Revised: 12/31/2001

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. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there are at least nine genetically distinct populations, including three within the present central California stock range (S. Chivers, pers. comm.).

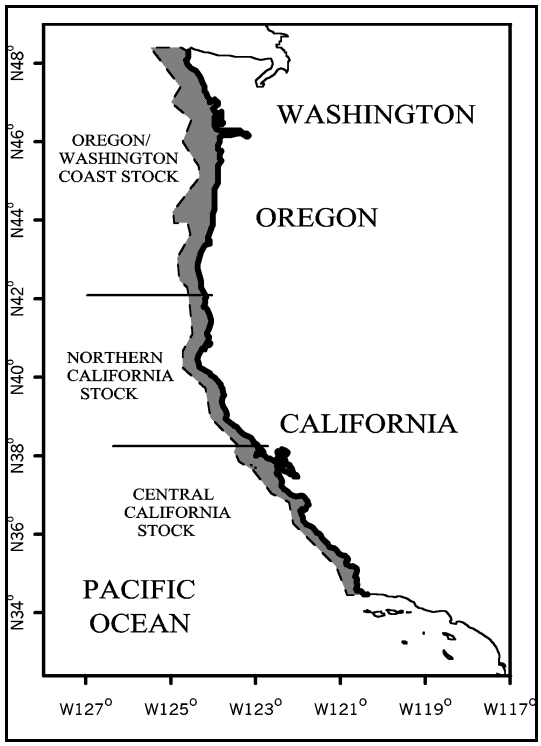

Figure 1. Stock boundaries and distributional range of harbor porpoise along the U.S. west coast. Shaded area represents harbor porpoise habitat (0-200 m) along the U.S. west coast.

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. However, based on recent genetic findings (Chivers, pers. comm.), it appears likely that the central California stock will be further subdivided into three stocks (with one division somewhere between Monterey Bay and San Francisco and another somewhere between Monterey Bay and Morro Bay) once the ongoing analyses have been finalized and peer-reviewed. Other U.S. West coast stocks are also likely to be re-evaluated at that time. For the 2000 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other Pacific coast harbor porpoise stocks 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 Forney et al. (2000) and are also reprinted unrevised in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Previous estimates of abundance for California harbor porpoise were based on aerial surveys conducted between the coast and the 50-fm isobath during 1988-95 (Barlow and Forney 1994, Forney 1999a). These estimates did not include an unknown number of animals found in deeper waters. Barlow (1988) found that the vast majority of harbor porpoise in California were within the 0-50-fm 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). A recent analysis of harbor porpoise trends including oceanographic data suggested that the proportion of California harbor porpoise in deeper waters may vary between years (Forney 1999b; see Current Population Trend below). In 1999, aerial surveys extended farther offshore (to at least the 200m depth contour) to provide a more complete abundance estimate. Although one harbor porpoise sighting was made in offshore waters under poor conditions (Beaufort sea state 3), only good conditions have traditionally been included in abundance analyses for this species (Barlow and Forney 1994, Forney 1999a), and therefore no offshore sightings contributed to the updated abundance estimate. Based on pooled 1995-99 aerial survey data, an updated estimate of abundance for the central California harbor porpoise stock is 7,579 harbor porpoise (CV=0.38; NMFS, K. Forney, unpublished data, following methods of Forney 1999a). Although this is higher than the previous estimate of 5,732 (CV=0.39, Forney 1999a), the confidence intervals overlap and the difference is not statistically significant.

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 1995-99 aerial surveys, or 5,563 animals.

Current Population Trend

Analyses of a 1986-95 time series of aerial surveys have been conducted to examine trends in harbor porpoise abundance in central California (Forney, 1995; 1999b). After controlling for the effects of sea state, cloud cover, and area on sighting rates, Forney (1995) found a negative trend in population size; however, that trend was no longer significant when sea surface temperature (a proxy measure of oceanographic conditions) was included in an updated non-linear trend analysis (Forney 1999b). The negative correlation between harbor porpoise sighting rates and sea surface temperatures indicates 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. Although encounter rates during the 1999 aerial survey were again higher than in past years, the trend in relative abundance (following methods of Forney 1995) is not statistically significant (p=0.12, Figure 2). More detailed studies of encounter rate patterns in relation to satellite-derived sea surface temperature during 1993-99 are planned to shed light on potential oceanography-related movement patterns of harbor porpoise in this region.

