, 1978
<u>Tetrabothrius fosteri</u>	Baird et al, 1993; Dailey and Stroud, 1978

Protozoa

<u>Sarcocystis sp.</u>	Baird et al, 1993; Dailey and Stroud, 1978
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Ectoparasitic barnacle, Xenobalanus globicipitis and cyamids have also been recorded on stripededs (Baird et al, 1993).

Stripededs can live into their 40's and 50's (Baird et al, 1993; Honda and Tatsukawa, 1983; Kasuya and Miyazaki, 1982). Baird et al (1993) report that one striped of each sex was noted as reaching 57 years old.

Anthropogenic Interactions and Mortality

Pollution may affect stripededs. Many studies have been done on pollutant levels in stripededs caught in the Japanese commercial small cetacean fisheries, and various heavy metals and OCs have been detected (Honda et al, 1982; 1983; 1984; Honda and Tatsukawa, 1983; Itano et al, 1984a; 1984b; 1985a; 1985b; Kawai et al, 1988; Kwohn et al, 1986; Loganathan et al, 1990; Loganathan and Kannan, 1991; Tanabe et al, 1981; 1996).

Honda et al (1992) found that accumulation of heavy metals mainly depends on proteins, particularly metallothionein. Metallothioneins are thought to be involved in homeostasis of Zn and Cu and in detoxification of Cd and Hg (Kwohn et al, 1986). Honda et al (1992) observed high heavy metal levels in kidney and liver and low levels in brain. Honda et al (1983) found that heavy metal levels were generally higher in liver than other tissues, particularly in the case

of Hg. They found highest Cd levels in kidney. They also found that Fe, Pb, Ni, Cd, and Hg levels in muscle, Pb, Ni, Cd, and Hg levels in liver, and Hg levels in kidney increased with age and Mn, Zn, and Cu levels in liver and Mn and Cu levels in kidney decreased with age. They surmise that Pb, Ni, and Cd are transferred from mothers to calves via milk. They found no significant differences in heavy metals levels between males and females. Honda et al (1984) found Fe, Mn, Zn, Cu, Pb, Ni, Cd, Se, and Hg in bones of stripededs. Honda and Tatsukawa 1983) found that the kidney, liver, and pancreas are critical organs for the storage of Cd in stripededs. They found the highest levels of Zn to be in bone and skin. They discovered a significant correlation between Zn and Cd levels in kidney and liver but not in other tissues. They suggest that increase of Zn levels is a compensation for increase in Cd levels. Itano et al (1984a) report that Hg and MeHg levels increase with age, leveling off at about 16 years old. They also determined that Hg and MeHg levels are higher in males than females. They found that Se levels are constant from 5-12 years old and increase to 17 years old. They discovered that 90% of Hg burden is in blubber, muscle, and liver and 90% of MeHg burden is in muscle. They conclude that Se may protect stripededs from Hg poisoning. Itano et al (1984b) determined that Hg levels are highest in liver and that levels increase with age up to 20-25 years old. They noted that MeHg levels increased with age up to 10 years old. They found no differences in Hg levels between adult males, pregnant females, lactating females, and resting females. They discovered that Hg levels in muscle and Se levels in liver were higher in 1977 than in 1978 and 1979. They conclude that Hg levels are related to Se levels. Itano et al (1985a) also found that Hg levels correlated with Se levels. Itano et al (1984b) found that total Hg in brain is more than 10 ug/g in older stripededs, and this level could cause toxic effects. Itano et al (1985b) determined that most Hg and Se in the salt-insoluble fraction are present as a stable complex, which is unable to react readily with the tissue components.

Kawai et al (1988) found that PCB levels were high in the blubber of mature male stripededs. They determined that OC residues were higher in mature males than in pregnant females. Adult females contain 15% and 11% of PCB and DDE levels respectively than males (Subramanian et al, 1987). This is likely due to maternal transfer of OCs (Kawai et al, 1988). Transplacental transfer rates of CHs are 10% at the most and larger amounts are transferred through lactation than parturition (Subramanian et al, 1987). Female stripededs may reduce their OC load by 72-98% through reproductive activities, and a female transfers about 4-9% of her pollutant burden to her fetus (Subramanian et al, 1988). Lower chlorinated PCBs are more transferable by reproductive pathways than higher chlorinated ones (Subramanian et al, 1987; 1988). Kawai et al (1988) found that levels of HCH isomers were low in comparison to PCBs and DDT. They suggest that abnormal lipid metabolism might be induced in stripededs by the accumulation of PCBs and DDTs. Loganathan et al (1990) found no significant change in PCB or DDT residue levels or in PCB isomers and congeners from 1978-79 to 1986. They detected a decline in HCH residues and HCB from 1978-79 to 1986. Subramanian et al (1987) report that DDT decreases in stripededs after about 20 years old due to the decline in food intake amounts in older stripededs. Tanabe et al (1981) report that level of total DDT>PCBs> total HCH>HCB in stripededs. They found that over 90% of CH burden is in blubber and levels of CH are relatively low in muscle and brain. DDT and PCBs have also been detected in muscle and blubber of stripededs in the eastern tropical Pacific (Wagemann and Muir, 1984).

Fisheries are another source of anthropogenic mortality to stripededs. Stripededs exhibit an avoidance response to boats from as far away as six or more miles (Baird et al, 1993). 772

stripeds were caught incidentally in seine, set, and gillnet fisheries in Japan from 1976 to 1981 (Miyazaki, 1983). An estimated 3,072 were incidentally taken 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). A striped was killed in the experimental fishery for flying squid in British Columbia, which operated from 1983 to 1987 (Baird et al, 1993). Stripeds may be taken for use as bait in a shark fishery in the Gulf of CA (Baird et al, 1993). Hundreds of stripeds are killed annually in purse seines for yellowfin tuna in the eastern tropical Pacific (Baird et al, 1993). Average annual mortality for the CA/OR/WA stock in the CA/OR thresher shark/swordfish drift gillnet fishery is 1.2/yr. (Barlow et al, 1997). Similar drift and gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja CA and may also take stripeds from this stock (Barlow et al, 1997). No fisheries interactions with stripeds in the HI stock have been documented, but pelagic, bottomfish, and lobster fisheries, including trolls, handlines, longlines, local inshore gillnets, and traps, could potentially incidentally take stripeds in this stock (Barlow et al, 1997). Minimum total annual fisheries mortality for the CA/OR/WA stock is 1.2/yr.; this is less than 10% of PBR (15.4) and is considered insignificant (Barlow et al, 1997). Minimum total annual fisheries mortality for the HI stock is 0/yr., but this level of mortality cannot be considered insignificant because PBR of this stock is unknown (Barlow et al, 1997). Minimum total annual human-caused mortality for the CA/OR/WA stock is 1.2/yr.; this is less than PBR (154) and is considered insignificant (Barlow et al, 1997). Minimum total annual human-caused mortality for the HI stock is 0/yr., but this level of mortality cannot be considered insignificant because PBR of this stock is unknown (Barlow et al, 1997).

Stripeds are commercially harvested in the Japanese drive, hand harpoon, and small type whaling fisheries (Baird et al, 1993; Kasuya, 1985; Kasuya and Miyazaki, 1982; Kishiro and Kasuya, 1993; Miyazaki, 1977b; 1983; Miyazaki and Nishiwaki, 1978; Nishiwaki, 1982). 104 were harvested in the hand harpoon fishery in 1988 (Hobbs and Jones, 1993). Up to 20,000 have been taken annually in drive fisheries, but recent harvests have ranged from about 1,225 to 2,918/yr. (Baird et al, 1993). Declines in catch may reflect a decrease in population rather than a reduction in effort (Baird et al, 1993). Kasuya and Miyazaki (1982) estimate that about 14,000/yr. were harvested from the late 1950's to the early 1960's, and Nishiwaki (1982) estimates that about 5,000-10,000/yr. were harvested from the 1950's to the 1970's. 36% of the commercial small cetacean catch in Japan was stripeds and 39,537 stripeds were harvested from 1976 to 1981 (Miyazaki, 1977b). About 97% of the striped catch is taken by drive fisheries at Kawana, Futo, and Taiji (Miyazaki, 1983). Annual catch generally ranged from 2,000-10,000/yr. from 1942 to 1981 (Miyazaki, 1983). 107,562 were harvested at Arari from 1942 to 1970; 184,437 were harvested at Futo and Kawana from 1942 to 1981; and 31,297 were harvested at Taiji from 1963 to 1981 (Miyazaki, 1983). 157,136 were harvested in drive fisheries on the Pacific coast of Japan from 1963 to 1991 (Kishiro and Kasuya, 1993). Stripeds are also commercially harvested by Taiwan (Nishiwaki, 1982).

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Review of Pacific white-sided dolphins (Lagenorhynchus obliquidens) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Amchitka Island in the Aleutian Islands east through the Gulf of AK and south along the west coast of North America to the tip of Baja CA (23°N) and into the Gulf of CA in the eastern north Pacific; rarely in the southern Bering Sea; Kuril and Commander Islands south along the coast of Japan and Asia to Taiwan in the western north Pacific; in the pelagic mid-Pacific at temperate latitudes

Western and eastern north Pacific white-sideds are separated by a low density area along the central Aleutian Islands (Stacey and Baird, 1991). There are two forms of white-sideds in the eastern north Pacific: northern, which ranges from 32°N north up to AK; and southern, which ranges from 36°N south to the tip of Baja CA and into the Gulf of CA (Aurioles, 1989; Barlow et al, 1997; Hill et al, 1997). Cranial morphometrics and genetic analyses confirm the distinctness of these two forms of white-sideds (Barlow et al, 1997; Hill et al, 1997; Stacey and Baird, 1991).

