Marine Mammals of the Pacific Region and Hawaii

SEFSC Pascagoula Laboratory

Unit 22

JAY BARLOW

JIM CARRETTA

KARIN FORNEY

MARK LOWRY

NMFS Southwest Fisheries Science Center

La Jolla California

DAVE JOHNSTON

JASON BAKER

NMFS Pacific Islands Fisheries Science Center

Honolulu Hawaii

Photo above:
A killer whale breaks the ocean surface. The Southern Resident stock of killer whales is listed as Endangered under the ESA.

INTRODUCTION

The Pacific region has 64 stocks of at least 39 species of marine mammals. All species are protected under the Marine Mammal Protection Act (MMPA), and threatened and endangered species are also protected under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service is responsible for managing two stocks of sea otters (central California and Washington), while the National Marine Fisheries Service (NMFS) has management authority for cetacean and pinniped stocks. Of the 64 marine mammal stocks found in the Pacific region, 13 stocks are listed under the ESA (2 threatened, 11 endangered), and 16 stocks are strategic under the MMPA. In the eastern Pacific Ocean (i.e. waters off Washington, Oregon, California, and northern Mexico), the strategic stocks of marine mammals include endangered sperm, humpback, blue, fin, sei, and southern resident killer whales; short-finned pilot whales; long-beaked common dolphins; and threatened Guadalupe fur seals and California sea otters. Strategic stocks in Hawaiian waters include endangered sperm, blue, fin, and sei whales; false killer whales (Hawaii stock); and endangered Hawaiian monk seals. Fourteen stocks have known population trends: seven are increasing, one is stable/increasing, five are stable, and one is declining; the trends for the remaining 50 stocks are unknown. The status of marine mammal stocks in the Pacific region is summarized in Table 22-1. Seven marine mammal stocks are highlighted in this chapter: the Hawaiian monk seal, the Pacific Islands Stock Complex of false killer whales, the eastern North Pacific stocks of humpback and blue whales, and three stocks of

Table 22-1

Status of marine mammal stocks in the Pacific region.

Species/stock	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual fisheries-caused mortality[3]	Total annual human-caused mortality[4]	Strategic status[5]	MMPA/ESA status[6]	Trend[7]
Seals and sea lions							
California sea lion (U.S.)	141,842	8,511	≥ 159	≥ 232	No		I
Guadalupe fur seal	3,028	91	0.0	0.0	Yes	T	I
Harbor seal							
California	31,600	1,896	389	≥389	No		S
Oregon & Washington Coast	22,380	1,343	≥ 13	≥ 15.2	No		S
Washington Inland Waters	12,844	771	≥ 30	≥ 34	No		S
Hawaiian monk seal	1,214	Undet.	Unknown	Unknown	Yes	E	D
Northern elephant seal (California Breeding)	74,913	4,382	≥ 8.8	≥ 10.4	No		I
Northern fur seal (San Miguel Island)	5,096	219	≥ 1.0	≥ 1.0	No		U
Whales and porpoises							
Baird's beaked whale (CA / OR / WA)	203	2.0	0	0.2	No		U
Blainville's beaked whale (Hawaii)	1,204	9.6	0.8	0.8	No		U
Blue whale							
Eastern North Pacific	1,005	1.0	0	0.6	Yes	E	U
Western North Pacific	Unknown	Undet.	Unknown	Unknown	Yes	E	U
Bottlenose dolphin							
California Coastal	290	2.4	0.4	0.4	No		S
CA / OR / WA Offshore	2,295	23	0.2	0.2	No		U
Hawaii	2,046	20	≥ 0.2	≥ 0.2	No		U
Brydes whale							
Eastern Tropical Pacific	Unknown	Undet.	0	0	No		U
Hawaii	373	3.7	Unknown	Unknown	No		U
Common dolphin (CA / OR / WA)	392,687	3,927	59	59	No		U
Cuvier's beaked whale							
CA / OR / WA	1,234	10	0	≥ 0.2	No		U
Hawaii	6,919	69	Unknown	Unknown	No		U
Dall's porpoise (CA / OR / WA)	43,425	347	1.8	1.4	No		U
Dwarf sperm whale							
CA / OR / WA	Unknown	Undet.	0	0	No		U
Hawaii	11,555	116	Unknown	Unknown	No		U
False killer whale							
Hawaii	249	2.4	4.9	4.9	Yes		U
Palmyra Atoll	806	7.7	1.9	1.9	No		U
Fin whale							
CA / OR / WA	2,760	16	0	1.4	Yes	E	U
Hawaii	101	0.2	Unknown	Unknown	Yes	E	U
Fraser's dolphin (Hawaii)	7,917	79	Unknown	Unknown	No		U
Harbor porpoise							
Morro Bay	1,206	10	4.5	4.5	No		I
Monterey Bay	1,149	10	9.5	9.5	No		S
Northern California / Southern Oregon	12,940	259	≥ 0	≥ 0	No		U
Oregon / Washington Coast	27,705	277	0.6	0.6	No		U
San Francisco–Russian River	6,254	63	≥ 0.8	≥ 0.8	No		S/I
Washington Inland Waters	7,841	63	15.2	15.4	No		U
Humpback whale (CA / OR / WA)	1,236	2.5	≥ 1.8	≥ 2.2	Yes	E	I
Killer whale							
Eastern North Pacific Offshore	331	3.3	0	0	No		U
Eastern North Pacific Southern Resident	89	0.18	0	0.2	Yes	E	U
Hawaii	250	2.5	Unknown	Unknown	No		U
Long-beaked common dolphin (California)	1,152	11	12.5	12.5	Yes		U
Longman's beaked whale (Hawaii)	371	3.7	Unknown	Unknown	No		U
Melon-headed whale (Hawaii)	1,386	14	Unknown	Unknown	No		U
Mesoplodont beaked whales (CA / OR / WA)	576	5.7	0	0	No		U

Table 22-1

Continued from the previous page.

Species/stock	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual fisheries-caused mortality[3]	Total annual human-caused mortality[4]	Strategic status[5]	MMPA/ESA status[6]	Trend[7]
Minke whale							
CA / OR / WA	544	5.4	0	0	No		U
Hawaii	Unknown	Undet.	Unknown	Unknown	No		U
Northern right whale dolphin (CA / OR / WA)	11,754	113	18	18	No		U
Pacific white-sided dolphin (CA / OR / WA)	39,822	382	5.4	5.4	No		U
Pantropical spotted dolphin (Hawaii)	7,362	74	$\geq$ 0.8	$\geq$ 0.8	No		U
Pygmy killer whale (Hawaii)	382	3.8	Unknown	Unknown	No		U
Pygmy sperm whale							
CA / OR / WA	Unknown	Undet.	0	0.2	No		U
Hawaii	4,082	41	Unknown	Unknown	No		U
Risso's dolphin							
CA / OR / WA	9,947	80	6.6	6.6	No		U
Hawaii	1,426	14	Unknown	Unknown	No		U
Rough-toothed dolphin (Hawaii)	13,184	132	Unknown	Unknown	No		U
Sei whale							
Eastern North Pacific	27	0.005	0	0	Yes	E	U
Hawaii	37	0.1	Unknown	Unknown	Yes	E	U
Short-finned pilot whale							
CA / OR / WA	123	0.98	1.0	1.0	Yes		U
Hawaii	5,986	60	0.8	0.8	No		U
Sperm whale							
CA / OR / WA	1,719	3.4	0.2	0.2	Yes	E	U
Hawaii	5,531	11	0.0	0.0	Yes	E	U
Spinner dolphin (Hawaii)	1,691	17	0	0	No		U
Striped dolphin							
CA / OR / WA	16,737	167	0	0	No		U
Hawaii	7,078	71	Unknown	Unknown	No		U
Other marine mammals[8]							
Sea otter							
California	2,376	7	Unknown	Unknown	Yes	T	I
Washington[9]	790	8	Unknown	Unknown	No		I

[1] N_{min} is a conservative estimate of abundance used to estimate PBR; it provides reasonable assurance that the stock size is equal to or greater than the estimate.

