NOAA Technical Memorandum NMFS

JUNE 2007

PRELIMINARY ESTIMATES OF CETACEAN ABUNDANCE ALONG THE U.S. WEST COAST AND WITHIN FOUR NATIONAL MARINE SANCTUARIES DURING 2005

Karin A. Forney

NOAA-TM-NMFS-SWFSC-406

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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Karin A. Forney

National Marine Fisheries Service,NOAA
Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, California 95060

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U.S. DEPARTMENT OF COMMERCE
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Karin A. Forney
Southwest Fisheries Science Center
Protected Resources Division
110 Shaffer Road
Santa Cruz, CA 95060

ABSTRACT

The abundance of cetaceans along the U.S. West Coast was estimated from a ship line-transect survey conducted during 2005. The survey was designed to uniformly cover waters off California, Oregon and Washington from the coast to 300 nmi (556 km) offshore, and to provide fine-scale coverage within four of the five West Coast National Marine Sanctuaries (NMS) Preliminary abundance estimates for 19 species were calculated using a geographically stratified, multiple-covariate line-transect analysis. To increase samples sizes for estimating effective strip width based on sighting covariates, the 2005 sighting data were combined with data from four similar surveys conducted during 1991-2001. Trackline detection probabilities were obtained from other studies that used the same survey methods. Broad geographic strata for analysis included Southern California (south of Point Conception), Central and Northern California, and Oregon/Washington; fine-scale strata included the Olympic Coast NMS, adjacent areas over the continental slope and in Canadian waters, and the three combined central California NMS. As in past years, the most abundant species coastwide was the short-beaked common dolphin (*Delphinus delphis*), and the most abundant whale was the fin whale (*Balaenoptera physalus*). Off Oregon and Washington, Dall's porpoise (*Phocoenoides dalli*) was the most abundant species. Within the NMS, humpback whales (*Megaptera novaeangliae*) were the most common whale species and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) were the most common delphinid. Abundance estimates for most species during 2005 were comparable to estimates from a similar coast-wide survey in 2001. Blue whales have been less abundant along the U.S. West Coast in 2001 and 2005 than during the 1990s, whereas estimated humpback whale abundance is greater than during all previous assessments through 2002. The additional survey coverage within the NMS allowed an evaluation of the significance of these regions to cetaceans, and NMS waters clearly represent important habitat for several cetacean species.

INTRODUCTION

The abundance of most cetaceans along the U.S. West Coast has been assessed since 1991 based on broad-scale ship surveys conducted at roughly five-year intervals during summer and fall (Barlow 1995; Barlow 2003; Barlow and Forney, in press). Although these surveys are suitable for assessing the majority of common cetaceans in the California Current region, they are not well-suited for species with a limited nearshore distribution (e.g., harbor porpoise, *Phocoena phocoena*, coastal bottlenose dolphins, *Tursiops, truncatus*, and gray whales, *Eschrichtius* *robustus*), or for assessing cetaceans within smaller sub-regions of interest, such as the National Marine Sanctuaries. Harbor porpoise, bottlenose dolphins, and gray whales have been assessed in separate studies using aerial surveys or shore-based counts (Forney et al. 1991; Buckland et al. 1993; Carretta et al. 1998; Laake et al. 1998; Carretta and Forney 2004, Rugh et al. 2005), but detailed information on cetaceans within the National Marine Sanctuaries is limited (Calambokidis et al. 2004).

In December 2004, the National Marine Sanctuary Program and the National Marine Fisheries Office of Protected Resources held a strategic planning meeting to identify common goals and develop strategies for joint collaborations. As a result from the workshop, a joint marine mammal and ecosystem survey was identified as a priority project for the West Coast region. The 2005 Collaborative Survey of Cetacean Abundance and the Pelagic Ecosystem (CSCAPE) was subsequently developed as a collaboration between the National Marine Fisheries Service and the National Marine Sanctuary Program. The survey objectives were to assess the abundance and distribution of marine mammals and seabirds, and to characterize the pelagic ecosystem within the National Marine Sanctuaries and in the ecological context of the broader California Current region. CSCAPE contributes to NOAA's Ecosystem Goal Outcomes and Ecosystem Goal Strategies presented in the NOAA Strategic Plan (2005-2010) by improving the execution of collaborative, geographically based conservation and recovery of protected resources in National Marine Sanctuaries, and by protecting, restoring and managing the use of coastal and marine resources through Ecosystem Approaches to Management.

In this study, I present preliminary abundance estimates for all cetacean species encountered during the 2005 CSCAPE survey. The survey design included broad-scale transects along the entire U.S. West Coast (out to a distance of approximately 300 nmi or 556 km), and additional fine-scale survey coverage within the Olympic Coast (OCNMS), Cordell Bank (CBNMS), Gulf of the Farallones (GFNMS) and Monterey Bay (MBNMS) National Marine Sanctuaries. Field methods followed standard protocols developed by the Southwest Fisheries Science Center (SWFSC; Kinzey et al. 2000). Analysis methods largely follow those used for other recent SWFSC line-transect surveys (Barlow 2006; Barlow and Forney, in press). Sighting data for the 2005 cruise were pooled with previous similar surveys conducted off the U.S. West Coast in 1991, 1993, 1996 and 2001 to increase sample sizes for estimating the effective strip width (ESW) based on environmental and detection covariates. The results provide the first comprehensive assessment of cetacean abundance within four West Coast National Marine Sanctuaries and within the broader U.S. West Coast California Current Ecosystem. A detailed cruise report will be published separately (Forney et al., in prep), and this report presents only the results and analyses as they relate to the estimation of cetacean abundance.

METHODS

Field Methods

The 2005 survey was conducted using established SWFSC line-transect survey methods (Kinzey et al. 2000), aboard the National Oceanographic and Atmospheric Administration (NOAA) research vessels *McArthur II (McII)* and the *David Starr Jordan (DSJ)*. Surveys within the National Marine Sanctuaries (NMS) were conducted from 4 June through 23 July, and the coast-wide surveys extending 300 nmi (556 km) offshore were conducted from 2 August through 7 December (Table 1). Broad-scale transect lines followed a uniform grid that was established prior to the survey and was offset midway between the randomly placed grid surveyed during 2001 (Barlow 2003). Fine-scale surveys followed parallel lines spaced 10 nmi apart, between about the 20-m isobath and the offshore edge of the NMS study areas (see Fig. 1), with a randomly selected initial starting point. Fine-scale coverage for the Olympic Coast NMS region extended beyond the official sanctuary boundary, into offshore slope waters and Canadian waters to the north (Fig. 1B), to maintain compatibility with past surveys in this region (Calambokidis et al. 2004). Ships traveled at 9-10 kts (16.7- 18.5 km/hr) through the water, and observers searched from the flying bridge deck (observation height 15.2 m for the *McII*, and 10.5 m for the *DSJ*). Following marine mammal sightings, the ship was generally diverted for species identification and group size estimation ('closing mode' survey) if sightings were within 3 nmi of the trackline. The only exception to this rule occurred for sightings of species that can be readily identified and counted from the transect line, such as Dall’s porpoise and some large baleen whales. In these cases the survey vessel continued on transect without diverting. If the vessel diverted towards the sighting, any additional sightings were recorded as 'off effort' and were not included in the abundance analyses. During the large-scale surveys, search effort subsequently resumed on a course heading back to the original transect line at an oblique angle. During the fine-scale surveys, the ship returned to the point at which it diverted before resuming effort, to avoid getting too close to the next parallel transect line.

During search effort ('on effort' periods), the primary observer team consisted of six individuals who rotated every 40 minutes among three observation stations (left 25X binocular, data recorder, and right 25X binocular). Following each 2-hr watch period, they rested for two hours before returning to duty. The data recorder searched for marine mammals with unaided eyes (and occasionally 7X binoculars), and recorded effort and sighting information using a data entry program on a laptop computer connected to the ship's Global Positioning Satellite system (GPS). This program recorded time and geographic position whenever an event was recorded, and every 10 minutes along track. A fourth, conditionally independent observer (IO), was also available at times to monitor for animals near the transect line that were missed by the primary team. The IO was careful not to alert the primary team to the presence of animals and did not report sightings until they had passed the beam of the ship and were clearly missed by the primary team. If appropriate, the ship was subsequently diverted for species identification and group size estimation.

All primary observers had previous experience searching and identifying marine mammals at sea. At least four of the primary observers had previous line-transect experience with cetaceans and at least two were experts in at-sea marine mammal identification. Prior to the survey, all marine mammal observers were trained in marine mammal identification and group size estimation. At sea, group size and the percentage of each species in a group was estimated and recorded independently and confidentially by each on-duty observer. Generally, observers were given as much time as they felt was necessary to estimate group size and species composition. For sperm whales, whenever time and logistic constraints permitted, group size estimation was based on a 90-minute observation period, to provide reasonable confidence that all members of the group surfaced at least once.

Marine mammals were identified to the species level whenever observers could document relevant diagnostic identification characteristics and were certain of the identification. Otherwise, animals were identified to the lowest taxonomic level or general category (e.g., “large whale” or “beaked whale”) that an observer could determine with certainty. Observers were also encouraged to record their best assessment of the most probable species if the actual species could not be determined with certainty. Following the methods of Barlow (2003), this study includes these probable species identifications, when available, to estimate abundance, rather than pro-rating the unidentified sightings analytically.

