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RECENT INFORMATION ON THE STATUS OF LARGE WHALES IN CALIFORNIA WATERS

Jay Barlow

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

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ABSTRACT

The structure, size, growth, and status of whale populations is reviewed for species that are found in California waters. Humpback whales in the North Pacific are thought to have been severely depleted by historic whaling. The humpback whale stock which feeds in summer/fall from California to Washington is estimated to number 581 (C.V.=0.03) based on mark-recapture estimates from a minimum of 482 individual whales identified in a 1991-92 photo-identification study. Blue whales and fin whales were also depleted by whaling in the North Pacific, but probably not as severely as humpback whales. The blue whale stock which feeds in California during summer/fall numbers approximately 2,250 (C.V.=0.38; 95% C.I.=1,093-4,632), and the fin whale stock which may be resident in California numbers approximately 935 (C.V.=0.63; 95% C.I.=299-2,925). Sei whales are believed to be severely depleted in the North Pacific and are now rare in California. Bryde's whales were not severely depleted in the eastern Pacific but are also rare in California. Minke whales in California number approximately 526 (C.V.=0.97; 95% C.I.=106-2,596) and appear to be resident there. Minke whales were never subject to commercial whaling in the eastern Pacific. The sperm whale stock in the eastern North Pacific is very large and may not have been reduced much by commercial whaling. Sperm whale abundance in California is estimated as 756 (C.V.=0.49; 95% C.I.=303-1,886). Right whales were severely depleted by historic whaling and are nearly extinct in the North Pacific. Sightings of right whales in California are rare and noteworthy events. All of the above whales except minke whales and Bryde's whales are formally listed as "endangered" under the U.S. Endangered Species act. All suffer some human-caused mortality from drift gillnets and ship strikes in California.

INTRODUCTION

Most of the northern hemisphere species of large whales (defined here as baleen whales and sperm whales) are present, at least seasonally, in California coastal waters. Only the bowhead whale (Balaena mysticetus) is completely absent. Gray whales (Eschrichtius robustus), minke whales (Balaenoptera acutorostrata), humpback whales (Megaptera novaeangliae), and sperm whales (Physeter macrocephalus) have been observed entangled in drift gillnets in California (Heyning and Lewis 1990; NMFS unpubl. data), and all species are probably vulnerable to mortality in gillnets. Blue whales (Balaenoptera musculus), fin whales (Balaenoptera physalus), gray whales, minke whales, and humpback whales are known or suspected to have been killed in California by ship strikes (J. Heyning and J. Cordero, pers.

comm.), and all species are probably vulnerable to ship strikes. To put these human impacts into perspective, I review what is known about large whales in California. Previously, information on endangered large whales was reviewed in a series of articles published in 1984 (Braham 1984; Braham and Rice 1984; Gosho et al. 1984; Johnson and Wolman 1984; Mizroch et al. 1984a, b, & c), and this information was updated by Braham (1991). In this paper I review new information on large whales in California waters which has become available since the 1991 review. I exclude gray whales which were recently reviewed elsewhere (Federal Register 1991; Reilly 1992; Buckland et al. 1993), but I include information on Bryde's (Balaenoptera edeni) and minke whales, two non-endangered species that were excluded in previous reviews.

The goal of this paper is to concisely summarize the information that is required to manage large whales under the Marine Mammal Protection Act (MMPA). For each species, I will: 1) review information on population structure and propose stock structures to be used for management; 2) compile information on population size; 3) summarize information on population growth rates and on the status of populations; and 4) review information regarding human impacts on whale populations. First, however, I will review the concepts used to define stock structure and give some general caveats about the reliability of estimating pre-whaling abundance. A summary of this information for each species is provided in Table 1.

Population and Stock Structure

In this paper, population structure refers to the natural division of species into subgroups that are reproductively isolated. Isolation should be considered relative rather than absolute (Dizon et al. 1992), but the implication is that reproductive pairings within a population are much more likely than among populations. In contrast I use stock structure to refer to an artificial subdivision of species for management. Typically, stock structure is based on the best available information on population structure, but other subdivisions are equally valid if they facilitate meeting management objectives (Donovan 1991).

In Donovan's (1991) review of the stock structures that have been used by the International Whaling Commission (IWC) to manage whaling, he emphasizes that they are "management stocks" and should not be confused with "biological stocks" (or populations as I use the term). According to Donovan (1991), the IWC's management stocks were often determined without much information, and the currently recognized stock structures for 5 species in the North Pacific have not been reviewed since they were given protected status by the IWC [1946 for right whales (Eubalaena glacialis), 1966 for blue and humpback whales, and 1976 for fin whales and sei whales (Balaenoptera borealis)]. Given the sparsity of information on which the IWC stock structures were originally based, the length of time since they have been reviewed, and the difference in management objectives between the IWC and the MMPA, there are no compelling reasons to accept the IWC boundaries.

