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4. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region

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Abstract

In this review, we combine existing published and unpublished information along with expert judgment to identify and support the delineation of 28 Biologically Important Areas (BIAs) in U.S. waters along the West Coast for blue whales, gray whales, humpback whales, and harbor porpoises. BIAs for blue whales and humpback whales are based on high concentration areas of feeding animals observed from small boat surveys, ship surveys, and opportunistic sources. These BIAs compare favorably to broader habitat-based density models. BIAs for gray whales are based on their migratory corridor as they transit between primary feeding areas located in northern latitudes and breeding areas off Mexico. Additional gray whale BIAs are defined for the primary feeding areas of a smaller resident population. Two small and resident population BIAs defined for harbor porpoises located off California encompass the populations' primary areas of use. The size of the individual BIAs ranged from approximately 171 to 138,000 km^2. The BIAs for feeding blue, gray, and humpback whales represent relatively small portions of the overall West Coast area (< 5%) but encompass a large majority (77 to 89%) of the thousands of sightings documented and evaluated for each species. We also evaluate and discuss potential feeding BIAs for fin whales, but none are delineated due to limited or conflicting information. The intent of identifying BIAs is to synthesize existing biological information in a transparent format that is easily accessible to scientists, managers, policymakers, and the public for use during the planning and design phase of anthropogenic activities for which U.S. statutes require the characterization and minimization of impacts on marine mammals. To maintain their utility, West Coast region BIAs should be re-evaluated and revised, if necessary, as new information becomes available.

Key Words: feeding area, migratory corridor, resident population, anthropogenic sound, species distribution, U.S. West Coast, North Pacific Ocean

Introduction

This review document coalesces existing published and unpublished information to define Biologically Important Areas (BIAs) in U.S. waters of the West Coast region (shoreward of the offshore boundary of the U.S. Exclusive Economic Zone [EEZ]) for cetacean species that meet the criteria for feeding areas, migratory corridors, and small and resident populations defined in Table 1.2 of Ferguson et al. (2015b) within this issue. A comprehensive overview of the BIA delineation process; its caveats (Table 1.4), strengths, and limitations; and its relationship to international assessments also can be found in Ferguson et al. Table 1.3 provides a summary of all BIAs identified, including region, species, BIA type, and total area (in km^2). A summary also can be found at http://cetsound.noaa.gov/important. Table 1.1 defines all abbreviations used in this special issue. Metadata tables that concisely detail the type and quantity of information used to define many of these BIAs are available as an online supplement. Our intent is to delineate BIAs by synthesizing information that is not publicly available from existing sources, is only partially represented through peer-reviewed publications, or is not evident in habitat-based density (HD) models. The goal of identifying BIAs is to synthesize existing biological information in a transparent format that is easily accessible to scientists, managers, policymakers, and the public for use during the planning and design phase of anthropogenic activities for which U.S. statutes require the characterization and minimization of impacts on marine mammals.

Within the West Coast region, three species—blue whale (*Balaenoptera musculus*), gray whale (*Eschrichtius robustus*), and humpback whale (*Megaptera novaeangliae*)—were evaluated and found to meet the criteria for feeding or migratory corridor BIAs. Fin whale (*B. physalus*) feeding BIAs are discussed, but no BIAs were defined due to limited or conflicting information. Small and resident population BIAs were created for harbor porpoises (*Phocoena phocoena*). BIAs for reproductive areas were not evaluated in this initial exercise but should be considered in the future. Although none of the focal species included in this chapter have dedicated reproductive areas within U.S. waters, some are found with calves and, therefore, might warrant designating BIAs for reproductive areas. Other species found in this region, including minke whale (*B. acutorostrata*), killer whale (*Orcinus orca*), beaked whales (Ziphiidae), and sperm whale (*Physeter macrocephalus*), were not evaluated during this initial BIA exercise; these species should be evaluated in future efforts to create or revise BIAs for cetaceans in this region.

The feeding BIA boundaries for the U.S. West Coast were based on two considerations: (1) direct observation of feeding or surfacing patterns and associated species strongly suggestive of feeding (and in some cases documented with archival tag data), and (2) presence of concentrations and repeat sightings of animals in multiple years in an area and a time of year where feeding is known to occur. The area boundaries were based on expert judgment, outlining areas of high sighting concentrations from multiple years. The heterogeneity in survey effort across the West Coast region was subjectively factored in to decrease the degree to which results were biased by areas searched, although allocating greater survey effort in areas where sightings had been documented in the past could also introduce bias. In addition, bathymetric features were considered in defining the BIAs when sightings were associated with a specific habitat, but the BIAs were restricted to the areas where the highest concentrations of sightings were documented in multiple years. The exact BIA boundaries for feeding blue, humpback, and gray whales were initially drawn to encompass sighting concentrations documented in multiple years and then processed in *ArcGIS* (ESRI, Redlands, CA, USA), using the Buffer tool applied to the original polygon with a 5-km buffer distance for blue and humpback whales (with a 1 km from shore exclusion) and a 3-km buffer distance for gray whales (excluding any direct overlap with shoreline).

We compared the BIAs determined here with the mean predicted densities from the HD models generated from the Southwest Fisheries Science Center's line-transect data collected since the 1990s (Becker et al., 2012a; Forney et al., 2012), the results of which are available to view on the CetMap website (http://cetsound.noaa.gov/cetsound). In those models, functional relationships between cetacean density and a variety of static and dynamic habitat variables were derived from the multi-year data and subsequently used to estimate two types of parameters: (1) annual densities that take into account each year's oceanic conditions and (2) multi-year average densities (and variation therein) within the study area (Becker et al., 2012a). The data used to delineate the BIAs were predominantly based on coastal (< 50 nmi offshore), nonsystematic small boat surveys conducted to maximize encounters with target species (i.e., blue, fin, humpback, and gray whales) for photo-identification and tagging studies. In contrast, the HD models were based on systematic line-transect survey effort conducted from large ships at 3- to 5-y intervals in summer and fall that extended out to 300 nmi offshore. Due to their broad geographic area, coverage in each year is a course with lines spaced about 80 nmi apart. The two datasets provide complementary information on the occurrence of blue, fin, and humpback whales: the small boat surveys were better able to resolve nearshore, fine-scale patterns of occurrence, whereas the HD models provided a systematic assessment of broad-scale patterns of occurrence throughout nearshore and offshore waters. We identify where the results of the BIA exercise and the HD models are concordant, complementary, or subject to differing potential biases. It is our hope that this overview will aid the reader in gaining an understanding of the strengths, limitations, and combined implications of the information presented herein.

Biologically Important Areas in the West Coast Region

*Blue Whale (*Balaenoptera musculus*)*

General—The blue whale, the largest of all animals, is an endangered species of baleen whale that feeds almost exclusively on krill. With the advent of modern whaling ships, blue whales became a primary target of modern commercial whalers. Worldwide populations were reduced in the 20th century from over 200,000 to well under

10,000 individuals, with most of those killed from the southern oceans (Gambell, 1976, 1979). Blue whales in the North Pacific Ocean are thought to consist of at least a western/central and an eastern population based on distribution and vocalizations, although historically there may have been as many as five populations in the North Pacific Ocean (National Marine Fisheries Service [NMFS], 1998). The eastern North Pacific blue whales are now known to range from the Costa Rica Dome to the Gulf of Alaska (Calambokidis et al., 2009a, 2009b, 2009c).

Since the 1970s, large concentrations of blue whales have been documented feeding off California each summer and fall (Calambokidis et al., 1990). Relatively low numbers of blue whales were taken by whalers off the U.S. West Coast (Rice, 1963, 1974), so it was initially unclear how the animals feeding off the U.S. West Coast were related to those from the primary areas where they had been taken farther north (NMFS, 1998). Shifts in blue whale distribution that occurred since the late 1990s, including documented movements of blue whales from California northward to areas off British Columbia and Alaska, have shown that blue whales inhabit a broad and shifting feeding area throughout the eastern North Pacific (Calambokidis et al., 2009a). These changes in blue whale distribution appear related to decadal oceanographic variations because the timing coincided with shifts in the Pacific Decadal Oscillation (Calambokidis et al., 2009a).