Analytical Methods

Cetacean abundance was estimated following the methods of Barlow and Forney (in press), using line-transect methods with multiple covariates (Buckland et al. 2001; Marques and Buckland 2003). The study area (1,143,674 km^2) was divided into seven geographic strata to allow for differential survey coverage, geographic differences in the cetacean assemblage, and jurisdictional boundaries (Fig. 1): Southern California (south of Pt. Conception, 318,541 km^2), central and northern California excluding NMS waters (483,635 km^2), Oregon and Washington excluding OCNMS waters (311,118 km^2), central California NMS (17,394 km^2), Olympic Coast National Marine Sanctuary (OC-NMS; 7,422 km^2), Olympic Coast slope waters (OC-Slope, 3,697 km^2), and Canadian waters (OC-Canada, 1,867 km^2). Area sizes were calculated using the program GEOAREA[1], and all strata excluded regions shallower than 20m (see Barlow and Forney, in press, for details), because the vessels were generally restricted to waters deeper than this for safe navigation. Density, D_i , for a species within geographic stratum i was estimated as

$$D_i = \frac{1}{2 \cdot L_i} \sum_{j=1}^{n} \frac{f(0, c_j) \cdot s_j}{g_j(0)} \qquad (1)$$

where L_i is the length of “on-effort” transect lines in geographic stratum i,
$f(0, c_j)$ is the probability density of the detection function evaluated at zero perpendicular distance for sighting number j with associated covariate(s) c_j,
s_j is the estimated number of individuals of that species in sighting number j,
$g_j(0)$ is the trackline detection probability of sighting j, and
n_i is the number of sightings of that species in stratum i.

Only half-normal detection models were considered for estimating $f(0,c_j)$ because hazard-rate models have been shown to give highly variable estimates (Gerrodette and Forcada 2005). To increase sample sizes for estimating $f(0,c_j)$, sightings from previous survey years (1991, 1993, 1996, and 2001; Barlow 2003) were pooled with those from the 2005 survey and the multiple covariate detection functions were estimated for all geographic strata combined. Species with similar sighting characteristics were pooled into groups, following the methods used by Barlow and Forney (in press): Dall’s porpoise, delphinids (excluding killer whales), small whales, humpback whales, and all other large whales (Table 3). As recommended by Buckland et al. (2001), the most distant sightings were truncated prior to the analysis to improve the ability to fit

[1] T. Gerrodette, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

the detection function. Truncation distances were 2 km for Dall's porpoises, and 4 km for all other species.

Following the description of factors affecting the distance at which various species of cetaceans can be seen (Barlow et al. 2001), potential covariates included total group size (*TotGS*) or its natural logarithm (*LnTotGS*), Beaufort sea state (*Beauf*), survey year (*Year*), survey vessel (*Ship*: *McArthur*, *McArthur II*, or *Jordan*), geographic stratum (*Region*), the presence of rain or fog within 5 km of the ship (*RainFog*), the presence of glare on the trackline (*Glare*), the estimated visibility in nautical miles (*Vis*), the method used to first detect the group (*Bino*: 25X binoculars or other), and the cue that first drew an observer's attention to the presence of a group (*Cue*: splash, blow, body, or other). *TotGS*, *LnTotGS*, *Beauf*, and *Vis* were treated as continuous variables and the others were treated as factors. Additional covariates (*SppGroup*) representing individual species or subgroups were also included to allow for potential differences in detection distances between species within each *a priori* species group: small vs. large delphinids, beaked whales vs. other small whales, and humpback whales vs. other large whale species. Covariates for the detection function were selected by forward stepwise model building, using an AIC_c criteria. All models that were within 2 AIC_c units of the best model (deltaAIC<2) were averaged for abundance estimation, weighting by exp(-0.5 deltaAIC) (Burnham and Anderson 1998).

The probability of detecting a group of animals on the transect line, *g(0)*, has been previously estimated for 1991-2005 SWFSC surveys (Barlow and Sexton 1996; Barlow 1999, Barlow and Forney, in press), and the same estimates are applied in the present analysis for small and large groups (Table 4). As in these previous studies, the abundance analysis for Dall's porpoise (*Phocoenoides dalli*) and small whales presented here is based only on surveys conducted during calm weather conditions (Beaufort sea states 0-2), because *g(0)* decreases dramatically for these species sea state increases.

Group size estimates have been shown to vary between observers, and individual calibration factors have been developed based independent counts of a subset of schools that were photographed from a helicopter during SWFSC research cruises (Barlow et al. 1998; Gerrodette et al. 2002; Barlow and Forney, in press). For the present analysis, we have applied the correction factors estimated by Barlow and Forney (in press) to each observer's estimate before calculating mean group size for each sighting.

Total abundance, N, for each species was estimated as the sum of the abundance estimates in each of the geographic strata, calculated as the density in that stratum times the size of the stratum, A_i:

$$N = \sum_{i=1}^{5} D_i \cdot A_i \qquad (2)$$

Coefficients of variation (CV) for the cetacean abundances were estimated using a combined parametric and nonparametric bootstrap procedure (Barlow 2006, Barlow and Forney, in press), which involved resampling the data with replacement, fitting and selecting new detection functions based on the full set of covariates, and averaging models within 2 AIC_c units of the best model (Buckland et al. 2001, Burnham and Anderson 1998).

The CSCAPE survey was not suitably designed for highly coastal species, such as the gray whale (*Eschrichtius robustus*) and harbor porpoise (*Phocoena phocoena*). Therefore, no abundance estimates or sighting information will be presented for these species. More appropriate abundance estimates for these two species can be found elsewhere (Carretta and Forney 2004, Rugh et al. 2005).

RESULTS

Survey Effort and Sightings

Survey effort and sightings for 1991-2001 have been described in detail by Barlow (2003) and only key information is summarized in this report (Table 2). Systematic survey effort during 2005 (12,373 km) was comparable to past CA/OR/WA surveys during 1996 (14,522 km) and 2001 (9,538). Coverage was broad and relatively uniform, with the exception of a gap off Oregon and Washington, where persistent severe weather prevented completion of several planned transect lines. Coverage within NMS waters was completed as planned, although fog was present on many survey days within the central CA NMS during July. Sea state conditions, as during past cruises, were dominated by Beaufort sea states of 3-5, with only 19% of survey effort occurring during calm conditions (sea states 0-2). The majority of calm conditions were encountered aboard the *McII*, which spent a majority of time within NMS waters closer to shore. Survey effort aboard the *DSJ*, which completed the majority of the large-scale, offshore grid, included only 13% calm conditions. This is a similar percentage to 1996 and 2001 cruises. Offshore regions were underrepresented in calm conditions, and NMS waters were over-represented during calm conditions (Fig. 1, Table 2).

The total number of on-effort marine mammal sightings during 2005 (n = 1,085) was greater than during past cruises (Table 3), primarily because of the additional fine-scale survey effort within the high density regions of the NMS waters. The distribution patterns of most cetacean species (Figs. 2-6) were similar to patterns documented during a coast-wide survey in 2001 (Appler et al. 2004). The most frequently encountered large whale in 2005 was the humpback whale, *Megaptera novaeangliae*, and the most frequently encountered small cetacean was the Dall's porpoise (Table 3). Multi-species sightings (Table 3) were observed for all species except short-finned pilot whale (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutorostrata*), harbor porpoise, gray whale, and beaked whales. Striped dolphins (*Stenella coeruleoalba*), long-beaked common dolphins (*Delphinus capensis*), and northern right whale dolphins (*Lissodelphis borealis*) were seen in mixed groups in the majority of sightings of these species. Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), and short-beaked common dolphins (*Delphinus delphis*) were also frequently observed in mixed groups.

Detection function estimation

The detection models for the four species groups (Table 4) differed in the covariates included and number of models averaged. As found previously by Barlow (2003), the most complex models were selected for delphinids, which had the largest sample size. Factors that were found to significantly affect the detection of delphinids included (in order of inclusion in the model) method of detection (*Bino*), sea state (*Beauf*), *Cue*, *LnTotSS*, *RainFog*, and *Ship*. The additional species category separating small delphinids from large delphinids (*SppGroup*) was not selected by any of the individual species models. No other models were within 2 AIC_c units of this best model for delphinids. The best detection function model for Dalls' porpoise, based only on calm conditions, included (in order of inclusion) *Bino*, *Ship*, and *LnTotSS*. Three additional models, which differed from the best model by one covariate addition or substitution (Table 4), were within 2 AIC_c units of the best model and were included in the model-averaging for Dall's porpoise.

The best models for killer whales, blue whales, fin whales, sei whales, sperm whales, and Baird's beaked whales were identical and included only *Bino* and *TotSS*. Three additional models within 2 AIC_c units of the best model substituted *LnTotSS*, *Beauf*, and *RainFog*, respectively, for *TotSS*. The best humpback whale model included *Bino*, *Vis*, and *Glare*, and it was averaged with a second-best model that also included *Year*. For small whales (calm conditions only), the best model did not include any covariates, but three models with one covariate each (*Year*, *RainFog*, and *Glare*, respectively) were within 2 AIC_c units and were included in the model-averaging procedure.

The average ESW for Dall's porpoise, with sightings truncated at 2km perpendicular distance, was estimated as 1.34 km. The mean ESW for all other species, truncated at 4km perpendicular distance, ranged from about 1.9 to 3.6 km. Within this category, short-finned pilot whales had the greatest estimated ESW, and short-beaked common dolphins and striped dolphins had the smallest. ESW estimates for all small and large whales ranged from 2.6 to 2.8 km.