In this review, I recommend that management stocks be based on the smallest unit that obviously includes animals subject to mortality in west-coast drift gillnet fisheries. If there is no evidence of migration, the stock range will only include waters of California, Oregon, and Washington. For species that are only seasonally present in this area, the geographic range of the stocks will include the full range of the migration. This strategy of defining management stocks based on the smallest practical area is recommended because there are no international agreements for the joint management of incidental mortality of large whales. [Although the International Whaling Commission manages the direct take of whales, this is no longer a factor for any of the stocks found in California waters, except for gray whales which are considered elsewhere.] There is little value in defining management stocks that extend outside the management authority of the United States. This strategy is consistent with the stock recommendations made for odontocetes in California (Forney, in press) and with recommendations made by outside reviewers at the Status of California Cetacean Stocks Workshop (Barlow, Sisson, and Reilly 1993).

Historic Abundance Estimates

For completeness in the report, I will mention historical estimates of population size and levels of stock depletion that have been derived from whaling statistics. Information used to make these estimates includes catch-per-unit effort data, sighting data collected ancillary to whaling activities, and historical catch data. Many problems and biases have been found in making abundance estimates from such data (Tillman 1977; Beddington 1979). Although originally published in reports of the International Whaling Commission (IWC), these estimates are now viewed with skepticism by the IWC and would not likely pass current review procedures. The catch data have been recently questioned, and evidence exists that countries deliberately under-reported whale takes and that animals continued to be taken from protected stocks (Yablokov 1994). Estimates of abundance derived from whaling statistics are likely to be wildly inaccurate. The estimates of the depletion level of whale stocks (expressed as a percentage of pre-exploitation abundance), give only a rough idea of the relative whaling pressure experienced by the various whale stocks.

Depletion levels will be expressed in terms of post-whaling abundance as a percentage of historical (pre-whaling) abundance. Pre-whaling abundance can be crudely considered historical carrying capacity (K). There is no information on how carrying capacity might have changed since the demise of commercial whaling, so there is no way to evaluate status relative to current K.

HUMPBACK WHALES

Population and Stock Structure

Biological Basis for Populations

Although the IWC only considered one stock (Donovan 1991), there is good evidence for multiple populations of humpback whales in the North Pacific (Johnson and Wolman 1984;

Baker et al. 1990). Four relatively separate migratory populations have been identified based on sightings of distinctively-marked individuals: 1) winter/spring populations in coastal Central America and Mexico which migrate to the west coast of the continental U.S. in summer/fall (Steiger et al. 1991; Calambokidis et al. 1993); 2) winter/spring populations of Mexico's offshore islands whose migratory destination is not well known but which do not go the west coast of the continental U.S. (Calambokidis et al. 1993); 3) winter/spring populations of the Hawaiian Islands which migrate to Alaska (Baker et al. 1990); and 4) winter/spring populations of Japan which probably migrate to the Bering Sea and Aleutian Islands in summer/fall (Darling 1991).

Significant levels of genetic differences were found between the California and Alaska feeding groups based on analyses of mitochondrial DNA (Baker et al. 1990) and nuclear DNA (Baker et al. 1993). The genetic exchange rate between California and Alaska is estimated to be less than 1 female per generation (Baker 1992). Two breeding areas (Hawaii and coastal Mexico) showed fewer genetic differences than did the two feeding areas (Baker 1992). This is substantiated by the observed movement of individually-identified whales between Hawaii and Mexico (Baker et al. 1990). There have been no individual matches between 607 humpbacks photographed in California and 567 humpbacks photographed in Alaska (Calambokidis et al. 1993). Few of the whales photographed in British Columbia have matched with the California catalog (Calambokidis et al. 1993), indicating that British Columbia is the approximate geographic boundary between feeding populations. Population structure in humpback whales appears to be based on matrilineal fidelity to feeding areas.

Recommendation for Management Stocks

For management, I propose that the feeding population along the coasts of California, Oregon, and Washington be treated as a separate stock. This population includes animals that migrate to coastal regions of Mexico and Central America during winter and spring.

Population Size

Population Estimates: North Pacific

Based on whaling statistics, the pre-1905 population of humpback whales was estimated to be 15,000 (Rice 1978). In 1984, the population was estimated to be 1,200 (Johnson and Wolman 1984), but the methods used to derive that estimate were not presented. More recently, the estimate for the North Pacific increased to 1,398-2,040 (Braham 1991), which was calculated by taking a range of estimates for the Hawaii breeding population (1,407, 95% C.I.=1,113-1,701) (Baker and Herman 1987), and adding approximately 300 to account for the Mexican and western Pacific breeding populations. Subsequent data indicate that abundance in each of these areas is greater than previously thought. The Hawaii breeding population may be greater than 2,000 (J. Mobley, pers. comm.). The portion of the Mexican breeding population that migrates to California is believed to be approximately 600 (see below). The separate Mexican breeding population on offshore islands contains at least 449 individuals based on photo-identification studies and is estimated to contain 1,131 based on mark-recapture methods (Urbán-R. et al. 1994). Approximately 400 humpbacks have been individually identified in the western Pacific breeding population (K. Mori, pers. comm. to R. Brownell), and this population

is believed to be as large as 500-1000 (Darling 1991). The North Pacific total is now probably greater than 3000 humpback whales.

