Data Used In the Assessment

The maps in the marine mammal assessment are based on different types of surveys: the efforts of individual researchers to study marine mammal spatial and temporal patterns, Federal and state government efforts to assess stock sizes and the potential biological impacts of oil development, and state government efforts to respond to oil spills.

Most of the at-sea data sets used in this assessment were compiled into the "CDAS central California data set (1980-2003)", developed by the R.G. Ford Consulting Company, in Portland Oregon. Another data set, the marine mammal stock assessment surveys (1991-2001), was from NOAA's Southwest Fisheries Science Center; this data set was used to develop separate sighting and effort maps along the California, Oregon and Washington coast for selected mammal species.

Estuaries and the coastline were initially not part of this GIS study area or analysis, but exceptions were made for sea otters, pinniped haulouts and rookeries, when data were available, to provide a more complete view of important areas for these species. Data for southern sea otter, pinniped haulouts and rookeries, and map descriptions came from a variety of sources - see individual map descriptions for sources.

Table 4.2. Summary of at-sea data sets in the CDAS central California data set (1980-2003) used in the marine mammal assessment.

Data Set	Principal Investigator	Vessel Name & Platform Height	Habitat Covered[2]	Years	Ocean Seasons Covered	Total Transect Width: Pinnipeds	Total Transect Width: Cetaceans
MMS High-Altitude Aerial Surveys	Dohl	Pembroke, 270m	Surface survey of the shelf, slope & deep ocean beyond	1980-1983	All three seasons	N/A	harbor porpoise, 254m; great whales, 1130m; all others, 885m
MMS Low-Altitude Aerial Surveys	Bonnell	Pembroke, 62m	Surface survey of the shelf, slope & deep ocean beyond	1980-1983	All three seasons	109m	109m
EPOCS Shipboard Surveys	Ainley	Surveyor, 12m, Discoverer, Oceano-grapher, 15m	Surface survey of the deep ocean	1984-1994	All three seasons	300-600m	800m
CA Seabird Ecology Low-Altitude Aerial Surveys	Briggs	Partenavia, 62m	Surface survey of shelf and slope	1985	Mainly Upwelling	50m	50m
NMFS Midwater Trawls for Juv. Rockfish: Ship Surveys	Ainley	David Starr Jordan,10m	Surface survey of shelf and slope to 3000 m	1985-2001	Mainly Upwelling	300m	800m
OSPR Low Altitude Aerial Surveys	Bonnell, Tyler	Partenavia, 62m	Surface survey of shelf and slope	1994-1998, 2001-2003	All three seasons	50m	50m
MMS Santa Barbara Channel Low Altitude Aerial Surveys	Bonnell	Partenavia, 62m	Surface survey of shelf and slope	1995-1997	All three seasons	50m	50m
SF-DODS Shipboard Surveys	Ainley	Point Sur, 8m	Surface survey of shelf and slope to 3000 m	1996-2000	All three seasons	300m	800m

Note: See additional descriptions of these data sets in the chapter.

The CDAS Central California Data Set (1980-2003)

This data set was developed using software called the 'Marine Mammal and Seabird Computer Data Analysis System' (CDAS), by the R.G. Ford Consulting Company, in Portland Oregon. The data set contains data from eight survey programs (five aerial surveys, three ship surveys) conducted between 1980 and 2003, and extends from Pt. Arena to Pt. Sal. Four of the data sets were from high and low altitude aerial surveys from the Minerals Management Service, and the fifth aerial data set was from the California Department of Fish and Game, Office of Spill Prevention and Response (CDFG-OSPR, unpublished data). The source of data for the three ship-based survey data sets is David Ainley of H. T. Harvey and Associates and collaborators (unpublished data; Keiper *et al.,* 2005 for details on methods). See Table 4.2 for a summary of the eight at-sea data sets, and the Data and Analyses section of the bird chapter for detailed descriptions of the at-sea surveys. Figures 3.1 and 3.2 in the bird chapter contain maps of the survey extent of each at-sea data set in CDAS, and Figures 4.1 and 4.2 are summary maps of CDAS survey effort for pinnipeds and cetaceans.

