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By

Jay Barlow

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Jay Barlow
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
La Jolla, California 92038

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Jay Barlow
Southwest Fisheries Science Center
P.O. Box 271, La Jolla CA 92038 USA

ABSTRACT

Visual sighting surveys on two ships in summer/fall 1996 were used to estimate the abundance of most cetaceans found within 555 km (300 nmi) of the coasts of California, Oregon, and Washington. Surveys systematically covered 14,400 km of pre-determined transect lines within this study area. Line-transect methods were used on the surveys and in the analyses of these data. Survey modes were alternated, with two days in closing mode followed by one day in passing mode. Species were grouped based on sighting characteristics for the purpose of estimating f(0), and values of g(0) were taken from previous studies. Distributions of perpendicular distance were not significantly different between the two vessels used on this survey, so data from the two ships were pooled. Abundance was estimated separately for two geographic strata: California and Oregon/Washington. The most abundant small cetaceans were short-beaked common dolphins (338,000, CV=0.41), Dall's porpoise (124,000, CV=0.47), long-beaked common dolphins (72,000, CV=0.83), Pacific white-sided dolphins (67,000, CV= 0.77), northern right whale dolphins (14,000, CV=0.57), and Risso's dolphins (14,000, CV=0.36). The most abundant large whales were blue whales (2,100, CV=0.23), fin whales (2,000, CV=0.55), humpback whales (1,700, CV=0.32), and sperm whales (800, CV=0.34). Passing mode resulted in a higher fraction of sightings that could not be identified to species and a lower mean group size for most species. Encounter rates were higher in passing mode for some species and higher in closing mode for other species. These abundance estimates are preliminary and many suggestions are made for future approaches that can improve these estimates.

INTRODUCTION

Abundance has been estimated for most cetaceans within 555 km (300 nmi) of the California coast from previous ship (Barlow 1995; Barlow and Gerrodette 1996) and aerial (Forney et al. 1995; Barlow and Forney 1994) line-transect surveys. For waters off Oregon and Washington, cetacean abundance has been estimated only for the most abundant cetacean species, only by aerial surveys, and only within 100 nmi from the coast (Green et al. 1992, 1993). In 1996, a large-scale ship survey was conducted to estimate cetacean abundance along the entire region within 300 nmi of the coasts of California, Oregon, and Washington. This report presents preliminary estimates of cetacean abundance from that 1996 survey, thereby updating California estimates and greatly increasing the information about cetacean abundance off Oregon and Washington in summer and fall.

During the 1996 survey, an experiment was conducted to determine whether encounter rates and group size estimates differed between "passing" or "closing" modes. When a cetacean was seen by the observers, the ship was either allowed to continue on course without diverting (passing mode) or was diverted to the vicinity of the individual or group (closing mode). In general, it is expected that passing mode will give less biased estimates of encounter rates (because effort is continuous in high density areas) and that closing mode will give fewer unidentified groups and less biased estimates of group size and species percentages (because observers will have a closer view of groups). Most cetacean ship surveys conducted by the Southwest Fisheries Science Center (SWFSC) have typically used closing mode in order to better estimate group size and identify species (Holt 1987; Holt and Sexton 1989; Wade and Gerrodette 1993; Barlow 1995); however, SWFSC harbor porpoise cruises have used passing mode in order to maintain searching efficiency in high density areas (Barlow 1988). Passing mode was used experimentally on this cruise to investigate the potential biases that could be introduced by diverting from the trackline.

METHODS

Field Methods

The 1996 survey was conducted using two National Oceanographic and Atmospheric Administration (NOAA) research vessels: the 53 m *McArthur* (17 July - 14 October 1996) and the 52m *David Starr Jordan* (4 September - 6 November 1996). Teams of three observers searched from the flying bridge deck of both vessels using line-transect methods (Hill and Barlow 1992; Mangels and Gerrodette 1994). Two observers searched through 25x pedestal-mounted binoculars while the third observer searched with unaided eyes and a 7x hand-held binocular; observation height at eye level was approximately 10 m above the water's surface for both vessels. The third observer was also responsible for recording all data on searching effort and sightings on a lap-top computer. [Typically a fourth "independent" observer also searched with unaided eyes and a 7x binocular to detect groups that were missed by the three primary observers. Independent observer data are not presented in this preliminary analysis.] During daylight hours, the ships traveled at approximately 18 km/hr (10 kts) along a grid of pre-determined tracklines that uniformly covered the region between the coast and 555 km (300 nmi) from shore. At night, the vessels either remained in an area (to begin the next morning where effort was terminated the previous evening) or transited to a new transect line.

Passing and closing modes were alternated throughout the cruise, with two closing days followed by one passing day. In passing mode, the observer who initially sighted the group would typically estimate group size and identify species while the vessel traveled along the trackline and the other observers continued to search. Occasionally, the other observers would help in identifying species or would be able to estimate group size without a significant interruption of their continued searching. In closing mode, all observers aided in identifying species and made independent estimates of group size. In closing mode, the ship did not necessarily end effort or divert from the trackline if observers believed that they could determine species present and obtain good estimates of abundance without doing so. Four relatively rare species were identified *a priori* as species of special interest for behavioral and genetic studies and were always treated in closing mode: sperm whale, short-finned pilot whale, Baird's beaked whale, and right whale (of these, only right whales were not seen on this survey). Dall's porpoise (and harbor porpoise, not presented here) were always treated in passing mode because group size and species could be easily determined without diverting from the transect line.

Estimates of group size and quantitative estimates of the percentage of each species present were not discussed among observers and were recorded independently in personal notebooks. Estimates of group size and species percentages were transcribed into the computer record at the end of each day by the cruise leader.

Each observer team included at least one expert in species identification. Species were positively identified in the field only if the observers were certain of the species identification. For groups that could not be identified to the species level, observers recorded the lowest classification level of which they could be certain (eg. genus, delphinoid, "small whale", or "large whale"). Observers were required to describe and draw all diagnostic features used to identify species, and if species could not be identified with certainty, they were asked to list the most likely species. Beaked whales and other small whales are typically difficult to distinguish with certainty in the field; therefore, a large fraction of these species are simply classified as "unidentified beaked whale" or "unidentified small whale". After the survey, I reviewed the written descriptions, drawings, and likely identifications of all "unidentified beaked whales" and "unidentified small whales" and (if possible) determined the most probable species identification. Of the 28 sightings in these categories, I was able to assign a probable species identification to 13. These probable species identifications were used in the analyses presented here.

Analytical Methods

Cetacean abundance was estimated using line-transect methods (Buckland et al. 1993). The study area was divided into two geographic strata: waters off California (south of 42°N; 815,000 km^2) and waters off Oregon and Washington (north of 42°N; 324,000 km^2) (Figure 1). Sightings were stratified by group size to account for differences in visibility and to avoid size bias (Buckland et al. 1993, p. 77). The density, D_{aij}, for species j within geographic stratum a and group-size stratum i was estimated as

$$D_{aij} = \frac{n_{aij} \; S_{aij} \; f_{ik}(0)}{2 \; L_a \; g_{ik}(0)} \qquad (1),$$

where n = number of sightings,
S = mean group size,
$f(0)$ = sighting probability density at zero perpendicular distance,

L = length of transect line completed,
$g(0)$ = probability of seeing a group directly on the trackline, and
k = species group to which species j belongs.

Passing and closing modes were pooled for this abundance estimation. To facilitate comparisons with earlier estimates, I used the same group size strata that were used by Barlow (1995) and Barlow and Gerrodette (1996) and the same geographic stratum for California. In estimating f(0), geographic strata were pooled, and species were pooled into groups with similar sighting characteristics: small delphinids, large delphinids, cryptic species[1], small whales, and large whales (Table 1). I estimated f(0) using options for hazard-rate and half-normal key functions with cosine adjustments using the program DISTANCE (Laake et al. 1994). Akaike Information Criterion (AIC) was used to select the best model. I used the same critical truncation distances (5.55 km for large whales and 3.70 km for other species) as Barlow and Gerrodette (1996) to eliminate distant sightings before estimating f(0). Estimates of g(0) for these species and group size strata (Table 2) were taken from Barlow (1995) and Barlow and Sexton (1996). Because g(0) increases dramatically with sea state for small whales and cryptic species, estimates for those species were based on search effort conducted in Beaufort sea state 0 to 2; abundances of other species were based on search effort in Beaufort 0 to 5.