Abundance Estimates

Estimates of abundance for most species varied considerably between geographic strata (Tables 5-6), although stratum-specific coefficients of variation (CVs) are high. The most abundant cetacean along the U. S. West Coast (Table 5) was the short-beaked common dolphin ($N_{CA/OR/WA}$ = 459,615, CV=0.34), as in past studies in this region (Barlow 1995, 2003). The most abundant large whales were the fin whale ($N_{CA/OR/WA}$ = 3,281, CV=0.25), and the sperm whale ($N_{CA/OR/WA}$ =3,140, CV=0.40), and both species were widespread, particularly in waters off central and northern California. Humpback whales were more abundant than during past surveys ($N_{CA/OR/WA}$ =1,769, CV=0.16, see Table 6), and were concentrated primarily within waters of the two NMS strata. Dall's porpoise ($N_{CA/OR/WA}$ =66,035, CV=0.46) were abundant from central California northward, and were the most common cetacean off Oregon and Washington.

Comparison to 2001 surveys

In general, 2005 abundance estimates for most species were similar to or slightly higher than those estimated for 2001, and mostly within the statistical confidence limits of the earlier estimates (based on CVs, Table 7). Species with large relative differences in abundance between the two survey periods, such as long-beaked common dolphins, have high CVs (>0.8) and a large degree of uncertainty in both estimates. Average abundances for 2001 and 2005, and the minimum abundance estimates (N_{min}) used for marine mammal stock assessment reports (e.g. Carretta et al. 2007) are presented in Table 7.

DISCUSSION

The results of this survey provide the first direct assessment of cetacean abundance, density and distribution within both the California Current region and four of the West Coast NMS. It is apparent, based on the stratified estimates, that NMS waters represent important habitat for many cetacean species. Densities of Dall's porpoise, Pacific white-sided dolphins, and humpback whales were markedly higher within the two NMS strata than in the other, larger strata (Table 5). This pattern is consistent with previous studies relating these species to marine habitats within the California Current region (Forney and Barlow 1998, Forney 2000, Keiper et al. 2005, Calambokidis et al. 2004). In fact, over half (974 out of 1769) of the entire estimated humpback whale population off the U.S. West Coast during the study period was found within waters of the central California NMS during July, with an additional estimated 176 humpback whales within the OCNMS. Because of this concentration in nearshore regions, the estimate of humpback whales in this study is more accurate and precise than the estimate of 1137 animals presented by Barlow and Forney (in press) based only on the broad-scale transects. This example illustrates the value of conducting additional fine-scale surveys in biologically productive areas, such as the NMS, which represent important foraging regions for many species. Particularly in years with poor prey recruitment, e.g., during El Niño events or when seasonal upwelling patterns are disrupted as during 2005 (Peterson et al. 2006), animals may concentrate in the most productive nearshore areas, such as Monterey Bay and adjacent Sanctuary waters (Benson et al. 2002, this study).

Waters of the OCNMS and adjacent slope and Canadian waters have been surveyed annually or bi-annually since 1995 (Calambokidis et al. 2004), providing a basis for comparison with 2005 results. The estimated abundance of humpback whales within the combined three OC strata during 2005 (208, CV=0.28) (Table 6) was about twice the observed abundance during 1995-2000 (range of abundance estimates: 85 - 125, CVs ~0.32), but lower than the peak year of 2002 with 562 (CV=0.21) humpback whales. Whales were observed largely in the same areas as during previous years (Fig 5, see Calambokidis et al. 2004), and it is clear that the regions within and to the north (Canadian waters) and west (slope waters) of the OCNMS are important foraging regions for West Coast humpback whales. The species composition of other cetaceans within the OC strata was similar to previous observations, except that Risso's dolphins were not recorded during our survey. Pacific white-sided dolphins were the most common species, followed by Dall's porpoise and northern right whale dolphins. The greater estimate of Dall's porpoise during 2005 (2,114, CV=0.45) compared to previous estimates ranging from 181 (CV=0.49) to 876 (C= 0.30) may be attributable to a difference in methodology, as the earlier surveys generally used only one observer and did not use 25x binoculars.

Although no previous shipboard surveys of the three combined central California NMS have been completed, previous studies have investigated cetacean occurrence within portions of this stratum, including the Gulf of the Farallones (Allen 1994, Keiper et al 2005), and Monterey Bay (Benson et al. 2002, Croll et al. 2005). The dominant species are similar in all studies, with Pacific white-sided dolphins, Dall's porpoise, northern right whale dolphins, Risso's dolphins, and harbor porpoise being the most common delphinids, and humpback whales being the most abundant large whale.

Coast-wide abundance estimates for 2005 are largely consistent with past years, although there has been considerable interannual variability in the abundance of some species, particularly the temperate delphinids (see Barlow 2003). Blue whales, however, have exhibited markedly lower abundance within U.S. West Coast waters during both the 2001 survey (*N* = 888, CV=0.40, Barlow 2003) and the 2005 survey (*N* = 721, CV=0.27, this study), compared to previous estimates based on 1991-1996 surveys (*N* = 2,997, CV=0.14, Calambokidis and Barlow 2004). Possible explanations for this observed decrease in estimated abundance include a true decline in population abundance, or a shift in the foraging distribution of blue whales outside of the CSCAPE study area since the late 1990s, when an oceanographic shift was documented (Chavez et al. 2003, Peterson and Schwing 2003, King 2005). Krill recruitment was poor off central California during 2005, and blue whales may have been foraging more widely and outside of the CSCAPE study area. Future mark-recapture analyses that include photographs obtained during CSCAPE are planned (Calambokidis, pers. comm.) and may shed light on the status of this population.

In contrast to blue whales, humpback whales were extremely abundant along the West Coast during 2005, and were highly concentrated within waters of the surveyed NMS, particularly off central California. The 2005 abundance estimate (1,769, CV=0.16) is higher than for both previous coastwide surveys (1996: 1,287; 2001: 1,089; Barlow and Forney, in press). The humpback whale population that forages off the U.S. West Coast increased at a rate of about 8% between 1991 and 1996 (Calambokidis and Barlow 2004). The most recent mark-recapture estimate, following a three-year decline in estimated abundance, is 1,391 (CV=0.22) humpback whales during 2002-2003 (Calambokidis et al. 2003). The line-transect estimate of abundance presented in this study suggests that the humpback whale population along the U.S. West Coast has continued to grow in recent years.

The abundance of sperm whales off California during 2005 was also higher than estimates during the 1990s (838 in 1991, 1,331 in 1993: 593 in 1996, Barlow and Forney, in press), but comparable to the estimate of 2,501 for 2001. Following the 1997-98 El Niño, giant squid (*Dosidicus gigas*) have been more frequently observed off northern California and Oregon, in particular beginning in 2002 (Pearcy 2002, Field et al., in press). Sperm whales are known to forage on giant squid, and their increased abundance within our study area may be related to the increased availability of this prey species in recent years.

ACKNOWLEDGMENTS

A survey of this magnitude would not be possible without the tremendous dedication and support of many people. Foremost, I would like to thank the CSCAPE survey coordinator, Annette Henry, for her outstanding coordination of logistics, personnel, and research planning. Jim Cotton was instrumental in ensuring that the required equipment was always available and in good working order. I also owe special thanks to the many dedicated observers who collected the many days of data under often challenging conditions (J. Cotton, E. Bowlby, A. Douglas, H. Fearnbach, G. Friedrichsen, J. Gilpatrick, J. Hall, K. Hough, J. Larese, S. Lyday, L. Morse C. Oedekoven, B. Phillips, M. Richlen, J. Roletto, J.C. Salinas, S. Tezak, T. O'Toole, B. Troutman, and E. Vasquez), and the officers and crew aboard the NOAA ships *David Starr Jordan* and *McArthur II*. The collaborative nature of this project was possible through the support and efforts of many NMS staff, particularly B. Blackie, E. Bowlby, J. de Marignac, A. DeVogelaere, W. Douros, D. Howard, S. Lonhart, and J. Roletto. Cruise leaders were E. Bowlby, S. Chivers, J. Carretta, S. Mesnick, E. Archer, and J. Redfern. R. Holland wrote the data entry software (WinCruz). Data were edited and archived by A. Jackson. I owe special thanks to J. Barlow and J. Laake for providing R code to conduct the multiple covariate line-transect analysis. This manuscript was improved through the helpful reviews of J. Barlow, S. Benson, E. Bowlby, J. Carretta, A. DeVogelaere, J. Roletto, and the members of the Pacific Scientific Review Group. Funding was provided by NOAA's National Marine Fisheries Service (Southwest Fisheries Science Center and Southwest Region) and the National Ocean Service (National Marine Sanctuary Program). This work was supported by a contract from the Monterey Bay Sanctuary Foundation through the Sanctuary Integrated Monitoring Network (SIMoN) program at the Monterey Bay National Marine Sanctuary, NOAA. Research in U.S. waters was conducted under NMFS permit nos. 540-1502-00 and 774-1714-03. Research in Canadian waters was conducted under USA Marine Scientific Research Request #2005-045 and License to Study Marine Mammals #MML 2005-005/SARA-08.

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Table 1. Survey dates for the Collaborative Survey of Cetacean Abundance and the Pelagic Ecosystem (CSCAPE) 2005.

NOAA Ship *McArthur II*:	
LEG 1a: 04 Jun – Depart Astoria, OR	13 Jun – Arrive Port Angeles, WA
LEG 1b: 05 Jul – Depart Seattle, WA	23 Jul – Arrive San Francisco, CA
NOAA Ship *David Star Jordan*:	
LEG 2: 01 Aug – Depart San Diego, CA	18 Aug – Arrive Newport, OR
LEG 3: 21 Aug – Depart, Newport, OR	09 Sep – Arrive Eureka, CA
LEG 4: 12 Sep – Depart Eureka, OR	01 Oct – Arrive San Diego
LEG 5: 06 Oct – Depart San Diego, CA	24 Oct – Arrive Astoria, OR
LEG 6: 29 Oct – Depart Astoria, OR	15 Nov – Arrive San Francisco, CA
LEG 7: 18 Nov – Depart San Francisco, CA	07 Dec – Arrive San Diego, CA

Table 2. Summary of systematic survey effort by year and Beaufort sea state conditions for 1991-2001 surveys (Barlow 2003) and the 2005 CSCAPE survey (this study). Some additional survey effort completed on non-standard transect lines (while heading to port or between standard transect lines) is not included.