Population Estimates: U.S. West Coast

Dohl et al. (1983) first estimated the central California feeding population to be 338 (C.V.=0.29) based on aerial surveys in August through November of 1980-83; however, this estimate does not include a correction for submerged animals. More recently, the size of the "California" feeding stock of humpback whales has been estimated by three independent methods. 1) Calambokidis et al. (1993) estimated the number of humpback whales in California-Washington to be 581 (C.V.=0.03) based on mark-recapture estimates comparing their 1991 and 1992 photo-identification catalogs. 2) Barlow (submitted) estimates 626 (C.V.=0.41) humpbacks in California waters based on ship line-transect surveys in summer/autumn 1991. 3) Forney, Barlow, and Carretta (in press) estimate 304 (C.V.=0.41) humpback whales in California coastal waters based on aerial line-transect surveys in winter/spring 1991. In addition, Green et al. (1991) report that humpback whales were the second most abundant large whale (after the gray whale) in aerial surveys of Oregon and Washington, but they did not estimate population size.

These estimates for the west-coast stock are not significantly different for each other, but the survey estimates are likely to be negatively biased. The aerial surveys are likely to be biased because submerged animals are missed, and both the ship and aerial line-transect estimates do not include members of this stock that were in Washington, Oregon, or Mexico at the time of the survey (this is especially true of the winter/spring survey during which it was surprising to see any humpback whales north of Mexico). Mark-recapture estimates may also be negatively biased due to heterogeneity in sighting probabilities (Hammond 1986). However, given that the above mark-recapture estimate is based on a large fraction of the entire population (the 1991-92 catalog contained 482 known individuals), this bias is likely to be minimal. Also, when methods were used which account for heterogeneity, estimates were comparable or smaller (Calambokidis et al. 1993). The most precise and least biased estimate is likely to be the mark-recapture estimate of 581 (C.V.=0.03) humpback whales for this population. The coefficient of variation (0.03) was estimated using methods that typically underestimate true sampling variability; therefore, caution should be used in interpreting confidence intervals based on this estimate. Calambokidis (pers. comm.) intends to make improved estimates of variance based on robust jackknife estimators, which should allow reliable estimates of confidence intervals.

Population Growth Rates and Trends

Trends in Abundance

There is some indication that humpback whales have increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994), but this trend is not significant. Although the population in the North Pacific might be expected to be growing after being given protected status in 1966, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain.

Growth Rate at MNPL

There are no estimates of the growth rate of humpback whale populations in the North Pacific (Best 1993).

Stock Status

Based on whaling statistics, humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity (K) by commercial whaling (Braham 1991). Clearly the North Pacific population is severely depleted. The initial abundance has never been estimated separately for the "California" stock, but this stock was also probably depleted by whaling. Humpback whales are formally listed and "endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the MMPA.

Historic Removals

The reported take of North Pacific humpback whales by commercial whalers totalled approximately 7,700 between 1947 and 1987 (C. Allison, IWC, pers. comm.). In addition, approximately 7,300 were taken along the west coast of North America from 1919 to 1929 (Tonnessen and Johnsen 1982). Total 1910-1965 catches from the California-Washington stock includes at least the 2,000 taken in Oregon and Washington, the 3,400 taken in California, and the 2,800 taken in Baja California (Rice 1978).

Current Removals

Incidental Take

The deaths of two humpback whales in the Southern California Bight have been attributed to entanglement in fishing gear (Heyning and Lewis 1990). Also, two unidentified whales, possibly humpbacks, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No humpback whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes were implicated in the deaths of at least 2 humpback whales in 1993 and 2 unidentified whales (possibly humpbacks) in 1990 (J. Cordero, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or do not have obvious signs of trauma.

Other Take

There was a prohibition on taking humpback whales after 1966, but the accuracy of reported catch data has been recently questioned (Yablokov 1994).

BLUE WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC has only considered one management stock for blue whales in the North Pacific

(Donovan 1991), but now this ocean is thought to include more than one population (Braham 1991). One group of animals appears to migrate from Mexico to feed in coastal California waters from June to November. During this feeding period, there is an apparent hiatus in distribution south of the tip of Baja California (Reilly and Thayer 1990; Wade and Gerrodette 1993) and north of California in Oregon and Washington (Green et al. 1991; Barlow, submitted). Two blue whales were, however, tracked using on a seafloor seismic array approximately 500 km offshore from Astoria, Oregon in August 1990 (McDonald et al. 1994). Although there are blue whales near the Costa Rican Dome in the eastern tropical Pacific from June to November, Reilly and Thayer (1990) speculate that these are likely to be part of a southern hemisphere population or an isolated resident population. Rice (1974) hypothesized that blue whales from Baja California migrated far offshore to fed in the eastern Aleutians or Gulf of Alaska and returned to feed in California waters; however, he has more recently concluded that the California population is separate from the Gulf of Alaska population (Rice 1992). Recently, blue whale feeding aggregations have not been found in Alaska despite several surveys (Leatherwood et al. 1982b; Stewart et al. 1987). Blue whales are now very common in southern California in June-September (Barlow, submitted). Distinctively marked individuals have been shown to move between feeding areas in California and coastal waters of Mexico, including the Gulf of California (Calambokidis et al. 1990). Strong evidence exists for a separate population that spends winter/spring in Mexican coastal waters and summer/autumn in California waters, and there are no verified links to any other feeding areas. Historical links between this population and feeding aggregations in Alaska and British Columbia are possible, but there is no evidence that they currently exist.

Recommendation for Management Stocks

I propose that the California feeding population be treated as a separate stock. This stock includes animals that migrate to coastal Mexico in winter and spring, but does not include blue whales found on the Costa Rica Dome.

