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Marine Mammal Stock Assessments: 1999

by

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TABLE OF CONTENTS

PREFACE iii

PINNIPEDS

HAWAIIAN MONK SEAL (*Monachus schauinslandi*) 1

CETACEANS - U.S. WEST COAST

HARBOR PORPOISE (*Phocoena phocoena*): Central California Stock 8
HARBOR PORPOISE (*Phocoena phocoena*): Northern California Stock 12
HARBOR PORPOISE (*Phocoena phocoena*): Oregon/Washington Coast Stock 15
HARBOR PORPOISE (*Phocoena phocoena*): Inland Washington Stock 20
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Transient Stock 27
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Offshore Stock 33
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock 37
SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): California/Oregon/Washington Stock 42
SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock 46
HUMPBACK WHALE (*Megaptera novaeangliae*): California/Oregon/Washington - Mexico Stock 51

APPENDICES

APPENDIX 1: Chronology of U. S. Pacific Stock Assessment Reports, 1995-1999 57
APPENDIX 2: Summary of 1999 Pacific Marine Mammal Stock Assessment Reports 62

PREFACE

Under the 1994 amendments to the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are required to publish Stock Assessment Reports for all stocks of marine mammals within U.S. waters, to review new information every year for strategic stocks and every three years for non-strategic stocks, and to update the stock assessment reports when significant new information becomes available. This report presents updated information for several stocks in the Pacific Region under NMFS jurisdiction, including both strategic stocks and stocks for which new information on abundance and population structure has become available. These assessments include stocks studied by the Southwest Fisheries Science Center (SWFSC, La Jolla, California and Honolulu, Hawaii) and the National Marine Mammal Laboratory (NMML, Seattle, Washington). The southern sea otter, which is under the management jurisdiction of the USFWS, is covered in a separate report. A 1995-99 chronology of revision and publication dates for all Pacific Region stocks under NMFS jurisdiction is provided in Appendix 1.

The National Marine Fisheries Service reviewed new information pertaining to the status of all stocks within the Pacific Region and, in consultation with the Pacific Scientific Review Group, decided that there was sufficient new information to warrant the revision of assessment reports for 11 stocks. The Stock Assessment Reports for 1999 include four written by staff of the National Marine Mammal Laboratory: Oregon & Washington Coast Harbor Porpoise, Inland Washington Harbor Porpoise, Eastern North Pacific Southern Resident Killer Whale and Eastern North Pacific Transient Killer Whale. Southwest Fisheries Science Center personnel prepared stock assessments for the following seven stocks: Hawaiian Monk Seal, Central California Harbor Porpoise, Northern California Harbor Porpoise, Eastern North Pacific Offshore Killer Whale, California/Oregon/ Washington Short-finned Pilot Whale, California/Oregon/ Washington Sperm Whale, and California/ Oregon/Washington-Mexico Humpback Whale. A summary table for these revised stock assessment reports is provided in Appendix 2.

In the 1999 Stock Assessment Reports, the previous California/Oregon/Washington Killer Whale stock (Barlow et al. 1997) has been eliminated, based on new information on stock structure of eastern North Pacific killer whales. The animals from this stock have now been divided among two other stocks: 1) the existing Eastern North Pacific Transient stock, whose range description has been expanded southward to include California, and 2) a new 'Eastern North Pacific Offshore' stock, ranging from Southeast Alaska to California. The Eastern North Pacific Transient Killer Whale stock, which was previously published in the Stock Assessment reports for the Alaska Region (Hill and DeMaster 1998), has also been moved and is now included with the 1999 Pacific Region reports.

Fishery mortality sections in the 1999 stock assessment reports have been updated to include information on fishery mortality through 1997, where possible. New abundance estimates are available and have been included for 10 of the 11 stocks. Additional information on historic whaling has been included for sperm whales, and several distribution maps have been revised to include survey data through 1996 and to exclude data from the 1970s and early 1980s that are now considered outdated. The recovery factor was revised for four stocks (central California harbor porpoise, California/Oregon/Washington short-finned pilot whale, eastern North Pacific southern resident killer whale and eastern North Pacific transient killer whale). There were no changes in the status of any of the eleven stocks, with four remaining strategic and seven non-strategic. The four strategic stocks include three stocks of endangered species that are automatically considered strategic, and the California/Oregon/Washington short-finned pilot whale, for which a take reduction plan has been implemented.

The following is the Final 1999 U.S. Pacific Stock Assessment Report. A draft version of this document was made available for public comment from May 28 - August 26, 1999 (Federal Register: May 28, 1999, Volume 64, Number 103, Pages 29000-29005). No public comments were received. Earlier versions of these stock assessment reports were reviewed by members of the Pacific and Alaska Scientific Review Groups and by Jay Barlow, Doug DeMaster, Scott Hill, and Paul Wade; we thank them for their helpful comments. The authors also wish to thank those who provided unpublished data. Any omissions or errors are the sole responsibility of the authors.

This is a working document and individual stock assessment reports will be updated as new information becomes available and as changes to marine mammal stocks and fisheries occur. The authors solicit any new information or comments which would improve future stock assessment reports.

References:

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-248. 223 pp.

Hill, P. S. and D. P. DeMaster. 1998. Alaska Marine Mammal Stock Assessments, 1998. U. S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-97. 166 pp.

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HAWAIIAN MONK SEAL (*Monachus schauinslandi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI) in six main reproductive populations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll. Small populations at Necker Island and Nihoa Island are maintained by immigration, and a few seals are distributed throughout the main Hawaiian Islands. Studies of Hawaiian monk seals have focused on their abundance and behavior on land during the reproductive season (spring and summer). Expanded research is underway, but currently the pelagic distribution and behavior of monk seals cannot be fully characterized.

In the last two centuries, the species has experienced two major declines which, presumably, have severely reduced its genetic variation. The tendency for genetic drift may have been (and continue to be) relatively large, due to the small size of different island/atoll populations. However, 10-15% of these seals migrate among the populations (Johnson and Kridler 1983, National Marine Fisheries Service [NMFS] unpubl. data) and, to some degree, this movement should counter the development of separate genetic stocks. Genetic variation among the different island populations is low (Kretzmann et al., 1997).

Demographically, the different island populations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly during the 1950s to the 1980s, while other populations declined rapidly. However, variation in past population trends may be partially explained by changes in the level of human disturbance (Gerrodette and Gilmartin 1990). Current demographic variability among the island populations probably reflects a combination of different recent histories and varying environmental conditions. While research and recovery activities focus on the problems of single island/atoll populations, the species is managed as a single stock.

POPULATION SIZE

Abundance of the main reproductive populations is best estimated using the number of seals identified at each site. Individual seals are identified by applied flipper-tags and bleach-marks, and natural features such as scars and distinctive pelage patterns. Flipper-tagging of weaned pups began in the early 1980s, and the majority of the seals in the main reproductive populations can be identified on the basis of those tags. In 1997, identification efforts were conducted during two- to six-month studies at all main reproductive sites except Midway Atoll, where the study period was 10 months. A total of 1295 seals (including pups) were observed at the main reproductive populations in 1997 (NMFS, unpubl. data). Removal analyses in previous years and sighting probability calculations suggest that 90% or more of the seals were identified at each site (i.e., any negative bias should be less than 10%).

Monk seals also occur at Necker and Nihoa Islands, where repeated counts in a single year were last conducted in 1993. Single counts in subsequent years do not indicate abundance at those sites has changed appreciably. The 1993 studies were not of sufficient duration to identify all individuals, so local abundance is best estimated by correcting mean beach counts and assuming that abundance at these sites has not changed. In 1993, mean (±SD) counts (excluding pups) were 22 (±5.2) at Necker Island and 18 (±7.3) at Nihoa Island (Ragen and Finn 1996). The observed relationship between mean counts and total abundance at the reproductive sites indicates that the total abundance can be estimated by multiplying the mean count by a correction factor (±SE) of 2.89 (±0.06, NMFS unpubl. data). Resulting estimates (plus the number of pups born in 1993) are 65 (±15.1) at Necker Island and 56 (±21.1) at Nihoa Island.

Finally, a small number of seals are distributed throughout the main Hawaiian Islands. These include an unknown number of seals, which naturally occur in the main Hawaiian Islands. In addition, twenty-one seals were released around these islands in 1994. All but two were subsequently resighted near their respective release sites, but their survival to 1997 is unknown. Sporadic reports indicate total abundance on the main Hawaiian Islands (including seals released in 1994) may be as high as 40 seals.

Minimum Population Size

The total number of seals identified at the main reproductive sites is the best estimate of minimum population size at those sites (i.e., 1295 seals). Minimum population sizes for Necker and Nihoa Islands (based on the formula provided by Wade and Angliss (1997)) are 54 and 41, respectively. If it is (arbitrarily) assumed that the abundance estimate for seals in the main Hawaiian Islands is, say, 40 ±10 seals (i.e., a coefficient of variation of 0.25), then an estimate of the minimum population size in the main Islands is 33 seals. The minimum population size for the entire stock (species) is the sum of these estimates, or 1423 seals.

Current Population Trend

Between 1958 and 1997, the total of mean beach counts at the main reproductive populations declined by 60%. From 1985 to 1997, the rate of decline was ca. 4% yr^{-1}, although there has been little change since 1993 (Fig. 1). Further decline is likely, due to extremely high juvenile mortality and an imminent drop in reproductive recruitment in the largest population (French Frigate Shoals).

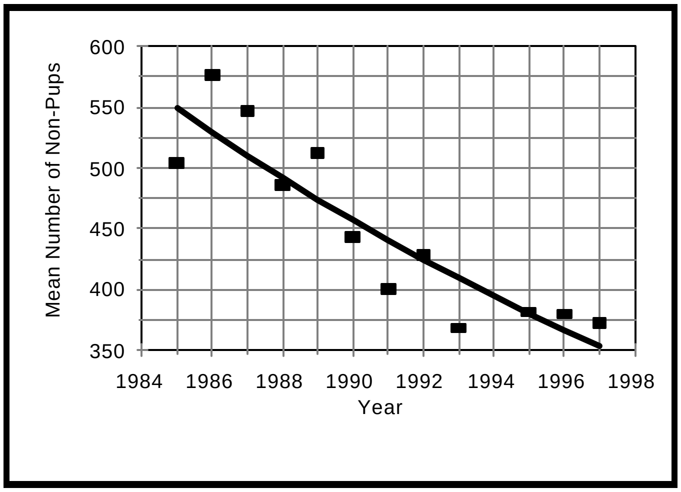

Figure 1. Total of mean beach counts (non-pups) at the main reproductive populations (excluding Midway Atoll) of the Hawaiian monk seal, 1986-97.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Assuming mean beach counts are a reliable index of total abundance, then the current net productivity rate for this species is -0.04 yr^{-1} (loglinear regression of beach counts of non-pups, 1985-97; R^2 = 0.82, P<0.001). This trend is largely due to a catastrophic decline at French Frigate Shoals, where beach counts decreased by 56% between 1989 and 1997. Populations at Laysan and Lisianski Islands have not grown, but have remained relatively stable since approximately 1990.

Contrary to trends at the above sites, the population at Kure Atoll has grown at ca. 5% yr^{-1} since 1983 (loglinear regression of beach counts, 1983-97; R^2 = 0.75, P<0.001), due largely to decreased human disturbance and introduced females. The population at Pearl and Hermes Reef has grown at approximately 7% yr^{-1} since 1975 (loglinear regression of beach counts, 1975-1997; R^2 = 0.91, P<0.001). The latter annual growth rate is the best indicator of the maximum net productivity rate (R_{max}) for this species. Finally, the small population at Midway Atoll is showing signs of incipient recovery.

POTENTIAL BIOLOGICAL REMOVAL

Using the values of N_{min} and R_{max} given above (1423 and 0.07 yr^{-1}, respectively) and a recovery factor (F_R) of 0.1 (the Hawaiian monk seal was designated as both endangered and depleted in 1976), the potential biological removal (PBR) for this species is calculated as 1423 * (0.07 * (0.5)) * 0.1 = 5.0 seals. However, the Endangered Species Act takes precedence in the management of this species and, under the Act, allowable take is zero.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal. In the 1800s, this species was decimated by sealers, crews of wrecked vessels, and guano and feather hunters (Dill and Bryan 1912, Wetmore 1925, Clapp and Woodward 1972). Several populations may have been driven extinct; for example, no seals were seen at Midway Atoll during a 14-month period in 1888-89, and only a single seal was seen during three months of observations at Laysan Island in 1912-13 (Bailey 1952). A survey in 1958 indicated at least partial recovery of the species in the first half of this century (Rice 1960). However, subsequent surveys revealed that all populations except French Frigate Shoals declined severely after the late 1950s (or earlier). This second decline has not been explained at Pearl and Hermes Reef, or Lisianski and Laysan Islands. At Kure Atoll, Midway Atoll, and French Frigate Shoals, trends appear to have been determined by the pattern of human disturbance from military or U.S. Coast Guard activities. Such disturbance caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups (Kenyon 1972, Gerrodette and Gilmartin 1990). The result was a decrease in pup survival, which led to poor reproductive recruitment, low productivity, and population decline.

Since 1979, disturbance from human activities on land has been limited primarily to Kure and Midway Atolls. The U.S. Coast Guard LORAN station at Kure Atoll was closed in 1992 and vacated in 1993. The U.S. Naval Air Facility at Midway was closed in 1993 and, following clean-up and restoration activities, jurisdiction was transferred in 1997 to the U.S. Fish and Wildlife Service, which manages the atoll as a National Wildlife Refuge. The refuge station and the atoll runway are maintained cooperatively with a commercial aircraft company, which supports its Midway operations, in part, by establishing a tourism center at the site. Strict regulations have been established to prevent further human disturbance of the seals, but careful monitoring of human activities will be essential to ensure that the regulations are both adequate and observed (see Habitat Issues below).

In addition to disturbance on land, disturbance at sea (e.g., direct and indirect fisheries interactions) may also impede recovery. As described below, however, the possible types of disturbance at sea can not yet be characterized or quantified.

Fishery Information

Detrimental fishery interactions with monk seals fall into four categories: operations/gear conflict, entanglement in fisheries debris (most of which likely originate in North Pacific fisheries outside the NWHI), seal consumption of potentially toxic discards, and competition for prey. Since 1982, a total of seven fishery-related monk seal deaths have been recorded, including four from entanglement in fisheries debris (Henderson 1990; NMFS, unpubl. data), one from entanglement in the bridle rope of lobster trap (1986; NMFS, unpubl. data), one from entanglement in an illegally set gill net off the western shore of Oahu (1994; NMFS, unpubl. data), and one from ingestion of a recreational fish hook and probable drowning off the island of Kauai (1995; NMFS, unpubl. data). In addition, 16 other seals have been observed with embedded fish hooks, 23 seals have been observed with wounds attributed to interactions with fishing gear, and 154 cases of seals entangled in fishing gear or other debris have been observed. Importantly, the majority of these deaths and injuries have been observed incidentally during land-based research or other activities; monk seal/fisheries interactions need to be studied more thoroughly to assess the rate of fisheries-related injury or mortality for this species.

Four fisheries interact with Hawaiian monk seals. The NWHI lobster fishery began in the late 1970s, and developed rapidly in the early 1980s (Polovina 1993). Annual landings peaked in 1985 (1.92 million lobsters) and 1986 (1.69 million lobsters; Haight and DiNardo 1995). Thereafter, the fishery declined and was closed temporarily in 1993 due to low spawning stock biomass of spiny lobster. Since 1994, landings remained lower than in the mid- to late 1980s, while abundance of slipper lobster have increased in some areas. The number of vessels in the fishery increased from four in 1983 to 17 in 1985, then declined to 9, 12, 0, 5, 1, 5, and 9 in 1991through 1997, respectively (Dollar 1995, DiNardo et al.1998). Both effort and landings have been concentrated at Gardner Pinnacles, Maro Reef, Necker Island, and St. Rogatien Bank (Clarke and Todoki 1988, Polovina and Moffitt 1989). Seasonal and area differences in direct and indirect fisheries interactions remain to be evaluated, but neither incidental mortality nor serious injury were observed in 1997. As was noted, one mortality was documented in 1986; a monk seal drowned after becoming entangled in the bridle rope of an actively fishing lobster trap near Necker Island. However, the potential for indirect interaction due to competition for prey has not been thoroughly investigated (see Habitat Issues below).

The NWHI bottomfish fishery also interacts with monk seals. This fishery occurred at low levels (< 50 t per year) until 1977, steadily increased to 460 t in 1987, and then dropped to ca. 140 to 190 t per year from 1988 to 1994 (Kawamoto 1995). During 1995-1997 landings again increased to 384 to 486 t per year (Kawamoto, pers. comm.). The number of vessels rose from 19 in 1984 to 28 in 1987, and then varied from 10 to 17 in 1988 through 1997 (Kawamoto 1995, Kawamoto pers. comm.). The fishery was monitored by observers from October 1990 to December 1993 (ca. 13% coverage), but is currently monitored by the State of Hawaii using logbooks. Importantly, the State logbook *does not include information on protected species* and, therefore, the nature and extent of interactions with monk seals cannot be reliably assessed. Nitta and Henderson (1993) evaluated observer data from 1991-92 and reported an interaction rate of one event per 34.4 hours of fishing, but they do not provide a confidence interval for their estimate. The events included seals damaging and removing hooked catch, seals being hooked in the process, and seals consuming discarded fish, which may contain high levels of ciguatoxin or other biotoxins. Mortality rates resulting from hooking or consumption of toxic discards cannot be estimated with the available data. The ecological effects of this fishery on monk seals (e.g., competition for prey or alteration of prey assemblages by removal of key predator fishes) are unknown.

A third fishery which interacts with monk seals is the pelagic longline fishery. This fishery targets swordfish and tunas, primarily, and does not compete with Hawaiian monk seals for prey. The fishery began in the 1940s, and operated at a relatively low level (< 5000 t per year) until the mid-1980s. In 1987, 37 vessels participated, but by 1991, the number had grown to 141 (Ito 1995). Entry is currently limited to a maximum of 167 vessels, and 124, 110, 103, and 105 vessels were active in 1994-1997, respectively (Ito, pers. comm.). Total landings ranged from 9,100-13,500 tons during 1991-1997. While much of the fishery has operated outside of the NWHI Exclusive Economic Zone, the rapid expansion raised concerns about the potential for interactions with protected species, including the monk seal. Evidence of interactions began to accumulate in 1990, including three hooked seals and 13 unusual seal wounds thought to have resulted from interactions. In October 1991, NMFS established a permanent Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands. Subsequent shore-based observations of seals suggest that interactions decreased substantially after establishment of the Protected Species Zone, although they may still be occurring; at French Frigate Shoals in 1994, a parturient female was observed with a hook in her mouth. At present, interactions with protected species are assessed using Federal logbooks and observers (4-5% coverage), which may lack sufficient statistical power to estimate monk seal mortality/serious injury rates from longline interactions. However, since 1991, there have been no observed or reported interactions of this fishery with monk seals.

Table 1. Summary of incidental mortality of Hawaiian monk seals due to commercial and recreational fisheries since 1990 and calculation of annual mortality rate. n/a indicates that sufficient data are not available.

Fishery Name	Years	Current est. # of vessels	Date type	Range of observer coverage	Observed mort. (in given years)	Estimated mort. (in given years)	Mean annual mort.
NWHI lobster	91-97	9, 12, 0, 5, 1, 5, 9	Log book	n/a	n/a	n/a	n/a
NWHI Bottomfish	91-97	17, 13, 12, 16, 17, 16, 14	n/a	n/a	n/a	n/a	n/a
Pelagic longline	91-97	141, 123, 122, 125, 110, 103, 105	Observer Log book	4-5%	0	n/a	n/a
Recreational	91-95	n/a	n/a	n/a	[0,0,0,1,1]†	n/a	n/a

† Data collected incidentally.

There have also been interactions between recreational fisheries and monk seals in both the NWHI and around the main Hawaiian Islands. At least three seals have been hooked at Kure Atoll, but such incidents should no longer occur at this site because the atoll was vacated by the U.S. Coast Guard in 1993. In the main Hawaiian Islands, one seal was found dead in an offshore (non-recreational) gillnet in 1994 and a second seal was found dead with a recreational hook lodged in its esophagus. At least seven other seals have been hooked. Three of these incidents involved hooks used to catch ulua (Caranx spp.). One hooked seal had been translocated from Laysan Island to the main Hawaiian Islands in July 1994. The recent establishment of sport fishing at Midway clearly increases the potential for monk seals to be harmed by hooks at that site.

Recent interest in the harvest of precious coral in the NWHI represents a potential for future interactions with monk seals. The removal of coral and the subsequent impact on monk seal prey resources is currently unknown.

Fishery Mortality Rate

Because monk seals continue to die as a result of entanglement in fishing debris and data are unavailable to assess interaction with specific fisheries, one must conclude that the total fishery mortality and serious injury for this stock is greater than 1) zero allowable take under the Endangered Species Act and 2) 10% of the calculated PBR. Therefore, total fishery mortality and serious injury can not be considered to be insignificant and approaching a rate of zero.

Importantly, fishery interactions with this species have not been adequately studied and, therefore, the information above represents only the minimum level of interactions, not the true level. Without further study, the true level of interaction cannot be estimated. In addition, interactions may be indirect (i.e., involving competition for prey or consumption of discards from the bottomfish fishery) and, to date, the extent or consequences of such indirect interactions have not been evaluated.

Other Mortality

Since 1982, 19 seals have died during rehabilitation efforts, five during research activities, three while held in permanent captivity, and two when captured for translocation.

Seals have also died after encounters with marine debris from sources other than fisheries. In 1986, a weaned pup died at East Island, French Frigate Shoals, after becoming entangled in wire left when the U.S. Coast Guard abandoned the island three decades earlier. In 1991, a seal died after becoming trapped behind an eroding seawall on

Tern Island, French Frigate Shoals. This seawall continues to erode and poses an ongoing threat to the safety of seals and other wildlife.

The only documented case of illegal killing of an Hawaiian monk seal occurred when a resident of Kauai killed an adult female in 1989.

Other sources of mortality which are (or may be) impeding the recovery of this population include mobbing, sharks, poisoning by ciguatoxin or other biotoxins, and disease/parasitism. Mobbing occurs when multiple males attempt to mount and mate with an adult female or immature animal of either sex, often leading to the injury or death of the attacked seal. Since 1982, at least 64 seals have died or disappeared after being mobbed. The resulting increase in female mortality appears to be a major impediment to recovery at Laysan and Lisianski Islands. It has also been documented at French Frigate Shoals, Kure Atoll (although not recently), and Necker Island. The primary cause of mobbing is thought to be an imbalance in the adult sex ratio, with males outnumbering females. In 1994, 22 adult males were removed from Laysan Island, and only one seal is thought to have died from mobbing at this site since their removal (1995-97). Such imbalances in the adult sex ratio are more likely to occur when populations are reduced (Starfield et al. 1995).

