The Great Whales: History and Status of Six Species Listed as Endangered Under the U.S. Endangered Species Act of 1973

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The Status of Endangered Whales: An Overview

Introduction and Background

In the history of whaling from prehistoric to modern times, the large whales, sometimes called the "great whales," were hunted most heavily owing in part to their corresponding value in oil, meat, and baleen. Regional populations of North Atlantic right whales, *Eubalaena glacialis glacialis*, were already decimated by 1700, and the North Atlantic gray whale, *Eschrichtius robustus*, was hunted to extinction by the early 1700's (Mitchell and Mead[1]).

Then, as whalers turned to modern, mechanized forms of whaling in the 1860's, worldwide populations of gray; bowhead, *Balaena mysticetus*; humpback, *Megaptera novaeangliae*; blue, *Balaenoptera musculus*; fin, *Balaenoptera physalus*; sei, *Balaenoptera borealis*; and sperm, *Physeter macrocephalus*, whales were in some instances greatly reduced (Tønnessen and Johnsen, 1982). However, as their numbers have diminished, concern for their (and other species) well-being has increased, and has resulted in such U.S. laws as the Endangered Species Conservation Act (ESCA) of 1969, the Marine Mammal Protection Act (MMPA) of 1972, and the Endangered Species Act (ESA) of 1973. Under these laws, eight species of large whales have been added to the List of Endangered and Threatened Wildlife (the List). Smaller species of whales (e.g. minke whale, *Balaenoptera acutorostrata*), whose numbers have remained fairly constant, have not been listed as endangered.

This report reviews the history and status of six species of endangered whales: right, humpback, blue, fin, sei, and sperm whale (Fig. 1). The other two

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[1] Mitchell, E. D., and J. G. Mead. 1977. History of the gray whale in the Atlantic Ocean (Abstr.). *In* Proceedings of the second conference on the biology of marine mammals, San Diego, Calif., p. 12.

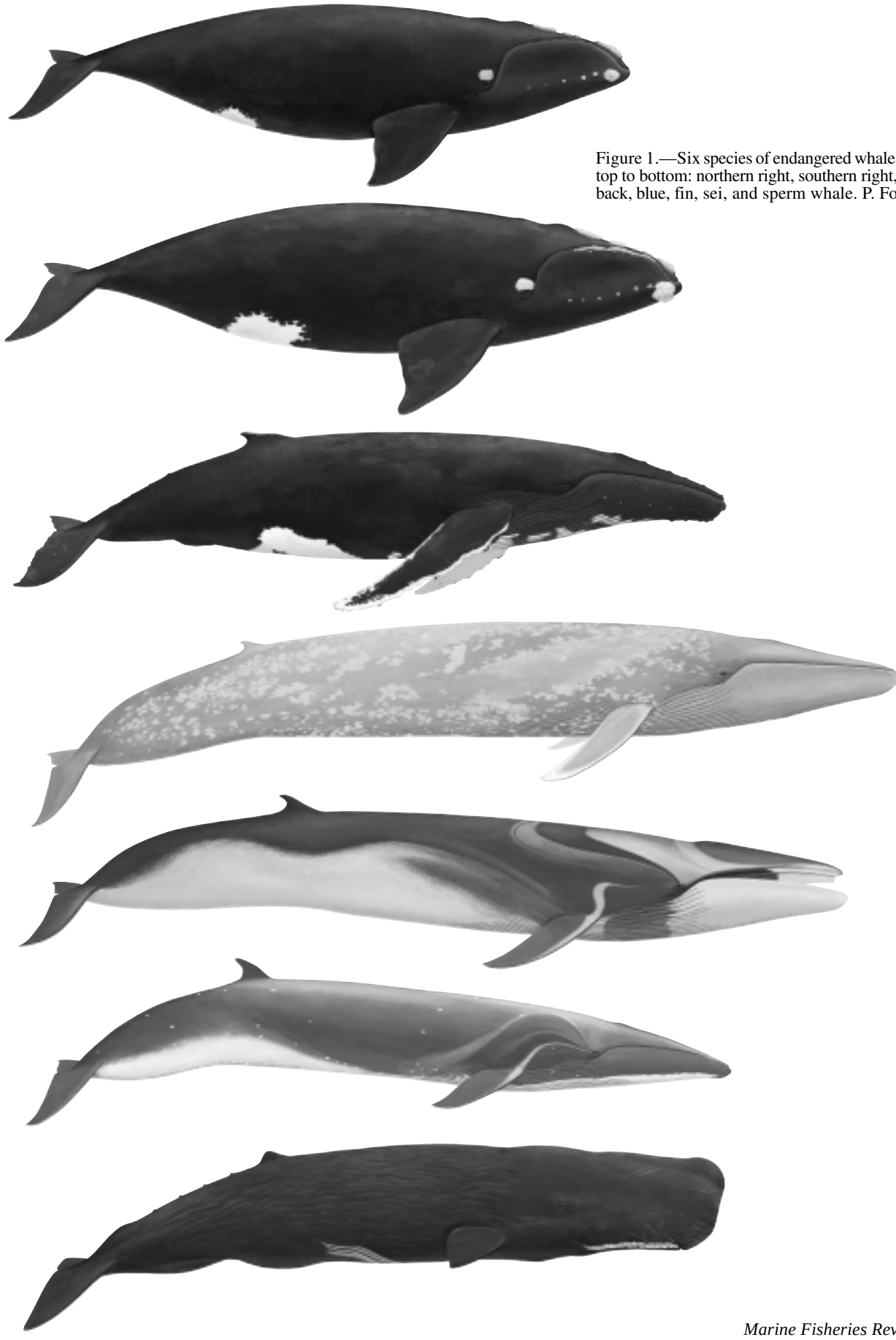


Figure 1.—Six species of endangered whales. From top to bottom: northern right, southern right, humpback, blue, fin, sei, and sperm whale. P. Folkens.

species of large whales were not included in this volume because 1) the eastern North Pacific stock of gray whale was removed from the endangered species list in June 1994 and 2) a status review of bowhead whale stocks was recently published (Shelden and Rugh, 1995).

As defined in the ESA, a species[2] should be classified as endangered if it is in danger of extinction throughout all or a significant portion of its range as a result of any one of the five factors specified in Section 4(a)(1) (Table 1). In addition, a species should be classified as threatened if it is likely to become endangered in the foreseeable future due to any of the factors listed in Table 1.

On 10 November 1978, the U.S. Congress passed Public Law 95-632, which amended the ESA and required the Secretaries of Commerce and Interior to review the status and degree of endangerment of all species on the List at least once every 5 years. Within the 5-year status report, the results of a determination are to be reported as to whether a listed species should be 1) removed from the list, 2) reclassified from endangered to threatened, or 3) reclassified from threatened to endangered. In response to this Congressional mandate, the National Marine Mammal Laboratory of NOAA's National Marine Fisheries Service (NMFS) began its first such review in 1982, publishing the status reports jointly in the *Marine Fisheries Review* (Rice et al., 1984; Mizroch et al., 1984a, b, c; Johnson and Wolman, 1984; Braham and Rice, 1984; Braham, 1984a; and Gosho et al., 1984). Braham (1984b) reported in a summary article that only the eastern North Pacific stock of gray whale and perhaps the western North Atlantic stock of humpback whale may have recovered to levels approaching their preexploitation population size. He further noted that "On the basis of population size alone, these two stocks plus most sperm whale stocks seem likely candidates for reclassification. However, population size is not the only criteria to be considered in deciding whether a stock warrants continued protection under the ESA."

In the 14 years that followed, there were no formal status reviews or publications produced similar to the 1984 issue (46(4)) of the *Marine Fisheries Review*. However, several significant actions regarding the status of endangered species of large whales took place. First, from 1984 to 1998 the International Whaling Commission (IWC) continued to review the status of all stocks of large whales and to make management recommendations when there was agreement within the Commission. For example, the IWC imposed a moratorium on commercial whaling for all stocks starting with the 1986 coastal and the 1985–86 pelagic seasons (IWC, 1995b).

Although the Government of Norway formally objected to the classification of the northeastern stock of minke whales as a "Protected Stock" (i.e. a stock for which commercial whaling was not allowed) and therefore was not bound by the IWC moratorium for this stock, there were no objections to the moratorium for any of the species listed under the ESA (IWC, 1995b). In addition, the IWC continued to manage the aboriginal subsistence harvest for the following stocks of large whales: Bering-Chukchi-Beaufort stock of bowhead whale, eastern North Pacific stock of gray whale, west Greenland and central North Atlantic stocks of minke whale, west Greenland stock of fin whale, and the North Atlantic stock of humpback whale (IWC, 1995b). Because aboriginal whaling quotas are set by the IWC for a specified time period, comprehensive status reviews for most of the stocks taken by aboriginal hunters were performed every 3–5 years.

Braham[3] completed a status update of endangered whales in April 1991. While this report was never formally published, it was widely distributed. In that report, Braham noted the following: 1) the eastern North Pacific gray and sperm whale stocks were not in danger of becoming extinct and were not threatened with becoming endangered in the foreseeable future (i.e. recommendation to delist), 2) the Bering-Chukchi-Beaufort bowhead whale stock was not in danger of becoming extinct in the foreseeable future (i.e. recommendation to downlist to threatened), and 3) all other stocks of large whales were either severely depleted or the data were inconclusive to warrant changing their current listing status of endangered.

In 1991 the NMFS published Recovery Plans for two species of large whales: Final Recovery Plan for the northern right whale (Anonymous, 1991a) and Final Recovery Plan for the humpback whale (Anonymous, 1991b). In each of these Recovery Plans, the status of stocks within U.S. waters was reviewed. Further, while definitions of endangered and threatened for the western North Atlantic stock of right whale and the definition of threatened for stocks of North Pacific and North Atlantic humpback whales were provided in the Plans (Table 2), their relevance to the ESA definitions of endangered and threatened has been questioned (DeMaster and Gerber[4] ; Shelden[5]).

A summary of environmental threats to baleen whales was recently completed by Clapham and Brownell[6] . In

[2] In the implementation of the ESA, the term species has been interpreted to mean "any distinct population segment of any species of vertebrate, fish, or wildlife, which interbreeds when mature" (ESA§3[16], as amended in 1978).

Table 1.—Summary of factors for listing a species as threatened or endangered under authority of the ESA (ESA § 4 (a)(1)). Only one factor is needed for classification.

1. The present or threatened destruction, modification, or curtailment of a species' habitat or range.
2. Overutilization for commercial, recreational, scientific, or educational purposes.
3. Disease or predation.
4. The inadequacy of existing regulatory mechanisms.
5. Other natural or manmade factors affecting a species' continued existence.

[3] Braham, H. W. 1991. Endangered whales: status update. Unpubl. doc., 56 p., on file at Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

[4] DeMaster, D., and L. Gerber. 1997. A new approach to classifying the central North Pacific stock of humpback whales under the U.S. Endangered Species Act. NMFS Alaska Fisheries Science Center *Quarterly Report*, Oct.-Nov.-Dec. 1997, p. 1–4.