[2] The maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or stay at its optimum sustainable population level (50–100% of its carrying capacity); calculated as the product of N_{min}, one-half of R_{max} (the maximum productivity rate), and F_r (the recovery factor). Undet. = undetermined.

[3] An estimate of the total number of annual mortalities and serious injuries (likely to result in death) caused by commercial fisheries; represents injuries/mortalities occurring only within the U.S. Exclusive Economic Zone.

[4] An estimate of the total number of annual mortalities and serious injuries (likely to result in death) caused by humans; includes other sources of mortality, such as ship strikes, strandings, orphaned animals collected for public display, mortalities associated with research activities, take by foreign countries, and mortalities associated with activities authorized through incidental take regulations.

[5] As defined in the Marine Mammal Protection Act (MMPA) Amendments of 1994, any marine mammal stock 1) for which the level of direct human-caused mortality exceeds the PBR level; 2) which is declining and likely to be listed as threatened under the Endangered Species Act (ESA); or 3) which is listed as threatened or endangered under the ESA or as depleted under the MMPA.

[6] As defined in the MMPA, any species that is listed as threatened (T) or endangered (E) under the ESA is also considered to be a depleted (D) stock.

[7] Trends: I=increasing; S/I=stable/increasing; S=stable; D=decreasing; U=unknown.

[8] These species are under the jurisdiction of the U.S. Fish and Wildlife Service, and are not included in the stock-status tables of the National Overview.

[9] There is no formal Federal ESA designation for the northern sea otter, but this stock is legally designated as endangered by the State of Washington (Washington Administrative Code 232-12-014).

Charles Littnan, NMFS

Juvenile monk seal.

harbor porpoise in central California. Additional details and information about all 62 stocks managed by NMFS in the Pacific region can be found in the MMPA stock assessment reports (Carretta et al., 2007).

HAWAIIAN MONK SEAL

Stock Definition and Geographic Range

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI) in six main reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll. Additional populations with limited reproduction are found at Necker and Nihoa Islands, and a small but apparently growing number of seals occur throughout the main Hawaiian Islands (MHI).

Genetic variation among NWHI monk seals appears low and may reflect both a long-term history of low population levels and more recent declines due to human influences. On average, 10–15% of the seals migrate among the NWHI subpopulations (Johnson and Kridler, 1983; Harting, 2002). These subpopulations are therefore not demographically isolated, although the different island subpopulations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly from the 1950's to the 1980's, while other subpopulations rapidly declined. NWHI and MHI seals have not been compared genetically, but observed interchange of individuals among the regions is extremely rare, suggesting that these may be more appropriately designated as separate stocks. Further evaluation of a separate MHI stock will be pursued following genetic stock structure analysis (currently underway) and additional studies of MHI monk seals. In the meantime, while research and recovery activities may focus on the problems of single island/atoll subpopulations, the species is managed as a single stock.

Population Size and Current Trend

The total Hawaiian monk seal abundance in 2007 was estimated at 1,247; this estimate is the sum of estimated abundance at the six main NWHI subpopulations, an extrapolation of counts at Necker and Nihoa Islands, and a minimum abundance estimate for the MHI. A total of 1,072 seals (including pups) were estimated for the main reproductive subpopulations in 2005. Estimates for Necker and Nihoa Islands (± standard deviation) were 48.5 (± 19.9) and 51.7 (± 22.1), respectively. The total number of individually identifiable seals in the MHI was 77 for 2005, and is the current best minimum abundance estimate for this area. The minimum population estimate (N_{min}) for the entire Hawaiian monk seal population in 2007 was 1,214 seals.

Total mean non-pup beach counts at the six main reproductive NWHI subpopulations in 2005 were 67% lower than in 1958. From 1998 (the first year for which a reliable total abundance estimate has been obtained) through 2005, abundance has declined at 3.8% per year; this is the best estimate of current population trend.

Natural sources of mortality which may impede the recovery of Hawaiian monk seals include food limitation, shark predation, single- and multiple-male aggression, and disease/parasitism. Various measures to detect and mitigate male aggression have been developed and successfully applied. Shark-related injury and mortality incidents occur throughout the monk seal's range, but shark predation on monk seal pups has emerged as a serious threat since the late 1990's. Various mitigation measures are ongoing to address this problem.

An Unusual Mortality Event (UME) contingency plan has recently been published for the monk seal (Yochem et al., 2004). While disease effects on monk seal demographic trends are uncertain, there is concern that diseases of livestock, feral animals, pets, or humans could be transferred to native monk seals in the MHI and potentially spread to the core population in the NWHI. Recent diagnoses confirm that in 2003 and 2004, two deaths of free-ranging monk seals were associated with diseases not previously found in the species: leptospirosis and toxoplasmosis. *Leptospira* bacteria are found in many of Hawaii's streams and estuaries and are associated with livestock and rodents. Cats, domestic and feral, are a common source of toxoplasma parasites.

Human-induced mortality has caused two major declines of the Hawaiian monk seal (Ragen, 1999). Sealers, surviving sailors of wrecked ships, guano gatherers, and feather hunters decimated this species in the 1800's (Dill and Bryan, 1912; Wetmore, 1925; Clapp and Woodward, 1972). A 1958 survey indicated at least a partial recovery of the species during the first half of this century (Rice, 1960); however, subsequent surveys documented a second major decline beginning in 1958 (or earlier), during which several populations (Kure Atoll, Midway Atoll, and Pearl and Hermes Reef) decreased by 80–100%. The causes of this second decline have not been fully explained, but population trends at some sites appear to have been determined by the pattern of human disturbance (Kenyon, 1972; Gerrodette and Gilmartin, 1990; Ragen, 1999). Such disturbances have caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups, thereby increasing juvenile mortality. Currently, human activity in the NWHI is highly restricted and human disturbance of seals has become relatively rare. In contrast, a small number of seals coexist with 1.2 million residents and over 6 million tourists each year in the MHI, where disturbance of seals is a concern.

Fishery interactions with monk seals include operations/gear conflict, seal consumption of discarded fish, and competition for prey. Entanglement of monk seals in discarded fishing gear, which is believed to originate outside the Hawaiian Archipelago, is a source of mortality and injury throughout the seal's range. The NWHI lobster fishery has been closed since 2000 due to uncertainty in stock assessments, removing a potential source of interactions with monk seals. The NWHI bottomfish fishery, which has been reported to interact with monk seals, will close no later than 2011 in accordance with President Bush's establishment of the Papahānaumokuākea Marine National Monument in 2006. Interactions between the pelagic longline fishery and monk seals apparently ceased in 1991 after NMFS established a permanent Protected Species Zone extending 50 nautical miles (n.mi.) around the NWHI and the corridors between the islands. Interactions between nearshore fisheries and monk seals also occur in the MHI, mostly involving hookings of seals. A total of 32 seals were observed with embedded hooks in the MHI during 1990–2005, and the frequency of such hookings appears to be on the rise.

In addition to disturbance and nearshore fishery interactions, monk seals face other challenges in the MHI. These include exposure to feral and domestic animals, which represent potential disease vectors. Additionally, vessel traffic around the populated islands carries the potential for collisions with seals and impacts from oil spills. Thus, issues surrounding the presence of monk seals in the MHI will likely become an increasing focus for management and recovery of this species.