The total abundance for species j in area a, ($N_{a\,j}$), is estimated as the sum of the densities in all s strata times the size of the study area, A_a,

$$N_{aj} = A_a \sum_{i=1}^{s} D_{a\,ij}$$

The coefficient of variation (CV) of the abundances were estimated as the square root of the sum of the squared CVs of f(0), g(0), and the encounter rate ($n \cdot S / L$). The CV of the encounter rate was estimated empirically by breaking the transects into 75 nmi segments and calculating the standard error among segments (Buckland et al. 1993, p. 110). The CV of f(0) was estimated by the program DISTANCE using an information matrix approach. The CV of g(0) was estimated using an analytical formula for most species (Barlow 1995, Appendix) and was estimated from a simulation model based on search behavior and dive times for long-diving species (sperm whales, pygmy sperm whales, Cuvier's beaked whales, and mesoplodont beaked whales) (Barlow and Sexton 1996).

RESULTS

Transects in Beaufort sea states 0 to 5 almost uniformly covered the defined study area

[1] Harbor porpoise, included with cryptic species in analyses of 1991-93 surveys (Barlow and Gerrodette 1996), were excluded here because the survey design was inappropriate for this species.

(Figure 1). A few planned transect lines were not covered, including an area of persistent fog along the coasts of northern California and southern Oregon. Transects completed in Beaufort 0-5 totaled 10,100 km in the California stratum and 4,300 km in the Oregon/Washington stratum. Combined effort included 2,100 km in calm conditions (Beaufort 0-2) and 12,300 km in rough conditions (Beaufort 3-5). A total of 738 cetacean sightings were made during the survey in Beaufort sea states 0-5. The encounter rates for most species were similar to those observed on previous surveys (Table 3).

Effective Search Widths

Distributions of perpendicular distance were truncated at 5.55 km for large whales and 3.7 km for all other species prior to estimating the effective search widths (ESW=1/f(0), Eq. 1). This excluded approximately the most distant 10% of sightings (15.9% for small delphinids, 13.9% for large delphinids, 4.8% for cryptic species, 14.3% for small whales, and 8.3% for large whales). The sample size for large delphinids (31) was not adequate to stratify by group size as was done in analyses of the 1991/93 surveys (Barlow and Gerrodette 1996). The best fits to the observed distributions of perpendicular distance were obtained using different line transect models for different species. The Hazard rate model with cosine adjustments gave the best fit for small groups of small delphinids, cryptic species, and large whales. The half-normal model with cosine adjustments gave the best fit for medium and large groups of small delphinids, large delphinids, small whales, and larger groups of large whales.

The estimated effective search widths (1/f(0), Eq. 1) were similar to those estimated for the 1991/93 cetacean surveys in California (Table 4). The biggest apparent differences were the approximately two-fold greater effective search widths for medium-sized groups of small delphinids, for small groups of large delphinids, and for cryptic species. None of these differences are statistically significant (t-test, $p > 0.05$).

Abundance Estimates

Estimates of 1996 cetacean abundance in the California and Oregon/Washington strata are given in Table 5. Estimates from 1991/93 are provided in the same table for comparison.

Passing vs. Closing Modes

Overall, 9,100 km (63%) of search effort was conducted in closing mode and 5,310 km (37%) were conducted in passing mode. Although passing and closing days were assigned systematically and should have been random with respect to other variables, some deviations from these overall percentages were observed. When sighting conditions were very good (Beaufort 0-2), the ratio of closing mode to passing mode was 70:30. In the Oregon/Washington stratum, this ratio of closing:passing modes was 59:41, and in the California stratum this ratio was 65:35. Search effort was halted 433 times in closing mode and 110 times in passing mode. When effort is stopped, an area in front of the ship had already been searched; therefore, the true distance searched was greater than the distance traveled by the ship (up to the effective search width) for each stop. Given a typical search width of 2 km (Table 4), search effort might be underestimated by up to 10% in closing mode and up to 5% in passing mode.

The fraction of groups that could not be identified to species (unidentified common dolphins, unidentified delphinoids, unidentified large whales, unidentified baleen whales, unidentified small whales, and unidentified whales) was higher in passing mode than in closing mode (Table 6). Average group sizes were smaller (approaching statistical significance) when estimated in passing mode than in closing mode for both small delphinids and baleen whales (Table 6, t-test, $p = 0.04$ and 0.06, respectively) and were significantly smaller for common dolphins separately ($p = 0.025$). The encounter rates (number of groups seen per 1000nmi of transect) were significantly different between passing and closing mode only for common dolphins ($p = 0.01$).

Differences between closing and passing modes appear greatest for common dolphins. Both average group size and encounter rates were approximately two times greater in closing mode than in passing mode for the combined category of short-beaked, long-beaked and unidentified common dolphins (Table 6). The distributions of search effort in passing/closing modes (Fig. 2) indicates that the dominant habitat of these species (the Southern California Bight and the central California offshore areas between 100-200 nmi from shore) may have been undersampled in passing mode.

Biases caused by using closing mode are likely to be greatest for species with a very patchy distribution. The distributions of distances between sightings of the same species (Table 7) can be used as an index of patchiness. Patchiness appears greatest for Dall's porpoise and humpback whales; for these species almost 2/3 of sightings are within 5nmi of the previous sighting of that species. Patchiness is high for a wide variety of other species, including short-beaked common dolphins, Pacific white-sided dolphins, blue whales, and fin whales, for which approximately 1/3 of sightings are within 5nmi of the previous sighting of that species.

Vessel Differences

The two vessels used for this survey used identical methods and have virtually the same observation height (10 m). The areas surveyed by the two vessels were similar, but more of the far northern area was covered by the *McArthur* and more of the far southern area was covered by the *Jordan* (Fig. 3). To ensure a continuity of methods, two identification experts were transferred after 30 days on the *McArthur* to the *Jordan* at the beginning of its survey and another observer was transferred to the *Jordan* after the *McArthur* had finished its survey. Nonetheless, there are some differences between the vessels that could result in different effective search distances. In particular, the *McArthur* rolls more which make it more difficult to hold the binoculars steady. The distributions of perpendicular sighting distances for small delphinids within 2 nmi of the transect line were not statistically different (K/S test, $p = 0.06$, $n = 106$ and 63 respectively for the *McArthur* and the *Jordan*). Similarly, the distributions of perpendicular sighting distances for large whales within 3 nmi of the transect line were not significantly different (K/S test, $p = 0.14$, $n = 152$ and 103 respectively for the *McArthur* and the *Jordan*). Sample sizes for other species groups were too small from the *Jordan* to meaningfully test differences in perpendicular distance distributions. In general, there was a non-significant tendency for sightings to be made at greater perpendicular distances from the *McArthur* than from the *Jordan*, despite its greater roll.

DISCUSSION

Abundance Estimates

Abundance estimates from this 1996 survey in the California stratum are roughly similar to previous 1991/93 estimates (Barlow and Gerrodette 1996) for the same stratum, but for some species differences of 3x and greater are not uncommon (or unexpected given the high CVs of many estimates). The most abundant cetaceans in the California stratum (in rank order) are short-beaked common dolphins, long-beaked common dolphins, Dall's porpoise, Pacific white-sided dolphins, northern right whale dolphins, Risso's dolphins, striped dolphins, Cuvier's beaked whales, blue whales, fin whales, and humpback whales. Among delphinids, long-beaked common dolphins and Pacific white-sided dolphins appear more abundant than previously and striped dolphins, bottlenose dolphins, and pilot whales appear less abundant. Beaked whales appear to be generally less abundant in the California stratum in 1996. Among large whales, an apparent increase in abundance is seen in fin whales and humpback whales. These apparent increases or decreases are statistically significant only for striped dolphins and pilot whales[2] (two-tailed t-test[3], $p < 0.05$), and the best estimates of the average abundance of all species would be a weighted average of the 1991/93 and 1996 estimates (Table 5). The distribution of search effort in calm seas (Fig.4) tended to be skewed towards the shoreward side of the study area. Therefore, the abundance of species estimated for calm seas alone (cryptic species and small whales) might be geographically biased; in particular, near shore species like Dall's porpoise might be over estimated and offshore species like beaked whales may be under estimated.

