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Habitat Requirements and Extinction Risks of Eastern North Pacific Right Whales

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HABITAT REQUIREMENTS AND EXTINCTION RISKS OF EASTERN NORTH PACIFIC RIGHT WHALES

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Cover photo: Right whale (*Eubalaena japonica)* sighted in the Bering Sea, Alaska, on 8 September 2004.
Photographer: H. Fearnbach (AFSC-NMML).

PREFACE

The two documents in this AFSC *Processed Report* were prepared to address questions about the habitat requirements and extinction risks facing northern right whales (*Eubalaena japonica*) in the eastern North Pacific. The first document, by Clapham et al., was completed and submitted to the National Marine Fisheries Service (NMFS) Alaska Regional Office (AKR) in August 2005. Its purpose was to scientifically evaluate possible habitat needs of North Pacific right whales as defined under the U.S. Endangered Species Act (ESA). In October 2000, NMFS was petitioned by the Center for Biological Diversity to designate critical habitat for North Pacific right whales. In February 2002, NMFS announced its decision that critical habitat could not be designated at that time because the essential biological requirements of the population were not sufficiently understood. However, in June 2005, a Federal judge found this reasoning invalid and ordered the agency to publish a proposed rule designating critical habitat by 28 October 2005. As a result of this order, the Clapham et al. document was created to assist in an assessment of which areas may represent critical habitat for right whales in the eastern North Pacific. The second document, by Shelden and Clapham, was completed and submitted to the NMFS-AKR in February 2006. As part of the process evaluating the status of northern right whales under the ESA and the recognition of North Pacific right whales as a species distinct from the populations in the North Atlantic and Southern Hemisphere, this document provided a scientific evaluation of the potential risks faced by the right whale population found in the eastern North Pacific.

Kim E. W. Shelden

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OVERVIEW OF BIOLOGY, HUNTING HISTORY AND PRESENT STATUS

The North Pacific right whale (*Eubalaena japonica*) is a member of the family *Balaenidae* and is closely related to the right whales that inhabit the North Atlantic and the Southern Hemisphere[1]. Right whales are large baleen whales which grow to lengths and weights exceeding 18 m and 100 tons, respectively. They are filter feeders whose prey consists exclusively of zooplankton (notably copepods). Right whales attain sexual maturity at an average age of 8-10 years, and females produce a single calf at intervals of 3-5 years (Kraus et al. 2001). Their life expectancy is unclear, but one female was believed to be at least 70 years old based on photo documentation over a 60-year period (Hamilton et al. 1998, Kenney 2002).

Right whales are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Kraus et al. 1986, Clapham et al. 2004). In the North Pacific, the feeding range is known to include the Gulf of Alaska, the Aleutian Islands, the Bering Sea and the Sea of Okhotsk. Although a general northward movement is evident in spring and summer, it is unclear whether the entire population undertakes a predictable seasonal migration, and the location of calving grounds remains completely unknown (Scarff 1986, 1991; Brownell et al. 2001; Clapham et al. 2004; Shelden et al. 2005). Further details of occurrence and distribution are provided below.

Worldwide, right whales were probably the first of the great whales to be hunted on a regular basis for commercial profit, beginning with the Basque fishery in the Bay of Biscay in the 11th century (Aguilar 1986). North Atlantic right whales were extensively depleted throughout their range and a remnant population in the eastern North Atlantic was all but

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[1]The taxonomic status of right whales worldwide has recently been revised in light of genetic analysis (see Rosenbaum et al. 2000, Gaines et al. 2005). Applying a phylogenetic species concept to molecular data separates right whales into three distinct species: *Eubalaena glacialis* (North Atlantic), *E. japonica* (North Pacific) and *E. australis* (Southern Hemisphere). The National Marine Fisheries Service formally recognized this distinction for the purpose of management in a final rule published in April 2003 (68 FR 17560), but subsequently determined that the issuance of this rule did not comply with the requirements of the Endangered Species Act (ESA), and thus rescinded it (70 FR 1830) prior to beginning the process anew. As of the time of writing, North Atlantic and North Pacific right whales are thus both officially considered to be "northern right whales" (*Balaena glacialis*) under the ESA; however, the latter are referred to here as *E. japonica* given the wide acceptance of this taxon in both the scientific literature and elsewhere (e.g., by the International Whaling Commission).

extirpated by whaling off Scotland and Iceland at the turn of the 20th century (Clapham et al. 1999).

In the North Pacific, whaling for right whales began in the Gulf of Alaska (known to whalers as the "Northwest Ground") in 1835 (Webb 1988). By 1849, right whales were sufficiently depleted in the eastern North Pacific such that many whalers turned their attention to newly discovered stocks of bowhead whales (*Balaena mysticetus*) in the Arctic. Right whales were extensively hunted in the western North Pacific in the latter half of the 19th century, and by 1900 were scarce throughout their range.

Right whales were protected worldwide in 1935 through a League of Nations agreement. However, because neither Japan nor the USSR signed this agreement both nations were theoretically free to continue hunting right whales until 1949, when the newly created International Whaling Commission endorsed this ban. Following this, a total of 23 North Pacific right whales were legally killed by Japan and the USSR under Article VIII of the International Convention for the Regulation of Whaling (1946), which permits the taking of whales for scientific research purposes. However, it is now known that the USSR illegally caught many right whales in the North Pacific (Doroshenko 2000, Brownell et al. 2001). In the eastern North Pacific, 372 right whales were killed by the Soviets between 1963 and 1967; of these, 251 were taken in the Gulf of Alaska south of Kodiak, and 121 in the southeastern Bering Sea. These takes devastated a population that, while undoubtedly small, may have been undergoing a slow recovery (Brownell et al. 2001)[2].

As a result of this historic and recent hunting, right whales in the North Pacific today are among the most endangered of all whales worldwide. Right whales were listed in 1970 following passage of the Endangered Species Conservation Act (ESCA) of 1969 and were automatically granted endangered status when the ESCA was repealed and replaced by the Endangered Species Act (ESA) of 1973. Right whales were also protected in U.S. waters under the Marine Mammal Protection Act of 1972. The National Marine Fisheries Service (NMFS) issued a Recovery Plan for the northern right whale in 1991 which covered both the North Atlantic and North Pacific species (NMFS 1991). Brownell et al. (2001) noted that there was no

[2]In the western North Pacific, 136 right whales are known to have been illegally caught in the Okhotsk Sea and the Kurile Islands in 1967 and 1971 (Doroshenko 2000).

evidence for exchange between the western and eastern Pacific, and that the two populations had different recovery histories; consequently, they argued that these stocks should be treated as separate for the purpose of management, a division which has been duly recognized by NMFS in the Alaska marine mammal stock assessment report document (Angliss and Lodge 2004).

In the western North Pacific (the Sea of Okhotsk and adjacent areas), current abundance is unknown but is probably in the low to mid-hundreds (Brownell et al. 2001). There is no estimate of abundance for the eastern North Pacific (Bering Sea, Aleutian Islands, and Gulf of Alaska), but sightings are rare; most biologists believe the current population is unlikely to exceed a hundred individuals and is probably much smaller. Prior to the illegal Soviet catches of the 1960s, an average of 25 whales were observed each year in the eastern North Pacific (Brownell et al. 2001); in contrast, the total number of records in the 35 years from 1965 to 1999 was only 82, or 2.3 whales per annum.

Since 1996, NMFS and other surveys (directed or otherwise) have detected small numbers of right whales in the southeastern Bering Sea, including an aggregation estimated at 24 animals in the summer of 2004. Photo-identification and genetic data have identified 17 individuals from the Bering Sea, and the high interannual resighting rate further reinforces the idea that this population is small. However, the number of animals using habitats other than the Bering Sea is not known.

CRITICAL HABITAT DESIGNATION

History

Critical habitat is defined under Section 7(a)(2) of the ESA as: “the specific areas within the geographical area occupied by the species, at the time it is listed... on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection.”

Critical habitat was designated for North Atlantic right whales in 1994. In October 2000, NMFS was petitioned by the Center for Biological Diversity to designate critical habitat for North Pacific right whales. In February 2002, NMFS announced its decision that critical habitat could not be designated at that time because the essential biological requirements of the population were not sufficiently understood. However, in June 2005, a Federal judge found this reasoning invalid and ordered the agency to publish a proposed rule designating critical habitat by 28th October 2005. As a result of this order, we here review information to assist in an assessment of which areas may represent critical habitat for right whales in the eastern North Pacific. Because the waters of the western North Pacific are not under U.S. jurisdiction, we do not consider critical habitat for the separate population in that region.