In addition to mobbing, aggressive attacks by single adult males have resulted in several monk seal mortalities. This was most notable at French Frigate Shoals in 1997, where at least 8 pups died as a result of adult male aggression. Many more pups were likely killed in the same way but the cause of their deaths could not be confirmed.

The incidence of shark-related injury and mortality may have increased in the late 1980s and early 1990s at French Frigate Shoals, but such mortality is probably not the primary cause of the recent decline at this site (Ragen 1993). The annual rate and number of shark-related mortalities is being investigated. Poisoning by ciguatoxin or related toxins is suspected as the primary cause of the Laysan die-off in 1978, and may have contributed to the high mortality of juvenile seals translocated to Midway Atoll in 1992 and 1993. While virtually all wild monk seals carry parasites after they begin to forage, the role of parasitism in monk seal mortality is unknown. The effect of disease on monk seal demographic trends is also uncertain.

STATUS OF STOCK

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act of 1972 and as endangered under the Endangered Species Act of 1973. The species is assumed to be well below its Optimum Sustainable Population (OSP) and, since 1985, has declined 4% per year. Therefore, the Hawaiian monk seal is characterized as a strategic stock.

Habitat Issues

The catastrophic decline at French Frigate Shoals is thought to be related to lack of available prey and subsequent emaciation and starvation. The two leading hypotheses to explain the lack of prey are 1) the local population reached its carrying capacity in the 1970s and 1980s, and essentially diminished its own food supply, and 2) carrying capacity was simultaneously reduced by changes in oceanographic conditions and a resulting decrease in productivity (Polovina et al. 1994; Craig and Ragen, in press). Thus, this population may have significantly exceeded its carrying capacity, leading to a catastrophic increase in juvenile mortality. In addition, available prey also may have been reduced by competition with the NWHI lobster fishery. Monk seals forage at the four main banks where the fishery operates: Maro Reef, Gardiner Pinnacles, St. Rogatien Bank, and Necker Island. Thus, competition for prey merits investigation. This potential for competition cannot yet be evaluated because it is not known if lobster is an important component of the monk seal diet.

A second important habitat issue is the management of human activities at Midway Atoll. Historically, human activities have led to the near extinction of the resident monk seal population at Midway both in the late 1800s, and again in the 1960s. The seal population failed to recover in the 1970s and 1980s, but is finally beginning to show some signs of growth due to immigration from nearby sites. Management jurisdiction of Midway Atoll has been transferred from the U.S. Navy to the Fish and Wildlife Service. The Fish and Wildlife Service maintains a refuge station at Midway Atoll by cooperating with a commercial aircraft company that uses the runway on Sand Island (the largest island at Midway Atoll), and support its operations, in part, by establishing an on-site eco-tourism destination. Tourist activities include a range of land-based and marine recreational activities (e.g., scuba diving and sport fishing), as well as harbor services to visiting vessels. As the tourism venture develops, so does a potential conflict of interest. The economic success of the venture may depend on the nature and variety of human activities or privileges allowed at the site. Importantly, those activities that are intended to enhance the Midway experience may be disruptive or detrimental to the refuge and its wildlife. The issue is whether such potential conflicts can be identified and resolved in a manner that allows for continuation of the ecotourism venture but does not impede monk seal recovery. The Fish and Wildlife Service and NMFS are working cooperatively to ensure that human activities do not impede recovery at this important site.

An important habitat issue is the degrading seawall at Tern Island, French Frigate Shoals. Tern Island is the site of the U.S. Fish and Wildlife refuge station, and is one of two sites in the NWHI accessible by aircraft. The island and the runway have played a key role in efforts to study the local monk seal population, and to mitigate its severe and ongoing decline. During World War II, the U.S. Navy enlarged the island to accommodate the runway. A sheet-pile seawall was constructed to maintain the modified shape of the island. Degradation of the seawall is creating entrapment hazards for seals and other wildlife, and is threatening to erode the runway. The loss of the runway could lead to the closure of the Fish and Wildlife Service station at the site and would thereby reduce on-site management of the refuge. The loss of the runway and refuge station would also hinder research and management efforts to recover the monk seal population.

A fourth important habitat issue involves entanglement in marine debris as described above. Marine debris is removed from the beaches and from entangled seals during annual population assessment activities at the main reproductive sites. Efforts to remove potentially entangling marine debris from the reefs surrounding haulout sites utilized by monk seal have recently begun. In 1996, efforts commenced to assess and remove potentially entangling marine debris from reefs surrounding haulout sites utilized by monk seals. Preliminary surveys suggest a very large number of nets are fouled on nearshore reefs in the NWHI, and may pose a serious threat to seals foraging in these areas. During 1996-1998 debris survey and removal efforts, 11,000 kg of derelict net and other debris were removed from coral reefs at French Frigate Shoals and Pearl and Hermes Reef (Boland, pers. comm.). Efforts to remove nets from monk seal habitat are continuing and will include several cooperating agencies.

REFERENCES

Bailey, A. M. 1952. The Hawaiian monk seal. Museum Pictorial, Denver Museum of Natural History 7:1-32.

Boland, R., Joint Institute for Marine and Atmospheric Science, 2570 Dole St. Honolulu, HI 96822

Clapp, R. B., and P. W. Woodward. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands, Atoll Res. Bull. 164:303-304

Clarke, R. P., and A. C. Todoki. 1988. Comparison of three calculations of catch rates of the lobster fishery in the Northwestern Hawaiian Islands. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-88-6, 30 p.

Craig, M. P. and T. J. Ragen. In press. Size, survival, and decline of juvenile Hawaiian monk seals. Mar. Mamm. Sci.

Dill, H. R., and W. A. Bryan. 1912. Report on an expedition to Laysan Island in 1911. U.S. Dept. of Agric. Surv. Bull. 42:1-30.

DiNardo, G. T., W. R. Haight, and J. A. Wetherall. 1998. Status of lobster stocks in the Northwestern Hawaiian Islands, 1995-97, and outlook for 1998. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. 98-05, 35 p.

Gerrodette, T. M., and W. G. Gilmartin. 1990. Demographic consequences of changed pupping and hauling sites of the Hawaiian monk seal. Conserv. Biol. 4:423-430.

Haight, W. R., and G. T. DiNardo. 1995. Status of lobster stocks in the Northwestern Hawaiian Islands, 1994. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-95-03, 17 p.

Henderson, J. R. 1990. Recent entanglements of Hawaiian monk seals in marine debris. In R. S. Shomura and M. L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, Hawaii, p. 540-553. U.S. Dep. Commer., NOAA, Tech. Memo. NMFS-SWFSC-154.

Ito, R. Y., Southwest Fisheries Science Center, NMFS, 2570 Dole St., Honolulu, HI 96822-2396.

Ito, R. Y. 1995. Annual report of the 1994 Hawaii-based longline fishery. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-95-08, 36 p.

Johnson, A. M., and E. Kridler. 1983. Interisland movement of Hawaiian monk seals. 'Elepaio 44(5):43-45.

Kawamoto, K. E., Southwest Fisheries Science Center, NMFS, 2570 Dole St., Honolulu, HI 96822-2396.

Kawamoto, K. E. 1995. Northwestern Hawaiian Islands bottomfish fishery, 1994. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-95-07, 26 p.

Kenyon, K. W. 1972. Man versus the monk seal. J. of Mammal. 53(4):687-696.

Kretzmann, M. B., W. G. Gilmartin, A. Meyer, G. P. Zegers, S. R. Fain, B. F. Taylor, and D. P. Costa. 1997. Low genetic variability in the Hawaiian monk seal. Conserv. Biol. 11(2):482-490.

Nitta, E. T., and J. R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Mar. Fish. Rev. 55(2):83-92.

Polovina, J. J. 1993. The lobster and shrimp fisheries in Hawaii. Mar. Fish. Rev. 55(2):28-33.

Polovina, J. J., G. T. Mitchum, N. E. Graham, M. P. Craig, E. E. DeMartini, and E. N. Flint. 1994. Physical and biological consequences of a climate event in the central North Pacific. Fish. Ocean. 3:15-21.

Polovina, J. J., and R. B. Moffitt. 1989. Status of lobster stocks in the Northwestern Hawaiian Islands, 1988. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-89-3, 10 p.

Pooley, S. G., and K. E. Kawamoto. 1998. Annual report of the 1995-97 western Pacific lobster fishery. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-98-09, 34 p.

Ragen, T. J. 1993. Status of the Hawaiian monk seal in 1992. Available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-93-05, 79 p.

Ragen, T. J., and M. A. Finn. 1996. The Hawaiian monk seal on Nihoa and Necker Islands, 1993. Pages 89-104 in T. C. Johanos and T. J. Ragen (eds.), The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1993. U.S. Dep. Commer., NOAA, Tech. Memo. NMFS-SWFSC-227.

Rice, D. W. 1960. Population dynamics of the Hawaiian monk seal. J. of Mammal. 41:376-385.

Starfield, A. M., J. D. Roth, and K. Ralls. 1995. "Mobbing" in Hawaiian monk seals (Monachus schauinslandi): The value of simulation modeling in the absence of apparently crucial data. Conserv. Biol. 9:166-174.

Wade, P. R. and R. P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12 available from Office of Protected Resources, National Marine Fisheries Service, Silver Springs, MD. 93pp.

Wetmore, A. 1925. Bird life among lava rock and coral sand. The Natl. Geograp. Mag. 48:77-108.

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HARBOR PORPOISE (*Phocoena phocoena*): Central California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved.

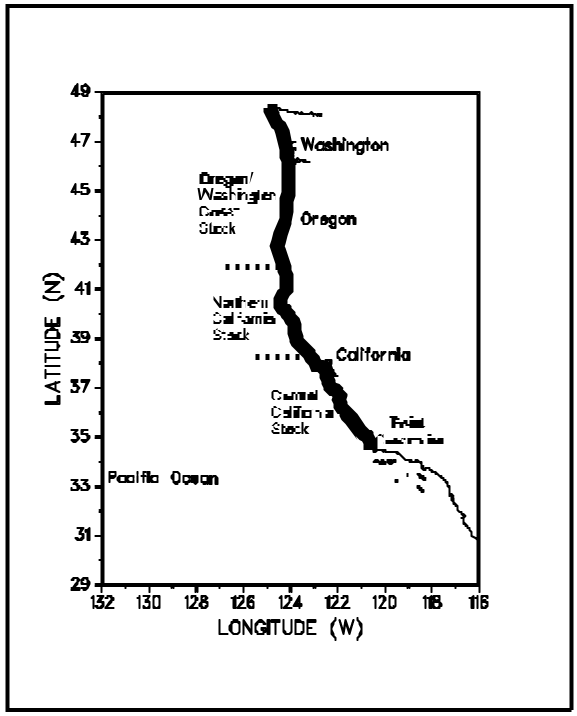

Figure 1. Stock boundaries and distributional range of harbor porpoise along the U.S. west coast.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise is limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Following the guidance of Barlow and Hanan (1995), we will consider the harbor porpoise in central California as a separate stock. Other Pacific coast Marine Mammal Protection Act (MMPA) stock assessment reports for harbor porpoise include: 1) a northern California stock 2) an Oregon/Washington coast stock, 3) an Inland Washington stock, 4) a Southeast Alaska stock, 5) a Gulf of Alaska stock, and 6) a Bering Sea stock. Stock assessment reports for northern California and the Oregon and Washington stocks appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Forney (1999a) estimates the abundance of central California harbor porpoise to be 5,732 (CV=0.39) based on aerial surveys in 1993-97. This estimate is not significantly different from the estimate of 4,120 (CV=0.22) presented by Barlow and Forney (1994). The more recent estimate is higher and less precise, because it was calculated using a more recently developed correction factor for submerged animals (3.42 = 1/g(0) with g(0)=0.292, CV=0.366; Laake et al. 1997); this correction factor is slightly higher than and has a larger estimated variance than the one used by Barlow and Forney (1994; g(0)=0.324, CV=0.173). Both of these estimates only include the region between the coast and the 50-fathom (91m) isobath. Barlow (1988) found that the vast majority of harbor porpoise in California were within this depth range; however, Green et al.(1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). The above abundance estimates are likely to underestimate the total abundance of harbor porpoise by an unknown, but non-trivial amount.

Minimum Population Estimate

The minimum population estimate for harbor porpoise in central California is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from the 1993-97 aerial surveys (Forney 1999a) or 4,172.

Current Population Trend

An analysis of a 1986-95 time series of aerial surveys was conducted to examine trends in harbor porpoise abundance in central California (Forney 1999b). After controlling for the effects of sea state, cloud cover, and area on sighting rates, Forney (1999b) found a negative trend in population size, but that trend was not statistically significant (p=0.15) (Figure 2). Between 1986 and 1995, harbor porpoise abundance was negatively correlated with sea surface temperature (Forney 1999b), indicating that apparent trends could be caused by changing oceanographic conditions and movement of animals into and out of the study area. Encounter rates for the 1997 survey, however, were very high (Forney 1999a) despite the warmer sea surface temperatures caused by strong El Niño conditions. These observations suggest that patterns of harbor porpoise movement are not directly related to sea surface temperature, but rather to the more complex distribution of potential prey species in this area.

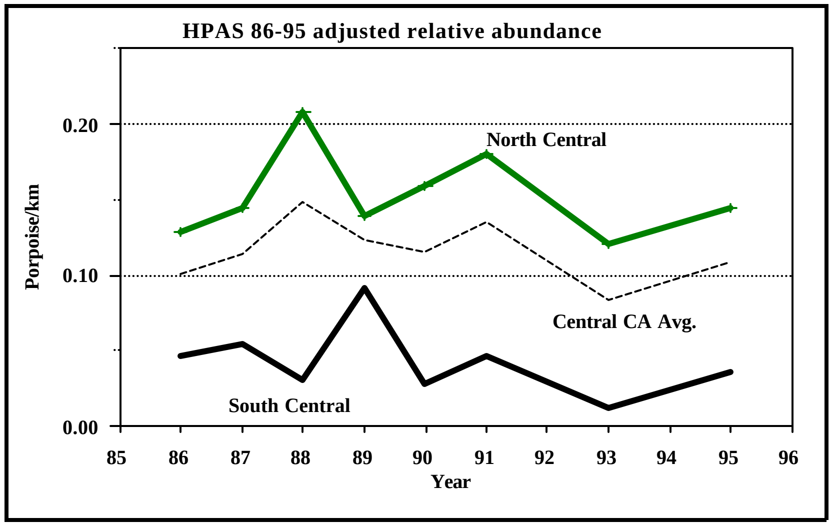

Figure 2. Harbor porpoise relative abundance in central California from 1986-95 aerial surveys (corrected for effects of sea state and cloud cover, Forney 1999b).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year (Barlow and Boveng 1991). This maximum theoretical rate may not be achievable for any real population. [Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified.] Population growth rates have not actually been measured for any harbor porpoise population. We therefore conclude that the current and maximum net productivity rates are unknown for the central California population of harbor porpoise.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (4,172) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with a mortality rate CV$\leq$0.30; Wade and Angliss 1997), resulting in a PBR of 42.

HUMAN-CAUSED MORTALITY

Fishery Information

The incidental capture of harbor porpoise is largely limited to set gillnet fisheries in central California (coastal setnets are not allowed in northern California, and harbor porpoise do not occur in southern California). Detailed information on this fishery is provided in Appendix 1 of Barlow et al. (1997). A summary of estimated fishery mortality and injury for this stock of harbor porpoise is given in Table 1, based on analyses of entanglement rate data for a 1990-94 observer program (Julian 1997, Cameron 1998, Julian and Beeson 1998). These data indicate that an average of 24 harbor porpoise (range 13-49, CV=0.27) have been killed in all of central California (including both Morro Bay and Monterey Bay regions) each year for the period 1993-1997. However, since 1994, there has been a shift in set gillnet effort, with more effort in areas of high harbor porpoise density (Monterey Bay) and less effort in the lower density regions around Morro Bay, where no harbor porpoise mortalities were observed after 1990. Therefore, the mortality estimates presented below (Table 1) may be negatively biased. In a more recent preliminary analysis of mortality using effort and entanglement data only for the Monterey Bay region and including additional 1987-90 entanglement data for the areas presently being fished, Forney (1998) suggests that mortality could be substantially higher. Average annual estimates of mortality for 1993-97 in that study are 107 harbor porpoise (range 49 to 202; CV=0.12) using a stratified analysis, or 99 harbor porpoise (range 62-160, CV=0.19) using an unstratified analysis for the entire Monterey Bay region. An observer program was initiated this area in April 1999, and more accurate data are expected to be available in the near future.

Table 1. Summary of available information on incidental mortality and injury of harbor porpoise (central CA stock) in commercial fisheries that might take this species (Barlow and Hanan 1995; Julian 1997, Cameron 1998, Julian and Beeson 1998). n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes 1993-97 (CV in parentheses)
CA angel shark / halibut and other species large mesh (>3.5") set gillnet fishery	1993 1994 1995 1996 1997	NMFS observer data	15.4% 7.7% 0.0% 0.0% 0.0%	2 1 - - -	13 (0.64) 14 (0.96) 14 (0.64) [1] 32 (0.28) [1] 49 (0.27) [1]	24 (0.27)
CA set and drift gillnet fishery that use a stretched mesh size of 3.5" or less (white croaker)	1980s	CDFG observer data	n/a	1 in 200 sets	n/a	n/a
Total annual takes						24 (0.27)

[1] The CA set gillnets were not observed after 1994; mortality was extrapolated from effort estimates and previous entanglement rates.

STATUS OF STOCK

Harbor porpoise in California are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. Barlow and Hanan (1995) calculate the status of harbor porpoise relative to historic carrying capacity (K) using a technique called back-projection. They calculate that the central California population could have been reduced to between 30% and 97% of K by incidental fishing mortality, depending on the choice of input parameters. They conclude that there is no practical way to reduce the range of this estimate. New information does not change this conclusion, and the status of harbor porpoise relative to their Optimum Sustainable Population (OSP) levels in central California must be treated as unknown. The average mortality rate over the last five years (24) is less than the calculated PBR (42) for central California harbor porpoise; therefore, the central California harbor porpoise population is not "strategic" under the MMPA. The Pacific Scientific Review Group (established by the MMPA) recommended that this stock be considered strategic because it was thought to be declining. Because the apparent decline in the population is likely to be natural and is no longer statistically significant, the NMFS does not believe that a strategic status is justified at this time. However, this determination should be reviewed after additional mortality data become available at the end of 1999 for the Monterey Bay area set gillnet fishery, because true mortality may be higher than the currently published estimates. Research activities will continue to monitor the population size and to investigate population trends. The average gillnet mortality for the last 5 years (24 porpoise per year) is greater than 10% of the calculated PBR; therefore, the fishery mortality cannot be considered insignificant and approaching zero mortality and serious injury rate. There are no known habitat issues that are of particular concern for this stock.

REFERENCES

Barlow, J. 1988. Harbor porpoise (*Phocoena phocoena*) abundance estimation in California, Oregon and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J. and P. Boveng. 1991. Modeling age-specific mortality for marine mammal populations. Marine Mammal Sci. 7(1):84-119.

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the U.S. and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn, Special Issue 15:405-425.

Barlow, J. and K. A. Forney. 1994. An assessment of the 1994 status of harbor porpoise in California. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-205. 17pp.

Barlow, J. and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rept. Int. Whal., Special Issue 16:123-140.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223p.

Calambokidis, J. and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. pp. 101-110 In: J. E. Reynolds III and D. K. Odell (eds.) Marine mammal strandings in the United States. NOAA Technical Report NMFS 98.

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Forney, K. A. 1998. A review of 1990-97 set gillnet fisheries in the Monterey Bay area and revised estimates of mortality for harbor porpoise, *Phocoena phocoena*, and sea otters, *Enhydra lutris*. Background paper 98-PSRG-4 submitted to the Pacific Scientific Review Group Meeting, Seattle, WA, November 16-18, 1998.

Forney, K. A. 1999a. The abundance of California harbor porpoise estimated from 1993-97 aerial line-transect surveys. Admin. Rep. LJ-99-02. Available from Southwest Fisheries Center, P.O. Box 271, La Jolla, CA 92038. 16pp.

Forney, K. A. 1999b. Trends in harbor porpoise abundance off central California, 1986-95: Evidence for interannual changes in distribution? *Journal of Cetacean Research and Management* 1:73-80.

Gaskin, D. E. 1984. The harbour porpoise (*Phocoena phocoena* L.): regional populations, status, and information on direct and indirect catches. Rep. int. Whal. Commn 34:569-586.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1 In: J. J. Brueggeman (ed.). Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426 prepared for the Pacific OCS Region.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F. and M. Beeson. 1998. Estimates for marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-95. Fishery Bulletin 96:271-284.

Laake, J. L., J. C. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). Journal of Wildlife Management 61:63-75.

Polacheck, T., F. W. Wenzel, and G. Early. 1995. What do stranding data say about harbor porpoise (*Phocoena phocoena*)? Report International Whaling Commission, Special Issue 16:169-179.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, Univ. Calif. San Diego. 191pp.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, Phocoena phocoena, on inter-oceanic and regional scales. Can. J. Fish. and Aquat. Sci. 52:1210-1219.

Wade, P. R. and R. P. Angliss. 1997. Guidelines for Assessing Marine Mammal Stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U. S. Dep. Commerce, NOAA Technical Memorandum NMFS-OPR-12. 93 pp.

Woodley, T. H. and A. J. Read. 1991. Potential rates of increase of a harbour porpoise (Phocoena phocoena) population subjected to incidental mortality in commercial fisheries. Can. J. Fish. Aquat. Sci. 48:2429-2435.

Revised 09/30/99

HARBOR PORPOISE (*Phocoena phocoena*): Northern California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved.