The Oregon/Washington stratum included generally low numbers of most species; the most abundant species in that stratum (in rank order) are Dall's porpoise, Pacific white-sided dolphins, Risso's dolphins, northern right whale dolphins, short-beaked common dolphins, and mesoplodont beaked whales. Previous aerial surveys in this area found Pacific white-sided dolphins and Risso's dolphins to be the most common small cetaceans followed by harbor porpoise (not included here) and Dall's porpoise. Aerial survey abundance was only estimated for these four species. Aerial estimates of Pacific white-sided dolphins were greatest in spring, and their numbers in spring were estimated to be 38,500 (CV = 0.48) in 1989-90 within 100 nmi of the coast (Green et al. 1992) and 13,100 (CV = 0.35) in 1992 between the 200 m isobath and 100 nmi from shore (Green et al. 1993). Aerial estimates of Risso's dolphins were greatest in spring and summer, and their numbers in those seasons were estimated to be 7,700 (CV = 0.29) in 1989-90 within 100 nmi of the coast (Green et al. 1992) and 7,900 (CV = 0.36) in spring 1992 between the 200 m isobath and 100 nmi from shore (Green et al. 1993). Previous aerial survey estimates of Dall's porpoise abundance for Oregon/Washington in 1989-90 are 2,150 (CV = 0.17) (there were no significant seasonal patterns so all seasons were combined). Dall's porpoise abundance was not estimated for 1992 aerial surveys.

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[2] Short-finned pilot whales were, in fact, seen twice on the survey, but both sightings were outside the established truncation distance of 2 nmi.

[3] Note that t-tests are only approximate with these non-normal distributions, and future analyses should include bootstrap confidence interval tests (Forney and Barlow, in press).

The new abundance estimates for Pacific white-sided dolphins (7,200, CV = 1.7) and for Risso's dolphins (7,100, CV = 0.51) in the Oregon/Washington stratum are roughly consistent with previous estimates. The new estimates of Dall's porpoise abundance in the Oregon/Washington stratum (63,000, CV = 0.78) are, however, more than an order of magnitude greater than previous estimates from aerial surveys. Even allowing for an approximate 3-fold correction for diving porpoises missed on aerial surveys (by analogy to harbor porpoise, Laake et al. 1997), a large discrepancy appears to exist between the recent ship survey estimates and the previous aerial survey estimates of Dall's porpoise abundance. Previous studies of the behavior of Dall's porpoise at the time they are first sighted from a ship with 25X binoculars (Barlow 1995) indicate that attraction to the ship is not likely to be causing a large positive bias in ship-based estimates.

Passing vs. Closing Modes

Passing and closing modes offer different advantages and disadvantages when conducting line transect surveys for cetaceans. The main disadvantage of passing mode is that the species composition of groups and group size cannot be evaluated as well without approaching the group. Species can be detected at distances greater than they can be identified. Less conspicuous species are likely to be overlooked in a mixed species group seen at greater distances (eg. northern right whale dolphins in a mixed group with Pacific white-sided dolphins or striped dolphins in a mixed group with short-beaked common dolphins). Because at greater distances only the more active members of a group may be visible, group size is likely to be underestimated. The data presented here support some of these expectations: the fraction of unidentified species is larger in passing mode and mean group sizes are significantly smaller in passing mode for most species groups (small delphinids, small whales, and baleen whales). The potential problem of overlooking inconspicuous species within a group cannot be adequately evaluated with this sample but is anticipated to be a problem in passing mode. The inability to accurately estimate group sizes in passing mode has been long recognized by the International Whaling Commission (IWC) from analyses of southern Hemisphere minke whale surveys, and the IWC only considers group sizes to be "confirmed" and useful for estimating mean group size if the group is approached to within 0.25 nmi (IWC 1988).

Biases resulting from closing mode are more difficult to predict or evaluate but are most likely to affect estimates of encounter rates. The standard SWFSC procedure of terminating search effort, departing from the trackline approach groups (for species identification and group size estimation), and returning to effort immediately afterwards can introduce a variety of conflicting biases. If a species' distribution is very patchy, a large fraction of time may be spent off-effort in high density areas, which is expected to result in an underestimate of abundance for that species (Haw 1991). The procedure of reinitiating effort immediately after approaching a group could lead to the ship being lead gradually into the center of a high-density area, which would result in an overestimate of abundance (Haw 1991). Finally, the procedure of terminating effort to approach groups can result in many short segments whose actual length may be underestimated [because search actually extends some distance in front of the vessel and the distance searched is not simply the length of transect covered by the vessel]; underestimating distance searched would result in an overestimate of abundance.

The differences between closing and passing modes are not clear even from this relatively large-scale study. Previous studies of minke whales in the Antarctic concluded that school density is "consistently and significantly lower (by some 20-25%) in closing mode" than in passing mode (Haw 1991). In that larger study (n > 2,000 minke whale sightings), some of this difference could be attributed to the use of an additional observer when in passing mode but the undersampling of high density areas in closing mode was also responsible for a major part of the difference. If closing mode is deemed necessary to accurately determine species representation and group sizes (as appears to be the case in this study), efforts should be made to minimize *potential* biases. Clearly, deviations from the trackline should only be made when necessary. In this study, deviations were not typically needed to determine species or group sizes for Dall's porpoise and were often not needed for large whales. Also, we did not depart from the transect line for sightings which were more than 3 nmi perpendicular distance and which would not be used for abundance estimation. The potential bias caused by covering a large fraction of transect line in "off effort" mode in high density areas is a concern because for many species the distance between sightings is less than 5 nmi. This bias could be minimized by returning to the transect line at the same point that effort was discontinued; however, experience has shown that there is a high probability of double-counting the same group unless that group is literally left in the wake. This bias could be potentially corrected using simulation models to determine the extent of the bias for various levels of group patchiness. The potential bias caused by following sightings into a high density area can be limited (as in this study) by defining effort to include only those areas within 10 nmi of pre-determined transect lines. The potential bias caused by underestimating the distance searched can be addressed in post-cruise analysis by adding an appropriate search distance each time effort is terminated or by using a 2-dimensional line-transect model that includes both perpendicular and forward sighting distances (Sweder et al. 1996). Results from this study suggest that even the most extreme case (adding a segment equal to the effective search width each time effort is terminated) would result in a bias of only 10% in closing mode and 5% in passing mode.

Few conclusions can be drawn from the analysis presented here. The fraction of unidentified species was higher and mean group sizes were lower in passing mode. The encounter rates were higher in closing mode for some species and higher in passing mode for other species. The greatest expected bias from closing mode is likely to be the underestimation of abundance by lost effort in high-density areas (Haw 1991); however, the encounter rate of common dolphins was significantly higher in closing mode. One approach (adopted by the IWC for their Southern Hemisphere minke whales surveys) would be to use closing mode only to estimate group size and passing mode to estimate the density of groups. Such a design is, however, relatively inefficient, which becomes critical when trying to estimate the abundance of many species, some of which are uncommon. On future west-coast surveys, it would probably be more effective to minimize biases by using a hybrid passing/closing mode (eg. maintaining search effort while closing on a group and treating subsequent sightings in passing mode) and to deal with biases in analysis rather than to do additional experiments with passing and closing modes.