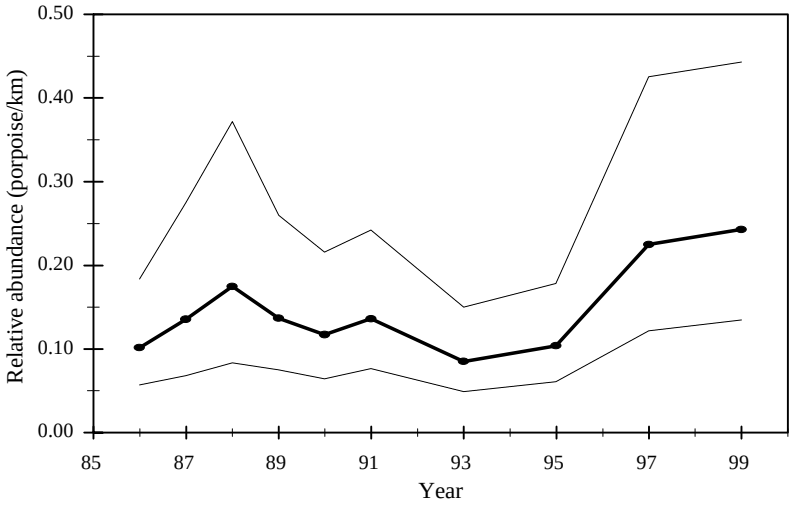

Figure 2. Relative abundance (+/- one standard error) of central California harbor porpoise, 1986-99, adjusted for sea state and cloud cover (following methods of Forney 1995).

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. Because a reliable estimate of the maximum net productivity rate is not available for central California harbor porpoise, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (5,563) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status and a mortality rate CV $\leq$ 0.30; Wade and Angliss 1997), resulting in a PBR of 56.

HUMAN-CAUSED MORTALITY

Fishery Information

The incidental capture of harbor porpoise is largely limited to the halibut set gillnet fishery 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. A summary of estimated fishery mortality and injury for this stock of harbor porpoise is given in Table 1. The most recent mortality estimate for 1999 is based on a 1999 National Marine Fisheries Service monitoring program in Monterey Bay (Cameron and Forney 2000). Mortality estimates for 1995-98 are based on total estimated fishing effort and prior-year entanglement rate data (Julian and Beeson 1998), because no observer program was in place during those years. Forney et al. (2001) evaluated uncertainties in estimating mortality for unobserved years, and presented several alternate analyses of harbor porpoise mortality for this fishery during 1995-98. Their analysis 'C', which is stratified to reflect regional differences in bycatch rates between Monterey Bay and Morro Bay and includes data from both a 1987-90 California Department of Fish and Game observer program and a 1990-94 National Marine Fisheries Service observer program, best captures the range of variability in entanglement rates and is most consistent with the patterns observed more recently in the 1999 observer program. Although mortality estimates for the most recent five years (1995-99) are presented in Table 1, average annual takes in the setnet fishery are calculated using only 1996-99 data, because fishing effort approximately doubled after 1995, and the majority of recent effort has taken place in the southern areas of Monterey Bay, where very little effort took place prior to 1996. The revised mortality data indicate that an average of 79 harbor porpoise (CV= 0.21) were killed annually in this fishery in central California during the period 1996-99. Preliminary data for calendar year 2000 indicate that mortality in the halibut set gillnet fishery has dropped, most likely because fishing effort was lower and part of the fleet began using pingers to reduce porpoise mortality in late 1999 and early 2000.

On September 13, 2000, the California Department of Fish and Game (CDFG) issued emergency regulations which restricted fishing in the central California halibut set gillnet fishery to waters deeper than 60 fathoms, citing concerns over the continued mortality of common murres and decline of the southern sea otter population. The closure area extended from Point Reyes to Yankee Point in Monterey County and from Point Arguello to Point Sal in Santa Barbara County (the area from Yankee Point to Point Sal remained open to fishing outside of 30 fathoms). On April 13, 2001, CDFG proposed permanent year-round regulations to eliminate set gillnet fishing inshore of 60 fathoms from Point Reyes to Point Arguello.

Two harbor porpoise mortalities were inaccurately reported in Marine Mammal Authorization Permit (MMAP) fisher self-reports for the California drift gillnet fishery during 1996-98. Both of the mortalities occurred on an observed fishing trip and were actually short-beaked common dolphins (NMFS, Southwest Fisheries Science Center, unpublished data). This fishery has not previously been known to take harbor porpoise.

