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HARBOR PORPOISE (*Phocoena phocoena*): Morro Bay 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 is small-scale subdivision within the U.S. portion of this range (Chivers *et al.*, 2002).

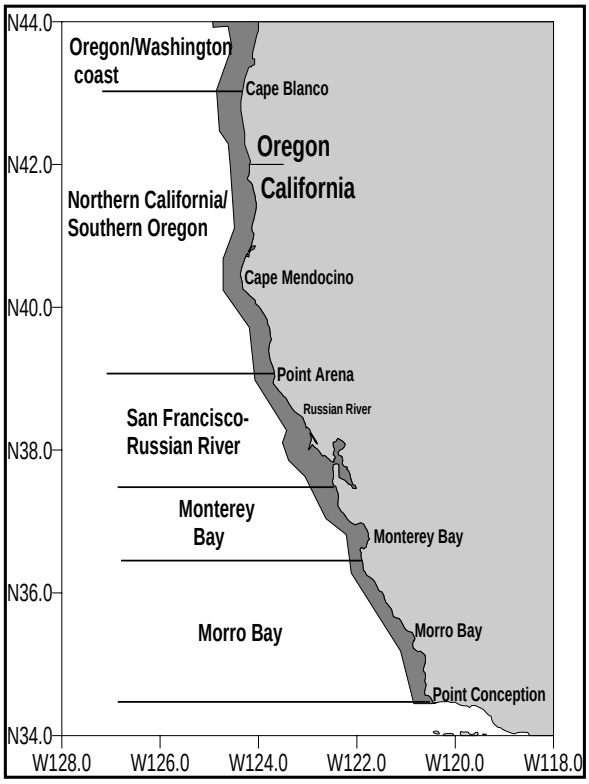

Figure 1. Stock boundaries and distributional range of harbor porpoise along the California/southern Oregon coast. Shaded area represents harbor porpoise habitat (0-200 m) along the U.S. west coast.

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. Based on recent genetic findings (Chivers *et al.*, 2002), California coast stocks were re-evaluated, and significant genetic differences were found among 4 identified sampling sites. Revised stock boundaries are presented here based on these genetic data and density discontinuities identified from aerial surveys, resulting in six California/Oregon/Washington stocks where previously there had been four (Carretta *et al.* 2001a). The stock boundaries for animals that occur in California/southern Oregon waters are shown in Figure 1. For the 2004 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other Pacific coast harbor porpoise stocks include: 1) a Monterey Bay stock, 2) a San Francisco-Russian River stock, 3) a northern California/southern Oregon stock, 4) an Oregon/Washington coast stock, 5) an Inland Washington stock,

6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. Stock assessment reports for Monterey Bay, San Francisco-Russian River, northern California/southern Oregon, Oregon/Washington coast, and Inland Washington waters harbor porpoise appear 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 systematic ship survey of depth strata out to 90 m in northern California showed that porpoise abundance declined significantly in waters deeper than 60 m (Carretta *et al.* 2001b). A recent analysis of harbor porpoise trends including oceanographic data suggests that the proportion of California harbor porpoise in deeper waters may vary between years (Forney 1999b). In 1999 and 2002, aerial surveys extended farther offshore (to the 200m depth contour or a minimum of 10 nmi from shore in the region of the Morro Bay stock) to provide a more complete abundance estimate. Based on 1999 and 2002 aerial surveys under good survey conditions (Beaufort #2, cloud cover #25%) the estimate of abundance for this stock is 1,656 animals (CV = 0.39) (Carretta and Forney 2004).

Minimum Population Estimate

The minimum population estimate for the Morro Bay harbor porpoise stock is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from the 1999-2002 aerial surveys, or 1,206 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. There has been an increasing trend in porpoise abundance in the Morro Bay stock since 1988, which is statistically significant ($p < 0.002$), Figure 2. More detailed studies of encounter rate patterns in relation to satellite-derived sea surface temperature are planned to shed light on potential oceanography-related movement patterns of harbor porpoise in this region.