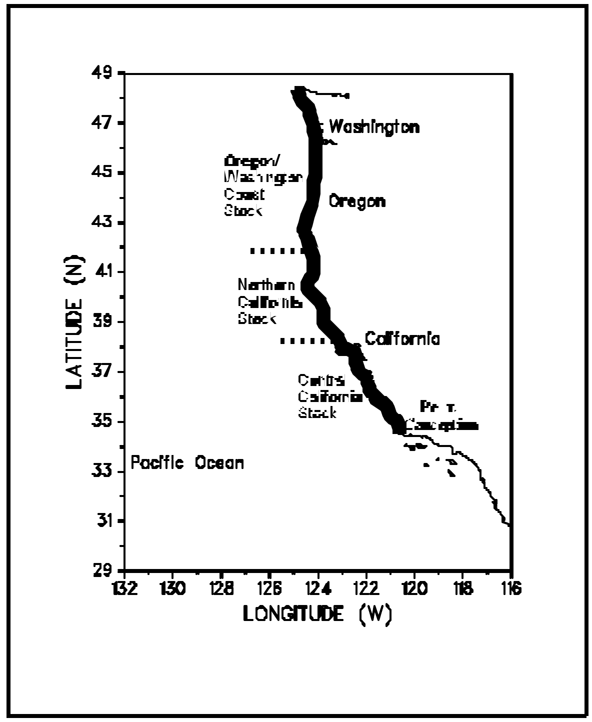

Figure 1. Stock boundaries and distributional range of harbor porpoise along the U.S. west coast.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise is limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Following the guidance of Barlow and Hanan (1995), we will consider the harbor porpoise in northern California as a separate stock. Other Pacific coast Marine Mammal Protection Act (MMPA) stock assessment reports for harbor porpoise include: 1) a central California stock, 2) an Oregon/Washington coast stock, 3) an Inland Washington stock, 4) a Southeast Alaska stock, 5) a Gulf of Alaska stock, and 6) a Bering Sea stock. Stock assessment reports for central California and the Oregon and Washington stocks appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Forney (1999a) estimates the abundance of northern California harbor porpoise to be 11,066 (CV=0.39) based on aerial surveys in 1993-97. This estimate is not significantly different from the estimate of 9,250 (CV=0.23) presented by Barlow and Forney (1994) based on a series of aerial surveys from 1989 to 1993. The more recent estimate is higher and less precise, because it was calculated using a more recently developed correction factor for submerged animals (3.42 = 1/g(0) with g(0)=0.292, CV=0.366; Laake et al. 1997); this correction factor is slightly higher than and has a larger estimated variance than the one used by Barlow and Forney (1994; g(0)=0.324, CV=0.173). Both estimates only include the region between the coast and the 50-fathom (91m) isobath. Barlow (1988) found that the vast majority of harbor porpoise in California were within this depth range; however, Green et al. (1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). The above abundance estimates are likely to underestimate the total abundance of harbor porpoise by an unknown, but non-trivial amount.

Minimum Population Estimate

The minimum population estimate for harbor porpoise in northern California is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from the 1993-97 aerial surveys (Forney 1999a) or 8,061.

Current Population Trend

Forney (1999b) examines trends in relative harbor porpoise abundance in central and northern California based on aerial surveys from 1989-95. No significant trends were evident over this time period for the Northern California Stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year (Barlow and Boveng 1991). This maximum theoretical rate may not be achievable for any real population. [Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified.] Population growth rates have not actually been measured for any harbor porpoise population. We therefore conclude that the current and maximum net productivity rates are unknown for the northern California stock of harbor porpoise.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (8,061) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a species of unknown status), resulting in a PBR of 81.

HUMAN-CAUSED MORTALITY

Fishery Information

The incidental capture of harbor porpoise in California is largely limited to set gillnet fisheries in central California. Coastal setnets are not allowed in northern California (to protect salmon resources there).

Fishery Mortality Rates

Because there is no known fishery mortality in northern California, the fishery mortality can be considered insignificant and approaching zero mortality and serious injury rate.

STATUS OF STOCK

Harbor porpoise in California are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. Because of the lack of recent or historical sources of human-caused mortality, the harbor porpoise stock in northern California has been concluded to be within their Optimum Sustainable Population (OSP) level (Barlow and Forney 1994). Because there is no known human-caused mortality or serious injury, this would not be considered a "strategic" stock under the MMPA. There are no known habitat issues that are of particular concern for this stock.

REFERENCES

Barlow, J. 1988. Harbor porpoise (*Phocoena phocoena*) abundance estimation in California, Oregon and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J. and P. Boveng. 1991. Modeling age-specific mortality for marine mammal populations. Marine Mammal Sci. 7(1):84-119.

Barlow, J. and K. A. Forney. 1994. An assessment of the 1994 status of harbor porpoise in California. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-205. 17pp.

Barlow, J. and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rept. Int. Whal., Special Issue 16:123-140.

Calambokidis, J. and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. pp. 101-110 In: J. E. Reynolds III and D. K. Odell (eds.) Marine mammal strandings in the United States. NOAA Technical Report NMFS 98.

Forney, K. A. 1999a. The abundance of California harbor porpoise estimated from 1993-97 aerial line-transect surveys. Admin. Rep. LJ-99-02. Available from Southwest Fisheries Center, P.O. Box 271, La Jolla, CA 92038. 16pp.

Forney, K. A. 1999b. Trends in harbor porpoise abundance off central California, 1986-95: Evidence for interannual changes in distribution? *Journal of Cetacean Research and Management* 1:73-80.

Gaskin, D. E. 1984. The harbour porpoise (*Phocoena phocoena* L.): regional populations, status, and information on direct and indirect catches. Rep. int. Whal. Commn 34:569-586.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1 In: J. J. Brueggeman (ed.). Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426 prepared for the Pacific OCS Region.

Laake, J. L., J. C. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). Journal of Wildlife Management 61:63-75.

Polacheck, T., F. W. Wenzel, and G. Early. 1995. What do stranding data say about harbor porpoise (*Phocoena phocoena*). Report International Whaling Commission, Special Issue 16:169-179.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, Univ. Calif. San Diego. 191pp.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, Phocoena phocoena, on inter-oceanic and regional scales. Can. J. Fish. and Aquat. Sci. 52:1210-1219.

Woodley, T. H. and A. J. Read. 1991. Potential rates of increase of a harbour porpoise (*Phocoena phocoena*) population subjected to incidental mortality in commercial fisheries. Can. J. Fish. Aquat. Sci. 48:2429-2435.

Revised 09/30/99

HARBOR PORPOISE (*Phocoena phocoena*): Oregon/Washington Coast Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise primarily frequent coastal waters. Harbor porpoise are known to occur year-round in the inland trans-boundary area of Washington and British Columbia, Canada (Osborne et al. 1988), and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggests that harbor porpoise distribution varies by depth (Green et al. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl et al. 1983, Barlow 1988), harbor porpoise have also been conspicuously absent in offshore areas in late November (B. Taylor, pers. comm.) leaving a gap in the current understanding of their movements.

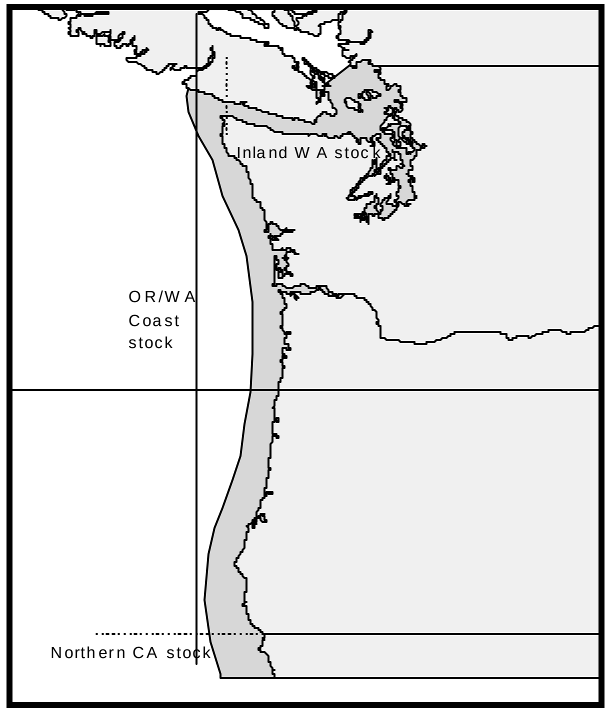

Figure 1. Approximate distribution of harbor porpoise in the U.S. Pacific Northwest (shaded area). Stock boundaries separating the stocks are shown.

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek et al. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Further genetic testing of the same data mentioned above, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and that movement is sufficiently restricted to evolve genetic differences. This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

Using the 1990-91 aerial survey data of Calambokidis et al. (1993) for water depths < 50 fathoms, Osmek et al. (1996) found significant differences in harbor porpoise mean densities ($z=5.9$, $p<0.01$) between the waters of coastal Oregon/Washington and inland Washington/southern British Columbia, Canada (i.e., Strait of Juan de Fuca/San Juan Islands). Although differences in density exist between coastal Oregon/Washington and inland Washington, a specific stock boundary line cannot be identified based upon biological or genetic differences. However, because harbor porpoise movements and rates of intermixing within the northeast Pacific are restricted, there has been a significant decline in harbor porpoise sightings within southern Puget Sound since the 1940s and, following a risk averse management strategy, two stocks are recognized to occur in Oregon and Washington waters (the Oregon/Washington Coast stock and the Inland Washington stock), with the boundary at Cape Flattery. Recent genetic evidence suggests that a population of animals at Spike Rock (on the northern coast of Washington, south of Cape Flattery) is more similar to the Inland Washington stock of harbor porpoise than to the Oregon/Washington Coast stock (S. Chivers, pers. comm.). All relevant data (e.g., additional genetic samples, contaminant studies, and satellite tagging) will be reviewed to determine whether to adjust the stock boundaries for harbor porpoise in Oregon and Washington waters.

In their assessment of California harbor porpoise, Barlow and Hanan (1995) recommended two stocks be recognized in California, with the stock boundary at the Russian River. Based on the above information four separate harbor porpoise stocks are recognized to occur along the west coast of the continental U.S. (see Fig. 1): 1) the Inland Washington stock, 2) the Oregon/Washington Coast stock, 3) the Northern California stock, and 4) the Central California stock. This report considers only the Oregon/Washington Coast stock, with stock assessment reports for the Inland Washington and both California stocks appearing in this volume. Three harbor porpoise stocks are also recognized in the inland and coastal waters of Alaska, including the Southeast Alaska, Gulf of Alaska, and Bering Sea stocks. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region. The harbor porpoise occurring in British Columbia have not been included in any stock assessment report from either the Alaska Region or Pacific Northwest (Oregon/Washington).

POPULATION SIZE

In August and September 1997, an aerial survey of Oregon, Washington, and southern British Columbia coastal waters, from shore to 200 m depth, resulted in an observed abundance of 13,036 (CV=0.11) harbor porpoise in U.S. waters (Laake et al. 1998a). Using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) to adjust for groups missed by aerial observers, the corrected estimate of abundance for harbor porpoise in coastal Oregon and Washington waters is 44,644 (CV=0.38). This estimate represents a substantial increase over the 1991 estimate of 26,175 (Osmek et al. 1996) due to: 1) the larger sampling region in the 1997 survey (out to water depths of 200 m vs. 91 m in 1991), and 2) a different estimate of g(0) (Laake et al. 1998a).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842*[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 44,644 and its associated CV(N) of 0.38, N_{MIN} for the Oregon/Washington Coast stock of harbor porpoise is 32,769.

Current Population Trend

There are no reliable data on population trends of harbor porpoise for coastal Oregon, Washington, or British Columbia waters.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently not available for harbor porpoise. Therefore, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed for the Oregon/Washington Coast harbor porpoise stock.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 re-authorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for a cetacean stock with an unknown population status (Wade and Angliss 1997). Thus, for the Oregon/Washington Coast stock of harbor porpoise, PBR = 328 animals (32,769 × 0.02 × 0.5).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Within the EEZ boundaries of coastal Oregon and Washington, human-caused (fishery) mortalities of harbor porpoise are presently known to occur only in the northern Washington marine set gillnet fishery. During 1992-93 the WA/OR Lower Columbia River, WA Grays Harbor, and WA Willapa Bay drift gillnet fisheries were monitored at observer coverages of approximately 4% and 2%, respectively. There were no observed harbor porpoise mortalities in these fisheries.

With the exception of 1994, NMFS observers monitored the northern Washington marine set gillnet fishery during 1992-97 (Gearin et al. 1994; P. Gearin, unpubl. data). For the entire area fished, observer coverage ranged from approximately 59 to 98% during those years. Fishing effort is conducted within the range of both harbor porpoise stocks (Oregon/Washington Coast and Inland Washington stocks) occurring in Washington State waters. Some of the animals taken in the inland waters portion of the fishery (see stock assessment report for the Inland Washington stock for details) may have been animals from the coastal stock. Similarly, some of the animals taken in the coastal portion of the fishery may have been from the inland stock. For the purposes of this stock assessment report, the animals taken in the inland portion of the fishery are assumed to have belonged to the Inland Washington stock and the animals taken in the coastal portion of the fishery are assumed to have belonged to the Oregon/Washington Coast stock. Some movement of harbor porpoises between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. Accordingly, Table 1 includes data only from that portion of the northern Washington marine set gillnet fishery occurring within the range of the Oregon and Washington Coast stock (those waters south and west of Cape Flattery), where observer coverage ranged from 70-100% between 1992 and 1997. No fishing effort occurred in the coastal portion of the fishery in 1993 and, as noted above, no observer program occurred in 1994. Data from 1992 to 1997 are included in the Table 1, although the mean estimated annual mortality is calculated using the most recent 5 years of available data. The mean estimated mortality for this fishery is 12.4 (CV=0.46) harbor porpoise per year from this stock.

Table 1. Summary of incidental mortality of harbor porpoise (Oregon and Washington Coast stock) due to commercial fisheries from 1992 through 1997 and calculation of the mean annual mortality rate. Only data from 1993 to 1997 (or the most recent 5 years of available data) are used to calculate mean annual mortality (n/a indicates that data are not available).

Fishery name	Years	Data type	Range of observer coverage	Observed mortality (in given yrs.)	Estimated mortality (in given yrs.)	1993-97 Mean annual mortality
Northern WA marine set gillnet (coastal waters)	92-97	obs data	70-100%	0, 0, n/a, 20, 29, 13	0, 0, n/a, 20, 29, 13	12.4 (CV= 0.46)
Observer program total						12.4 (CV=0.46)
Estimated total annual mortality						12.4 (CV=0.46)

The 1995-96 data for the northern Washington marine set gillnet fishery were collected as part of an experiment, conducted in cooperation with the Makah Tribe, designed to explore the merits of using acoustic alarms to reduce bycatch of harbor porpoise in salmon gillnets. The nets equipped with acoustic alarms had significantly lower entanglement rates, as only two of the 49 mortalities occurred in alarmed nets (Gearin et al. 1996, Laake et al. 1997). Harbor porpoise were displaced by an acoustic buffer around the net, but it is unclear whether the porpoise were repelled by the alarms or whether it was their prey that were repelled (Kraus et al. 1997, Laake et al. 1998b). Because this fishery is likely to have acoustic devices on all nets in the future, the mean mortality estimated from non-alarmed nets may not be applicable. In 1997, 13 mortalities were observed (100% observer coverage) in this fishery and 96% of the sets were equipped with acoustic alarms.

An additional source of information on the number of harbor porpoise killed or injured incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. During the period between 1990 and 1997, there were no fisher self-reports of harbor porpoise mortalities from any fisheries operating within the range of the Oregon/Washington Coast stock. However, because logbook records (fisher self-reports required during 1990-94) are most likely negatively biased (Credle et al. 1994), these are considered to be minimum estimates. Self-reported fisheries data are incomplete for 1994, not available for 1995, and considered unreliable after 1995 (see Appendix 4 in Hill and DeMaster 1998).

There have been no fishery-related strandings of harbor porpoise from this stock dating back to at least 1990.

STATUS OF STOCK

Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened " or "endangered" under the Endangered Species Act. Based on the currently available data, the level of human-caused mortality and serious injury (12) does not exceed the PBR (328). Therefore, the Oregon/Washington Coast stock of harbor porpoise is not classified as strategic. The total fishery mortality and serious injury for this stock (12; based on observer data) is not known to exceed 10% of the calculated PBR (33) and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to its Optimum Sustainable Population and population trends is unknown.

REFERENCES

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J., and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rep. Int. Whal. Commn. Special Issue 16:123-140.

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: II. Aerial Surveys. Fish. Bull. 86:433-444.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. Reynolds, J. E., III, and D. K. Odell (eds.), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987, Miami, Florida. NMFS, NOAA Technical Rep. NMFS 98:101-110.

Calambokidis, J., J. C. Cubbage, J. R. Evenson, S. D. Osmek, J. L. Laake, P. J. Gearin, B. J. Turnock, S. J. Jeffries, and R. F. Brown. 1993. Abundance estimates of harbor porpoise in Washington and Oregon waters. Final Rep. by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 55 pp.

Chivers, S. Southwest Fisheries Science Center, NMFS, P.O. Box 271, La Jolla, CA 92038.

Credle, V. R., D. P. DeMaster, M. M. Merklein, M. B. Hanson, W. A. Karp, and S. M. Fitzgerald (eds.). 1994. NMFS observer programs: minutes and recommendations from a workshop held in Galveston, Texas, November 10-11, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-94-1. 96 pp.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: Status, abundance, and distribution. OCS study MMS 84-0045. Pacific OCS Region Minerals Management Service, 1340 Sixth Street, Los Angeles, CA 90014. 284 pp.

Gaskin, D. E. 1984. The harbour porpoise *Phocoena phocoena* (L.): Regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Commn. 34:569-586.

Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington state. Rep. Int. Whal. Commn. Special Issue 15:427-438.

Gearin, P. J., M. E. Gosho, L. Cooke, R. DeLong, and J. Laake. 1996. Acoustic alarm experiment in the 1995 northern Washington marine setnet fishery: methods to reduce by-catch of harbor porpoise. Paper SC/48/SM10 presented to the International Whaling Commission, June 1996 (unpublished). 15 pp.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1, *In:* Brueggeman, J. J. (ed.), Oregon and Washington Marine Mammal and Seabird Surveys. Final Rep. OCS Study MMS 91-0093.

Hill, P. S., and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-97. 166 pp.

Kraus, S. D., A. J. Read, A. Solow, K. Baldwin, T. Spradlin, E. Anderson, and J. Williamson. 1997. Acoustic alarms reduce porpoise mortality. Nature 388:525.

Laake, J. L., P. J. Gearin, M. E. Gosho, and R. L. DeLong. 1997. Evaluation of the effectiveness of pingers to reduce incidental entanglement of harbor porpoise in a set gillnet fishery. Annual Report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 7 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J., J. Calambokidis, and S. Osmek. 1998a. Survey report for the 1997 aerial surveys for harbor porpoise and other marine mammals of Oregon, Washington and British Columbia Outside Waters. Pp. 77-97, *In:* Hill, P. S., and D. P. DeMaster (eds.), 1997 MMPA/ESA Implementation Program. U.S. Dep. Commer., AFSC Processed Report 98-10. 246 pp.

Laake, J. L., D. J. Rugh, and L. S. Baraff. 1998b. Observations of harbor porpoise in the vicinity of acoustic alarms on a set gillnet. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-84. 40 pp.

Osborne, R., J. Calambokidis, and E. M. Dorsey. 1988. A Guide to Marine Mammals of Greater Puget Sound. Island Publishers, Anacortes, WA. 191 pp.

Osmek, S. D., P. E. Rosel, A. E. Dizon, and R. L. DeLong. 1994. Harbor porpoise, *Phocoena phocoena*, population assessment studies for Oregon and Washington in 1993. Annual Report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 14 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and R. Brown. 1996. Assessment of the status of harbor porpoises, *Phocoena phocoena,* in Oregon and Washington waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-76. 46 pp.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, Univ. Calif. San Diego, La Jolla, CA. 191 pp.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. and Aquat. Sci. 52:1210-1219.

Taylor, B. Southwest Fisheries Science Center, NMFS, P. O. Box 271, La Jolla, CA 92038.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Revised 09/30/99

HARBOR PORPOISE (*Phocoena phocoena*): Inland Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise primarily frequent coastal waters. Harbor porpoise are known to occur year-round in the inland trans-boundary area of Washington and British Columbia, Canada (Osborne et al. 1988), and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggests that harbor porpoise distribution varies by depth (Green et al. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl et al. 1983, Barlow 1988), harbor porpoise have also been conspicuously absent in offshore areas in late November (B. Taylor, pers. comm.) leaving a gap in the current understanding of their movements.

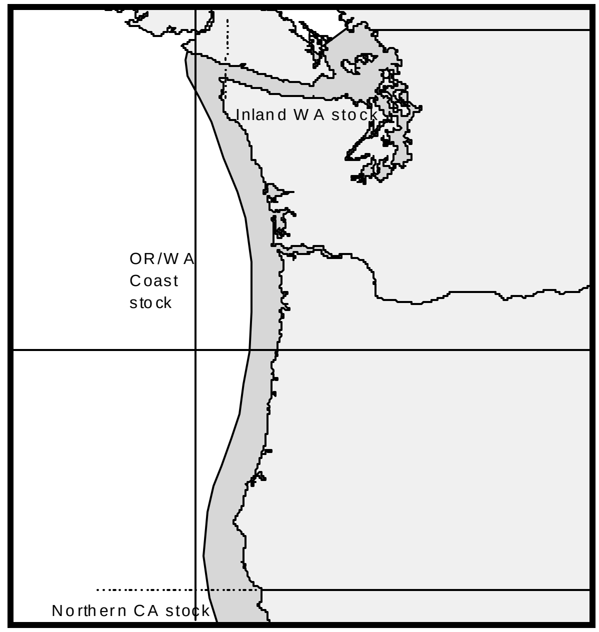

Figure 1. Approximate distribution of harbor porpoise in the U.S. Pacific Northwest (shaded area). Stock boundaries separating the stocks are shown.

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek et al. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Further genetic testing of the same data mentioned above, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and that movement is sufficiently restricted to evolve genetic differences. This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

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POPULATION SIZE

Aerial surveys of the inside waters of Washington and southern British Columbia were conducted during August of 1996 (Calambokidis et al. 1997). These aerial surveys included the Strait of Juan de Fuca, San Juan Islands, Gulf Islands, and Strait of Georgia, which includes waters inhabited by harbor porpoise from British Columbia, as well as the Inland Washington stock. A total of 2,117 km of survey effort was completed within U.S. waters, resulting in an uncorrected abundance of 1,025 (CV=0.151) harbor porpoise in the inside waters of Washington (Calambokidis et al. 1997, Laake et al. 1997a). When corrected for availability and perception bias, using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366), the estimated abundance for the Inland Washington stock of harbor porpoise is 3,509 (CV=0.396) animals (Laake et al. 1997a, 1997b).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842*[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 3,509 and its associated CV(N) of 0.396, N_{MIN} for the Inland Washington stock of harbor porpoise is 2,545.