Unlike other baleen whale species in the eastern North Pacific whose populations have increased, such as fin, humpback, and gray whales, blue whales have not shown signs of recovery from whaling over the last 20 y. Blue whale population size from capture-recapture of photo-identified individuals has stayed relatively unchanged at around 2,000 since the early 1990s (Calambokidis & Barlow, 2004, 2013), and average abundance of animals from line-transect surveys off the U.S. West Coast has declined from close to 2,000 in the 1990s to 500 to 800 in the 2000s (Barlow & Forney, 2007; Barlow, 2010). These two methodologies provided different measures of abundance: data from line-transect surveys estimated the number of animals in the region during the survey period, whereas the photo-identification data provided estimates of the total population size (Calambokidis & Barlow, 2004). Part of the reason for the divergence in the estimates from capture-recapture and line-transect density appears to be the switch in distribution related to oceanographic conditions and related prey abundance mentioned above. The most recent stock assessment report (Carretta et al., 2013) reports blue whale abundance for the Eastern North Pacific Stock to be 2,497 (CV = 0.24) based on the capture-recapture of photographically identified whales from 2005 to 2008 (Calambokidis et al., 2009a), although new estimates using an alternate and more promising capture-recapture model have indicated an estimate closer to 1,500 based on data through 2011 (Calambokidis & Barlow, 2013).

Feeding Area BIAs—Blue whales are not evenly distributed along the West Coast; rather, they are found in aggregations, especially on the continental shelf edge (Croll et al., 2005; Keiper et al., 2011), with greater tendency to aggregate off California than Oregon and Washington. Based on 9,054 visual sightings of 17,178 blue whales, primarily from small boat surveys conducted from 1986 to 2011 by Cascadia Research (www.cascadiaresearch.org) and collaborators along the U.S. West Coast, nine common feeding areas of high blue whale concentration have been identified (Table 4.1; Figure 4.1). Additionally, feeding by blue whales on krill has also been documented in eight of the nine BIAs using

Table 4.1. Blue whale (*Balaenoptera musculus*) BIAs with map references (see Figure 4.1), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Point Arena to Fort Bragg	Aug-Nov	1,419	170	4
2	Gulf of the Farallones	July-Nov	5,243	1,565	24
3	Monterey Bay to Pescadero	July-Oct	2,378	801	16
4	Point Conception/Arguello	June-Oct	1,743	151	10
5	Santa Barbara Channel and San Miguel	June-Oct	1,981	3,117	18
6	Santa Monica Bay to Long Beach	June-Oct	1,187	764	5
7	San Nicolas Island	June-Oct	427	105	5
8	Tanner-Cortez Bank	June-Oct	1,076	52	5
9	San Diego	June-Oct	984	443	10
	Total blue whale BIA areas and sightings		16,438	7,168	
	Total EEZ area and sightings		820,809	8,244	
	Percentages		2%	87%	

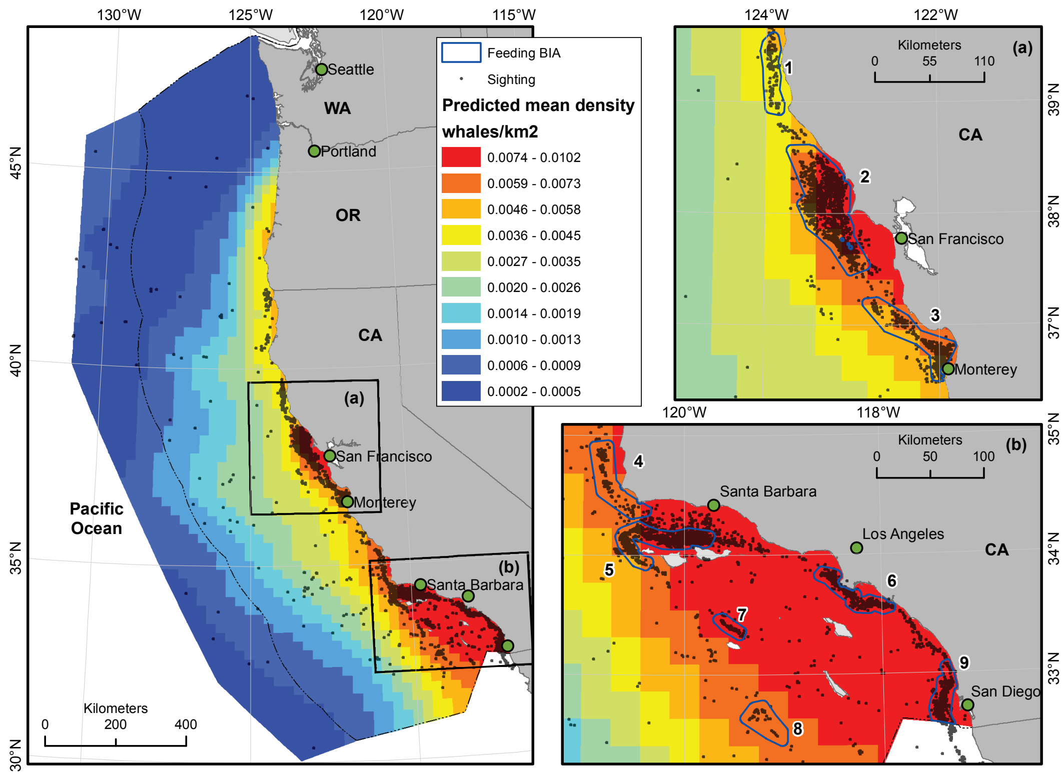

Figure 4.1. Nine blue whale (*Balaenoptera musculus*) Biologically Important Areas (BIAs), overlaid with all sightings and predicted mean densities of blue whales from habitat-based density (HD) models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a). Panels a and b show more detail for the areas where the BIAs are located. The BIAs are (from north to south) (1) Point Arena to Fort Bragg, August-November; (2) Gulf of the Farallones, July-November; (3) Monterey Bay to Pescadero, July-October; (4) Point Conception/Arguello, June-October; (5) Santa Barbara Channel and San Miguel, June-October; (6) Santa Monica Bay to Long Beach, June-October; (7) San Nicholas Island, June-October; (8) Tanner-Cortez Bank, June-October; and (9) San Diego, June-October (see Table 4.1 for details).

suction-cup attached multi-sensor archival tags (Calambokidis et al., 2008b; Goldbogen et al., 2011, 2013; Friedlaender et al., 2014; Cascadia Research, unpub. data). Six of these areas are in or near the Southern California Bight.

Feeding BIAs for blue whales may extend farther north and for longer time periods than we currently are able to delineate. Despite limited effort in winter, two of the three known blue whale sightings off Washington in the last 50 y have been in December and January; one of these, made in December 2011, consisted of at least five blue whales with other unidentified whales (Cascadia Research, unpub. data, 2011; see also Figure 4.1). Satellite-tag data from blue whales also show animals that were thought to be feeding offshore of Washington in the winter (Bailey et al., 2010; Irvine et al., 2014). Unlike many other mysticete whales, blue whales appear to continue feeding through their winter breeding season, both in northern latitudes and in productive offshore lower latitude areas (Calambokidis et al., 2009c; Bailey et al., 2010).