Year	Area Surveyed	Dates	Vessel(s)	km surveyed				No. on-effort sightings
				Calm (0-2)	Rough (3-5)	Total	% calm	
1991	CA	28 Jul - 05 Nov	*McArthur*	2,296	7,715	10,011	23%	536
1993	CA	28 Jul - 06 Nov	*McArthur*	1,386	4,797	6,183	22%	350
1996	CA,OR,WA	17 Jul - 14 Oct	*McArthur*	1,468	7,800	9,267	16%	583
		04 Sep - 06 Nov	*David Starr Jordan*	621	4,634	5,255	12%	222
			TOTAL	2,089	12,433	14,522	14%	805
2001	CA,OR,WA	30 Jul - 10 Nov	*David Starr Jordan*	1,013	6,328	7,341	14%	336
		15 Nov - 08 Dec	*McArthur*	220	1,977	2,197	10%	74
			TOTAL	1,233	8,305	9,538	13%	410
2005	CA,OR,WA[1]	04 Jun - 23 Jul	*McArthur II*	1,041	1,248	2,289	45%	647
		02 Aug - 07 Dec	*David Starr Jordan*	1,345	8,739	10,084	13%	438
			TOTAL	2,386	9,987	12,373	19%	1,085

[1] The survey on the *McArthur II* included about 121 km within Canadian waters (see Fig. 1)

Table 3. On and off effort sightings of all species seen during CSCAPE 2005. Mixed schools are counted once for each species seen, so total exceeds the actual number of sightings.

Common name	Scientific name	Pure Schools	Mixed Schools	TOTAL	Average School size
Harbor porpoise	*Phocoena phocoena*	78	0	78	2.9
Dall's porpoise	*Phocoenoides dalli*	219	5	224	3.9
Short-beaked common dolphin	*Delphinus delphis*	86	35	121	172.3
Striped dolphin	*Stenella coeruleoalba*	1	24	25	54.5
Long-beaked common dolphin	*Delphinus capensis*	0	6	6	87.4
Unspecified common dolphin	*Delphinus* sp.	5	3	8	114.4
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	66	29	95	43
Northern right whale dolphin	*Lissodelphis borealis*	13	26	39	82.3
Bottlenose dolphin	*Tursiops truncatus*	4	3	7	15.9
Risso's dolphin	*Grampus griseus*	59	9	68	18.9
Short-finned pilot whale	*Globicephala macrorhynchus*	1	0	1	26.4
Killer whale	*Orcinus orca*	13	2	15	6.7
Humpback whale	*Megaptera novaeangliae*	396	12	408	1.7
Blue whale	*Balaenoptera musculus*	60	8	68	1.4
Fin whale	*Balaenoptera physalus*	106	11	117	1.9
Sei whale	*Balaenoptera borealis*	2	1	3	1.2
Minke whale	*Balaenoptera acutorostrata*	15	0	15	1.1
Gray whale	*Eschrichtius robustus*	2	0	2	1
Sperm whale	*Physeter macrocephalus*	28	1	29	6.3
Baird's beaked whale	*Berardius bairdii*	5	0	5	6.2
Cuvier's beaked whale	*Ziphius cavirostris*	5	0	5	2.5
Mesoplodont beaked whale	*Mesoplodon sp.*	5	0	5	2.2
Ziphiid whale		7	0	7	1.7
Unid. baleen whale		48	6	54	1.2
Unid. large whale		52	2	54	1.3
Unid. small whale		5	0	5	3.4
Unid. whale		1	0	1	1
Unid. dolphin		53	4	57	33.1
Unid. medium delphinid		3	1	4	5.6
Unid. porpoise		1	0	1	2
Unid. cetacean		8	0	8	1.6

Table 4. Species groupings, probability of detection on the transect line, *g(0)*, number of sightings for model fitting (Model n), estimated mean effective strip width (ESW), and best detection models averaged for estimation of $f(0,c_j)$. ESW is equal to $1/f(0,c_j)$. Values for *g(0)* are taken from the analysis of Barlow and Forney (in press).

SPECIES GROUP Species	Trackline Detection Probability g(0) (CV in parentheses)		Model n	Mean ESW (km)	No. models averaged	Best Model (and additional models within 2 AICc units of best model); '~1' represents the null model
DALL'S PORPOISE (2km, Beaufort 0-2)	0.822 (0.101)		**268**	1.34	4	~1+Bino+Ship+LnTotSS (~1+Bino+Ship+RainFog, ~1+Bino+Ship+LnTotSS+Beauf, ~1+Bino+Ship+LnTotSS+Glare)
DELPHINIDS (4km, Beaufort 0-5)	**Groups of 1-20**	**Groups >20**	**864**			
Short-beaked common dolphin	0.856 (0.056)	0.970 (0.017)		1.93	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Long-beaked common dolphin	0.856 (0.056)	0.970 (0.017)		2.77	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Unclassified common dolphin	0.856 (0.056)	0.970 (0.017)		2.57	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Striped dolphin	0.856 (0.056)	0.970 (0.017)		2.00	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Pacific white-sided dolphin	0.856 (0.056)	0.970 (0.017)		2.51	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Northern right whale dolphin	0.856 (0.056)	0.970 (0.017)		2.59	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Bottlenose dolphin	0.856 (0.056)	0.970 (0.017)		2.40	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Risso's dolphin	0.856 (0.056)	0.970 (0.017)		2.35	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
Short-finned pilot whale	0.856 (0.056)	0.970 (0.017)		3.63	1	~1+Bino+Beauf+Cue+LnTotSS+RainFog+Ship
LARGE WHALES (4km, Beaufort 0-5)			**593**			
Killer whale	0.921 (0.023)			2.82	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
Blue whale	0.921 (0.023)			2.64	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
Fin whale	0.921 (0.023)			2.56	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
Sei whale	0.921 (0.023)			2.84	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
Sperm whale	0.870 (0.090)			2.78	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
Baird's beaked whale	0.960 (0.023)			2.72	4	~1+Bino+TotSS (~1+Bino+LnTotSS, ~1+Bino+Beauf, ~1+Bino+RainFog)
HUMPBACK WHALE (4km, Beaufort 0-5)	0.921 (0.023)		**292**	2.84	2	~1+Bino+Vis+Glare (~1+Bino+Vis+Glare+Year)
SMALL WHALES (4km, Beaufort 0-2)			**67**			
Cuvier's beaked whale	0.230 (0.35)			2.57	4	~1 (~1+Year, ~1+RainFog, ~1+Glare)
Blainville's beaked whale	0.450 (0.23)			2.63	4	~1 (~1+Year, ~1+RainFog, ~1+Glare)
Unid. Mesoplodon beaked whale	0.450 (0.23)			2.63	4	~1 (~1+Year, ~1+RainFog, ~1+Glare)
Unid. beaked whale	0.340 (0.29)			2.81	4	~1 (~1+Year, ~1+RainFog, ~1+Glare)
Minke whale	0.856 (0.056)			2.66	4	~1 (~1+Year, ~1+RainFog, ~1+Glare)

Table 5. Abundance and density estimates by geographic stratum (CA, OR and WA only): **No. Si** = Number of sightings included in the analysis, **D** = estimated density (animals per 100 km^2), **N** = estimated abundance, **CV** = coefficient of variation in N, **CI** = lognormal 95% confidence interval for N.

		Large-scale surveys			Fine-scale surveys			
		So CA	**Cen/No CA**	**OR/WA**	**OC-Slope**	**OC-NMS**	**CenCA-NMS**	**TOTAL**
Species	Area Size:	318,541 km^2	483,635 km^2	311,118 km^2	3,697 km^2	7,422 km^2	17,394 km^2	1,141,807 km^2
Dall's porpoise	No. Si	5	11	8	2	14	28	40
	D	0.90	7.62	7.21	17.18	11.61	13.82	5.78
	N	**2,861**	**36,851**	**22,422**	**635**	**862**	**2,404**	**66,035**
	CV	0.97	0.57	0.95	0.93	0.81	0.50	0.46
	95% CI	580 - 14,115	13,131 - 103,421	4,641 - 108,325	135 - 2,981	214 - 3,473	946 - 6,110	28,078 - 155,306
Short-beaked common dolphin	No. Si	40	36	1	0	0	0	77
	D	55.89	56.03	3.41	0.00	0.00	0.00	40.25
	N	**178,023**	**270,992**	**10,601**	**0**	**0**	**0**	**459,615**
	CV	0.36	0.48	1.11	-	-	-	0.34
	95% CI	89,810 - 352,880	111,009 - 661,537	1,831 - 61,390	-	-	-	240,358 - 878,881
Long-beaked common dolphin	No. Si	6	0	0	0	0	0	0
	D	3.68	0.00	0.00	0.00	0.00	0.00	1.03
	N	**11,714**	**0**	**0**	**0**	**0**	**0**	**11,714**
	CV	0.99	-	-	-	-	-	0.99
	95% CI	2,318 - 59,192	-	-	-	-	-	2,318 - 59,192
Unclassified common dolphin	No. Si	7	0	0	0	0	0	0
	D	6.30	0.00	0.00	0.00	0.00	0.00	1.76
	N	**20,066**	**0**	**0**	**0**	**0**	**0**	**20,066**
	CV	0.94						0.94
	95% CI	4,218 - 95,455	-	-	-	-	-	4,218 - 95,455
Striped dolphin	No. Si	7	11	0	0	0	0	11
	D	2.40	3.71	0.00	0.00	0.00	0.00	2.24
	N	**7,633**	**17,928**	**0**	**0**	**0**	**0**	**25,561**
	CV	0.69	0.85	-	-	-	-	0.66
	95% CI	2,247 - 25,934	4,225 - 76,073	-	-	-	-	7,865 - 83,067
Pacific white-sided dolphin	No. Si	1	3	2	15	11	21	53
	D	0.07	1.99	2.46	32.35	19.29	20.66	2.08
	N	**220**	**9,641**	**7,645**	**1,196**	**1,432**	**3,594**	**23,728**
	CV	0.95	0.76	0.82	0.57	0.79	0.79	0.38
	95% CI	46 - 1,059	2,567 - 36,213	1,875 - 31,175	423 - 3,382	366 - 5,607	918 - 14,072	11,552 - 48,739