Vessel Differences

Sample sizes from this cruise were meager for testing differences between such similar sighting platforms as the *McArthur* and *Jordan*, and it is not surprising that no significant differences were found. Analysis of the much larger sample from five years of cetacean surveys using the same two vessels in the eastern tropical Pacific (Wade and Gerrodette 1993) would provide a much better opportunity to look for differences between similar sighting platforms.

Suggestions for Future Analyses

The analyses presented here are preliminary and do not include several approaches that might improve estimates of cetacean abundance. Previous studies have shown that individual observers may tend to over- or under-estimate group sizes and that their estimation can be improved by calibration based on a subset of groups with known size (Gerrodette and Perrin 1991) or based on comparison to an unbiased observer (Barlow 1995). Future analyses of this survey will incorporate calibration factors for those observers whose group size estimates can be improved. Estimates of f(0) may be improved by pooling detection distances for the 1991, 1993, and 1996 west-coast surveys. A larger sample size can be used to improve precision or can be used to justify greater levels of stratification and thus reduced bias. Levels of stratification and truncation points for perpendicular distances should be optimized specifically for this survey (here I used values that were optimized for the 1991 survey in order to facilitate comparisons to previous surveys). Buckland et al.'s (1993) approach to correcting group size bias should be investigated as an alternative to stratification. Additional geographic stratification should be investigated to obtain uniform distribution of search effort within strata for calm sea states. The use of "probable" species identifications (limited here to "unidentified small whales" and "unidentified beaked whales") can be extended to include all "unidentified" categories. The probability of missing trackline groups, g(0), due to perception bias should be re-estimated based on additional data collected in 1993 and 1996. Additional dive-time data are also available to improve estimates of the probability of missing trackline groups, g(0), due to availability bias for sperm whales and Baird's beaked whales. Taken together, the planned re-analysis of the 1996 survey data is expected to improve the precision and reduce the bias of cetacean abundance estimates; however, at this time it is not possible to determine whether estimates of specific species are likely to increase or decrease.

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Table 1. Species groups used in estimating $f(0)$ and $g(0)$.

Species Group	Species
Small Delphinids	
	short-beaked common dolphin (Delphinus delphis)
	long-beaked common dolphin (Delphinus capensis)
	unclassified common dolphin (Delphinus delphis)
	striped dolphin (Stenella coeruleoalba)
	Pacific white-sided dolphin (Lagenorhynchus obliquidens)
	northern right whale dolphin (Lissodelphis borealis)
	unidentified delphinoid
Cryptic Species	
	Dall's porpoise (Phocoenoides dalli)
	pygmy sperm whale (Kogia breviceps)
	Pygmy or dwarf sperm whale (Kogia breviceps or simus)
Large Delphinids	
	bottlenose dolphin (Tursiops truncatus)
	Risso's dolphin (Grampus griseus)
	Short-finned pilot whale (Globicephala macrorhynchus)
	killer whale (Orcinus orca)
Small Whales	
	unidentified beaked whale
	mesoplodont beaked whale (Mesoplodon spp.)
	Blainville's beaked whale (Mesoplodon densirostris)
	Cuvier's beaked whale (Ziphius cavirostris)
	minke whale (Balaenoptera acutorostrata)
	unidentified small whale
	unidentified cetacean
Large Whales	
	sperm whale (Physeter macrocephalus)
	Baird's beaked whale (Berardius bairdii)
	Bryde's whale (Balaenoptera edeni)
	Bryde's or sei whale (Balaenoptera edeni/borealis)
	fin whale (Balaenoptera physalus)
	blue whale (Balaenoptera musculus)
	humpback whale (Megaptera novaeangliae)
	unidentified baleen whale
	unidentified large whale

Table 2. Values of g(0) (the probability of detecting a trackline group of animals) and its coefficient of variation (CV) used in the 1991/93 (Barlow and Gerrodette 1996) and the 1996 abundance estimates. Values for long-diving whales (sperm whales, dwarf/pygmy sperm whales, and Cuvier's and mesoplodont beaked whales) were estimated from a simulation model (Barlow and Sexton 1996). Values for other species were estimated using conditionally independent observer methods (Barlow 1995). [CV was not defined when g(0) = 1.0, so g(0) was treated as a constant in those cases.]

Species Group Species/Strata	g(0)	CV(g(0))
Small Delphinids		
Group size 1-20	0.77	0.14
Group size 21-100	1.00	0.00
Group size 100+	1.00	0.00
Cryptic Species		
Dall's porpoise	0.79	0.10
dwarf and pygmy sperm whale	0.19	0.33
Large Delphinids		
Group size 1-20	0.74	0.39
Group size 20+	1.00	0.00
Small Whales		
unidentified beaked whale	0.26	0.28
mesoplodont beaked whale	0.26	0.28
Blainville's beaked whale	0.26	0.28
Cuvier's beaked whale	0.13	0.35
minke whale	0.84	0.22
unidentified small whale	0.84	0.22
unidentified cetacean	0.84	0.22
Large Whales		
Sperm whale	0.87	0.08
Other large whales, group size 1-3	0.90	0.07
Other large whales, group size 4+	1.00	0.00

Table 3. Comparison of encounter rates of groups *(n/L)* and individuals *(n·S/L)* for species seen during 1991, 1993, and 1996 surveys off California and during 1996 off Oregon/Washington in Beaufort sea states 0 to 5. Distant sightings were not truncated in this presentation. Coefficients of variation (CVs) are based on the variance in encounter rates for consecutive 75 nmi segments of survey effort. Tallies of sightings differ from previously published values for some species due to the inclusion of "probable" species identifications.

Species Group / Species / Survey	Number Groups n	Groups per 1000nmi	CV Groups per 1000nmi	Animals per 1000nmi	CV Animals per 1000nmi
Small Delphinids					
short-beaked common dolphin					
1991 Survey - CA	122	22.5	0.17	2134	0.22
1993 Survey - CA	106	31.1	0.15	5010	0.21
1996 Survey - CA	101	18.5	0.17	3610	0.21
1996 Survey - OR/WA	1	0.4	1.00	254	1.00
long-beaked common dolphin					
1991 Survey - CA	6	1.1	0.66	181	0.77
1993 Survey - CA	2	0.6	0.41	129	0.55
1996 Survey - CA	5	0.9	0.47	635	0.74
1996 Survey - OR/WA	0	0.0	-	0.0	-
striped dolphin					
1991 Survey - CA	24	4.4	0.25	193	0.36
1993 Survey - CA	18	5.3	0.20	304	0.42
1996 Survey - CA	12	2.2	0.29	54	0.36
1996 Survey - OR/WA	1	0.4	1.00	3	1.00
Pacific white-sided dolphin					
1991 Survey - CA	12	2.2	0.38	54	0.47
1993 Survey - CA	8	2.3	0.28	32	0.46
1996 Survey - CA	23	4.2	0.39	776	0.60
1996 Survey - OR/WA	6	2.6	0.33	507	0.62
northern right whale dolphin					
1991 Survey - CA	16	3.0	0.48	47	0.62
1993 Survey - CA	8	2.3	0.23	33	0.38
1996 Survey - CA	12	2.2	0.38	230	0.68
1996 Survey - OR/WA	6	2.6	0.28	79	0.54
unidentified common dolphin					
1991 Survey - CA	0	0.0	0.22	0	0.28
1993 Survey - CA	0	0.0	0.17	0	0.41
1996 Survey - CA	15	2.7	0.28	249	0.49
1996 Survey - OR/WA	0	0.0	-	0	-
unidentified delphinoid					
1991 Survey - CA	21	3.9	0.22	13	0.28
1993 Survey - CA	24	7.0	0.17	229	0.41
1996 Survey - CA	38	7.0	0.22	117	0.29
1996 Survey - OR/WA	6	2.6	0.27	14	0.41
Large Delphinids					
bottlenose dolphin					
1991 Survey - CA	16	3.0	0.37	23	0.43
1993 Survey - CA	5	1.5	0.27	25	0.53
1996 Survey - CA	5	0.9	0.35	5	0.46
1996 Survey - OR/WA	0	0.0	-	0	-
Risso's dolphin					
1991 Survey - CA	28	5.2	0.23	102	0.31
1993 Survey - CA	17	5.0	0.21	91	0.36
1996 Survey - CA	15	2.7	0.31	68	0.50
1996 Survey - OR/WA	11	4.7	0.25	179	0.47
short-finned pilot whale					
1991 Survey - CA	1	0.2	1.00	0.2	1.00
1993 Survey - CA	4	1.2	0.44	16	0.49
1996 Survey - CA	1	0.2	1.00	11	1.00
1996 Survey - OR/WA	1	0.4	1.00	8	1.00
killer whale					
1991 Survey - CA	5	0.9	0.52	4	0.56
1993 Survey - CA	2	0.6	0.41	4	0.53
1996 Survey - CA	4	0.7	0.37	5	0.48
1996 Survey - OR/WA	3	1.3	0.79	7	0.79