Of the nine blue whale BIAs identified here, six overlap with areas of highest density identified in the HD model and the rest falling within areas of moderately high mean density (Figure 4.1). The areas of agreement occur in two regions: (1) the Southern California Bight, which represents the largest area of high density in the HD models and also is where a majority of the BIAs we identified occur; and (2) the Gulf of the Farallones where the BIA we identify (encompassing the area north including Cordell Bank and waters west of Bodega Bay) and where the HD model also predicts a high-density area. The BIAs are more centered along areas near the shelf edge as opposed to the mean density maps that show highest densities continuing all the way to shore, reflecting the HD models' lack of resolution at finer spatial scales. The three BIAs not shown in the HD model as areas of highest mean density do agree with predicted areas of moderately high density and also encompass areas predicted to have highest densities in some of the annual HD models. These three BIAs include the following:

1. An area along the shelf edge from Point Arena north to Fort Bragg, which is located farther north than any of the highest density areas from the mean HD models but is predicted to be a high-density area in some of the annual models
2. The Monterey Bay area north to Pescadero Point, which borders areas of highest mean density and which also is predicted to be a high-density area in some of the annual HD models
3. An area near Tanner and Cortez Banks where we have seen large blue whale concentrations on a number of surveys despite our low effort in this region

The six BIAs that we identified in the Southern California Bight represent only a fraction of the total area within the bight that the HD models predict to have high densities of blue whales. Our BIAs represent 2% of U.S. waters in the West Coast region but encompass 87% of the sightings we document within U.S. waters. While there is some evidence of annual variation in blue whale occurrence in both sighting locations and in the annual HD models (Figure 4.2), the areas identified represent those with the more consistent occurrence year to year.

*Gray Whale (*Eschrichtius robustus*)*
General—Gray whales were historically distributed in both the North Pacific and North Atlantic Oceans, although only the populations in the North Pacific Ocean remain today. In the North Pacific Ocean, two primary populations have been recognized: (1) an eastern (ENP) and (2) a western (WNP) population. More recently, the distinction between these two populations has been debated due to evidence that gray whales from the western feeding area are coming to breeding areas in the eastern North Pacific (Weller et al., 2012). These data suggest that animals from both eastern and western feeding areas migrate along the U.S. West Coast. Additionally, there is recent genetic evidence supporting the existence of a more distinct local subpopulation of ENP gray whales

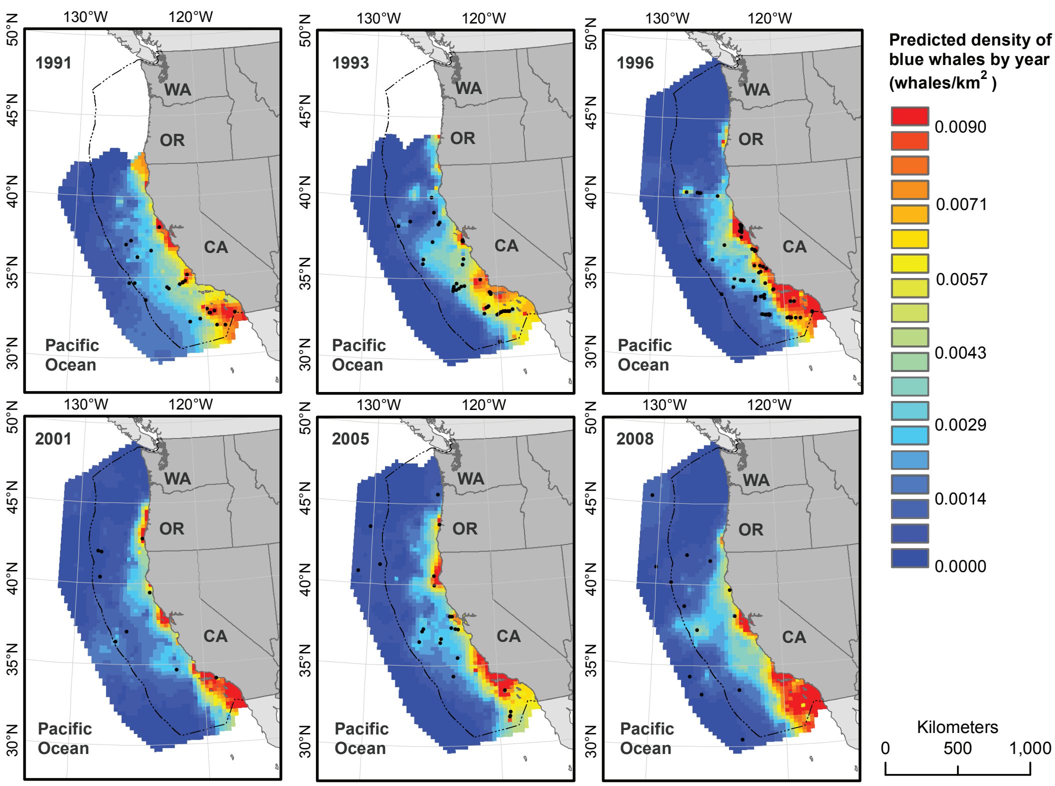

Figure 4.2. Predicted mean densities and sightings (black dots) of blue whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

called the Pacific Coast Feeding Group (PCFG) (Frasier et al., 2011; Weller et al., 2012; Lang et al., 2014). The PCFG is a trans-boundary subgroup shared by the U.S. and Canada, and PCFG whales are observed almost year-round, though primarily from spring to fall. During the migration, PCFG whales are intermixed with the larger overall ENP population, but from June to November, they are the only gray whales within the region between northern California and northern Vancouver Island (from 41° N to 52° N) (Calambokidis et al., 2002, 2010, 2014; International Whaling Commission [IWC], 2011c). PCFG gray whales are also occasionally seen in waters farther north during summer and autumn, including off Kodiak Island, Alaska (Gosho et al., 2011). The primary feeding areas for ENP gray whales are thought to be in the Bering and Beaufort Seas, while WNP gray whales are thought to feed primarily near Sakhalin Island, Russia, in the Okhotsk Sea. Therefore, proposed feeding BIAs in this region focus on the feeding PCFG gray whales.

Gray whales in the PCFG likely mate with animals from the ENP population. Although earlier work had not revealed significant genetic differences between PCFG and ENP gray whales (Ramakrishnan et al., 2001; Steeves et al., 2001), a later study of mitochondrial DNA (mtDNA) haplotypes (classification of maternally inherited mtDNA) using a larger sample size found significant differences between gray whales that were part of the PCFG and those from the overall ENP population (Frasier et al., 2011). This information is considered sufficient to represent the PCFG gray whales separately for the BIA exercise. Currently, PCFG whales are not treated as a distinct stock in the NMFS stock assessment reports, but this may change in the future based on the recently published genetic information mentioned above.

Photo-identification studies from 1998 through 2012 conducted between northern California and northern British Columbia estimate that the PCFG comprises approximately 200 animals (Calambokidis et al., 2002, 2010, 2014) compared to the population of close to 20,000 gray whales for the overall eastern North Pacific. The photo-identification data suggest that the range of at least some of the PCFG whales exceeds the pre-defined 41°N to 52°N boundaries that have previously been used in abundance estimates.

Feeding Area BIAs—Information from nonsystematic, visual boat-based surveys (4,907 sightings of 8,556 animals from 1991 to 2011) and tagging data collected by Cascadia Research (www.cascadiaresearch.org) and other collaborators (see Calambokidis et al., 2004, 2010, 2014; Moore et al., 2007) support the existence of five PCFG feeding aggregations within the West Coast region (Figure 4.3; Table 4.2).

Additionally, we designate a BIA in northern Puget Sound, around the south end of Whidbey and Camano Islands. Gray whales come to this area for 2 to 3 mo in the spring (typically beginning in March) to feed, but then generally leave the area before 1 June and, therefore, are not treated as PCFG gray whales (Calambokidis et al., 1992, 2002). While this area is not used by a large number of individuals, the same animals have been documented returning to this relatively small area for over 20 y, and it may, therefore, be important for this group (Calambokidis et al., 2014).

Most of the PCFG feed and are found in coastal nearshore waters, and our BIAs correspondingly are close to shore. Our BIAs encompass a relatively small portion of U.S. waters (0.2%) but contain 77% of the sightings we document. A dense aggregation of feeding gray whales was seen 20 to 25 km off the Washington coast in 2007 (Oleson et al., 2009), but it is unclear if this is a consistent feeding area, so it is not included as a BIA.