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Table 5 (continued). Abundance and density estimates by geographic stratum (CA, OR and WA only): **No. Si** = Number of sightings included in the analysis, **D** = estimated density (animals per 100 km^2), **N** = estimated abundance, **CV** = coefficient of variation in N, **CI** = lognormal 95% confidence interval for N.

		Large-scale surveys			Fine-scale surveys			
Species		**So CA**	**Cen/No CA**	**OR/WA**	**OC-Slope**	**OC-NMS**	**CenCA-NMS**	**TOTAL**
Northern right whale dolphin	No. Si	1	0	3	2	2	6	14
	D	0.26	0.00	2.48	4.19	0.43	13.56	0.97
	N	**831**	**0**	**7,723**	**155**	**32**	**2,359**	**11,100**
	CV	0.98	-	0.86	1.11	0.72	0.70	0.6
	95% CI	166 - 4,149	-	1,796 - 33,202	27 - 898	9 - 114	684 - 8,133	3,744 - 32,910
Bottlenose dolphin	No. Si	5	1	0	0	0	0	1
	D	0.63	0.05	0.00	0.00	0.00	0.00	0.20
	N	**2,011**	**262**	**0**	**0**	**0**	**0**	**2,273**
	CV	0.62	0.91	-	-	-	-	0.55
	95% CI	658 - 6,150	57 - 1,201	-	-	-	-	830 - 6,226
Risso's Dolphin	No. Si	6	4	1	0	0	31	5
	D	1.47	0.44	0.20	0.00	0.00	12.19	0.84
	N	**4,694**	**2,145**	**616**	**0**	**0**	**2,121**	**9,575**
	CV	0.49	0.61	1.07	-	-	0.26	0.29
	95% CI	1,891 - 11,652	712 - 6,459	111 - 3,413	-	-	1,285 - 3,501	5,486 - 16,712
Short-finned pilot whale	No. Si	1	0	0	0	0	0	0
	D	0.15	0.00	0.00	0.00	0.00	0.00	0.04
	N	**489**	**0**	**0**	**0**	**0**	**0**	**489**
	CV	0.97	-	-	-	-	-	0.97
	95% CI	99 - 2,413	-	-	-	-	-	99 - 2,413
Killer whale	No. Si	0	3	2	0	2	1	7
	D	0.00	0.09	0.13	0.00	0.28	0.18	0.08
	N	**0**	**424**	**419**	**0**	**21**	**32**	**895**
	CV	-	0.69	0.63	-	0.98	1.11	0.43
	95% CI	-	125 - 1,441	135 - 1,301	-	4 - 105	6 - 185	399 - 2,006
Humpback whale	No. Si	1	11	8	3	40	130	193
	D	0.02	0.07	0.06	0.22	2.37	5.60	0.15
	N	**58**	**351**	**202**	**8**	**176**	**974**	**1,769**
	CV	0.96	0.43	0.68	0.58	0.33	0.19	0.16
	95% CI	12 - 283	157 - 787	60 - 676	3 - 23	93 - 331	673 - 1,409	1,292 - 2,422

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Table 5 (continued). Abundance and density estimates by geographic stratum (CA, OR and WA only): **No. Si** = Number of sightings included in the analysis, **D** = estimated density (animals per 100 km^2), **N** = estimated abundance, **CV** = coefficient of variation in N, **CI** = lognormal 95% confidence interval for N.

		Large-scale surveys			Fine-scale surveys			
Species		**So CA**	**Cen/No CA**	**OR/WA**	**OC-Slope**	**OC-NMS**	**CenCA-NMS**	**TOTAL**
Blue whale	No. Si	2	12	4	0	0	13	16
	D	0.04	0.08	0.04	0.00	0.00	0.52	0.06
	N	**117**	**402**	**111**	**0**	**0**	**91**	**721**
	CV	0.85	0.39	0.51	-	-	0.48	0.27
	95% CI	28 - 496	192 - 840	43 - 285	-	-	37 - 222	429 - 1,213
Fin whale	No. Si	9	54	11	0	0	5	65
	D	0.11	0.52	0.12	0.00	0.00	0.17	0.29
	N	**366**	**2,502**	**384**	**0**	**0**	**29**	**3,281**
	CV	0.60	0.31	0.35	-	-	0.61	0.25
	95% CI	123 - 1,085	1,382 - 4,530	197 - 748	-	-	10 - 87	2,025 - 5,316
Sei whale	No. Si	0	1	2	0	0	0	3
	D	0.00	0.00	0.02	0.00	0.00	0.00	0.01
	N	**0**	**19**	**55**	**0**	**0**	**0**	**74**
	CV	-	0.99	1.12			-	0.88
	95% CI	-	4 - 96	9 - 322	-	-	-	17 - 326
Minke whale	No. Si	4	1	0	0	0	2	1
	D	0.24	0.04	0.00	0.00	0.00	0.09	0.08
	N	**763**	**178**	**0**	**0**	**0**	**16**	**957**
	CV	0.94	2.64	-	-	-	1.84	1.36
	95% CI	160 - 3,630	11 - 2,998	-	-	-	1 - 173	129 - 7,112
Sperm whale	No. Si	3	11	3	1	0	0	15
	D	0.11	0.41	0.26	0.11	0.00	0.00	0.28
	N	**341**	**1,986**	**809**	**4**	**0**	**0**	**3,140**
	CV	0.86	0.47	1.01	1.16		-	0.40
	95% CI	79 - 1,466	827 - 4,767	156 - 4,185	1 - 24	-	-	1,476 - 6,681

(Continued on next page)

Table 5 (continued). Abundance and density estimates by geographic stratum (CA, OR and WA only): **No. Si** = Number of sightings included in the analysis, **D** = estimated density (animals per 100 km^2), **N** = estimated abundance, **CV** = coefficient of variation in N, **CI** = lognormal 95% confidence interval for N.

		Large-scale surveys			Fine-scale surveys			
Species		**So CA**	**Cen/No CA**	**OR/WA**	**OC-Slope**	**OC-NMS**	**CenCA-NMS**	**TOTAL**
Baird's beaked	No. Si	0	0	3			0	3
whale	D	0.00	0.00	0.27	0.00	0.00	0.00	0.07
	N	**0**	**0**	**839**			**0**	**839**
	CV	-	-	0.92			-	0.92
	95% CI	-	-	181 - 3,894	-	-	-	181 - 3,894
Cuvier's	No. Si	0	1	0	0	0	1	1
beaked whale	D	0.00	0.49	0.00	0.00	0.00	0.61	0.22
	N	**0**	**2,385**	**0**	**0**	**0**	**106**	**2,491**
		-	1.38	-	-	-	1.03	1.34
	95% CI	-	315 - 18,048	-	-	-	20 - 561	341 - 18,174
Blainville's	No. Si	0	0	1	0	0	0	1
beaked whale	D	0.00	0.00	0.39	0.00	0.00	0.00	0.11
	N	**0**	**0**	**1,206**	**0**	**0**	**0**	**1,206**
	CV	-	-	1.16	-	-	-	1.16
	95% CI	-	-	197 - 7,367	-	-	-	197 - 7,367
Mesoplodont	No. Si	0	0	1	0	0	0	1
beaked whale	D	0.00	0.00	0.27	0.00	0.00	0.00	0.07
	N	**0**	**0**	**841**	**0**	**0**	**0**	**841**
	CV	-	-	0.88	-	-	-	0.88
	95% CI	-	-	191 - 3,710	-	-	-	191 - 3,710
Unidentified	No. Si	1	1	0			0	1
beaked whale	D	0.21	0.09	0.00	0.00	0.00	0.00	0.10
	N	**659**	**448**	**0**			**0**	**1,107**
	CV	1.31	1.00	-			-	1.00
	95% CI	93 - 4,675	88 - 2,291	-	-	-	-	217 - 5,660

Table 6. Abundance and density information for cetacean species seen during the Olympic Coast (OC) fine-scale surveys, including Canadian waters. **No. Si** = number of sightings included in the analysis, **D** = estimated density (animals per 100 km^2), **N** = estimated abundance, **CV** = coefficient of variation for N, **CI** = lognormal 95% confidence interval for N.