Species Group / Species / Survey	Number Groups n	Groups per 1000nmi	CV Groups per 1000nmi	Animals per 1000nmi	CV Animals per 1000nmi
Cryptic Species					
Dall's porpoise					
1991 Survey - CA	96	17.7	0.27	65	0.29
1993 Survey - CA	13	3.8	0.27	16	0.36
1996 Survey - CA	101	18.5	0.33	68	0.34
1996 Survey - OR/WA	85	36.6	0.30	140	0.31
pygmy or dwarf sperm whale					
1991 Survey - CA	3	0.6	0.54	0.8	0.56
1993 Survey - CA	3	0.9	0.41	0.9	0.41
1996 Survey - CA	0	0.0	-	0.0	-
1996 Survey - OR/WA	1	0.4	1.00	0.4	1.00
Small Whales					
unidentified beaked whale					
1991 Survey - CA	0	0.0	-	0.0	-
1993 Survey - CA	2	0.6	0.58	0.9	0.67
1996 Survey - CA	0	0.0	-	0.0	-
1996 Survey - OR/WA	0	0.0	-	0.0	-
mesoplodont beaked whales					
1991 Survey - CA	7	1.3	0.40	2	0.42
1993 Survey - CA	8	2.3	0.22	6	0.35
1996 Survey - CA	12	2.2	0.26	3	0.30
1996 Survey - OR/WA	3	1.3	0.40	3	0.54
Cuvier's beaked whale					
1991 Survey - CA	19	3.5	0.30	7	0.32
1993 Survey - CA	12	3.5	0.21	6	0.26
1996 Survey - CA	7	1.3	0.29	2	0.33
1996 Survey - OR/WA	2	0.9	0.53	2	0.70
minke whale					
1991 Survey - CA	5	0.9	0.49	1.0	0.49
1993 Survey - CA	0	0.0	-	0.0	-
1996 Survey - CA	4	0.7	0.39	0.7	0.39
1996 Survey - OR/WA	5	2.2	0.29	2.2	0.29
unidentified small whale					
1991 Survey - CA	8	1.5	0.32	2	0.33
1993 Survey - CA	5	1.5	0.30	2	0.38
1996 Survey - CA	8	1.5	0.31	2	0.34
1996 Survey - OR/WA	4	1.7	0.28	3	0.44
unidentified cetacean					
1991 Survey - CA	8	1.5	0.36	2	0.42
1993 Survey - CA	5	1.5	0.32	5	0.43
1996 Survey - CA	3	0.5	0.56	2	0.67
1996 Survey - OR/WA	4	1.7	0.32	2	0.32

Table 3. (continued).

Species Group Species Survey	Number Groups n	Groups per 1000nmi	CV Groups per 1000nmi	Animals per 1000nmi	CV Animals per 1000nmi
Large Whales					
sperm whale					
1991 Survey - CA	13	2.4	0.43	11	0.49
1993 Survey - CA	15	4.4	0.26	38	0.33
1996 Survey - CA	12	2.2	0.32	9	0.45
1996 Survey - OR/WA	7	3.0	0.34	15	0.55
Baird's beaked whale					
1991 Survey - CA	1	0.2	1.00	1	1.00
1993 Survey - CA	4	1.2	0.44	18	0.47
1996 Survey - CA	3	0.5	0.42	5	0.45
1996 Survey - OR/WA	3	1.3	0.38	2	0.38
Bryde's or sei whale					
1991 Survey - CA	3	0.6	0.74	0.8	0.74
1993 Survey - CA	2	0.6	0.58	0.6	0.58
1996 Survey - CA	0	0.0	-	0.0	-
1996 Survey - OR/WA	0	0.0	-	0.0	-
fin whale					
1991 Survey - CA	23	4.2	0.53	8	0.56
1993 Survey - CA	32	9.4	0.27	18	0.28
1996 Survey - CA	58	10.6	0.25	21	0.30
1996 Survey - OR/WA	5	2.2	0.38	3	0.42
blue whale					
1991 Survey - CA	50	9.2	0.22	18	0.23
1993 Survey - CA	46	13.5	0.22	22	0.22
1996 Survey - CA	73	13.4	0.19	20	0.20
1996 Survey - OR/WA	0	0.0	-	0	-
humpback whale					
1991 Survey - CA	13	2.4	0.39	7	0.51
1993 Survey - CA	17	5.0	0.26	8	0.28
1996 Survey - CA	52	9.5	0.34	18	0.35
1996 Survey - OR/WA	3	1.3	0.40	2	0.47
unidentified baleen whale					
1991 Survey - CA	9	1.7	0.39	2	0.41
1993 Survey - CA	15	4.4	0.26	6	0.28
1996 Survey - CA	42	7.7	0.23	11	0.25
1996 Survey - OR/WA	7	3.0	0.27	3	0.29
unidentified large whale					
1991 Survey - CA	22	4.1	0.31	5	0.33
1993 Survey - CA	11	3.2	0.21	16	0.60
1996 Survey - CA	18	3.3	0.36	5	0.36
1996 Survey - OR/WA	1	0.4	1.00	0.4	1.00
unidentified whale					
1991 Survey - CA	1	0.2	1.00	0.2	1.00
1993 Survey - CA	1	0.3	1.00	0.3	1.00
1996 Survey - CA	1	0.2	1.00	0.2	1.00
1996 Survey - OR/WA	0	0.0	-	0.0	-
baleen whale total					
1991 Survey - CA	98	18.1	0.18	36	0.20
1993 Survey - CA	112	32.9	0.13	54	0.14
1996 Survey - CA	225	41.2	0.13	70	0.15
1996 Survey - OR/WA	15	6.5	0.20	8	0.22

Table 4. Values of f(0) and effective search width (ESW = 1/f(0)) estimated from data collected on the 1996 survey in California, Oregan, and Washington and earlier estimates for the California stratum only (Barlow and Gerrodette 1996). CV indicates coefficients of variation for these estimates. Best-fit models for the 1996 data were determined by AIC to be the hazard-rate and half-normals models, both modified by cosine terms.

Main Stratum	1996 Data				1991+1993 Data		
Sub-strata	f(0) /km	ESW km	C.V. f(0)	Best-Fit Model	f(0) /km	ESW km	C.V. f(0)
Small Delphinids (3.7 km Truncation)							
Group size 1-20	1.567	0.64	0.348	hazard/cosine	1.724	0.58	0.255
Group size 21-100	0.519	1.93	0.186	half-norm/cos	0.905	1.10	0.240
Group size 101+	0.503	1.99	0.193	half-norm/cos	0.528	1.89	0.239
Large Delphinids (3.7 km Truncation)							
Group size 1-20	0.366	2.73	0.167	half-norm/cos	0.912	1.10	0.395
Group size 21+	0.366	2.73	0.167	half-norm/cos	0.383	2.61	0.232
Cryptic Species (3.7 km Truncation)							
Calm seas	0.855	1.17	0.169	hazard/cosine	1.568	0.64	0.200
Small Whales (3.7 km Truncation)							
Calm seas	0.362	2.76	0.197	half-norm/cos	0.369	2.71	0.160
Large Whales (5.5 km Truncation)							
Group size 1-3	0.462	2.17	0.156	hazard/cosine	0.437	2.29	0.100
Group size 4+	0.215	4.66	0.184	half-norm/cos	0.238	4.20	0.147

Table 5. Abundance of cetaceans in California and Oregon/Washington strata estimated from the 1996 survey and in the California strata from previous surveys in 1991 and 1993 (Barlow and Gerrodette 1996). Abundances are based on values of f(0) given in Table 4 and values of g(0) given in Table 2. Overall estimates of abundance are made from a weighted average of the 1991/93 and 1996 survey estimates for the California stratum (weighted by the inverse of the squared coefficients of variation) plus the 1996 estimate for the Oregon/Washington stratum.