[5] Shelden, K. W. 1998. The bowhead whale: a case study for development of criteria for classification on the List of Endangered and Threatened Wildlife. Master's thesis, School Mar. Affairs, Univ. Wash., Seattle, 137 p.

[6] Clapham, P. J., and R. L. Brownell, Jr. 1999. Vulnerability of migratory baleen whales to ecosystem degradation. Convention of Migratory Species Special Publications (In press). Rep. avail. from P. J. Clapham, NEFSC, 166 Water St., Woods Hole, MA 02543-1097.

Table 2.—Summary of criteria for downlisting Northern Hemisphere right and humpback whales as reported in recovery plans for each species (Anonymous, 1991a, 1991b).

	Criteria	
Stock	Endangered	Threatened
North Pacific right whale	Not developed	Not developed
Western North Atlantic right whale	1. Population <6,000 2. Population not increasing at 2% per year over 20-year period. 3. No effective program in place to control mortality.	Population <7,000
North Pacific humpback whale	Not developed	Population <0.6 of *K*
North Atlantic humpback whale	Not developed	Population <0.6 of *K*

addition, the NMFS has completed a Recovery Plan for North Pacific and North Atlantic blue whale stocks (Anonymous, 1998), and efforts are now focused on the completion of a Recovery Plan for the North Pacific and North Atlantic stocks of fin and sei whales (Anonymous[7]). Completion of the fin and sei whale Recovery Plan is expected in 1999.

An additional action concerning the status of listed stocks of large whales involved the gray whale. In November 1991 the NMFS issued a proposed determination that the eastern North Pacific stock of gray whales be removed from the List. The NMFS issued a final determination to delist on 7 January 1993, but concurrence from the U.S. Fish and Wildlife Service (FWS) was not received until June 1994, when this stock was officially removed from the List. This delisting was the first such action for any species of marine mammal since the passage of the ESA in 1973. As a part of the delisting process, in 1993 the NMFS also developed a 5-year plan for research and monitoring[8] . The development of such a plan is a requirement of the ESA, where the agency responsible for management (i.e. U.S. Department of Commerce for cetaceans) must commit to monitor the status of the delisted stock for a period of at least 5 years following delisting. If at any time during this period the Secretary of Commerce finds that the species' well-being is at risk, the ESA provides that emergency protective regulations, under Section 4(b)(7), shall be issued by the Secretary to ensure the conservation of any recently delisted species. As part of the 5-year plan for research and monitoring, the NMFS conducted three biennial surveys during southbound migrations for the purposes of estimating annual abundance and determining trends in abundance and four annual surveys during northbound migrations for the purpose of estimating calf production. Also required as part of the delisting process is a formal review of the status of a delisted stock 5 years following the action to delist. A workshop was held during the spring of 1999 to review the status of the eastern stock of North Pacific gray whale.

Shelden and Rugh (1995) published a formal status review of the bowhead whale, which included a status summary of the five recognized stocks. No specific recommendations to change the listing status of any of these bowhead whale stocks were proposed by them. However, they did report that NMFS would undertake to develop objective criteria to determine whether the current classification of one of these stocks, bowhead whales of the Bering-Chukchi-Beaufort Seas, is accurate (Shelden[5]).

The following report officially updates the status of the remainder of the stocks of endangered large whales (i.e. right, humpback, blue, fin, sei, and sperm whales). In the remainder of this overview, we summarize problems that have been identified in defining classification criteria under the ESA, discuss possible changes to the classification of endangered large whale stocks, and provide an update on the currently listed large whale species (except bowhead whales).

Problems with Marine Mammal Classification Under the Endangered Species Act

One of the most difficult problems in implementing the ESA is that objective criteria for what constitutes being in danger of extinction is not defined in the Act or elsewhere (Rohlf, 1991). As already noted by several authors (Tear et al., 1995; Easter-Pilcher, 1996; Shelden[5]) the NMFS and FWS have used an ad hoc and subjective approach to classifying individual species. This has led to considerable disparity in the type and quality of classification criteria among species that are listed. In 1988, the U.S. Congress amended the ESA to require that each Recovery Plan incorporate objective, measurable criteria for recovery (i.e. delisting). Nonetheless, these criteria have yet to be developed for species of large whales for which Recovery Plans exist. Further, the Recovery Plans currently being developed for listed species do not include such criteria (DeMaster and Gerber[4]). Finally, we believe that Congress also intended to have delisting criteria developed for those species for which Recovery Plans have not been developed.

There has been some confusion in the literature between a classification of threatened under the ESA and a classification of depleted under the Marine Mammal Protection Act (MMPA). In some cases, it has been assumed that a population sufficiently large to be classified as healthy under the MMPA (i.e. population greater than 60% of its carrying capacity (*K*)) is also sufficiently large to be removed from the List of Endangered and Threatened Wildlife of the ESA. Unfortunately, there is nothing inherent about the definition of threatened that makes such a relationship valid. To further complicate matters, the status of a population relative to its carrying capacity (*K*) is not necessarily well correlated with the probability of extinction in the foreseeable future. Obviously, populations at very low status levels (e.g. less than 10% of *K*) are often very small in number and therefore more likely to become extinct over a given period of time than a population several times larger. However,

[7] Anonymous. 1999. Draft recovery plan for the fin whale, *Balaenoptera physalus* and sei whale *Balaenoptera borealis*, 68 p. Avail. from F/OPR, NMFS, NOAA, 1315 East-West Highway, Silver Spring, MD 20910.

[8] Braham, H. W., and D. P. DeMaster (Editors). 1993. A 5-year plan for research and monitoring of the eastern North Pacific population of gray whale. Unpubl. doc., 54 p., prep. for the Asst. Admin. Fish., NOAA, 1315 East-West Highway, Silver Spring, MD 20910.

over a wide range of population sizes, status relative to *K* alone is not a good predictor as to whether extinction is imminent.

The World Conservation Union (IUCN) recently developed objective classification criteria for the purposes of identifying species that are, or may be, threatened with extinction (IUCN, 1996). As noted in Gnam (1993) and Shelden[5], these criteria seemed to have been developed with terrestrial species in mind, and some of the definitions or parameters used in the criteria are not easily applied to marine species. For example, one of the criteria refers to the area of occurrence, but it is not clear how to apply such a criterion to species like large whales that migrate over great distances. Nonetheless, this approach represents a significant improvement over the ad hoc system previously used by the NMFS and FWS. As noted by DeMaster and Gerber[4], the IUCN criteria can be modified to make the criteria more pertinent to marine species, including species of large whales.

Most endangered whale species occur in geographically and, in some cases, genetically discrete populations. These populations are typically referred to as stocks, and may be designated on the basis of species' biology, management objectives, or a combination of biological and management goals. However, since biological information necessary to make reliable stock structure determinations is generally lacking for the large whales, management objectives tend to play a large role in how stocks are designated (Barlow[9]).

Two different approaches for stock designation are referred to in this document. The first of these approaches has been adopted by the NMFS in the production of annual stock assessment reports. As a default in the absence of biological data, the NMFS approach defines stock structure relative to discontinuities in the distribution of the stock in question and relative to the distribution of commercial fisheries in the North Pacific and North Atlantic Oceans (Barlow et al., 1995a). The second approach uses stock determinations currently recognized by the IWC (Donovan, 1991). The former approach uses smaller areas to define the range of a stock than does the latter, and has been adopted in an effort to minimize the risk of adverse interactions between commercial fisheries and marine mammals. The latter approach generally uses much larger areas to designate stocks (i.e. typically an ocean basin). While detailed evaluation of the merits of these two approaches is beyond the scope of this report, we summarize the status of six endangered large whale species based on current stock designations that currently rely on these approaches (Tables 3, 4, 5).

Summary and Recommendations Regarding the Listing Status of Large Whales

As discussed above, all large whale species currently listed as endangered under the ESA were severely depleted as a result of commercial whaling. The effects of low population size and the continued threat of overexploitation were the primary reasons that the species were first listed. Because commercial overexploitation is no longer imminent, or at least is greatly diminished, the listed species could, theoretically, be delisted. However, the potential for adverse effects from human activities still exists, and the lingering effects of low population size do remain (Clapham et al. [10]). For example, northern right whale stocks, which are still severely depleted, have shown no sign of recovery or at least no substantial population growth in the last two decades even though local commercial hunting ceased in 1949 (Anonymous, 1991a). Clearly, the listing classification of this species should remain (Table 5).

Stock identity of North Atlantic and North Pacific humpback whales is relatively well understood, and some humpback whale populations are showing significant increases (see the review beginning on page 24). Most notable are the western North Atlantic and the central North Pacific stocks. For example, Smith et al.[11] estimated there are 5,543 whales in the western North Atlantic, which may be greater than estimated preexploitation levels (Table 4). As population estimates are refined, population structure is better understood, and as mortality and serious injury from human activities are reduced, these stocks may be considered for downlisting or delisting if the appropriate long-term monitoring programs can be established (Table 5).

Blue whale stocks off the west coast of North America also show signs of growth. For example, the stock of blue whales that feed in waters off California, Oregon, and Washington, which was once thought to include fewer than 500 individuals, was recently estimated at 1,785 (CV = 0.24; Barlow et al., 1997). While additional data are still needed on stock structure, trends in abundance, and habitat requirements, this stock may be a candidate for downlisting as long as reliable monitoring programs are established and long-term research is continued (Table 5).

In contrast, for several other species there is insufficient information about stock structure and abundance to make determinations regarding changes in listing status at this time (Table 5). These

Table 3.—Available potential biological removal (PBR) levels for five species of endangered whales from Hill and DeMaster (1998); Barlow et al. (1997); Waring et al. (1998). PBR = product of N_{min}, $^1/_2$ maximum net productivity rate, and a specified "recovery" factor for endangered stocks, threatened stocks, or stocks of unknown status relative to OSP (Wade and Angliss, 1997). Stocks without PBR indicate that data were insufficient.

Species	Stock	PBR
Northern right whale	Western North Atlantic	0.4
Humpback whale	Western North Pacific	0.7
	Central North Pacific	7.4
	CA/OR/WA and Mexico	1.1
	CA/OR/WA (U.S. only)	0.5
	Western North Atlantic	9.7
Blue whale	CA and Mexico	2.9
	CA (U.S. only)	1.5
	Western North Atlantic	0.6
Fin whale	CA/OR/WA	2.1
	Western North Atlantic	3.4
Sperm whale	CA/OR/WA	1.8
	Western North Atlantic	3.2
	Northern Gulf of Mexico	0.8

[9] Barlow, J. 1998. Chief Scientist, Southwest Fisheries Science Center, NMFS, P.O. Box 271, La Jolla, CA 92038. Personal commun.