Migration—Gray whales migrate annually between their winter breeding grounds in the

Table 4.2. Gray whale (*Eschrichtius robustus*) BIAs with map references (see Figure 4.3), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Northern Puget Sound	March-May	326	263	15
2	Northwest Washington	May-Nov	515	744	14
3	Grays Harbor area, Washington	April-Nov	298	183	17
4	Depoe Bay, Oregon	June-Nov	199	92	9
5	Cape Blanco & Orford Reef, Oregon	June-Nov	171	126	9
6	Point St. George, California	June-Nov	418	110	10
	Total PCFG gray whale BIA areas and sightings		1,927	1,518	
	Total EEZ area and sightings		820,809	1,968	
	Percentages		0.2%	77.1%	

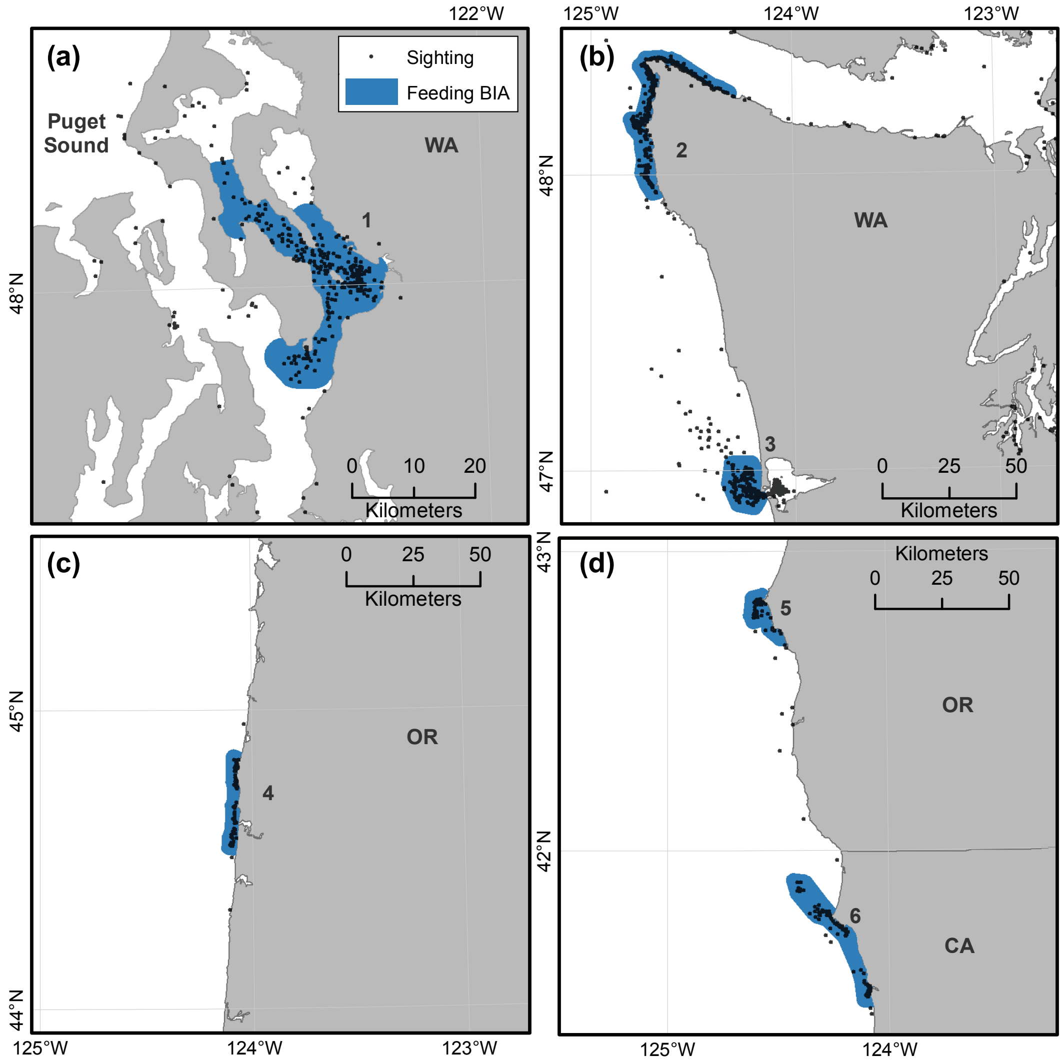

Figure 4.3. Six gray whale (*Eschrichtius robustus*) feeding BIAs shown in four panels a, b, c, and d that span the West Coast region from Washington to California. The BIAs are, from north to south, (1) Northern Puget Sound, March-May; (2) Northwestern Washington, May-November; (3) Grays Harbor, April-November; (4) Depoe Bay, June-November; (5) Cape Blanco & Orford Reef, June-November; and (6) Point St. George, June-November (see Table 4.2 for details). Also shown are sightings primarily from small boat surveys for photographic identification.

lagoons of Baja California, Mexico, and their summer feeding grounds in North Pacific and Arctic waters. This migration is comprised of ENP, PCFG, and at least some of the gray whales that feed in the western North Pacific (Perryman & Lynn, 2002; Shelden et al., 2004; Weller et al., 2012). The spatial and temporal parameters of the gray whale migratory corridor that is found nearshore along the U.S. West Coast are relatively well defined based on tagging studies, dedicated line-transect ship and aerial surveys for marine mammals, land-based counts, infrared technology to investigate nighttime passage rate, "coupled" aerial- and land-based visual surveys, and observations from whale-watching operations and recreational and commercial fishermen (Daily et al., 1993; Rugh et al., 2001, 2006; Mate & Urbán-Ramirez, 2003).

The gray whale migration along the U.S. West Coast (Figure 4.4; Table S4.1) can be loosely categorized into three phases (Rugh et al., 2001, 2006). The Southbound Phase includes all age classes as they migrate to the lagoons in Mexico (October-March, peaking in December-March).

Northbound Phase A consists mainly of adults and juveniles that lead the beginning of the northbound migration (late January-July, peaking in April-July). Cow-calf pairs generally begin their northward migration later (March-July) and are referred to as Northbound Phase B. The three phases are not always distinct, and the sea ice cover in the Bering Sea may influence migration dates (Perryman & Lynn, 2002). Historical gray whale land-based counts suggest that the migration rate (number of individuals/d) begins with a rapid spike, followed by moderate numbers over a few weeks before slowly tapering off (Rugh et al., 2006). The migration corridors used by most gray whales are within 10 km of the U.S. West Coast. The following breakdown by phase of distance from shore was used to define the three BIAs for the gray whale migration in this region based on the detailed information highlighted above and substantiated by expert judgment (Mate & Perryman, pers. comm., 2011):

1. Southbound Phase – 10 km
2. Northbound Phase A – 8 km
3. Northbound Phase B – 5 km

Some gray whales may take a migration path farther offshore, so an additional potential presence buffer extending 47 km from the coastline was added to the BIAs. Although gray whales typically tightly follow the coastline near the mainland, they have been observed taking a more direct route across larger bodies of water in California (Rice & Wolman, 1971; Mate & Urbán-Ramirez, 2003). Particularly during the northbound migration, gray whales with calves migrate closer inside the bay than adults and juveniles. In the Southern California Bight, migrating gray whales may deviate farther from the mainland as some are routinely seen near the Channel Islands (Daily et al., 1993).

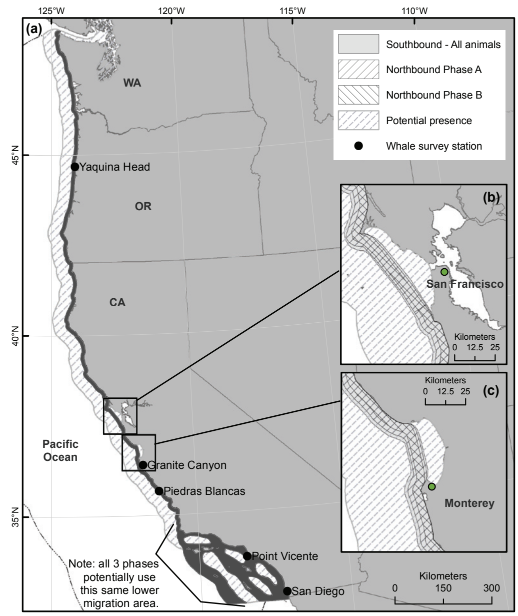

Figure 4.4. BIAs for the three phases (Southbound, Northbound Phase A, and Northbound Phase B) and for the potential presence area of the gray whale migratory corridor (a) along the West Coast of the U.S. from California to Washington, (b) keeping just outside of San Francisco Bay, and (c) keeping just outside of Monterey Bay; substantiated through vessel-, aerial-, and land-based survey data, satellite-tag data, and expert judgment.