Stock Status

In 1976, the Hawaiian monk seal was designated as endangered under the ESA and depleted under the MMPA. The species is well below its optimum sustainable population (OSP) and therefore is characterized as a strategic stock under the MMPA. According to the methodology specified in the 1994 Amendments to the MMPA and guidelines subsequently developed by NMFS, potential biological removal (PBR) for the monk seal is undetermined. The original 1983 Recovery Plan for the Hawaiian monk seal was revised in 2007.

J. P. McVey, NOAA Sea Grant

Hawaiian monk seal, Laysan Island, Hawaii.

Wayne Hoggard, SEFSC

False killer whales and dolphins seen from the bow of a NOAA Research Vessel.

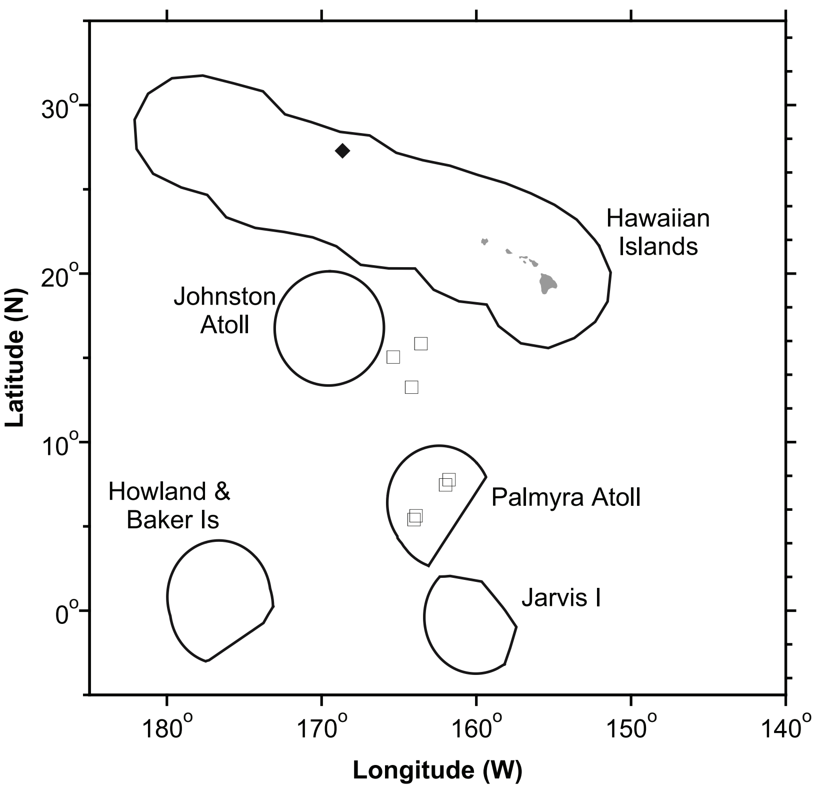

Figure 22-1

False killer whale sighting locations during standardized shipboard surveys of the Hawaiian U.S. EEZ (2002, black diamond), the Palmyra U.S. EEZ (2005, open squares), and pelagic waters of the central Pacific south of the Hawaiian Islands (2005, open squares). Outer lines represent approximate boundary of U.S. EEZs.

FALSE KILLER WHALE: PACIFIC ISLANDS STOCK COMPLEX

Stock Definition and Geographic Range

False killer whales are found worldwide in tropical and warm-temperate waters. In the North Pacific, this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. Most knowledge about this species comes from outside of Hawaiian waters, although there are six stranding records from Hawaiian waters (Nitta, 1991; Maldini et al., 2005) and two sightings of false killer whales were made during a 2002 shipboard survey of U.S. waters surrounding the Hawaiian Islands (Figure 22-1; Barlow, 2006). Smaller-scale surveys conducted in the MHI show that false killer whales are also commonly encountered in nearshore waters (Mobley et al., 2000; Mobley, 2001, 2002, 2003, 2004; Baird et al., 2005).

Genetic analyses of tissue samples collected near the main Hawaiian Islands indicate that Hawaiian false killer whales are reproductively isolated from false killer whales found in the eastern tropical Pacific Ocean (Chivers et al., 2007); however, the offshore range of this Hawaiian population is unknown. Fishery interactions demonstrate that this species also occurs in U.S. territorial waters around Palmyra Atoll (Table 22-2; Figure 22-2), but it is not known whether these animals are part of the Hawaiian stock or whether they represent a separate stock of false killer whales. Recent surveys have confirmed the presence of false killer whales in the U.S. Exclusive Economic Zone (EEZ) waters of American Samoa and Johnston Atoll. For the MMPA stock assessment reports, there are currently two Pacific Island Region management stocks: 1) the Hawaiian stock, which includes animals found within the EEZ of the Hawaiian Islands; and 2) the Palmyra stock, which includes false killer whales found in the EEZ of Palmyra Atoll.

Population Size and Current Trend

Population estimates for this species have been made from shipboard surveys in Japan and the eastern tropical Pacific, but genetic evidence suggests that false killer whales around Hawaii form a distinct population. A recent mark–recapture

		Outside of U.S. EEZ			Hawaiian Island EEZ			Palmyra Island EEZ		
Year	% observer coverage	Obs.	Est.	Mean annual takes	Obs.	Est.	Mean annual takes	Obs.	Est.	Mean annual takes
2001	23.0	2	11 (0.71)		0	0 (-)		1	4 (1.00)	
2002	24.8	3	12 (0.58)		0	0 (-)		2	5 (0.71)	
2003	21.9	0	0 (-)	7.7 (0.34)	2	8 (0.68)	4.9 (0.41)	0	0 (-)	1.9 (0.59)
2004	25.4	3	12 (0.58)		3	13 (0.58)		0	0 (-)	
2005	34.2	1	4 (1.00)		1	3 (1.00)		0	0 (-)	

Table 22-2
Summary of available information on observed (Obs.) and estimated (Est.) incidental mortality and serious injury of false killer whales (Hawaiian stock) in commercial fisheries, by EEZ region. Data is based on observer data from the Hawaii-based longline fishery. Mean annual take estimates are based on 2001–05 data; the coefficient of variation (CV) is in parentheses. The minimum total annual take within U.S. EEZ waters is estimated to be 6.8 (CV = 0.34).

photo-identification study of false killer whales in the inshore waters of the main Hawaiian Islands produced an estimate of 123 individuals (CV = 0.72; Baird et al., 2005). Analyses of a 2002 shipboard line-transect survey of the entire Hawaiian EEZ (Hawaiian Islands Cetacean and Ecosystem Assessment Survey or HICEAS) resulted in an abundance estimate of 236 (CV = 1.13) false killer whales (Barlow, 2006). A re-analysis of the HICEAS data using improved methods and incorporating additional sighting information obtained during line-transect surveys south of the Hawaiian EEZ during 2005 resulted in a revised estimate of 484 (CV = 0.93) false killer whales within the Hawaiian Islands EEZ (Barlow and Rankin, 2007). This is the best available abundance estimate for false killer whales within the Hawaiian Islands EEZ.

Recent line-transect surveys in the Palmyra EEZ produced an estimate of 1,329 (CV = 0.65) false killer whales (Barlow and Rankin, 2007). This is the best available abundance estimate for false killer whales within the Palmyra Atoll EEZ.

Information on the current population trend of false killer whales is not available for either Hawaii or Palmyra Atoll.

Stock Status

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the types of gear used in Hawaiian fisheries (including gillnets, traps, and longlines) are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used, and float lines from lobster traps and longlines occasionally entangle whales. Interactions with cetaceans have been reported for all Hawaiian pelagic fisheries, and false killer whales have been identified in fishermen's logs and NMFS observer catches from pelagic longlines (Nitta and Henderson, 1993).