For management purposes, white-sideds are separated into two stocks: CA/OR/WA and central north Pacific (Barlow et al, 1997; Hill et al, 1997). Population of the CA/OR/WA stock was 121,693 in 1991 and 1992 (Barlow et al, 1997; Forney et al, 1995). N_{\min} of this stock is 82,939, and PBR is 796 (Barlow et al, 1997). No long term trends in population are apparent for this stock (Barlow et al, 1997). Population of the central north Pacific stock was 931,000 in 1987-1990 (Hill et al, 1997; Buckland et al, 1993; Hobbs and Jones, 1993). N_{\min} of this stock is 486,719, and PBR is 4,867 (Hill et al, 1997). However, Hill et al (1997) caution that population estimates of the central north Pacific stock may be biased upward by more than five fold. There is no reliable information on trends in abundance for this stock (Hill et al, 1997). Population in Japan was 30,000-50,000 in the early 1970's (Consiglieri et al, 1982; Kajimura and Loughlin, 1988; Leatherwood et al, 1984; Stacey and Baird, 1991). In the early 1990's, the population was estimated to be 729,000 in the area of the Japanese squid driftnet fisheries (Hiramatsu, 1993). Tanaka (1993) reports that the population in the north Pacific was 947,692 in 1989. Stacey and Baird (1991) state that white-sideds may be the most abundant delphinid in the temperate eastern north Pacific. White-sideds are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (Barlow et al, 1997; Hill et al, 1997)

White-sideds are commonly found both on the high seas and along the continental margins, primarily in shelf and slope waters (Barlow et al, 1997; Brueggeman et al, 1990; Hill et al, 1997). They undertake northern and southern movements (Aurioles et al, 1989; Barlow et al, 1997; Brueggeman et al, 1990; Consiglieri et al, 1982; Stacey and Baird, 1991) as well as inshore and offshore movements (Aurioles et al, 1989; Brueggemant et al, 1990; Consiglieri et al, 1982; Jones, 1981; Stacey and Baird, 1991). Generally, they occur in the southern part of their range in winter and shift north in spring and summer (Barlow et al, 1997; Brueggeman et al, 1990; Consiglieri et al, 1982; Forney and Barlow, 1998; Kajimura and Loughlin, 1988; Stacey and Baird, 1991). They occur in the Gulf of CA from January to August (Aurioles et al, 1989). Inshore densities are usually highest in fall and winter, and most move offshore in spring and

summer (Consiglieri et al, 1982; Brueggeman et al, 1990; Leatherwood et al, 1984; Stacey and Baird, 1991).

Food and Feeding

White-sideds are opportunistic feeders that prey on a variety of schooling fish and cephalopods (Aurioles et al, 1989; Brueggeman et al, 1990; Consiglieri et al, 1982; Fiscus and Kajimura, 1981; Kajimura and Loughlin, 1988; Stacey and Baird, 1991; Walker and Jones, 1993). Walker and Jones (1993) found that white-sidedes caught in the Japanese high seas squid driftnet fishery in 1990 fed mostly on mesopelagic fish and squid. Of these prey, 91.7% of fish species were in families Argentinidae, Bathylagidae, Gonostomatidae, Melanostomiidae, Myctophidae, Paralepididae, Scopelarchidae, and Scopelosauridae, with Myctophidae making up 78.6% of the total (Walker and Jones, 1993). 18.4% of prey species were cephalopods, with 14.0% in the families Enoploteuthidae and Onychoteuthidae (Walker and Jones, 1993).

White-sideds feed mostly at night or in the morning (Fiscus and Kajimura, 1981). Inshore-offshore movements may be correlated with prey movements (Jones, 1981).

The following prey species have been determined for white-sideds:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cnidaria		
	Scyphozoa	Jellyfish
Cephalopoda		
	<u>Abraliopsis felis</u>	Enope squid
	<u>Abraliopsis</u> sp.	Enope squid
	<u>Berryteuthis anonychus</u>	Armhook squid
	<u>Berryteuthis</u> sp.	Armhook squid
	Decapoda	Squid
	Chiroteuthidae	Whiplash squid
	<u>Chiroteuthis</u> sp.	Whiplash squid
	Cranchiidae	Cranch squid
	Enoploteuthidae	Enope squid
	<u>Enoploteuthis chuni</u>	Enope squid
	<u>Galiteuthis phyllura</u>	Cranch squid
	Gonataidae	Gonata squid
	<u>Gonatopsis borealis</u>	Gonata squid
	<u>Gonatopsis</u> sp.	Gonata squid
	<u>Gonatus</u> sp.	Gonata squid
	Loliginidae	Common squid
	<u>Loligo opalescens</u>	Market squid
	<u>Mastigoteuthis</u> sp.	Whiplash squid
	Octopoda	Octopus
	Octopoteuthidae	Octopus squid
	<u>Octopoteuthis deletron</u>	Octopus squid
	<u>Octopoteuthis</u> sp.	Octopus squid
	<u>Ocythoe tuberculata</u>	Pelagic octopus

	<u>Ommastrephes bartrami</u>	Arrow squid
	<u>Ommastrephes sloani pacificus</u>	Arrow squid
	Onychoteuthidae	Hooked squid
	<u>Onychoteuthis borealijaponicus</u>	Nail squid
	<u>Onychoteuthis sp.</u>	Hooked squid
	<u>Watasenia scintellans</u>	Firefly squid
Agnatha		
	<u>Lampetra tridentata</u>	Pacific lamprey
	(<u>Entosphenus tridentatus</u>)	
Osteichthys		
	<u>Alosa sapidissima</u>	American shad
	<u>Argentina sp.</u>	Argentine
	Bathylagidae	Deepsea smelts
	<u>Bathylagus sp.</u>	Blacksmelt
	<u>Benthalbella dentata</u>	Northern pearleye
	<u>Ceratoscopelas sp.</u>	Lampfish
	<u>Citharichthys sordidus</u>	Pacific sanddab
	<u>Clupea pallasii</u>	Pacific herring
	<u>Cololabis saira</u>	Pacific saury
	<u>Diaphus gigas</u>	Headlightfish
	<u>Diaphus sp.</u>	Headlightfish
	<u>Diaphus theta</u>	California headlightfish
	<u>Engraulis japonica</u>	Japanese anchovy
	<u>Engraulis mordax</u>	Northern anchovy
	<u>Gempylus serpens</u>	Snake mackerel
	Gonostomatidae	Bristlemouths
	<u>Hygophum sp.</u>	Flashlightfish
	<u>Ichthyococcus sp.</u>	Bristlemouth
	<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 sp.</u>	Lampfish
	<u>Lestidiops ringens</u>	Slender barracudina
	<u>Leuroglossus schmidti</u>	Northern smoothtongue
	Melanostomiidae	Dragonfish
	<u>Merluccius productus</u>	Pacific whiting/hake
	Myctophidae	Lanternfish
	<u>Myctophum asperum</u>	Lanternfish
	<u>Myctophum nitidulum</u>	Pearly lanternfish
	<u>Nansenia candida</u>	Bluethroat argentine
	<u>Notoscopelas japonica</u>	Lampfish
	<u>Notoscopelas resplendens</u>	Patchwork lampfish
	<u>Oncoryhchus keta</u>	Chum salmon
	<u>Oncoryhchus kisutch</u>	Coho salmon

<u>Oncorhynchus</u> sp.	Salmon
Osmeridae	Smelts
<u>Paralepis atlantica</u>	Duckbill barracudina
<u>Pentaceros richardsoni</u>	Pelagic armorhead
<u>Phanerodon furcatus</u>	White seaperch
Pleuronectidae	Flatfish
<u>Porichthys notatus</u>	Plainfin midshipman
<u>Protomyctophum</u> sp.	Flashlightfish
<u>Sardinops sagax caeruleus</u>	Sardine
<u>Scomber japonicus</u>	Chub mackerel
<u>Scopelosaurus harryi</u>	Scaly paperbone
Scorpaenidae	Rockfish
<u>Sebastes jordani</u>	Shortbelly rockfish
<u>Sebastes</u> sp.	Rockfish
<u>Seriphus politus</u>	Queenfish
<u>Spirinchus starksi</u>	Night smelt
<u>Stenobranchius</u> sp.	Lampfish
<u>Symbolophorus californiensis</u>	California lanternfish
<u>Symbolophorus</u> sp.	Lanternfish
<u>Tarletonbeania</u> sp.	Lanternfish
<u>Tetragonurus cuvieri</u>	Smalleye squaretail
<u>Thaleichthys pacificus</u>	Eulachon
<u>Trachipterus altivelis</u>	King-of-the-salmon
<u>Trachurus symmetricus</u>	Jack mackerel

Habits

White-sideds are gregarious and usually travel in pods of hundreds or even several thousand (Kajimura and Loughlin, 1988; Fiscus and Kajimura, 1981; Stacey and Baird, 1991). Their groups are among the largest of any dolphin species (Stacey and Baird, 1991).

White-sideds bow ride and are very acrobatic (Stacey and Baird, 1991). They occasionally somersault in the air, a behavior not described for any other cetacean (Leatherwood et al, 1972).

White-sideds are frequently observed associating with other marine mammal species (Stacey and Baird, 1991). They have been seen riding the "bow waves" of gray whales and associating with copulating gray whales (Shelden et al, 1995). They have also been seen in association with Risso's dolphins (Shelden et al, 1995; Kajimura and Loughlin, 1988), northern right whale dolphins (Kajimura and Loughlin, 1988), and California sea lions (Aurioles et al, 1989).

Reproduction

Breeding season: Late spring to fall

Calving season: Late spring to fall

Sexual maturity
Female: 6-11 yrs. old; 170-216 cm (ave. 192 cm)
Male: 6-11 yrs. old; 167-213 cm (ave. 190 cm)

Gestation: 10-12 months

Neonate length: 80-124 cm

Mortality and Economics

Natural Mortality

White-sideds are preyed upon by orcas and sharks (Consiglieri et al, 1982; Dahlheim and Towell, 1994; Hoyt, 1984; Stacey and Baird, 1991; Matkin and Dahlheim, 1995). White-sideds have been found with their central nervous system infested by air sinus trematodes (Consiglieri et al, 1982). Nastrema sp. parasites have been associated with brain lesions in white-sideds. At least 9 parasites and 1 bacterium have been found in or on white-sideds:

Bacteria

Neisseria mucosa heidelbergensis Smith et al, 1978

Parasites

Cestoda

Monorygma grimaldii Stacey and Baird, 1991
Phyllobothrium delphini Stacey and Baird, 1991
Phyllobothrium sp. Dailey and Brownell, 1972
Strobilocephalus triangularis Stacey and Baird, 1991
Tetrabothrius sp. Stacey and Baird, 1991

Trematoda

Nastrema globicephalae Neiland et al, 1970
Nastrema sp. Stacey and Baird, 1991

Nematoda

Anisakis sp. Stacey and Baird, 1991
Crassicauda sp. Stacey and Baird, 1991

Also, ectocommensal barnacle, Xenobalanus globicipitus, and diatom, Cocconeis cetocola have been found on white-sideds (Stacey and Baird, 1991).