*Humpback Whale (*Megaptera novaeangliae*)*

General—Humpback whales occur widely in the world's oceans and, although they remain endangered from hunting during the modern era of commercial whaling, many populations have made strong recoveries in the last 50 y (Calambokidis & Barlow, 2004; Barlow et al., 2011). In the North Pacific Ocean, humpback whales tend to alternate between winter breeding areas, including those in the western North Pacific Ocean, Hawai'i, Mexico, and Central America, and more coastal feeding areas in spring, summer, and fall that range from California, north into Alaskan waters, and west to waters off Russia (Calambokidis et al., 2001, 2008a). Both photo-identification and genetic data indicate that, in the North Pacific Ocean, humpback whales remain loyal to specific feeding and wintering areas, although their migrations between these areas reveal a mixed stock structure (Calambokidis et al., 2008a; Barlow et al., 2011; Baker et al., 2013).

Humpback whales are most abundant off the U.S. West Coast from spring through fall, with most migrating to low-latitude areas located primarily off Mexico and Central America in winter (Calambokidis et al., 2000). However, sightings and passive acoustic detections off the U.S. West Coast in winter and spring indicate a portion of the population can be in northern waters even in winter (Forney & Barlow, 1998; Oleson et al., 2009). There are also indications of seasonal shifts in occurrence both up and down the coast as well as inshore and offshore. During small boat surveys taken off the Washington coast in 2004 through 2008, humpback whales were seen farther offshore (along the shelf edge) and in lower densities in winter and spring than during the remainder of the year (Oleson et al., 2009).

There is little interchange between the humpback whale feeding aggregation off California/southern Oregon and the feeding aggregation off Washington/

southern British Columbia (Calambokidis et al., 1996, 2000, 2001, 2004, 2008a); this apparent segregation is not represented in the population units currently being considered by NMFS in the stock assessment reports. Genetic (mtDNA) studies have confirmed the distinctness of these Washington/British Columbia animals (Baker et al., 2008), and their abundance has been roughly estimated at about 200 animals in 2004-2005 (Calambokidis et al., 2008a).

Humpback whales that feed off the U.S. West Coast migrate primarily to wintering grounds off mainland Mexico and Central America (Calambokidis et al., 2000). The proportion of humpback whales going to different breeding grounds varies by latitude along the U.S. West Coast, with the highest proportions migrating to Central America from southern California feeding areas, in contrast to whales that feed in areas farther north that tend to migrate to areas off Mexico (Calambokidis et al., 2000, 2008a; Rasmussen et al., 2011). Humpback whales wintering off Central America have significant differences in mtDNA haplotypes from other North Pacific wintering areas, including mainland Mexico (Baker et al., 2008). The Central American wintering ground is inhabited by the smallest number of whales that occur in the North Pacific wintering grounds, consisting of just a few hundred whales (Calambokidis et al., 2008a; Rasmussen et al., 2011).

Feeding Area BIAs—Based on 11,757 visual sightings of 27,224 humpback whales, primarily from small boat surveys conducted from 1986 to 2011 by Cascadia Research (www.cascadiaresearch.org) and collaborators along the U.S. West Coast, seven areas where humpback whales are commonly sighted feeding in high concentrations have been identified (Figure 4.5; Table 4.3).

Humpback whale distribution on feeding areas off California, Oregon, and Washington is clumped and concentrated in coastal waters from the continental shelf to the shelf edge. HD models built on broad-scale line-transect survey data (extending 300 nmi offshore) capture coast-wide habitat relationships (Becker et al., 2012b). Effort-corrected sighting rates from coastal photo-identification surveys (1991 to 2010; Calambokidis et al., 2009b) off central California reveal high concentrations of humpback whales along the continental shelf edge, with densities generally decreasing inshore of those areas (Keiper et al., 2011). Humpback whales have also been documented feeding on both krill and small fish in three of the BIAs off California based on data from suction-cup attached multisensor archival tags (Goldbogen et al., 2008; Cascadia Research, unpub. data). Localized coastal boat-based photo-identification surveys conducted in the West Coast region by Cascadia Research reveal a high degree of variation in some areas of humpback whale concentration across years, whereas other areas appear to be used fairly consistently (Calambokidis et al., 2009b). Inter-annual variations are apparent in the annual HD models (Figure 4.6).

Of the seven BIAs identified for humpback whales, by far the largest encompasses the broad area extending south from west of Bodega Bay to and including Monterey Bay and encompassing Cordell Bank and the Gulf of the Farallones. This region agreed closely with the single region of highest density in the mean HD model (Figure 4.6). Another broad area of agreement between our BIA delineations and the mean HD model is the absence of BIAs south of the northern Channel Islands, where the HD model similarly showed mean densities declining. While the BIA off northern Washington appeared as a moderately high-density area in the mean HD model, the

Table 4.3. Humpback whale (*Megaptera novaeangliae*) BIAs with map references (see Figure 4.5), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Northern Washington	May-Nov	3,393	298	17
2	Stonewall and Heceta Bank	May-Nov	2,573	62	7
3	Point St. George	July-Nov	1,233	283	12
4	Fort Bragg to Point Arena	July-Nov	1,591	184	8
5	Gulf of the Farallones–Monterey Bay	July-Nov	9,761	5,196	25
6	Morro Bay to Point Sal	April-Nov	1,908	472	14
7	Santa Barbara Channel–San Miguel	March-Sept	2,639	2,250	18
	Total humpback whale BIA areas and sightings		23,098	8,745	
	Total EEZ area and sightings		820,809	9,850	
	Percentages		3%	89%	