Species Group / Species	Survey	Number Groups n	Mean Size of Groups S	Pop. Size N	C.V. N
Small delphinids					
short-beaked common dolphin					
	CA 1991/93	205	115.7	372,425	0.22
	CA 1996	90	170.0	326,815	0.42
	OR/WA 1996	1	591.0	11,194	1.00
	1996 Total			338,009	0.41
	1991-96 Wt. Avg.			373,573	0.19
long-beaked common dolphin					
	CA 1991/93	5	128.0	8,980	0.64
	CA 1996	5	693.0	72,251	0.83
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			72,251	0.83
	1991-96 Wt. Avg.			32,239	0.18
common dolphin (unclassified)					
	CA 1991/93	11	55.8	10,120	1.42
	CA 1996	15	90.0	30,345	0.54
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			30,345	0.54
	1991-96 Wt. Avg.			27,831	0.39
striped dolphin					
	CA 1991/93	34	45.8	24,910	0.31
	CA 1996	10	22.9	5,734	0.55
	OR/WA 1996	1	6.0	113	2.00
	1996 Total			5,847	0.54
	1991-96 Wt. Avg.			20,235	0.14
Pacific white-sided dolphin					
	CA 1991/93	19	20.9	11,187	0.36
	CA 1996	16	177.0	60,026	0.84
	OR/WA 1996	3	116.0	7,180	1.66
	1996 Total			67,206	0.77
	1991-96 Wt. Avg.			25,825	0.49
northern right whale dolphin					
	CA 1991/93	21	14.7	8,977	0.50
	CA 1996	8	55.0	9,131	0.77
	OR/WA 1996	5	30.0	4,683	0.77
	1996 Total			13,814	0.57
	1991-96 Wt. Avg.			13,705	0.38
unidentified delphinoid					
	CA 1991/93	33	10.7	10,585	0.57
	CA 1996	31	13.6	17,998	0.73
	OR/WA 1996	2	2.0	306	1.31
	1996 Total			18,304	0.72
	1991-96 Wt. Avg.			13,701	0.40
Large delphinids					
bottlenose dolphin					
	CA 1991/93	16	7.5	1,850	0.50
	CA 1996	4	4.0	320	0.43
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			320	0.43
	1991-96 Wt. Avg.			956	0.14
Risso's dolphin					
	CA 1991/93	41	15.4	10,720	0.41
	CA 1996	15	24.6	7,366	0.52
	OR/WA 1996	9	42.0	7,065	0.51
	1996 Total			14,431	0.36
	1991-96 Wt. Avg.			16,483	0.28
short-finned pilot whale					
	CA 1991/93	4	13.8	1,004	0.37
	CA 1996	0	0.0	0	2.00
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			0	2.00
	1991-96 Wt. Avg.			970	0.37

Species Group / Species	Survey	Number Groups n	Mean Size of Groups S	Pop. Size N	C.V. N
killer whale					
	CA 1991/93	5	4.8	747	0.71
	CA 1996	3	5.4	323	0.60
	OR/WA 1996	3	5.7	319	0.80
	1996 Total			642	0.50
	1991-96 Wt. Avg.			819	0.38
Cryptic species					
Dall's porpoise					
	CA 1991/93	69	3.2	47,661	0.40
	CA 1996	64	3.4	60,756	0.50
	OR/WA 1996	53	3.6	63,152	0.78
	1996 Total			123,909	0.47
	1991-96 Wt. Avg.			116,016	0.45
pygmy sperm whale					
	CA 1991/93	3	1.2	3,145	0.54
	CA 1996	0	0.0	0	2.00
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			0	2.00
	1991-96 Wt. Avg.			2,933	0.54
pygmy or dwarf sperm whale					
	CA 1991/93	1	1.0	891	2.04
	CA 1996	0	0.0	0	2.00
	OR/WA 1996	1	1.0	1,376	2.00
	1996 Total			1,376	2.00
	1991-96 Wt. Avg.			1,813	2.04
Small whales					
unidentified beaked whale					
	CA 1991/93	1	2.0	307	0.54
	CA 1996	0	0.0	0	2.00
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			0	2.00
	1991-96 Wt. Avg.			286	0.54
mesoplodont beaked whale					
	CA 1991/93	5	1.4	1,378	0.58
	CA 1996	1	1.0	362	2.00
	OR/WA 1996	2	2.9	2,438	0.68
	1996 Total			2,800	0.64
	1991-96 Wt. Avg.			3,738	0.46
Blainville's Beaked whale					
	CA 1991/93	1	4.8	728	2.03
	CA 1996	0	0.0	0	2.00
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			0	2.00
	1991-96 Wt. Avg.			360	2.03
Cuvier's beaked whale					
	CA 1991/93	12	2.4	9,163	0.52
	CA 1996	2	1.5	2,162	0.55
	OR/WA 1996	0	0.0	0	2.00
	1996 Total			2,162	0.55
	1991-96 Wt. Avg.			5,870	0.20
minke whale					
	CA 1991/93	4	1.1	201	0.65
	CA 1996	4	1.0	446	0.44
	OR/WA 1996	2	1.0	262	1.00
	1996 Total			708	0.46
	1991-96 Wt. Avg.			631	0.45
unidentified small whale					
	CA 1991/93	5	1.0	237	0.45
	CA 1996	4	1.3	558	0.51
	OR/WA 1996	1	1.0	131	2.00
	1996 Total			689	0.56
	1991-96 Wt. Avg.			508	0.55

Table 5 (continued)

Species Group Species Survey	Number Groups n	Mean Size of Groups S	Pop. Size N	C.V. N
unidentified cetacean				
CA 1991/93	4	1.5	285	0.59
CA 1996	1	1.0	112	2.00
OR/WA 1996	1	1.0	131	2.00
1996 Total			243	1.42
1991-96 Wt. Avg.			402	0.73
Large whales				
sperm whale				
CA 1991/93	25	6.8	1,231	0.39
CA 1996	9	4.6	503	0.42
OR/WA 1996	4	7.6	303	0.57
1996 Total			807	0.34
1991-96 Wt. Avg.			1,191	0.22
Baird's beaked whale				
CA 1991/93	5	12.8	380	0.53
CA 1996	2	9.1	157	0.53
OR/WA 1996	3	1.9	110	0.41
1996 Total			267	0.35
1991-96 Wt. Avg.			379	0.23
Bryde's whale				
CA 1991/93	1	2.0	24	2.00
CA 1996	0	0.0	0	2.00
OR/WA 1996	0	0.0	0	2.00
1996 Total			0	2.00
1991-96 Wt. Avg.			12	2.00
Bryde's or sei whale				
CA 1991/93	3	1.0	36	0.71
CA 1996	0	0.0	0	2.00
OR/WA 1996	0	0.0	0	2.00
1996 Total			0	2.00
1991-96 Wt. Avg.			32	0.71
fin whale				
CA 1991/93	51	1.9	933	0.27
CA 1996	55	2.0	1,896	0.59
OR/WA 1996	5	1.4	136	0.41
1996 Total			2,031	0.55
1991-96 Wt. Avg.			1,236	0.20
blue whale				
CA 1991/93	91	1.8	1,723	0.23
CA 1996	71	1.5	2,146	0.23
OR/WA 1996	0	0.0	0	2.00
1996 Total			2,146	0.23
1991-96 Wt. Avg.			1,927	0.16
humpback whale				
CA 1991/93	27	2.2	577	0.32
CA 1996	50	2.0	1,701	0.33
OR/WA 1996	2	1.0	39	0.42
1996 Total			1,740	0.32
1991-96 Wt. Avg.			1,152	0.15
unidentified baleen whale				
CA 1991/93	13	1.4	194	0.29
CA 1996	34	1.4	828	0.25
OR/WA 1996	7	1.1	154	0.32
1996 Total			983	0.21
1991-96 Wt. Avg.			721	0.10
unidentified large whale				
CA 1991/93	20	1.3	303	0.29
CA 1996	17	1.5	469	0.39
OR/WA 1996	1	1.0	19	2.00
1996 Total			488	0.38
1991-96 Wt. Avg.			382	0.23