White-sideds can live up to at least 46 years old (Stacey and Baird, 1991).

Anthropogenic Interactions and Mortality

Pollution may affect white-sideds. α -HCH, β -HCH, and γ -HCH have been detected in white-sideds (Tanabe et al, 1996).

A minimum of 128 white-sideds were collected for live display from CA from the late 1950's to 1993 (Barlow et al, 1997). Western north Pacific white-sideds are harvested in the Japanese dolphin/porpoise fishery (Stacey and Baird, 1991). In this fishery, 2,765 were taken in 1984 and 37 were taken in 1986 (Stacey and Baird, 1991).

Fisheries are an anthropogenic source of mortality for white-sideds (Barlow et al, 1994; 1997; Hill et al, 1997). White-sideds have been reported accidentally hooked on fishing lines (Stacey and Baird, 1991). White-sideds were taken in the now discontinued OR and WA experimental gillnet fishery for thresher shark (1986-1988) (Barlow et al, 1997), the experimental western Canadian driftnet fishery for neon flying squid (1983-1987) (Stacey and Baird, 1991; Barlow et al, 1994), and the CA/OR/WA joint venture groundfish trawl fisheries (ended in 1990) (Barlow et al, 1997). Thousands were incidentally taken each year in the high seas fisheries that operated in the north Pacific from 1978 to 1991 (Hill et al, 1997). Miyazaki (1983) reports that 241 were incidentally in seine, set, and gillnet fisheries in Japan from 1976-81. An estimated 5,759 were taken incidentally in the Japanese, Taiwanese, and Korean high seas squid drifnet fisheries and the Japanese and Taiwanese high seas large-mesh fisheries in 1990 (Hobbs and Jones, 1993). Fisheries currently in operation that incidentally take white-sideds and average annual mortality are as follows (Barlow et al, 1994; 1997; Hill et al, 1997; Stacey et al, 1997; U.S. Dept. of Comm., 1996):

CA/OR/WA stock:

CA/OR thresher shark/swordfish drift gillnet	22 (CV=0.34)
Baja CA shark/swordfish drift gillnet	
WA/OR/CA domestic groundfish trawl	
CA set net	
British Columbia salmon drift gillnet	
British Columbia salmon troll	
British Columbia salmon seine	
British Columbia salmon trawl	

Central Pacific stock

Bering Sea/Aleutian Islands groundfish trawl	0.2 (CV=1.0)
Bering Sea/Aleutian Islands groundfish longline	0.8 (CV=1.0)
Bering Sea/Aleutian Islands pot	
Gulf of AK groundfish trawl	
Gulf of AK groundfish longline	
Gulf of AK groundfish pot	
Southeastern AK salmon drift gillnet	>0.25
Prince William Sound salmon drift gillnet	>1.25
Prince William Sound salmon setnet	
Bristol Bay salmon drift gillnet	>0.75

White-sideds have also been reported taken in the Japanese, Korean, and Taiwanese squid fisheries and in the Taiwanese large mesh fishery (Tanaka, 1993). Minimum total annual fisheries mortality for the CA/OR/WA stock is 22/yr., which is less than 10% of PBR (79.6) and is considered insignificant (Barlow et al, 1997). Minimum total annual fisheries mortality for the central Pacific stock is 4/yr., which is less than 10% of PBR (487) and is also considered insignificant (Hill et al, 1997).

Miyazaki (1983) reports that 694 were caught commercially (harpoon, drive, and longline fisheries or small-type whaling) in Japan from 1976-81. There are no reports of subsistence harvest of white-sideds (Hill et al, 1997). Minimum total annual human-caused mortality for the CA/OR/WA stock is 22/yr., which is less than PBR (796) and is considered insignificant (Barlow et al, 1997). Minimum total annual human-caused mortality for the central Pacific stock is 4/yr., which is less than PBR (4,867) and is also considered insignificant (Hill et al, 1997).

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Review of Dall's Porpoises (Phocoenoides dalli) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Temperate and subarctic waters of the north Pacific; Ballenas Bay, Baja CA north along the west coast of North America, to the Bering Sea and Aleutian Islands, west to the Okhotsk Sea and Sea of Japan, and south to Japan

There are at least two morphotypes of Dall's: dalli-type and truei-type (Amano and Kuramochi, 1992; Kasuya and Jones, 1984; Kasuya and Ogi, 1987; Kasuya and Shiraga, 1985; Miyazaki et al, 1984; Miyashita and Kasuya, 1988; Szczepaniak; Crawford, 1981). Jefferson (1990) and Kasuya (1982) also list a black-type Dall's morphotype. Originally, dalli-type and truei-type Dall's were considered separate species (Phocoenoides truei and Phocoenoides dalli), but they are now classified as morphotypes of the same species (Phocoenoides dalli) (Szczepaniak et al, 1992). Dalli-type Dall's have a white area on the flank that extends to the level of the dorsal fin; truei-type Dall's usually have spots on the flank and have a white area that reaches the base of the flipper; black-type are all black (Kasuya, 1982; Szczepaniak et al, 1992).

Each of the three morphotypes can be considered as belonging to separate stocks, and there may be stocks within the same morphotype (Kasuya, 1982; Amano and Kuramochi, 1992; Kasuya and Ogi, 1987; Kasuya, 1978). Dalli-type Dall's are found throughout the entire range of Dall's (Miyashita and Kasuya, 1988). Only dalli-type Dall's are found in the range from the Okhotsk Sea and Kamchatka peninsula to western Hokkaido, Japan, the central Sea of Japan, the Bering Sea, and the north Pacific east of 170°E (Kasuya, 1982; Amano and Kuramochi, 1992). Truei-type Dall's range off the Pacific coast of Hokkaido, Japan to the southern Kuril Islands (a few as far as the southeastern Kamchatka peninsula) and are rare east of 155°E, though have been sighted as far as 180°E (Kasuya and Jones, 1984; Amano and Kuramochi, 1992; Miyazaki et al, 1984). One newborn female truei-type Dall's washed up in San Mateo County, CA on August 28, 1989 (Szczepaniak et al, 1992). This is the first record of a truei-type Dall's in the eastern north Pacific (Szczepaniak et al, 1992). On the Pacific coast of Japan, 96% of the inshore Dall's are truei-type, and offshore Dall's are mostly dalli-type (Kasuya and Shiraga, 1985). Black-type Dall's are found in the northwestern Pacific and Bering Sea (Kasuya, 1982). Their range overlaps the range of truei-type Dall's on the Pacific coast of Japan, and their eastern boundary is unknown (Kasuya, 1982).

Kasuya and Ogi (1987) suggest that there are at least two local stocks of dalli-type Dall's, each breeding to the north and south of the western Aleutian Islands. They also state that there is probably a third stock which calves off the eastern coasts of the northern Kuril Islands. McMillan and Bermingham (1996) found that mtDNA analysis supports the distinctiveness of Bering Sea and western north Pacific stocks. Differential timing of reproduction between the Bering Sea and western north Pacific is also indicative of separate stocks (Hill et al, 1997).

For management purposes, eastern north Pacific Dall's are separated into two stocks: CA/OR/WA stock and AK stock (Barlow et al, 1997; Hill et al, 1997). Population of the CA/OR/WA stock was 47,661 in 1991 and 1993 (Barlow et al, 1997). N_{\min} of this stock is 34,393, and PBR is 330 (Barlow et al, 1997). Population of the AK stock was 83,400 in 1987 to 1991 (Hill et al, 1997). N_{\min} of this stock is 76,874, and PBR is 1,537 (Hill et al, 1997). There is

no reliable information on population trends for either stock (Barlow et al, 1997; Hill et al, 1997).

Population estimates in the north Pacific and Bering Sea have varied widely from 840,000 to 10 million (Brueggeman et al, 1990). Population was 0.8-2.3 million in the late 1970's (Crawford, 1981), was 1.4-2.8 million in the mid-1980's (Brueggeman et al, 1990; Jefferson, 1990) and was 1.3 million and stable in the late 1980's (Swartzman and Hogman, 1991). Population in the western north Pacific was 30,000-50,000 in the early 1970's (Crawford, 1981) and was 740,000 in the mid-1980's (Hobbs and Jones, 1993). Population in the eastern north Pacific was 500,000-1,000,000 in the mid-1980's (Hobbs and Jones, 1993). Population in the north Pacific, excluding CA, OR, and WA was 837,460-1,342,518 in the early to mid-1980's (Consiglieri et al, 1982; Kajimura and Loughlin, 1988), and population in the entire north Pacific was 997,000-1,410,000 in 1987-1990 (Hobbs and Jones, 1993). Population in the Bering Sea was 200,000 in the late 1980's (Swartzman and Hogman, 1991).

Dall'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 cooperative Dall's management agreements between Canada, the U.S. and Mexico (Barlow et al, 1997).

Dalli-type Dall's in the Sea of Japan migrate north in spring (Amano and Kuramochi, 1992). About 1/3 pass through Tsugaru Strait to summer off the Pacific coast of Japan, and most of the rest pass through Soya Strait to summer in the Okhotsk Sea (Amano and Kuramochi, 1992). Most of the Dall's that summer off the Pacific coast of Japan are immature, and most that summer in the Okhotsk Sea are mature (Amano and Kuramochi, 1992). Truei-type Dall's on the Pacific coast of Japan are mainly on the east coast of Hokkaido and the southern Kuril Islands (and a few as far north as the southeastern Kamchatka peninsula) in summer and migrate south to Choshi in winter (Kasuya, 1982). Black-type Dall's in the Bering Sea and northwest Pacific also undergo north-south migrations, moving south in winter, with some leaving the Bering Sea because of ice (Hill et al, 1997; Perez, 1990; Kasuya, 1982; Temte, 1985).