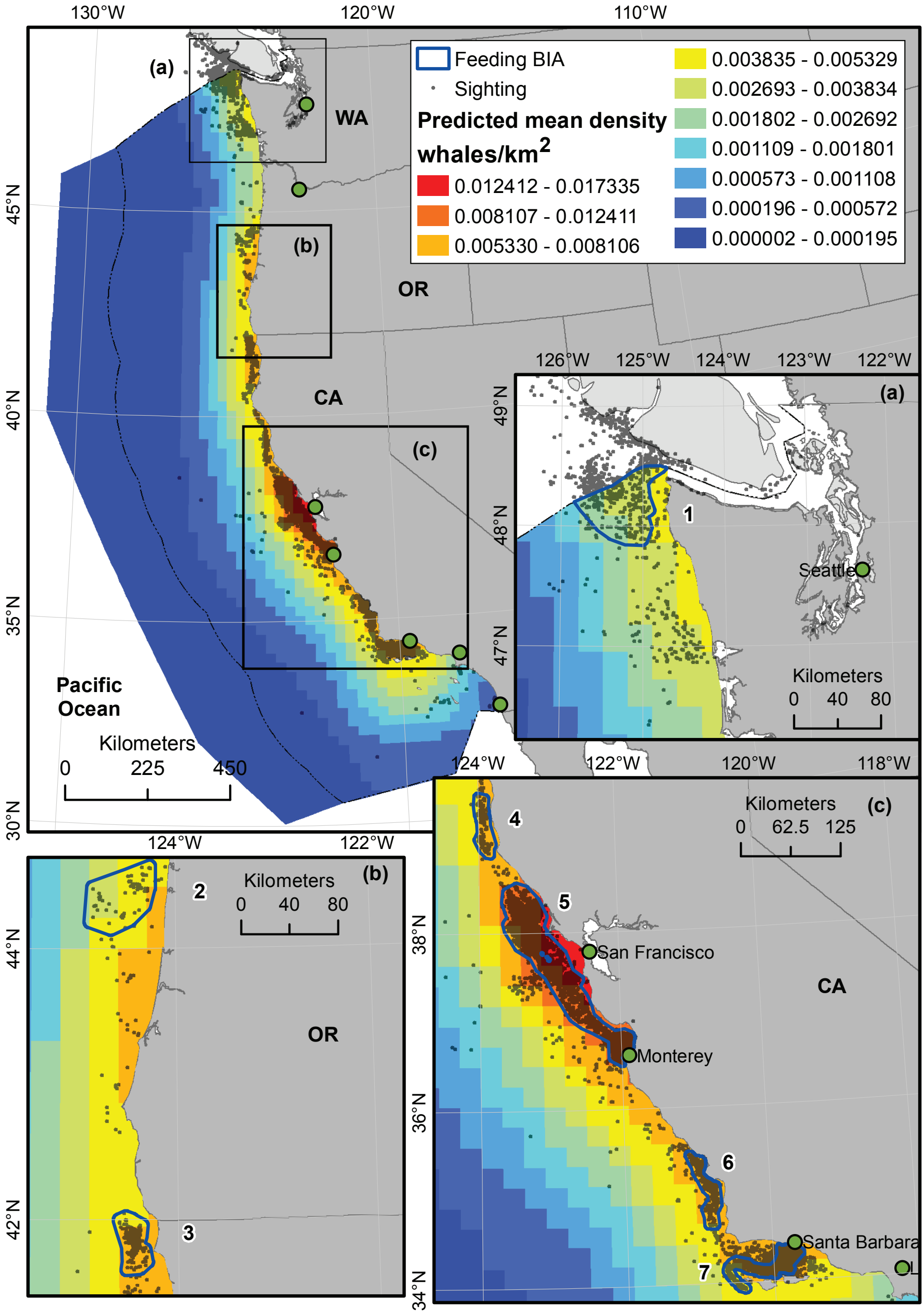

Figure 4.5. Seven humpback whale (*Megaptera novaeangliae*) feeding BIAs overlaid with all sightings and predicted mean densities of humpback whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a). Panels a, b, and c show more detail in the areas where the BIAs are located. The BIAs are (from north to south) (1) Northern Washington, May-November; (2) Stonewall and Heceta Bank, May-November; (3) Point St. George, July-November; (4) Fort Bragg to Point Arena, July-November; (5) Gulf of the Farallones–Monterey Bay, July-November; (6) Morro Bay to Point Sal, April-November; and (7) Santa Barbara Channel–San Miguel, March-September (see Table 4.3 for details).

annual HD model results for 2001 and 2008 (2 of the 3 y this region was covered) showed high densities in this area (Figure 4.6). This represented the area used by a smaller feeding aggregation of humpback whales that is distinct from those feeding off California and Oregon (Calambokidis et al., 1996, 2001, 2004), and it meets the criteria of a feeding BIA. The BIA located west and southwest of San Miguel Island, although not in the highest density area in the HD model, is an area of high density in some of the annual HD model predictions. These annual predictions agree with our observations that, similar to blue whales in this region, it is an area inhabited intermittently by some of the highest concentrations of humpback whales that have been observed in southern California.

The seven BIAs for humpback whales represented only 3% of U.S. waters in the West Coast region, but the areas we identified encompassed 89% of the sightings documented. Along with the good agreement with the areas identified by the HD model, these BIAs effectively identify the most critical areas for humpback whales.

*Harbor Porpoise (*Phocoena phocoena*) Small and Resident Populations*
Harbor porpoises in the northeastern Pacific Ocean range from Point Conception, California, through waters of British Columbia, and around the coast of Alaska to Point Barrow. They inhabit both coastal and inland waters, and are known to be particularly sensitive to anthropogenic impacts such as bycatch in fisheries and disturbance by vessel traffic or underwater noise. BIAs for this species are also designated for populations in the East Coast region (see LaBrecque et al., 2015, in this issue).

Several lines of evidence indicate segregation of separate harbor porpoise populations within the West Coast region. Early work showed regional differences in pollutant residues indicating that harbor porpoises do not move extensively along the U.S. West Coast (Calambokidis & Barlow, 1991). Based on more recent genetic studies and aerial surveys along the U.S. West Coast (Chivers et al., 2002, 2007; Carretta et al., 2009), NOAA Fisheries recognizes six distinct harbor porpoise populations in this region. Two of these populations (the Northern California/Southern Oregon

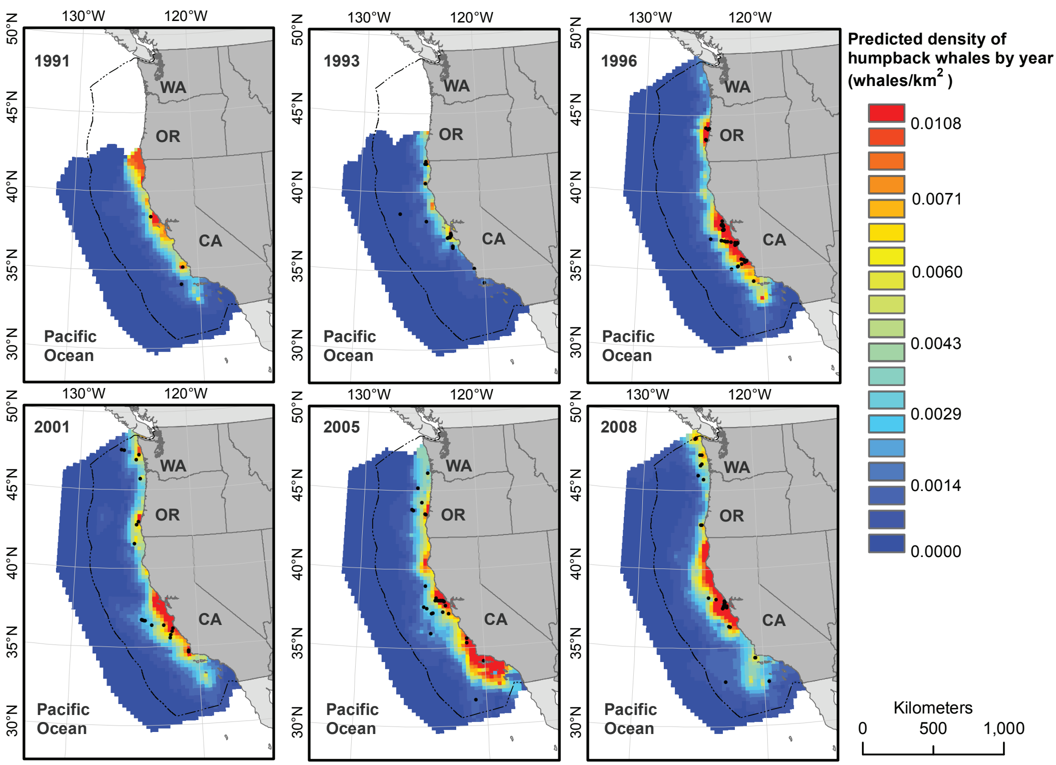

Figure 4.6. Predicted mean densities and sightings (black dots) of humpback whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

Stock and the Northern Oregon/Washington Coast Stock) number in the tens of thousands of animals. The San Francisco/Russian River Stock and the Washington Inland Waters Stock are estimated at 9,189 (Carretta et al., 2009) and 10,682 animals (Laake, unpub. data, as cited in Carretta et al., 2013), respectively. The remaining two populations are located along the coast of California near Morro Bay and Monterey Bay. Due to their relatively small abundance estimates of just a few thousand animals (see below) and restricted geographic ranges, the Morro Bay Stock and the Monterey Bay Stock meet CetMap's definition of a small and resident population, and BIAs were created for each stock (Figure 4.7). Stock boundaries were delineated based on (1) molecular genetic differences (Chivers et al., 2002), (2) differences in pollutant concentrations (Calambokidis & Barlow, 1991), and (3) density minima observed from aerial surveys (Forney et al., 1991; Forney, 1995, 1999; Carretta et al., 2009). All populations are described in the *U.S. Pacific Marine Mammal Stock Assessments* (Carretta et al., 2013).