Current Population Trend

There are no reliable data on long-term population trends of harbor porpoise for most waters of Oregon, Washington, or British Columbia. For comparability to the 1996 survey, a re-analysis of the 1991 aerial survey data was conducted (Calambokidis et al. 1997). The abundance of harbor porpoise in the Inland Washington stock in 1996 was not significantly different than in 1991 (Laake et al. 1997a).

A different situation exists in southern Puget Sound where harbor porpoises are now rarely observed, a sharp contrast to 1942 when they were considered common in those waters (Scheffer and Slipp 1948). Although quantitative data for this area are lacking, marine mammal survey effort (Everitt et al. 1980), stranding records since the early 1970s (Osmek et al. 1995), and the results of harbor porpoise surveys of 1991 (Calambokidis et al. 1992) and 1994 (Osmek et al. 1995) indicate that harbor porpoise abundance has declined in southern Puget Sound. In 1994 a total of 769 km of vessel survey effort and 492 km of aerial survey effort conducted during favorable sighting conditions produced no sightings of harbor porpoise in southern Puget Sound. Reasons for the apparent decline are unknown, but it may be related to fishery interactions, pollutants, vessel traffic, or other activities that may affect harbor porpoise occurrence and distribution in this area (Osmek et al. 1995). Research to identify trends in harbor porpoise abundance is also needed for the other areas within inland Washington.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not currently available for harbor porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed for the Inland Washington harbor porpoise stock.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 re-authorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.4, the value for a cetacean stock with an unknown population status and with a CV of mortality estimates greater than 0.8 (Wade and Angliss 1997). Thus, for the Inland Washington stock of harbor porpoise, PBR = 20 animals (2,545 × 0.02 × 0.4).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

With the exception of 1994, NMFS observers monitored the northern Washington marine set gillnet fishery during 1992-97 (Gearin et al. 1994; P. Gearin, unpubl. data). For the entire area fished, observer coverage ranged from approximately 59 to 98% during those years. Fishing effort is conducted within the range of both harbor porpoise stocks (Oregon/Washington Coast and Inland Washington stocks) occurring in Washington State waters. Some of the animals taken in the inland waters portion of the fishery may have been animals from the coastal stock. Similarly, some of the animals taken in the coastal portion of the fishery (see stock assessment report for the Oregon/Washington Coast stock for details) may have been from the inland stock. For the purposes of this stock assessment report, the animals taken in the inland portion of the fishery are assumed to have belonged to the Inland Washington stock and the animals taken in the coastal portion of the fishery are assumed to have belonged to the Oregon/Washington Coast stock. Some movement of harbor porpoise between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. Accordingly, Table 1 includes data only from that portion of the northern Washington marine set gillnet fishery occurring within the range of the Inland Washington stock (those waters east of Cape Flattery), where observer coverage ranged from 6-80% between 1992 and 1997. Data from 1992-97 are included in Table 1, although the mean estimated annual mortality is calculated using the most recent 5 years of available data. No mortalities were observed in the inland portion of the fishery between 1992 and 1997. As noted above, there was no observer program in 1994. Little effort occurred in 1995 and observer coverage was lower than usual (24%). Effort increased in 1996, however, the observer coverage decreased to a low of 6%. In 1997, observer coverage increased to 80%, although little effort occurred. The mean estimated mortality for this fishery is zero harbor porpoise per year from this stock.

In 1993, as a pilot for future observer programs, NMFS in conjunction with the Washington Department of Fish and Wildlife (WDF&W) monitored all non-treaty components of the Washington Puget Sound Region salmon gillnet fishery (Pierce et al. 1994). Observer coverage was 1.3% overall, ranging from 0.9% to 7.3% for the various components of the fishery. No harbor porpoise mortalities were reported (Table 1). Pierce et al. (1994) cautioned against extrapolating these mortalities to the entire Puget Sound fishery due to the low observer coverage and potential biases inherent in the data. The area 7/7A sockeye landings represented the majority of the non-treaty salmon landings in 1993, approximately 67%. Results of this pilot study were used to design the 1994 observer programs discussed below.

In 1994, NMFS in conjunction with WDF&W conducted an observer program during the Puget Sound non-treaty chum salmon gillnet fishery (areas 10/11 and 12/12B). A total of 230 sets were observed during 54 boat trips, representing approximately 11% observer coverage of the 500 fishing boat trips comprising the total effort in this fishery as estimated from fish ticket landings (Erstad et al. 1996). No harbor porpoise were reported within 100 meters of observed gillnets. The Puget Sound treaty chum salmon gillnet fishery in Hood Canal (areas 12, 12B, and 12C) and Puget Sound treaty sockeye/chum gillnet fishery in the Strait of Juan de Fuca (areas 4B, 5, and 6C) were also monitored in 1994 (NWIFC 1995). No harbor porpoise mortalities were reported in the observer programs covering these treaty salmon gillnet fisheries, where observer coverage was estimated at 2.2% (based on % of total catch observed) and approximately 7.5% (based on % of observed trips to total landings), respectively.

Also in 1994, NMFS in conjunction with the WDF&W and the Tribes conducted an observer program to examine seabird and marine mammal interactions with the Puget Sound treaty and non-treaty sockeye salmon gillnet fishery (areas 7 and 7A). During this fishery, observers monitored 2,205 sets, representing approximately 7% of the estimated 33,086 sets occurring in the fishery (Pierce et al. 1996). There was one observed harbor porpoise mortality (one other was entangled and released alive with no indication the animal was injured), resulting in a mortality rate of 0.00045 harbor porpoise per set, which extrapolates to 15 mortalities (CV=1.0) for the entire fishery. In 1996, Washington Sea Grant Program conducted a test fishery in the non-treaty sockeye salmon gillnet fishery (area 7) to compare entanglement rates of seabirds and marine mammals and catch rates of salmon using three experimental gears and a control (monofilament mesh net). The experimental nets incorporated highly visible mesh in the upper quarter (50 mesh gear) or upper eighth (20 mesh gear) of the net or had low-frequency sound emitters attached to the corkline (Melvin et al. 1997). In 642 sets during 17 vessel trips, 2 harbor porpoise were killed in the 50 mesh gear.

Combining the estimates from the 1994 observer programs (15) with the northern Washington marine set gillnet fishery (0) results in an estimated mean mortality rate in observed fisheries of 15 harbor porpoise per year from this stock. It should be noted that the 1994 observer programs did not sample all segments of the entire Washington Puget Sound Region salmon set/drift gillnet fishery, and further, the extrapolation of total kill did not include effort for the unobserved segments of this fishery. Therefore, 15 is an underestimate of the harbor porpoise mortality due to the entire fishery. Though it is not possible to quantify what percentage of the Washington Puget Sound Region salmon set/drift gillnet fishery was actually observed in 1994, the observer programs covered those segments of the fishery which had the highest salmon catches, the majority of vessel participation, and the highest likelihood of interaction with harbor porpoise (J. Scordino, pers. comm.). Accordingly, the estimated harbor porpoise mortality (15) appears to be only a slight underestimate for the fishery. See Appendix 1 of Barlow et al. (1997) for additional information, including a map depicting fishing areas, regarding the Washington Puget Sound Region salmon set/drift gillnet fishery.

Table 1. Summary of incidental mortality of harbor porpoise (Inland Washington stock) due to commercial fisheries from 1992 through 1997 and calculation of the mean annual mortality rate. Only data from 1993 to 1997 (or the most recent 5 years of available data) are used to calculate mean annual mortality (n/a indicates that data are not available).

Fishery name	Years	Data type	Range of observer coverage	Observed mortality (in given yrs.)	Estimated mortality (in given yrs.)	1993-97 Mean annual mortality
Northern WA marine set gillnet (inland waters)	92-97	obs data	6-80%	0, 0, n/a, 0, 0, 0	0, 0, n/a, 0, 0, 0	0
WA Puget Sound Region salmon set/drift gillnet (observer programs listed below covered segments of this fishery):	-	-	-	-	-	-
Puget Sound non-treaty salmon gillnet (all areas and species)	93	obs data	1.3%	0	0	see text
Puget Sound non-treaty chum salmon gillnet (areas 10/11 and 12/12B)	94	obs data	11%	0	0	0
Puget Sound treaty chum salmon gillnet (areas12,12B, and 12C)	94	obs data	2.2%	0	0	0
Puget Sound treaty chum and sockeye salmon gillnet (areas 4B, 5, and 6C)	94	obs data	7.5%	0	0	0
Puget Sound treaty and non-treaty sockeye salmon gill net (areas 7 and 7A)	94	obs data	7%	1	15	15 (CV=1.0)
Observer program total						15 (CV=1.0)
				Reported mortalities		
WA Puget Sound Region salmon set/drift gillnet	90-97	self reports	n/a	6, 4, 6, 2, n/a, n/a, n/a, n/a	n/a	see text
Minimum total annual mortality						$15 (CV=1.0)

An additional source of information on the number of harbor porpoises killed or injured incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. Self-reported fishery data from 1990 to 1997 for the Washington Puget Sound Region salmon set and drift gillnet fishery are shown in Table 1. Unlike the 1994 observer program data, the self-reported fisheries data cover the entire fishery. However, because logbook records (fisher self-reports required during 1990-94) are most likely negatively biased (Credle et al. 1994), these are considered to be minimum estimates of harbor porpoise mortality. Self-reported fisheries data are incomplete for 1994, not available for 1995, and considered unreliable after 1995 (see Appendix 4 of Hill and DeMaster 1998). Though the 1994 observer program data may underestimate the total fishery mortality for this stock, it is considered more reliable than the self-reported data. Thus, the self-reported fisheries data were not used in the mortality rate calculation.

Strandings of harbor porpoise wrapped in fishing gear or with injuries caused by interactions with gear are a final source of fishery-related mortality information. During the period from 1992 to 1997 the only reported fishery-related strandings of harbor porpoise occurred in 1992 (1 animal) and 1993 (1 animal). The mortalities likely occurred in the Washington Puget Sound Region salmon set and drift gillnet fishery. As the 1994 observer program already accounts for 15 harbor porpoise mortalities per year from this fishery, these strandings have not been included in Table 1.

There are few data concerning the mortality of marine mammals incidental to commercial gillnet fisheries in Canadian waters, which have not been monitored but are known to have taken harbor porpoise in the past (Barlow et al. 1994, Stacey et al. 1997). As a result, the number of harbor porpoise from this stock currently taken in the waters of southern British Columbia is not known.

STATUS OF STOCK

Harbor porpoise are not listed as “depleted” under the MMPA or listed as “threatened “ or “endangered” under the Endangered Species Act. Based on currently available data, the level of human-caused mortality and serious injury (15) is not known to exceed the PBR (20). Therefore, the Inland Washington harbor porpoise stock is not classified as strategic. The minimum total fishery mortality and serious injury for this stock (15) exceeds 10% of the calculated PBR (2.0) and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to its Optimum Sustainable Population and population trends is unknown, although harbor porpoise sightings in the southern Puget Sound have declined since the 1940s.

Although this stock is not recognized as strategic at this time, there is cause for concern due to the following issues: 1) the estimated take level is close to exceeding the PBR (i.e., one additional observed mortality or serious injury in the area 7/7A sockeye drift gillnet fishery would increase the estimated annual take level above the PBR), 2) the extent to which harbor porpoise from U. S. waters frequent the waters of British Columbia, and are therefore subject to fishery-related mortality, is unknown, and 3) the mortality rate is based on observer data from a subset of the Washington Puget Sound Region salmon set and gillnet fishery.

REFERENCES

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J., and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rep. Int. Whal. Commn. Special Issue 16:123-140.

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon and Washington: II. Aerial surveys. Fish. Bull. 86:433-444.

Barlow , J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn. Special Issue 15:405-425.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223 pp.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. Reynolds, J. E., III, and D. K. Odell (eds.), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987, Miami, Florida. NMFS, NOAA Technical Rep. NMFS 98:101-110.

Calambokidis, J., J. R. Evenson, J. C. Cubbage, P. J. Gearin, and S. D. Osmek. 1992. Harbor porpoise distribution and abundance off Oregon and Washington from aerial surveys in 1991. Final Rep. by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 44 pp.

Calambokidis, J., J. C. Cubbage, J. R. Evenson, S. D. Osmek, J. L. Laake, P. J. Gearin, B. J. Turnock, S. J. Jeffries, and R. F. Brown. 1993. Abundance estimates of harbor porpoise in Washington and Oregon waters. Final Rep. by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 55 pp.

Calambokidis, J., S. D. Osmek, and J. L. Laake. 1997. Aerial surveys for marine mammals in Washington and British Columbia inside waters. Final Rep. by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 96 pp.

Chivers, S. Southwest Fisheries Science Center, NMFS, P.O. Box 271, La Jolla, CA 92038.

Credle, V. R., D. P. DeMaster, M. M. Merklein, M. B. Hanson, W. A. Karp, and S. M. Fitzgerald (eds.). 1994. NMFS observer programs: minutes and recommendations from a workshop held in Galveston, Texas, November 10-11, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-94-1. 96 pp.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: Status, abundance, and distribution. OCS study MMS 84-0045. Pacific OCS Region Minerals Management Service, 1340 Sixth Street, Los Angeles, CA 90014. 284 pp.

Erstad, P., S. L. Jeffries, and D. J. Pierce. 1996. 1994 Report for the Puget Sound fishery observer program in management areas 10/11 & 12/12B: nontreaty chum gill net fishery. Wash. Dept. Fish and Wildlife., Olympia, WA. 14 pp.

Everitt, R. D., C. H. Fiscus, R. L. DeLong. 1980. Northern Puget Sound marine mammals. U.S. Department of Commerce EPA-6000/7-80-139. 134 pp.

Gaskin, D. E. 1984. The harbour porpoise *Phocoena phocoena* (L.): Regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Commn. 34:569-586.

Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington state. Rep. Int. Whal. Commn. Special Issue 15:427-438.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1, *In:* Brueggeman, J. J. (ed.), Oregon and Washington Marine Mammal and Seabird Surveys. Final Rep. OCS Study MMS 91-0093.

Hill, P. S., and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-97. 166 pp.

Laake, J. L., R. L. DeLong, J. Calambokidis, and S. D. Osmek. 1997a. Abundance and distribution of marine mammals in Washington and British Columbia inside waters, 1996. Annual rep. to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 7 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J. L., J. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997b. Probability of detecting harbor porpoise from aerial surveys: Estimating g(0). J. Wildl. Manage. 61(1):63-75.

Melvin, E. F., L. L. Conquest, and J. K. Parrish. 1997. Seabird bycatch reduction: New tools for Puget Sound drift gillnet salmon fisheries. 1996 Sockeye and 1995 Chum Salmon Test Fisheries Final Report. Washington Sea Grant Program, Seattle, WA. 48pp.

Northwest Indian Fisheries Commission. 1995. Monitoring of marbled murrelet and marine mammal interactions with 1994 tribal gillnet fisheries in northern Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Final Report to NMFS Contract No. 52ABNF400087. Unpubl. report. Northwest Indian Fisheries Commission. 43 pp. Available at NWIFC, 6730 Martin Way E, Olympia, WA 98516.

Osborne, R., J. Calambokidis, and E. M. Dorsey. 1988. A Guide to Marine Mammals of Greater Puget Sound. Island Publishers, Anacortes, WA. 191 pp.

Osmek, S. D., P. E. Rosel, A. E. Dizon, and R. L. DeLong. 1994. Harbor porpoise *Phocoena phocoena* population assessment studies for Oregon and Washington in 1993. Annual Rep. to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 14 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Osmek, S. D., M. B. Hanson, J. L. Laake, S. J. Jeffries, and R. L. DeLong. 1995. Harbor porpoise *Phocoena phocoena* population assessment studies for Oregon and Washington in 1994. Annual Rep. to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 32 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and R. Brown. 1996. Assessment of the status of harbor porpoises, *Phocoena phocoena,* in Oregon and Washington waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-76. 46 pp.

Pierce, D. J., W. P. Ritchie, and R. Kreuziger. 1994. Preliminary findings of seabird interactions with the non-treaty salmon gill net fishery: Puget Sound and Hood Canal Washington. Unpubl. report. Washington Department of Fish and Wildlife, Olympia, WA. 39 pp. Available at WDFW, 600 Capitol Way N, Olympia, WA, 98501.

Pierce, D. J., M. Alexandersdottir, S. J. Jeffries, P. Erstad, W. Beattie, and A. Chapman. 1996. Interactions of marbled murrelets and marine mammals with the 1994 Puget Sound sockeye gill net fishery. Final Report, Wash. Dept. Fish and Wildlife, Olympia, WA. 21 pp.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, Univ. Calif. San Diego, La Jolla, CA. 191 pp.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. and Aquat. Sci. 52:1210-1219.

Scheffer, V. B., and J. W. Slipp. 1948. The whales and dolphins of Washington state with a key to the cetaceans of the west coast of North America. Am. Midl. Nat. 39(2):257-337.

Scordino, J. National Marine Fisheries Service, Northwest Region, 7600 Sand Point Way NE, Seattle, WA 98115.

Stacey, P. J., R. W. Baird, and D. A. Duffus. 1997. A preliminary evaluation of incidental mortality of small cetaceans, in coastal fisheries in British Columbia, Canada. Mar. Mamm. Sci. 13:321-326.

Taylor, B. Southwest Fisheries Science Center, NMFS, P. O. Box 271, La Jolla, CA 92038.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Transient Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where pods have been labeled as 'resident,' 'transient,' and 'offshore' (Bigg et al. 1990, Ford et al. 1994) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982, Baird and Stacey 1988, Baird et al. 1992, Hoelzel et al. 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Heise et al. 1991) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994).

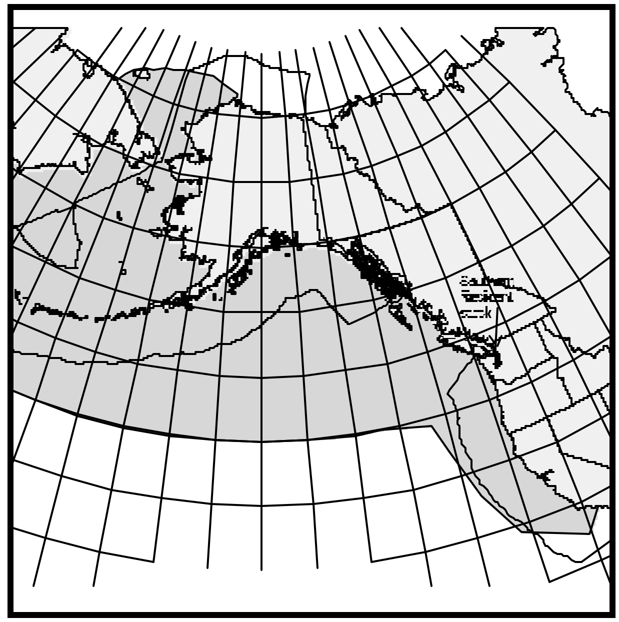

Figure 1. Approximate distribution of killer whales in the eastern North Pacific (shaded area). The distribution of the Eastern North Pacific Northern Resident and Transient stocks are largely overlapping (see text).

Studies on mtDNA restriction patterns provide evidence that the 'resident' and 'transient' types are genetically distinct (Stevens et al. 1989, Hoelzel 1991, Hoelzel and Dover 1991, Hoelzel et al. 1998). Analysis of 73 samples collected from eastern North Pacific killer whales from California to Alaska has demonstrated significant genetic differences among 'transient' whales from California through Alaska, 'resident' whales from the inland waters of Washington, and 'resident' whales ranging from British Columbia to the Aleutian Islands and Bering Sea (Hoelzel et al. 1998).

Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, five killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 2) the Eastern North Pacific Southern Resident stock - occurring within the inland waters of Washington State and southern British Columbia, 3) the Eastern North Pacific Transient stock - occurring from Alaska through California (see Fig. 1), 4) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, and 5) the Hawaiian stock. 'Transient' whales in Canadian waters are considered part of the Eastern North Pacific Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Northern Resident stock

POPULATION SIZE

The Eastern North Pacific Northern Transient stock is a trans-boundary stock, including killer whales from British Columbia. Preliminary analysis of photographic data resulted in the following minimum counts for 'transient' killer whales belonging to the Eastern North Pacific Transient stock (Note: individual whales have been matched between geographical regions and missing animals likely to be dead have been subtracted). In British Columbia and southeastern Alaska, 213 'transient' whales have been cataloged (Ford and Ellis 1999). In the Gulf of Alaska, 17 'transient' killer whales have been identified genetically and acoustically (L. Barrett-Lennard, pers. comm.). The 'transient' group AT1, commonly seen in Prince William Sound, was thought to have 11 whales alive in 1997 (Matkin et al. 1998). Based on data collected from all Alaska waters west of Seward (Dahlheim and Waite 1993, Dahlheim 1994, 1997), 68 whales are considered 'residents' as they have been linked by association to 'resident' whales from Prince William Sound (G. Ellis, pers. comm.), and the remainder are provisionally classified as 174 'residents' and 53 'transients.' Provisional classifications were based primarily on morphological differences identified from the photographs. Accordingly, the numbers of 'residents' and 'transients' in Alaska waters west of Seward are considered preliminary at this time. Off the coast of California, Black et al. (1997) identified 105 'transient' whales: 10 whales were matched to photos of 'transients' in other catalogs and the remaining 95 were linked by association. Combining the counts of 'transient' whales gives a minimum number of 336 (213 + 17 + 11 + 95) killer whales belonging to the Eastern North Pacific Transient stock.

Minimum Population Estimate

The survey technique utilized for obtaining the abundance estimate of killer whales is a direct count of individually identifiable animals. Given that researchers continue to identify new whales, the estimate of abundance based on the number of uniquely identified individuals known to be alive is likely conservative. However, the rate of discovering new whales within Southeast Alaska and Prince William Sound is relatively low. In addition, the abundance estimate does not include 53 unclassified whales from western Alaska that have been provisionally classified as 'transients'.

Other estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) are not currently available. Thus, the minimum population estimate (N_{MIN}) for the Eastern North Pacific Transient stock of killer whales is 336 animals, which includes animals found in Canadian waters (see PBR Guidelines regarding the status of migratory trans-boundary stocks, Wade and Angliss 1997). Information on the percentage of time animals typically encountered in Canadian waters spend in U.S. waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1996).