[10] Citation updated in proof: see Clapham et al., 1999 in literature cited.

[11] Citation updated in proof: see Smith et al., 1999 in literature cited.

Table 4.—Estimates of pre-exploitation ("initial") and current ("recent") population sizes for six large whale species currently listed as "endangered" under the ESA. See text for references and estimates CV, CI, and ranges (N.e.= no published estimate).

Species	Population Estimate	
	Initial	Recent
Right Whale		
North Pacific		
Total	N.e.	N.e.
Eastern North Pacific	N.e.	100–500
Sea of Okhotsk[1]	N.e.	900
Western North Atlantic	N.e.	300–500
Eastern North Atlantic	N.e.	N.e.
Southern Hemisphere	N.e.	7,000
Humpback Whale		
North Pacific		
Total	N.e.	6,000–8,000
Western North Pacific	N.e.	394
Central North Pacific	N.e.	4,005
North Atlantic		
Total	N.e.	10,600
Western North Atlantic	N.e.	N.e.
Eastern North Atlantic	N.e.	N.e.
Southern Hemisphere	N.e.	17,000
Blue Whale		
North Pacific		
Total	N.e.	1,600
CA/OR/WA[2]	N.e.	1,930
Western North Atlantic	N.e.	100–560
Northern Indian Ocean	N.e.	N.e.
Southern Indian Ocean[3]	N.e.	5,000
Southern Hemisphere	N.e.	1,260
Fin Whale		
North Pacific	N.e.	14,620–18,630
Western North Atlantic	N.e.	3,590–6,300
East Greenland/Iceland	N.e.	11,560
British Isles/Spain and Portugal	N.e.	4,490–17,360
Southern Hemisphere	N.e.	85,200
Sei Whale		
North Pacific	N.e.	9,110
North Atlantic		
Total	N.e.	4,000
Iceland/Davis Strait	N.e.	1,590
Nova Scotia	N.e.	1,390–2,250
Labrador Sea	N.e.	N.e.
Southern Hemisphere	N.e.	9,720–12,000
Sperm Whale		
North Pacific		
Total	N.e.	N.e.
CA/OR/WA[2,4]	N.e.	995
Western North Pacific	N.e.	N.e.
Eastern North Pacific	N.e.	N.e.
North Atlantic		
Total	N.e.	N.e.
Western North Atlantic	N.e.	220–2,700
Northern Gulf of Mexico	N.e.	530
Iceland	N.e.	1,230
Azores	N.e.	N.e.
Spain	N.e.	N.e.
Northern Indian Ocean	N.e.	N.e.
Southern Hemisphere		
Total	N.e.	N.e.
South of 60°S	N.e.	3,200–14,000
South of 30°S	N.e.	128,000–290,000
Equatorial East Pacific	N.e.	3,891

[1] Recent estimate 95% CI = 404–2,108 (from IWC, 1998, Workshop on the Comprehensive Assessment of Right Whales, Unpubl. Doc. SC/50/REP4).
[2] CA/OR/WA = California/Oregon/Washington
[3] Pygmy blue whale only
[4] Recent minimum population estimate (N_{min}) from Barlow (text footnote 75).

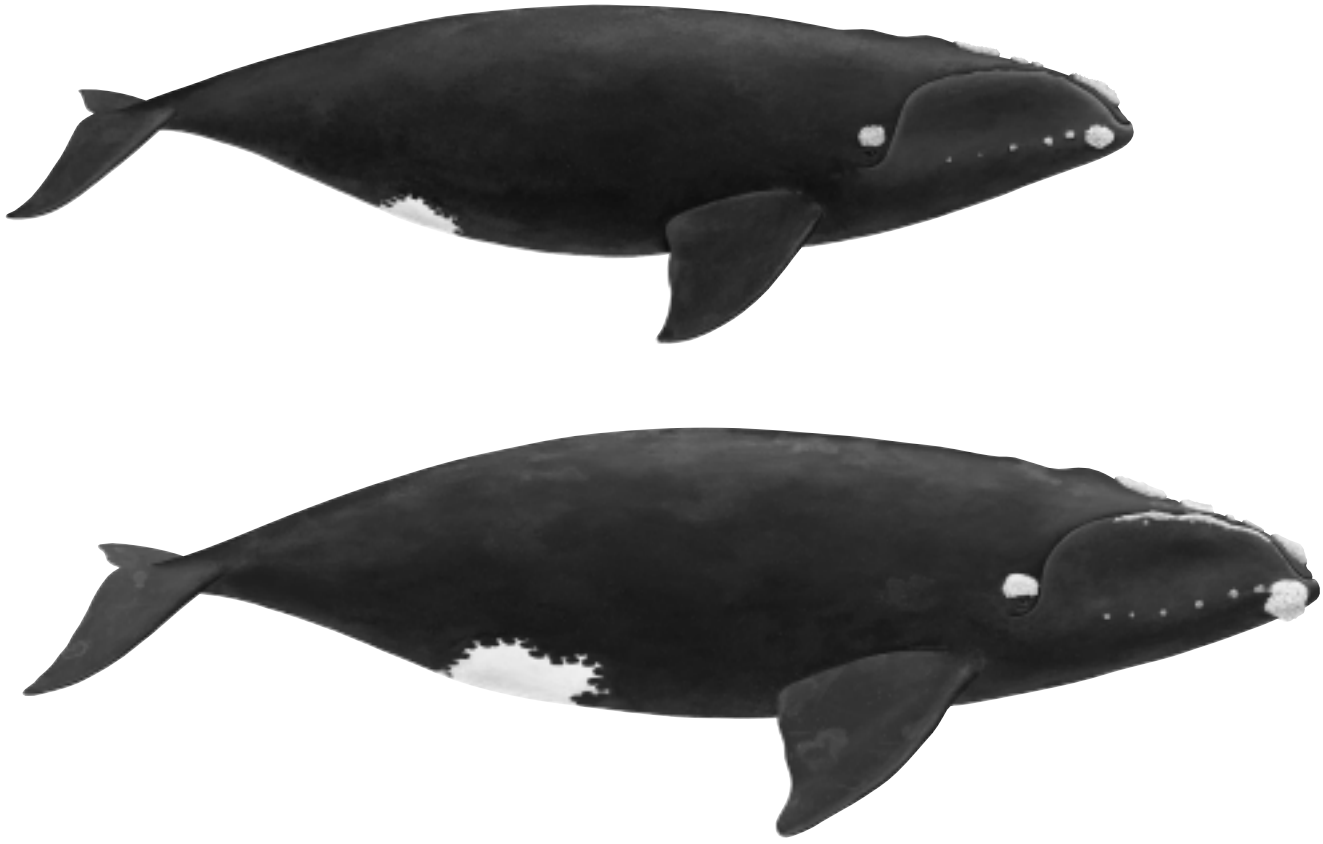
Table 5.—A general evaluation of the possible recovery of endangered large whales by stock or region. Note: Stocks and regions listed represent current knowledge on distribution and density. These are not formal stock designations.

Status
Perhaps recovered[1]
Central North Pacific humpback whale
Western North Atlantic humpback whale
California, Oregon, Washington blue whale
British Isles/Spain & Portugal fin whale
Depleted[2]
Southern Hemisphere right whale
Western North Pacific humpback whale
Southern Hemisphere humpback whale
North Pacific blue whale
Western North Atlantic blue whale
Southern Hemisphere blue whale
Southern Indian Ocean (pygmy) blue whale
Southern Hemisphere fin whale
North Pacific fin whale
Western North Atlantic fin whale
North Pacific sei whale
Southern Hemisphere sei whale
Iceland sperm whale
Critically low population level[3]
North Pacific right whale
Western North Atlantic right whale
Insufficient data for judgment
Eastern North Atlantic right whale
Eastern North Atlantic humpback whale
Northern Indian Ocean blue whale
East Greenland/Iceland fin whale
Iceland/Davis Strait sei whale
Nova Scotia sei whale
All sperm whale stocks

[1] Recent population abundance estimate at or near population size prior to commercial whaling.
[2] Well below initial population size estimates, but may include low populations that have shown some recent increase (e.g. Southern Hemisphere right whales).
[3] Recent population estimates number in the tens to hundreds.

include fin, sei, and sperm whales. Therefore, while the abundance of some stocks may be increasing or their total abundance in any given ocean basin is relatively large (e.g. sperm whale), data on stock structure and habitat requirements are too inconclusive to warrant changing their listing status in the near future.

The comprehensive status reviews that follow are based on published literature from about 1980 through 1998. In some instances, where important data remains unpublished, we have cited personal communications, manuscripts in press, and draft documents. In other instances, where no new data has been collected since the 1984 reviews, we have cited pre-1980 literature. Scientists continue to develop new methods of gathering and analyzing population data, thus expanding our knowledge of large whale population biology; however, new and important publications after early 1999 were excluded from these reviews for the sake of timeliness. As it stands, these reviews are already more than 10 years later than the Congressionally mandated 5-year review period.



The Right Whales

Introduction

The right whales, *Eubalaena* spp., are identified by their robust body, black coloration, lack of a dorsal fin, callosities on the head region, and large, strongly bowed lower jaw (Fig. 2). While nomenclature for this species varies, (some authors use the genus *Balaena* spp. (Braham and Rice, 1984; Rice[12]), they are referred to under the genus *Eubalaena* spp. by the IWC (Hershkovitz, 1966; Schevill, 1986). The Northern and Southern Hemisphere species have been taxonomically separated based on skeletal data (Müller, 1954; Schaeff et al., 1991; Rice[12]). A genetic study of the right whale mitochondrial DNA control region suggests that this current taxonomical separation is not valid, but through phylogenetic analysis of mitochondrial lineages there is evidence of independent taxonomic status for right whales in the North Pacific, North Atlantic, and Southern Oceans (Rosenbaum et al.[13]). In this review, Northern Hemisphere right whales will be referred to as *Eubalaena glacialis glacialis* Muller 1776, and the Southern Hemisphere right whales will be referred to as *E. g. australis* Desmoulins 1822 after Rice[12] and IWC designations.

Northern right whales are now the most endangered of the large whales. Recent data indicate that there is a small but unknown number of individuals in the eastern North Pacific, and that there are approximately 300 individuals in the western North Atlantic (Carretta et al., 1994; Goddard and Rugh, 1998; Knowlton et al., 1994). Southern right whales, in contrast, have shown signs of recovery over the past 20 years (Bannister, 1990; Best, 1990; Payne, 1990). The scarcity of right whales is the result of an 800-year history of whaling that continued into the 1960's (Klumov, 1962) or as late as 1980 (Zemsky et al., 1995).

Northern right whales have been protected for more than 60 years from commercial whaling, yet their numbers remain low. In the North Pacific, the wide distribution of such low numbers of animals may have diminished mating

[12] Citation updated in proof: see Rice, 1998 in literature cited.