Review of Relevant Information

Critical habitat is defined based upon the existence of primary constituent elements (PCEs). These must be tangible, recognizable, and measurable features of the environment that are essential for the conservation of the species in question. We consider the PCEs involved with right whales to be their prey (large species of copepods), as detailed below.

In the following sections, we first review the designation of critical habitat for North Atlantic right whales, then summarize available information for the North Pacific regarding the distribution of right whales, their prey and the factors which promote the prey's abundance and aggregation. At various points in this document we apply knowledge gained from demographic and ecological investigations of the well-studied North Atlantic right whale to gain perspective on the behavior and habitat requirements of right whales in the North Pacific. Although as noted above these are widely regarded as separate species, they are very similar in their general biology and behavior, notably in the prey characteristics which determine their high-latitude distribution.

Basis of Critical Habitat Designation for North Atlantic Right Whales

As noted above, critical habitat for North Atlantic right whales was designated by a NMFS final rule published in June 1994 (59 FR 28793). The three areas for this designation were defined primarily using the distribution of right whales, although the final rule noted that the two feeding grounds identified as critical habitat (the Great South Channel and Cape Cod Bay) were characterized by abundant prey resources and by physical features which promoted biological productivity and/or the aggregation of copepods. Thus, the final rule recognized the concept of PCEs as based upon the best scientific information available at the time (Pace and Merrick 2005). The boundaries of critical habitat for the North Atlantic right whale were drawn to encompass 90% of the recorded sightings in the areas concerned.

NORTH PACIFIC RIGHT WHALE DISTRIBUTION

Here we describe the distribution of right whales in historical times as well as at the time the species was listed as endangered, and we consider whether the present range is likely to be significantly different from the latter. A listing of all 20th century records of North Pacific right whales was presented by Brownell et al. (2001), and those data were mapped by month (together with 19th century records) by Clapham et al. (2004). A detailed assessment of the features and areas important to right whales in the Bering Sea and Gulf of Alaska was recently reviewed by Shelden et al. (2005); that publication is of particular importance to our assessment here, and their findings are summarized later in this document.

Historical Distribution

Prior to the onset of commercial whaling in 1835, right whales were widely distributed across the North Pacific (Scarff 1986, Clapham et al. 2004, Shelden et al. 2005). In the eastern North Pacific, the waters adjacent to the Aleutian Islands and much of the Bering Sea below 60^{o}N were major feeding grounds during spring, summer, and autumn, as was virtually the entire Gulf of Alaska. Neither the historical nor present-day breeding/calving grounds for this population have ever been identified. Historical distribution as derived from whaling ship logbook abstracts by Maury (1853 *et seq.*) and Townsend (1935) is given in Clapham et al. (2004) and Shelden et al. (2005).

Distribution at the Time of Listing and at Present Time

As noted by Clapham et al. (2004), the current range of right whales in the North Pacific is likely considerably diminished relative to the situation during the peak period of whaling in the 19th century. However, too little sighting effort has been expended to delineate which (if any) areas have been abandoned, or not yet rediscovered, by the extant population.

Northern right whales were listed under the ESA in 1973, and under the precursor to this Act (the ESCA) in 1970. Thus, for the purpose of this analysis the "time of listing" is considered to be 1970. This was after the occurrence of the large illegal Soviet catches in the Bering Sea and Gulf of Alaska (1963-67).

Sightings of right whales since World War II are shown in Figure 1 (1941-68) and Figure 2 (1979-2004); with the exception of a few Japanese sightings for which exact positions do not exist, there are no records from 1969 to 1978, and thus none from the actual year of listing. However, there is no reason to suspect that the animals that remain alive today are inhabiting a substantially different range than whales alive during the time of the Soviet catches; indeed, given the longevity of this species, it is likely that some of the individuals who survived that whaling episode remain extant now. Consequently, recent habitat use is unlikely to be different from that at or before the time of listing. As a result, all post-war sightings data have been combined (see Figure 3) for subsequent analysis herein.

Both the southeastern Bering Sea and the western Gulf of Alaska (shelf and slope waters south of Kodiak) have been the focus of many sightings (as well as the illegal Soviet catches) in recent decades. Recent acoustic detections of right whale calls have been made in both areas (Munger et al. 2003, Mellinger et al. 2004) using autonomous recording packages deployed for extended periods; these data are shown in Figure 2 (as star symbols over the respective acoustic sighting). They confirm the presence of right whales in the southeastern Bering Sea from May into November; records from the Gulf of Alaska are somewhat more sporadic, but include detections in August and September.

Seasonal movements are evident in the 20th century data, with a general northward migration into the Gulf of Alaska and Bering Sea in spring and summer, and a gradual movement away from these areas in autumn (Clapham et al. 2004, Shelden et al. 2005). There are very few records of right whales anywhere in the North Pacific in winter.

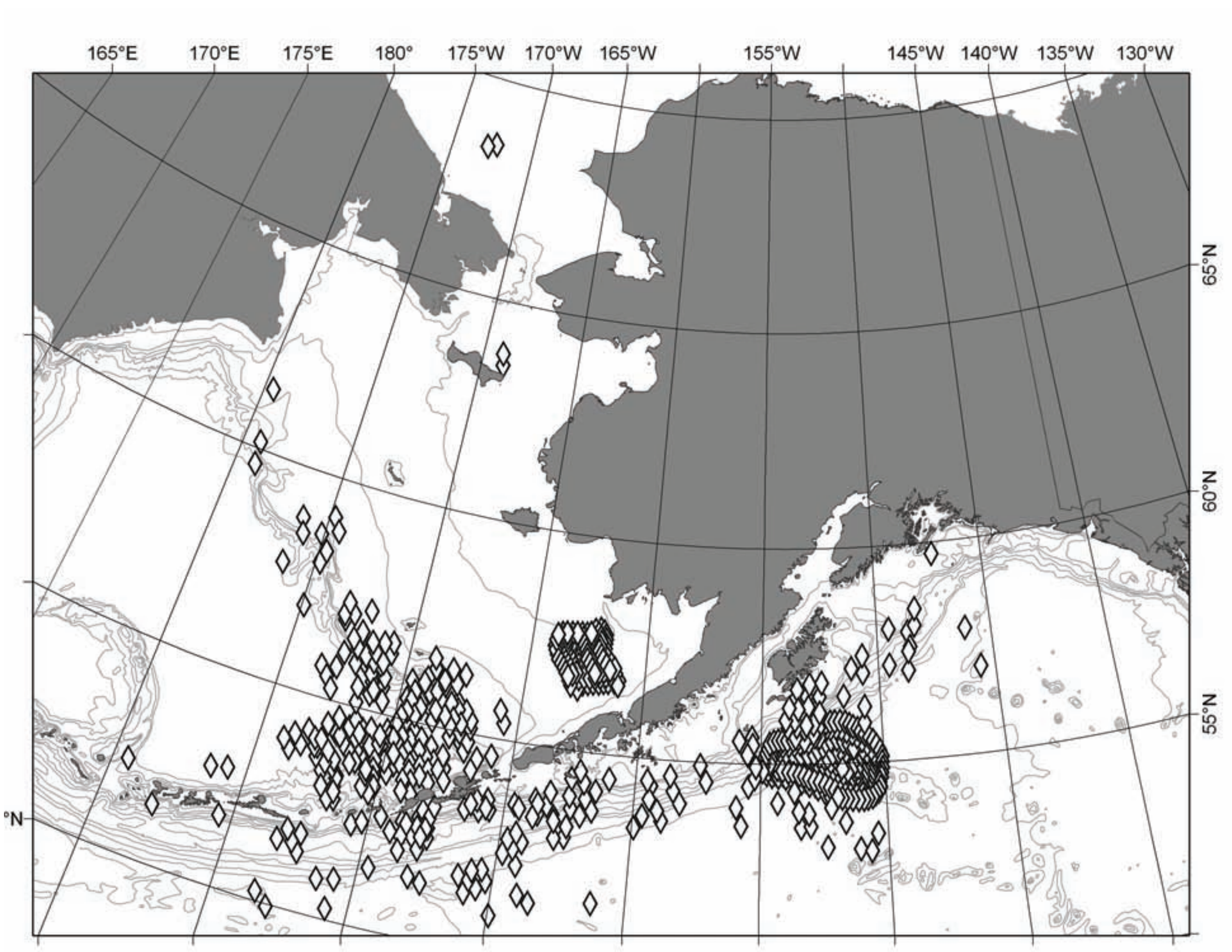

Figure 1. Japanese sighting data (1941-68) and Soviet illegal whaling data (1963-67) of eastern North Pacific right whales.