In the eastern north Pacific, Dall's are common in southern CA in winter and probably range into Baja CA during cold water periods (Barlow et al, 1997; Brueggeman et al, 1990; Leatherwood et al, 1972). Dall's prefer water less than 17°C (Brueggeman et al, 1990). North-south movements between CA, OR, WA, and Baja CA occur as oceanographic conditions change both seasonally and inter-annually, shifting distribution south during cooler water periods (Barlow et al, 1997; Brueggeman et al, 1990; Fiscus and Kajimura, 1981; Forney and Barlow, 1998; Jefferson, 1990; Leatherwood et al, 1972). Dall's in Prince William Sound and the Gulf of AK may also move south in winter (Hill et al, 1997; Crawford, 1981). Eastern north Pacific Dall's may also display seasonal inshore-offshore migrations, moving offshore in winter and inshore in summer, possibly following seasonal distribution of prey species (Brueggeman et al, 1987; 1990; Consiglieri et al, 1982; Hill et al, 1997; Jefferson, 1990; Kajimura and Loughlin, 1988; Crawford, 1981). Despite migrations, Dall's are present year-round in many locations (Consiglieri et al, 1982; Hill et al, 1997; Jefferson, 1991; Kajimura and Loughlin, 1988; Miller, 1990; Crawford, 1981).

Food and Feeding

Dall's are opportunistic feeders (Amano et al, 1998; Fiscus and Kajimura, 1981; Jefferson, 1990). They feed on a variety of epi- and mesopelagic squid and small schooling fish

(Amano et al, 1998; Balsiger, 1995; Brueggeman et al, 1987; 1990; Fiscus and Kajimura, 1981; Jefferson, 1990; Kajimura and Loughlin, 1988; Perez, 1990; Crawford, 1981). Dall's also feed on crustaceans, such as euphausiids and shrimp (Perez, 1990; Subramanian et al, 1987a; Crawford, 1981). Dall's have been considered nocturnal feeders (Brueggeman et al, 1990; Fiscus and Kajimura, 1981), but some studies suggest that they do not necessarily feed mostly at night (Amano et al, 1998; Walker, 1996). They may alter their feeding time according to availability of prey species. (Amano et al, 1998; Walker, 1996). Dall's can dive to great depths for prey (Brueggeman et al, 1990). Dall's may use echolocation to find prey (Crawford, 1981).

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

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	<u>Abraliopsis</u> sp.	Enope squid
	<u>Berryteuthis anonychus</u>	Gonata squid
	<u>Berryteuthis magister</u>	Magistrate armhook squid
	<u>Berryteuthis</u> sp.	Gonata squid
	<u>Chiroteuthis</u> sp.	Whiplash squid
	Cranchiidae	Cranch squid
	Decapoda	Squid
	<u>Eogonatus tinro</u>	Gonata squid
	<u>Galiteuthis phyllura</u>	Cranch squid
	Gonatidae	Gonata squid
	<u>Gonatopsis borealis</u>	Gonata squid
	<u>Gonatopsis</u> sp.	Gonata squid
	<u>Gonatus berri</u>	Gonata squid
	<u>Gonatus madokai</u>	Gonata squid
	<u>Gonatus middendorffi</u>	Gonata squid
	<u>Gonatus onyx</u>	Gonata squid
	<u>Gonatus pyros</u>	Gonata squid
	<u>Gonatus tinro</u>	Gonata squid
	<u>Gonatus</u> sp.	Gonata squid
	<u>Histioteuthis</u> sp.	Umbrella or jewel squid
	<u>Loligo opalescens</u>	Market squid
	<u>Octopoteuthis</u> sp.	Octopus squid
	<u>Octopus bimaculatus</u>	Two-spotted octopus
	<u>Octopus</u> sp.	Octopodid octopus
	<u>Ommastrephes sloani pacificus</u>	Arrow squid
	<u>Ommastrephes</u> sp.	Arrow squid
	<u>Onychoteuthis borealijaponicus</u>	Nail squid
	<u>Onychoteuthis</u> sp.	Hooked squid
	<u>Taonius pavo</u>	Giant squid
	<u>Todarodes pacificus</u>	Pacific flying squid
	<u>Watasenia scintillans</u>	Firefly squid
	<u>Watasenia</u> sp.	Firefly squid

Crustacea

Osteichthys

Decapoda	Shrimp
Euphausiidae	Euphausiids, krill
<u>Alosa sapidissima</u>	American shad
<u>Ammodytes hexapterus</u>	Pacific sand lance
Anguiliformes	Eels
<u>Anoplopoma fimbria</u>	Sablefish
Bathylagidae	Deepsea smelts
<u>Bathylagus milleri</u>	Robust blacksmelt
<u>Bathylagus ochotensis</u>	Blacksmelt
<u>Bathylagus pacificus</u>	Pacific blacksmelt
<u>Bathylagus stilbius</u>	California smoothtongue
<u>Benthabella dentata</u>	
<u>Boreogadus saida</u>	Arctic cod
<u>Bothrocara molle</u>	Soft eelpout
<u>Bothrocarina microcephala</u>	Eelpout
<u>Ceratoscopelus</u> sp.	Lampfish
<u>Citharichthys sordidus</u>	Pacific sanddab
<u>Clupea pallasii</u>	Pacific herring
<u>Cololabis saira</u>	Pacific saury
Cottidae	Sculpins
<u>Diaphus</u> sp.	Headlightfish
<u>Diaphus theta</u>	California headlightfish
<u>Dolichopteryx</u> sp.	Spookfish
<u>Engraulis japonica</u>	Japanese anchovy
<u>Engraulis mordax</u>	Northern anchovy
<u>Ichthyococcus</u> sp.	Lightfish
<u>Laemonema longipes</u>	Longfin codling
<u>Laemonema morosum</u>	Codling/hake
<u>Laemonema</u> sp.	Codling
<u>Lampanyctus achirus</u>	Lampfish
<u>Lampanyctus jordani</u>	Brokenline lampfish
<u>Lampanyctus regalis</u>	Pinpoint lampfish
<u>Lampanyctus</u> sp.	Lampfish
<u>Lestidiops ringens</u>	Slender barracudina
<u>Leuroglossus schmidti</u>	Northern smoothtongue
<u>Liparis</u> sp.	Snailfish
<u>Macroparalepis</u> sp.	Barracudina
<u>Macropinna microstoma</u>	Barreleye
Macrouridae	Grenadiers
<u>Mallotus villosus</u>	Capelin
<u>Melamphaes lugubris</u>	Highsnout bigscale
<u>Merluccius productus</u>	Pacific hake/whiting
<u>Microgadus proximus</u>	Pacific tomcod
Moridae	Moras

Myctophidae	Lanternfish
<u>Myctophum</u> sp.	Lanternfish
<u>Nansenia candida</u>	Bluethroat argentine
<u>Notolepis rissoi rissoi</u>	Ribbon barracudina
<u>Notoscopelus</u> sp.	Lampfish
<u>Oncorhynchus keta</u>	Chum salmon
<u>Oncorhynchus nerka</u>	Sockeye salmon
<u>Oncorhynchus</u> sp.	Salmon
<u>Otophidium taylori</u>	Cusk-eel
<u>Paralepis atlantica</u>	Duckbill barracudina
<u>Paralepis</u> sp.	Barracudina
<u>Peprilus simillimus</u>	Pacific pompano
<u>Pleurogrammus azonus</u>	Greenling/lingcod
<u>Pleurogrammus monoptygius</u>	Atka mackerel
Pleuronectidae	Flatfish
<u>Poromitra crassiceps</u>	Crested bigscale
<u>Protomyctophum thompsoni</u>	Northern flashlightfish
<u>Sardinops melanostictus</u>	Japanese pilchard
<u>Scopelosaurus harryi</u>	Scaley paperbone
Scopelidae	Lanternfish
<u>Sebastes</u> sp.	Rockfish
<u>Spirinchus starksi</u>	Night smelt
<u>Stenobranchius</u> sp.	Lampfish
Stichaeidae	Pricklebacks
Stomiidae	Dragonfish
<u>Tarletonbeania crenularis</u>	Blue lanternfish
<u>Tarletonbeania taylori</u>	Lanternfish
<u>Tarletonbeania</u> sp.	Lanternfish
<u>Thaleichthys pacificus</u>	Eulachon
<u>Theragra chalcogramma</u>	Walleye pollock
<u>Trachurus symmetricus</u>	Jack mackerel/horse mackerel
Zoarcidae	Eelpouts

Habits

Dall's are usually seen in groups of 2-15, but groups of more than 500 have been reported (Brueggeman et al, 1987; Consiglieri et al, 1982; Jefferson, 1990; 1991; Kajimura and Loughlin, 1988; Leatherwood et al, 1972). Jefferson (1990) reports that aggregations of up to several thousand are sometimes sighted. Average group size observed by Jefferson (1991) in Monterey Bay, CA was 5.7, but aggregations of up to 20 were seen, usually in sub-groups of 2-6. Dall's are rarely solitary (Kajimura and Loughlin, 1988) and may segregate by maturity and sex (Kasuya, 1982; Amano and Kuramochi, 1992). Groups with calves tend to be larger than groups without calves (Jefferson, 1987). Individuals tend to be associated with aggregations of fairly constant size (Miller, 1990). Groups are fluid (Jefferson, 1990). Miller (1990) reports that the associations between pairs of Dall's revealed low numbers (0.3%) traveling with consistent

companions. Schools of dalli-type, truei-type, and both types together have been seen (Miyazaki et al, 1984).

Dall's are most common in waters greater than 183 m deep; however, in CA they are often observed in continental shelf waters less than 183 m deep (Brueggeman et al, 1990). Jefferson (1987) found that travel dives of Dall's in Johnstone Strait, British Columbia lasted an average of 35.9 s and deep dives lasted an average of 2-4 minutes for adults and up to 2 minutes for calves. Lancaster (1983) reports a maximum recorded speed of a Dall's at 31 knots. Dall's ride the bow waves of boats and commonly form a roostertail of water as they surface while swimming quickly (Amano and Kuramochi, 1992; Consiglieri et al, 1982; Forney and Barlow, 1998; Jefferson, 1990; 1991; Lancaster, 1983; Leatherwood et al, 1972; Crawford, 1981). Dall's rarely perform aerial behaviors (Jefferson, 1990).