[13] Rosenbaum, H., R. L. Brownell Jr., M. Brown, C. Schaeff, V. Portway, B. White, S. Malik, L. Pastene, P. B. Best, P. J. Clapham, P. Hamilton, M. Moore, R. Payne, V. Rowntree, C. Tynan, and R. Desalle. 1998. A genetic review of inter-relationships between right whales in different ocean areas. Unpubl. doc. SC/M989/RW23 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

Figure 2.—A right whale skimming the water's surface for its zooplankton prey. Notice the whitish callosities and dark colored baleen. (W. A. Watkins, NMML Collection)

opportunities; therefore, chances of recovery for this stock appear bleak (Braham and Rice, 1984). At least in the North Atlantic, human interactions (e.g. vessel strikes and fisheries entanglements) on their coastal calving grounds and elsewhere are thought to be one of the predominate factors keeping abundance levels low.

Distribution and Migration

Right whales have occurred historically in all the world's oceans from temperate to subarctic latitudes (Fig. 3). Right whales prefer shallow coastal waters, but their distribution is also strongly correlated to the distribution of their zooplankton prey. In both hemispheres, they have been observed in low latitudes and nearshore waters during winter, where calving takes place, and they tend to migrate to high latitudes during the summer. In the North Atlantic and Southern Hemisphere, it appears that not all reproductively active females return to the calving grounds each year (Kraus et al., 1986; Payne, 1986). Right whale distribution in summer and fall in both hemispheres is likely linked to the patchy distribution of their principal zooplankton prey (Winn et al., 1986).

North Pacific

Historically, right whales ranged across the entire North Pacific north of lat. 35°N (Braham and Rice, 1984). Sightings in the 20th century are from as far south as the Yellow Sea and central Baja California to as far north as the Okhotsk Sea and the Bering Sea (Fig. 4, 5) (Scarff, 1986). The IWC recognizes North Pacific right whales as one contiguous stock, stating that at this time there is not enough evidence on their specific distribution to designate otherwise (IWC, 1986a). During the 1983 IWC Right Whale Workshop (IWC, 1986a), the Scientific Committee recommended distinguishing two stocks, one in the east and one in the west, but it stated "no conclusion can be reached concerning the identity of biological populations." At the 1998 IWC Right Whale Comprehensive Assessment Workshop[14] , it was tentatively decided that there was insufficient data about where calving and breeding take place to confirm or deny the existence of more than one stock in the North Pacific. However, several preliminary recommendations regarding North Pacific stock structure were made during this 1998 workshop. First, the western area of the North Pacific should be designated a management unit based on current sighting information. Second, the current east and west separation should stay in place until new data become available. And third, additional genetic analysis using historical samples should be undertaken (IWC[14]).

Lack of data on calving area locations in the North Pacific and a number of sightings of right whale concentrations in the mid Pacific north of Hawaii, have challenged the separation of eastern and

[14] IWC. 1998. Draft report of the workshop on a comprehensive assessment of right whales: a worldwide comparison. Unpubl. doc. SC/50/Rep4 submitted by the Scientific Committee to the IWC, Cape Town, South Africa, May 1998.

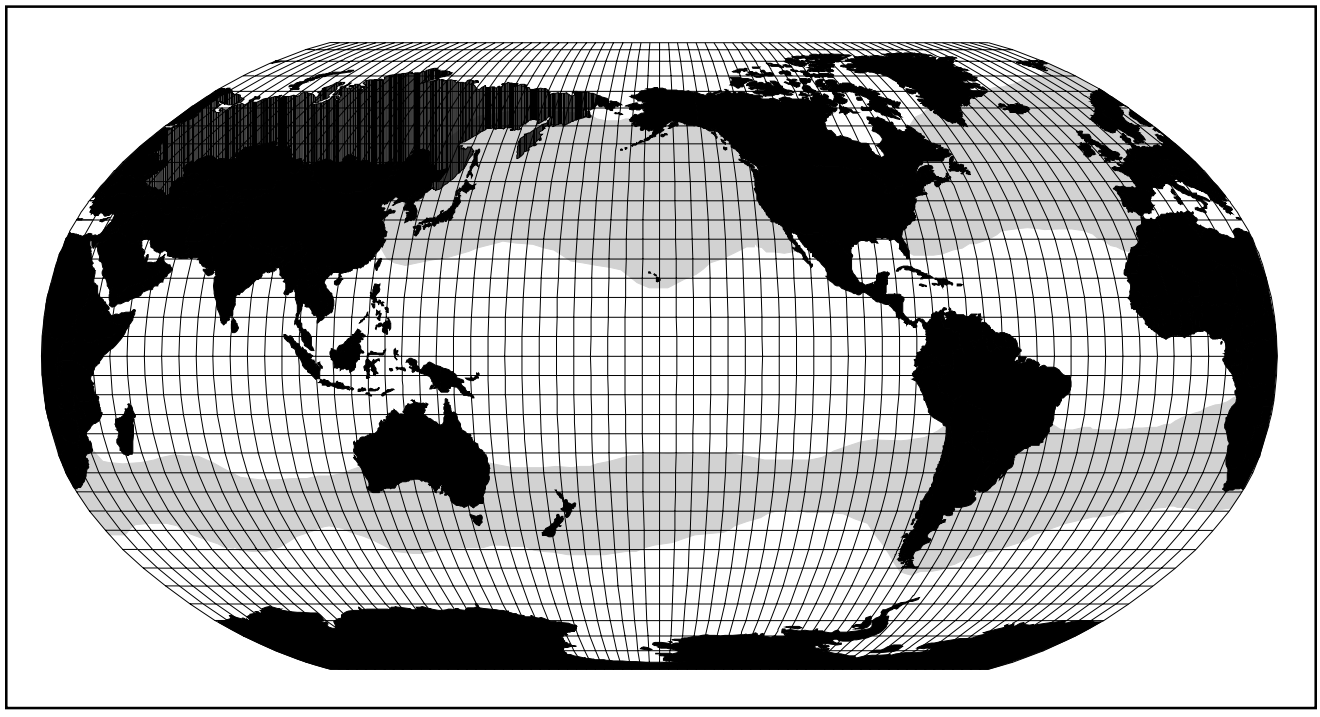


Figure 3.—Historic worldwide right whale distribution. Adapted from Braham and Rice (1984).

western stocks in the North Pacific (Scarff, 1986). Some researchers have suggested the possibility of two western North Pacific right whale stocks because of differences in migration routes and summer ranges: one traveling into the Okhotsk Sea and the other to the east of the Kuril Islands and Kamchatka Peninsula during summer (Klumov, 1962; Omura, 1986). Furthermore, the relative scarcity of current and historic sighting records from the eastern North Pacific (despite historic whaling in British Columbia) suggests that, if a separate eastern North Pacific right whale stock exists, it may be close to extinction (Braham and Rice, 1984; Scarff, 1986).

Historical whaling records provide the only information on possible migration patterns for North Pacific right whales (Scarff, 1986). During summer, whales were found in the Okhotsk Sea, along the east coast of the Kamchatka Peninsula, the Kuril Islands, south of the Aleutian Islands, the Bering Sea (Bristol Bay), and the Gulf of Alaska (Fig. 4, 5). The fall and spring distribution was the most widely dispersed, with whales found in mid ocean waters and spanning from the Sea of Japan to the eastern Bering Sea. In winter, the whales were found in the Ryukyu Islands (south of Kyushu, Japan), the Bonin (Ogasawari) Islands, the Yellow Sea, and the Sea of Japan (Fig. 5). The current distribution patterns and migration routes of these whales are not known.

In the 20th century, individual right whale sightings have been scarce and geographically scattered in the North Pacific. For example, a lone right whale was sighted off San Clemente Island, Calif. (Fig. 4) in 1992. This was only the twelfth reliable right whale sighting of this century in the eastern North Pacific (Carretta et al., 1994). The animal was photogrammetrically measured to be 12.6 m (SD = 0.6 m), a relatively small animal, perhaps not yet sexually mature (Carretta[15]). In July 1996, a group of right whales was sighted in western Bristol Bay (Fig. 4) (Goddard and Rugh, 1998). The group consisted of four individuals, one of which was considerably smaller than the others. This was one of the first sightings of a group of right whales in the northeast Pacific this century, although sightings of individual animals have occurred more frequently (Goddard and Rugh, 1998).

The Bristol Bay sighting was followed by another confirmed sighting in September of a group of four individuals 108 km southwest of the July sighting (Goddard and Rugh, 1998). These are only the fourth and fifth reliable sightings of right whales in the Bering Sea since 1975.[16] There are insufficient good quality photographs to confirm resightings of particular individuals, but increased search effort and reporting of sightings to the appropriate investigators is resulting in a better understanding of where these whales occur.

North Atlantic

The IWC recognizes two right whale stocks in the North Atlantic: western

[15] Carretta, J. 1997. NMFS Southwest Fisheries Science Center, La Jolla, CA 92038. Personal commun.

[16] Platform of Opportunity Program 1975-1996. Unpubl. data on file at NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