Three fishery-related harbor porpoise strandings were reported in central California in 1998, north of the known set gillnet fishing areas: two near Bodega Head and one inside San Francisco Bay (NMFS, Southwest Region, unpublished data). These mortalities were probably taken from the central California harbor porpoise stock, although it is possible that the northern two animals were taken from the northern California stock and drifted southward to the

stranding location. Efforts are underway to identify possible fisheries responsible for these mortalities. Based on experience with other fisheries (e.g. the set gillnet fishery), the proportion of incidentally killed animals that strand is generally only a fraction of the total mortality, and therefore these unidentified fisheries are likely to have taken more than the three observed harbor porpoise.

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 annual mortality for 1996-99 (80 harbor porpoise) is greater than the calculated PBR (56) for central California harbor porpoise; therefore, the central California harbor porpoise population is "strategic" under the MMPA. The average gillnet mortality for 1996-99 (80 porpoise per year) is greater than the calculated PBR; therefore, the fishery mortality cannot be considered insignificant and approaching zero mortality and serious injury rate. The pending closure of the set gillnet fishery from Point Reyes to Point Arguello inside of 60 fathoms effectively will eliminate set gillnets from most harbor porpoise habitat in central California and thus it is expected that fishery mortality for this stock will be significantly reduced. Research activities will continue to monitor the population size and to investigate population trends. There are no known habitat issues that are of particular concern for this stock.

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 (Cameron and Forney 2000, Forney et al., 2001; NMFS/SWFSC, unpublished data). Mean annual takes are based on 1995-99 data unless noted otherwise. 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 (CV in parentheses)
CA angel shark / halibut and other species large mesh (>3.5") set gillnet fishery	1995	1987-90	0%	-	42 (0.19)	
	1996	and	0%	-	48 (0.19)	
	1997	1990-94	0%	-	80 (0.19)	79 (0.21)[1]
	1998	observer data	0%	-	57 (0.19)	
	1999	1999 observer data	23.0%	28[2]	133 (0.23)[2]	
Unknown fishery	1995-99	Strandings	-	3 (in 1998)	n/a	$\geq$ 0.60 (n/a)
Minimum total annual takes						80 (0.21)

[1]Only 1996- 99 mortality estimates are included in the average because of changes in the distribution and amount of fishing effort after 1995 (see text).

[2] This includes one unidentified cetacean that was almost certainly a harbor porpoise; without this animal the mortality estimate would be 128 (CV=0.23).

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. Mar. Mamm. Sci. 7(1):84-119.

Barlow, J. and K. A. Forney. 1994. An assessment of the 1994 status of harbor porpoise in California. U.S. Dep. Commer., NOAA Tech. Memo. 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 Tech. Rep. 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.

Cameron, G.A. and K.A. Forney. 2000. Preliminary Estimates of Cetacean Mortality in California/Oregon Gillnet Fisheries for 1999. Paper SC/52/O24 presented to the International Whaling Commission, 2000 (unpublished). 12 pp. Available from NMFS, Southwest Fisheries Science Center, P.O. Box 271, La Jolla, California, 92038, USA.

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

Forney, K. A. 1995. A decline in the abundance of harbor porpoise, *Phocoena phocoena*, in nearshore waters off California, 1986-93. Fish. Bull. 93: 741-748.

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, National Marine Fisheries Service, 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? J. Cetacean Res. Manage. 1:73-80.

Forney, K. A., J. Barlow, M. M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb, and J.V. Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-300. 276 pp.

Forney, K. A., S. R. Benson, and G. A. Cameron. 2001. Central California gillnet effort and bycatch of sensitive species, 1990-98. In: E. F. Melvin and J. K. Parrish (eds.), Seabird Bycatch: Trends, Roadblocks and Solutions, Proceedings of an International Symposium of the Pacific Seabird Group, Semi-Ah-Moo, Washington, February 1999. University of Alaska Sea Grant, Fairbanks, AK.

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

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

NMFS, Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038-0271

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

Polacheck, T., F. W. Wenzel, and G. Early. 1995. What do stranding data say about harbor porpoise (*Phocoena phocoena*)? Rep. Int. Whal. Comm., 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.

Trippel, E. A., M. B. Strong, J. M. Terhune, and J. D. Conway. 1999. Mitigation of harbour porpoise (*Phocoena phocoena*) by-catch in the gillnet fishery in the lower Bay of Fundy. Can. J. Fish. Aquat. Sci. 56:113-123.

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. Commer., NOAA Tech. Memo. 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.