		OC-Slope	**OC-NMS**	**OC-Canada**	**OC-TOTAL**
Species	Area Size:	3,697 km^2	7,422 km^2	1,867 km^2	12,986 km^2
Dall's porpoise	No. Si	2	14	10	26
	D	17.18	11.61	33.05	16.28
	N	**635**	**862**	**617**	**2,114**
	CV	0.93	0.81	0.27	0.45
	95% CI	135 - 2,981	214 - 3,473	367 - 1,037	911 - 4,905
Short-beaked common dolphin	No. Si	0	0	1	1
	D	0.00	0.00	6.53	0.94
	N	**0**	**0**	**122**	**122**
	CV	0.00	0.00	0.60	0.60
	95% CI	-	-	41 - 362	41 - 362
Pacific white-sided dolphin	No. Si	15	11	4	30
	D	32.35	19.29	12.05	21.97
	N	**1,196**	**1,432**	**225**	**2,853**
	CV	0.57	0.79	0.57	0.46
	95% CI	423 - 3,382	366 - 5,607	80 - 636	1,209 - 6,733
Northern right whale dolphin	No. Si	2	2	3	7
	D	4.19	0.43	6.48	2.37
	N	**155**	**32**	**121**	**308**
	CV	1.11	0.72	0.53	0.66
	95% CI	27 - 898	9 - 114	46 - 321	95 - 1,001
Killer whale	No. Si	0	2	1	3
	D	0.00	0.28	4.02	0.74
	N	**0**	**21**	**75**	**96**
	CV	0.00	0.98	0.67	0.55
	95% CI	-	4 - 105	23 - 247	35 - 263
Humpback whale	No. Si	3	40	7	50
	D	0.22	2.37	1.29	1.60
	N	**8**	**176**	**24**	**208**
	CV	0.58	0.33	0.16	0.28
	95% CI	3 - 23	93 - 331	17 - 33	121 - 356
Sperm whale	No. Si	1	0	0	1
	D	0.11	0.00	0.00	0.03
	N	**4**	**0**	**0**	**4**
	CV	1.16	0.00		1.16
	95% CI	1 - 24	-	-	1 - 24

Table 7. Abundance estimates (N) and coefficients of variation (CV) for the 2001 and 2005 surveys, and average 2001/2005 estimates of N, CV, and N_{min}.

Species	2001 Estimate		2005 Estimate		2001/2005 Average [1]		
	N	CV	N	CV	N	CV	Nmin [2]
Dall's porpoise	**50,153**	0.54	**66,035**	0.46	**57,549**	0.34	*43,425*
Short-beaked common dolphin	**517,335**	0.41	**459,615**	0.34	**487,622**	0.26	*392,687*
Long-beaked common dolphin	**306**	1.02	**11,714**	0.99	**1,893**	0.65	*1,152*
Unspecified common dolphin	**1,872**	1.03	**20,066**	0.94	**6,129**	0.64	*3,754*
Striped dolphin	**22,316**	0.65	**25,561**	0.66	**23,883**	0.44	*16,737*
Pacific white-sided dolphin	**26,833**	0.35	**23,728**	0.38	**25,233**	0.25	*20,441*
Northern right whale dolphin	**21,104**	0.30	**11,100**	0.60	**15,305**	0.32	*11,754*
Bottlenose dolphin	**4,666**	0.73	**2,273**	0.55	**3,257**	0.43	*2,295*
Risso's dolphin	**15,274**	0.38	**9,575**	0.29	**12,093**	0.24	*9,947*
Short-finned pilot whale	**0**	-	**489**	0.97	**245**	0.97	*123*
Killer whale	**1,647**	0.42	**895**	0.43	**1,214**	0.29	*953*
Humpback whale	**1,109**	0.36	**1,769**	0.16	**1,401**	0.19	*1,192*
Blue whale	**888**	0.40	**721**	0.27	**800**	0.24	*657*
Fin whale	**3,636**	0.50	**3,281**	0.25	**3,454**	0.27	*2,760*
Sei whale	**25**	1.01	**74**	0.88	**43**	0.61	*27*
Minke whale	**843**	0.67	**957**	1.36	**898**	0.65	*544*
Sperm whale	**1,634**	0.57	**3,140**	0.40	**2,265**	0.34	*1,719*
Baird's beaked whale	**117**	0.76	**839**	0.92	**313**	0.55	*203*
Cuvier's beaked whale	**1,892**	1.08	**2,491**	1.34	**2,171**	0.75	*1,234*
Blainville's beaked whale	**0**	-	**1,206**	1.16	**603**	1.16	*277*
Mesoplodont beaked whale	**0**	-	**841**	0.88	**421**	0.88	*222*
Unid. Beaked Whales	**0**	-	**1,107**	1.00	**554**	1.00	*275*

[1] Calculated as a geometric average when both N>0, or an arithmetic average when one N=0

[2] Calculated as: *Nmin=exp(ln(N)-0.842*sqrt(ln(1+(CV*CV))))*

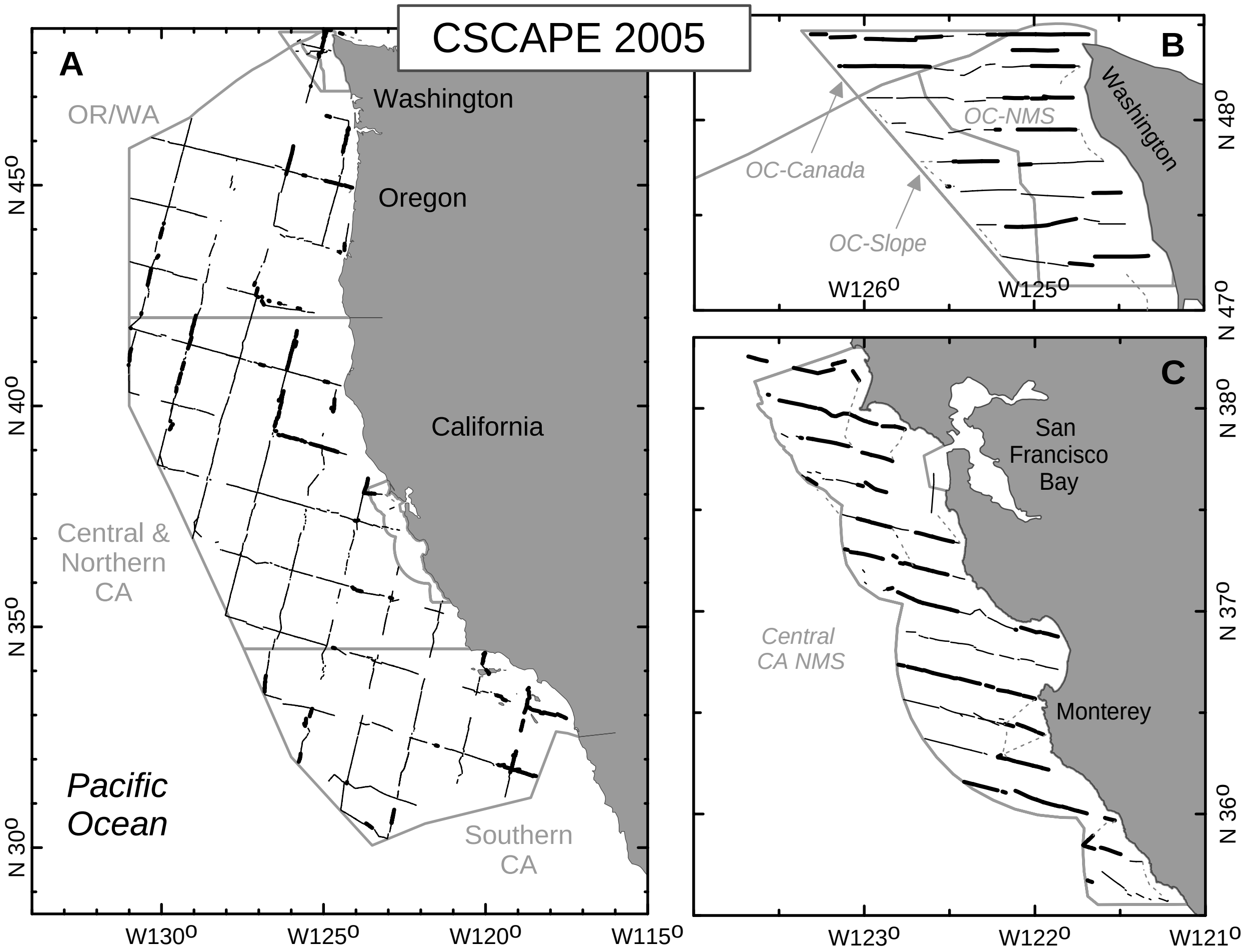

Figure 1. Completed survey coverage during the 2005 CSCAPE cruise for A) broad-scale transects, B) Olympic Coast NMS transects, and C) central California NMS transects. Thick black lines represent survey coverage in Beaufort sea states 0-2, thin black lines Beaufort sea states 3-5. Dashed lines represent non-systematic survey effort that was not included in the analysis. Gray lines and text indicate geographic strata used in the analysis.