Dall's have been observed associating with other species of marine mammals (Jacobsen, 1986; Shelden et al, 1995). Dall's have been seen interacting with orcas with no predator response from the orcas (Jacobsen, 1986). They have been seen riding the "bow waves" of gray whales (Shelden et al, 1995). They have also been recorded associating with Risso's dolphins (Shelden et al, 1995).

Reproduction

Breeding season:

Japan:	Mid-August to late October, with a peak in September
Sea of Okhotsk and Sea of Japan:	Late June to October, with a peak in September
Bering Sea and north Pacific:	July to August
Western U.S.:	Year-round

Calving season:

Dalli-type:	mid-June to early August in the western north Pacific and western Bering Sea; April to June in Japan; possibly year-round in the eastern north Pacific, but may peak June to August and again in March
Truei-type:	August to September

Sexual maturity

Males:	5.7-7.9 yrs. old; 180-203 cm
Females:	2.0-7.0 yrs. old; 174-196 cm

Gestation:	7-11.4 months
Lactation:	1-4 months to 2 yrs.
Cycle:	May calve every year; calve every 3 yrs. on average

Neonate length:	95-100 cm
Neonate weight:	16.5 kg

In the western north Pacific, most of the Dall's that migrate from the Sea of Japan into the Pacific through the Tsugaru Strait are immature and most that enter the Okhotsk Sea through the

Soya Strait are mature and breed in the Okhotsk Sea (Amano and Kuramochi, 1992). Truei-type Dall's reach sexual maturity at about 12-17 cm longer than dalli-type Dall's (Jefferson, 1990). Most females ovulate within a month or so after parturition and enter next gestation (Subramanian et al, 1987a). After 5-6 yrs. old, resting periods between parturitions may increase (Subramanian et al, 1987a; 1988). Pregnancy rate is 95.5% for mature females in the north Pacific (Temte, 1985).

Dalli-type and truei-type Dall's may interbreed (Miyazaki et al, 1984). A 60 cm female fetus recovered from a Dall's found dead in southern British Columbia was fathered by a harbor porpoise (Baird et al, 1998). This is the first report of a hybrid within the family Phocoenidae and one of the first well-documented cases of cetacean hybridization in the wild (Baird et al, 1998). Hybrid status was confirmed through genetic analysis, with species-specific repetitive DNA sequences of both Dall's and harbor porpoises being found in the fetus (Baird et al, 1998). Atypically pigmented porpoises (usually traveling with and behaving like Dall's) are regularly observed in the area around southern Vancouver Island; these, as well as a previously noted fetus from CA, may also represent hybridization events (Baird et al, 1998).

Mortality and Economics

Natural Mortality

Orcas and, to a lesser extent, sharks prey on Dall's (Baird and Dill, 1996; Consiglieri et al, 1982; Felleman et al, 1991; Hemlich-Boran, 1988; Hoyt, 1984; Jacobsen, 1986; Jefferson, 1990; Kajimura and Loughlin, 1988; Perez, 1990). Natural mortality rate for adult females was less than 10%/yr. in the mid-1970's (Kasuya, 1978). Ten Dall's were found dead in Victoria, Vancouver Island, British Columbia April to May, 1993 (Osmek et al, 1996). Most had enlarged mesenteric lymph nodes, but cause of death could not be investigated thoroughly (Osmek et al, 1996).

Parasite infestations are common and extensive in Dall's (Jefferson, 1990). At least 9 parasites have been found in or on Dall's:

Trematoda

Campula oblonga

Consiglieri et al, 1982

Nasitrema dalli

Yamaguti, 1951

Cestoda

Phyllobothrium sp.

Houck, pers. comm.

Nematoda

Anisakis sp.

Kagel et al, 1967

Crassicauda sp.

Consiglieri et al, 1982

Halocercus dalli

Consiglieri et al, 1982

Halocercus kirbyi

Dougherty, 1944; Delyamure, 1955

Placentonema sp.

Ridgeway, 1966

Stenurus sp.

Norris and Prescott, 1961

Dall's generally live up to 24 yrs old (Consiglieri et al, 1982). Maximum life span of Dall's is about 40 yrs. old for males and 35 yrs. old for females (Gaskin et al, 1984).

Anthropogenic Interactions and Mortality

Pollution may affect Dall's. Dall's have a poor ability to metabolize PCBs, and high PCB and DDE levels can lower testosterone levels and impair reproduction in Dall's (Jefferson, 1990; Subramanian et al, 1987b). In addition to PCBs and DDE, heavy metals have been detected in Dall's (Fujise et al, 1988). CHL, DDT, and HCH have also been found in Dall's (Kawano et al, 1986). Tanabe et al (1994) found that level of PCBs>DDTs>HCHs in dalli-type Dall's from Sanriku, Japan. OC accumulation patterns are different in populations of Dall's inhabiting different geographical locations (Tanabe et al, 1996). This can be attributed to specific feeding patterns of populations in certain areas (Tanabe et al, 1996).

DDE and PCB level in males vary widely between areas (Subramanian et al, 1986). Subramanian et al (1986) found that levels were lower in Bering Sea dalli-type Dall's than in northern north Pacific dalli-type Dall's. They also found that levels in Dall's in the Aleutian Islands were comparable to levels in Dall's in the northern north Pacific. They report that dalli-type Dall's in the northern north Pacific had higher levels than those in the Bering Sea and lower levels than truei-type Dall's in the northwestern north Pacific. Male dalli-type Dall's on the Pacific coast of Hokkaido have similar PCB levels to male dalli-type Dall's in the north Pacific but have higher DDE levels (Subramanian et al, 1986). Male dalli-type Dall's in the Sea of Japan have high DDT levels (Subramanian et al, 1986).

Females have lower PCB and DDE levels than males because females excrete OCs via gestation and lactation (Subramanian et al, 1986; 1987a; 1988; Jefferson, 1990). Subramanian et al (1987a) found that PCB and DDE levels increase in Dall's from about 100 cm body length to about 160 cm. Above 160 cm, levels are consistent in males up to 190 cm, and above 190 cm, there is a sharp increase in PCB and DDE levels until about 210 cm (Subramanian et al, 1987a). In females, PCB and DDE levels decrease sharply with body length as it grows larger than 180 cm (2 years old) until about 5 or 6 years old, when decrease slows (Subramanian et al, 1987a; 1988). Levels are about the same in 8 and 12 year old females (Subramanian et al, 1987a). Female Dall's contain 24-35% and 28-35% of the levels of PCBs and DDE respectively as males (Subramanian et al, 1987a; 1988).

Fisheries are also a source of anthropogenic mortality to Dall's. At least 55 Dall's, harbor porpoises, and Pacific white-sided dolphins collide with gillnets in British Columbia each year, and 53-62% die as a result (Barlow et al, 1994). At least 95 Dall's were incidentally taken in the western Canadian driftnet fishery for neon flying squid, which operated from 1983 to 1987 (Barlow et al, 1994). Several hundred Dall's were killed each year in the driftnet fishery for salmon in eastern Russia from 1992 to 1994 (Barlow et al, 1994). Annual incidental take may have reached 20,000 in the Japanese high seas salmon driftnet fishery (Brueggeman et al, 1987; Kasuya, 1982), and Consiglieri et al (1982) report an average of 3,220/yr. were taken from 1955 to 1975. An estimated 3,838 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). Dall's were the most commonly caught cetacean, with at least 20 mortalities, in the foreign and joint venture trawl fishery, which operated from 1973 to 1988 (Perez and Loughlin, 1991). At least four Dall's were taken in the CA/OR/WA joint venture groundfish trawl fisheries from 1989 to 1990; these fisheries were discontinued in 1990 (Barlow et al, 1997). In Japan, 167 Dall's were harpooned for study in the mid-1980's (Kasuya and

Shiraga, 1985). One Dall's was incidentally taken in a surface trawl research fishery on salmon smolts in 1990 (Barlow et al, 1994). Fisheries that incidentally take Dall's and annual mean mortality are as follows (Barlow et al, 1994; 1997; Hill et al, 1997; U.S. Dept. of Comm., 1996):

CA/OR/WA stock:

CA/OR thresher shark/swordfish drift gillnet	22 (CV=0.52)
WA/OR/CA domestic groundfish trawl	n/a
CA/OR/WA salmon troll	n/a
WA Puget Sound region salmon drift gillnet	n/a
OR experimental thresher shark gillnet	0
San Juan Islands salmon seine	
British Columbia salmon dritnet	

AK stock:

Bering Sea/Aleutian Islands groundfish trawl	4.6 (CV=0.20)
Bering Sea/Aleutian Islands groundfish pot	0
Bering Sea/Aleutian Islands groundfish longline	1.6 (CV=0.61)
Gulf of AK groundfish trawl	0.6 (CV=1.0)
Gulf of AK groundfish pot	0
Gulf of AK groundfish longline	0
AK peninsula/Aleutian Islands salmon drift gillnet	28
Prince William Sound salmon drift gillnet	0.5
Southeast AK salmon drift gillnet	5.5
Cook Inlet set and drift gillnet	0.5
Kodiak, AK peninsula, and South Unimak salmon set and driftnet	
Copper River Delta salmon	

Minimum total annual fisheries mortality is 22/yr. for the CA/OR/WA stock; this is less than 10% of PBR (33) and is considered insignificant (Barlow et al, 1997). Minimum total annual fisheries mortality for the AK stock is 42/yr.; this is less than 10% of PBR (154) and is considered insignificant (Hill et al, 1997).