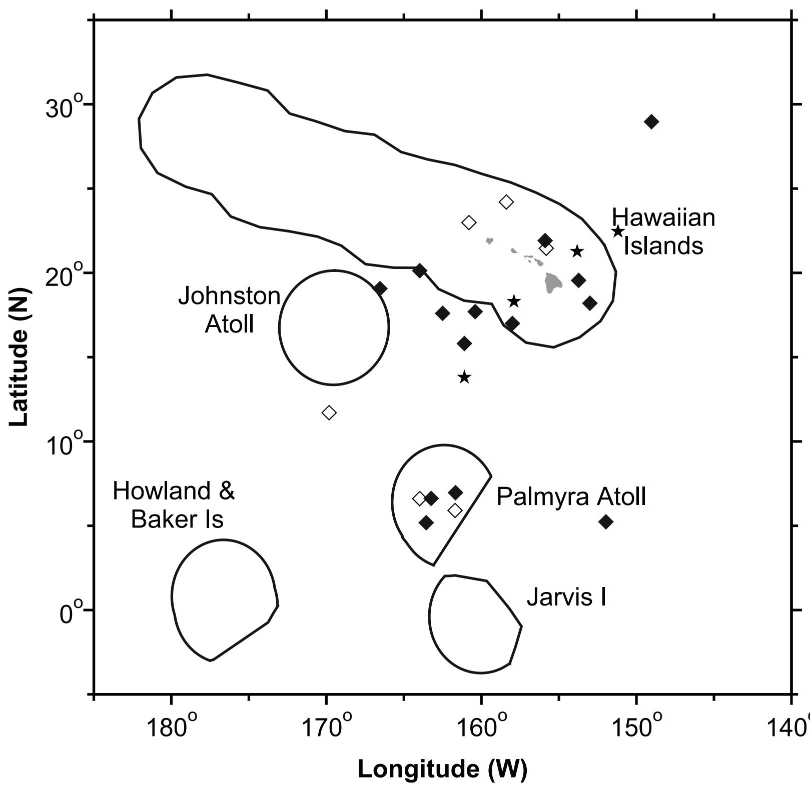

Figure 22-2
Locations of observed false killer whale takes (filled symbols) and possible takes of this species (open symbols) in the Hawaii-based longline fishery, 2001–05. Stars are locations of genetic samples from fishery-caught false killer whales. Solid lines represent the U.S. EEZ.

Between 1994 and 2005, 20 false killer whales were observed hooked in the Hawaii-based longline fishery, with approximately 4–34% of all effort observed (Forney and Kobayashi, 2007; Figure 22-2). The average interaction rate of false killer whales was 0.81 animals per 1,000 sets. All false killer whales caught were considered seriously injured, based on the nature of the interactions (Forney


Stan Butler

Humpback whale breaching, Hawaiian Islands Humpback Whale National Marine Sanctuary.

and Kobayashi, 2005). Average 5-year estimates of mortality and serious injury for 2001–05 are 7.7 (CV = 0.34) false killer whales per year outside of the U.S. EEZ, 4.9 (CV = 0.41) false killer whales within the Hawaiian Islands EEZ, and 1.9 (CV = 0.59) false killer whales within the Palmyra Atoll EEZ (Table 22-2). Total U.S. EEZ mortality and serious injury for all areas combined averaged 6.8 (CV = 0.34) false killer whales per year between 2001 and 2005.

False killer whales are not listed as threatened or endangered under the ESA or as depleted under the MMPA. Because the rate of mortality and serious injury to false killer whales within the Hawaiian Islands EEZ (4.9 animals per year) exceeds the PBR (PBR = 2.4) under the MMPA, this stock is considered a strategic stock under the 1994 amendments to the MMPA. The total fishery mortality and serious injury for Hawaiian false killer whales cannot be considered to be insignificant and approaching zero, because it exceeds the PBR. The rate of mortality and serious injury to false killer whales within the Palmyra Atoll EEZ in the Hawaii-based longline fishery (1.9 animals per year) does not exceed the PBR (7.7) for this stock and thus, this stock is not considered strategic. The total fishery mortality and serious injury for the Palmyra stock is greater than 10% of the PBR and, therefore, cannot be considered insignificant and approaching zero.

HUMPBACK WHALE: CALIFORNIA/ OREGON/WASHINGTON STOCK

Stock Definition and Geographic Range

Within the North Pacific, at least three separate stocks of humpback whales migrate between their winter/spring calving and mating areas and their summer/fall feeding areas: 1) the California/ Oregon/Washington stock (CA/OR/WA stock, also called the eastern North Pacific stock), which includes whales that migrate from Mexico and Central America to feeding grounds off the U.S. west coast and southern British Columbia in summer/fall (Figure 22-3); 2) the Central North Pacific stock, which includes whales that migrate from the Hawaiian Islands to northern British Columbia, Southeast Alaska, and Prince William Sound west to Kodiak; and 3) the Western North Pacific stock, which includes whales that migrate from islands in the western Pacific to feeding areas off Russia, along the Aleutian Islands, and in the Bering Sea. Winter/spring populations of humpback whales also occur in Mexico's offshore islands, but the summer/fall feeding destination of these whales is not well known. Although this structure represents the predominant migration pathways, some individual whales migrate from Mexico to the Gulf of Alaska and others migrate from Japan to British Columbia. In general, interchange occurs (at low levels) between breeding areas, but fidelity is extremely high among the feeding areas.

Significant genetic differences exist between the California and Alaska feeding groups based on analyses of mitochondrial DNA and nuclear DNA. The genetic exchange rate between the California and Alaska groups is estimated to be less than one female per generation. The two breeding areas (Hawaii and coastal Mexico) showed fewer genetic differences than did the corresponding feeding areas. The observed movement of individually identified whales between Hawaii and Mexico substantiates these findings.

Population Size and Current Trend

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000, but whaling reduced this population to approximately 1,200 by 1966. The entire North Pacific total now almost certainly exceeds 6,000 humpback whales. For the CA/OR/WA stock, the more recent abundance estimate is 1,300–1,400 whales based on ship surveys in 1996 and 2001 and on mark–recapture studies in 2002 and 2003. Ship surveys provide some indication that humpback whales increased in abundance in California coastal waters between 1979–80 and 1991 and between 1991 and 1996; however, estimates declined between 1996 and 2001. Mark–recapture population estimates increased steadily from 1988–90 to 1997–98 at about 8% per year. The CA/OR/WA stock appears to have declined in abundance between 1998 and 1999, but the most recent mark–recapture estimate shows that growth may have resumed. Population estimates for the entire North Pacific have also increased substantially, from 1,200 whales in 1966 to between 6,000 and 10,000 whales circa 1992. Although these estimates are based on different methods and the earlier estimate is extremely uncertain, the population growth rate implied by these estimates (6–8%) is consistent with the recently observed growth rate of the CA/OR/WA stock. The best estimate of humpback whale abundance in the CA/OR/WA region is the average of the 2001–05 line-transect estimate (1,401 animals) and the 2002/2003 mark–recapture estimate (1,391 animals) or 1,396 whales.

Stock Status

Humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity (K) by commercial whaling. The initial abundance has never been estimated separately for the CA/OR/WA stock, but this stock was also depleted (probably twice) by whaling. Both the central and eastern stocks have been recovering since the end of commercial whaling in 1964, and recent population growth rates have been 6–8% annually. Humpback whales are formally listed as endangered under the 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 (1.8 per year), ship strikes (0.2 per year), and other anthropogenic sources (0.2 per year) is less than the potential biological removal (PBR = 2.5) estimated for U.S. waters.