Current Population Trend

At present, reliable data on trends in population abundance for the Eastern North Pacific Transient stock of killer whales are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of 'resident' killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). However, a population increases at the maximum growth rate (R_{MAX}) only when the population is at extremely low levels; thus, the estimate of 2.92% is not a reliable estimate of R_{MAX}. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 re-authorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.45, the value for cetacean stocks with unknown population status and a mortality estimate CV between 0.6 and 0.8 (Wade and Angliss 1997). Thus, for the Eastern North Pacific Transient killer whale stock, PBR = 3.0 animals (336 × 0.02 × 0.45). The proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, pers. comm.).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Six different commercial fisheries in Alaska that could have interacted with killer whales were monitored for incidental take by fishery observers from 1993 to 1997: Bering Sea (and Aleutian Islands) and Gulf of Alaska groundfish trawl, longline, and pot fisheries. Of the six observed fisheries, killer whale mortalities occurred only in the Bering Sea groundfish trawl and longline fisheries. For the fisheries with observed takes, the range of observer coverage over the 5-year period, as well as the annual observed and estimated mortalities, are presented in Table 1. The 1995 mortality in the longline fishery occurred during an unmonitored haul and could not be used to estimate total mortality for the fishery (28% observer coverage in 1995). For computational purposes, the estimated mortality in 1995 was set at 1, because at a minimum, one whale is known to have perished in that year. The 1993 mortality in the trawl fishery occurred under similar circumstances and was treated in the same manner (66% observer coverage in 1993).

NMFS observers also monitored the California/Oregon thresher shark/swordfish drift gillnet fishery from 1993 to 1997 (Table 1; Julian 1997, Cameron 1998, Julian and Beeson 1998). The observed mortality in this fishery, in 1995, was a transient whale as determined by genetic testing (S. Chivers, pers. comm.). Additional fisheries that could interact with the Eastern North Pacific Transient stock of killer whales are listed in Appendix 1 of Barlow et al. (1997).

The mean annual mortality was 0.6 (CV=0.67) for the Bering Sea groundfish trawl fishery, 0.2 (CV=1.0) for the combined Bering Sea longline fishery, and 1.2 (CV=1.0) for the California/Oregon thresher shark/swordfish drift gillnet fishery, resulting in a mean annual mortality rate of 2.0 (CV=0.64) killer whales per year from observed fisheries.

An additional source of information on the number of killer whales killed or injured incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. During the period between 1990 and 1997, fisher self-reports from all Alaska fisheries operating within the range of this stock indicated only one killer whale mortality, which occurred in the Bering Sea groundfish trawl fishery in 1990. However, because logbook records (fisher self-reports required during 1990-94) are most likely negatively biased (Credle et al. 1994), these are considered to be minimum estimates. Self-reported fisheries data are incomplete for 1994, not available for 1995, and considered unreliable after 1995 (see Appendix 4 of Hill and DeMaster 1998). Thus, the observer program provides more reliable estimates of mortality than the fisher self-reports.

The estimated minimum mortality rate incidental to U.S. commercial fisheries recently monitored is 2.0 animals per year, based exclusively on observer data. As the animals which were taken incidental to commercial fisheries in Alaska have not been identified genetically, it is not possible to determine whether they belonged to the Eastern North Pacific Northern Resident or the Eastern North Pacific Transient killer whale stock. Accordingly, these same mortalities can be found in the stock assessment report for the Northern Resident stock.

Table 1. Summary of incidental mortality of killer whales (Eastern North Pacific Northern Transient stock) due to commercial fisheries from 1993 through 1997 and calculation of the mean annual mortality rate. Only data from 1993 to 1997 (or the most recent 5 years of available data) are used to calculate mean annual mortality.

Fishery name	**Years**	**Data type**	**Range of observer coverage**	**Observed mortality (in given yrs.)**	**Estimated mortality (in given yrs.)**	**1993-97 Mean annual mortality**
Bering Sea/Aleutian Is. (BSAI) groundfish trawl	93-97	obs data	64-67%	1, 0, 0, 0, 1	1, 0, 0, 0, 2	0.6 (CV=0.67)
BSAI groundfish longline (incl. misc. finfish and sablefish fisheries)	93-97	obs data	27-33%	0, 0, 1, 0, 0	0, 0, 1, 0, 0	0.2 (CV=1.0)
CA/OR thresher shark/swordfish drift gillnet	93-97	obs data	12-27%	0, 0, 1, 0, 0	0, 0, 6, 0, 0	1.2 (CV=1.0)
Estimated total annual mortality						2.0 (CV=0.64)

Due to a lack of Canadian observer programs, there are few data concerning the mortality of marine mammals incidental to Canadian commercial fisheries, which are analogous to U.S. fisheries that are known to interact with killer whales. The sablefish longline fishery accounts for a large proportion of the commercial fishing/killer whale interactions in Alaska waters. Such interactions have not been reported in Canadian waters where sablefish are taken via a pot fishery. Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. However, in 1994, one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther et al. 1995). Data regarding the level of killer whale mortality related to commercial fisheries in Canadian waters, though thought to be small, are not readily available or reliable which results in an underestimate of the annual mortality for this stock.

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska or Canada.

Other Mortality

Since 1986, research efforts have been made to assess the nature and magnitude of killer whale/blackcod (sablefish; *Anoplopoma fimbria*) fishery interactions (Yano and Dahlheim 1995, Dahlheim 1988). Fishery interactions have occurred each year in the Bering Sea and Prince William Sound, with the number of annual reports varying considerably. Data collected from the Japan/U.S. cooperative longline research surveys operating in the Bering Sea indicate that interactions may be increasing and expanding into the Aleutian Island region (Yano and Dahlheim 1995). During the 1992 surveys conducted in the Bering Sea and western Gulf of Alaska, 9 of 182 (4.9%) individual whales in 7 of the 12 (58%) pods encountered had evidence of bullet wounds (Dahlheim and Waite 1993). The relationship between wounding due to shooting and survival is unknown. In Prince William Sound, the pod responsible for most of the fishery interactions has experienced a high level of mortality: between 1986 and 1991, 22 whales out of a pod of 37 (59%) are missing and considered dead (Matkin et al. 1994). The cause of death for these whales is unknown, but may be related to gunshot wounds or effects of the *Exxon Valdez* oil spill (Dahlheim and Matkin 1994).

The shooting of killer whales in Canadian waters has also been a concern in the past. However, in recent years there have been no reports of shooting incidents in Canadian waters. In fact, the likelihood of shooting incidents involving 'transient' killer whales is thought to be minimal since commercial fishermen are most likely to observe 'transients' feeding on seals or sea lions instead of interacting with their fishing gear (G. Ellis, pers. comm.).

Other Issues

Although only small numbers of killer whales are taken in the Bering Sea fisheries, there is considerable interaction between the whales and the fisheries. Interactions between killer whales and longline vessels have been well documented (Dahlheim 1988, Yano and Dahlheim 1995). In 1997, the first year that predation data were collected in the Bering Sea and Gulf of Alaska groundfish trawl, longline and pot fisheries, NMFS observers recorded killer whale predation and/or deterrence events during 187 longline sets: 179 in the Bering Sea and 8 in the Gulf of Alaska. A total of 183 whales were deterred (through the use of seal bombs or acoustic alarms suspended from the vessels) from 20 sets in the Bering Sea and one group of 35 whales was deterred from a set in the Gulf of Alaska. Less has been documented regarding interactions with the trawl fishery, but several observers reported that large groups of killer whales in the Bering Sea followed vessels for days at a time, actively consuming the processing waste (Fishery Observer Program, unpubl. data). However, it may be the 'resident' stock of killer whales that is involved in such fisheries interactions since these whales are known to be fish eaters, while 'transient' whales have only been observed feeding on marine mammals.

STATUS OF STOCK

Killer whales are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Recall, that the human-caused mortality has been underestimated primarily due to a lack of information on Canadian fisheries, and that the minimum abundance estimate is considered conservative (because researchers continue to encounter new whales and unclassified whales from western Alaska were not included), resulting in a conservative PBR estimate. Based on currently available data, the estimated annual fishery-related mortality level (2.0) exceeds 10% of the PBR (0.30) and, therefore, can not be considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury (2.0 animals per year) is not known to exceed the PBR (3.0). Therefore, the Eastern North Pacific Transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

REFERENCES

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66 (11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25pp.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223 pp.

Barrett-Lennard, L. Univ. of British Columbia, 6270 University Blvd., Vancouver, BC V6T1Z4.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Pp. 386-406, *In:* Hammond, P. S. , S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Commn. Special Issue 12.

Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247. 174 pp.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Commn. 32:643-646.

Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Chivers, S. Southwest Fisheries Science Center, NMFS, P. O. Box, 271, La Jolla, CA 92038.

Credle, V. R., D. P. DeMaster, M. M. Merklein, M. B. Hanson, W. A. Karp, and S. M. Fitzgerald (eds.). 1994. NMFS observer programs: minutes and recommendations from a workshop held in Galveston, Texas, November 10-11, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-94-1. 96 pp.

Dahlheim, M. E. 1988. Killer whale (*Orcinus orca*) depredation on longline catches of sablefish (*Anoplopoma fimbria*) in Alaskan waters. NWAFC Processed Rep. 88-14. 31 pp. (available upon request - Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115).

Dahlheim, M. E. 1994. Abundance and distribution of killer whales (*Orcinus orca*) in Alaska in 1993. Annual Report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

Dahlheim, M. E. 1997. A photographic catalogue of killer whales (*Orcinus orca*) from the Central Gulf of Alaska to the southeastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-131. 54 pp.

Dahlheim, M. E., and J. M. Waite. 1993. Abundance and distribution of killer whales (*Orcinus orca*) in Alaska in 1992. Annual Report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

Dahlheim, M. E., and C. O. Matkin. 1994. Assessment of injuries to Prince William Sound killer whales. Pp. 163-171, *In* Loughlin, T. R. , (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, Inc., San Diego, CA. xix +395 pp.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 pp. + appendices.

DeMaster, D. P. 1996. Minutes from the 11-13 September 1996 meeting of the Alaska Scientific Review Group, Anchorage, AK. 20 pp + appendices. (available upon request - D. P. DeMaster, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115).

Ellis, G. Pacific Biological Station, Nanaimo, BC V9R 5K6.

Fishery Observer Program. AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115

Ford, J. K. B., and G. M. Ellis. 1999. Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska. University of British Columbia Press, Vancouver, BC. 96 pp.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Commn. 32:671-679.

Ford, J. K. B., G. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press and University of Washington Press. 102 pp.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15-26.

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pp. 1-100, *In:* Brueggeman, J.J. (ed.), Oregon and Washington Marine Mammal and Seabird Surveys. Final Rep. OCS Study MMS 91-0093.

Guenther, T. J., R. W. Baird, R. L. Bates, P. M. Willis, R. L. Hahn, and S. G. Wischniowski. 1995. Strandings and fishing gear entanglements of cetaceans on the west coast of Canada in 1994. Paper SC/47/O6 presented to the International Whaling Commission, May 1995 (unpublished). 7pp.

Heise, K., G. Ellis, and C. Matkin. 1991. A catalogue of Prince William Sound Killer Whales. North Gulf Oceanic Society, Homer, AK. Published for the National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Hill, P. S., and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-97. 166 pp.

Hoelzel, A. R. 1991. Analysis of regional mitochondrial DNA variation in the killer whale; implications for cetacean conservation. Rep. Int. Whal. Commn. Special Issue 13:225-233.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66: 191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the Eastern North Pacific, and genetic differentiation between foraging specialists. J. Heredity 89:121-128.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F., and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fish. Bull. 96(2):271-284.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Naturalist 104:362-371.

Matkin, C. O., G. M. Ellis, M. E. Dahlheim, and J. Zeh. 1994. Status of killer whales in Prince William Sound, 1985-1992. Pp. 141-162, *In:* Loughlin, T. R. (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, Inc., San Diego, CA. xix + 395 pp.

Matkin, C.O., D. Scheel, G. Ellis, L. Barrett-Lennard, H. Jurk, and E. Saulitis. 1998. Comprehensive Killer Whale Investigation, Exxon Valdez Oil Spill Restoration Project Annual Report (Restoration Project 97012), North Gulf Oceanic Society, Homer, AK. 58 pp.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Bd. Can. 32:914-916.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Commn. Special Issue 12:209-242.

Stevens, T. A., D. Duffield, E. Asper, K. Hewlett, A. Bolz, L. Gage, and G. Bossart. 1989. Preliminary findings of restriction fragment differences in mitochondrial DNA among killer whales (*Orcinus orca*). Can. J. Zool. 67:2592-2595.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, WA. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Yano, K., and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish. Bull. 93:355-372.

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Offshore Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where pods have been labeled as 'resident', 'transient' and 'offshore' (Bigg et al. 1990, Ford et al. 1994) based on aspects of morphology, ecology, genetics and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992, Hoelzel et al. 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Heise et al. 1991) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994).

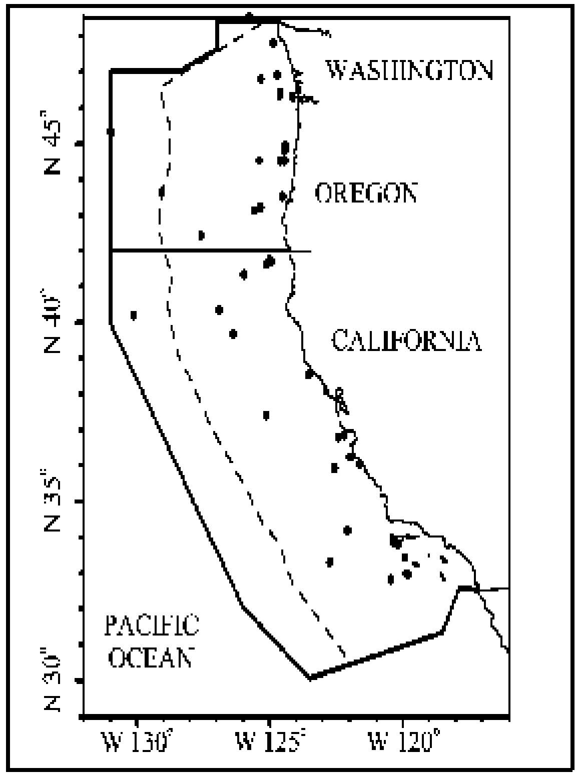

Figure 1. Killer whale sightings based on aerial and shipboard surveys off California, Oregon and Washington, 1989-96. Sightings include killer whales from all stocks found in this region. Dashed line represents the U.S. EEZ, thick line indicates the outer boundary of all surveys combined. Greater effort was conducted off California (south of 42/N) and in the inshore half of the U.S. EEZ. See Appendix 2 of Barlow et al. (1997) and Barlow (1997) for data sources and information on timing and location of survey effort.

Offshore killer whales have more recently also been identified off the coasts of California, Oregon, and rarely, in Southeast Alaska (Ford et al. 1994, Black et al. 1997, Dahlheim et al. 1997). They apparently do not mix with the transient and resident killer whale stocks found in these regions (Ford et al. 1994, Black et al. 1997). Studies indicate the 'offshore' type, although distinct from the other types ('resident' and 'transient'), appears to be more closely related genetically, morphologically, behaviorally, and vocally to the 'resident' type killer whales (Black et al. 1997, Hoelzel et al. 1998; J. Ford, pers. comm.; L. Barrett-Lennard, pers. comm.). Based on data regarding association patterns, acoustics, movements, genetic differences, and potential fishery interactions, five killer whale stocks are recognized within the Pacific U.S. EEZ 1) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 2) the Eastern North Pacific Southern Resident stock - occurring within the inland waters of Washington State and southern British Columbia, 3) the Eastern North Pacific Transient stock - occurring from Alaska through California, 4) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California (this report), and 5) the Hawaiian stock. 'Offshore' whales in Canadian waters are considered part of the Eastern North Pacific Offshore stock. The Stock Assessment Reports for the Alaska Region contain assessments of the Eastern North Pacific Northern Resident stock, and the most recent assessment for the Hawaii Stock can be found in Barlow et al. (1997).

POPULATION SIZE

Off British Columbia, approximately 200 offshore killer whales were identified between 1989 and 1993 (Ford et al. 1994), and 20 of these individuals have also been seen off California (Black et al. 1997). Using only good quality photographs that clearly show characteristics of the dorsal fin and saddle patch region, an additional 11 offshore killer whales that were not previously known have been identified off the California coast, bringing the total number of known individuals in this population to 211. This is certainly an underestimate of the total population size, because not all animals in this population have been photographed. In the future, it may be possible estimate the total abundance of this transboundary stock using mark-recapture analyses based on individual photographs. Based on summer/fall shipboard line-transect surveys in 1991, 1993 and 1996 (Barlow 1997), the total number of killer whales within 300 nmi of the coasts of California, Oregon and Washington was recently estimated to be 819 animals (CV=0.38). There is currently no way to reliably distinguish the different stocks of killer whales from sightings at sea, but photographs of individual animals can provide a rough estimate of the proportion of whales in each stock. A total of 161 individual killer whales photographed off California and Oregon have been determined to belong to the transient (105 whales) and offshore (56 whales) stocks (Black et al. 1997). Using these proportions to prorate the line transect abundance estimate yields an estimate of 56/161 * 819 = 285 offshore killer whales along the U.S. west coast. This is expected to be a conservative estimate of the number of offshore killer whales, because offshore whales apparently are less frequently seen near the coast (Black et al. 1997), and therefore photographic sampling may be biased towards transient whales. For stock assessment purposes, this combined value is currently the best available estimate of abundance for offshore killer whales off the coasts of California, Oregon and Washington.

Minimum Population Estimate

The total number of known offshore killer whales along the U.S. West coast, Canada and Alaska is 211 animals, but it is not known what proportion of time this transboundary stock spends in U.S. waters, and therefore this number is difficult to work with for PBR calculations. A minimum abundance estimate for all killer whales along the coasts of California, Oregon and Washington can be estimated from the 1991-1996 line-transect surveys as the 20th percentile of the abundance estimate, or 601 killer whales. Using the same prorating as above, a minimum of 56/161 * 601 = 209 offshore killer whales are estimated to be in U.S. waters off California, Oregon and Washington.

Current Population Trend

No information is available regarding trends in abundance of Eastern North Pacific offshore killer whales.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for killer whales in this region.

POTENTIAL BIOLOGICAL REMOVAL

Based on this stock's unknown status and growth rate and the lack of observed fishery mortality, the recovery factor (F_r) is 0.5. ½R_{max} is the default value of 0.02. Multiplying these two values times the minimum population estimate of 209 yields a potential biological removal (PBR) of 2.1 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for this killer whale stock is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1 of Barlow et al. (1997). In the California drift gillnet fishery, no offshore killer whales have been observed entangled (Julian and Beeson 1998, Julian 1997, Cameron 1998), but one killer whale from the Eastern North Pacific Transient Stock was observed taken in 1995, and offshore killer whales may also occasionally be entangled.

Additional potential sources of killer whale mortality are set gillnets and longlines. In California, an observation program between July 1990 and December 1994 monitored 5-15% of all sets in the large mesh (>3.5") set gillnet fishery for halibut and angel sharks, and no killer whales were observed taken. Based on observations for longline fisheries in other regions (i.e. Alaska; Yano and Dahlheim 1995), fishery interactions may also occur with U.S. West coast pelagic longline fisheries, but no such interactions have been documented to date.

Set and drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and may take animals from the same population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which increased from two vessels in 1986 to 29 vessels in 1992 (Sosa-Nishizaki et al. 1993). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2700, with an observed rate of marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set; Julian and Beeson, in press), but species-specific information is not available for the Mexican fisheries.

Table 1. Summary of available information on the incidental mortality and injury of killer whales (Eastern North Pacific Offshore Stock) in commercial fisheries that might take this species.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes 1993-97
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	1993	13.4%	0	0	
		1994	17.9%	0	0	
		1995	15.6%	0	0	
		1996	12.4%	0	0	
		1997	26.6%	0	0	0
Minimum total annual takes 1993-97						0

Historical mortality

California coastal whaling operations killed five killer whales between 1962 and 1967 (Rice 1974). An additional killer whale was taken by whalers in British Columbian waters (Hoyt 1981). It is unknown whether any of these animals belonged to the Eastern North Pacific Offshore stock.

STATUS OF STOCK

The status of killer whales in California in relation to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. There has been no documented human-caused mortality of this stock, and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for offshore killer whales is zero and can be considered to be insignificant and approaching zero mortality and serious injury rate.

REFERENCES

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66:2582-2585.

Baird, R. W., Abrams, P. A., and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25p.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223 pp.

Barrett-Lennard, L. Univ. of British Columbia, 6270 University Blvd., Vancouver, BC V6T1Z4.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. int. Whal. Commn Special Issue 12:386-406.

Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western

Mexico: A Catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247. 174p.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Commn., 32:643-646.

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 pp. + appendices.

Ford, J. K. B., Vancouver Aquarium, P.O. Box 3232, Vancouver, BC V6B 3XB, Canada.

Ford, J. K. B., G. M. Ellis, and K.C. Balcomb. 1994. Killer whales. The natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. UBC Press, Vancouver, Canada

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Commn 32:671-679.

Forney, K. A., J. Barlow and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15-26.

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington. Ch. 1. In: Oregon and Washington Marine Mammal and Seabird Surveys. OCS Study 91-0093. Final Report prepared for Pacific OCS Region, Minerals Management Service, U.S. Department of the Interior, Los Angeles, California.

Heise, K., G. Ellis, and C. Matkin. 1991. A catalogue of Prince William Sound Killer Whales. North Gulf Oceanic Society, Homer, AK. Published for the National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the Eastern North Pacific, and genetic differentiation between foraging specialists. J. Heredity 89:121-128.

Hoyt, E. 1981. The Whale Called Killer. E. P. Dutton, New York.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F. and M. Beeson. 1998. Estimates of mammal, turtle and bird mortality for two California gillnet fisheries: 1990-1995. Fishery Bulletin 96:271-284.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Naturalist 104:362-371.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Canada, 32:914-916.

Rice, D. W. 1974. Whales and whale research in eastern North Pacific. p. 170-195 *In:* W. E. Schevill (ed.), The Whale Problem - A Status Report. Harvard University Press, Cambridge, MA.

Sosa-Nishizaki, O., R. De la Rosa-Pacheco, R. Castro-Longoria, M. Grijalva Chon, and J. De la Rosa Velez. 1993. Estudio biologico pesquero del pez (*Xiphias gladius*) y otras especies de picudos (marlins y pez vela). Rep. Int. CICESE, CTECT9306.

Yano, K. and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fishery Bulletin 93:355-372.

Revised 09/30/99

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where pods have been labeled as 'resident,' 'transient,' and 'offshore' (Bigg et al. 1990, Ford et al. 1994) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982, Baird and Stacey 1988, Baird et al. 1992, Hoelzel et al. 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Heise et al. 1991) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994).

