ABOUT THESE MAPS

Figure 4.22 a, b and c show the density (animals/km^2) of humpback whales (*Megaptera novaeangliae*) in three ocean seasons – Upwelling, Oceanic, and Davidson Current, displayed in cells of 10' latitude by 10' longitude. Figure 4.22 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 humpback 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

The humpback whale is distributed worldwide in all ocean basins and is federally listed as endangered under the Endangered Species Act. In the North Pacific Ocean and within the U.S. Exclusive Economic Zone, there are at least three relatively separate populations: the eastern, central, and western North Pacific stocks (Carretta *et al.,* 2006). The eastern North Pacific stock (the California/ Mexico stock) is considered as a "depleted" and "strategic" stock under the MMPA. (Carretta *et al.,* 2006). The eastern North Pacific stock feeds in the waters off California, Oregon, Washington, and British Columbia in the summer, and in the fall, migrates to its wintering calving and mating areas off coastal mainland Mexico and Central America (Calambokidis *et al.,* 2001). Fidelity is extremely high among feeding areas and low-level interchange occurs between breeding areas (Calambokidis *et al.,* 2001). The eastern North Pacific humpback whales seen along the coasts of California, Oregon, and Washington in the spring, summer and fall are part of a distinct feeding aggregation, with little interchange with feeding areas in British Columbia or Alaska (Calambokidis *et al.,* 1996). Based on mark-recapture methods (Calambokidis *et al.,* 2004), the population size estimate for 2002/2003 for the eastern north Pacific stock of humpback whales was 1,391 (CV=0.22); this estimate is considered to be more precise than the estimate based on ship line-transect surveys in 1996 and 2001, which was 1,314 (CV=0.30).

In the central California CDAS data set used in this study, the humpback whale was among the most commonly sighted whales, and was distributed mostly over shelf and slope habitats; humpbacks are often found feeding along canyon edges where prey concentrate. Humpback whales are sighted from the Farallon Islands in all months (Pyle and Gilbert, 1996), though they are more frequently sighted off central California from March through November, with peaks in the summer and fall (Calambokidis *et al.,* 1996). Patterns of occurrence were evident in the seasonal maps: the seasonal summer/fall peak was evident in the Oceanic Season map, whereas a decline in sightings and abundance during the Davidson Current Season (winter) coincided with the humpback whale migration south in the fall. The distribution and abundance of humpback whales was more widespread during the Upwelling Season and more concentrated with greater density in the

Sophie Webb

Oceanic Season, a pattern most likely related to the distribution and concentration of prey resources.

The Upwelling Season and beginning of the Oceanic Season is characterized by a seasonal peak in euphausiid (krill) density that occurs in July/August but can extend into the Oceanic Season. Krill abundance increases one to four months after seasonal peaks in primary production (Croll *et al.,* 1998). One of the dominant species of krill (*Thysanoessa spinifera*) forms dense shoals in the shelf region from Fort Ross south to the Channel Islands (Kieckhefer, 1994). Primary feeding sites of humpback whales in the study area are located at Monterey Bay (Benson *et al.,* 2002), Bodega Canyon, Cordell Bank, the Farallon Islands (Kieckhefer, 1992) and Pt. Reyes (S. Allen, pers. comm.). There is considerable interchange and inter-regional movement of humpback whales within a feeding season between the Santa Barbara Channel in the southern California Bight, Monterey Bay, and to the north off Eureka (Calambokidis *et al.,* 1996; Calambokidis *et al.,* 1998). During the Davidson Current Season, most humpback whales are in breeding/calving areas to the south, hence the relatively few sightings in the study area (1980, 1982, and 1993) during this season.

In the study area, the CDAS data shows humpback whales were more concentrated in areas of the Gulf of Farallones and Cordell Bank National Marine sanctuaries, and the northwest corner of the Monterey Bay National Marine Sanctuary, and adjacent slope areas. Rather than a real absence from an area or time period, the absence of sightings of a species may reflect insufficient survey effort. Overall seasonal densities for humpback whale in the CDAS data set were highest in the Oceanic season and lowest in the Davidson Current season.

See an additional map for this species in Figure 4.31 from NOAA's Southwest Fisheries Science Center stock assessment surveys (July-December, 1991, 1993, 1996 and 2001). This map provides additional information on the range of the species off the coasts of California, Oregon and Washington.

Human related sources of injury and mortality include: fisheries interactions with California's drift gillnet fishery; entanglement in polypropylene line and fishing gear such as crab pot lines; ship strikes; and other anthropogenic sources (Carretta *et al.,* 2006; NMFS unpub. data). Annual humpback whale mortality and serious injury in California's drift gillnet fishery is likely greater than 10% of the Potential for Biological Removal, and may not be approaching zero mortality/serious injury rate (2005, NMFS unpub. data).

In support of the need for coordination of conservation measures by diverse countries sharing migratory or trans-boundary species, Canada, Mexico, and the United States have developed a North American Conservation Action Plan (NACAP 2005, see Commission for Environmental Cooperation, 2005) for the humpback whale. Ship collisions and entanglements in fishing gear appear to be the greatest sources of mortality and injury for humpback whales. Food availability, climate change, noise disturbance, and loss of prey habitat may also threaten their recovery (Commission for Environmental Cooperation, 2005). Key tri-national collaborative conservation actions identified for the humpback whale include: 1) support the SPLASH initiative (Structure of Population Levels of Abundance and Status of Humpbacks (see below); 2) reduce entanglement; 3) prevent ship strikes; 4) address impacts of ecotourism; and 5) address acoustic impacts (Commission for Environmental Cooperation, 2005). The increasing levels of anthropogenic noise in the world's oceans is a habitat concern, particularly for baleen whales that may communicate using low-frequency sound (Carretta *et al.,* 2006). Potentially detrimental sound sources in the ocean include: Naval activities (Low Frequency Active sonar, mid-range sonar); oceanographic experiments, such as the Acoustic Thermometry of Ocean Climate (ATOC); seismic air-gun surveys; and vessel traffic (Commission for Environmental Cooperation, 2005).

An international, collaborative research effort to study humpback whales in the North Pacific was initiated in 2004, with proposed completion in 2007. The objectives of SPLASH include determining: 1) the abundance of humpback whales for each feeding and wintering area in the North Pacific; 2) trends in population size; 3) the identity and boundaries of feeding areas, especially in previously unstudied areas; 4) population structure and migratory movements; and 5) human impacts, including

entanglement. (http://www.cascadiaresearch.org/SPLASH/Proposal.htm).

In the study area, humpback whales feed on seasonally abundant, small schooling fishes (e.g., northern anchovy, Pacific sardine, Pacific herring) and euphausiids (krill, primarily *T. spinifera* and *E. Pacifica*; Kieckhefer, 1994). However, humpbacks are considered to be generalist feeders that also feed on copepods, sand lance, capelin, herring, juvenile salmon, Arctic cod, juvenile walleye Pollock, Atlantic mackerel, and some cephalopods (Commission for Environmental Cooperation, 2005).