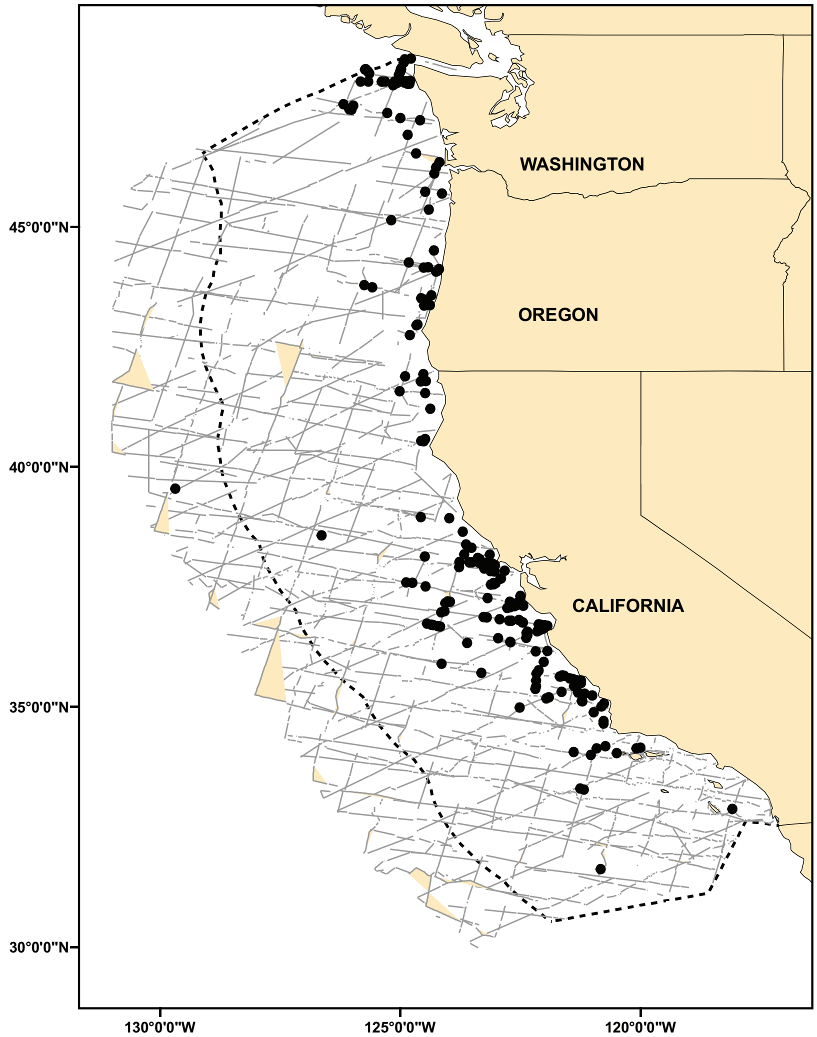

Figure 22-3
Humpback whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991–2005. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

BLUE WHALE: EASTERN NORTH PACIFIC STOCK

Stock Definition and Geographic Range

The North Pacific contains at least two stocks of blue whales that are distinguishable based on stable differences in call characteristics. Up to five stocks

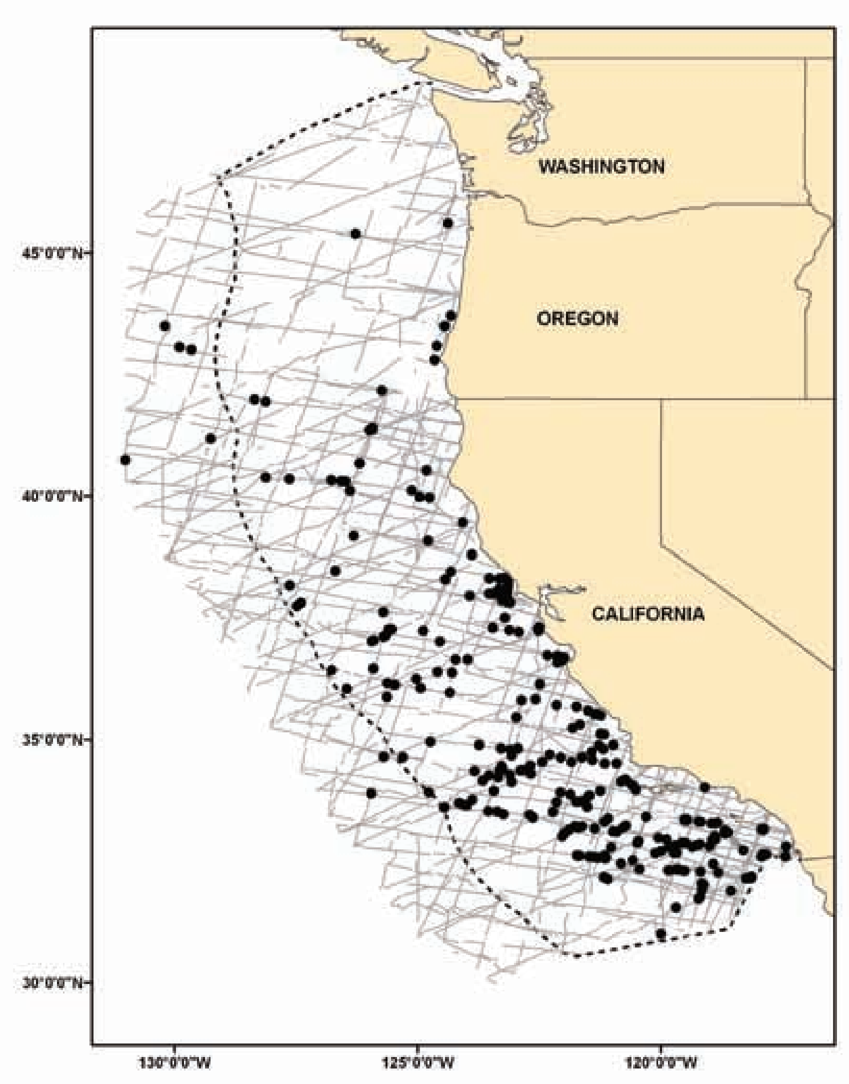

Figure 22-4
Blue whale sighting locations based on aerial and summer/autumn shipboard surveys off California, Oregon, and Washington, 1999–2005. Dashed line represents the U.S. EEZ; thin lines represent completed transect effort for all surveys combined.

SWFSC Protected Resources Division

Aerial photo of a blue whale with her calf in the eastern tropical Pacific Ocean.

have been proposed for the North Pacific. This section covers the Eastern North Pacific stock that feeds primarily in California waters in summer/fall (from June to November) and migrates south to reproductive areas off Mexico and as far south as the Costa Rica Dome (10°N) in winter/spring. Blue whales have been seen and heard off Oregon with increasing frequency since 2000 (Figure 22-4). In 2004, blue whales were seen in the northern Gulf of Alaska for the first time in approximately two decades. One of those whales was identified by photographers as a whale that was previously seen off southern California in the 1990's. In recent years, acoustic researchers have documented Eastern North Pacific blue whale calls in the Gulf of Alaska. It is not known whether blue whales are now rediscovering this historical feeding area or whether they have continued to use this area in small numbers that escaped the notice of whale biologists.

Population Size and Current Trend

The size of the feeding stock of blue whales in California was estimated recently using both line-transect methods and mark–recapture methods. The line-transect estimates of 800 whales were based on ship surveys off California, Oregon, and Washington in 2001 and 2005. The mark-recapture estimates were based on photographs of individual whales taken off California in 2000–02, and averaged 1,567 individuals. The best current estimate of blue whale abundance is the average of the line-transect and mark–recapture estimates, or approximately 1,186 blue whales off the U.S. West Coast.