Dall's have been harvested in the Japanese hand harpoon fishery on the Pacific coast of Japan, Sea of Japan, and Sea of Okhotsk since prehistoric times (Kasuya, 1978; 1982; 1992; Amano and Kuramochi, 1992; Brueggeman et al, 1987). 200-1,800/yr. were harvested from 1957 to 1966 (Kasuya, 1982). 5,000-10,000 were harvested from 1963 to 1980, 10,000-13,000 were harvested from 1981 to 1987, and 30,000 were harvested in 1988 (Kasuya, 1992). However, estimates may be low, and corrections for underestimates show 37,200 and 45,600 were harvested in 1987 and 1988 respectively (Kasuya, 1992). Hobbs and Jones (1993) report 40,367 harvested in 1988. In 1989, 29,000 were harvested, 45% (13,000) of which were truei-type Dall's and 55% (16,000) of which were dalli-type Dall's (Kasuya, 1992). Miyazaki (1983) reports that 50,557 were caught commercially (harpoon, drive, and longline fisheries or small-type whaling) in Japan from 1976-81. There are no reports of subsistence takes of Dall's in AK (Hill et al, 1997).

Minimum annual human-caused mortality for the CA/OR/WA stock is 22/yr.; this is less than PBR (330) and is considered insignificant (Barlow et al, 1997). Minimum annual human-caused mortality for the AK stock is 42/yr.; this is less than PBR (1,537) and is considered insignificant (Hill et al, 1997).

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Review of Harbor Porpoises (Phocoena phocoena) in the North Pacific 1978-1997

Population, Abundance, and Distribution

Range:

Coastal and inland waters, including bays, harbors, and river mouths, from Point Conception, CA (possibly Banderas Bay, Mexico, but the sighting there was most likely a cochito instead) to Point Barrow, AK west to the Pribilof and Aleutian Islands, Kamchatka, and the Bering and Okhotsk Seas and south into the Sea of Japan to Hokkaido and central Honshu, Japan; occasionally in the Chukchi and Beaufort Seas and Bering Strait; may occur in the southern Kuril Islands and on the Amurland and Korean coasts

For management purposes, harbor porpoises are separated into seven stocks: central CA, northern CA, OR/WA coast, WA inland, southeast AK, Gulf of AK, and Bering Sea (Barlow et al, 1997; Hill et al, 1997). The central CA stock ranges from Point Conception, CA to Russian River, CA, and the northern CA stock ranges from Russian River, CA to OR (Barlow et al, 1997). The OR/WA coast and WA inland stocks are separated at Cape Flattery, WA (Barlow et al, 1997). The southeast AK stock occurs from the northern border of British Columbia to Cape Suckling, AK; the Gulf of AK stock occurs from Cape Suckling to Unimak Pass; and the Bering Sea stock occurs throughout the Aleutian Islands and all waters north of Unimak Pass (Hill et al, 1997).

Population of the central CA stock out to the 91 m isobath was 4,120 in 1988-1993 (Barlow et al, 1997). Population trends show slight declines but these could be caused by changing oceanographic conditions that cause the harbor porpoises to move elsewhere (Barlow et al, 1997; Forney, 1995). Relative abundance in central CA declined 9.3%/yr. from 1986 to 1993 (Forney, 1995). Population in 1989 was 30-97% of the population in 1969 (Barlow and Hanan, 1995), and local populations may have been reduced to less than 50% of their pre-fishery abundance in central CA (Barlow et al, 1994). Maximum growth rate of this stock is 9.4%/yr. (Barlow et al, 1997; Barlow and Hanan, 1995). N_{\min} of this stock is 3,431, and PBR is 33 (Barlow et al, 1997).

Population of the northern CA stock out to the 91 m isobath was 26,175 in 1990-1991 (Barlow et al, 1997). No significant population trends were evident from 1989 to 1995 (Barlow et al, 1997). N_{\min} of this stock is 7,640, and PBR is 76 (Barlow et al, 1997).

Population of the OR/WA coast stock was 26,175 in 1990-1991 (Barlow et al, 1997; Osmek et al, 1996). There are no reliable data on population trends for this stock (Barlow et al, 1997). Harbor porpoise density in this stock is highest in southern WA, lower in OR, and lowest in northern WA (Osmek et al, 1996). N_{\min} of this stock is 22,046, and PBR is 212 (Barlow et al, 1997).

Population of the WA inland stock was 3,352 in 1990-1991 (Barlow et al, 1997; Osmek et al, 1996). There are no reliable data on population trends for this stock (Barlow et al, 1997). However, population has declined considerably in Puget Sound since the 1940's (Barlow et al, 1997; Brueggeman et al, 1990; NMFS, 1991; 1992; 1993; Osmek et al, 1996), and harbor porpoises are currently absent from southern Puget Sound (Brueggeman et al, 1990). Miller (1996) and Osmek et al (1996) state that population is declining in the inland waters of WA and

British Columbia and that these declines may be a result of pollution, incidental fisheries takes, declines in prey abundance, anthropogenic noise, decreased reproductive output, immunosuppression, recreational and commercial vessel traffic, and competition from increased numbers of Dall's porpoises. N_{\min} of the WA inland stock is 2,681 (Barlow et al, 1997).

Population of the southeast AK stock was 10,301 in 1991-1993 (Hill et al, 1997). There are no reliable data on population trends for this stock (Hill et al, 1997), but fairly high densities of harbor porpoises can be found in certain localities year after year (Taylor and Dawson, 1984). N_{\min} for this stock is 8,156, and PBR is 82 (Hill et al, 1997).

Population of the Gulf of AK stock was 8,497 in 1991-1993 (Hill et al, 1997). There are no reliable data on population trends for this stock (Hill et al, 1997). N_{\min} of this stock is 7,085, and PBR is 71 (Hill et al, 1997).

Population of the Bering Sea stock was 10,946 in 1991 (Hill et al, 1997). There are no reliable data on population trends for this stock (Hill et al, 1997). N_{\min} for this stock is 8,549, and PBR is 86 (Hill et al, 1997).

Harbor porpoises are not considered depleted or strategic under the MMPA or endangered or threatened under the ESA (NMFS, 1991; 1992; 1993; U.S. Dept. of Comm., 1996; Balsiger, 1995; Barlow et al, 1997; Hill et al, 1997).

Most harbor porpoises in CA are within the area from the coast to 91 m deep (Barlow et al, 1997). Brueggeman et al (1990) report that harbor porpoises in central CA are most common in water 37-73 m deep and that the majority occur in side the 18 m contour. Barlow et al (1997) report that 24% of harbor porpoises in WA and OR are found in water 100-200 m deep. However, Osmek et al (1996) found that harbor porpoises in OR and WA in summer are mainly in water less than 37 m deep, but harbor porpoises in the San Juan Islands are often in water deeper than 91 m. Overall, Osmek et al (1996) found that harbor porpoises are generally at depths shallower than 100 m and rarely at depths greater than 200 m in OR and WA in summer. Harbor porpoises are usually found within 32-40 km of shore, mainly in water shallower than 18.3 m (Jones, 1981; Kajimura and Loughlin, 1988). Generally, harbor porpoises are found in inshore, coastal waters and in harbors, bays, estuaries, tidal channels, and rivers (Barlow et al, 1997; Brueggeman et al, 1990; Jones, 1981; Kajimura and Loughlin, 1988; Perez, 1990; Sekiguchi, 1995).

Harbor porpoises are reported to occur year-round in the Gulf of AK, inland WA and British Columbia, along the OR/WA coast, along the northern and central CA coast, and in the Gulf of Farallones (Barlow et al, 1997; Kajimura and Loughlin, 1988; Gaskin, 1984; Osmek et al, 1996; Sekiguchi, 1995). They occur at relatively high densities in WA and northern OR and CA and at lower densities in AK (Hill et al, 1997). According to Osmek et al (1996), No strong seasonal migration has been documented. Phylogeographic analyses of genetic data from the eastern north Pacific do not show complete concordance between DNA sequence types and geographic location (Barlow et al, 1997). However, an AMOVA analysis shows significant genetic differences for 4 of the 6 pair-wise comparisons in CA, WA, British Columbia, and AK (Barlow et al, 1997; Hill et al, 1997). This suggests movement of harbor porpoises is sufficiently restricted such that genetic differences have evolved (Barlow et al, 1997). However, Rosel et al (1995) state that harbor porpoises collected from different regions often exhibited mtDNA haplotypes more closely related to each other than to those collected from the same geographic location. They suggest the presence of several haplotypes across a broad geographic range may indicate that a relatively high amount of gene flow is occurring between CA, WA, British

Columbia, and AK (no samples were taken in OR). Two distinct mtDNA clades have been found to exist: one is present in CA, WA, British Columbia, and AK (no samples were taken in OR) and the other is found only in CA and WA (Rosel et al, 1995; Barlow et al, 1997; Hill et al, 1997; Osmek et al, 1996). Differences in pollutant levels in harbor porpoise blubber from CA, OR, and WA also suggest that harbor porpoises do not move extensively between these three areas (Barlow et al, 1997; Calambokidis and Barlow, 1991; Forney, 1995; Rosel et al, 1995; Hill et al, 1997; Osmek et al, 1996). Differences are also found in pollutant levels of harbor porpoise blubber in different regions of CA (Barlow et al, 1997; Hill et al, 1997; Sekiguchi, 1995).

However, despite the fact that some studies indicate non-mixing, non-migratory, year-round stocks of harbor porpoises in certain locations, other studies show distinct seasonal changes in abundance (Barlow et al, 1997; Brueggeman et al, 1990; Rosel et al, 1995; Sekiguchi, 1995). For example, Brueggeman et al (1990) report that abundance increases 47% off central and northern CA between summer and fall, that harbor porpoises are relatively abundant in northern OR and WA in September but scarce in January, and that abundance is highest in September in the Strait of Juan de Fuca, WA. These changes in abundance may be due to shifts in distribution to deeper offshore waters in late winter (Barlow et al, 1997; Brueggeman et al, 1990). However, harbor porpoises have been conspicuously absent in offshore areas in late November, leaving a gap in understanding of their movements (Barlow et al, 1997). Sekiguchi (1995) states that harbor porpoises in the Farallon Islands move offshore in winter, concentrating at depths of 35-80 m, and inshore in summer, concentrating at depths of less than 45 m.