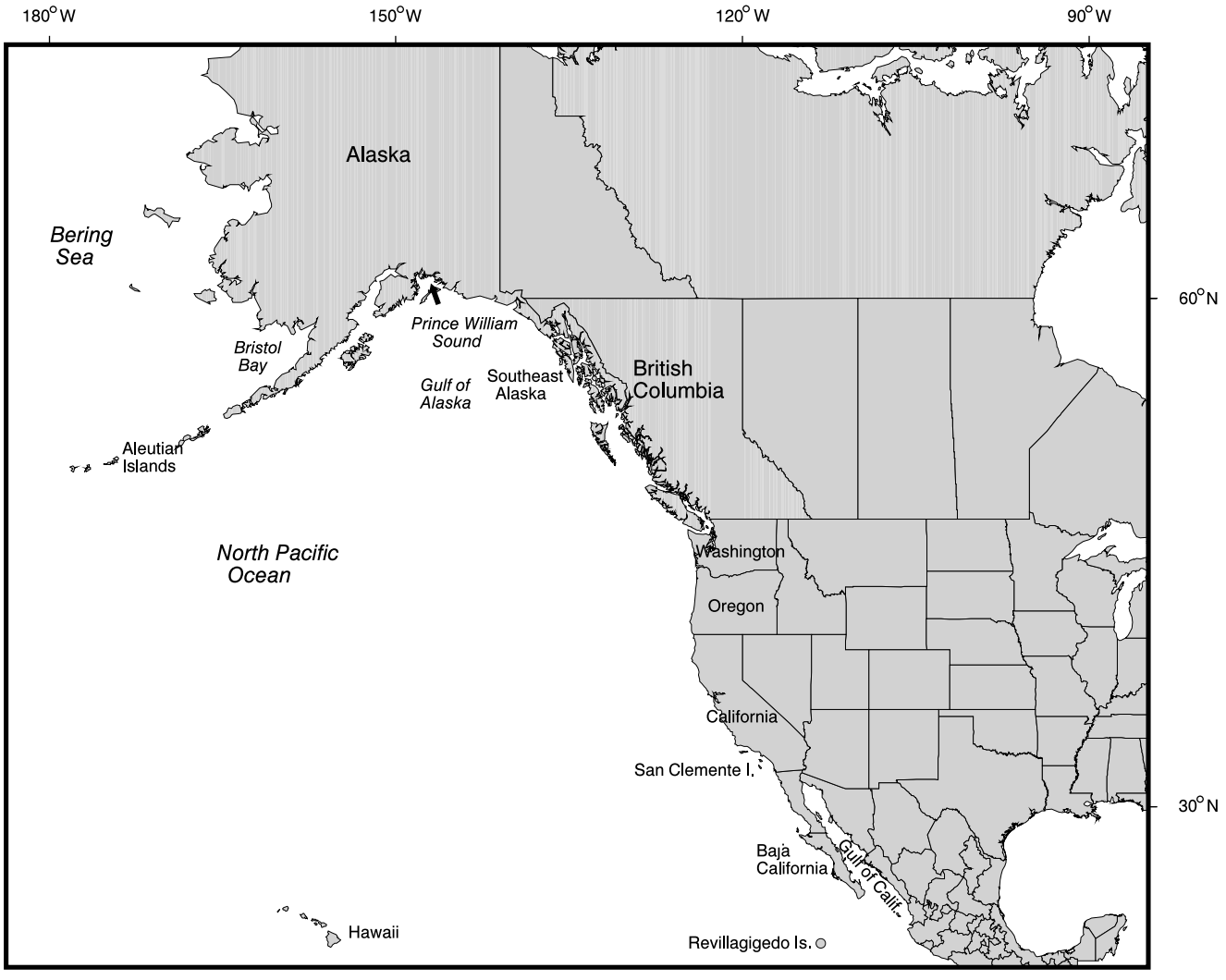


Figure 4.—Eastern North Pacific region.

and eastern (IWC, 1986a). The western stock migrates along the North American coast from Nova Scotia to Florida (Fig. 6). The eastern stock was historically hunted by whalers along coastal Iceland, off the British Isles, in the Bay of Biscay, and in Cintra Bay (Fig. 7). From whaling records, it appears that these whales migrated along the coast from northern Europe to northwest Africa. Today the distribution and migration patterns of this eastern stock are unknown. There is also evidence from whaling records that a third stock may have existed in the central Atlantic Ocean, migrating from east of Greenland to the Azores or Bermuda (Fig. 6, 7) (Reeves and Mitchell, 1986).

In the western North Atlantic, five areas of "high use" were identified in the final recovery plan for the northern right whale (Fig. 8) (Anonymous, 1991a):

1) Coastal Florida and Georgia (Sebastian Inlet, Florida to mid-coast Georgia),
2) The Great South Channel (east of Cape Cod),
3) Massachusetts Bay and eastern Cape Cod Bay,
4) The Bay of Fundy, and
5) Browns and Baccaro Banks (south of Nova Scotia).

These areas were designated as northern right whale critical habitat[17] due to their importance to the reproductive and feeding activities of the species (Kraus and Kenney[18]). Generally, right whales occur off New England in spring and

[17] Under Section 4 of the ESA, "critical habitat" must be designated "on the basis of the best scientific data available and after taking into consideration the economic impact." Critical habitat is defined under Section 3 of the ESA as "specific areas within the geographical area occupied by the species....on which are found physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection." Except under special circumstances, critical habitat shall not include the entire geographical area occupied by the species. (See also Fed. Regist. 50 CFR pt. 226, Designated critical habitat.)

[18] Kraus, S. D., and R. D. Kenney. 1991. Information on right whales (*Eubaleana glacialis*) in three proposed critical habitats in U.S. waters of the western North Atlantic Ocean. Final rep. to U.S. Mar. Mamm. Comm., Contr. T-75133740, T-75133753, 64 p., I-vi.

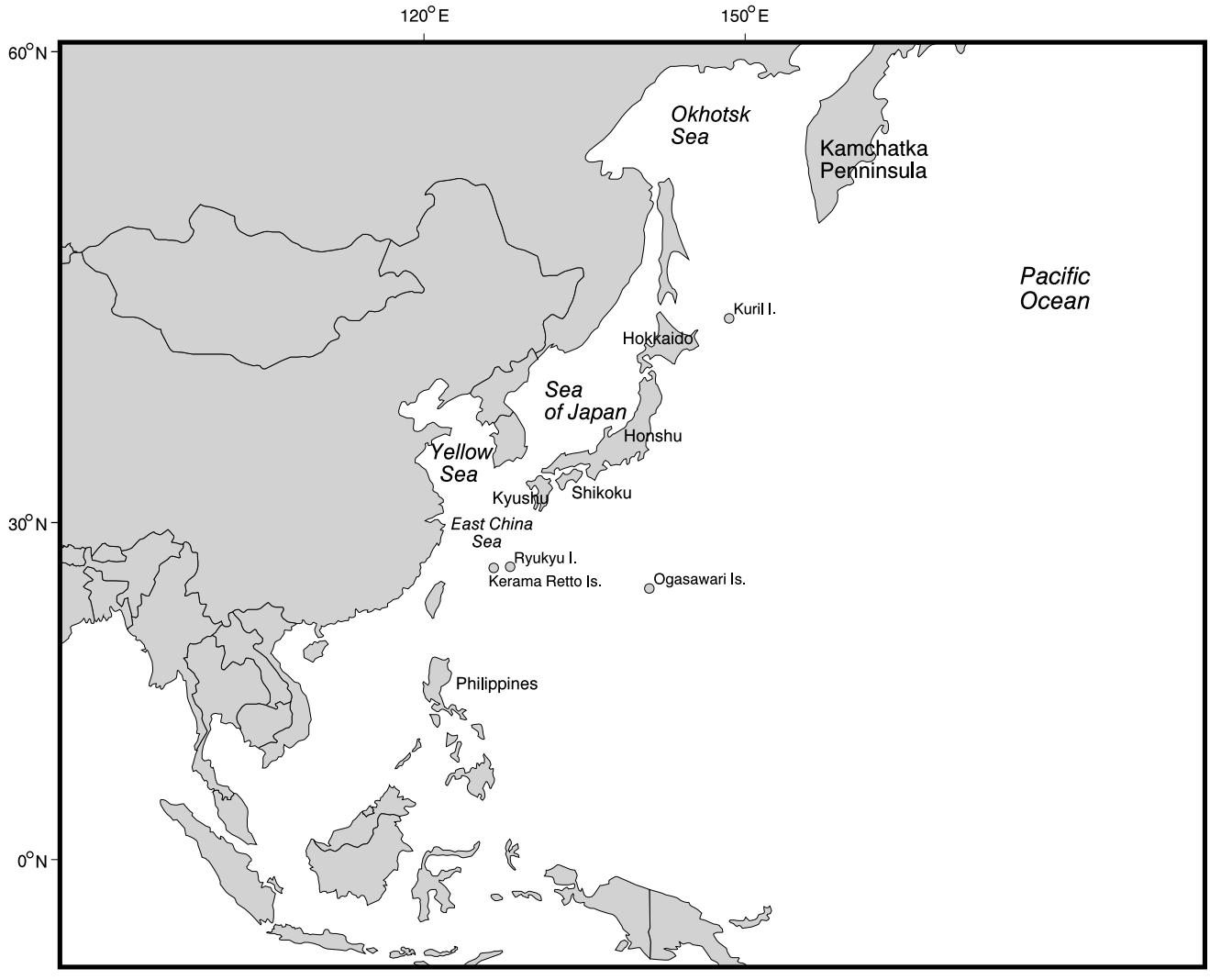


Figure 5.—Western North Pacific region.

early summer. Peak abundance occurs in the Great South Channel along the 100 m isobath and the paralleling thermal front in May (Kenney et al., 1995). In summer and fall, right whales occur farther north into Canadian waters (i.e. the Bay of Fundy and Browns and Baccaro Banks) (Mitchell et al., 1986). Whales found on Browns and Baccaro Banks are predominately adult males, while those in the Bay of Fundy are mostly mother-calf pairs and juveniles. In fall and early winter, the whales move south. Known wintering areas for this stock are along the southeastern U.S. coast, where calving takes place generally from January through March (Brownell et al., 1986; Kraus et al., 1986; Winn[19]). However, the wintering areas for an estimated 85% of the population are unknown (Kraus et al., 1986). Wintering areas may exist in the Gulf of St. Lawrence (Lien et al.[20]), Newfoundland (Beamish, 1981; Lien et al.[20]), Greenland, Bermuda (Payne and McVay, 1971), the Gulf of Mexico (Mead, 1986), and coastal waters of New York and New Jersey (Mead, 1986) (Fig. 6). Telemetry studies have revealed movement patterns of considerable length and duration (Mate et al.[21]). Similar studies may identify additional areas where right whales occur during winter.

Southern Hemisphere

The IWC recognized six stock areas in the Southern Hemisphere (Fig. 9) (Ohsumi and Kasamatsu, 1986; Dono-

[19] Winn, H. E. 1984. Development of a right whale sighting network in the southeastern U.S. Final report for Mar. Mamm. Comm. Contr. MM2324805-6. NTIS PB84-240548, 12 p.

[20] Lien, J., W. Ledwell, and J. Huntington. 1989. Whale and shark entrapments in inshore fishing gear in Newfoundland and Labrador during 1989. Unpubl. rep. to the Newfoundland and Labrador Dep. Fish.and Dep. Fish. Oceans, Can., 30 p.

[21] Mate, B. R., S. Nieukirk, R. Mesecar, and T. Martin. 1992. Application of remote sensing methods for tracking large cetaceans: North Atlantic right whales (*Eubalaena glacialis*). Final rep. to U.S. Dep. Inter., Minerals Manage. Serv., Alaska and Atl. OCS Reg. Off. Contr. 14-12-0001-30411, 167 p.