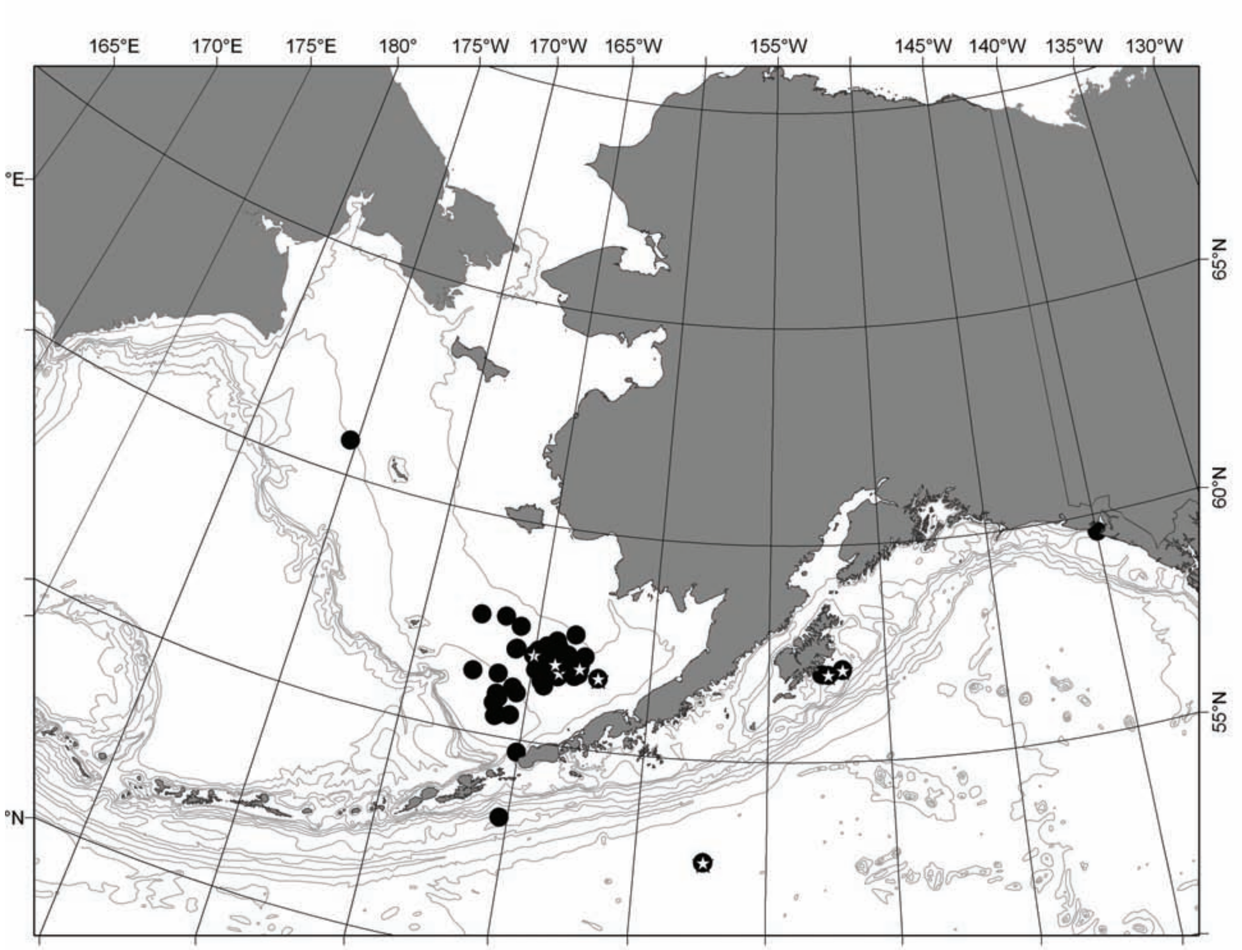

Figure 2. Research sightings and acoustic detections of eastern North Pacific right whales (1979-2004). Star symbols represent sites where right whale calls were recorded using autonomous recording packages (ARPs) or sonobuoys.

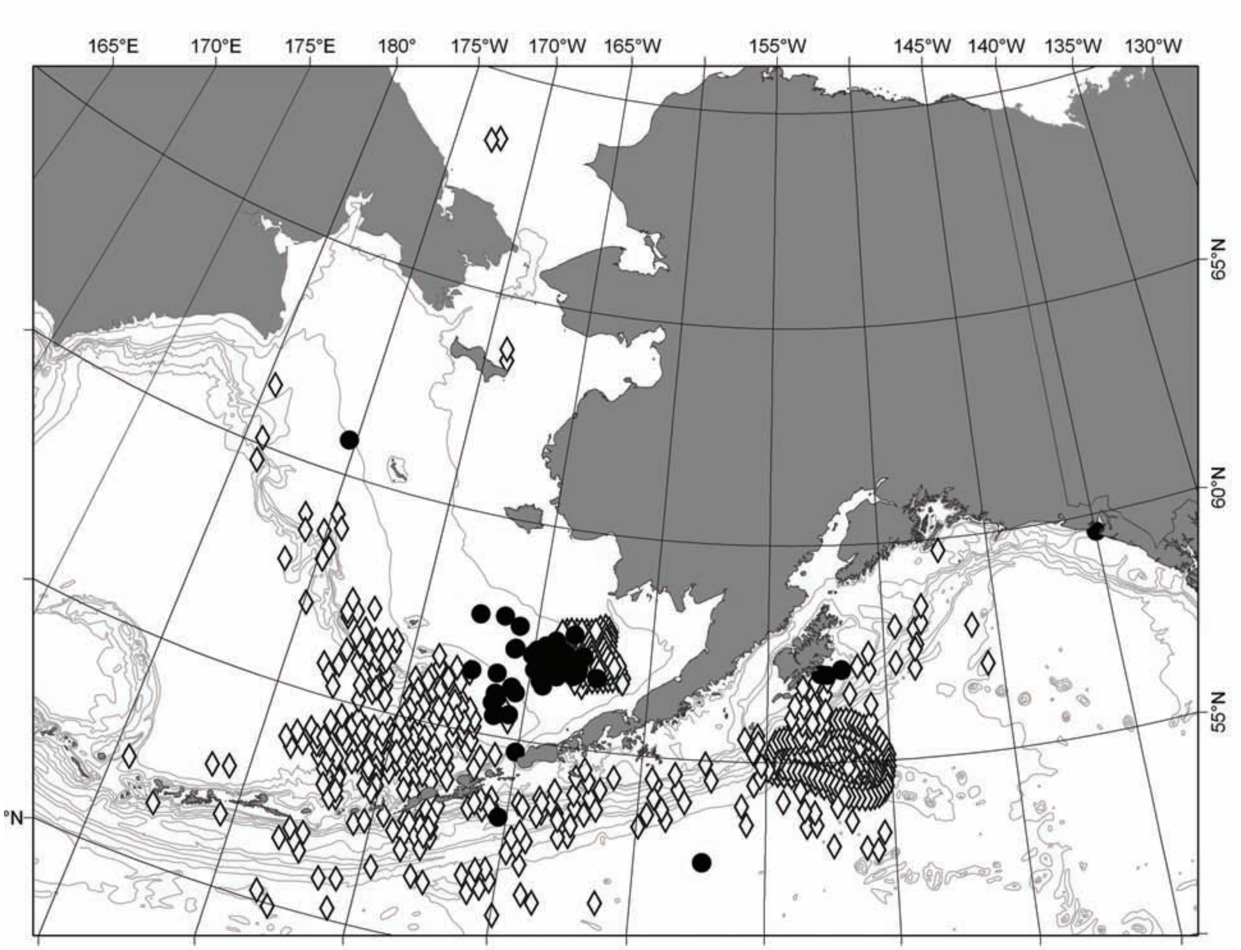

Figure 3. Combined data set of eastern North Pacific right whale encounters (1941-2004) for the purpose of analysis.

Distribution Overview

In general, the majority of North Pacific right whale sightings (historically and in recent times) have occurred from about 40ºN to 60ºN. There are historical records from north of 60ºN, but these are rare and are likely to be misidentified bowhead whales. Right whales have on rare occasions been recorded off California and Mexico, as well as off Hawaii. However, as noted by Brownell et al. (2001), there is no evidence that either Hawaii or the West Coast of North America from Washington State to Baja California were ever important habitats for right whales;

given the amount of whaling effort as well as the human population density in these regions, it is highly unlikely that substantial concentrations of right whales would have passed unnoticed. Furthermore, there is no archaeological evidence from the U.S. West Coast suggesting that right whales were the target of local Native hunts. Consequently, the few records from this region are considered to represent vagrants.