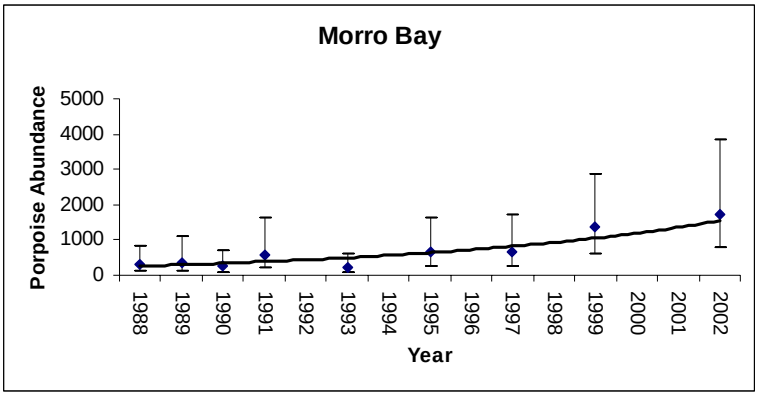

Figure 2. Aerial survey estimates of abundance for the Morro Bay stock of harbor porpoise, 1988-2002. Error bars represent lower and upper 95% confidence intervals. Solid line represents a linear regression on the natural logarithm of abundance over time. The slope of this regression is statistically significant ($p < 0.002$).

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 Morro Bay harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (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 (1,206) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.4 (for a stock of unknown status with a mortality rate CV $ 0.80; Wade and Angliss 1997), resulting in a PBR of 10.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The set gillnet fishery for halibut and angel shark has operated in the vicinity of Morro Bay, and fishing effort there peaked in 2001. A ban on set gillnets inshore of 60 fathoms from Point Arguello to Point Reyes, California, has been in place since September 2002. California Department of Fish and Game (CDFG) estimated fishing effort for 1998-2002 in this fishery is 139, 121, 284, 391, and 21 days respectively. Mortality rates of harbor porpoise in the set gillnet fishery in this region are available only from 43 trips observed between 1990-94 (Julian and Beeson 1998), in which one harbor porpoise was killed. This represents a kill rate of 0.023 porpoise/day fished (bootstrap CV = 0.97). Projected mortality levels based on this kill rate and effort levels for 1998-2002 are summarized in Table 1. It should be noted that this kill rate includes sets made in less than 30 fathoms of water, where the potential to entangle porpoise is higher. The white seabass set gillnet fishery also has operated in the vicinity of Morro Bay, and this fishery has been documented to take harbor porpoise in the past (Norris and Prescott 1961). Effort in the white seabass fishery in the vicinity of Morro Bay for the last five years (1998-2002) has been 26, 7, 61, 132, and 32 fishing days respectively. Because of the aforementioned depth restrictions for gillnets in this region, it is expected that harbor porpoise interactions with the white seabass set gillnet fishery would be near zero.

Table 1. Summary of available information on incidental mortality and injury of harbor porpoise (Morro Bay stock) in commercial fisheries that might take this species (Cameron and Forney 2000, Carretta 2001, Forney et al., 2001; Carretta 2002, Carretta and Chivers 2003). Mean annual takes are based on 1998-2002 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Kill/Day	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	1998	1990-94 observer data	0%	-	0.023[1]	3 (0.97)	4.5 (0.97)[2]
	1999		0%	-		3 (0.97)	
	2000		0%	-		7 (0.97)	
	2001		0%	-		9 (0.97)	
	2002	Fishery closed permanently in waters < 60 fathoms				0.5 (n/a)	
Minimum total annual takes							4.5 (0.97)[2]

[1]Mortality rate is based on 1 observed mortality from 43 observed trips in this region between 1990-94.

[2]Mean annual takes are based on 1998-2002 effort data and 1990-94 kill rates.

Both of the above central California gillnet fisheries were restricted by a series of emergency closures beginning in September 2000, because of concern over mortality of Common Murres and a decline in the southern sea otter population. During the emergency closure, fishing was allowed in waters deeper than 30 fathoms between Yankee Point (Monterey County) and Pt. Sal (Santa Barbara County) until April 2002, and fishing effort initially increased within the range of the Morro Bay harbor porpoise stock. A ban on the use of gill and trammel nets in all ocean waters 60 fathoms or less between Point Reyes (Marin County) and Point Arguello (Santa Barbara County) became effective on September 4, 2002. The ban is expected to virtually eliminate bycatch of Morro Bay harbor porpoise in these two gillnet fisheries, because this species is primarily found in waters shallower than 60 fathoms.

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 (including Morro Bay, Monterey Bay, and San Francisco-Russian River stocks) 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 central California harbor porpoise populations relative to their Optimum Sustainable Population (OSP) levels must be treated as unknown.

Based on the last 5 years of fishing effort (1998-2002), mean annual takes are 4.5 porpoise per year, which is less than the PBR of 10 animals, resulting in a "non-strategic" classification. A set gillnet closure inside of 60 fathoms was finalized in September 2002, effectively eliminating set gillnets from most harbor porpoise habitat in the region of this stock. This is expected to reduce fishery mortality of Morro Bay harbor porpoise to near zero. Although in recent years the average fishery mortality exceeded 10% of the PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and injury rate, it is likely that this goal will be met following the 2002 gillnet closure. 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.

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