Summarizing Survey Data into Grid Cells for CDAS Maps

The distributions of effort and species sightings from the data sets in Table 4.2 were mapped into 10' latitude by 10' longitude cells using CDAS, a custom geographic information system for analyzing marine bird and mammal surveys, developed by R.G. Ford Consulting Co.

The data sets were processed to compensate and correct for differences in survey methodology, including platform type (ship or aerial) and strip width, among the various studies, as well as differential sightability among species. Because wind speed affects detection of marine mammals, data collected when wind speed exceeded 25 knots were excluded. Mammal observation data and survey trackline data from these studies were converted to a common format of observations and trackline surveyed. All aerial data were continuous; ship-based data were converted separately into a continuous transect to the extent possible. The continuous aerial data were binned into the appropriate cell.

For the SF-DODS and EPOCS studies, and the Rockfish Assessment cruises prior to 1997, the beginning position, ship heading, and ship speed were used to compute the end position of each 2-4 km continuous transect. From this, a midpoint of the transect was determined. Times of observations were not available, therefore the position of midpoint was used to select the cell to which the survey effort was assigned. If this midpoint fell on a cell boundary, it was assigned to the cell to the north or west. To maintain the correspondence between effort and mammal observations, observations were also assigned to the transect midpoints. For the Rockfish Assessment Cruises from 1997 onward, effort was assigned to the cells through which the vessel passed based on the proportion of trackline that fell within each cell, and observations were interpolated along the cruise track according to the time of each observation.

The length and width of the survey trackline in a given cell were used to estimate the area sampled on a particular survey. An additional species-specific adjustment was made to the area surveyed to correct for detectability and availability bias. The number of mammals of each species seen in a cell was then divided by the area sampled in the cell to estimate density per cell. If a cell was surveyed more than once, densities were averaged, with an adjustment made for effort.

Analysis of CDAS Data

Effort Summary. For all at-sea surveys in the CDAS central California data set (1980-2003), 164,479 kilometers of trackline (pinnipeds and cetaceans) and 78,487 kilometers of additional trackline (cetaceans only) were analyzed; see Table 4.3. A total of

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3,979 observations of 8,286 pinnipeds and 4,257 observations of 103,701 cetaceans were included in analyzed data. Survey effort used in this assessment for pinnipeds and cetaceans are summarized as maps in Figures 4.1 and 4.2, below. As evident in Table 4.3, the Upwelling Season had the greatest amount of survey effort, followed by the Davidson Current Season; the Oceanic Season had the lowest amount of effort. Unlike the other seasons, the Oceanic Season had no data from the 1980s. Because of the variation in effort coverage across space and time (and methods, as well as many other factors), interpretation of the data requires careful consideration. The mapped occurrence patterns only confirm that species have been sighted in certain areas and time periods; rather than a real absence from an area, the absence of sightings may reflect insufficient survey effort.

Organizing CDAS Data by Ocean Season**.** When adequate data existed for a species, the at-sea CDAS data were organized by ocean season to provide maps of the seasonal patterns of species. Survey effort and species sighting data were organized and mapped into three distinct ocean seasons (Bolin and Abott, 1963): Upwelling (~spring/summer), Oceanic (~fall), and Davidson Current (~winter). The ocean seasons were used because ocean conditions differ distinctly among these seasons and are known to have a strong influence on the biota and biogeography of the California Current system (Ainley, 1976; Briggs *et al.,* 1987). Although there is significant interannual variation in the actual duration, start, and end of these seasons, the following dates were chosen for each season for purposes of analysis: Upwelling Season is 15 March-14 August; Oceanic Season is 15 August-14 November; and Davidson Current Season is 15 November-14 March.

Although the at-sea data span the years from 1980 to 2003, data are not available for all seasons and all cells in all years. For the Upwelling Season, data are from 1980-1982 and 1985-2002; for the Oceanic Season, data are from 1980-1982, 1991, and 1994-2002; and for the Davidson Current Season, data are from 1980-1986 and 1991-2003.

Calculating Density and Developing Seasonal and Overall Density CDAS Maps**.** From the digitized survey data, the distribution of effort and of species observations was mapped into a grid of 10' by 10' cells, using the MMS-CDAS mapping system (MMS, 2001). The larger cell size (marine bird analysis used 5'x5' cells) was determined to be more meaningful for marine mammals by experts at a prelimi-

Table 4.3. A summary of combined at-sea effort in the CDAS central California data set for marine mammals (1980-2003).