Recent data indicate that while the present range of the remnant population is likely reduced relative to pre-whaling times, the southeastern Bering Sea and western Gulf of Alaska (south of Kodiak) remain important and commonly utilized habitats. Consequently, they are the focus of the critical habitat discussion presented here.

PREY AND HABITAT CHARACTERISTICS

Shelden et al. (2005) reviewed prey and habitat characteristics of North Pacific right whales. They noted that habitat selection is often associated with features that influence abundance and availability of a predator's prey. Right whales in the North Pacific are known to prey upon a variety of zooplankton species including *Calanus marshallae, Euphausia pacifica, Metridia* spp., and copepods of the genus *Neocalanus* (Omura 1986). *C. marshallae* was only recently recognized as a species distinct from *C. glacialis* (Frost 1974), and the species names are used interchangeably in the literature. Both of these species were once referred to as *C. finmarchicus*, the principal prey of North Atlantic right whales (Baumgartner and Mate 2003; Baumgartner et al. 2003a,b). North Atlantic right whales require dense prey aggregations (minimum prey patch concentrations >3,000 copepods m^{-3}) to forage efficiently (Baumgartner and Mate 2003); densities exceeding 1,000,000 organisms m^{-3} have been recorded next to feeding right whales in Cape Cod Bay, Massachusetts (C. Mayo, Center for Coastal Studies, unpublished data). Given this, and the ecological similarity of right whales worldwide, there is little doubt that availability of suitably dense prey also greatly influences the distribution of the small North Pacific population on their feeding grounds in the southeastern Bering Sea and Gulf of Alaska.

Southeastern Bering Sea Slope Waters

The Bering Sea slope is a very productive zone, sometimes referred to as the 'Greenbelt', where annual primary production can exceed that on the adjacent shelf and basin by 60% and 270%, respectively (Springer et al. 1996). Physical processes at the shelf edge, such as intensive tidal mixing, eddies and up-canyon flow, bring nutrients to the surface thereby supporting enhanced productivity and elevated biomass of phytoplankton, zooplankton, and fish. This elevated productivity appears to influence whale distribution as well. For example, fin whales aggregate to feed along the Bering Sea slope, with densities an order of magnitude higher than on the adjacent middle-shelf (Moore et al. 2002). Recent studies of this dynamic habitat reveal the importance of cyclonic (anti-clockwise) and anticyclonic (clockwise) eddies to nutrient transport and patterns of meso-scale productivity (Okkonen 2001, Mizobata et al. 2002). These features are roughly 100-150 km in diameter and can pump nutrients to the surface from depths of 100 to 500 m. Specifically, very high chlorophyll α concentrations develop in the center of cyclonic and around the periphery of anticyclonic eddies, features that typically form at the intersection of the slope with the eastern Aleutian Islands and propagate northwestward along the Bering Sea slope current (Okkonen 2001, Mizobata et al. 2002). In the North Atlantic, right whales were associated with thermal fronts (Brown and Winn 1989), areas of upwelling along the continental shelf, and at least one satellite-tagged right whale fed along the edge of a warm-core eddy (Mate et al. 1997). Western North Pacific right whales have also been observed in association with oceanic frontal zones that produce eddies southeast of Hokkaido Island, Japan, and southeast of Cape Patience (Mys Terpeniya), Sakhalin Island, in the Okhotsk Sea (Omura et al. 1969). Whether or not the Bering Slope Current, or eddies shed from it, support production or entrain right whale prey is unknown.

From August to October in 1955 and 1956, Soviet scientists observed aggregations of *Calanus* between the Pribilof Islands and the Aleutian Islands (around 170ºW) that were identified as *C. finmarchicus*, though, as mentioned above, were probably *C. marshallae* (Klumov 1963). Flint et al. (2002) also report high concentrations of *C. marshallae* at frontal zones near the Pribilof Islands, with especially high biomass noted for the subthermohaline layer. This oceanographic front effectively separates slope and outer shelf *Neocalanus* spp. from the inshore middle shelf community of *C. marshallae* (Vidal and Smith 1986). Right whales were found on both sides of this frontal zone (that coincides with the shelf break at 170 m) during both the 19th and 20th centuries. This is similar to the habitat described by Baumgartner et al. (2003a) for right whales feeding in the North Atlantic. Six right whales that were caught under scientific permit in late July-early August 1962-63 in Bering Sea slope waters had exclusively consumed *Neocalanus cristatus* (*Calanus cristatus*: Omura et al. 1969). Although oceanic species such as *Neocalanus* usually enter diapause and migrate to depths greater than 200 m by late summer in the slope waters of the Bering Sea (Vidal and Smith 1986), right whales may still be able to utilize these resources by targeting regions where the bottom mixed layer forces the zooplankton into shallower, discrete layers (e.g., Baumgartner et al. 2003a).

Southeastern Bering Sea Middle-Shelf Waters

The southeastern Bering Sea shelf has been the focus of intense oceanographic study since the late 1970s (e.g., Schumacher et al. 1979; Coachman 1986; Napp et al. 2000; Hunt et al. 2002a,b), largely due to the considerable commercial fishing effort in the area (National Research Council 1996). Coachman (1986) described the now well-established hydrographic domains of the inner-, middle- and outer-shelf, separated by a front or transition zone at roughly the 50 m (inner front) and 100 m (outer front) isobaths. During the 1990s, research focused on these domains demonstrated dynamic advection of nutrient-rich Bering slope water onto the shelf in both winter and summer, via eddies, meanders and up-canyon flow (Schumacher and Stabeno 1998, Stabeno and Hunt 2002). These intrusions of nutrient-rich water, physical factors related to water column stratification, and long summer day length results in a very productive food web over the southeastern Bering Sea shelf (e.g., Livingston et al.1999, Napp et al. 2002, Coyle and Pinchuk 2002, Schumacher et al. 2003). Specifically, copepod species upon which right whales feed (e.g., *C. marshallae*, *Pseudocalanus* spp. and *Neocalanus* spp.) are among the most abundant of the zooplankton sampled over the middle shelf (Cooney and Coyle 1982, Smith and Vidal 1986). Small, dense patches (to > 500 mg/m^{-3}) of euphausiids (*Thysanoessa raschii, T. inermis*), potential right whale prey, have also been reported for waters near the southeastern Bering Sea inner front (Coyle and Pinchuk 2002).

Zooplankton sampled near right whales seen in the southeastern Bering Sea in July 1997 included *C. marshallae*, *Pseudocalanus newmani*, and *Acartia longiremis* (Tynan 1998). *C. marshallae* was the dominant copepod found in these samples as well as in samples collected near right whales in the same region in 1999 (Tynan et al. 2001). *Calanus marshallae* is the only "large" calanoid species found over the southeastern Bering Sea middle shelf (Cooney and Coyle 1982, Smith and Vidal 1986). Concentrations of copepods were significantly higher in 1994-98 than in 1980-81 by at least an order of magnitude (Napp et al. 2002) and Tynan et al. (2001) suggest that this increased production may explain the presence of right whales in middle shelf waters. However, at least three right whales were observed in 1985 in the same location as the middle shelf sightings reported in the late 1990s (Goddard and Rugh 1998), and right whales have been present in middle shelf waters during all the time periods reviewed within this document. Therefore, the middle shelf is not a new habitat for right whales and consumption of *C. marshallae* does not constitute a change in prey selection.

Eastern Aleutian Islands

The area around the eastern Aleutians is an oceanographically dynamic zone. The primary currents run parallel to the coast and include the Alaska Coastal Current (ACC), the Alaskan Stream (AS), the Aleutian North Slope Current and the Bering Sea Current. The ACC is dominated by freshwater discharge and flows southwestward between 20 and 50 km of shore along the Alaska Peninsula and Aleutian archipelago, turning northward at passes between Unimak and Samalga Island (Royer et al. 1979, Ladd et al. 2005). The AS also flows southwestward along the shelf break, approaching the archipelago as the shelf narrows west of Samalga Pass. Both the Aleutian North Slope Current and the Bering Sea Current flow eastward, north of the islands, the latter continuing northward. Flow through the passes of the eastern and central Aleutian Islands was the focus of an interdisciplinary study in 2001-02 (e.g., Ladd et al. 2005, Stabeno et al. 2005). Although right whales were not seen during recent research cruises in this area (Sinclair et al. 2005), results indicate the eastern Aleutians are dynamic and productive, with dense patches of both copepod and euphausiid zooplankton reported within and at the margins of the passes (Coyle 2005). The importance of such passes as a source of *Neocalanus* spp. has been documented for western North Pacific right whales taken in waters adjacent to the Kuril Islands, Russia (Klumov 1962).