Table 6. Observed differences between passing and closing modes for average group size, group encounter rates, and the proportion of groups identified to species level for the five principal species groups. Also included are subcategories of total common dolphins (*Delphinus* spp., including short-beaked, long-beaked, and unidentified common dolphins) under "small delphinids" and baleen whales (including fin, blue, humpback, and unidentified baleen whales) under "large whales".

Species/mode	number of groups	average group size	CV avg group size	groups per 1000nmi	CV groups / 1000nmi	Proportion Identified to Species
Small Delphinids						
closing	118	166	0.16	24.0	0.16	0.84
passing	51	109	0.11	17.7	0.23	0.43
(Total Common Dolphins)						
closing	87	212	0.16	17.7	0.20	0.94
passing	51	109	0.29	7.3	0.27	0.52
Large Delphinids						
closing	23	24	0.32	4.7	0.27	n.a.
passing	8	30	0.58	2.8	0.44	n.a.
Cryptic Species						
closing	67	3.0	0.08	84.6	0.49	n.a.
passing	53	3.9	0.12	153.0	0.52	n.a.
Small Whales						
closing	14	1.4	0.15	17.7	0.23	0.50
passing	4	1.0	0.50	11.5	0.48	1.00
Large Whales						
closing	131	2.1	0.10	26.6	0.23	0.84
passing	124	1.8	0.09	43.2	0.23	0.69
(Baleen Whales)						
closing	123	1.9	0.10	25.0	0.25	0.89
passing	114	1.5	0.04	39.7	0.25	0.75

Table 7. Distributions of numbers of sightings made at the given distances from the previous sighting of the same species or species category. Numbers include all sightings made in Beaufort sea states 0-5, for all perpendicular distances, and for both passing and closing modes.

	NMI. BETWEEN SIGHTINGS															
Species/category	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	>75
short-beaked common dolphin	30	14	6	10	0	4	2	2	2	3	1	0	1	0	2	23
long-beaked common dolphin	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
unidentified common dolphin	2	2	1	2	0	0	0	0	0	0	0	0	0	0	0	6
striped dolphin	2	0	0	0	0	1	0	0	0	0	1	1	0	0	0	6
Pacific white-sided dolphin	11	2	2	0	2	0	0	0	0	0	0	0	0	0	0	10
northern right whale dolphin	1	0	3	0	1	1	0	0	0	0	1	0	0	0	0	9
unidentified delphinoid	4	9	2	2	0	1	2	1	2	0	0	1	1	2	0	15
bottlenose dolphin	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Risso's dolphin	5	0	2	1	1	0	0	0	0	0	1	1	0	1	0	12
pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
harbor porpoise	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Dall's porpoise	122	21	9	4	3	3	3	0	1	1	1	1	0	0	0	15
dwarf or pygmy sperm whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mesoplodont beaked whale	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9
Cuvier's beaked whale	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
minke whale	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
unidentified small whale	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	8
unidentified cetacean	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
sperm whale	4	2	1	0	0	0	0	0	0	0	0	0	0	0	1	9
Baird's beaked whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
unidentified baleen whale	17	3	0	3	0	2	1	1	0	0	2	0	0	1	2	15
fin whale	25	5	6	4	1	2	1	2	1	0	0	0	0	0	1	13
blue whale	27	8	5	4	3	1	3	2	2	2	0	2	1	0	0	11
humpback whale	36	2	5	1	0	2	1	0	0	0	0	0	0	0	1	5
unidentified large whale	5	2	0	2	0	0	0	0	1	0	0	0	0	1	0	6
unidentified whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1. Transect lines surveyed during Beaufort sea states of 0 to 5. Broad lines indicate the boundaries of the "California" and "Oregon/Washington" strata.

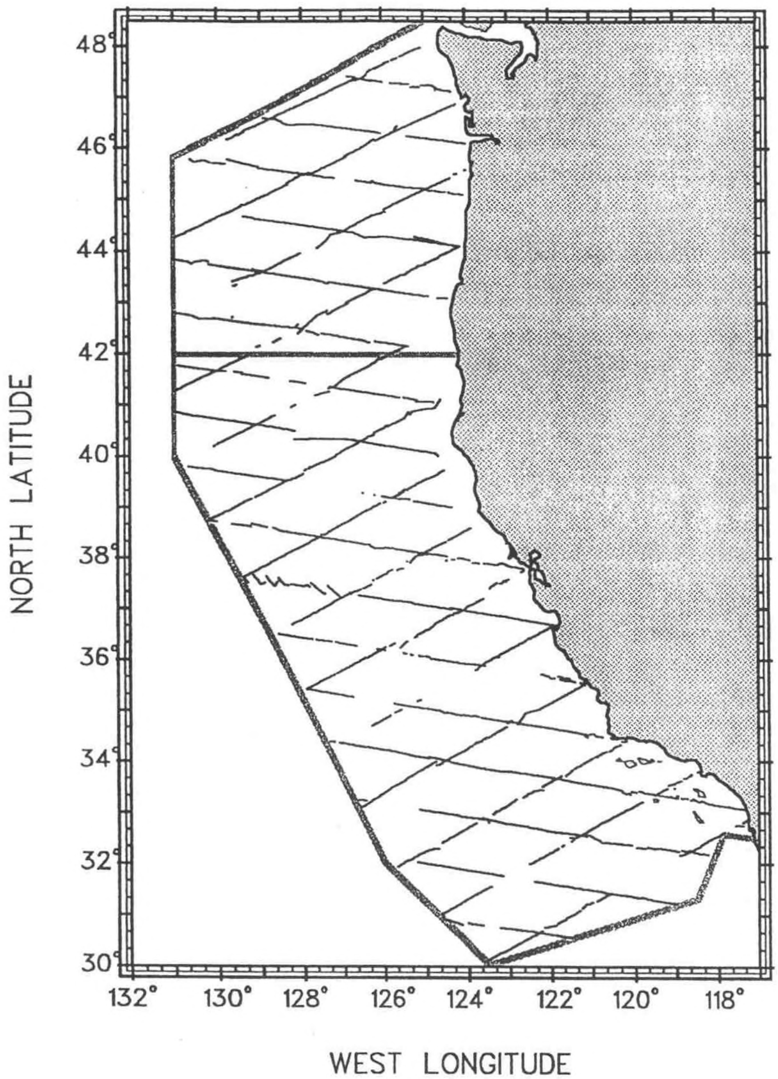


Figure 2. Distribution of search effort and sightings of common dolphins in passing (left) and closing (right) survey modes in Beaufort sea states 0-5..