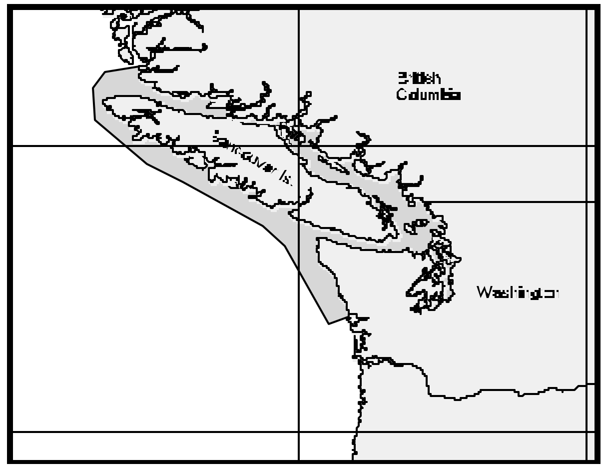

Figure 1. Approximate distribution of the Eastern North Pacific Southern Resident killer whale stock, April through October (shaded area).

Studies on mtDNA restriction patterns provide evidence that the 'resident' and 'transient' types are genetically distinct (Stevens et al. 1989, Hoelzel 1991, Hoelzel and Dover 1991, Hoelzel et al. 1998). Analysis of 73 samples collected from eastern North Pacific killer whales from California to Alaska has demonstrated significant genetic differences among 'transient' whales from California through Alaska, 'resident' whales from the inland waters of Washington, and 'resident' whales ranging from British Columbia to the Aleutian Islands and Bering Sea (Hoelzel et al. 1998). Although some pods belonging to the Eastern North Pacific Southern Resident stock have been sighted off the outer Washington coast as far south as Grays Harbor (Bigg et al. 1990), most killer whale sightings in Washington have occurred in the inland waters.

Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, five killer whales stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 2) the Eastern North Pacific Southern Resident stock - occurring within the inland waters of Washington State and southern British Columbia (see Fig. 1), 3) the Eastern North Pacific Transient stock - occurring from Alaska through California, 4) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, and 5) the Hawaiian stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Northern Resident stock.

POPULATION SIZE

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford et al. 1994). Counts remained in the mid-high 90s until a recent decrease to 89 whales (Fig. 2; Center for Whale Research, unpubl. data).

Minimum Population Estimate

The survey technique utilized for obtaining the abundance estimate for this stock of killer whales is a direct count of individually identifiable animals. Other estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) are not currently available. Thus, the minimum population estimate (N_{MIN}) for the Eastern North Pacific Southern Resident stock of killer whales is 89 animals.

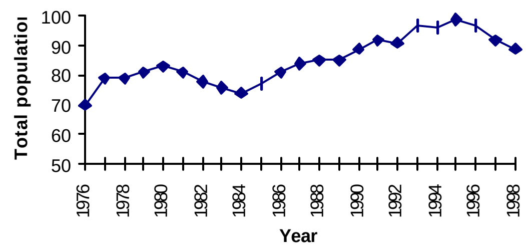

Figure 2. Population of Eastern North Pacific Southern Resident stock of killer whales, 1976-1998. Each year's count includes animals first seen and first missed; a whale is considered first missed the year after it was last seen alive (Center for Whale Research, unpubl. data).

Current Population Trend

During the live-capture fishery that existed from 1967 to 1973, it is estimated that 47 killer whales, mostly immature, were taken out of this stock (Ford et al. 1994). The first complete census of this stock occurred in 1974. Between 1974 and 1993 the Southern Resident stock increased approximately 35%, from 71 to 96 individuals (Ford et al. 1994). This represents an annual growth rate of 1.8% during those years. The population peaked at 99 whales in 1995 then decreased to 89 whales from 1995 to 1998 (Center for Whale Research, unpubl. data).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of 'resident' killer whale pods in British Columbia and Washington waters resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). However, a population increases at the maximum growth rate (R_{MAX}) only when the population is at extremely low levels; thus, the estimate of 2.92% is not considered a reliable estimate of R_{MAX}. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 re-authorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5 R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks of unknown status (Wade and Angliss 1997). Thus, for the Eastern North Pacific Southern Resident killer whale stock, PBR = 0.9 animals (89 × 0.02 × 0.5).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

NMFS observers have monitored the northern Washington marine set gillnet fishery since 1988. No killer whale mortalities have been recorded in this fishery since the inception of the observer program. Observer coverage has ranged from approximately 59 to 98% in this fishery between 1992 and 1997, excluding 1994 in which no observer program occurred (Gearin et al. 1994, P. Gearin, unpubl. data).

In 1993, as a pilot for future observer programs, NMFS in conjunction with the Washington Department of Fish and Wildlife (WDF&W) monitored all non-treaty components of the Washington Puget Sound Region salmon gillnet fishery (Pierce et al. 1994). Observer coverage was 1.3% overall, ranging from 0.9% to 7.3% for the various components of the fishery. Encounters (whales within 10 meters of a net) with killer whales were reported, but not quantified, though no entanglements occurred.

In 1994, NMFS and WDF&W conducted an observer program during the Puget Sound non-treaty chum salmon gillnet fishery (areas 10/11 and 12/12B). A total of 230 sets were observed during 54 boat trips, representing approximately 11% observer coverage of the 500 fishing boat trips comprising the total effort in this fishery, as estimated from fish ticket landings (Erstad et al. 1996). No interactions with killer whales were observed during this fishery. The

Puget Sound treaty chum salmon gillnet fishery in Hood Canal (areas 12, 12B, and 12C) and Puget Sound treaty sockeye/chum gillnet fishery in the Strait of Juan de Fuca (areas 4B, 5, and 6C) were also monitored in 1994 at 2.2% (based on % of total catch observed) and approximately 7.5% (based on % of observed trips to total landings) observer coverage, respectively (NWIFC 1995). No interactions resulting in killer whale mortalities were reported in either treaty salmon gillnet fishery.

Also in 1994, NMFS, WDF&W, and the Tribes conducted an observer program to examine seabird and marine mammal interactions with the Puget Sound treaty and non-treaty sockeye salmon gillnet fishery (areas 7 and 7A). During this fishery, observers monitored 2,205 sets, representing approximately 7% of the estimated number of sets in the fishery (Pierce et al. 1996). Killer whales were observed within 10 meters of the gear during 10 observed sets (32 animals in all), though none were observed to have been entangled.

An additional source of information on the number of killer whales killed or injured incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. During the period between 1990 and 1997, there were no fisher self-reports of killer whale mortalities from any fisheries operating within the range of this stock. However, because logbook records (fisher self-reports required during 1990-94) are most likely negatively biased (Credle et al. 1994), these are considered to be minimum estimates. Self-reported fisheries data are incomplete for 1994, not available for 1995, and considered unreliable after 1995 (see Appendix 4 of Hill and DeMaster 1998).

Table 1. Summary of incidental mortality of killer whales (Eastern North Pacific Southern Resident stock) due to commercial fisheries from 1992 through 1997 and calculation of the mean annual mortality rate. Only data from 1993 to 1997 (or the most recent 5 years of available data) are used to calculate mean annual mortality (n/a indicates that data are not available).

Fishery name	Years	Data type	Range of observer coverage	Observed mortality (in given yrs.)	Estimated mortality (in given yrs.)	1993-97 Mean annual mortality
Northern WA marine set gillnet	92-97	obs data	59-98%	0, 0, n/a, 0, 0, 0	0, 0, n/a, 0, 0, 0	0
WA Puget Sound Region salmon set/drift gillnet (observer programs listed below covered segments of this fishery):	-	-	-	-	-	-
Puget Sound non-treaty salmon gillnet (all areas and species)	93	obs data	1.3%	0	0	0
Puget Sound non-treaty chum salmon gillnet (areas 10/11 and 12/12B)	94	obs data	11%	0	0	0
Puget Sound treaty chum salmon gillnet (areas12,12B, and 12C)	94	obs data	2.2%	0	0	0
Puget Sound treaty chum and sockeye salmon gillnet (areas 4B, 5, and 6C)	94	obs data	7.5%	0	0	0

Fishery name	Years	Data type	Range of observer coverage	Observed mortality (in given yrs.)	Estimated mortality (in given yrs.)	1993-97 Mean annual mortality
Puget Sound treaty and non-treaty sockeye salmon gill net (areas 7 and 7A)	94	obs data	7%	0	0	0
Observer program total						0
Minimum total annual mortality						0

Due to a lack of observer programs, there are few data concerning the mortality of marine mammals incidental to Canadian commercial fisheries. Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. However, in 1994 one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther et al. 1995). Data regarding the level of killer whale mortality related to commercial fisheries in Canadian waters are not available, though the mortality level is thought to be minimal.

During this decade there have been no reported takes from this stock incidental to commercial fishing operations (D. Ellifrit, pers. comm.), no reports of interactions between killer whales and longline operations (as occurs in Alaskan waters; see Yano and Dahlheim 1995), no reports of stranded animals with net marks, and no photographs of individual whales carrying fishing gear. The total fishery mortality and serious injury for this stock is zero.

STATUS OF STOCK

Killer whales are not listed as "depleted" under the MMPA or listed as "threatened " or "endangered" under the Endangered Species Act. Based on currently available data, the total fishery mortality and serious injury for this stock (0) is not known to exceed 10% of the calculated PBR (0.09) and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury of zero animals per year is not known to exceed the PBR (0.9). Therefore, the Eastern North Pacific Southern Resident stock of killer whales is not classified as a strategic stock. The stock size has decreased in recent years, although at this time it is not possible to assess the status of this stock relative to its Optimum Sustainable Population.

REFERENCES

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66 (11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25pp.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Pp. 386-406, *In:* Hammond, P. S. , S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Commn. Special Issue 12.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Commn. 32:643-646.

Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.

Center for Whale Research. 1359 Smugglers Cove Rd., Friday Harbor, WA 98250.

Credle, V. R., D. P. DeMaster, M. M. Merklein, M. B. Hanson, W. A. Karp, and S. M. Fitzgerald (eds.). 1994. NMFS observer programs: minutes and recommendations from a workshop held in Galveston, Texas, November 10-11, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-94-1. 96 pp.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 pp. + appendices.

Ellifrit, D. Center for Whale Research, 1359 Smugglers Cove Rd., Friday Harbor, WA 98250.

Erstad, P., S. L. Jeffries, and D. J. Pierce. 1996. 1994 Report for the Puget Sound fishery observer program in management areas 10/11 & 12/12B: nontreaty chum gill net fishery. Wash. Dept. Fish and Wildlife., Olympia, WA. 14 pp.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Commn. 32:671-679.

Ford, J. K. B., G. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press and University of Washington Press. 102 pp.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15-26.

Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington state. Rep. Int. Whal. Commn. Special Issue 15:427-438.

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pp. 1-100, *In:* Brueggeman, J.J. (ed.), Oregon and Washington Marine Mammal and Seabird Surveys. Final Rep. OCS Study MMS 91-0093.

Guenther, T. J., R. W. Baird, R. L. Bates, P. M. Willis, R. L. Hahn, and S. G. Wischniowski. 1995. Strandings and fishing gear entanglements of cetaceans on the west coast of Canada in 1994. Paper SC/47/O6 presented to the International Whaling Commission, May 1995 (unpublished). 7pp.

Heise, K., G. Ellis, and C. Matkin. 1991. A Catalogue of Prince William Sound Killer Whales. North Gulf Oceanic Society, Homer, AK. Published for the National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Hill, P. S. and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-97. 166 pp.

Hoelzel, A. R. 1991. Analysis of regional mitochondrial DNA variation in the killer whale; implications for cetacean conservation. Rep. Int. Whal. Commn. Special Issue 13:225-233.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the Eastern North Pacific, and genetic differentiation between foraging specialists. J. Heredity 89:121-128.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Naturalist 104:362-371.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Bd. Can. 32:914-916.

Northwest Indian Fisheries Commission. 1995. Monitoring of marbled murrelet and marine mammal interactions with 1994 tribal gillnet fisheries in northern Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Final Report to NMFS Contract No. 52ABNF400087. Unpubl. report. Northwest Indian Fisheries Commission. 43 pp. Available at NWIFC, 6730 Martin Way E, Olympia, WA 98516.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Commn. Special Issue 12:209-242.

Pierce, D. J., W. P. Ritchie, and R. Kreuziger. 1994. Preliminary findings of seabird interactions with the non-treaty salmon gill net fishery: Puget Sound and Hood Canal Washington. Unpubl. report. Washington Department of Fish and Wildlife, Olympia, WA. 39 pp. Available at WDFW, 600 Capitol Way N, Olympia, WA 98501.

Pierce, D. J., M. Alexandersdottir, S. J. Jeffries, P. Erstad, W. Beattie, and A. Chapman. 1996. Interactions of marbled murrelets and marine mammals with the 1994 Puget sound sockeye gill net fishery. Final Report, Wash. Dept. Fish and Wildlife, Olympia, WA. 21 pp.

Stevens, T. A., D. Duffield, E. Asper, K. Hewlett, A. Bolz, L. Gage, and G. Bossart. 1989. Preliminary findings of restriction fragment differences in mitochondrial DNA among killer whales (*Orcinus orca*). Can. J. Zool. 67:2592-2595.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, WA. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Yano, K., and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish. Bull. 93:355-372.

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SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Short-finned pilot whales were once commonly seen off Southern California, with an apparently resident population around Santa Catalina Island, as well as seasonal migrants (Dohl et al. 1980). After a strong El Niño event in 1982-83, short-finned pilot whales virtually disappeared from this region, and despite increased survey effort along the entire U.S. west coast, few sightings were made from 1984-1992 (Jones and Szczepaniak 1992; Hill and Barlow 1992; Carretta and Forney 1993; Shane 1994; Green et al. 1992, 1993). In 1993, six groups of short-finned pilot whales were again seen off California (Mangels and Gerrodette 1994; Carretta et al. 1995), and mortality in drift gillnets increased (Julian and Beeson, 1998). Figure 1 summarizes the sighting history of short-finned pilot whales off the U.S. west coast. Although the full geographic range of the California/Oregon/Washington population is not known, it may be continuous with animals found off Baja California, and its individuals are morphologically distinct from short-finned pilot whales found farther south in the eastern tropical Pacific (Polisini 1981). Separate southern and northern forms of short-finned pilot whales have also been documented for the western North Pacific (Kasuya et al. 1988; Wada 1988; Miyazaki and Amano 1994). For the Marine Mammal Protection Act (MMPA) stock assessment reports, short-finned pilot whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Hawaiian waters.

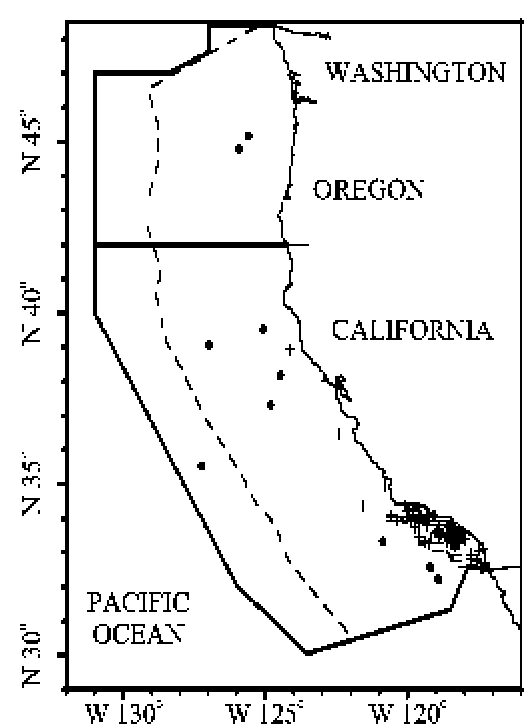

Figure 1. Short-finned pilot whale sightings made during aerial and shipboard surveys conducted off California in 1975-83 (+) and off California, Oregon and Washington, 1989-96 (!). Dashed line represents the U.S. EEZ, thick line indicates the outer boundary of all surveys combined. Greater effort was conducted off California (south of 42/N) and in the inshore half of the U.S. EEZ. See Appendix 2 of Barlow et al. (1997) and Barlow (1997) for data sources and information on timing and location of survey effort.

POPULATION SIZE

Based on surveys conducted within 300 nmi of the California, Oregon and Washington coast in 1991, 1993, and 1996, Barlow (1997) has recently calculated an abundance estimate of 970 (CV = 0.37) short-finned pilot whales.

Minimum Population Estimate

The log-normal 20th percentile of the above abundance estimate is 717 short-finned pilot whales.

Current Population Trend

Approximately nine years after the virtual disappearance of short-finned pilot whales following the 1982-83 El Niño, they appear to have returned to California waters, as indicated by an increase in sighting records as well as incidental fishery mortality (Mangels and Gerrodette 1994; Carretta et al. 1995; Julian and Beeson, 1998). However, this cannot be considered a true growth in the population, because it merely reflects large-scale, long-term movements of this species in response to changing oceanographic conditions. It is not known where the animals went after the 82-83 El Niño, nor where the recently observed animals came from. Until the range of this population and the movements of animals in relation to environmental conditions are better documented, no inferences can be drawn regarding trends in abundance of short-finned pilot whales off California, Oregon and Washington.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for short-finned pilot whales off California, Oregon and Washington.

POTENTIAL BIOLOGICAL REMOVAL

Based on this stock's unknown status and growth rate and given the precision of the estimate of annual fishery mortality (CV= 0.50), the recovery factor (F_r) is 0.48. ½R_{max} is the default value of 0.02. Multiplying these two values times the minimum population estimate of 717 yields a potential biological removal (PBR) of 6.9 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of known fishery mortality and injury for this stock of short-finned pilot whale is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1 of Barlow et al. (1997). The average estimated annual mortality for short-finned pilot whales in this fishery for the five most recent years of monitoring, 1993-97, is 13 (CV= 0.50) animals (Julian and Beeson 1998; Julian 1997, Cameron 1998). In 1996-97, a pinger experiment was conducted to evaluate whether these acoustic alarms may reduce cetacean entanglement rates in the drift gillnet fishery. Based on the positive results of this study (Cameron 1998), pingers were made mandatory in this fishery in November 1997. The observed mortality of a single short-finned pilot whale in 1997 was in a pingered net.

Table 1. Summary of available information on the incidental mortality and injury of short-finned pilot whales (California/ Oregon/Washington Stock) in commercial fisheries that might take this species. All observed entanglements of pilot whales resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes 1993-97
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	1993 1994 1995 1996 1997	13.4% 17.9% 15.6% 12.4% 26.6%	8 0 0 0 1	60 (0.54) 0 0 0 6 (0.96)	13 (0.50)
Undetermined (probably squid purse seine fishery)	strandings	1975-90	14 short-finned pilot whales stranded in Southern California with evidence of fishery interactions, probably with the squid purse seine fishery			n/a
Minimum total annual takes 1993-97						13 (0.50)

Drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and may take animals from the same population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which has increased from two vessels in 1986 to 29 vessels in 1992 (Sosa-Nishizaki et al. 1993). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2700, with an observed rate of marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set; Julian and Beeson 1998), but species-specific information is not available for the Mexican fisheries.

Historically, short-finned pilot whales were also killed in squid purse seine operations off Southern California (Miller et al. 1983; Heyning et al. 1994). No recent mortality has been reported, presumably because short-finned pilot whales are no longer common in the areas of squid purse seine fishing activity; however, there have been recent anecdotal reports of pilot whales seen near squid fishing operations off Southern California during the October 1997-

April 98 fishing season. This fishery is not currently monitored, and has expanded markedly since 1992 (California Department of Fish and Game, unpubl. data).

STATUS OF STOCK

The status of short-finned pilot whales off California, Oregon and Washington in relation to OSP is unknown. They have declined in abundance in the Southern California Bight, likely a result of a change in their distribution since the 1982-83 El Niño, but the nature of these changes and potential habitat issues are not adequately understood. Short-finned pilot whales are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Because the average annual human-caused mortality for 1993-97 (13 animals per year) exceeds the PBR (6.9) short-finned pilot whales off California are a "strategic" stock under the MMPA, and the total fishery mortality and injury cannot be considered to be insignificant and approaching zero. A take reduction plan for the drift gillnet fishery, including mandatory pingers and a minimum 6-fathom suspender length, was implemented in 1997, and preliminary results indicate that cetacean mortality has decreased markedly (Cameron 1998).

REFERENCES

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25p.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223p.

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Carretta, J. V. and K. A. Forney. 1993. Report of the two aerial surveys for marine mammals in California coastal waters using a NOAA DeHavilland Twin Otter aircraft, March 9-April 7, 1991, February 8-April 6, 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-185. 77p.

Carretta, J. V., K. A. Forney. And J. Barlow 1995. Report of 1993-94 marine mammal surveys conducted within the U.S. Navy Outer Sea Test Range off Southern California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-217. 90p.

Dohl, T. P., K. S. Norris, R. C. Guess, J. D. Bryant, and M. W. Honig. 1980. Summary of marine mammal and seabird surveys of the Southern California Bight area, 1975-1978. Part II. Cetacea of the Southern California Bight. Final Report to the Bureau of Land Management, NTIS Rep. No. PB81248189. 414p.

Green, G., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington. Ch. 1. In: Oregon and Washington Marine Mammal and Seabird Surveys. OCS Study 91-0093. Final Report prepared for Pacific OCS Region, Minerals Management Service, U.S. Department of the Interior, Los Angeles, California.

Green, G., R. A. Grotefendt, M. A. Smultea, C. E. Bowlby, and R. A. Rowlett. 1993. Delphinid aerial surveys in Oregon and Washington waters. Final Report prepared for NMFS, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, Washington, 98115, Contract #50ABNF200058.

Heyning, J. E., T. D. Lewis and C. D. Woodhouse. 1994. A note on odontocete mortality from fishing gear entanglements off Southern California. Rep. Int. Whal. Commn. Special Issue 15:439-442.

Hill, P. S. and J. Barlow. 1992. Report on a marine mammal survey of the California coast aboard the research vessel *McARTHUR* July 28 - November 5, 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-169.

Jones, P. A. and I. D. Szczepaniak. 1992. Report on the seabird and marine mammal censuses conducted for the long-term management strategy (LTMS), August 1990 through November 1991, for the U.S. Environmental Protection Agency, Region IX, San Francisco, July 1992.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F. and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-95. Fishery Bulletin 96:271-284.

Kasuya, O., T. Miyashita, and F. Kasamatsu. 1988. Segregation of two forms of short-finned pilot whales off the Pacific coast of Japan. Sci. Rep. Whales Res. Inst. 39:77-90.