Gulf of Alaska

The central Gulf of Alaska is dominated by the Alaskan Gyre, a cyclonic feature that is demarcated to the south by the eastward flowing North Pacific Current and to the north by the AS and ACC, which flow westward near the shelf break. The bottom topography of this region is rugged and includes seamounts, ridges, and submarine canyons along with the abyssal plain. Strong semi-diurnal tides and current flow generate numerous eddies and meanders (Okkonen et al. 2001) that influence the distribution of zooplankton.

Copepods are the dominant taxa of mesozooplankton found in the Gulf of Alaska and are patchily distributed across a wide variety of water depths. Three large herbivorous species comprise more than 70% of the biomass: *N. cristatus*, *N. plumchrus*, and *Eucalanus bungii* (Cooney 1986, 1987). In northern Gulf of Alaska shelf waters, the late winter and spring zooplankton is dominated by calanoid copepods (*Neocalanus* spp.), with a production peak in May—a cycle that appears resistant to environmental variability associated with El Niño/Southern Oscillation (ENSO) events (Coyle and Pinchuk 2003). In oceanic waters (50ºN, 145ºW), *N. plumchrus* dominate (Miller and Nielsen 1988, Miller and Clemons 1988) and have demonstrated dramatic shifts in the timing of annual peak biomass from early May to late July (Mackas et al. 1998). From late summer through autumn, *N. plumchrus* migrate to deep water ranging from 200 to 2000 m depending on location within the Gulf of Alaska (Mackas et al. 1998). The three right whales caught under scientific permit on 22 August 1961 south of Kodiak Island had all consumed *N. plumchrus* (*Calanus plumchrus*: Omura et al. 1969), potentially by targeting areas where adult copepods remained above 200 m (e.g., Baumgartner et al. 2003a).

CRITICAL HABITAT: ALTERNATIVES FOR DISCUSSION

Following the process used by NMFS and other agencies for other taxa, we address below questions concerning the area occupied by North Pacific right whales (at the time of listing), and the physical and biological features that may be essential to the species' conservation. We then present the results of distribution analyses as a basis for subsequent discussions of critical habitat.

What is the Area Occupied by the Species?

As noted above, the overall range of the North Pacific right whale is from about 40ºN to 60ºN. Whether right whales migrate south of 40ºN in winter is not clear. Based upon our review, the general regions which should be considered in any critical habitat analysis for the eastern North Pacific are the western Gulf of Alaska (the shelf and slope waters south of Kodiak) and the southeastern Bering Sea; portions of these regions clearly represent regularly utilized feeding grounds for the remaining population, and were also important at and prior to the time of listing. However, because of recent survey effort in the southeastern Bering Sea, our knowledge of right whales there is much better than in the Gulf of Alaska.

What are the Physical and Biological Features Essential to Conservation?

First, we note that it is impossible to describe critical habitat for North Pacific right whale breeding/calving areas because the past and present location of these grounds remains completely unknown. Accordingly, this assessment focuses exclusively on the known feeding grounds.

For the purpose of this assessment, we consider PCEs for North Pacific right whale critical habitat to be the species of large copepods on which they are known or believed to feed. In particular, these include but are not necessarily limited to: *C. marshallae, N. cristatus* and *N. plumchris.* In addition, *T. raschii* is a copepod whose very large size, high lipid content and occurrence in the region likely makes it a preferred prey item for right whales (J. Napp, Alaska

Fisheries Science Center, pers. comm.) Accordingly, critical habitat is defined as areas in which the physical and biological oceanography combines to promote high productivity and aggregation of large copepods into patches of sufficient density for right whales, and these features are presumed to be essential for the conservation of the population.

As noted above, right whales require - and are very efficient at locating - copepod patches of very high density, and these are typically small and widely scattered in space and time. Because of this constraint, typical zooplankton sampling is too broad-scale in nature to detect patches of these densities, and directed studies employing fine-scale sampling cued by the presence of feeding right whales are the only means of doing this. Accordingly, there may be no obvious correlation between the abundance and distribution of copepods (as measured by broad-scale oceanographic sampling) and the distribution of right whales (M. Baumgartner, Woods Hole Oceanographic Institution, in prep.).

In light of this, we must rely upon the whales themselves to indicate the location of important feeding areas in the North Pacific. Therefore, in the absence of the appropriate data on the PCEs themselves, the distribution of right whales is used here as a proxy for the existence of suitably dense copepod patches and thus to help identify possible candidates for critical habitat. More specifically, we have focused on areas in which right whales have been observed to aggregate consistently rather than where they have appeared singly or in low numbers, or in transit. In some cases (such as portions of the southeastern Bering Sea), we have been able to substantiate this assumption with observations of feeding behavior, or records of stomach contents of dead whales. These assumptions underlie the recommendations given below. It is not clear whether the area immediately south of the Aleutian Islands represents a feeding ground, very little survey effort has occurred there in recent years.

ASSESSMENTS BY AREA

The entire data set on right whale distribution summarized above represents numerous sightings spread over various parts of the southeastern Bering Sea and Gulf of Alaska; some of these sightings are clearly concentrated, while others are more scattered outside the areas of core distribution. In order to identify areas that may be of particular importance to right whales as feeding grounds (referred to here as "areas of concentration"), we adopted the following approach in our analysis of the data.

In the first step, data sets containing right whale encounters made as close as possible to the time of ESA listing (1972) were plotted (Fig. 1). For the southeastern Bering Sea, this included Japanese sighting data (1941-68) and Soviet illegal whaling data (1964 and 1967). For the Gulf of Alaska, this included Japanese sighting data (1941-68) and Soviet illegal whaling data (1963-66)[3]. Next, all observations in the post-listing period were plotted, including research sightings and acoustic detections since 1982 and 1979, respectively (Fig. 2). As noted above, since there was no marked difference in general distribution between the two periods, the entire combined data set (1941-2004) was used for the purpose of analysis (Fig. 3).

In the second step, a density plot of these sightings was generated (Fig. 4). To create this plot, a circular search area was applied to each region (in this case 0.05 mile cells). The search area, set at 1 mile, determined the distance to search for right whale encounters in order to calculate the density value for these 0.05 mile cells. We used a kernel density calculation which weighs the encounters lying near the center of the cell's search area more heavily than those lying near the edges; this provided a smoother distribution of values compared to using a simple density calculation (though visually the two techniques yielded similar results when mapped). This technique provided a density surface for the right whale encounters, showing where they were more highly concentrated in the southeastern Bering Sea, along the Aleutian Islands and in the Gulf of Alaska. In the final step of the analysis, we focused on regions spreading from the area of highest density, excluding low-density patches or patches which were peripheral to the core distribution (unless stated otherwise below).

[3]The locations of all Soviet catches are taken directly from the unnumbered figure on page 100 of Doroshenko (2000). Since individual catch records are no longer available, the accuracy of Doroshenko's plots are unclear. This is an important caveat, since these catch locations drive much of the density plots generated in the present document. While the plotted locations of the Soviet catches are certainly consistent with what is known of the distribution of North Pacific right whales in the Bering Sea and Gulf of Alaska, neither the accuracy nor precision of the data on which they are based have been established.