There is some indication that blue whales have increased in abundance in California coastal waters between 1979–80 and 1991, and between 1991 and 1996. This may be due to an increase in the blue whale stock as a whole, but could also be the result of increased use of California waters as a feeding area. Although the population in the North Pacific is expected to have grown since being given protected status in 1966, the possibility of continued unauthorized takes after blue whales were protected and the existence of incidental ship strikes make this uncertain.

Stock Status

Previously, blue whales in the entire North Pacific were estimated to be at 33% (1,600) of historic carrying capacity (4,900). The initial abundance has never been estimated separately for the eastern stock, but this stock was almost certainly depleted by whaling. Blue whales are formally listed as endangered under the ESA, and consequently the eastern North Pacific stock is automatically considered as a depleted and strategic stock under the MMPA. There were no observed fishery entanglements during the period of 1998–2002, and the total estimated human-caused mortality and serious injury due to ship strikes (0.6 per year) is less than the potential biological removal (PBR = 1.0) calculated for this stock.

HARBOR PORPOISE: CENTRAL CALIFORNIA STOCKS

Stock Definition and Geographic Range

In the Pacific, harbor porpoises are found in coastal and inland waters from Point Conception, California, north to Alaska and west to the Kamchatka Peninsula (in eastern Russia) and Japan (Gaskin, 1984). Most harbor porpoise along the California coast are found in waters less than 60 m deep (Barlow, 1988; Carretta et al., 2001). In contrast to harbor porpoises on the U.S. East Coast, which exhibit seasonal migrations between the Carolinas and the Gulf of Maine (Polacheck et al., 1995), U.S. West Coast harbor porpoises appear to have limited geographic movement. Along the California coast, harbor porpoise were previously divided into two stocks (central California and northern California) based on regional differences in pollutant levels and other evidence of limited movement in this region (Calambokidis and Barlow, 1991). Recent molecular genetic evidence has revealed further population subdivision within this region (Chivers et al., 2002), and four harbor porpoise stocks are now recognized off California (Figure 22-5). This stock structure includes three stocks in central California (Morro Bay, Monterey Bay, and San Francisco–Russian River; Table 22-3), and a Northern California/Southern Oregon stock. Harbor porpoise stock boundaries may be further refined as additional genetic samples are analyzed in this region.

Small-scale movements of harbor porpoises along the California coast in response to changing oceanographic conditions, such as El Niño, have been suggested by Forney (1999), who found that porpoise abundance off central California was negatively correlated with higher than normal sea surface temperatures.

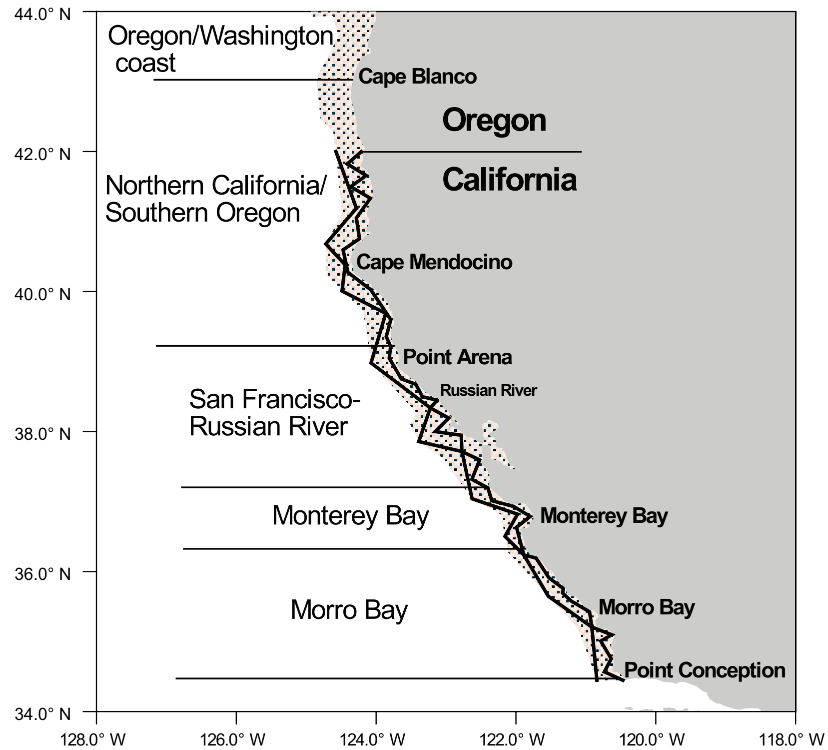

Figure 22-5
Harbor porpoise stocks and boundaries in California and southern Oregon. Stippled area shows approximate harbor porpoise habitat between 0–200 m depths. The thick solid line represents survey transects flown during 1989–2002 aerial surveys. Survey coverage north of the California/Oregon border has been completed by the National Marine Mammal Laboratory.

Stock	Population size	Lower 95% confidence interval	Upper 95% confidence interval	Coefficient of variation
Morro Bay	1,656	730	3,183	0.39
Monterey Bay	1,149	675	3,353	0.42
San Francisco–Russian River	8,521	4,151	17,145	0.38

Table 22-3
Estimated population sizes for harbor porpoise stocks in central California based on 1999 and 2002 aerial surveys.