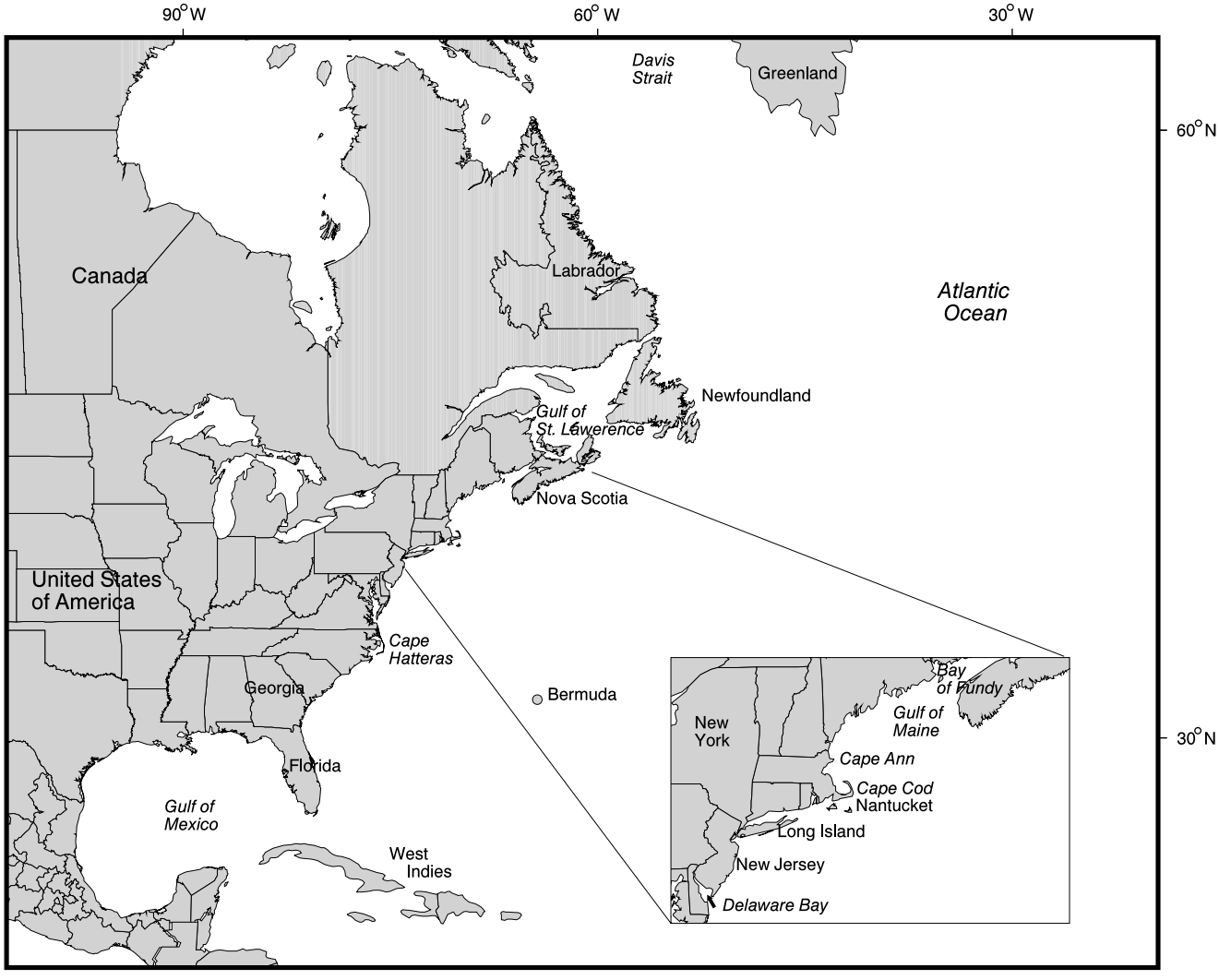


Figure 6.—Western North Atlantic region.

van, 1991). Eight areas were provisionally designated as management units during a 1986 IWC Right Whale Workshop, based loosely on Figure 9, catch histories, and distributional data (IWC, 1986a; Brownell et al., 1986). These eight units were used for mainly statistical purposes. During the 1998 Workshop on the Comprehensive Assessment of Right Whales, a critical evaluation was conducted regarding designation of right whale stock areas for management and statistical purposes. Information considered in this preliminary evaluation included catch histories, recent sighting data, photographic identification, stable isotope analysis, morphology, parasites, and genetic analysis (IWC[14]). This evaluation revealed a complex distribution. There were some preliminary designations of stock separations, but overall no final stock designations for the Southern Hemisphere were made.

Ohsumi and Kasamatsu (1986) reported high concentrations of right whales between the subtropical and Antarctic Convergences (Fig. 10), with the highest density of sightings south of western Australia. These Japanese sighting data indicated that the whales were found farthest south in January (the austral summer) and began moving north in February. This follows the seasonal residence patterns of whales studied in both South Africa and South America, where animals begin arriving on these wintering grounds from May through June, peaking in abundance during September, and then leaving these lower latitudes from December through January (Payne, 1986; Best and Scott, 1993).

Current and Historical Abundance

Most areas where right whales are known to occur have only incomplete catch histories, which confounds any estimates based on back-calculation and

Figure 7.—Eastern North Atlantic region.

catch per unit of effort (CPUE)[22] (IWC, 1986a). What is currently known about right whale abundance and accepted by the scientific community has been summarized in Table 4.

North Pacific

The only population estimate from the North Pacific is for the Okhotsk Sea, a northern right whale summering area. Data from surveys in 1989, 1990, and 1992 have yet to be fully analyzed, but a preliminary analysis indicates the population likely includes only a few hundred animals (Brownell[23]). This estimate has wide confidence intervals and may be negatively biased (IWC[14]).

North Atlantic

In the western North Atlantic, the current best estimate of 300 right whales (Knowlton et al., 1994) is based on photographic identification. Despite uncertainty surrounding this estimate (IWC[14]), it is clear that near failure of calf production from 1993 to 1995, increased calving intervals, and the relatively large number of human-induced mortalities, have contributed to a growing concern over the future of the North Atlantic right whale.

Southern Hemisphere

A preliminary best estimate for total Southern Hemisphere right whale abundance is "about 7,000," based on a tally of estimates from separate breeding areas (IWC[14]). During the 1998 Compre-

[22] From IWC (1992a:238): "In practice, use of 'CPUE' data was abandoned in each of the [*IWC*] management procedures during the later stages of the [*Revised Management Procedure*] development process, in view of the great difficulty usually experienced by the [*Scientific*] Committee in agreeing on the validity and interpretation of such data" [italics added].

[23] Brownell, Robert L. 1998. NMFS Southwest Fisheries Science Center, La Jolla, CA 98038. Personal commun.

Figure 8.—Western North Atlantic right whale "high-use areas": 1-coastal Florida and Georgia, 2-the Great South Channel, 3-Massachusetts and eastern Cape Cod Bay, 4-Bay of Fundy, 5-Browns and Baccaro Banks (Anonymous, 1991a).

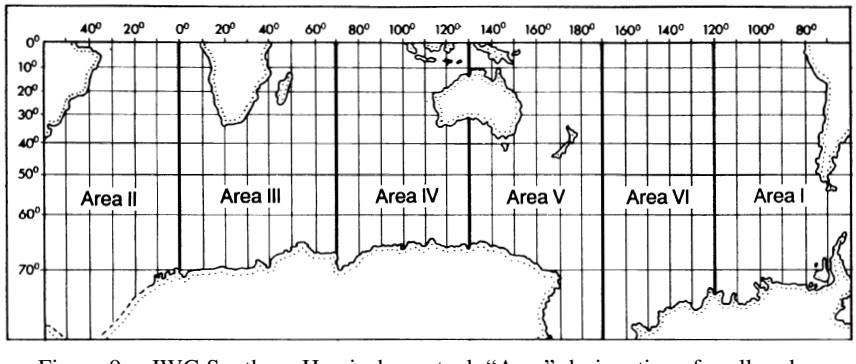


Figure 9.—IWC Southern Hemisphere stock "Area" designations for all endangered baleen whales (Donovan, 1991).

hensive Assessment Workshop, population models were constructed applying this preliminary current estimate and catch history data to a back-calculation simulation using various estimated rates of growth (IWC[14]).

Trends in Abundance

In the North Pacific, there are no data on trends in abundance, but the paucity of sightings strongly suggests there has been little or no growth in this population. As noted above, a number of sightings have occurred in recent years, but this may be linked to increased survey effort.

If the western North Atlantic right whale stock has grown since the period of commercial exploitation, the increase has been modest. The estimated annual

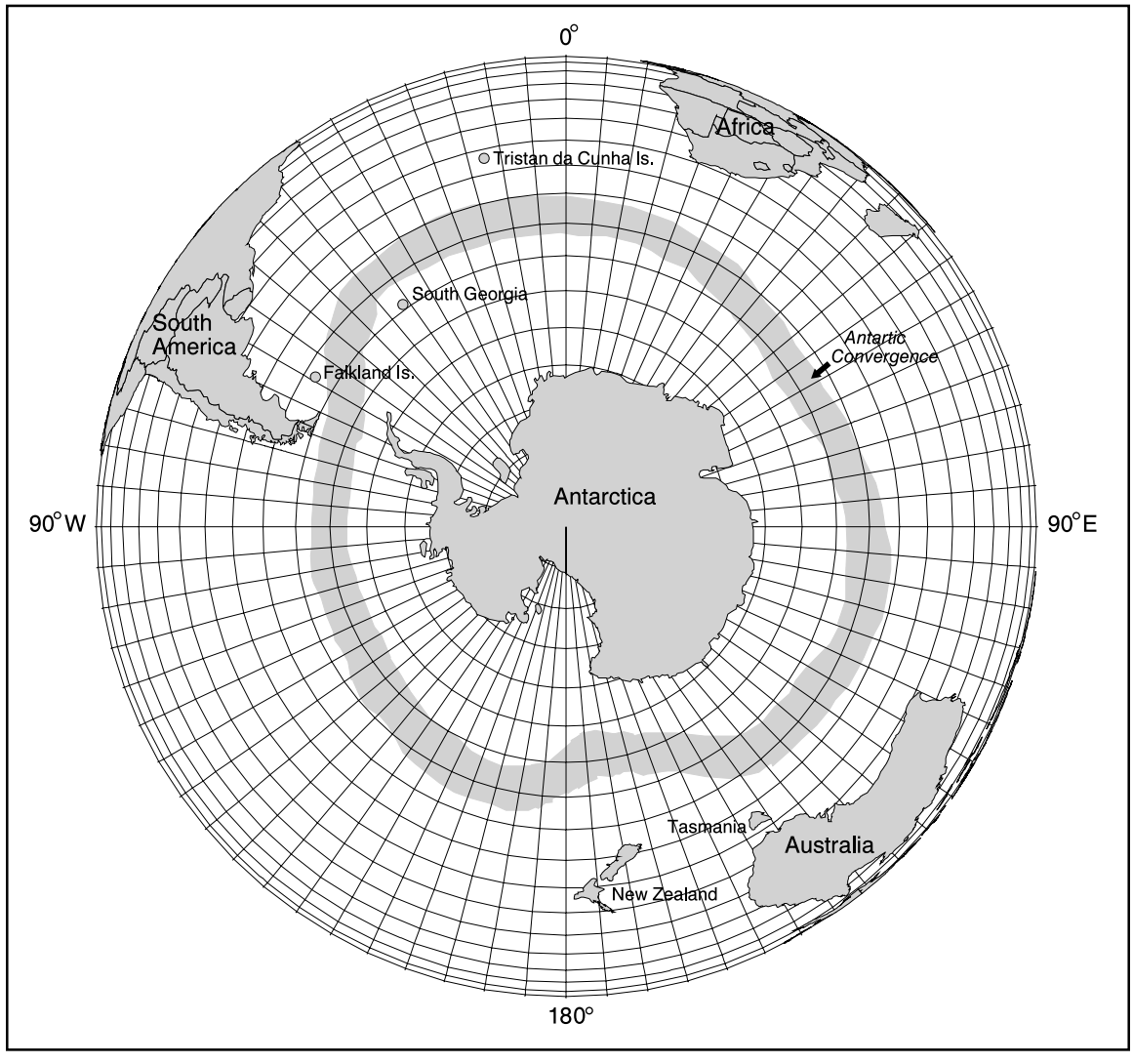


Figure 10.—Antarctic region; shaded area represents approximate location of Antarctic Convergence.

population growth rate from 1986 to 1992 was estimated at 2.5% (CV = 0.12) using photographic identification data (Knowlton et al., 1994). A significant increase in the calving interval for 1985–97 from 3.33 to 5.36 years (P<0.001) is further indication that growth and recovery may indeed be slow (Kraus et al.[24]). Kenney et al. (1995) reported a long-term increase in sighting rates within one feeding area of the western North Atlantic (i.e. Great South Channel) of 3.8% per year between 1979 and 1989, but extrapolation of this rate to the entire stock is inappropriate.