Population Size

Population Estimates: North Pacific

Based on whaling statistics, blue whale abundance in the North Pacific was estimated as 4,900 before whaling and 1,600 after they were given protected status (Omura and Ohsumi 1974). Recently, Wade and Gerrodette (1993) estimate 1,400 (C.V.=0.24) blue whales in the eastern tropical Pacific, mostly near the tip of Baja California and the Costa Rica Dome. The only other recent estimates for the North Pacific are for the California population (see below).

Population Estimates: U.S. West Coast

The size of the feeding stock of blue whales in California was estimated recently by both line-transect and mark-recapture methods. Barlow (submitted) estimates 2,250 (C.V.=0.38) blue whales in California waters based on ship line-transect surveys. Calambokidis et al. (1993) used photographic mark-recapture and estimated population sizes of 904 (C.V.=0.41) based on photographs of left sides and 1,112 (C.V.=0.34) based on right sides. The average of the mark-recapture estimates (1,008) is outside the log-normal 95% confidence intervals of the line-transect estimate (1,093 to 4,632). Mark-recapture estimates are often negatively biased by

individual heterogeneity in sighting probabilities. Calambokidis et al. (1993) tried to minimize such effects by selecting one sample that was taken randomly with respect to distance from the coast. Also, they explored models which explicitly account for individual heterogeneity. Still, the mark-recapture estimates are much less than the line-transect estimates. Furthermore, the line-transect estimates may also be negatively biased because some blue whales in this stock are probably along Baja California and, therefore, out of the study area at the time of survey (Wade and Gerrodette 1993). Additional data on blue whales collected in 1993 may help resolve the apparent discrepancy between line-transect and mark-recapture estimates of abundance. Until then, the line-transect estimates should be taken as the best estimates of blue whale abundance for this population. No blue whales were seen in recent aerial surveys off Oregon and Washington (Green et al. 1991); therefore, the estimate for that area is zero.

Population Growth Rates and Trends

Trends in Abundance

There is some indication that blue whales have significantly increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994). Although this may be due to an increase in the stock as a whole, it could also be the result of an increased use of California as a feeding area. The size of the apparent increase is too large to possibly be accounted for by population growth alone. Although the population in the North Pacific might be expected to be growing after being given protected status in 1966, the possibility of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality makes this uncertain.

Growth Rate at MNPL

No information exists on the rate of growth of blue whale populations in the Pacific (Best 1993).

Stock Status

Previously, blue whales in the entire North Pacific were estimated to be at 33% of K (Braham 1991). The initial abundance has never been estimated separately for the "California" stock, but this stock was also probably depleted by whaling. Blue whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the Marine Mammal Protection Act (MMPA).

Historic Removals

The reported take of North Pacific blue whales by commercial whalers totalled 9,500 between 1910 and 1965 (Ohsumi and Wada 1972). Approximately 2,000 were taken off the west coast of North America between 1919 and 1929 (Tonnessen and Johnsen 1982), a minimum of 1,378 were taken by factory ships off California and Baja California between 1913 and 1937 (Rice 1992). Between 1947 and 1987, reported takes of blue whales in the North Pacific were approximately 2,400. Shore-based whaling stations in central California took 48 blue whales between 1958 and 1965 (Rice 1974).

Current Removals

Incidental Take

Two unidentified whales, possibly blues, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No blue whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes were implicated in the deaths of blue whales in 1980, 1986, 1987, and 1993, plus 2 unidentified whales (possibly blue whales) in 1990 (J. Cordero and J. Heyning, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or do not have obvious signs of trauma.

Other Take

There was a prohibition on taking blue whales after 1966, but the accuracy of reported catch data has been recently questioned (Yablokov 1994).

FIN WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC recognizes two stocks of fin whales in the North Pacific: the East China Sea and the rest of the North Pacific (Donovan 1991). Mizroch et al. (1984b) cites evidence for additional fin whale subpopulations in the North Pacific. From whaling records, fin whales that were marked in winter off southern California were later taken in commercial whaling operations between central California and the Gulf of Alaska in summer (Mizroch et al. 1984b).

More recent observations show aggregations of fin whales year-round in southern/central California (Carretta and Forney 1993; Barlow, submitted; Forney et al., in press),-year-round in the Gulf of California (Tershy et al. 1993), and in summer/autumn in the Shelikof Strait/Gulf of Alaska (Brueggeman et al. 1990). In aerial surveys off Oregon and Washington, Green et al. (1991) reported that fin whales were the fourth most abundant large whale (after gray whales, humpback whales, and sperm whales) with all sightings being in Oregon, mostly during June and July. Fin whales appear very scarce in the eastern tropical Pacific in summer (Wade and Gerrodette 1993) and winter (Lee 1993).

There is still insufficient information to accurately determine population structure, but from a conservation perspective it may be risky to assume panmixia in the entire North Pacific. The year-round distribution of fin whales in California suggests the possibility of a resident population. In the North Atlantic fin whales were locally depleted in some feeding areas by commercial whaling (Mizroch 1984b), in part because subpopulations were not recognized.

