## ABOUT THESE MAPS

Figures 4.23a, b and c show the density (animals/km$^2$) of gray whales (*Eschrichtius robustus*) in three ocean seasons – Upwelling, Oceanic, and Davidson Current, displayed in cells of 10' latitude by 10' longitude. Figure 4.23 d shows the overall density combining all three seasons. Densities are based on the combined data sets of several studies conducted from 1980-2003; see Data Sources below and the Data and Analyses section of this chapter for more information. The color and mapping intervals were selected to show the most structure and highlight significant areas, while allowing comparisons among species. Cells that were surveyed but in which no gray whales were observed have a density of zero. Areas not surveyed appear white; no information is available for these areas. Dark blue lines indicate the boundaries of the National Marine Sanctuaries in the study area: Cordell Bank, Gulf of the Farallones and Monterey Bay. Bathymetric contours for the 200 meter and 2,000 meter isobaths are shown in blue.

## DATA SOURCES AND METHODS

Densities for marine mammals at sea in this assessment are based on the CDAS central California data set (2003), developed using software called Marine Mammal and Seabird Computer Data Analysis System (CDAS), by the R.G. Ford Consulting Co. This data set contains data from eight survey programs (five aerial surveys, three ship surveys) conducted between 1980 and 2003; the data extends from Pt. Arena to Pt. Sal in the study area. See the Data and Analyses section of this chapter for information on the at-sea survey data sets and methods used to estimate density.

## RESULTS AND DISCUSSION

Two stocks of gray whales have been recognized in the North Pacific: the Western North Pacific or 'Korean stock', which lives along the coast of eastern Asia; and the Eastern North Pacific stock, which lives along the west coast of North America (Angliss and Outlaw, 2005),

The eastern North Pacific stock of the gray whale migrates south from summer feeding grounds in the northern Bering and Chukchi seas, into waters off Southeast Alaska, British Columbia, Washington, Oregon, and California. Most whales begin their migration from Alaska in November and December and travel south along the west coast of North America to their winter breeding and calving areas in lagoons along the coast of Baja California, Mexico. (Rugh *et al.,* 2001). Calves are generally born from January to mid-February (Rice *et al.,* 1981). The southward migration includes (in the order of sex and age-class) females in late pregnancy, females that have recently ovulated, adult males, immature females, and lastly, immature males. In the study area, this southward migration generally occurs from December through February and peaks in January.

The northward migration generally occurs from February through May in the study area; it peaks in March and includes (in the order of reproductive condition, sex, age-class) newly pregnant females, adult males, immature females and males, and last in this migration, the females with calves. The females with calves migrate northward through the study area during April and May, and sometimes June. Some animals do not undertake the full migration and remain in coastal waters from Kodiak Island, Alaska, to central California through the summer (Darling *et al.,* 1998; Calambokidis and Quan, 1999; Dunham and Duffus, 2001).

The strong seasonal patterns of the gray whale evident in the maps reflect the seasonal biological cycle of this species. During the Upwelling Season (the end of the northward migration), gray whales are distributed in the coastal and shelf habitats throughout the study area, en route to their northern feeding grounds. During the Oceanic Season they are virtually absent (because they are at their summer feeding grounds to the north); and during the Davidson Current Season, densities are highest

Sophie Webb

because much of their southern and northern migrations pass through the study area during this period. Overall density patterns of the gray whale reflect the nearshore and coastal occurrence on the shelf as it moves through the study area. Gray whales also have been seen regularly off Point Reyes, Tomales Bay, Drakes Bay, and the Farallon Islands during non-migratory periods (Allen, pers. comm.).

In the study area and CDAS central data sets, the gray whale was the second most numerous baleen whale. Based on analysis of the CDAS data, the greatest concentrations of gray whales occurred along the coast near Cypress Point, south of Point Sur to Lopez Point, and north of the boundaries for Gulf of the Farallones and Cordell Bank national marine sanctuaries.

Overall, the Eastern North Pacific gray whale stock has been increasing (Angliss and Outlaw, 2005); however, variations in population estimates have been reported. Abundance estimates by Rugh *et al.,* (2005) were the following: in 1997/98, 29,758 (CV=10.49%; 95% CI = 24,241 to 36,531), the highest estimate since 1967/68; in 2000/01, 19,448 (CV=9.67%; 95% CI=16,096 to 23,498); and in 2001/02, 18,178 (CV=9.79%; 95% CI=15,010 to 22,015). The lower estimates were probably related to the high mortality rates (see below) observed in 1999 and 2000 (Rugh *et al.,* 2005). However, the lower abundance estimates in 2001-02 may be attributed to a true drop in the population size (see Rugh *et al.,* 2005). Angliss and Outlaw, 2005, report the minimum population estimate ($N_{min}$, estimated by calculating the lower 20th percentile of the log-normal distribution of the population estimate) of 17,752 gray whales (CV=0.069); (Wade and Angliss, 1997).