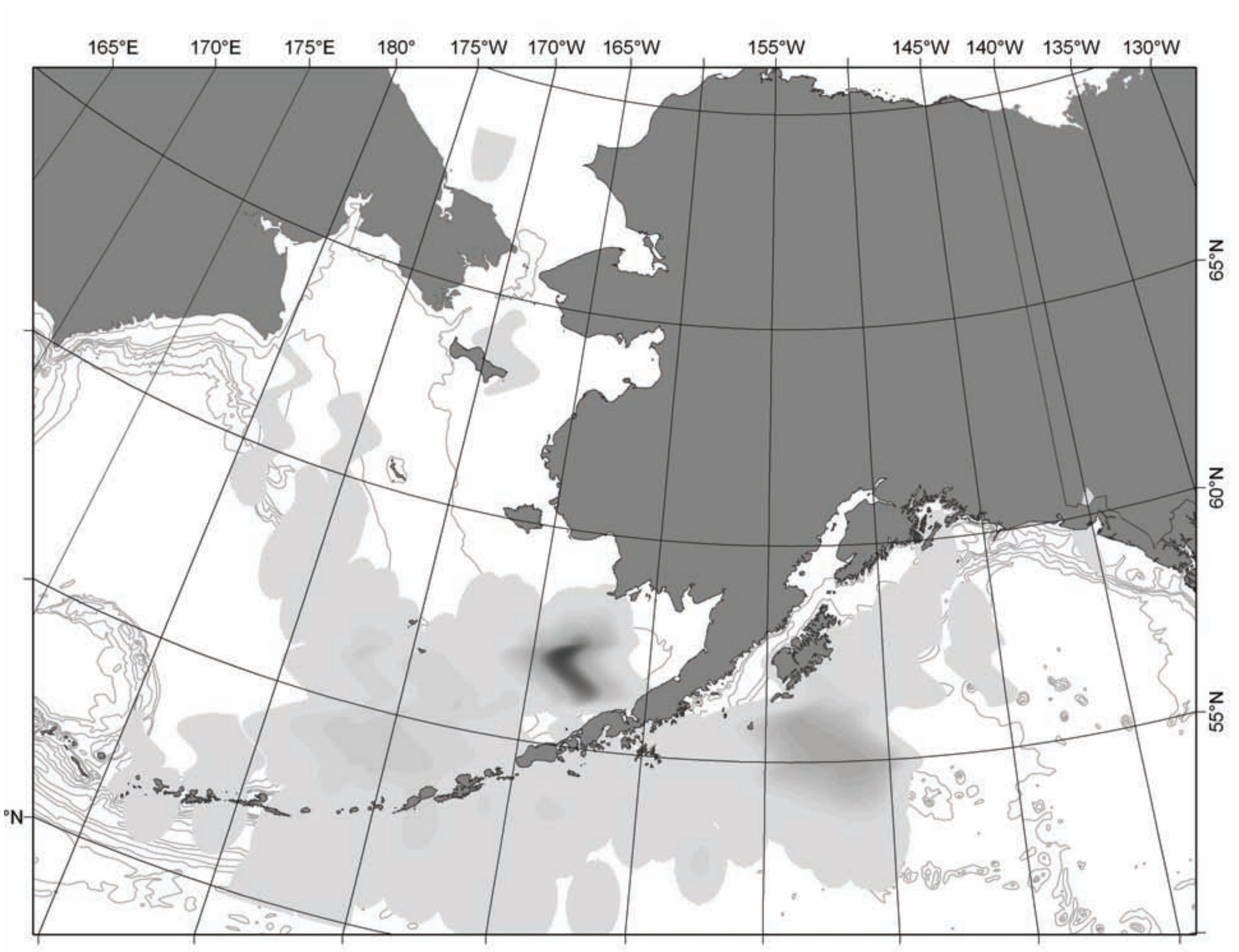

Figure 4. Density plot of eastern North Pacific right whale encounters (1941-2004).

Assessment: Southeastern Bering Sea

The area of densest concentration of right whales in the southeastern Bering Sea (Fig. 4) spreads roughly east from 173°W longitude to 161°W longitude and south from 58°N latitude. Right whale encounters totaled 474 within this area, out of the 504 encounters north of the Aleutian Islands. This represents 91% of all encounters. Comparing pre-listing to post-listing totals yields similar results: 94% of pre-listing sightings (291 of 320) and 99% of post-listing encounters (183 of 184) occur within this region of densest concentration.

Assessment: Gulf of Alaska

The area of densest concentration of right whales in the Gulf of Alaska (Fig. 4) spreads roughly east from 170^{o}W longitude to 150^{o}W longitude and south to 52^{o}N latitude. Right whale encounters within this area of concentration totaled 385 of the 426 encounters in the Gulf. This represents 90% of all encounters. Comparing pre-listing to post-listing totals yields similar results: 90% of pre-listing sightings (373 of 413) and 92% of post-listing encounters (12 of 13) occur within this region of densest concentration.

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ASSESSMENT OF EXTINCTION RISK FOR NORTHERN RIGHT WHALES IN THE EASTERN NORTH PACIFIC

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BACKGROUND

The northern right whale in the eastern North Pacific is a member of the family Balaenidae and is closely related to the right whales that inhabit the North Atlantic and the Southern Hemisphere. The taxonomic status of right whales worldwide has recently been revised in light of genetic analysis (see Rosenbaum et al. 2000, Gaines et al. 2005). Applying a phylogenetic species concept to molecular data separates right whales into three distinct species: *Eubalaena glacialis* (North Atlantic), *E. japonica* (North Pacific), and *E. australis* (Southern Hemisphere). Presently, North Atlantic and North Pacific right whales are both officially considered to be "northern right whales" (*Balaena glacialis*) under the Endangered Species Act (ESA); however, the National Marine Fisheries Service (NMFS) has accepted the new taxon, *E. japonica*, for the purpose of managing the eastern North Pacific stock under the Marine Mammal Protection Act (MMPA).

This document is a compilation of biological data and a description of past, present, and likely future threats to the eastern North Pacific right whale. It does not represent a decision by NMFS on whether this taxon should be proposed for listing as threatened or endangered under the ESA. That decision will be made by NMFS after reviewing this document, other relevant biological and threat data not included herein, and all relevant laws, regulation and policies. The results of the decision will be posted on the NMFS web site and announced in the *Federal Register*.

In comparison to most other marine mammal stocks, the eastern North Pacific right whale population is extremely small (Angliss and Lodge 2004, Carretta et al. 2005) possibly only in the tens. From sighting survey data, Miyashita and Kato (1998) provided a population estimate of 900 whales for the western North Pacific; however the associated confidence limits were large (404 to 2,108) and it is likely that this number will be revised. Given this, and levels of recent sightings in the western North Pacific (Brownell et al. 2001), it is clear that this population is significantly larger than that in the eastern North Pacific. There are no data on trends in abundance, survival or fecundity for either the eastern or western population. The historic population size is unknown but their distribution ranged across pelagic waters of the North Pacific from the northern waters of the Bering Sea, Gulf of Alaska, and Okhotsk Sea to as far south as Hawaii (Clapham et al. 2004). Currently, no data are available (e.g., tagging, genetics, photographs) that would indicate these two populations intermingle during the winter, let alone where these animals spend the winter.

The current size of the eastern North Pacific right whale population is the direct result of overutilization for commercial purposes. By 1960, North Pacific right whales were showing signs of recovery following the 1935 prohibition on catches (Brownell et al. 2001). However, Soviet pelagic whalers illegally killed at least 508 right whales in the North Pacific; this total included at least 251 animals from the Gulf of Alaska and 121 in the southeastern Bering Sea from 1963 to 1967 (Doroshenko 2000). The portion of the population found during summer in the Bering Sea has been studied since 1997 and as of 2004 a total of 23 individuals have been identified from genotyping of biopsy samples, 16 males and 7 females ((Wade et al. 2006). This includes two male calves accompanied by females that shared at least one allele for each microsatellite marker, as well as sharing a mitochondrial haplotype (Wade et al. 2006). In 2004, the number of females detected in this region rose from one whale biopsied in 2002 to seven, including the female from 2002 (Wade et al. 2006).

POTENTIAL RISK FACTORS

Oil Spills

Probably the most dramatic source of habitat degradation for baleen whales is from spilled oil. Data on the effects of oil pollution on cetaceans are inconclusive, and the large baleen whales appear to be generally unaffected by oil *per se* (Geraci 1990, Loughlin 1994). General concerns with regard to oil pollution are ingestion of contaminated prey, potential irritation of skin and eyes, inhalation of toxic fumes, and abandonment of polluted feeding habitat (Geraci and St. Aubin 1990, Geraci 1990). Although there is currently no oil exploration underway in known right whale habitat in offshore areas of the Bering Sea or Gulf of Alaska, the possibility remains that there will be proposed lease sales in these areas in the future. In the last week of July 2005, Congress passed a comprehensive national energy policy bill which included a provision for an inventory of offshore oil and gas resources of the entire country. This provision calls for offshore seismic surveys to be conducted along the Nation's coasts, even in areas where the Congressional moratorium bans offshore drilling and areas like Bristol Bay, that are (at least for now) withdrawn by the President. A call for comments on the new 5-year Outer Continental Shelf Oil and Gas Leasing Program was issued on 24 August 2005 by the Minerals Management Service (MMS) (70 FR 49669-49678). This begins the 2–year review process that will result in the 2007–2012 Offshore Leasing Program. Although Bristol Bay is currently withdrawn from the lease until 2012, other areas where right whales have been observed (e.g., along the Aleutians, southeastern Bering Sea, Kodiak Island, and Gulf of Alaska) are included in the planning area boundary. Furthermore, much oil is transported by ship along the western North American coast through areas that have been used by right whales in the past, and where they are occasionally seen today (Brownell et al. 2001).