Recommendation for Management Stocks

I propose that we treat fin whales along the west coast of the continental U.S. as belonging to a distinct management stock. Because fin whale abundance appears lower in winter/spring in California (Forney et al., in press) and in Oregon (Green et al. 1991), it is likely that the distribution of this stock extends seasonally outside these coastal waters. Coincidentally, fin whale abundance in the Gulf of California increases seasonally in winter and spring (Tershy et al. 1993). It is premature, however, to conclude that the Gulf whales are part of the U.S. west coast population.

Population Size

Population Estimates: North Pacific

The initial pre-whaling population of fin whales in the North Pacific was estimated to be 42,000-45,000 (Ohsumi and Wada 1974). In 1973, the North Pacific population was estimated to have been reduced to 13,620-18,680 (Ohsumi and Wada 1974), of which 8,520-10,970 were estimated to belong to the eastern Pacific stock. A minimum of 148 individually-identified fin whales are found in the Gulf of California (Tershy et al. 1990).

Population Estimates: U.S. West Coast

Recently, 935 (C.V.=0.63) fin whale were estimated to be in California waters based on ship surveys in summer/autumn 1991 (log-normal 95% C.I.=299-2,925) (Barlow, submitted). Fin whale abundance in California was estimated as only 47 (C.V.=1.0) based on aerial surveys in winter/spring of 1991/92 (Forney et al., in press); however, this estimate does not include a correction for diving animals that were missed. No estimate exists for Oregon or Washington (Green et al. 1991).

Population Growth Rates and Trends

Trends in Abundance

There is some indication that fin whales have increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994), but this trend is not significant. Although the population in the North Pacific might be expected to be growing after being given protected status in 1976, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain.

Growth Rate at MNPL

There are no estimates of the growth rate of fin whale populations in the North Pacific (Best 1993).

Stock Status

Based on whaling statistics, fin whales in the entire North Pacific were estimated to be at less than 37% of K (Braham 1991). The initial abundance has never been estimated separately for the "west coast" stock, but this stock was also probably depleted by whaling. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the Marine Mammal Protection Act (MMPA).

Historic Removals

Approximately 46,000 fin whales were taken from the North Pacific by commercial whalers between 1947 and 1987 (C. Allison, IWC, pers. comm.). In addition, approximately 3,800 were taken off the west coast of North America between 1919 and 1929 (Tonnessen and Johnsen 1982). Shore-based whaling stations took 1,060 fin whales in central California between 1958 and 1965 (Rice 1974).

Current Removals

Incidental Take

Two unidentified whales, possibly fins, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No fin whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes were implicated in the deaths of one fin whale in 1991 and two unidentified whales (possibly fins) in 1990 (J. Heyning and J. Cordero, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or do not have obvious signs of trauma.

Other Take

There was a prohibition on taking fin whales in the North Pacific after 1976, but the accuracy of reported catch data has been recently questioned (Yablokov 1994).

SEI WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC only considers one stock of sei whales in the North Pacific (Donovan 1991), but some evidence exists for 3 populations (Masaki 1977; Mizroch 1984c). Sei whales are distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features. The catch has been distributed continuously across the North Pacific around 45-55°N (Masaki 1977). Two sei whales that were tagged off California were later killed off Washington and British Columbia (Rice 1974) and the movement of tagged animals has been noted in many other regions of the North Pacific. In summer, sei whales are rare in California coastal waters (Barlow, submitted) and are extremely rare south of California (Wade and Gerrodette 1993).

Recommendation for Management Stocks

Lacking adequate information on sei whale population structure and following the guidelines set forth in the Introduction, I recommend sei whales in California, Oregon, and Washington be managed as a separate stock.

Population Size

Population Estimates: North Pacific

Based on whaling statistics, Ohsumi and Wada (1974) estimate the pre-whaling abundance of sei whales to be 58,000-62,000 in the North Pacific. Later, Tillman (1977) used a variety of different methods to estimate the abundance of sei whales in the North Pacific and revised this estimate to 42,000. His estimates for the year 1974 ranged from 7,260 to 12,620. All methods depend on using the history of catches and trends in CPUE or sighting rates; there have been no direct estimates of sei whale abundance in the North Pacific based on sighting surveys.

Population Estimates: West Coast of U.S.

Only one confirmed sighting of sei whales and 5 possible sightings (identified as sei or Bryde's whales) were made in California waters during extensive ship and aerial surveys in 1991, 1992, and 1993 (Hill and Barlow 1992; Carretta and Forney 1993; NMFS unpubl. data). Green et al. (1991) did not report any sightings of sei whales in aerial surveys of Oregon and Washington. There is no abundance estimate for sei whales along the west coast of the U.S.

Population Growth Rates and Trends

Trends in Abundance

There are no data on trends in sei whale abundance in California coastal waters. Although the population in the North Pacific might be expected to be growing after being given protected status in 1976, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain.

Growth Rate at MNPL

There are no estimates of the growth rate of sei whale populations in the North Pacific (Best 1993).

Stock Status

Previously, sei whales were estimated to be at 23% of K in the North Pacific (Braham 1991). The initial abundance has never been estimated separately for the "west-coast" stock, but this stock was also probably depleted by whaling. Sei whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the Marine Mammal Protection Act (MMPA).

Historic Removals

The reported take of North Pacific sei whales by commercial whalers totalled 61,500 between 1947 and 1987 (C. Allison, IWC, pers. comm.). Of these, 384 were taken by-shore-based whaling stations in central California between 1958 and 1965 (Rice 1974).