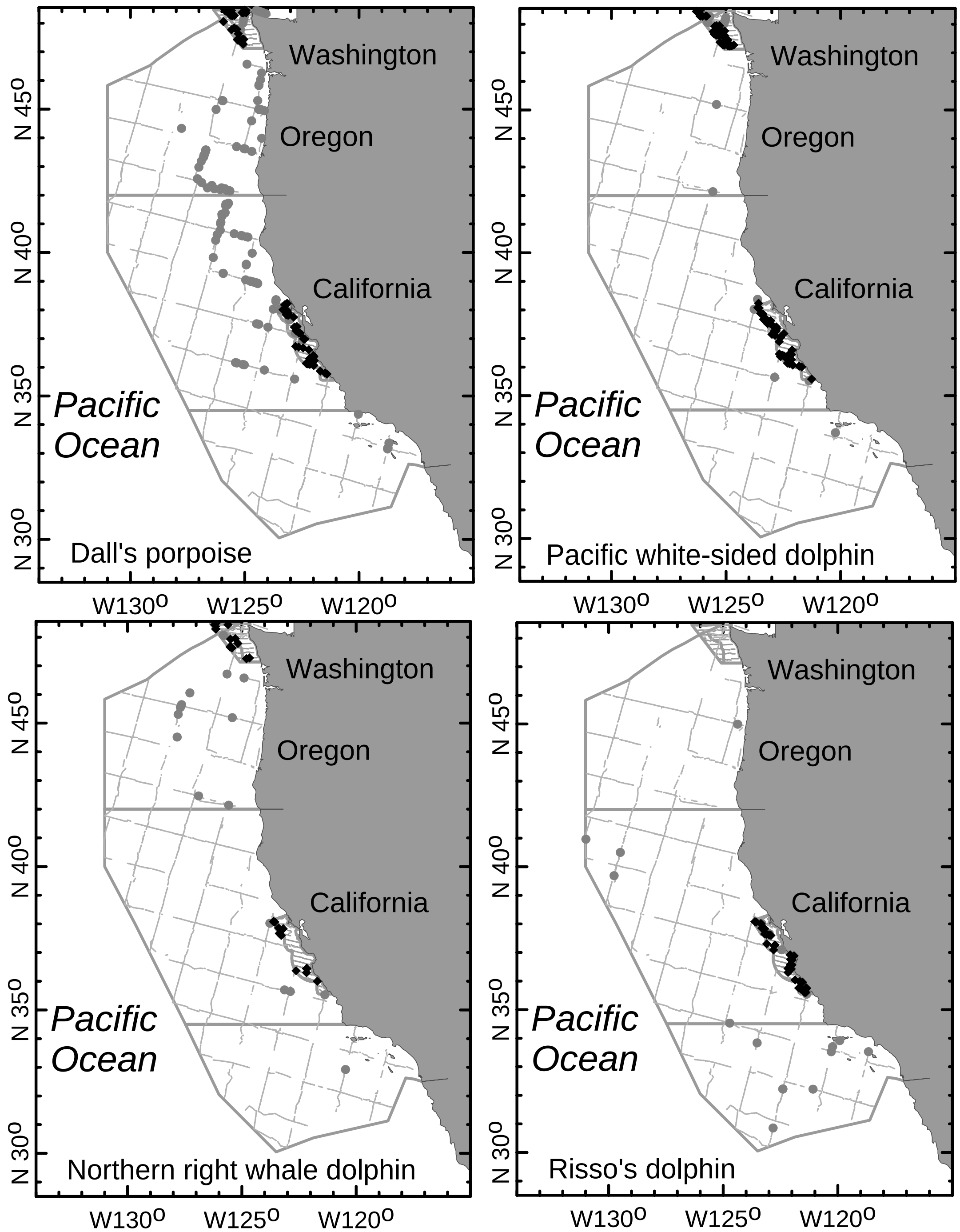

Figure 2. Transect lines and sighting locations of Dall's porpoise, Pacific white-sided dolphins, northern right whale dolphins, and Risso's dolphins during broad-scale surveys (●) and fine-scale NMS surveys (◆).

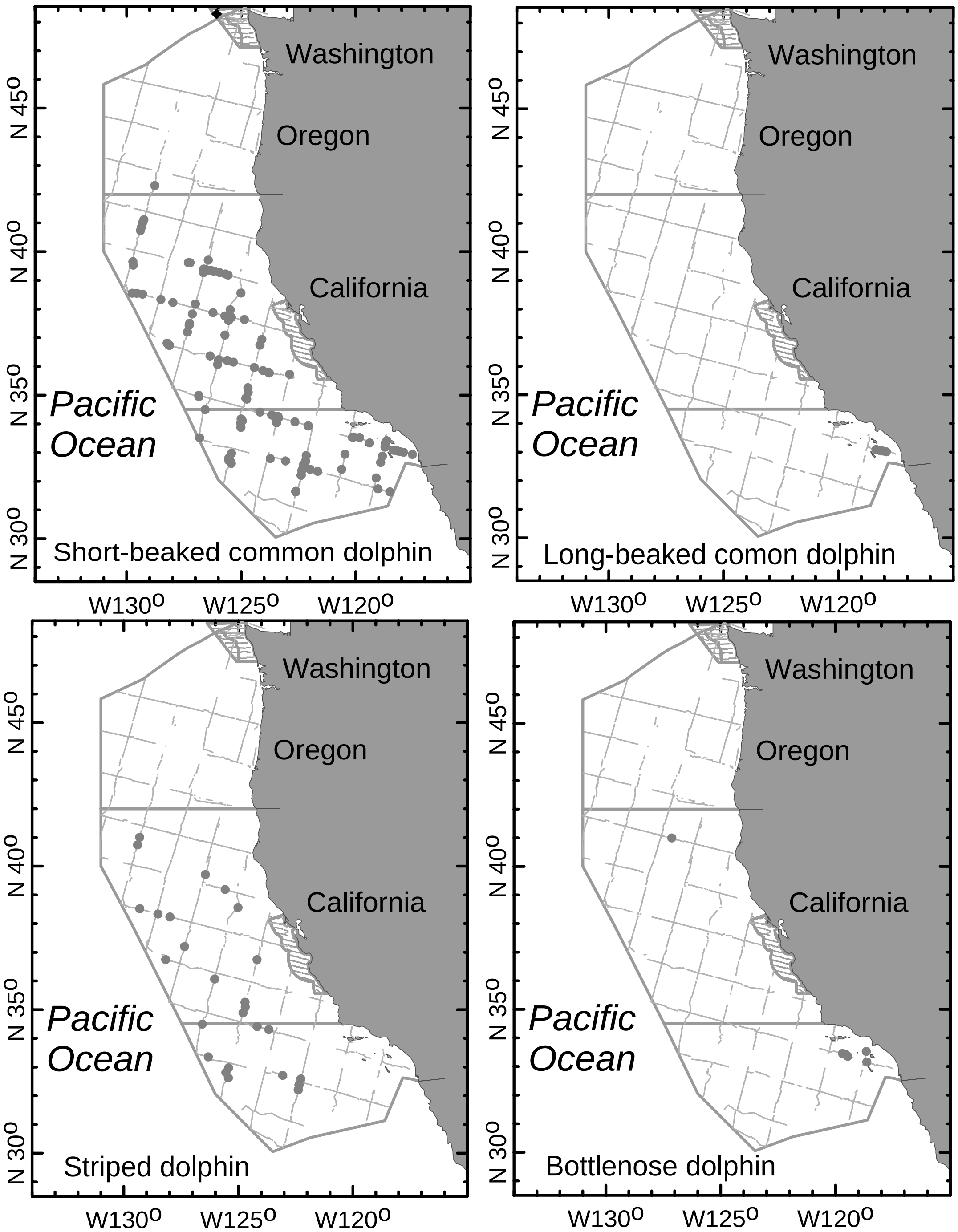

Figure 3. Transect lines and sighting locations of short-beaked common dolphins, long-beaked common dolphins, striped dolphins and bottlenose dolphins during broad-scale surveys (●) and fine-scale NMS surveys (◆).