Noise

It is believed that the human contribution to ambient noise in the ocean has increased dramatically within the past 50 years (Urick 1986, NRC 1994). The effect on critical behaviors (foraging, mating, nursing etc.) of noise pollution from low frequency sounds generated by shipping, oil and gas development, and military activities is unclear, although various observations suggest that marine mammals can habituate to even quite high levels of sound (Geraci and St. Aubin, 1990). However, as these activities become more ubiquitous their cumulative effect may seriously impact how effectively these whales forage, navigate and communicate (Croll et al. 2001). Mysticete whales, which include bowhead (*Balaena mysticetus*), humpback (*Megaptera novaeangliae*) and right whales, use low frequency sounds for contact calls, as well as during mating displays and migration (Tyack 1981, Clark 1982, Clark and Ellison 1989, Silber 1986). Gray whales (*Eschrichtius robustus*) temporarily abandoned a calving lagoon in Baja California when vessel traffic increased, returning only after traffic diminished (Gard 1974, Bryant et al. 1984). Humpback whale mothers and calves avoid waters where intense recreational vessel activities occur (Glockner-Ferrari and Ferrari 1990, Salden 1988). Humpback whales responded to loud noise from pile driving or seismic activity with avoidance, increased speed of travel or decreased abundance (McCauley et al. 2000, Wursig et al. 2000). Playback experiments on gray and bowhead whales indicate that whales will actively avoid a very loud sound source (Malme et al. 1984). With so few right whales observed in the North Pacific, any human activities that significantly curtail the ability of these whales to find one another and forage efficiently will likely diminish their reproductive success and population productivity.

Contaminants

An additional source of possible habitat degradation for right whales is contaminants. The impact of pollutants on right whales is debatable. The subject is reviewed by O'Shea and Brownell (1994), who conclude that there is currently no evidence for significant contaminant-related problems in baleen whales. Although much more research needs to be conducted, existing data on mysticetes support the view that the lower trophic levels at which these animals feed should result in smaller contaminant burdens than would be expected in many odontocetes, which typically show burdens that differ from those of baleen whales by an order of magnitude (O'Shea and Brownell 1994). A recent study by Switgard and Shirley (2004) demonstrated that copepods could potentially concentrate and transfer polyaromatic compounds, such as those found in weathered Alaska North Slope crude oil, to higher trophic levels but did not assess at what magnitude. There is currently no persuasive evidence for any of the problems that have been linked to excessive contaminant burdens in some terrestrial mammals, such as reproductive failure or immune system suppression (e.g., mink, *Mustela vison*; Kihlström et al. 1992). However, the manner in which pollutants negatively impact animals is complex and difficult to study, particularly in taxa (such as large whales) for which many of the key variables and pathways are unknown (Aguilar 1987, O'Shea and Brownell 1994). A more plausible potential problem is that of transgenerational accumulation (Colborn and Smolen 1996), but this remains unstudied in right whales or any other cetacean.

Whale Watching

There are no known recreational or educational uses of North Pacific right whales. However, if a right whale is seen in a highly accessible area, such as near the coast of California, there could be a large response from whale watching operations trying to get people to see the whale. Whale watching should be kept within current Federal guidelines to the point that a whale in this situation would not be disturbed or driven from its intended travel direction. A 500-yard minimum distance regulation for right whales is in effect for vessels in the North Atlantic (revised in 1997 from the 100-yard guideline generally recommended by NMFS, 62 FR 6729).

Scientific Research

Scientific studies of right whales may involve close approaches to the animals for the purpose of obtaining photographs, genetic samples, or tagging. These activities are controlled by permits in both U.S. and Canadian waters, and potential negative impact on the animals is considered in the permitting process. While the potential for disturbance or harassment exists for scientific research, the overall impact from this activity on North Pacific right whales is likely minimal, and the information gained in this research plays a critical role in helping manage and recover the species.

Disease

Disease was one of five explanations considered by a NMFS workshop held in 2001 (Reeves et al. 2001) for the decline in North Atlantic right whales, and the information and caveats summarized there are likely applicable to other balaenids. As noted earlier in this plan, nothing is known about disease in, or predation on, North Pacific right whales. Unlike what has been seen in some dolphins and pinnipeds, there have been no recorded epizootics in baleen whales. The two known cases of mass mortalities involved humpback whales (*Megaptera novaeangliae*) in the Gulf of Maine in 1987-88 and in 2003, and a multiple-species event in the same region in 2005. Geraci et al. (1989) provide strong evidence that, in the 1987-88 case, these deaths resulted from consumption of mackerel whose livers contained high levels of saxitoxin, a naturally occurring red-tide toxin originating with the dinoflagellate *Alexandrium*. It has been suggested that red tide phenomena are somehow related to increased freshwater runoff from coastal development, a link that has led some observers to suggest that such events may become more common among marine mammals. However, despite the occurrence of high levels of *Alexandrium* in at least one North Atlantic right whale habitat (the Bay of Fundy), there is currently no evidence linking red tide toxins to deaths or chronic health problems in right whales anywhere.

It is not known whether right whales suffer from stress-induced bacterial infections similar to those observed in captive cetaceans (Buck et al. 1987). Studies of bowhead whales killed in the Alaskan Native hunts have provided information on bacterial, mycotic and viral infections but not the level to which they contribute to mortality and morbidity (Philo et al. 1993). Skin lesions, found on all the hunted bowhead whales, were not malignant or contagious. However, potentially pathogenic microorganisms inhabit these lesions and may contribute to epidermal necrosis and the spread of disease (Shotts et al. 1990). Exposure of these roughened areas of skin to environmental contaminants, such as petroleum products, could have significant effects (Albert 1981, Shotts et al. 1990), although Bratton et al. (1993) concluded that such encounters were not likely to be hazardous. The occurrence of skin lesions on North Atlantic right whales has been documented in recent years, with an apparent increase in frequency culminating in a peak in 1995 when they were observed on 24% of photographed individuals (Pettis et al. 2004). The origins and significance of these lesions are unknown, and further research is required to determine whether they represent a topical or systemic health problem for the affected animals. The system developed by Pettis et al. (2004) to assess health and body condition of North Atlantic right whales is currently being applied to photographs of North Pacific right whales.

Predation

As in many cetacean species, some predation on right whales may occur by killer whales and large shark species, although no attacks have been observed. Scars recorded on the flukes and bodies of North Atlantic right whales do not originate from killer whales but are more consistent with harassment by some smaller cetacean, possibly pilot whales, *Globicephala* spp. (Mehta et al. in review). Of 195 bowhead whales examined during the Alaskan subsistence hunt (1976-92), 8 had been wounded by killer whales (George et al. 1994). Seven of the eight bowhead whales were greater than 13 m in length, suggesting either that scars are accumulated over time, or young animals do not survive a killer whale attack. Hunters on St. Lawrence Island reported two small (< 9 m) bowhead whales found dead as a result of killer whale attacks (George et al. 1994). Bowhead whales are pagophilic, unlike right whales, and ice-covered waters may provide some protection from killer whale attacks. The frequency of attacks is unknown and killer whale distribution in northern waters has not been well documented (George et al. 1994). Photographs of North Pacific right whales will be examined for evidence of killer whale scarring.

Genetic Variability

Commercial whaling very likely reduced the genetic variability of North Pacific right whales. According to Estes (1979) and Congdon et al. (1993), long-lived organisms have limited abilities to respond to chronic increases in juvenile mortality and even less ability to respond to increased mortality through commercial hunting of juveniles and adults. Life history characteristics such as low reproductive rates, delayed sexual maturity, and reliance on high juvenile survivorship make long-lived species such as whales particularly vulnerable to overexploitation. The small, remnant populations that survived commercial whaling likely lost genetic variability because of genetic drift and inbreeding, further confounding recovery efforts. For example, genetic analysis of North Atlantic right whales suggests that inbreeding depression is slowing the recovery of this stock, compared to South Atlantic right whales which exhibit greater genetic variation (Schaeff et al. 1997). Relatively out-bred marine mammals demonstrate

DNA fingerprint band sharing in the range of 0.17-0.37 (using J33.15) while North Atlantic right whales were significantly higher at 0.56 (see Schaeff et al. 1997 for a review). North Pacific right whale stocks may be experiencing similar problems. Low diversity potentially affects individuals by depressing fitness, resistance to disease and parasites, and adaptability to environmental changes, and it affects populations by decreasing growth rates, resilience, and adaptability over the long-term (Lacy 1997). Evidence of disease in right whales, particularly those that may be directly or indirectly linked to human activities, should be assessed.