Rosel et al (1995) report that harbor porpoises may move north-south on a seasonal basis in central and northern CA. Sekiguchi (1995) reports that peak abundance in central and northern CA occurs in the fall and that harbor porpoises may make a seasonal north-south migration along the coast in central and northern CA, wintering in the north and distributing evenly along the coast in summer and fall. Harbor porpoises increase in abundance from summer to fall and are nearly absent in winter in Glacier Bay, AK (Taylor and Dawson, 1984). They are widely distributed in the eastern Bering Sea from early summer through fall, but winter ice build-up forces populations to move south (Gaskin, 1984). Morris (1981) states that harbor porpoises occur in the Chukchi Sea in low abundance and only during summer, primarily in August. Perez (1990) suggests that harbor porpoises are affected by the formation of seasonal sea ice in the Chukchi and Bering Seas, occurring in the Chukchi Sea in summer and wintering in the Bering Sea. However, some of the southern Bering Sea summer population may leave the Bering Sea in winter (Perez, 1990). Ocean conditions may affect abundance and distribution in any given year (Forney, 1995).

Food and Feeding

Harbor porpoises are opportunistic feeders (Sekiguchi, 1995). They feed on a wide variety of schooling fish and some squid and shrimp (Brueggeman et al, 1987; Kajimura and Loughlin, 1988; Perez, 1990; Jones, 1981). Primary prey are clupeids and gadoids (Brueggeman et al, 1990; Consiglieri et al, 1982; Kajimura and Loughlin, 1988). They use echolocation to find prey (Sekiguchi, 1995) and may feed cooperatively (Taylor and Dawson, 1984).

In Monterey Bay, CA, 50.3% of all group behaviors observed by Sekiguchi (1995) were probable feeding. More instances of probable feeding were observed in the morning than in the

afternoon (Sekiguchi, 1995). Harbor porpoises dive up to at least 70 m for food (Consiglieri et al, 1982).

The following prey species have been determined for harbor porpoises:

<u>Category</u>	<u>Scientific Name</u>	<u>Common Name</u>
Cephalopoda	Decapoda	Squid
	<u>Loligo opalescens</u>	Market squid
	<u>Octopus sp.</u>	Octopodid octopus
Crustacea	Amphipoda	Amphipods
	Decapoda	Shrimp
Chondrichthys	<u>Mustelus californicus</u>	Smoothhound shark
Osteichthys	<u>Alosa sapidissima</u>	American shad
	<u>Ammodytes hexapterus</u>	Pacific sand lance
	<u>Anoplopoma fimbria</u>	Sablefish
	<u>Boreogadus saida</u>	Arctic cod
	<u>Chilara taylori</u>	Spotted cusk eel
	<u>Clupea pallasii</u>	Pacific herring
	Clupeidae	Herrings
	Cottidae	Sculpins
	<u>Cymatogaster aggregata</u>	Shiner perch
	<u>Eleginus gracilis</u>	Saffron cod
	Embiotocidae	Surfperch
	<u>Engraulis mordax</u>	Northern anchovy
	Gadidae	Cods
	<u>Hyperprosopogon anale</u>	Spotfin surfperch
	<u>Lepidogobius lepidus</u>	Bay goby
	<u>Leucichthys sp.</u>	Whitefish
	<u>Mallotus villosus</u>	Capelin
	<u>Merluccius productus</u>	Pacific hake/whiting
	<u>Microgadus proximus</u>	Pacific tomcod
	<u>Oncorhynchus sp.</u>	Salmon
	Ophidiidae	Cusk eels
	Osmeridae	Smelts
	<u>Phanerodon furcatus</u>	White seaperch
	Pleuronectidae	Flatfish
	<u>Porichthys notatus</u>	Plainfin midshipman
	<u>Sardinops sagax</u>	Pacific sardine
	<u>Sebastes sp.</u>	Rockfish
	Scianidae	Drums
	<u>Scomber japonicus</u>	Chub mackerel
	<u>Sprinchus starksi</u>	Night smelt

Habits

Harbor porpoises are usually seen alone or in pairs or small groups (Consiglieri et al, 1982; Kajimura and Loughlin, 1988; Leatherwood et al, 1972; Osmek et al, 1996). However, they will occasionally travel in schools of nearly one hundred (Leatherwood et al, 1972). Taylor and Dawson (1984) found that average group size increased from about 1 in summer to more than 3 in winter in Sitakaday, Galcier Bay, AK. Sekiguchi (1995) also reports that harbor porpoises are in larger groups in winter and spring in AK. Sekiguchi (1995) found that average group size in Monterey Bay, CA is 3.1, with a range of 1-25. However, average group size in Monterey Bay changes seasonally, being significantly higher in October, July, August, and September, significantly lower in March and April, and lowest in May (Sekiguchi, 1995). Harbor porpoises are shy and will not ride the bow waves of boats (Leatherwood et al, 1972).

Of all group behaviors recorded by Sekiguchi (1995) in Monterey Bay, CA, 50.3% were probable feeding, 48.2% were traveling, and 1.5% were playing. Traveling increased to more than 50% of observations in the afternoon, while playing occupied small amounts of time throughout the day (Sekiguchi, 1995). Sekiguchi (1995) also found that more individuals were observed Monterey Bay in the morning than other times of day, with a low in the afternoon. Harbor porpoises in Monterey Bay tend to be distributed evenly in the early morning, move farther offshore in the middle of the day, and move closer to shore during the late afternoon (Sekiguchi 1995). Sekiguchi (1995) did not observe any groups of harbor porpoises farther than 150 m offshore. Harbor porpoises in Monterey Bay are more frequently observed during flood tide than ebb tide (Sekiguchi, 1995).

Taylor and Dawson (1984) found that harbor porpoises in Glacier Bay, AK surface an average of 1.5 times/minute in Sitakaday and 2.5 times/minute in Adams. Calves had a significantly higher average rate, 3.3 times/minute (Taylor and Dawson, 1984). Also, Taylor and Dawson (1984) found that harbor porpoises submerge for an average of 2.3 minutes in Sitakaday and 1.5 minutes in Adams. Taylor and Dawson (1984) found that the average time for a stay-at-the-surface was 13.6 seconds in Sitakaday and 9.4 seconds in Adams. They also reported harbor porpoises engaging in a behavior termed pop-splashing. In this behavior the harbor porpoise moves faster than normal and surfaces with a vigorous vertical motion causing a vertical splash (Taylor and Dawson, 1984). Pop-splashing is rare in summer and regular in fall and winter in Sitakaday (Taylor and Dawson, 1984). Otani et al (1998) found that two females in Hokkaido Japan had mean surface intervals of 0.6 minutes between dives and that 80% of surface intervals were shorter than one minute. They also found that most time was spent at depths shallower than 20 m. They determined that more than 70% of dives lasted two minutes or less and that dive duration increased with dive depth. Otani et al (1998) also distinguished between two types of dives: a V-shaped dive and a dive during which more time was spent at the bottom. Most V-shaped dives were in water shallower than 20 m, and most bottom-time dives were in deeper water. Otani et al (1998) found no difference in average dive depth and average dive duration between day and night.

Reproduction

Breeding season: Mate June to August

Calving season: May to July

Sexual maturity

Female: 3-4 yrs. old

Male: 3-4 yrs. old

Gestation: 10-11 months

Neonate length: 80-86 cm

Copulation is rarely observed in coastal waters, and much seasonal sexual activity may occur outside the immediate coastal zone (Sekiguchi, 1995). Sekiguchi (1995) found that the number of calves in Monterey Bay, CA varies seasonally. The percentage of calves in Monterey Bay is lowest from January to May, increases in June, is highest in August, and decreases in November (Sekiguchi, 1995). Taylor and Dawson (1984) observed very small calves in Glacier Bay, AK beginning in early August. They state that calves are a constant 6% of the population.

A 60 cm female fetus recovered from a Dall's porpoise found dead in southern British Columbia was fathered by a harbor porpoise (Baird et al, 1998). This is the first report of a hybrid within the family Phocoenidae and one of the first well-documented cases of cetacean hybridization in the wild (Baird et al, 1998). Hybrid status was confirmed through genetic analysis, with species-specific repetitive DNA sequences of both Dall's porpoise and harbor porpoise being found in the fetus (Baird et al, 1998). Atypically pigmented porpoises (usually traveling with and behaving like Dall's porpoises) are regularly observed in the area around southern Vancouver Island; these, as well as a previously noted fetus from CA, may also represent hybridization events (Baird et al, 1998).

Mortality and Economics

Natural Mortality

Orcas and sharks prey on harbor porpoises (Baird and Dill, 1996; Consiglieri et al, 1982; Felleman et al, 1991; Gaskin, 1984; Hemlich-Boran, 1988; Hoyt, 1984; Kajimura and Loughlin, 1988; Perez, 1990; Matkin and Dahlheim, 1995). Matkin and Dahlheim (1995) found that 20% of identified transient predation in their study in northern southeastern AK was on harbor porpoises. Dall's porpoises may outcompete harbor porpoises in some areas such as Puget Sound, WA (Miller, 1996; Osmek et al, 1996).

Harbor porpoises may die of paralytic shellfish poisoning caused by dinoflagelates (Alexandrium spp.). Immunosuppression is one of the possible causes of the decline of the population in Puget Sound (Osmek et al, 1996). The most significant cause of natural mortality of harbor porpoises is parasites (Consiglieri et al, 1982). At least 22 parasites and 1 bacteria have been found in or on harbor porpoises:

Bacteria

Nocardia sp.

Macneill et al, 1978

Parasites

Trematoda

Campula oblonga

Cobbold, 1858; Baylis, 1932; Dailey and Stroud, 1978

Hadwenius mironovi

Dailey and Stroud, 1978

Hadwenius nipponicus

Dailey and Stroud, 1978

Lecithodesmus nipponicus

Yamaguti, 1951

Opisthorchis tenuicollis

Rudolphi, 1819; Baylis, 1932

Pholeter gastrophilus

Kossack, 1910; Baylis, 1932

Cestoda

Diphyllobothrium lanceolatum

Krabbe, 1865; Delyamure, 1955

Diphyllobothrium latum

Linnaeus, 1758; Delyamure, 1955

Diphyllobothrium stemmacephalum

Cobbold, 1858; Baylis, 1932

Nematoda

Anisakis simplex

Rudolphi, 1809; Baylis, 1932; Dailey and Stroud, 1978

Crassicauda sp.