Harbor porpoises are found primarily in waters shallower than about 200 m and are most abundant from shore to about the 92 m (50-fathom) isobath (Barlow, 1988; Forney et al., 1991; Carretta et al., 2001, 2009). Since 1999, aerial surveys off California have included coverage of lower density areas to provide a more complete abundance estimate, extending offshore to the 200-m isobath, or a minimum distance from shore of 10 nmi south of Point Sur and 15 nmi north of Point Sur. Off Oregon and Washington, where the shelf extends farther offshore, abundance has been estimated based on aerial surveys extending offshore to about the 200-m isobath (Laake, unpub. data, as cited in Carretta et al., 2013).

Morro Bay Small Resident Population—The southernmost population, called the Morro Bay Stock, extends from Point Conception to Point Sur and from land to the 200-m isobath (Figure 4.7; Table S4.2). The most recent aerial surveys (2002 to 2007), conducted by the Southwest Fisheries Science Center (NMFS/NOAA), yielded an abundance estimate of 2,044 animals for this population (Carretta et al., 2009). Aerial surveys have consistently indicated a core area of higher density near the center of the population's range between Point Arguello and Point Estero, with density decreasing toward the edges of the range (Forney et al., 1991; Forney, 1995, 1999; Carretta et al., 2009). The small core range of this small and resident harbor porpoise population makes this population particularly vulnerable to anthropogenic impacts.

Monterey Bay Small and Resident Population—The small and resident Monterey Bay population of harbor porpoises ranges from just south of Point Sur to Pigeon Point and out to the 200-m isobath (Figure 4.7; Table S4.3). The most recent aerial surveys (2002 to 2007) yielded an abundance estimate of 1,492 animals for this population (Carretta et al., 2009). The greatest densities are generally found in the northern portions of Monterey Bay (Forney et al., 1991; Forney, 1995). The small geographic range makes this population particularly vulnerable to anthropogenic impacts.

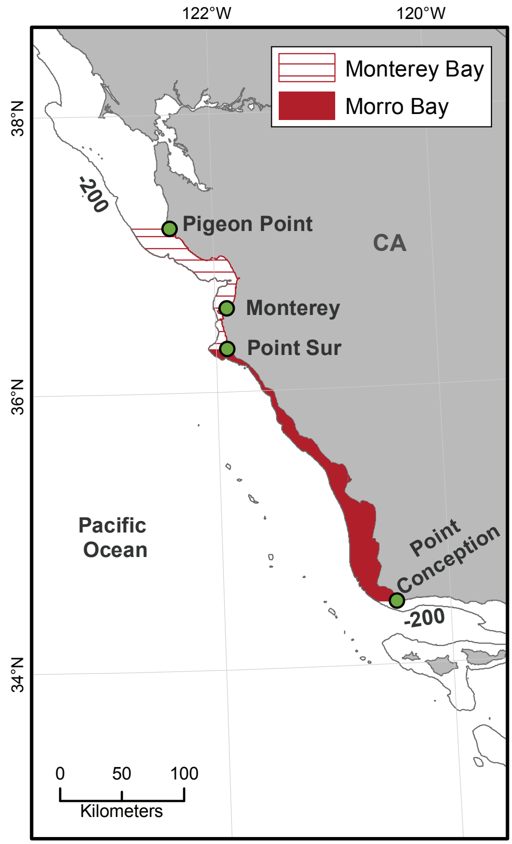

Figure 4.7. Two harbor porpoise (*Phocoena phocoena*) small and resident BIAs (Morro Bay and Monterey Bay) in California, substantiated through aerial survey data, genetic analyses, and expert judgment. Also shown is the 200-m isobath.

Additional Evaluation

Fin whales (*Balaenoptera physalus*), the second largest of all the whales, are considered endangered under the U.S. Endangered Species Act (ESA) and occur widely in the world's oceans (NMFS, 2010). Along with blue whales, they were heavily hunted in the 20th century during the modern era of commercial whaling. The population structure of fin whales is not well understood in most areas, including the North Pacific Ocean. They occur in both nearshore and pelagic waters, and they feed on both krill and fish.

A number of factors complicate our understanding of fin whales in the North Pacific Ocean, primarily because of uncertainties in their stock structure and movements along the U.S. West

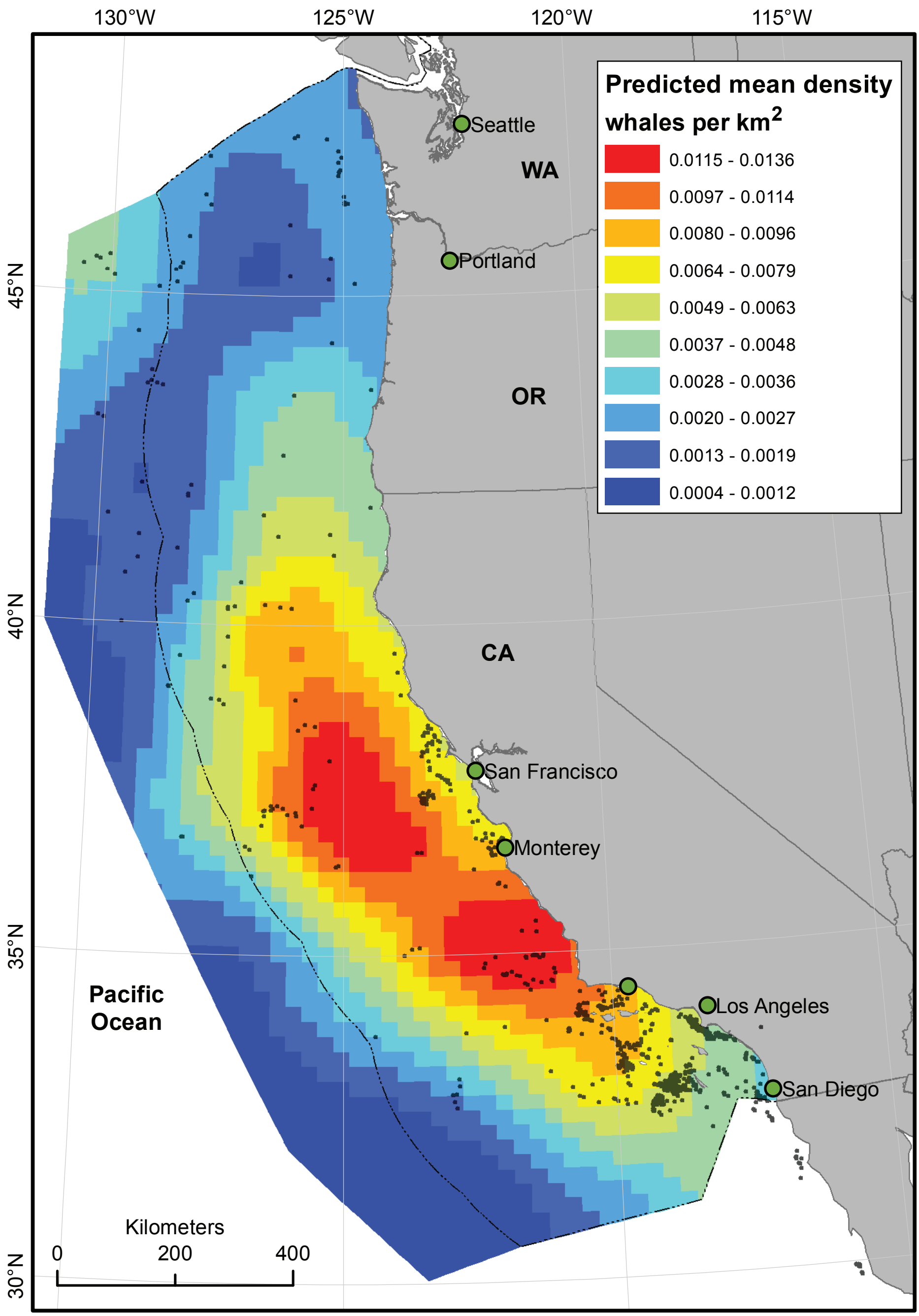

Figure 4.8. Predicted mean densities of fin whales (*Balaenoptera physalus*) from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a), overlaid with all sightings (including from Cascadia Research small boat and opportunistic surveys)