In contrast to northern right whale stocks, analysis of reproductive parameters and net recruitment rates for southern right whale stocks reveals a slow, steady rate of recovery. Best (1990) reported an average annual increase of 6.8% (95% CI = 4.6–9.0%) from 1971 to 1987 in right whales occurring off South Africa. However, Butterworth and Best (1990) point out that this stock only occupies 0.1 to 3.0% of its estimated initial (historical) carrying capacity. Right whale abundance increased by 11.7% (95% CI = 4.5–18.9%) to 13.0% (95% CI = 1.3–24.7%) per year from 1977 to 1987 (Bannister, 1990) in waters off western Australia. Payne (1990) reported an annual increase of 7.6% (SE 1.7%) from 1971 to 1986 in the population occurring off Argentina. These rates of increase must be viewed with caution, however, because they are based on only a portion of the population in any given year (i.e. not all mature females return to the calving grounds each year (IWC, 1986a; Best, 1993)), they are not based on any explicit stock designations, and they do not take into account per capita reproductive successes (IWC[14]).

[24] Kraus, S., P. K. Hamilton, R. D. Keeney, A. Knowlton, and C. K. Slay. 1998. Status and trends in reproduction of the North Atlantic right whale. Unpubl. doc. SC/M98/RW1 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

Figure 11.—A North Pacific right whale awaiting flensing at an Alaska whaling station, circa 1930. University of Washington Special Collections, Lagen Collection, negative UW17495.

Table 6.—Reported takes of North Pacific right whales after 1910 (Anonymous, 1991a).

Years	Takes	North Pacific region	Source
1910–30	123	Total (western and eastern)	Scarff, 1986
1917–37	24	Alaska, British Columbia	Brueggeman et al., 1986
1931–82	77	Western	Scarff, 1986

Historic Exploitation Patterns

North Pacific

In the North Pacific, Japan hunted right whales from as early as the 1570's (Omura, 1986) through 1964 (Du Pasquier, 1986). By the end of the 19th century, North Pacific right whales were rare (Fig. 11). Most of this depletion was due to pelagic whaling in the Sea of Japan (Omura, 1986), in the Okhotsk Sea (Kugler, 1986), and in the central and eastern North Pacific (Kugler, 1986) starting in the 1820's. The number of right whales reported taken after 1909 are summarized in Table 6. Right whales have been legally protected in the North Pacific and throughout their entire range since 1935 (Brownell[25]). However, recent reports indicate that Soviet whalers continued harvesting right whales until 1971 (Zemsky et al., 1995; Tormosov et al., 1998).

North Atlantic

Right whales were the first whale species to be exploited for commercial purposes. Their large size, slow, and fairly predictable movements, coastal distribution, and the fact that they floated when dead, made them the prime target of early European whalers (Cherfas, 1989). Basque whalers began harvesting the first eastern North Atlantic right whales in the Bay of Biscay (Fig. 7), off the Spanish coast, around the 1100's (Aguilar, 1986). When right whales in the Bay of Biscay became rare, the Basque whalers moved their operation to the Labrador and Newfoundland coasts where they took an estimated 25,000 to 40,000 right whales in an 80-year period (Aguilar, 1986). By the late 1600's, western North Atlantic right whales were severely depleted, causing the era of Basque whaling to come to a close (Barkham, 1984).

In the 1700's, English and Dutch whalers began commercial hunts for right whales off Spitsbergen, although by this time it appears that the whales were already scarce. In the late 1700's, the French expanded their search for right whales to the South Atlantic, eventually reaching Australia, New Zealand, and Chile (see below) (Cherfas, 1989).

Right whales were also hunted off the eastern United States from the 1600's to the early 1900's. The waters off eastern Canada, Cape Cod, Nantucket, Long Island, New Jersey, Delaware Bay, Georgia, and Florida all served as whaling grounds during this period

[25] Brownell, R. L. 1998. NMFS Southwest Fisheries Science Center, La Jolla, CA 92038. Personal commun.

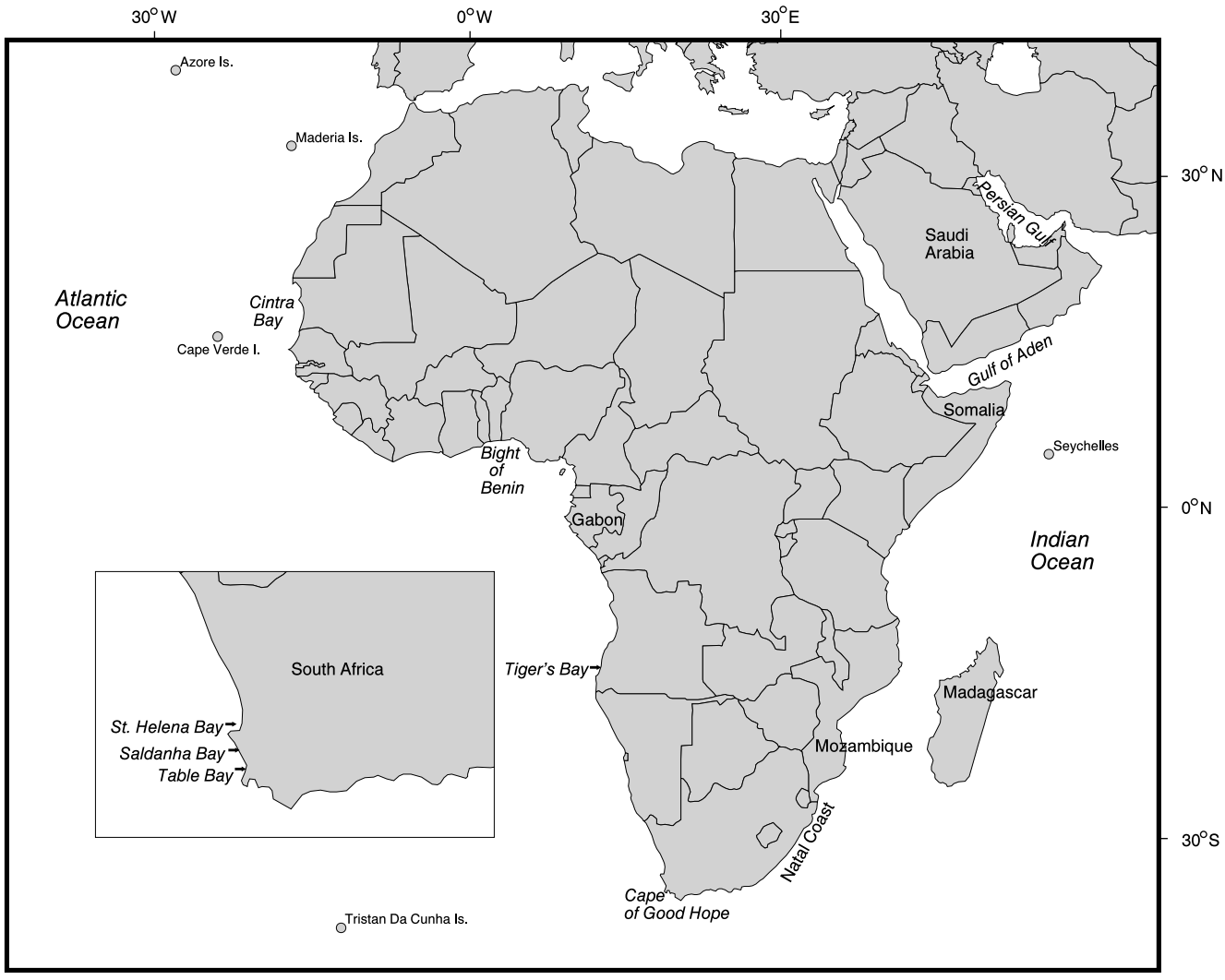


Figure 12.—Eastern South Atlantic/Western Indian Ocean region.

(Fig. 6) (Schevill and Moore, 1983; Reeves and Mitchell, 1986). Since catch records from this region are based on the quantity of commercial product sold rather than quantity of animals taken, no preexploitation trends or estimates of the population can be ascertained (Reeves and Mitchell, 1986). All stocks in the North Atlantic were severely depleted by the late 1700's (Kraus et al., 1988). However, between 1900 and 1982, a total of 138 or 141 right whales were taken from the eastern North Atlantic (Brown, 1986). The most intense episode of whaling in this region occurred off the Shetlands, Hebrides, and Ireland (Fig. 7) in the years 1906–10 (Brown, 1986). In addition, shore whaling along the U.S. east coast continued until 1924, with reported catches in the hundreds (Reeves and Mitchell, 1988).

Southern Hemisphere

When right whale numbers in the North Atlantic began to decline in the late 1700's, the French (and later the British) expanded their whaling operations to the South Atlantic (du Pasquier, 1986). From 1784 to 1794, under the command of mostly Nantucket whalemen, the coasts of Africa (e.g. Tiger's Bay, Saldanha Bay, Saint-Helena Bay, Table Bay), the Brazil Banks, and Falkland Islands were the focus of whaling for the French (Fig. 12, 13). During this 10 year period approximately 1,405 right whales were taken (du Pasquier, 1986). At this same time, shore-based open-boat whaling began along the South African coast and lasted until 1912. These South African operations took approximately 1,580 right whales (Best and Ross, 1986). By the 1830's, the right whale, which had been the principal target of all South African whaling, was in noticeable decline (Best, 1970).

From 1817 through 1837, the French increased whaling efforts on the Brazil Banks east of South America where, by 1837, they had taken an estimated 3,600 right whales (du Pasquier, 1986). After

Figure 13.—Western South Atlantic/Eastern South Pacific region.