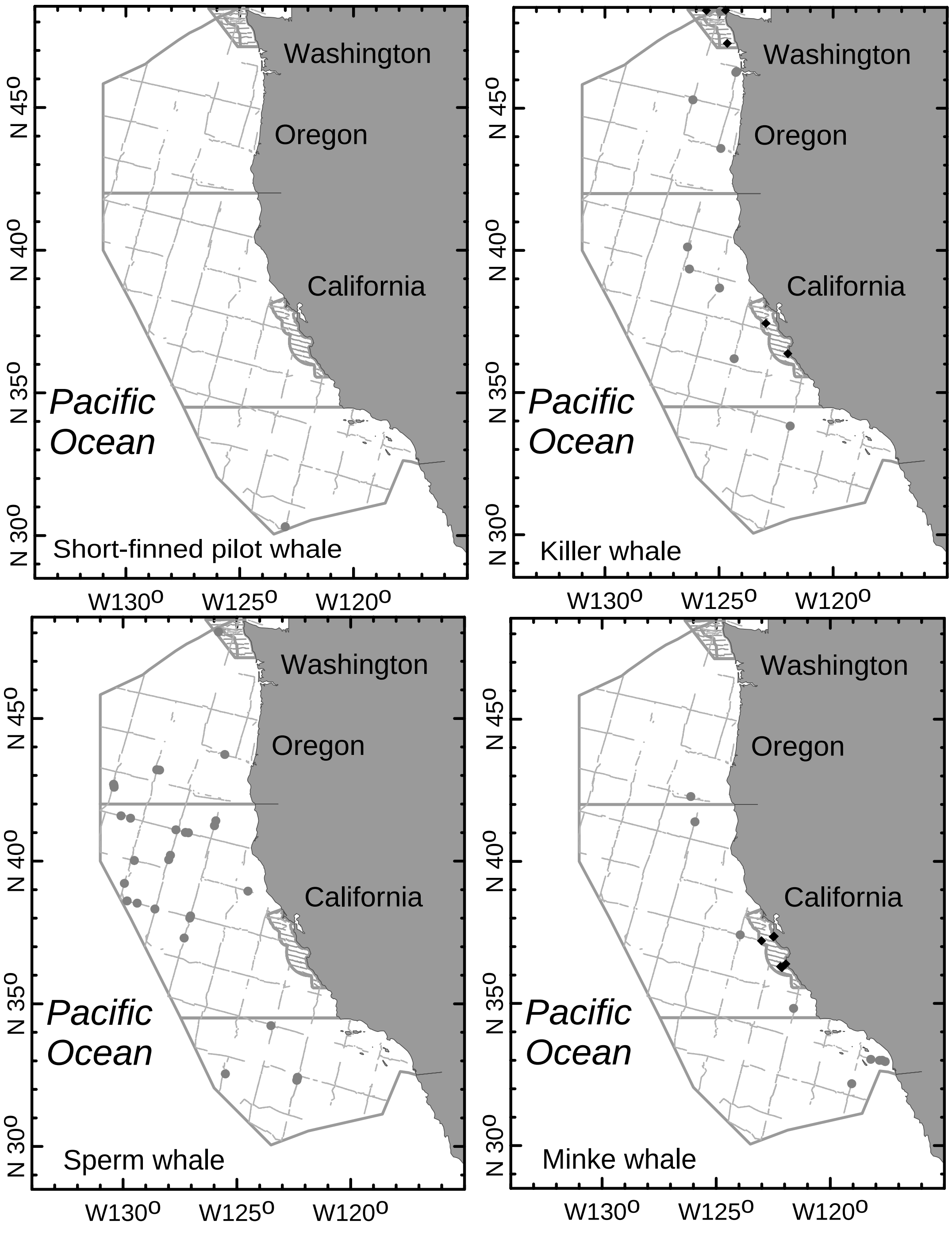

Figure 4. Transect lines and sighting locations of short-finned pilot whales, killer whales, sperm whales, and minke whales during broad-scale surveys (●) and fine-scale NMS surveys (◆).

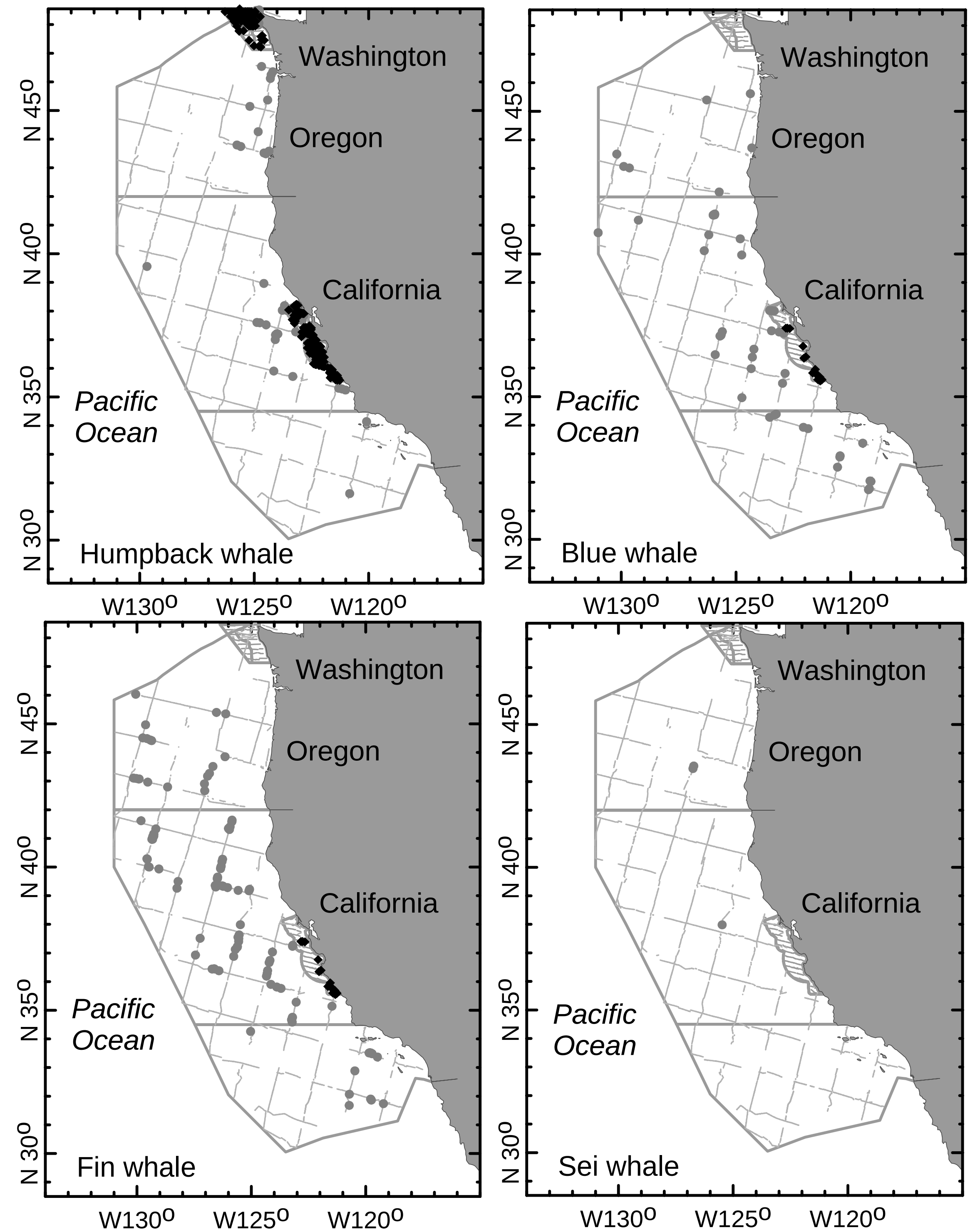

Figure 5. Transect lines and sighting locations of humpback whales, blue whales, fin whales, and sei whales during broad-scale surveys (●) and fine-scale NMS surveys (◆).

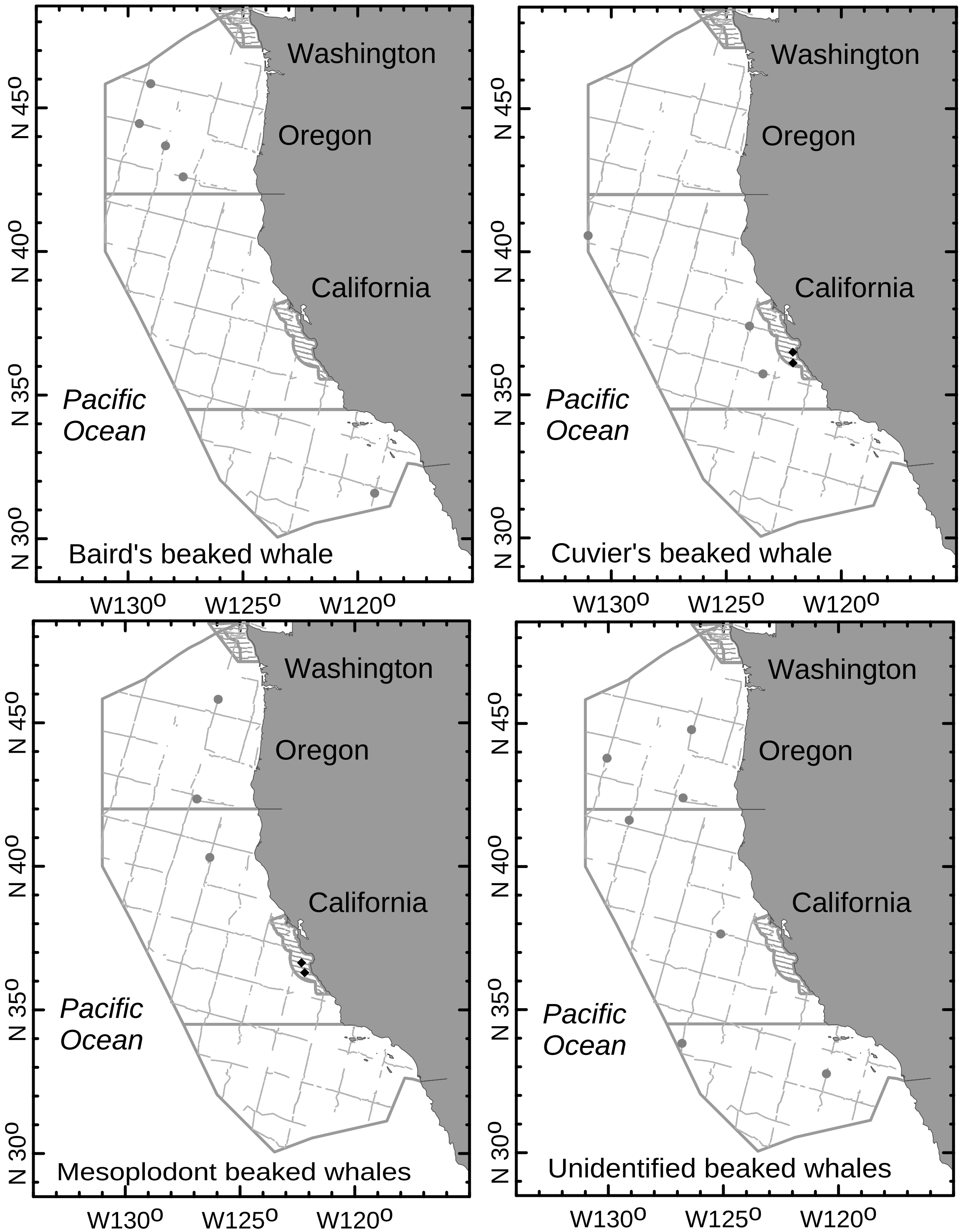

Figure 6. Transect lines and sighting locations of Baird's beaked whales, Cuvier's beaked whales, mesoplodont beaked whales, and undentified beaked whales during broad-scale surveys (●) and fine-scale NMS surveys (◆).

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