Fishery Interactions

Entanglements in fishing gear appear to be uncommon. Perry et al. (1999) reported two fishery-related mortalities from Russian waters (sources: Kornev (1994) and in the 1991 Final Recovery Plan for the Northern Right Whale (NMFS 1991)); however, on review of the original records in the Platforms of Opportunity Program database, the 1983 encounter was a sighting not an entanglement. Therefore, only one case of entanglement is known from the western North Pacific (Brownell et al. 2001), though the occurrence of right whales near trap fisheries in the Bering Sea may indicate a potential for conflict. For example, there have been several cases of entanglements of bowhead whales recorded during the Alaska Native subsistence hunt (Philo et al. 1992). These reports included three bowheads killed in the hunt that had scars attributed to rope entanglements, one bowhead found dead entangled in ropes similar to those used with fishing gear in the Bering Sea, and one bowhead with ropes on it that were attributed to rigging from a commercial offshore fishing pot, most likely a crab pot. There have been two other recent reports of bowheads with gear attached or marks that likely were from crab gear (J. C. George, North Slope Borough, Barrow, AK, pers. comm.). Aerial photographs in at least two cases have shown ropes trailing from the mouths of bowheads (NMFS, NMML, unpubl. data). A similar review of photographs of North Pacific right whales is planned.

The effects of disturbance caused by vessel traffic, fishing operations, or underwater noise associated with these activities on baleen whales are largely unknown. Most baleen whales appear to tolerate or habituate to fishing activity, at least as suggested by their reactions at the surface. Collisions with ships, however, have been a major source of mortality of North Atlantic right whales (Knowlton and Kraus, 2001). Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaska Native subsistence harvest (George et al. 1994); however, these whales are usually protected from vessel traffic by ice-covered waters unlike right whales. For some large whales (e.g., humpback whales), observed short-term effects have included avoidance and on rare occasions "charging" at the vessel while long-term effects included abandoning high-use areas (reviewed in Richardson et al. 1995). However, long-term negative effects were not apparent at the population level (Bauer et al. 1993). Bowheads often attempt to outswim vessels, turning perpendicular away from the vessel track only when the ship is about to overtake it. Displacement can be as much as a few kilometers while fleeing (Richardson et al. 1995). Reaction to gear, such as pelagic trawls is unknown, although the rarity of incidental takes suggests either partitioning or avoidance. Given the current known distribution of North Pacific right whales in shelf and slope waters of the Bering Sea and Gulf of Alaska, as well as coastal waters of Washington, California, and Mexico, at least some individuals may be expected to occasionally avoid contact with vessels or fishing gear, which would constitute a reaction to a disturbance. Assuming these instances occur, the effects are likely temporary.

Vessel noise and the routine use of various sonar devices are audible to whales and may be disturbance sources. When disturbed by vessels North Atlantic right whales were consistently silent (Watkins 1986). Given the continued occupation of the fishing grounds in the Bering Sea and Gulf of Alaska by North Pacific right whales, disturbance from vessels and sonar, if it occurs in these regions, may disrupt communication temporarily. Although other populations of whales have not shown long-term negative effects at the population level, these populations also number in the thousands, not hundreds. The long-term cumulative effects of these activities on communication, navigation and foraging could have serious repercussions for such a small right whale population.

ASSESSMENT OF EXTINCTION RISK

As mentioned in the preceding sections, basic life history parameters, including population abundance, growth rate, age structure, breeding ages, and distribution remain undetermined for North Pacific right whales. These data are necessary to perform quantitative population analyses or to develop surrogate models to evaluate the risk of extinction. We have also moved away from evaluating extinction risk based on the IUCN criteria which currently list North Pacific right whales as endangered (Cetacean Specialist Group 1996, Reeves et al. 2003) based on IUCN criterion D (ver. 2.3 (1994)), a population estimated to number fewer than 250 mature individuals, with the "population" in this case including both the eastern and western stocks. The NOAA Fisheries Quantitative Working Group (DeMaster et al. 2004) determined that the IUCN system was in many respects too simple. Applying the population size criteria for "critically endangered", "endangered", and "vulnerable" (250, 2,500, and 10,000 mature individuals, respectively) to a large whale species would trigger concern where many large whale populations at the 2,500 - 10,000 mature individual level would be considered "healthy" and in many cases above the optimal sustainable population (OSP) level of the population. In addition, the IUCN criteria do not meet the statutory requirements of the five factors (Section 4(a)(1)) under the ESA. We can conclude, however, that there are a number of factors that put North Pacific right whales at considerable risk of extinction. These include but are not limited to the following:

Life History Characteristics: Slow Growth Rate, Long Reproduction Intervals, and Longevity

Although there are no data for the North Pacific, studies of other right whale populations suggest calving intervals of 3-6 years, lifespans of at least 70 years, and population growth rates that are likely dependent upon feeding success (see Reynolds et al. 2002, Kenney 2002). Long-lived organisms have limited abilities to respond to chronic increases in juvenile mortality and even lesser abilities to respond to increased mortality through commercial hunt of juveniles and adults (Congdon et al. 1993). Although a protracted reproductive span provides some buffer against the long-term impacts of juvenile mortality, life history characteristics such as low reproductive rates and delayed sexual maturity make long-lived species such as whales particularly vulnerable to overexploitation. This may partly explains the paucity of sightings in the eastern North Pacific since the illegal kills by Soviet whalers in the 1960s.

Distorted Age, Size, or Stage Structure of the Population and Reduced Reproductive Success

Thus far photogrammetric data collected in the Bering Sea includes primarily adult animals (LeDuc et al. 2001). Of the 12 whales where lengths were determined (range: 14.7-17.6 m), none were smaller than the range of measurements given for sexually mature right whales (13-16 m: see Kenney 2002). Length measurements for two whales observed off California suggest that at least one of these whales was not yet sexually mature (12.6 m: Carretta et al. 1994). The observation of two calves during the 2004 season in the Bering Sea (Wade et al. 2006) is encouraging. However, to date, there is no evidence of reproductive success (i.e., young reared to breeding age) in this population.

Strong Depensatory or Allee Effects

In 2002, the ratio of females to males biopsied in the Bering Sea was 1:9. In 2004, biopsy results improved this ratio considerably to 7:16. Excluding the two male calves from the sample and assuming all other whales were adults provides a 1:2 ratio of females to males with a possible effective population size of 21. The Allee effect has been defined as the impact of reduced social interactions and loss of mating opportunities in a small population. At such low numbers, the potential for North Pacific right whales to find viable mates or even mates at all may be severely reduced. Populations with an effective size of a few dozen individuals are usually sufficiently large to avoid most of the deleterious consequences of inbreeding (Lande 1991). However, it has also been suggested that if the number of reproductive animals is fewer than 50, the potential for impacts associated with inbreeding depression increases substantially (IUCN 2003). Theoretically, during a rapid decline in population size nearly all (i.e., > 95%) of the diversity in a population is maintained in an effective population of 10 individuals, and more than 99% of the diversity in a population is maintained in an effective population of 50 individuals (Ralls et al. 1983). However, this is very much case-specific and the impacts of genetic diversity depend upon how the pattern of past exploitation interacted with genetic and social structure in the population.

Habitat Specificity or Site Fidelity

Other large whale populations such as humpback whales (*Megaptera novaeangliae*) appear to utilize common breeding grounds with a "maternally directed site-fidelity to specific feeding grounds" (Baker et al. 1990, 1994; Clapham et al. 1993; Palsbøll et al. 1995, 1997; Larsen et al. 1996). Genetic sampling revealed similar patterns in western North Atlantic right whales (*Eubalaena glacialis*) indicating that this population probably occupies a single breeding ground but segregates into distinct, maternally-linked subpopulations during migration to isolated nursery areas (Schaeff et al. 1993). There is some suggestion of site fidelity among right whales found in the Bering Sea. Of the whales observed between 1997 and 2004, at least five were photographed and five were biopsied over multiple years.

Habitat Sensitivity

Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (see Reynolds et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate 2003, Baumgartner et al. 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Napp and Hunt 2001, Baier and Napp 2003). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales.

CONCLUSIONS

To date, the largest number of individuals identified in the Bering Sea is 23 based on genetic sampling, which also appears to include at least two calves. The photograph database yields smaller numbers; however, image quality and survey platform problems have made it difficult to conclusively link photos taken from aerial and vessel surveys, as well as for photos taken outside the Bering Sea. The life history characteristics and habitat requirements of this species make it extremely vulnerable to environmental variation and demographic stochasticity change at such low numbers. The best available science at this time indicates that this population may already be below what would be considered a reasonable extinction or quasi-extinction threshold (Krahn et al. 2004, Fagan and Holmes 2006). The ability of this population to persist over the long-term is highly unlikely with only seven potentially viable females identified (Krahn et al. 2004), though extinction may take decades or longer given the life-span of these whales. The observations of several mothers with calves give hope that this whale population may have some capacity for recovery. In this regard, it is of critical importance to determine where breeding and calving occurs for the eastern North Pacific population, as well as for those animals feeding in the western North Pacific.

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