Current Removals

Incidental Take

Two unidentified whales, possibly sei whales, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No sei whales or

unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes may occasionally kill sei whales.

Other Take

There was a prohibition on taking sei whales after 1976, but the accuracy of reported catch data has been recently questioned (Yablokov 1994).

BRYDE'S WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC recognizes 3 stocks of Bryde's whales in the North Pacific (eastern, western, and East China Sea), 3 stocks in the South Pacific (eastern, western and Solomon Islands), and one cross-equatorial stock (Peruvian) (Donovan 1991). Bryde's whales are distributed widely across the tropical and warm-temperate Pacific (Leatherwood et al. 1982b), and there is no real justification for splitting stocks between the northern and southern hemispheres (Donovan 1991). Recent surveys (Wade and Gerrodette 1993) have shown them to be common and distributed throughout the eastern tropical Pacific with a concentration around the equator east of 110°W (corresponding approximately to the IWC's "Peruvian stock") and a reduction west of 140°W. They are also the most common baleen whale in the central Gulf of California (Tershy et al. 1990). Only one was positively identified in surveys of California coastal waters (Barlow, submitted). Bryde's whales in California are likely to belong to a larger population inhabiting at least the eastern part (and perhaps the entirety) of the tropical Pacific.

Recommendation for Management Stocks

Lacking adequate information on Bryde's whale population structure and following the guidelines set forth in the Introduction, I recommend Bryde's whales in California, Oregon, and Washington be managed as a separate stock.

Population Size

Population Estimates: North Pacific

In the western North Pacific, Bryde's whale abundance in the early 1980s was estimated independently by tag mark-recapture and ship survey methods to be 22,000 to 24,000 (Tillman and Mizroch 1982; Miyashita 1986). Bryde's whale abundance has never been estimated for the entire eastern Pacific; however, a portion of that stock in the eastern tropical Pacific was estimated recently as 13,000 (95% C.I.=8,900-19,900) (Wade and Gerrodette 1993), and the minimum number in the Gulf of California is 160 based on individually-identified whales (Tershy et al. 1990).

Population Estimates: West Coast of U.S.

Only 1 confirmed sighting of Bryde's whales and 5 possible sightings (identified as sei or Bryde's whales) were made in California waters during extensive ship and aerial surveys in 1991, 1992, and 1993 (Hill and Barlow 1992; Carretta and Forney 1993; NMFS unpubl. data). Green et al. (1991) did not report any sightings of Bryde's whales in aerial surveys of Oregon and Washington. The estimated abundance of Bryde's whales in California coastal waters is 61 (C.V. = 1.078) (Barlow, submitted).

Population Growth Rates and Trends

Trends in Abundance

There are no data on trends in Bryde's whale abundance in California coastal waters.

Growth Rate at MNPL

There are no estimates of the growth rate of Bryde's whale populations in the North Pacific (Best 1993).

Stock Status

Commercial whaling of Bryde's whales was largely limited to the western Pacific. Even if the total catch in the eastern Pacific is subtracted from the population estimate for the eastern tropical Pacific, the resulting population would not be considered depleted under the MMPA. Bryde's whales are not listed as "endangered" under the Endangered Species Act (ESA), and the eastern stock should probably be considered "at OSP" under the Marine Mammal Protection Act (MMPA).

Historic Removals

The reported take of North Pacific Bryde's whales by commercial whalers totalled 15,076 in the western Pacific from 1946-1983 (Holt 1986) and 2,873 in the eastern Pacific from 1973-81 (Cooke 1983). In addition, 2,304 sei-or-Bryde's whales were taken in the eastern Pacific from 1968-72 (Cooke 1983) (based on subsequent catches, most of these were probably Bryde's whales). None were reported taken by shore-based whaling stations in central California between 1958 and 1965 (Rice 1974).

Current Removals

Incidental Take

Two unidentified whales, possibly Bryde's whales, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No Bryde's whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes may occasionally kill Bryde's whales.

Other Take

There was a prohibition on taking Bryde's whales since 1988.

MINKE WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC recognizes 3 stocks of minke whales in the North Pacific: one in the Sea of Japan/East China Sea, one in the rest of the western Pacific west of 180°N, and one in the "remainder" of the Pacific (Donovan 1991). The "remainder" stock only reflects the lack of exploitation in the eastern Pacific and does not imply that only one population exists in that area (Donovan 1991). In the "remainder" area, minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Leatherwood et al. 1982b; Brueggeman et al. 1990). Minke whales are usually seen over continental shelves (Brueggeman et al. 1990). In the extreme north, minke whales are believed to be migratory, but in inland waters of Washington and in central California they appear to establish home ranges (Dorsey et al. 1990). Minke whales occur year-round in California and in the Gulf of California (Dohl et al. 1983; Tershy et al. 1990). Minke whales are present at least in summer/fall along the Baja California peninsula (Wade and Gerrodette 1993).

Recommendation for Management Stocks

I recommend that the management stock be defined to include minke whales within coastal waters of California, Oregon, and Washington.

Population Size

Population Estimates: North Pacific

No estimates have been made for the number of minke whales in the entire North Pacific.

Population Estimates: West Coast of U.S.