Ocean Season	Dates Used for Each Ocean Season	Number of Months	Years Included	Taxa	Kilometers of Trackline Surveyed	Number of Visits	Number of 10' Cells Sampled
Upwelling	15 Mar-14 Aug	5	1980-1982, 1985-2002	*Pinnipeds*	78,534	16,374	283
				Cetaceans	112,251	20,752	317
Oceanic	15 Aug-14 Nov	3	1980-1982, 1991, 1994-2002	*Pinnipeds*	36,337	6,710	263
				Cetaceans	55,875	9,261	322
Davidson Current	15 Nov-14 Mar	4	1980-1986, 1991-2003	*Pinnipeds*	49,608	9,542	364
				Cetaceans	74,840	12,845	387
TOTAL	1 Jan-31 Dec	12	1980-2003	*Pinnipeds*	164,479	32,626	396
				Cetaceans	242,966	42,858	417

nary map/data review session. Linear effort data (kilometers of trackline) was transformed into area surveyed on the basis of strip widths (which varied by ship or aerial platform, depending on speed and height above water; see Table 4.2). Individual body size, group size, and species-specific behaviors, such as proportion of time spent submerged, are all factors known to affect detection and hence, observed distribution and density estimates as well. Because of the very different attributes of aerial and shipboard platforms, these factors, and the associated adjustments for observations, vary among the studies. Platform-, study-, and species-specific correction factors for detectability were applied in order to calculate the effective area surveyed in each cell for each species in each study. The number of individuals of each species seen was then divided by the effective area surveyed for that species to estimate density in each cell for that data set. For construction of density plots, if a cell was censused in other years or the same year by another survey, densities in cells were averaged and weighted according to area surveyed. Seasonal and overall density maps were then constructed for each species, showing the estimated density in each 10 by 10' cell.

Details of Density Calculations for Marine Mammals at Sea. Densities of marine mammals (animals per square kilometer) were calculated by dividing the number of animals seen by the amount of area effectively surveyed.

The area surveyed was calculated by multiplying the length of the trackline of the vessel or aircraft by the width of the survey strip. Survey widths for marine mammals varied from 50 meters for most low altitude aerial surveys to 800 meters for cetaceans on most ship-based surveys. Some high altitude aerial surveys for marine mammals used line transect methodology. For the line transect surveys, f(0) was calculated for each species and effective strip width and effective strip width (ESW) was determined from f(0). F(0) is the decrease in sighting probability as the perpendicular distance from the transect increases; the value of f (0) is the inverse of the ESW.

Density estimates were calculated using the formulas described below, for each species observed during each study and for each season in each geographic cell. Multiple density estimates in a given cell were averaged, using the effective survey area as a weighting factor.

Density (animals per km^2) was estimated using the standard formula:

1) $D = n / (l \cdot w)$

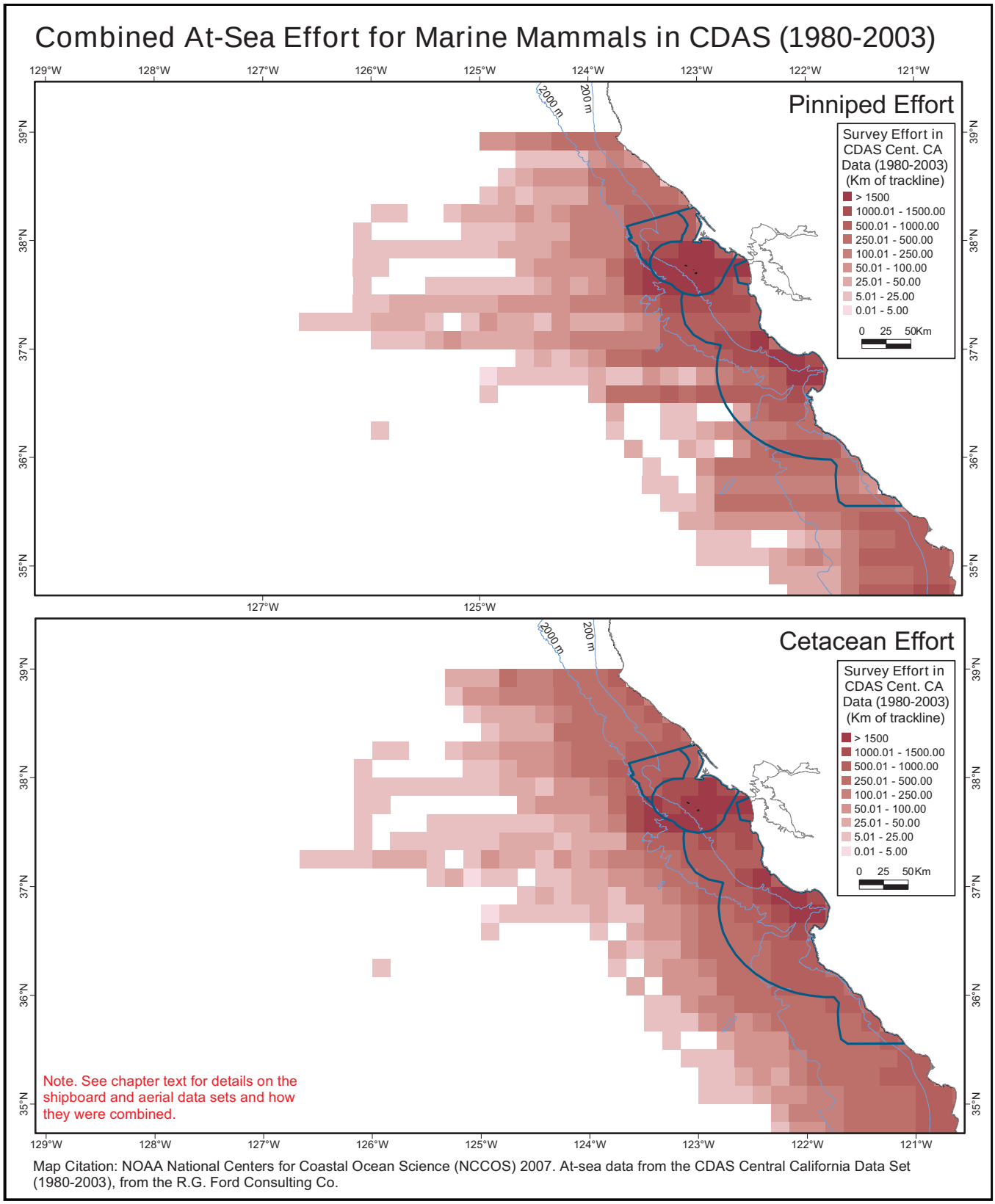
where D is density, n is the number of animals observed, l is the length of the trackline sampled (aircraft or ship), and w is the width of the sampled area. For strip transects, w was the specified strip width. For line transects, the Effective Strip Width (ESW) was calculated from f(0) using methods described in Thomas *et al.,* (2003) and Buckland *et al.,* (1993). All estimates of ESW were provided by the original investigators.

For all surveys, an additional adjustment, g(0), or the detection probability on the transect line, was made to the area surveyed to correct for perception and availability bias. This correction is the probability that an animal will be on the surface and available to be observed during the time period that the observer is passing, and includes the effects of surfacing and dive behavior of the species in question as well as the rate of movement of the survey platform. The maximum value of this parameter is 1.0; if the value is less than 1.0, the area effectively surveyed is less than the area that was estimated by multiplying trackline length by strip width. We corrected for limited time on the surface and perceptibility using the following equation (Burnham *et al.,* 1980):

2) $D = n / (g (0) \cdot l \cdot w)$

where g (0) is an estimate of the probability of detection, which combines the proportion of time spent at the surface (availability) with the probability that an animal available to be seen will be perceived by the observer (perceptibility). Estimates of g(0) for each species were based on Koski *et al.,* (1998).

Estimates of density were calculated using 10' by 10' cells for marine mammals. Block size was chosen as a compromise between larger size cells which minimize random variation between blocks and the number of unsampled blocks, and smaller size cells which provide greater spatial resolution. A larger block size was chosen for marine mammals than for birds because their densities are rela-



Figures 4.1 and 4.2. Summary maps of survey effort for pinnipeds (4.1) and cetaceans (4.2) from the CDAS central California data set (1980-2003).