Variations in population estimates may have been due in part to the following: 1) undocumented sampling variation; 2) differences in the proportion of the gray whale stock migrating as far as the central California coast (survey location at Granite Canyon); 3) responses to environmental limitations as the population approaches carrying capacity (Angliss and Outlaw, 2005); and 4) decline following high mortality rates observed in 1999 and 2000 (Rugh *et al.,* 2002; Gulland *et al.,* 2005). Also during this period (1999-2000), a greater number of visibly emaciated whales were observed, suggesting a decline in food resources as a possible cause for this observation (Le Boeuf *et al.,* 2000).

In 1999 and 2000, strandings along the west coast of North America increased approximately seven times (in 1999) and nine times (in 2000); the annual mean of 41 animals reported between 1995 and 1998, with highest numbers reported in Alaska and Mexico (Gulland *et al.,* 2005). This event was designated “an unusual mortality event”. Factors that may have contributed to the high number of strandings (1999: 273; 2000: 355) include: starvation, chemical contaminants, and biotoxins, infectious diseases, ship strikes, fisheries interactions, detection effort and reporting, and wind and current effects on carcass deposition (Gulland *et al.,* 2005). The underlying cause of starvation as a potentially significant contributing factor remains uncertain (Gulland *et al.,* 2005). While the stranding rate was much higher in 1999 and 2000 than in previous years, it may not indicate a higher mortality rate (Angliss and Outlaw, 2005); this stranding event appears to have been short-term. Counts of dead gray whales have dropped to levels below those seen prior to this event: only 21 and 26 strandings were reported in 2001 and 2002, respectively, and dead gray whale stranding have continued to be relatively low through 2006, with eight in 2003, 18 in 2004, 7 in 2005, and 11 in 2006 (Cordaro, pers. comm., 2006).

Low calf production in 1999, 2000, and 2001 appeared to be correlated with environmental conditions (Perryman *et al.,* 2002). Time of ice retreat in the spring off Alaska and calf production the following year were correlated, suggesting variations in calf production are likely the result of climate variables associated with seasonal changes in ice distribution in the Bering and Chukchi Seas (Perryman *et al.,* 2005 - 16th Biennial Conference on the Biology of Marine Mammals, 2005). These seasonal changes may influence the duration of whale feeding (and thus nutritional status prior to the southbound migration). Although ice distribution explained interannual variations in calf production (1,527 in 2004; 256 in 2000), observed longer-term variations in calf production are likely the result of

climate variables related to system-wide, bottom-up productivity (Perryman *et al.,* 2005).

Tracking of human-related causes of mortality and serious injury from 1999-2003 indicate that no gray whales were seriously injured or killed incidental to the coastal and inland waters set gillnet fishery or the thresher shark/swordfish drift gillnet fishery. A minimum annual mean of 7.4 gray whale mortalities resulting from interactions with commercial fishing gear is considered to be insignificant (Angliss and Outlaw, 2005). The annual subsistence take of the eastern stock of gray whales by Russian aboriginals and the Makah Tribe was 122 whales during the five-year period from 1999 to 2003 (Angliss and Outlaw, 2005).

Other sources of mortality include ship strikes, with a mortality rate of 1.2 gray whales reported per year. However, because ship strikes are likely unreported, either because the whales do not strand or do not have obvious signs of trauma, it is not possible to quantify the actual mortality of gray whales from ship strikes (Angliss and Outlaw, 2005).

Overall, the estimated annual level of human-caused mortality and serious injury (includes mortalities from commercial fisheries, Russian harvest, and ship strikes) does not exceed the Potential Biological Removal (PBR), and therefore this stock of gray whales is not classified as a strategic stock, and is no longer considered endangered or threatened under the endangered Species Act (ESA; Angliss and Outlaw, 2005). However, events associated with the 1999-2000 stranding event could be indicative of a population near carrying capacity (Gulland *et al.,* 2005).

Gray whales are opportunistic foragers, feeding mostly on benthic invertebrates (e.g., gammarid amphipods (Leatherwood and Reeves, 1983)), mysid shrimp, herring eggs/larvae, crab larvae, ghost shrimp (Darling *et al.,* 1998), and surface swarms of euphausiids (krill) (Benson *et al.,* 2002). Although most individuals of gray whales in the study area were non-feeding migrants, some individuals on their northern migration do feed on a regular basis near the South Farallon Islands, at the mouth of Tomales Bay and Drakes Bay (Allen, pers. comm., 2002). Gray whales also feed in San Francisco Bay (in some years: 1999, 2000-2001) (Oliver *et al.,* 2001); and Monterey Bay (Benson *et al.,* 2002). Gray whale calves are preyed upon by killer whales.