Barlow (submitted) estimated 526 (C.V. = 0.97; log-normal 95% C.I. = 106-2,596) minke whales in coastal California waters. Forney et al. (in press) estimate at total of 73 (C.V. = 0.62) in the same area based on an aerial survey, but this estimate is negatively biased because it excludes diving whales. In addition, Green et al. (1991) report 4 sightings of minke whales in aerial surveys of Oregon and Washington, but they did not estimate population size.

Population Growth Rates and Trends

Trends in Abundance

There are no data on trends in minke whale abundance in California coastal waters.

Growth Rate at MNPL

There are no estimates of the growth rate of minke whale populations in the North Pacific (Best 1993).

Stock Status

There were no known commercial takes of minke whales from Baja California to Washington. Minke whales are not listed as "endangered" under the Endangered Species Act and are not considered "depleted" under the MMPA. The greatest uncertainty in their status is whether entanglement in commercial gillnets and ship strikes could have reduced this relatively small population. Because of this uncertainty, the status of the west-coast stock should be considered "unknown".

Historic Removals

The estimated take of North Pacific minke whales by commercial whalers was approximately 31,000 from 1930 to 1987 (C. Allison, IWC, pers. comm.), all of which were taken in the western Pacific. None were reported taken by shore-based whaling stations in central California between 1958 and 1965 (Rice 1974), and minke whales were not harvested commercially in the eastern North Pacific. Reported aboriginal takes of minke whales in Alaska totalled 7 between 1930 and 1987 (C. Allison, IWC, pers. comm.).

Current Removals

Incidental Take

The deaths of two minke whales in the Southern California Bight have been attributed to entanglement in fishing gear (Heyning and Lewis 1990). Also, two unidentified whales, possibly minkes, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No minke whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data). Ship strikes were implicated in the death of one minke whale in 1977 and 2 unidentified whales (possibly minkes) in 1990 (J. Heyning and J. Cordero, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or do not have obvious signs of trauma.

Other Take

Minke whales have never been harvested commercially in the eastern North Pacific.

RIGHT WHALES

Population and Stock Structure

Biological Basis for Populations

The IWC has never formally considered the stock structure of right whales because they have been protected since in inception of the IWC. Recently there have been too few sightings of right whales in the North Pacific to infer anything about their current population structure. In the last 15 years there have been only 4 documented sightings in California coastal waters (Carretta, Lynn, and LeDuc 1994). Historically, right whales fed in summer in the Gulf of Alaska near the edge of the continental shelf, in the eastern Aleutian Islands, and in the Bering

and Okhotsk Seas. Based on the behavior of this species elsewhere in the world we can assume that they migrate to temperate coastal regions on both sides of the ocean basin to breed in winter. This would create a logical east-west population division (as exists for right whales in the North Atlantic). Reeves and Brownell (1982) conclude that their winter range in the eastern North Pacific is from northern California to Washington. Braham and Rice (1984) point out that the evidence for a winter distribution along the coast of the eastern Pacific is weak. Clearly, however, there are now some right whales present in California in winter.

Recommendation for Management Stocks

I recommend that we assume that right whales in California belong to a separate stock that migrates along the eastern Pacific coast to winter breeding areas from California to Washington.

Population Size

Population Estimates: North Pacific

There are no accurate estimates of the current abundance of right whales in the North Pacific, but Braham and Rice (1984) make a rough estimate of 100-200.

Population Estimates: West Coast of U.S.

Carretta et al. (1994) have identified at least 2 (and probably 3) distinct right whales which were seen along the west coast of the U.S. since 1980. Forney et al. (in press) estimate the winter/spring abundance of right whales to be 16 (C.V.=1.04; 95% C.I.=3-95) in California coastal waters.

Population Growth Rates and Trends

Trends in Abundance

There are no data on trends in right whale abundance in California coastal waters. Although the population in the North Pacific might be expected to be growing after being given protected status in 1935, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain. There is strong circumstantial evidence that these factors have prevented the recovery of right whales in the western North Atlantic (NMFS 1991).

Growth Rate at MNPL

There are no estimates of the growth rate of right whale populations in the North Pacific (Best 1993).

Stock Status

There are no previous estimates of the status of right whales in the North Pacific relative to carrying capacity because both current and initial abundance are unknown. An estimated 16,000 right whales were taken by whaling ships in the North Pacific, mostly prior to 1900. Given that current abundance is certainly no more than a few hundred, humpback whales are undoubtedly the most depleted whale species in the North Pacific. Worldwide they are estimated to be at approximately 2% of K (Braham 1991). Right whales are formally listed as

"endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the Marine Mammal Protection Act (MMPA).

Historic Removals

The reported take of North Pacific right whales by commercial whalers totalled approximately 16,000 (Scarff 1986) mostly before 1879. Only 26 were reported taken from 1947 to 1987 (C. Alllison, IWC, pers. comm.).

Current Removals

Incidental Take

Two unidentified whales, possibly rights, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). No right whales or unidentified baleen whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; NMFS, unpubl. data); however, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes may occasionally kill right whales in California.

Other Take

There was a prohibition on taking right whales after 1935, but the accuracy of reported catch data has been recently questioned (Yablokov 1994). Specifically, Yablokov reported that Soviet whalers illegally took right whales in the late 1950s near the Kurile Islands and took several hundred right whales in the Okhotsk Sea in the 1960s.