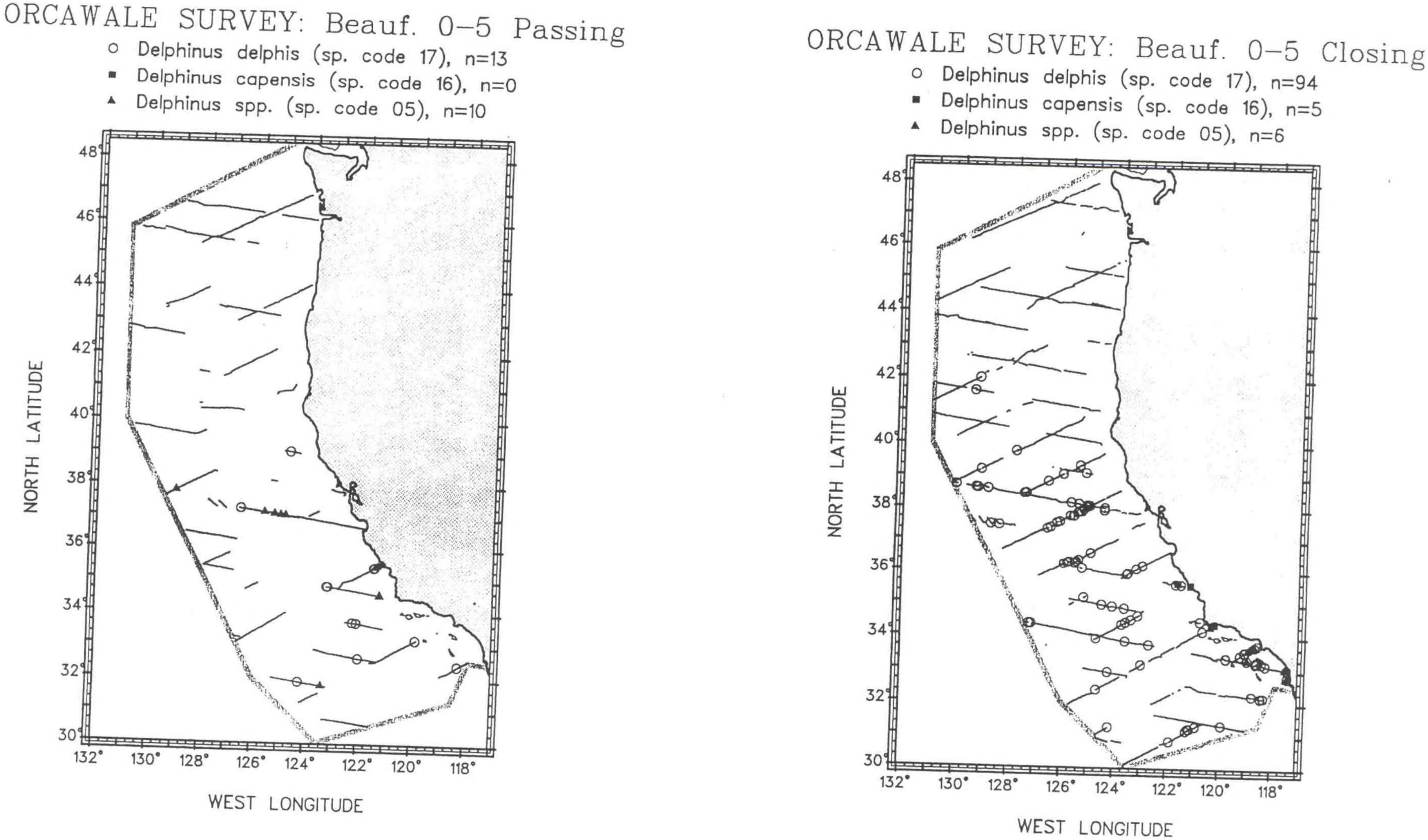
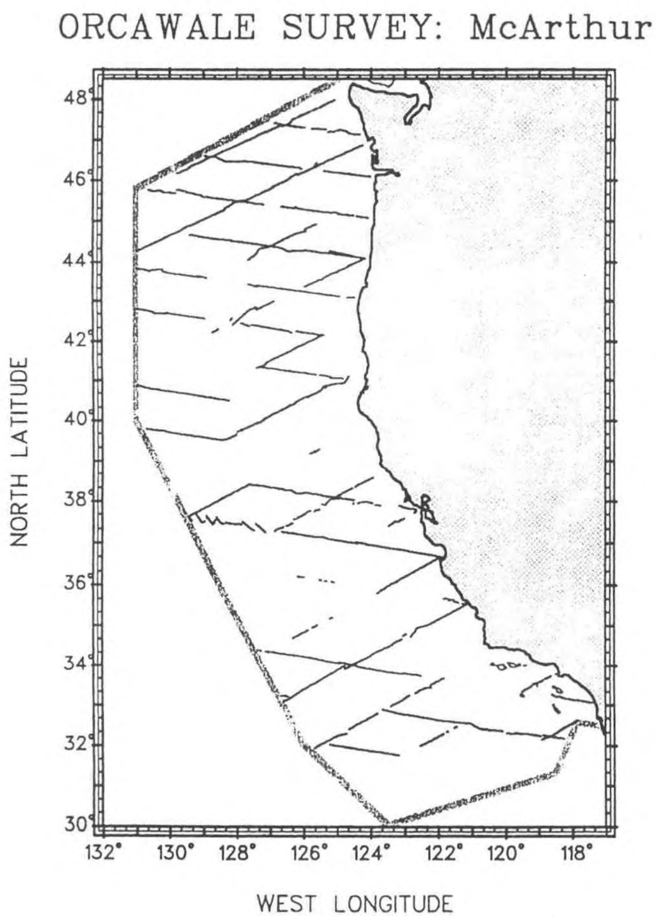


Figure 3. Survey effort conducted by the *McArthur* (left) and by the *David Starr Jordan* (right) in Beaufort sea states 0-5.



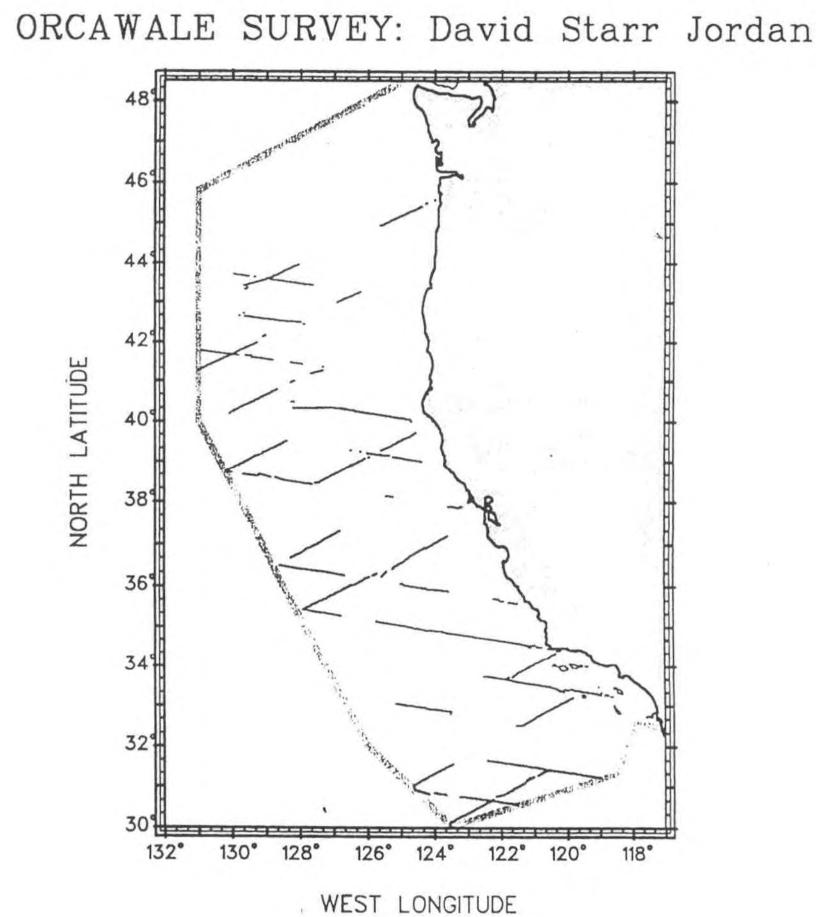


Figure 4. Survey effort conducted in Beaufort sea states 0-2 and locations of Dall's porpoise sightings in 1996.