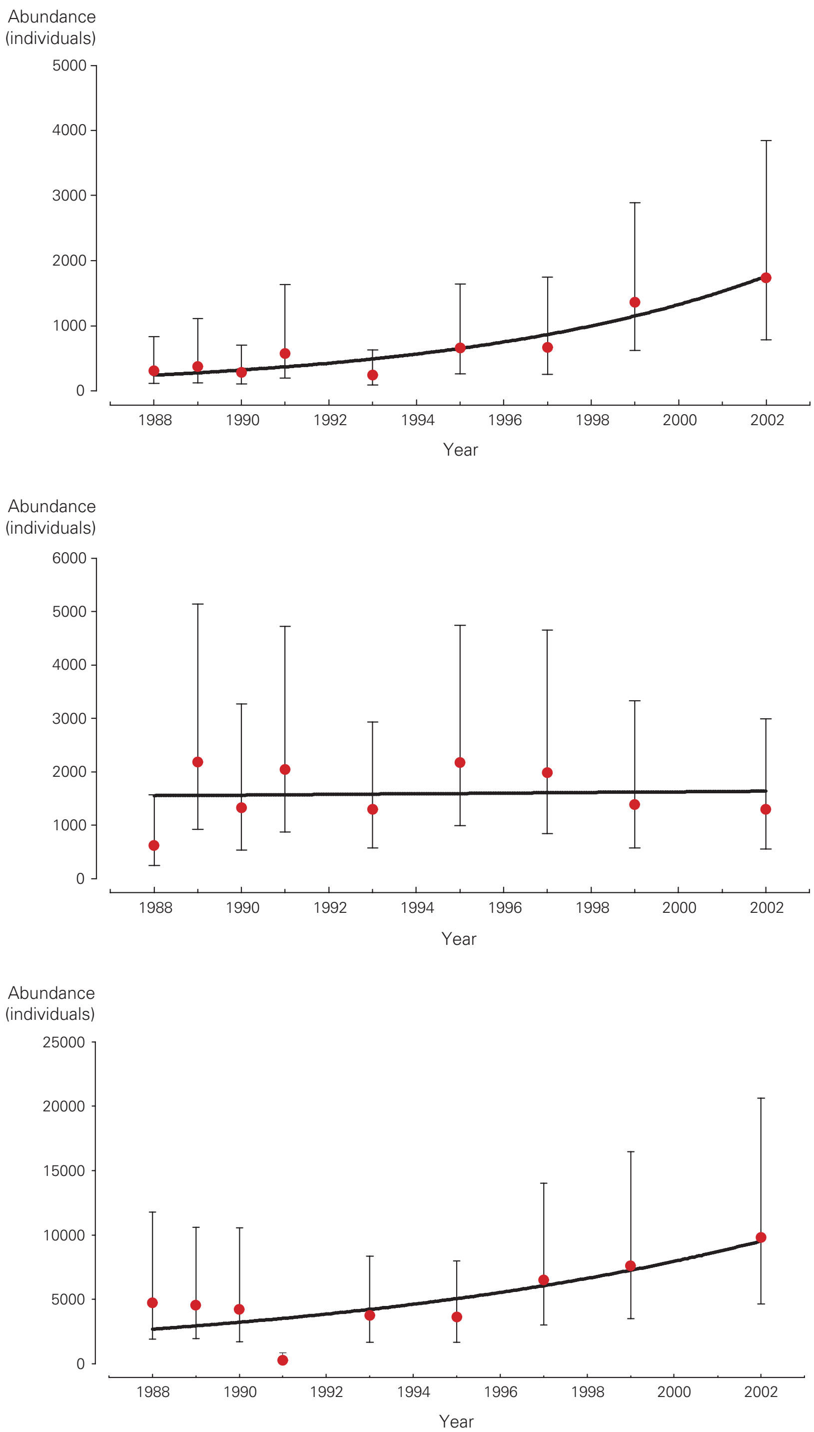

Figure 22-6

Aerial survey estimates of abundance for central California stocks of harbor porpoise, 1988–2002. Error bars represent the lower and upper 95% confidence intervals. Solid lines represent linear regressions on the natural logarithm of abundance over time. Top, Morro Bay stock (slope of regression is statistically significant, $p < 0.002$); middle, Monterey Bay stock (slope of regression is not statistically significant, $p = 0.64$); bottom, San Francisco–Russian River stock (slope of regression is not statistically significant, $p = 0.24$).

Population Size and Current Trend

The most recent estimates of population size for the three central California porpoise stocks are based on pooled data from aerial surveys conducted in 1999 and 2002 (Carretta and Forney, 2004; Table 22-3). A new series of aerial surveys was conducted between 2003 and 2007 to provide updates on the abundance of these stocks. Data from these surveys are currently being analyzed.

Morro Bay Stock: Abundance estimates from a series of nine aerial surveys conducted between 1988 and 2002 suggested that the Morro Bay population of harbor porpoise was increasing. The first five aerial surveys conducted between 1988 and 1993 yielded abundance estimates between 100 and 500 animals. Aerial surveys conducted between 1995 and 2002 yielded abundance estimates between 600 and 1,700 animals. Based on just the 1999–2002 aerial surveys, which were conducted under the best conditions, the abundance estimate is 1,656 animals. The slope of a linear regression on the natural logarithm of abundance from 1988 to 2002 is significantly different from zero ($p < 0.002$, Figure 22-6), indicating population growth.

Monterey Bay Stock: Harbor porpoise in Monterey Bay do not show any trend in abundance over the period of 1988–2002. The slope of a linear regression on the natural logarithm of abundance from 1988 to 2002 is not significantly different from zero ($p = 0.64$, Figure 22-6). Based on just the 1999–2002 aerial surveys, which were conducted under the best conditions, the abundance estimate is 1,613 animals.

San Francisco–Russian River Stock: Abundance of the San Francisco-Russian River stock of harbor porpoise appeared to be stable or declining between 1988–1991, and the slope of a linear regression on the natural logarithm of abundance from 1988 to 2002 is not significantly different from zero ($p = 0.24$, Figure 22-6). Based on just the 1999–2002 aerial surveys, which were conducted under the best conditions, the abundance estimate is 6,254 animals.

Stock Status

Harbor porpoise in California waters are not listed as threatened or endangered under the ESA or as depleted under the MMPA. In the early 1980's, harbor porpoise mortality in set gillnets off central California was estimated at more than 200 animals annually (Diamond and Hanan, 1986). In the mid-to-late 1990's, estimates of harbor porpoise mortality in Monterey Bay ranged from 40 to 130 animals annually (Forney et al., 2001). A ban on all gillnets in central California waters shallower than 110 m took effect in September 2002; this ban is expected to effectively reduce fishery-caused harbor porpoise mortality in this region to near zero. The current mean annual human-caused mortality (take) for the three central California stocks is less than the potential biological removal, and none of the stocks is considered strategic under the MMPA. The average annual mortality for each stock compared to PBR is given in Table 22-4.

Stock	PBR	Mean annual takes
Morro Bay	10	4.5 (0.97)
Monterey Bay	10	9.5 (0.66)
San Francisco–Russian River	63	0.8 (NA)

Table 22-4
Potential biological removal (PBR) and mean annual mortality and serious injury of harbor porpoise for the period 1998–2002, with the coefficient of variation in parentheses.

LITERATURE CITED

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden, and M. H. Deakos. 2005. False killer whales around the main Hawaiian islands. An assessment of inter-island movements and population size using individual photo-identification. Report prepared for the NMFS Pacific Islands Fisheries Science Center, Honolulu, HI.

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

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22:446–464.

Barlow, J., and S. Rankin. 2007. False killer whale abundance and density. Preliminary estimates for the PICEAS study area south of Hawaii and new estimates for the US EEZ around Hawaii. NMFS Southwest Fisheries Science Center Administrative Report LJ-07-02, La Jolla, CA.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use in describing population discreteness in harbor porpoises from Washington, Oregon, and California. *In* J. E. Reynolds and D. K. Odell (Editors), Marine Mammal Strandings in the United States, p. 101–110. U.S. Department of Commerce, NOAA Technical Report NMFS-98.

Carretta, J. V., and K. A. Forney. 2004. Preliminary estimates of harbor porpoise abundance in California from 1999 and 2002 aerial surveys. Southwest Fisheries Science Center Administrative Report LJ-04-01, 13 p. Internet site—http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/Coastal_Marine_Mammal/LJ-04-01_Carretta_Forney.pdf

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, and M. M. Muto. 2007. U.S. Pacific marine mammal stock assessments. 2007. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-414, 316 p.

Carretta, J. V., B. L. Taylor, and S. J. Chivers. 2001. Abundance and depth distribution of harbor porpoise (*Phocoena phocoena*) in northern California determined from a 1995 ship survey. Fishery Bulletin 99:29–39.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick, and J. C. Salinas. 2007. Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*). Canadian Journal of Zoology 85:783–794.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbour porpoises (*Phocoena*

NOAA Sanctuaries

Humpback Whale migrating through The Gulf of the Farallones National Marine Sanctuary.

phocoena), indicated by molecular genetic analyses. Journal of Cetacean Research and Management 4(2):111–122.

Clapp, R. B., and P. W. Woodward. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands. Atoll Research Bulletin 164:303–304.

Diamond, S. L., and D. A. Hanan. 1986. An estimate of harbor porpoise mortality in California set gillnet fisheries April 1, 1983 through March 31, 1984. NMFS Southwest Regional Office Administrative Report SWR-86-15, 40 p.

Dill, H. R., and W. A. Bryan. 1912. Report on an expedition to Laysan Island in 1911. U.S. Department of Agriculture Survey Bulletin 42:1–30.

Forney, K. A. 1999. 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.

Forney, K. A., and D. Kobayashi. 2005. Updated estimates of mortality and serious injury of cetaceans in the Hawaii-based longline fishery, January 1994–June 2004. Draft report. Document PSR6-07 presented to the Pacific Scientific Review Group, 4–6 January 2005. Available from the NMFS Southwest Fisheries Science Center, La Jolla, CA.

Forney, K. A., S. R. Benson, and G. A. Cameron. 2001. Central California gillnet effort and bycatch of sensitive species, 1990–1998. *In* E. F. Melvin and J. R. Parrish (Editors), Seabird Bycatch. Trends, Roadblocks, and Solutions, p. 141–160. Alaska Sea Grant, University of Alaska Fairbanks, AK.