Mangels, K. F. and Gerrodette, T. 1994. Report of cetacean sightings during a marine mammal survey in the eastern Pacific Ocean and Gulf of California aboard the NOAA ships *McARTHUR* and *DAVID STARR JORDAN* July 28 - November 6, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-211. 88p.

Miller, D. J., M. J. Herder and J. P Scholl. 1983. California marine mammal - fishery interaction study, 1979-1981. Administrative Report LJ-83-13C. Available from NMFS, Southwest Fisheries Science Center, P.O. Box 271, La Jolla, California, 92038. 233p.

Miyazaki, N. and M. Amano. 1994. Skull morphology of two forms of short-finned pilot whales off the Pacific coast of Japan. Rep. Int. Whaling Commn. 44:499-508.

Polisini, J. M. 1981. A comparison of *Globicephala macrorhyncha* (Gray, 1846) with the pilot whale of the North Pacific Ocean: An analysis of the skull of the broad-rostrum pilot whales of the genus *Globicephala*. Dissertation Abstracts International Vol. 41, No. 08, February 1981, p. 2928-B.

Shane, S. 1994. Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-91. Bull. Southern California Acad. Sci. 93:13-29.

Sosa-Nishizaki, O., R. De la Rosa-Pacheco, R. Castro-Longoria, M. Grijalva Chon, and J. De la Rosa Velez. 1993. Estudio biologico pesquero del pez (*Xiphias gladius*) y otras especies de picudos (marlins y pez vela). Rep. Int. CICESE, CTECT9306.

Wada, S. 1988. Genetic differentiation between forms of short-finned pilot whales off the Pacific coast of Japan. Sci. Rep. Whales Res. Inst. 39:91-101.

SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40°N in winter (Rice 1974; Gosho et al. 1984; Miyashita et al. 1995). For management, the International Whaling Commission (IWC) had divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150°W at the equator, is 160°W between 40-50°N, and ends up at 180°W north of 50°N; however, the IWC has not reviewed this stock boundary in many years (Donovan 1991). Sperm whales are found year-round in California waters (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974). They were seen in every season except winter (Dec.-Feb.) in Washington and Oregon (Green et al. 1992). Of three sperm whales that were marked off southern California in January, one was caught by whalers off northern California in June, one off Washington in June, and another far off British Columbia in April (Rice 1974). Recent summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150°W) and tapers off northward towards the tip of Baja California. The structure of sperm whale populations in the eastern tropical Pacific is not known, but the only photographic matches of known individuals from this area have been between the Galapagos Islands and coastal waters of South America (Dufault and Whitehead 1995), suggesting that the eastern tropical animals constitute a distinct stock. A recent survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific revealed no apparent hiatus in distribution between the U.S. EEZ off California and areas farther west, out to Hawaii (Barlow and Taylor 1998). Very preliminary genetic analyses revealed significant differences between sperm whales off the coast of California, Oregon and Washington and those sampled offshore to Hawaii (Mesnick et al., unpubl. data); analyses of additional genetic samples are ongoing at the NMFS, Southwest Fisheries Science Center.

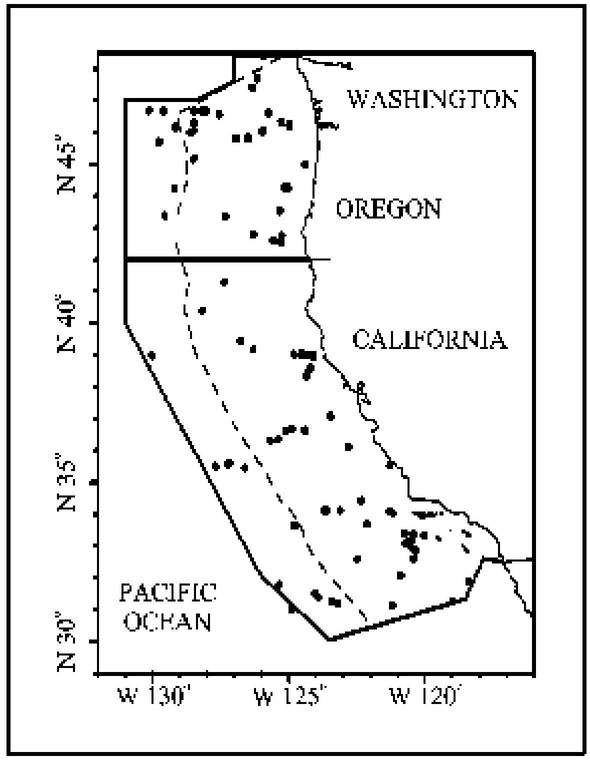

Figure 1. Sperm whale sighting locations based on aerial and shipboard surveys off California, Oregon, and Washington, 1989-96. Dashed line represents the U.S. EEZ, thick line indicates the outer boundary of all surveys combined. Greater effort was conducted off California (south of 42/N) and in the inshore half of the U.S. EEZ. See Appendix 2 of Barlow et al. (1997) and Barlow (1997) for data sources and information on timing and location of survey effort.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, sperm whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous areas: 1) California, Oregon and Washington waters (this report), 2) waters around Hawaii, and 3) Alaska waters.

POPULATION SIZE

Barlow (1997) estimates 1,191 (CV=0.22) sperm whales along the coasts of California, Oregon, and Washington during summer/fall based on ship line transect surveys in 1991, 1993, and 1996 (lognormal 95% C.I.= 778-1,824). Forney et al. (1995) estimate 892 (CV=0.99) sperm whales off California during winter/spring based on aerial line-transect surveys (95% C.I.=176-4,506), but this estimate does not correct for diving whales that were missed. Because of the long dive time of sperm whales (Leatherwood et al. 1982), it is reasonable to assume that the true abundance would be three to eight times the estimates from aerial surveys. Green et al. (1992) report that sperm whales were the third most abundant large whale (after gray and humpback whales) in aerial surveys off Oregon and Washington, but they did not estimate population size for that area. A large 1982 abundance estimate for the entire eastern North Pacific (Gosho et al. 1984) was based on a CPUE method which is no longer accepted as valid by the International Whaling Commission. Recently, a combined visual and acoustic line-transect survey conducted in the eastern temperate North Pacific in spring 1997 resulted in estimates of 24,000 (CV=0.46) sperm whales based on visual sightings, and 39,200 (CV=0.60) based acoustic detections and visual group size estimates (Barlow and Taylor 1998). However, it is not known whether any or all of these animals routinely enter the U.S. EEZ. In the eastern tropical Pacific, the abundance of sperm whales has been estimated as 22,700 (95% C.I.=14,800-34,600; Wade and Gerrodette 1993), but this area does not include areas where sperm whales are taken by drift gillnet fisheries in the U.S. EEZ and there is no evidence of sperm whale movements from the eastern tropical Pacific to the U.S. EEZ. The most precise estimate of sperm whale abundance within the area of the drift gillnet fishery is therefore from the ship survey estimate of Barlow (1997); however, this is probably an underestimate of true abundance because recent studies suggest sperm whale group sizes may have been underestimated on past line-transect surveys (Barlow and Taylor 1998).

Minimum Population Estimate

The minimum population estimate for sperm whales is taken as the lower 20th percentile of the log-normal distribution of abundance estimated from the summer/fall ship surveys off California, Oregon and Washington (Barlow 1997) or approximately 992. More sophisticated methods of estimating minimum population size would be available if a correction factor (and associated variance) were available to correct the aerial survey estimates for missed animals.

Current Population Trend

Sperm whale abundance appears to have been fairly stable in California coastal waters between 1979/80 and 1991 (Barlow 1994). Although the population in the eastern North Pacific is expected to have grown since large-scale pelagic whaling stopped in 1980, the possible effects of large unreported catches are unknown (Yablokov 1994) and the ongoing incidental ship strikes and gillnet mortality make this uncertain.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no published estimates of the growth rate for any sperm whale population (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the California portion of this stock is calculated as the minimum population size (992) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.1 (the default value for an endangered species), resulting in a PBR of 2.0.

HUMAN-CAUSED MORTALITY

Historic Whaling

Between 1800 and 1909, about 60,842 sperm whales were estimated taken in the North Pacific (Best 1976). The reported take of North Pacific sperm whales by commercial whalers between 1947 and 1987 totaled 258,000 (C. Allison, pers. comm.). Ohsumi (1980) lists an additional 28,198 sperm whales taken mainly in coastal whaling operations from 1910 to 1946. Based on the massive under-reporting of Soviet catches, Brownell et al. (1998) estimate that about 89,000 whales were additionally taken by the Soviet pelagic whaling fleet between 1949 and 1979. The Japanese coastal operations apparently also under-reported catches by an unknown amount (Kasuya 1998). Thus a total of at least 436,000 sperm whales were taken between 1800 and the end of commercial whaling for this species in 1987. Of this grand total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976 (Allen 1980, IWC statistical Areas II and III), and 965 were reported taken in land-based U.S. West coast whaling operations between 1947 and 1971 (Ohsumi 1980). In addition, 13 sperm whales were taken by shore whaling stations in California between 1919 and 1926 (Clapham et al. 1997). There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped earlier, in 1980.

Fishery Information

Sperm whales in this stock are likely to be caught only in offshore drift gillnets. Detailed information on this fishery is provided in Appendix 1 of Barlow et al. (1997). A summary of known fishery mortality and injury for this stock of sperm whales is given in Table 1. In 1996-97, a pinger experiment was conducted to evaluate whether these acoustic alarms may reduce cetacean entanglement rates in the drift gillnet fishery. Based on the positive results of this study (Cameron 1998), pingers were made mandatory in this fishery in November 1997. The 1996-97 mortality estimates were stratified for pingered and unpingered drift gillnets. Only one whale was observed in a pingered net in 1996; this whale sustained significant injuries and was not expected to survive (Cameron 1998). The average annual fishery mortality is estimated to be 3.0 sperm whales for the five most recent years of monitoring (1993-97). In addition, an estimated 1.6 sperm whales per year were entangled but released alive. In addition, some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net. The deaths of two stranded sperm whales in California were attributed to entanglement in fishing gear between 1983 and 1991 (J. Cordaro, pers. comm.). Drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and may take animals from the same population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which has increased from two vessels in 1986 to 29 vessels in 1992-(Sosa-Nishizaki et al. 1993). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2,700, with an observed rate of marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set, Julian and Beeson 1998), but species-specific information is not available for the Mexican fisheries.

Table 1. Summary of available information on the incidental mortality and injury of sperm whales (CA/OR/WA stock) for commercial fisheries that might take this species (Julian and Beeson 1998; Julian 1997; Cameron 1998). Injury includes any entanglement that does not result in immediate death and may include serious injury resulting in death. The injured whale observed in 1996 was not expected to survive . n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and injury in parentheses)	Estimated Mortality (CV in parentheses)	Mean Annual Takes 1993-97 (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	1993 1994 1995 1996 1997	observer data	13.4% 17.9% 15.6% 12.4% 26.6%	2 (1) 0 0 0 (1) 0	Mortality 15,0,0,0,0 (0.66,0) Injury 7,0,0,1,0	Mortality 3.0 (0.66) Injury 1.6 (n/a)
Total annual takes						4.6 (0.66)

Ship Strikes

Ship strikes were implicated in the deaths of two unidentified whales in 1990 (J. Cordaro, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma.

STATUS OF STOCK

The only estimate of the status of North Pacific sperm whales in relation to carrying capacity (Gosho et al. 1984) is based on a CPUE method which is no longer accepted as valid. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The annual rate of kill (3.0 per year) is greater than the calculated PBR for this stock (2.0) which would also result in the classification of this stock as “strategic”. In addition, an annual average of 1.6 sperm whales are estimated to be entangled and injured, but released alive. Total fishery mortality is not approaching zero mortality and serious injury rate. In comparing gillnet mortality with the PBR, it should be remembered that the PBR does not include sperm whales found further offshore which possibly belong to the same population. A fishery interaction problem appears to exist for sperm whales taken in the drift gillnet fishery, but enough uncertainties exist that one should not conclude from this information that sperm whales are necessarily declining in abundance off the U.S. West Coast. A take reduction plan for the drift gillnet fishery, including mandatory pingers and a minimum 6-fathom suspender length, was implemented in 1997, and preliminary results indicate that cetacean mortality has decreased markedly (Cameron 1998). The increasing levels of anthropogenic noise in the world’s oceans has been suggested to be a habitat concern for whales, particularly for deep-diving whales like sperm whales that feed in the oceans “sound channel”.

REFERENCES

Allison, C. International Whaling Commission. The Red House, 135 Station Road, Impington, Cambridge, UK CB4 9NP.

Allen, K. R. 1980. Size distribution of male sperm whales in the pelagic catches. Rep. Int. Whal. Commn. Special Issue 2:51-56.

Barlow, J. 1994. Abundance of large whales in California coastal waters: a comparison of ship surveys in 1979/80 and in 1991. Rept. Int. Whal. Commn. 44:399-406.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25p.

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the U.S. and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn, Special Issue 15:405-425.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223p.

Barlow, J. and B. L. Taylor. 1998. Preliminary abundance of sperm whales in the northeastern temperate Pacific estimated from a combined visual and acoustic survey. Paper SC/50/CAWS20 presented to the International Whaling Commission, June 1998 (unpublished).

Best, P. B. 1976. A review of world sperm whale stocks. Paper ACMRR/MM/SC/8 Rev. 1, FAO Scientific Consultation of Marine Mammals, Bergen, Norway.

Best, P. B. 1993. Increase rates in severely depleted stocks of baleen whales. ICES J. Mar. Sci. 50:169-186.

Brownell, R. L., Jr., A. V. Yablokov and V. A. Zemmsky. 1998. USSR pelagic catches of North Pacific sperm whales, 1949-1979: Conservation implications. Paper SC/50/CAWS27 presented to the International Whaling Commission, June 1998 (unpublished).

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Clapham, P. J., S. Leatherwood, I. Szczepaniak, and R. L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.

Cordaro, J. Southwest Region, NMFS, 501 West Ocean Blvd, Long Beach, CA 90802-4213.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-83: Status, abundance, and distribution. Final Report to the Minerals Management Service, Contract No. 14-12-0001-29090. 284p.

Donovan, G. P. 1991. A review of IWC stock boundaries. Rept. Int. Whal. Commn., Special Issue 13:39-68.

Dufault, S. and H. Whitehead. 1995. The geographic stock structure of female and immature sperm whales in the South Pacific. Rep. Int. Whal. Commn. 45:401-405.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15-26.

Gosho, M. E., D. W. Rice, and J. M. Breiwick. 1984. The sperm whale. Mar. Fish. Rev. 46(4):54-64.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1 In: J. J. Brueggeman (ed.). Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.

Hanan, D. A. 1986. California Department of Fish and Game coastal marine mammal study, annual report for the period July 1, 1983 - June 30, 1984. Admin. Rept. LJ-86-16 available from Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA. 55pp.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game Fish. Bull. No. 175. 95pp.

Heyning, J. E., and T. D. Lewis. 1990. Fisheries interactions involving baleen whales off southern California. Rep. int.

Whal. Commn. 40:427-431.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F. and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-95. Fishery Bulletin 96:271-284.

Kasuya, T. 1998. Evidence of statistical manipulations in Japanese coastal sperm whale fishery. Paper SC/50/CAWS10 presented to the International Whaling Commission, June 1998 (unpublished).

Leatherwood, S., K. Goodrich, A. L. Kinter, and R. M. Truppo. 1982. Respiration patterns and 'sightability' of whales. Rep. Int. Whal. Commn. 32:601-613.

Miyashita, T., H. Kato, and T. Kasuya (Eds.). 1995. Worldwide map of cetacean distribution based on Japanese sighting data. Volume 1. National Research Institute of Far Seas Fisheries, Shizuoka, Japan. 140pp.

Ohsumi, S. 1980. Catches of sperm whales by modern whaling in the North Pacific. Rep. Int. Whal. Commn. Special Issue 2: 11-18.

Rice, D. W. 1988. Sperm whale Physeter macrocephalus, Linnaeus 1758. pp. 177-233 In: S. H. Ridgway and R. J. Harrison (eds.). Handbook of Marine Mammals, Vol. 4. Academic Press, London.

Sosa-Nishizaki, O., R. De la Rosa Pacheco, R. Castro Longoria, M. Grijalva Chon, and J. De la Rosa Velez. 1993. Estudio biologico pesquero del pez (*Xiphias gladius*) y otras especies de picudos (marlins y pez vela). Rep. Int. CICESE, CTECT9306.

Wade, P. R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Rept. Int. Whal. Commn. 43:477-493.

HUMPBACK WHALE (*Megaptera novaeangliae*): California/Oregon/Washington - Mexico Stock

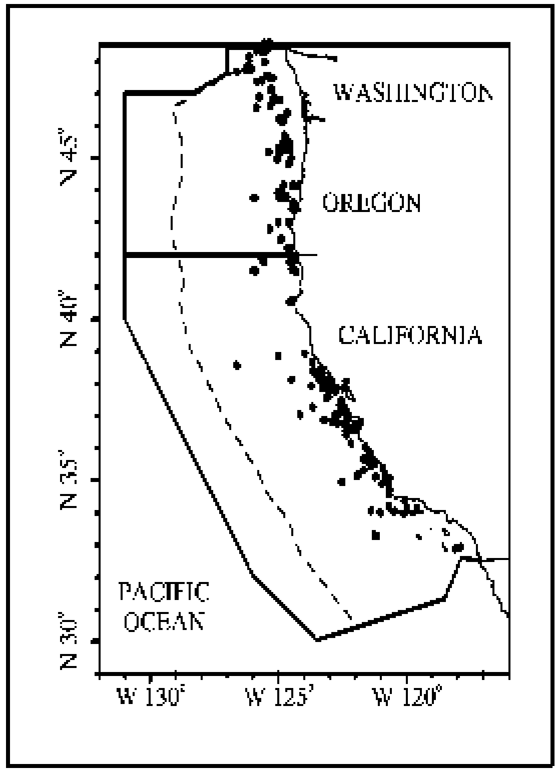

Figure 1. Humpback whale sighting locations based on aerial and shipboard surveys off California, Oregon, and Washington, 1989-96. Dashed line represents the U.S. EEZ, thick line indicates the outer boundary of all surveys combined. Greater effort was conducted off California (south of 42/N) and in the inshore half of the U.S. EEZ. See Appendix 2 of Barlow et al. (1997) and Barlow (1997) for data sources and information on timing and location of survey effort.

STOCK DEFINITION AND GEOGRAPHIC RANGE

Although the International Whaling Commission (IWC) only considered one stock (Donovan 1991), there is now good evidence for multiple populations of humpback whales in the North Pacific (Johnson and Wolman 1984; Baker et al. 1990). Aerial, vessel, and photo-identification surveys, and genetic analyses indicate that within the U.S. EEZ, there are at least three relatively separate populations that migrate between their respective summer/fall feeding areas and winter/spring calving and mating areas (Calambokidis et al. 1997, Baker et al. 1998): 1) winter/spring populations in coastal Central America and Mexico which migrate to the coast of California to southern British Columbia in summer/fall (Steiger et al. 1991, Calambokidis et al. 1993) - referred to as the California/ Oregon/Washington - Mexico stock (Figure 1); 2) winter/spring populations of the Hawaiian Islands which migrate to northern British Columbia/Southeast Alaska and Prince William Sound west to Kodiak (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997) - referred to as the Central North Pacific stock; and 3) winter/spring populations of Japan which, based on Discovery Tag information, probably migrate to waters west of the Kodiak Archipelago (the Bering Sea and Aleutian Islands) in summer/fall (Berzin and Rovnin 1966, Nishiwaki 1966, Darling 1991) - referred to as the Western North Pacific stock. Winter/spring populations of humpback whales also occur in Mexico's offshore islands, but the migratory destination of these whales is not well known (Calambokidis et al. 1993, Calambokidis et al. 1997). Significant levels of genetic differences were found between the California and Alaska feeding groups based on analyses of mitochondrial DNA (Baker et al. 1990) and nuclear DNA (Baker et al. 1993). The genetic exchange rate between California and Alaska is estimated to be less than 1 female per generation (Baker 1992). Two breeding areas (Hawaii and coastal Mexico) showed fewer genetic differences than did the two feeding areas (Baker 1992). This is substantiated by the observed movement of individually-identified whales between Hawaii and Mexico (Baker et al. 1990). There have been no individual matches between 597 humpbacks photographed in California and 617 humpbacks photographed in Alaska (Calambokidis et al. 1996). Only two of the 81 whales photographed in British Columbia have matched with a California catalog (Calambokidis et al. 1996), indicating that the U.S./Canada border is an approximate geographic boundary between feeding populations.

Until further information becomes available, three management units of humpback whales (as described above) are recognized within the U.S. EEZ of the North Pacific: the California/Oregon/Washington - Mexico stock (this report), the Central North Pacific Stock, and the Western North Pacific Stock. The Central and Western North Pacific stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000 (Rice 1978), but this population was reduced by whaling to approximately 1,200 by 1966 (Johnson and Wolman 1984). The North Pacific total now almost certainly exceeds 6,000 humpback whales (Calambokidis et al. 1997). Dohl et al. (1983) first estimated the central California feeding population to be 338 (CV=0.29) based on aerial surveys in August through November of 1980-83; however, this estimate does not include a correction for submerged animals. More recently, the size of the "California" feeding stock of humpback whales has been estimated by three independent methods. 1) Calambokidis et al. (1998) estimated the number of humpback whales in California-Washington to be 843 (CV=0.06) based on mark-recapture estimates comparing their 1996 and 1997 photo-identification catalogs. 2) Barlow (1997) estimates 1,152 (CV=0.15) humpbacks in California, Oregon and Washington waters based on ship line-transect surveys in summer/autumn of 1991, 1993, and 1996. 3) Forney et al. (1995) estimate 319 (CV=0.41) humpback whales in California coastal waters based on aerial line-transect surveys in winter/spring of 1991 and 1992 (not corrected for diving whales). In addition, Green et al. (1992) report that humpback whales were the second most abundant large whale (after the gray whale) in aerial surveys off Oregon and Washington, but they did not estimate population size. These estimates for the west-coast stock are not significantly different from each other, The shipboard estimates are likely to be the most unbiased, and the aerial surveys are likely to be the most negatively biased because submerged animals are missed. Mark-recapture estimates may also be negatively biased due to heterogeneity in sighting probabilities (Hammond 1986). However, given that the above mark-recapture estimate is based on a large fraction of the entire population (the 1996-97 catalog contained 492 known individuals), this bias is likely to be minimal. Also, in previous mark-recapture analyses on the same population, when methods were used which account for heterogeneity, estimates were comparable or smaller (Calambokidis et al. 1993). The most precise and least biased estimate is likely to be the mark-recapture estimate of 843 (CV=0.06) humpback whales for this population.