Dailey and Stroud, 1978

Halocercus invaginatus

Quekett, 1841; Delyamure, 1955;

Moser and Rhinehart, 1993; Dailey and Stroud, 1978

Halocercus ponticus

Delyamure, 1946; Delyamure, 1955

Halocercus taurica

Delyamure and Skrjabin, 1942;

Delyamure, 1955

Pharurus convolutus

Kühn, 1829; Baylis and Daubney, 1925; Delyamure, 1955; Dailey and Stroud, 1978

Porrocaecum decipiens

Krabbe, 1878; Delyamure, 1955

Pseudalius inflexus

Rudolphi, 1809; Baylis, 1932

Stenurus minor

Kühn, 1829; Baylis, 1932; Dailey and Stroud, 1978

Acanthocephala

Bolbosoma sp.

Dailey and Stroud, 1978

Corynosoma alaskensis

Golvan, 1959

Corynosoma semerme

Forssell, 1904; Delyamure, 1955

Corynosoma strumosum

Rudolphi, 1802; Delyamure, 1955

In addition, cookiecutter shark (*Isistius brasiliensis*) wounds have been found on harbor porpoises (Gallo-Reynoso and Figueroa-Carranza, 1992).

Anthropogenic Interactions and Mortality

PCBs, DDT, DDE, HCB and other pollutants have been detected in harbor porpoise tissues (Calambokidis, 1986; Calambokidis and Barlow, 1991; Forney, 1995; Jarman et al, 1996; Osmek et al, 1996; Sikiguchi, 1995; Varanasi et al, 1994). Pollution may be a cause of the decline in the harbor porpoise population in inland WA and British Columbia (Barlow et al, 1997; Miller, 1996). Also, the Exxon Valdez oil spill in Prince William Sound in March, 1989 may have caused the death of at least five harbor porpoises (Loughlin et al, 1996). Calambokidis (1986) found high correlations between latitude and DDE concentration, latitude and DDE/PCB, and latitude and HCB/DDE in CA, OR, and WA. DDE concentrations and DDE/PCB ratio were highest in CA and lowest in WA, and HCB/DDE ratio was lowest in CA and highest in WA (Calambokidis, 1986). Regional differences were also apparent within CA (Calambokidis, 1986). Calambokidis (1986) also found a positive correlation between PCB concentration and length and between PCB concentration and blubber thickness.

Harbor porpoises are extremely sensitive to human intrusion and anthropogenic noise (Miller, 1996). They avoid boats (Miller, 1996; Brueggeman et al, 1990) and may suffer negative effects after as few as 4 days of extreme stress (Miller, 1996). Vessel traffic and noise are possible causes of the decline of harbor porpoises in Puget Sound, WA (Miller, 1996; Osmek et al, 1996; Brueggeman et al, 1990; Barlow et al, 1997). In general, harbor porpoises actively avoid boats approaching within 100-200 m (Brueggeman et al, 1990). Some harbor porpoises stranded in CA died of gunshot wounds and boat collisions (Gaskin, 1984). However, Osmek et al (1996) state that much illegal take is unlikely because harbor porpoises are not known to feed on fish caught by fisherpeople and do not provide products of commercial value.

Fisheries are an anthropogenic source of mortality for harbor porpoises (Barlow et al, 1994; 1997; Hill et al, 1997). Harbor porpoises have been caught incidentally in set gillnets off central CA since at least 1958 (Forney, 1995). Incidental mortality in the central CA halibut fishery was 200-300/yr. from 1983 to 1987 and has been about 40/yr. since 1987 (Barlow et al, 1994; Barlow and Hanan, 1995). Some local populations of harbor porpoises may have been reduced to less than 50% of their pre-fishery abundance in central CA (Barlow et al, 1994). In general, fishery mortality in central CA has gone down due to a reduction in fishing effort and changes in geographic distribution of sets (Barlow et al, 1997; Forney, 1995). There is no known fishery mortality in northern CA (Barlow et al, 1997). At least 10%, and possibly as many as 20%, of deaths of 53 stranded harbor porpoises examined in CA were caused by net entanglement (Gaskin, 1984).

The most common cetacean/fishery interaction in the WA gillnet fisheries for salmon is with harbor porpoises (Barlow et al, 1994). Fish nets are responsible for a large number of harbor porpoise deaths in WA each year (Barlow et al, 1997; Gaskin, 1984). Incidental mortality may be a factor in the harbor porpoise declines in Puget Sound and other parts of WA (Barlow et al, 1997; Brueggeman et al, 1990). At least 55/yr. collide with salmon gillnets in British Columbia, and 53-62% of those die as a result (Barlow et al, 1994). Population may be declining in British Columbia because of mortality in gillnet fisheries (Stacey et al, 1997). Harbor porpoises were taken in the western Canadian driftnet fishery for neon flying squid from 1983 to 1987, but that fishery has been discontinued (Barlow et al, 1994). Of the harbor porpoises taken in the Prince William Sound driftnet and setnet fisheries for salmon, 50% are released alive (Barlow et al, 1997).

A harbor porpoise was reported taken in a monofilament sunken set gillnet used in a research fishery for dogfish shark in 1990 (Barlow et al, 1994). Harbor porpoises were also

reported taken in a beach seine in San Francisco, CA (Barlow et al, 1997). Ten harbor porpoises were caught incidentally in the Japanese high seas salmon mothership fishery in the vicinity of Attu and Agattu from 1978 to 1981 (Gaskin, 1984). Harbor porpoises were also taken in the foreign and joint venture trawl fisheries in the north Pacific and eastern Bering Sea from 1973 to 1988 (Perez and Loughlin, 1991). A harbor porpoise carcass was found with a sunken tuna longline in August, 1977 but cause of death was uncertain (Testaverde, 1978). Acoustic alarms may aid in reducing incidental mortality of harbor porpoises (Barlow et al, 1997).

Miyazaki (1983) reports that 86 were incidentally taken in seine, set, and gillnet fisheries in Japan from 1976-81. Fisheries that incidentally take harbor porpoises and annual mean mortality are as follows (Barlow et al, 1994; 1997; Hill et al, 1997; Braham, 1992; Gaskin, 1984; Osmek et al, 1996; Stacey et al, 1997; U.S. Dept. of Comm., 1996):

Central CA stock:

CA white seabass gillnet	
CA white croaker gillnet	
CA angel shark/halibut and other species large mesh (>3.5") set gillnet	14 (CV=0.44)
CA set and drift gillnet using a stretched mesh size of 3.5" or less	

WA inland stock:

Northern WA marine set gillnet	0
WA Puget Sound region salmon set/drift gillnet	
Puget Sound non-treaty salmon gillnet	
Puget Sound non-treaty chum salmon gillnet	0
Puget Sound treaty chum salmon gillnet	0
Puget Sound treaty chum and sockeye salmon gillnet	15 (CV=1.0)
WA Makah tribe set net	
Northwest WA chinook salmon set gillnet	0.5
British Columbia salmon drift gillnet	
British Columbia salmon troll	
British Columbia salmon seine	
British Columbia salmon trawl	

OR/WA coast stock:

British Columbia salmon drift gillnet	
Northern WA marine set gillnet	12.7
WA/OR loer Columbia River drift gillnet	0
WA Grays Harbor drift gillnet	0
Willapa Bay drift gillnet	0
WA Makah tribe set net	
Northwest WA chinook salmon set gillnet	9
CA/OR thresher shark/swordfish drift gillnet	
British Columbia salmon troll	
British Columbia salmon seine	
British Columbia salmon trawl	

Southeast AK stock:

Southeast AK salmon drift gillnet	3.25
Gulf of AK groundfish longline	0

Gulf of AK stock:	
Gulf of AK groundfish trawl	0
Gulf of AK groundfish longline	0
Gulf of AK pot	0
Prince William Sound salmon drift gillnet	20 (CV=0.60)
Cook Inlet salmon drift and set gillnet	0.75
Kodiak salmon set gillnet	3.75
Bering Sea stock:	
Bering Sea herring	
Bering Sea salmon	
Bering Sea/Aleutian Islands groundfish trawl	0.75
Bering Sea/Aleutian Islands groundfish longline	0
Bering Sea/Aleutian Islands groundfish pot	0
AK peninsula/Aleutian Islands salmon drift gillnet	0.75
AK Peninsula/Aleutian Islands salmon set gillnet	0.5
Bristol Bay salmon drift gillnet	0
Bristol Bay salmon set gillnet	0
AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	0

Minimum total annual fisheries mortality for each stock of harbor porpoises is as follows (Barlow et al, 1997; Hill et al, 1997):

Central CA stock	14/yr.
Northern CA stock	0/yr.
OR/WA coast stock	13/yr.
WA inland stock	15/yr.
Southeast AK stock	4/yr.
Gulf of AK stock	25/yr.
Bering Sea stock	2/yr.

Minimum total annual fisheries mortality exceeds 10% of PBR and is considered significant for the central CA (3.3), WA inland (2.1), and Gulf of AK (7.1) stocks (Barlow et al, 1997; Hill et al, 1997). Minimum total annual fisheries mortality is less than 10% of PBR and is considered insignificant for the northern CA (7.6), OR/WA coast (21.2), southeast AK (8.2), and Bering Sea (8.6) stocks (Barlow et al, 1997; Hill et al, 1997).

Harbor porpoises were historically harvested for subsistence by the Makah Indians in WA (Barlow et al, 1994; Brueggeman et al, 1990; Gaskin, 1984). There is no evidence of direct hunting in the Bering Sea (Gaskin, 1984). Some catches have been reported in Japan from 1977 to 1983 (Gaskin, 1984). Miyazaki (1983) reports that 73 were caught commercially (harpoon, drive, and longline fisheries or small-type whaling) in Japan from 1976-81. Subsistence hunts have not been reported from AK stocks (Hill et al, 1997) nor do they currently occur in other stocks along the west coast of North America (Barlow et al, 1997). There has not been a live-capture fishery for harbor porpoises (Osmek et al, 1996).

Minimum total annual human-caused mortality for each stock of harbor porpoises is the same as the minimum total annual fisheries mortality (Barlow et al, 1997; Hill et al, 1997). This

is less than PBR for all the stocks and is considered insignificant (Barlow et al, 1997; Hill et al, 1997).

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