Forney, K. A., and D. R. Kobayashi. 2007. Updated estimates of mortality and injury of cetaceans in the Hawaii-based longline fisheries, 1994–2005. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-412.

Gaskin, D. E. 1984. The harbour porpoise (*Phocoena phocoena* L.). Regional populations, status, and information on direct and indirect catches. Report of the International Whaling Commission 34:569–586.

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

Harting, A. L. 2002. Stochastic simulation model for the Hawaiian monk seal. Ph.D. thesis, Montana State University, Bozeman, MT, 328 p.

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

Kenyon, K. W. 1972. Man versus the monk seal. Journal of Mammology 53(4):687–696.

Maldini, D., L. Mazzuca, and S. Atkinson. 2005. Odontocete stranding patterns in the Main Hawaiian Islands (1937–2002): How do they compare with live animal surveys? Pacific Science 59(1):55–67.

Mobley, J. R. 2001. Results of 2001 aerial surveys of humpback whales north of Kauai. Report to North Pacific Acoustic Laboratory Program, Scripps Institution of Oceanography, San Diego, CA, 27 p. Internet site—http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2001NPAL.pdf.

Mobley, J. R. 2002. Results of 2002 aerial surveys of humpback whales north of Kauai. Report to North Pacific Acoustic Laboratory Program, Scripps Institution of Oceanography, San Diego, CA, 17 p. Internet site—http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2002NPAL.pdf.

Mobley, J. R. 2003. Results of 2003 aerial surveys of humpback whales north of Kauai. Report to North Pacific Acoustic Laboratory Program, Scripps Institution of Oceanography, San Diego, CA, 22 p. Internet site—http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2003NPAL.pdf.

Mobley, J. R. 2004. Results of 2004 aerial surveys of humpback whales north of Kauai. Report to North Pacific Acoustic Laboratory Program, Scripps Institution of Oceanography, San Diego, CA, 24 p. Internet site—http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2004NPAL.pdf.

Mobley, J. R., S. S. Spitz, K. A. Forney, R. A. Grotefendt, and P. H. Forestall. 2000. Distribution and abundance of odontocete species in Hawaiian waters. Preliminary results of 1993–98 aerial surveys. NMFS Southwest Fisheries Science Center Administrative Report LJ-00-14C, La Jolla, CA, 26 p.

Nitta, E. 1991. The marine mammal stranding network in Hawaii: an overview. *In* J. E. Reynolds III and D. K. Odell (Editors), Marine Mammal Strandings in the United States, p. 56–62. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-98.

Nitta, E., and J. R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Marine Fisheries Review 55(2):83–92.

Polacheck, T. F., W. Wenzel, and G. Early. 1995. What do stranding data say about harbor porpoise (*Phocoena phocoena*). *In* A. Bjørge and G. P. Donovan (Editors), Biology of the Phocoenids, p. 169–179. Report of the International Whaling Commission, Special Issue 16.

Ragen, T. J. 1999. Human activities affecting the population trends of the Hawaiian monk seal. *In* J. A. Musick (Editor), Life in the Slow Lane. Ecology and Conservation of Long-lived Marine Animals, p. 183–194. American Fisheries Society Symposium 23, American Fisheries Society, Bethesda, MD.

Rice, D. W. 1960. Population dynamics of the Hawaiian monk seal. Journal of Mammology 41:376–385.

Wetmore, A. 1925. Bird life among lava rock and coral sand. The National Geographic Magazine 48:77–108.

Yochem, P. K., R. C. Braun, B. Ryon, J. D. Baker, and G. A. Antonelis. 2004. Contingency plan for Hawaiian monk seal unusual mortality events. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-2, 27 p.

FOR FURTHER READING

Baker, C. S. 1992. Genetic variability and stock identity of humpback whales, world-wide. Final contract report to the International Whaling Commission, 45 p.

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*). Journal of Heredity 84:281–290.

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. Report of the International Whaling Commission 44:399–406.

Barlow, J. 2003a. Cetacean abundance in Hawaiian waters during summer/fall of 2002. NMFS Southwest Fisheries Science Center Administrative Report LJ-03-13, 20 p.

Barlow, J. 2003b. Preliminary estimates of the abundance of cetaceans along the U.S. west coast, 1991–2001. NMFS Southwest Fisheries Science Center Administrative Report LJ-03-03, 31 p.

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. *In* K. I. Panin (Editor), Soviet research on marine mammals of the Far East, p. 103–136. (Izvestiya Tikhookeanskogo Nauchno-Issledovatel'skogo Institut Rybnogo Khozyaistva I Okeanografii 58:179–207.) Translation from the original Russian. Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, Seattle, 1968.

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. National Marine Fisheries Service, unpublished report.

Calambokidis, J., T. Chandler, K. Rasmussen, G. H. Steiger, and L. Schlender. 1999. Humpback and blue whale photo-identification research off California, Oregon and Washington in 1998. Final contract report to NMFS Southwest Fisheries Science Center, La Jolla, CA, 35 p.

Calambokidis, J., T. Chandler, L. Schlender, K. Rasmussen, and G. H. Steiger. 2002. Research on humpback and blue whales off California, Oregon and Washington in 2001. Final contract report to NMFS Southwest Fisheries Science Center, La Jolla, CA, 51 p.

Calambokidis, J., G. H. Steiger, J. C. Cubbage, K. C. Balcomb, C. Ewald, S. Kruse, R. Wells, and R. Sears. 1990. Sightings and movements of blue whales off central California 1986–88 from photo-identification of individuals. Report of the International Whaling Commission, Special Issue 12:343–348.

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. Marine Mammal Science 12(2):215–226.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. Herman, S. Cerchio, D. R. Salden, J. Urbán-R., J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara-P., M. Yamaguchi, F. Sata, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17(4):769–794.

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 to NMFS Southwest Fisheries Science Center, La Jolla, CA, 72 p.

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.

Darling, J. D. 1991. Humpback whales in Japanese waters, Ogasawara and Okinawa, fluke identification catalog 1987–1990. Final contract report to World Wildlife Fund for Nature, Japan, 22 p.

Forney, K. A., and R. L. Brownell Jr. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. International Whaling Commission Paper SC/48/O11.

Hammond, P. S. 1986. Estimating the size of naturally marked whale populations using capture-recapture techniques. Report of the International Whaling Commission, Special Issue 8:253–282.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Marine Fisheries Review 46(4):30–37.

Larkman, V. E., and R. R. Veit. 1998. Seasonality and abundance of blue whales off southern California. California Cooperative Oceanic Fisheries Investigations, Report 39:236–239.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters. A guide to their identification. NOAA Technical Report NMFS-444, 245 p.

Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during their feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4):1246–1257.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The blue whale, *Balaenoptera musculus*. Marine Fisheries Review 46:15–19.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. *In* K. S. Norris (Editor), Whales, Dolphins and Porpoises, p. 172–191. University of California Press, Berkeley, CA.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. *In* K. S. Norris and R. R. Reeves (Editors), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii, p. 29–44. Contract report to U.S. Marine Mammal Commission, NTIS No. PB-280-794, 90 p.

Stafford, K. M., C. G. Fox, and D. S. Clark. 1998. Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. Journal of the Acoustical Society of America 104(6): 3616–3625.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb, and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Marine Mammal Science 7:306–310.

Stewart, B. S., S. A. Karl, P. K. Yochem, S. Leatherwood, and J. L. Laake. 1987. Aerial surveys for cetaceans in the former Akutan, Alaska, whaling grounds. Arctic 40(1):33–42.

Wade, P. R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Report of the International Whaling Commission 43:477–493.

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