Minimum Population Estimate

The minimum population estimate for humpback whales in the California/Mexico stock is taken as the lower 20th percentile of the log-normal distribution of 1996-97 abundance estimated from mark-recapture methods (Calambokidis et al. 1998) or approximately 802.

Current Population Trend

There is some indication that humpback whales increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994) and between 1991 and 1993 (Barlow and Gerrodette 1996), but these trends are not statistically significant. Mark-recapture population estimates increased steadily from 1988/90 to 1992/93 at about 5% per year (Calambokidis and Steiger 1994), and the even higher 1996-97 estimate suggests a continued population increase (Calambokidis et al. 1998). Although the population in the North Pacific is expected to have grown since being given protected status in 1966, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the growth rate of humpback whale populations in the North Pacific (Best 1993). The proportion of calves in the California/Mexico stock from 1986 to 1994 appeared much lower than previously measured for humpback whales in other areas (Calambokidis and Steiger 1994), but in 1995-97 a greater proportion of calves were identified, and the 1997 reproductive rates for this population are closer to those reported for humpback whale populations in other regions (Calambokidis et al. 1998).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (802) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.1 (for an endangered species), resulting in a PBR of 1.6. Because this stock spends approximately half its time in Mexican waters, the PBR allocation for U.S. waters is 0.8 whales per year.

HUMAN-CAUSED MORTALITY

Historic Whaling

The reported take of North Pacific humpback whales by commercial whalers totaled approximately 7,700 between 1947 and 1987 (C. Allison, pers. comm.). In addition, approximately 7,300 were taken along the west coast of North America from 1919 to 1929 (Tonnessen and Johnsen 1982). Total 1910-1965 catches from the California-Washington stock includes at least the 2,000 taken in Oregon and Washington, the 3,400 taken in California, and the 2,800 taken in Baja California (Rice 1978). Shore-based whaling apparently depleted the humpback whale stock off California twice: once prior to 1925 (Clapham et al. 1997) and again between 1956 and 1965 (Rice 1974). There has been a prohibition on taking humpback whales since 1966.

Fishery Information

Humpback whales are known to be killed only in offshore drift gillnets. A summary of known fishery mortality and injury for this stock of humpback whales is given in Table 1. Detailed information on this fishery is provided in Appendix 1 of Barlow et al. (1997). The average fishery mortality and injury is estimated to be 1.4 humpback whales per year for the five most recent years of monitoring (1993-97) based on the observation of one entangled whale (released alive). Some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net. The deaths of two humpback whales that stranded in the Southern California Bight have been attributed to entanglement in fishing gear (Heyning and Lewis 1990). A humpback whale was observed off Ventura, CA in 1993 with a 20 ft section of netting wrapped around and trailing behind. Other unobserved fisheries may also result in injuries or deaths of humpback whales. In 1997, one humpback whale was snagged by a central California salmon troller, and the animal swam away with the hook and many feet of trailing monofilament (NMFS, Southwest Region, unpublished data).

Drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and probably take animals from the same population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which has increased from two vessels in 1986 to 29 vessels in 1992 (Sosa-Nishizaki et al. 1993). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2,700, with an observed rate of marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set, Julian and Beeson 1998), but species-specific information is not available for the Mexican fisheries.

Table 1. Summary of available information on the incidental mortality and injury of humpback whales (CA/OR/WA - Mexico stock) for commercial fisheries that might take this species (Julian and Beeson 1998, Julian 1997, Cameron 1998). Injury includes any entanglement that does not result in immediate death and may include serious injury resulting in death. n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and Injury)	Estimated Mortality (CV in parentheses)	Mean Annual Takes 1993-97 (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	1993 1994 1995 1996 1997	observer data	13.4% 17.9% 15.6% 12.4% 26.6%	0 0 (1) 0 0 0	Mortality 0,0,0,0,0 Injury 0,6,0,0,0 (0.91)	Mortality 0 Injury 1.2 (0.91)
CA angel shark/halibut and other species large mesh (>3.5") set gillnet fishery	1991-95	observer data	0-15%	0,0,0,0,0	0,0,0,0,0	0
CA salmon troll fishery	1997	incidental report	0%	(1)	n/a	Injury 0.2 (n/a)
Total annual takes						1.4 (0.91)

Ship Strikes

Ship strikes were implicated in the deaths of at least two humpback whales in 1993 and one humpback whale in 1995, and one unidentified whale, which may have been a humpback whale, was struck and injured by a small boat in 1997 (J. Cordaro, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not have obvious signs of trauma. Several humpback whales have been photographed in California with large gashes in their dorsal surface that appear to be from ship strikes (J. Calambokidis, pers. comm.). The average number of humpback whale deaths by ship strikes from 1993-97 is at least 0.6 per year.

STATUS OF STOCK

Humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity (K) by commercial whaling (Braham 1991). Clearly the North Pacific population was severely depleted. The initial abundance has never been estimated separately for the "California" stock, but this stock was also depleted (probably twice) by whaling (Rice 1974; Clapham et al. 1997). Humpback whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California/Mexico stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated annual mortality and injury due to entanglement (1.4/yr) plus ship strikes (0.6/yr) in California is greater than the PBR allocation of 0.8 for U.S. waters. If none of the injuries from fishing gear entanglement resulted in death, the known mortality due to ship strikes alone would not exceed the PBR. In a review of the severity of injury to the humpback whale entangled in 1994, the Pacific Scientific Review Group determined that it this animal was not seriously injured. Based on strandings and gillnet observations, annual humpback whale mortality and serious injury in California's drift gillnet fishery is probably greater than 10% of the PBR; therefore, total fishery mortality is not approaching zero mortality and serious injury rate. The California stock appears to be increasing in abundance. The increasing levels of anthropogenic noise in the world's oceans, such as those produced by ATOC (Acoustic Thermometry of Ocean Climate) or LFA (Low Frequency Active) Sonar, have been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound.

REFERENCES

Allison, C. International Whaling Commission. The Red House, 135 Station Road, Impington, Cambridge, UK CB4 9NP.

Baker, C. S. 1992. Genetic variability and stock identity of humpback whales, world-wide. Final Contract Report to Int. Whal. Commn. 45pp.

Baker, C. S., D. A. Gilbert, M. T. Weinrich, R. Lambertsen, J. Calambokidis, B. McArdle, G. K. Chambers, and S. J. O'Brien. 1993. Population characteristics of DNA fingerprints in humpback whales (Megaptera novaeangliae). J. Heredity 84:281-290.

Baker, C. S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi, and O. von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Mol. Ecol. 7: (in press).

Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis, and S. J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344(15):238-240.

Barlow, J. 1994. Abundance of large whales in California coastal waters: a comparison of ship surveys in 1979/80 and in 1991. Rept. Int. Whal. Commn. 44:399-406.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25p.

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the U.S. and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn, Special Issue 15:405-425.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-248. 223p.

Barlow, J. and T. Gerrodette. 1996. Abundance of cetaceans in California waters based on 1991 and 1993 ship surveys. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-233. 15p.

Berzin, A. A., and A. A. Rovnin. 1966. The distribution and migrations of whales in the northeastern part of the Pacific, Chukchi and Bering Seas. Izvestiya Tikhookeanskogo Nauchno-Issledovatel'skogo Institut Rybnogo Khozyaistva I Okeanografii 58:179-207. (Translated by Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Seattle, 1968, pp. 103-136 *In:* K. I. Panin (ed.), Soviet Research on Marine Mammals of the Far East).

Best, P. B. 1993. Increase rates in severely depleted stocks of baleen whales. ICES J. Mar. Sci. 50:169-186.

Braham, H. W. 1991. Endangered whales: status update. A Report on the 5-year status of stocks review under the 1978 amendments to the U.S. Endangered Species Act. NMFS Unpublished Report.

Calambokidis, J. Cascadia Research Collective, 218 ½ West Fourth Avenue, Olympia, WA 98501.

Calambokidis, J., T. Chandler, K. Rasmussen, G. H. Steiger, and L. Schlender. 1998. Humpback and blue whale photographic identification: Report on research in 1997. Report prepared by Cascadia Research, 218½ W. Fourth Ave, Olympia, WA 98501. 41p.

Calambokidis, J., and G. H. Steiger. 1994. Population assessment of humpback and blue whales using photo-identification from 1993 surveys off California. Final Contract Report to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038. 31pp.

Calambokidis, J., G. H. Steiger, and J. R. Evenson. 1993. Photographic identification and abundance estimates of humpback and blue whales off California in 1991-92. Final Contract Report 50ABNF100137 to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038. 67pp.

Calambokidis, J., G. H. Steiger, J. R. Evenson, K. R. Flynn, K. C. Balcomb, D. E. Claridge, P. Bloedel, J. M. Straley, C. S. Baker, O. von Ziegesar, M. E. Dahlheim, J. M. Waite, J. D. Darling, G. Ellis, and G. A. Green. 1996. Interchange and isolation of humpback whales in California and other North Pacific feeding grounds. Mar. Mamm. Sci. 12(2):215-226.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. J. Quinn, II, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urbán R., J. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. Ladrón de Guevara P., S. A. Mizroch, L. Schlender and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific Basin. Final Contract Report 50ABNF500113 to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038. 72p.

Cameron, G. 1998. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1997. Paper SC/50/SM02 presented to the International Whaling Commission, June 1998 (unpublished). 15 pp.

Clapham, P. J., S. Leatherwood, I. Szczepaniak, and R. L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.

Cordaro, J. Southwest Region, NMFS, 501 West Ocean Blvd, Long Beach, CA 90802-4213.

Darling, J. D. 1991. Humpback whales in Japanese waters. Ogasawara and Okinawa. Fluke identification catalog 1987-1990. Final Contract Report, World Wildlife Fund for Nature, Japan. 22 pp.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-83: Status, abundance, and distribution. Final Report to the Minerals Management Service, Contract No. 14-12-0001-29090. 284p.

Donovan, G. P. 1991. A review of IWC stock boundaries. Rept. Int. Whal. Commn., Special Issue 13:39-68.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15-26.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1 <u>In:</u> J. J. Brueggeman (ed.). <u>Oregon and Washington Marine Mammal and Seabird Surveys</u>. Minerals Management Service Contract Report 14-12-0001-30426.

Hammond, P. S. 1986. Estimating the size of naturally marked whale populations using capture-recapture techniques. Rept. Int. Whal. Commn., Special Issue 8:253-282.

Hanan, D. A. 1986. California Department of Fish and Game coastal marine mammal study, annual report for the period July 1, 1983 - June 30, 1984. Admin. Rept. LJ-86-16 available from Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA. 55pp.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game Fish. Bull. No. 175. 95pp.

Heyning, J. E., and T. D. Lewis. 1990. Fisheries interactions involving baleen whales off southern California. Rep. int. Whal. Commn. 40:427-431.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, <u>Megaptera</u> <u>novaeangliae</u>. Mar. Fish. Rev. 46(4):30-37.

Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.

Julian, F. and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-95. Fishery Bulletin 96:271-284.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. Pp. 172-191 *In:* K. S. Norris (ed.), Whales, Dolphins and Porpoises. University of California Press, Berkeley, CA. Academic Press, New York.

Perry, A., C. S. Baker, L. M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: a summary and critique. Rep. Int. Whal. Commn. (Special Issue 12):307-317.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. pp. 170-195 In: W. E. Schevill (ed.). The Whale Problem: A Status Report. Harvard Press, Cambridge, MA.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. pp. 29-44 In: K. S. Norris and R. R. Reeves (eds.). Report on a Workshop on Problems Related to Humpback Whales (Megaptera novaeangliae) in Hawaii. Contr. Rept. to U. S. Marine Mammal Commn. NTIS PB-280-794. 90pp.

Sosa-Nishizaki, O., R. De la Rosa Pacheco, R. Castro Longoria, M. Grijalva Chon, and J. De la Rosa Velez. 1993. Estudio biologico pesquero del pez (*Xiphias gladius*) y otras especies de picudos (marlins y pez vela). Rep. Int. CICESE, CTECT9306.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb, and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Mar. Mamm. Sci. 7:306-310.

Tonnessen, J. N., and A. O. Johnsen. 1982. The History of Modern Whaling. Univ. Calif. Press, Berkeley and Los Angeles. 798pp.

Yablokov, A. V. 1994. Validity of whaling data. Nature 367:108.

APPENDIX 1

CHRONOLOGY OF U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENT REPORTS, 1995-1999.

Key: X=Revised with new information, R=Reprinted without revision, N=New stock, E=Eliminated Stock; Shading indicates that a stock was not defined for that year.

U.S. PACIFIC MARINE MAMMAL STOCK	**1995**	**1996**	**1998**[1]	**1999**
PINNIPEDS				
CALIFORNIA SEA LION (*Zalophus californianus californianus*): U.S. Stock	X	X		
HARBOR SEAL (*Phoca vitulina richardsi*): California Stock	X	X		
HARBOR SEAL (*Phoca vitulina richardsi*): Oregon & Washington Coastal Waters Stock	X	X	X	
HARBOR SEAL (*Phoca vitulina richardsi*): Washington Inland Waters Stock	X	X	X	
NORTHERN ELEPHANT SEAL (*Mirounga angustirostris*): California Breeding Stock	X	X		
GUADALUPE FUR SEAL (*Arctocephalus townsendi*)	X	R		
NORTHERN FUR SEAL (*Callorhinus ursinus*): San Miguel Island Stock	X	X	X	
HAWAIIAN MONK SEAL (*Monachus schauinslandi*)	X	X		X
CETACEANS - U. S. WEST COAST				
HARBOR PORPOISE (*Phocoena phocoena*): Central California Stock	X	X		X
HARBOR PORPOISE (*Phocoena phocoena*): Northern California Stock	X	X		X
HARBOR PORPOISE (*Phocoena phocoena*): Oregon/Washington Coast Stock	X	X	X	X
HARBOR PORPOISE (*Phocoena phocoena*): Inland Washington Stock	X	X	X	X
DALL'S PORPOISE (*Phocoenoides dalli*): California/Oregon/Washington Stock	X	X		
PACIFIC WHITE-SIDED DOLPHIN (*Lagenorhynchus obliquidens*): California/ Oregon/Washington, Northern and Southern Stocks	X	X		

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U.S. PACIFIC MARINE MAMMAL STOCK	**1995**	**1996**	**1998**[1]	**1999**
RISSO'S DOLPHIN (*Grampus griseus*): California/Oregon/Washington Stock	X	X		

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U.S. PACIFIC MARINE MAMMAL STOCK	**1995**	**1996**	**1998** [1]	**1999**
BOTTLENOSE DOLPHIN (*Tursiops truncatus*): California Coastal Stock	X	X		
BOTTLENOSE DOLPHIN (*Tursiops truncatus*): California/Oregon/Washington Offshore Stock	X	X		
STRIPED DOLPHIN (*Stenella coeruleoalba*): California/Oregon/Washington Stock	X	X		
SHORT-BEAKED COMMON DOLPHIN (*Delphinus delphis*): California/Oregon/Washington Stock	X	X		
LONG-BEAKED COMMON DOLPHIN (*Delphinus capensis*): California Stock	X	X		
NORTHERN RIGHT WHALE DOLPHIN (*Lissodelphis borealis*): California/Oregon/Washington Stock	X	X		
KILLER WHALE (*Orcinus orca*): California/Oregon/Washington Pacific Coast Stock	X	X		E
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock	X	X		X
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Transient Stock	(INCLUDED IN ALASKA REPORTS)			X
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Offshore Stock				N
SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): California/Oregon/Washington Stock	X	X		X
BAIRD'S BEAKED WHALE (*Berardius bairdii*): California/Oregon/Washington Stock	X	X		
MESOPLODONT BEAKED WHALES (*Mesoplodon* spp.): California/Oregon/Washington Stocks	X	X	X	
CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): California/Oregon/Washington Stock	X	X		
PYGMY SPERM WHALE (*Kogia breviceps*): California/Oregon/Washington Stock	X	X		
DWARF SPERM WHALE (*Kogia simus*): California/Oregon/Washington Stock	X	X		

CHRONOLOGY OF U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENT REPORTS, 1995-1999.

Key: X=Revised with new information, R=Reprinted without revision, N=New stock, E=Eliminated Stock; Shading indicates that a stock was not defined for that year.

U.S. PACIFIC MARINE MAMMAL STOCK	1995	1996	1998 [1]	1999
SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock	X	X		X
HUMPBACK WHALE (*Megaptera novaeangliae*): California/Oregon/Washington - Mexico Stock	X	X		X
BLUE WHALE (*Balaenoptera musculus*): California/Mexico Stock	X	X		
FIN WHALE (*Balaenoptera physalus*): California/Oregon/Washington Stock	X	X		
BRYDE'S WHALE (*Balaenoptera edeni*): Eastern Tropical Pacific Stock	X	X		
SEI WHALE (*Balaenoptera borealis*): Eastern North Pacific Stock	X	X		
MINKE WHALE (*Balaenoptera acutorostrata*): California/Oregon/Washington Stock	X	X	X	
CETACEANS - HAWAII				
ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Hawaiian Stock	X	R		
RISSO'S DOLPHIN (*Grampus griseus*): Hawaiian Stock	X	R		
BOTTLENOSE DOLPHIN (*Tursiops truncatus*): Hawaiian Stock	X	R		
PANTROPICAL SPOTTED DOLPHIN (*Stenella attenuata*): Hawaiian Stock	X	R		
SPINNER DOLPHIN (*Stenella longirostris*): Hawaiian Stock	X	R		
STRIPED DOLPHIN (*Stenella coeruleoalba*): Hawaiian Stock	X	R		
MELON-HEADED WHALE (*Peponocephala electra*): Hawaiian Stock	X	R		
PYGMY KILLER WHALE (*Feresa attenuata*): Hawaiian Stock	X	R		

CHRONOLOGY OF U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENT REPORTS, 1995-1999.

Key: X=Revised with new information, R=Reprinted without revision, N=New stock, E=Eliminated Stock; Shading indicates that a stock was not defined for that year.

U.S. PACIFIC MARINE MAMMAL STOCK	1995	1996	1998[1]	1999
FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Stock	X	R		
KILLER WHALE (*Orcinus orca*): Hawaiian Stock	X	R		
SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): Hawaiian Stock	X	R		
BLAINVILLE'S BEAKED WHALE (*Mesoplodon densirostris*): Hawaiian Stock	X	R		
CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): Hawaiian Stock	X	R		
PYGMY SPERM WHALE (*Kogia breviceps*): Hawaiian Stock	X	R		
DWARF SPERM WHALE (*Kogia simus*): Hawaiian Stock	X	R		
SPERM WHALE (*Physeter macrocephalus*): Hawaiian Stock	X	R		
BLUE WHALE (*Balaenoptera musculus*): Hawaiian Stock	X	R		
FIN WHALE (*Balaenoptera physalus*): Hawaiian Stock	X	R		
BRYDE'S WHALE (*Balaenoptera edeni*): Hawaiian Stock	X	R		
APPENDIX TITLES	**APPENDIX NUMBERS**			
Summary of Pacific Stock Assessment Reports	1	3	1	2
Description of U.S. Commercial Fisheries		1		
Cetacean Survey Effort		2		
Review of New Information for Pacific Marine Mammal Stocks			2	
Chronology of U. S. Pacific Stock Assessment Reports, 1995-1999				1

[1] The public comment, review and revision process has necessitated about a one-year time lag between the draft revision and final publication of Marine Mammal Stock Assessment Reports. Therefore, in 1997, the Stock Assessment Report dates were changed to '1998' to match the 1998 publication year of the report.

REFERENCES

Pacific Region

1995: Barlow, J., R. L. Brownell, Jr., D. P. DeMaster, K. A. Forney, M. S. Lowry, S. Osmek, T. J. Ragen, R. R. Reeves, and R. J. Small. 1995. U.S. Pacific marine mammal stock assessments. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-219. 162 pp.

1996: Barlow, J. K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U. S. Pacific Marine Mammal Stock Assessments: 1996. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-248. 223 pp.

1998: Barlow, J., P. S. Hill, K. A. Forney, and D. P. DeMaster. 1998. U. S. Pacific Marine Mammal Stock Assessments: 1998. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-258. 42 pp.

1999: Forney, K. A., M. M. Muto and J. Baker. 1999. U. S. Pacific Marine Mammal Stock Assessments: 1999. (This report).

Alaska Region:

1995: Small, R. J. and D. P. DeMaster. 1995. Alaska Marine Mammal Stock Assessments 1995. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-57, 93 pp.

1996: Hill, P. S., D. P. DeMaster and R. J. Small. 1996. Alaska Marine Mammal Stock Assessments, 1996. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-78, 150 pp.

1998: Hill, P. S. and D. P. DeMaster. 1998. Alaska Marine Mammal Stock Assessments, 1998. U. S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-97, 166 pp.

APPENDIX 2

SUMMARY OF 1999 PACIFIC MARINE MAMMAL STOCK ASSESSMENT REPORTS (FOR STOCKS UNDER NMFS JURISDICTION).

Species	Stock Area	Region	NMFS Center	Nmin	Rmax	Fr	PBR	Total Annual Mortality	Annual Fish. Mortality	Strategic Status
Monk seal	Hawaii	PAC	SWC	1,423	0.07	0.1	5.0[1]	N/A	N/A	Y
Harbor porpoise	Central California	PAC	SWC	4,172	0.04	0.50	42	24	24	N
Harbor porpoise	Northern California	PAC	SWC	8,061	0.04	0.5	81	0.0	0.0	N
Harbor porpoise	Oregon/ Washington Coast	PAC	AKC	32,769	0.04	0.5	328	12	12	N
Harbor porpoise	Inland Washington	PAC	AKC	2,545	0.04	0.4	20	15	15	N
Killer whale	Eastern North Pacific Transient	PAC	AKC	336	0.04	0.45	3.0	2.0	2.0	N
Killer whale	Eastern North Pacific Offshore	PAC	SWC	209	0.04	0.5	2.1	0.0	0.0	N
Killer whale	Eastern North Pacific Southern Resident	PAC	AKC	89	0.04	0.5	0.9	0.0	0.0	N
Short-finned pilot whale	California/ Oregon/ Washington	PAC	SWC	717	0.04	0.48	6.9	13	13	Y
Sperm whale	California/ Oregon/ Washington	PAC	SWC	992	0.04	0.1	2.0	3.0	3.0	Y
Humpback whale	California/ Oregon/ Washington - Mexico	PAC	SWC	802	0.04	0.1	0.8	2.0	1.4	Y

[1]The Endangered Species Act takes precedence in the management of this species and, under the Act, allowable take is zero.