Coast. Long-range movements along the entire U.S. West Coast do occur as shown by satellite and discovery tags (Mizroch et al., 2009; Falcone et al., 2011b); however, recent data demonstrate that not all fin whales undergo these long-range seasonal migrations. Photo-identification studies of fin whales off the U.S. West Coast show short-range seasonal movements in spring and fall (Falcone et al., 2011a, 2011b). In addition, photo-identification studies off southern California show that within-region movements are more common than inter-regional movements, suggesting that regional subpopulations may exist. Carretta et al. (1995) and Forney & Barlow (1998) also indicate a year-round presence of fin whales off southern California. These relatively recent changes in fin whale distribution in the West Coast region are thought likely to be from post-whaling local population growth, combined with shifts in the overall distribution of fin whales throughout their range (Moore & Barlow, 2011).

Coastal photo-identification surveys (1991 to 2010), in addition to satellite tagging off California and Washington, suggest that the greatest densities of fin whales occur near the continental shelf and slope (Schorr et al., 2010). The behavioral states of these satellite-tagged fin whales could be inferred by their movements over time. Tagged individuals appear to move between likely feeding areas, demonstrating patterns of rapid movement between slopes and plateaus, where they remain for longer periods of time to feed (Schorr et al., 2010). Fin whales feeding on krill in both offshore and coastal areas in the Southern California Bight were also documented via suction-cup attached multisensor archival tags (Goldbogen et al., 2006; Friedlaender et al., 2014).

We considered 1,243 visual boat-based sightings of 2,638 fin whales mostly from nonsystematic surveys collected by Cascadia Research (www.cascadiaresearch.org) and collaborators, conducted primarily in coastal waters from 1991 to 2011 (Figure 4.8). There were areas of concentration of sightings, including (from south to north) Tanner and Cortez Banks area, San Clemente Basin, the shelf edge west of San Nicolas Island, waters off the Palos Verdes Peninsula, waters south and west of San Miguel Island, Santa Lucia Bank, and Guide and Grays Canyons off Washington.

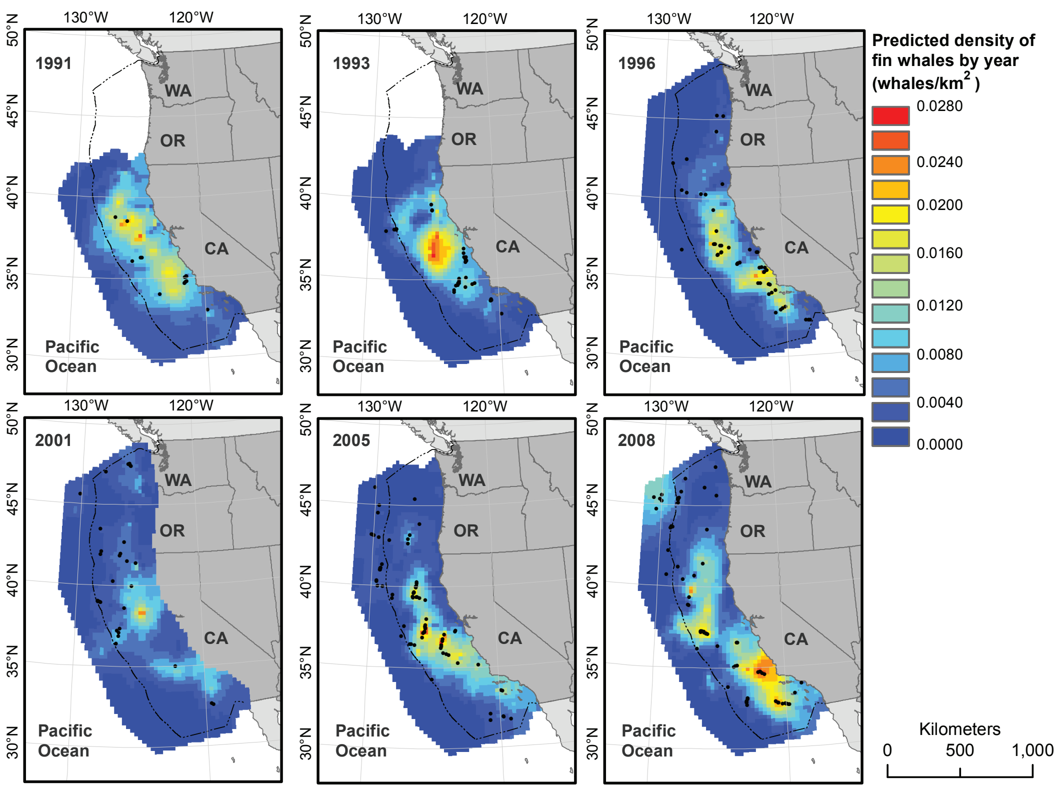

Figure 4.9. Predicted mean densities and sightings (black dots) of fin whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

While most of these areas fall within predicted moderately high or highest densities based on the mean HD model (Figure 4.8), there are some significant differences that largely stem from the generally offshore distribution of fin whales and the more coastal and island-specific bias in our small boat-based sightings. The HD model, which is based on surveys that include offshore waters, predicts high densities primarily in offshore waters outside the geographic range of most of our coastal surveys, including offshore waters centered about 100 nmi west of the Gulf of the Farallones and Monterey Bay (central California), and waters west of Point Buchon, from the coast to about 100 nmi offshore. While this latter area includes the Santa Lucia Bank, the predicted high-density area covers a much broader region. One factor that explains some of the discrepancy with the mean density model is the seasonal variation in fin whale distribution. Although fin whales are present year-round off California, their distribution appears to shift somewhat seasonally. Sightings from California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys off southern California that were conducted during all seasons show fin whales closer to shore in winter and spring and farther offshore in summer and fall (Douglas et al., 2014), coinciding with the survey period for the data used in the HD models. There were also apparent annual differences in fin whale occurrence off the U.S. West Coast and this was somewhat apparent in the annual habitat density models for fin whales (Figure 4.9).

BIAs for fin whales were difficult to determine at this time for a number of reasons, including their offshore distribution (in comparison to our primarily more coastal effort), the poor knowledge of their population structure, and the poor agreement between our areas of concentration from the overall sightings and the HD models. BIAs are therefore not designated here but likely should include offshore areas identified in the HD models as well as occasional concentrations in more coastal areas as documented in our small boat surveys.

Conclusion

In conclusion, 28 BIAs were identified for four cetacean species within the West Coast region based on expert review and synthesis of published and unpublished information. Identified BIAs included feeding areas for blue whales, gray whales, and humpback whales; migratory corridors for gray whales; and small and resident populations for harbor porpoises. The size of the individual BIAs in this region ranged from approximately 171 km^2 for a gray whale feeding area to over 138,000 km^2 for the potential presence migratory corridor BIA for gray whales. The BIAs for feeding blue, gray, and humpback whales represent a relatively small portion of the overall West Coast area (< 5%) but encompass a large majority (77 to 89%) of the thousands of sightings documented and evaluated for each species. This BIA assessment did not include minke whales (*Balaenoptera acutorostrata*), killer whales (*Orcinus orca*), beaked whales (Ziphiidae), and sperm whales (*Physeter macrocephalus*); however, these species should be considered in future efforts to identify BIAs. Also, the species considered herein—blue whales, gray whales, and humpback whales—should be considered for reproductive BIAs.