SPERM WHALES

Population and Stock Structure

Biological Basis for Populations

Sperm whales are widely distributed across the entire North Pacific, primarily south of 40°N (Gosho et al. 1984). For management, the IWC has divided the North Pacific into two management regions. The boundary is a zig-zag line which starts at 150°W at the equator, is 160°W between 40-50°N, and ends up at 180°W north of 50°N. Recent surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed, their relative abundance tapers off markedly towards the middle of the tropical Pacific (near the IWC stock boundary at 150°W). This provides some support for the hypothesis that two populations exist in the North Pacific.

Recommendation for Management Stocks

Lacking adequate information on sperm whale population structure and following the guidelines set forth in the Introduction, I recommend sperm whales in California, Oregon, and Washington be managed as a separate stock.

Population Size

Population Estimates: North Pacific

The abundance of sperm whales has been estimated recently as 22,700 (95% C.I. = 14,800-34,600) in the eastern tropical Pacific (Wade and Gerrodette 1993). These areas include only a portion of the eastern Pacific stock. The only estimates for the entire stock are based on a CPUE model which does not include measures of statistical precision. This estimate for 1982 is 550,042 sperm whales in the eastern North Pacific [based on estimates of the "exploitable" populations of male and females given by Gosho et al. (1984) multiplied by 2.5 (for males) or 1.67 (for females) to yield a total population size (Rice 1988)].

Population Estimates: West Coast of U.S.

Barlow (submitted) estimate 756 (C.V. = 0.49) sperm whales in California coastal waters during summer/fall based on ship line transect surveys (95% C.I. = 303-1,886). Forney et al. (in press) estimate 892 (C.V. = 0.99) sperm whales there during winter/spring based on aerial line-transect surveys (95% C.I. = 176-4,506), but these estimates do not correct for diving whales that were missed. Because of the long dive time of sperm whales (typically 20-75 minutes down followed by 4-10 minutes at the surface, Leatherwood et al. 1982a), it is reasonable to assume that the true abundance would be 3 to 8 times the estimate from aerial surveys. Green et al. (1991) report that sperm whales were the third most abundant large whale (after gray and humpback whales) in aerial surveys of Oregon and Washington, but they did not estimate population size.

Population Growth Rates and Trends

Trends in Abundance

Sperm whale abundance appears to have been fairly stable in California coastal waters between 1979/80 and 1991 (Barlow 1994). Although the population in the eastern North Pacific might be expected to be growing after being given protected status in 1980, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain.

Growth Rate at MNPL

There are no estimates of the growth rate for any sperm whale population (Best 1993).

Stock Status

Overall, sperm whales were estimated to be at 74% of K in the North Pacific (Braham 1991). There is no new information that would allow a better estimate to be made or provide separate estimates for the eastern and western stocks. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently are automatically considered "depleted" under the Marine Mammal Protection Act (MMPA).

Historic Removals

The reported take of North Pacific sperm whales by commercial whalers totalled 258,000 between 1947 and 1987 (C. Allison, IWC, pers. comm.).

Current Removals

Incidental Take

The deaths of two stranded sperm whales in California were attributed to entanglement in fishing gear between 1983 and 1991 (J. Cordero, pers. comm.). Also, two unidentified whales, possibly sperm whales, were taken in the approximately 1% of drift gillnets observed in 1980-85 (Hanan 1986; Heyning and Lewis 1990). Six sperm whales have been observed taken from 1990 to 1993 in gillnet observation programs which covered 5-13% of fishing effort (Lennert et al., in press; Perkins et al. 1992; Julian 1993; Julian 1994) and three were released alive. The resulting estimates of annual mortality of sperm whales are 23 in 1992 (Julian 1993) and 22 in 1993 (Julian 1994). In addition, much of the gillnet mortality of large whales may go unobserved because whales swim away with portion of the net. Ship strikes were implicated in the deaths of two unidentified whales (possibly sperm whales) in 1990 (J. Cordero, pers. comm.). Additional mortality from ship strikes probably goes unreported because the whales do not strand or do not have obvious signs of trauma.

Other Take

There was a prohibition on taking sperm whales after 1988.

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Table 1. Summary of population size (N), its coefficient of variation (C.V.), legal status under the Endangered Species Act and Marine Mammal Protection Act, and growth rates at maximum net productivity level (MNPL) for large whale stocks that are found in California coastal waters. Details for each are found in the text. Unknown is abbreviated Unk.

Species/Stock	N	C.V.	Legal Status	MNPL Growth Rate
humpback whale CA+OR+WA/Mexico stock	581	0.03[1]	Endangered	Unk.
blue whale CA/Mexico stock	2,250	0.38	Endangered	Unk.
fin whale CA+OR+WA stock	935	0.63	Endangered	Unk.
sei whale CA+OR+WA stock	Unk.	Unk.	Endangered	Unk.
Bryde's whale CA+OR+WA stock	61	1.08	Assumed at OSP	Unk.
minke whale CA stock	526	0.97	Unk.	Unk.
northern right whale eastern N. Pac. stock	16	1.11	Endangered	Unk.
sperm whale CA+OR+WA stock	756	0.49	Endangered	Unk.

[1] Coefficient of variation for humpback whales is underestimated and should not be used to calculate confidence intervals for this stock.

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