1831, when the number of right whales being caught declined in this area, whaling effort was expanded to Tristan da Cunha (Fig. 12), the African coast, and eventually west into the Pacific via Cape Horn.

By 1837, the French were whaling off the Chilean coast, where roughly 2,400 right whales were taken by the French until the year 1868 (du Pasquier, 1986). These catches included a high number of mature females with some calves and juveniles, with potentially damaging consequences to the right whale's reproductive potential in these areas (Best and Ross, 1986; du Pasquier, 1986).

Whaling for right whales also occurred in the southern Pacific Ocean off Australia and New Zealand (Bannister, 1986a, b; Dawbin, 1986; du Pasquier, 1986). Local bay whaling, or shore-based operations off the southern coasts of western Australia, first began in the 1800's for both right and humpback whales (Bannister, 1986a). Pelagic whaling (conducted by the Australians, British, and French) began in these waters during the mid to late 1830's and lasted until the late 1880's. After 1835, some French whaling vessels moved from the South Atlantic via the Cape of Good Hope and began whaling (using both pelagic and bay operations), operating mostly off New Zealand in the bays off Banks Peninsula, and in the South Indian Ocean, the bays of southern Australia, Tasmania, and the Chatham Islands (Fig. 14) (du Pasquier, 1986). Dawbin (1986) estimated from whaling logbooks and station records that at least 26,000 right whales were caught in southwest Pacific waters between 1827 and 1899 by both bay and pelagic whalers. Dawbin (1986) also surmised that a major portion of world right whale catches (one-third or more) from 1835 to 1846 were taken off southeastern Australia and New Zealand. This large catch, however, was followed by a rapid decline in the number of whales caught: 300 whales after 1846, and less than 50 whales after 1862 (Dawbin, 1986). In waters off southwestern Australia, a similar pattern of rapid decline occurred

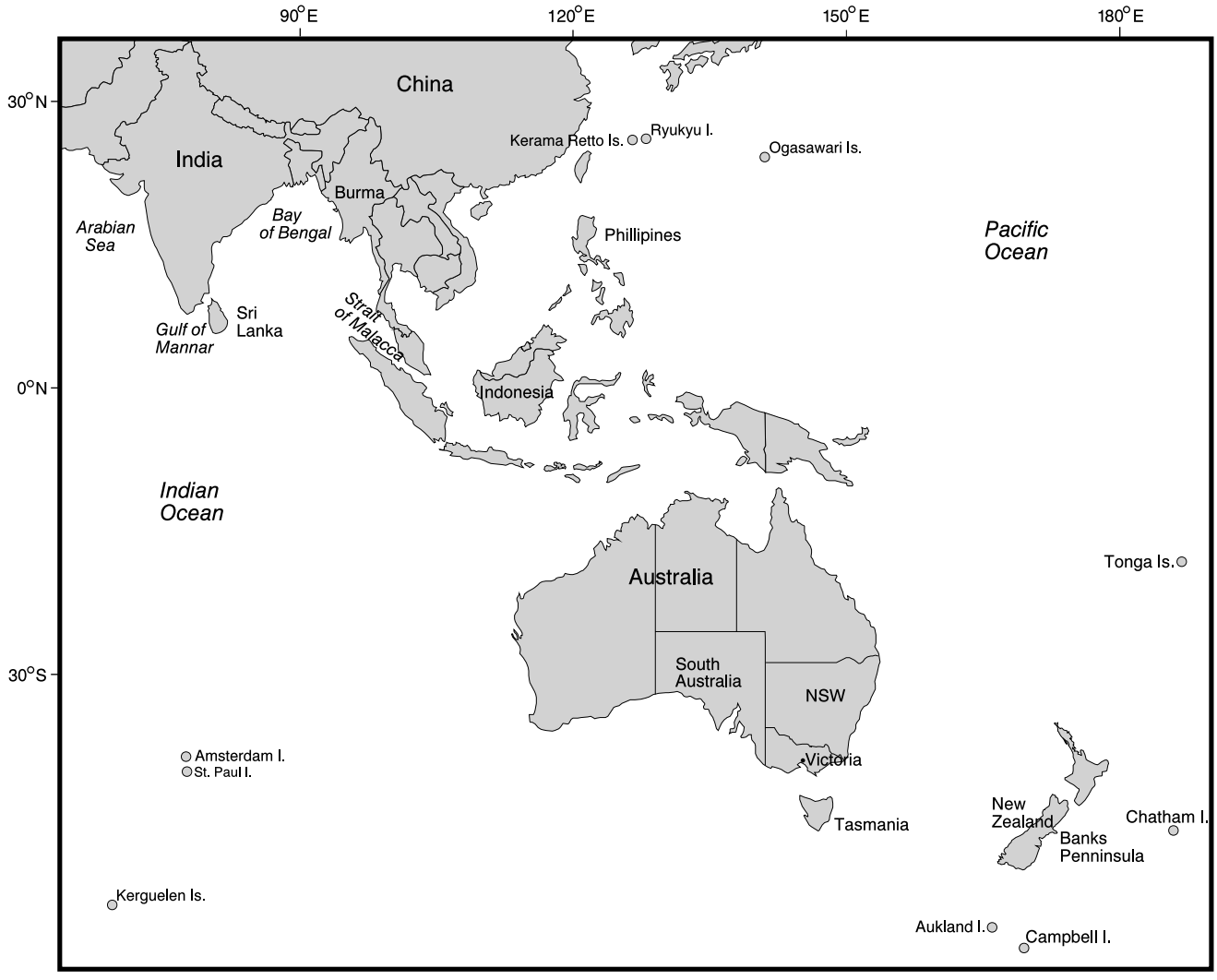


Figure 14.—Eastern Indian Ocean/Western South Pacific region.

after a peak pelagic catch between 1838 and 1849 (Bannister, 1986b). In the South Pacific, as in the South Atlantic, the high percentage of female and immature whales in the catches (particularly in the bay-type operations) most likely had long-term effects on the reproductive success of right whales in these areas.

Current Exploitation

Currently, the IWC has assigned "Protected Stock" status to all stocks of right whales (IWC, 1995b). The catch quota on these whales is therefore set at zero for all signatory nations of the IWC.

Recently revealed Soviet catch records show that at least 3,368 southern right whales were harvested between 1951 and 1971 (Tormosov et al., 1998). These records are still incomplete, and no information on the exact geographic distribution of these catches has been reported although they are known to have occurred in both the North Pacific and the Southern Hemisphere (Zemsky et al., 1995).

Life History and Ecology

Feeding

The feeding season for right whales occurs in the spring and fall in both hemispheres, where they take advantage of large concentrations of zooplankton, primarily copepods, found in temperate to subarctic waters. Oceanographic and bathymetric features, such as relatively cool water temperatures and depths of 100–200 m adjacent to steeply sloping bottom topography, also seem to correspond to the utilization of certain areas for feeding (Winn et al., 1986).

In the North Pacific, right whales feed primarily on copepods of the genus *Neocalanus*, but they are also known to prey on a variety of zooplankton species, namely *Calanus marshallae*, *Euphausia pacifica*, and *Metridia* spp. (Omura, 1986). In the North Atlantic, *Calanus marshallae* spp. are the primary copepod prey (Kraus et al., 1988; Wishner et al., 1988; Murison and

Gaskin, 1989; Mayo and Marx, 1990), with *Centropages, Pseudocalanus* (Mayo and Marx, 1990), juvenile euphausiids of the genus *Thysanoëssa* and *Meganyctiphanes* also found in the diet (Clapham, 1999). Southern right whales also feed upon calanoid copepods, as well as on the pelagic post-larval stage of *Munida gregaria* (Matthews, 1932), and krill, *Euphausia superba* (Braham[3]).

Interspecific competition may limit the prey available to northern right whales (Anonymous, 1991a; Kraus et al., 1988). In both the eastern North Pacific and the North Atlantic, sei whale, *Balaenoptera borealis,* distribution is sympatric with northern right whale distribution. Because both species feed on small zooplankton species, there may be some competition (Mitchell, 1975a). It is possible that some fish species also compete with right whales in the Gulf of Maine, including sandlance, *Ammodytes* spp.; herring, *Clupea* spp.; Atlantic mackerel, *Scomber scombrus*; river herrings (shad, bluebacks, *Alosa* spp.); menhaden, *Brevoortia tyrannus*; and basking sharks, *Cetorhinus maximus*. These fish share the northern right whale's summer distribution and to some extent utilize the same zooplankton prey species (Anonymous, 1991a).

Reproduction

Most right whale stocks utilize shallow, coastal waters for nursery areas. Calving takes place between December and April in the North Atlantic (Kraus et al.[26]) and between late July and late October in the Southern Hemisphere (Best, 1994a). Throughout their range, females give birth to their first calf around 9 years of age (Hamilton et al.[27]; Cooke et al.[28]; Best et al.[29]). Calves are born at 5.5–6.0 m in length (Best, 1994a). The calving interval for right whales is between 2 and 7 years, with means ranging from 3.12 (95% CI 3.05–3.17) to 3.6 years (95% CI [28]; Best et al.[29]; Burnell[30]). In the North Atlantic, there was a significant increase ($P<0.001$) in the calving interval from 1985 to 1997 from 3.33 to 5.36 years (Kraus et al.[26]). Gestation lasts from 357 to 396 days in southern right whales (Best, 1994a), and weaning seems to be variable, reported as 8–17 months in northern right whales (Hamilton and Marx, 1995).

Virtually nothing is known about reproductive parameters in North Pacific right whales. There have been no recently confirmed sightings of young right whales in the North Pacific; only the report of a relatively small whale in 1996 (Goddard and Rugh, 1998). In the western North Atlantic, a mean of 11.2 (SE = 0.90) calves were born annually between 1980 and 1992 (Waring et al., 1998). The 1986 Right Whale Working Group (IWC, 1986a) provided a mean gross annual reproductive rate (GARR) to aid in the calculation of population growth rates (Brownell et al., 1986). This GARR represents the number of young of the year as a proportion of the entire population. For the North Atlantic, the GARR has been estimated at 0.070 to 0.092 calves per year (Brownell, 1986; Knowlton and Kraus[31]).

Natural Mortality

Little is known about natural mortality in this species. North Atlantic right whales bearing scars from killer whale, *Orcinus orca*, attacks have been photographed (Kraus, 1990), but the number of whales killed by this predator is unknown. Using photo-identification data from the western North Atlantic stock, Kraus (1990) calculated an average natural mortality rate of 17% per year in first-year right whales, while second- through fourth-year whales had an average natural mortality rate of 3% per year.

An "unusual mortality" event occurred in the western North Atlantic from January through March 1996, when there were eight reported right whale mortalities off the southeastern United States. Of these, only four were examined for cause of death, with three showing signs of human interaction (e.g. vessel collision and fisheries entanglement). Waring et al. (1998) cautioned against making any assumptions about this event being related to increased mortality in the population as a whole. However, there were at least three calf mortalities in 1996 which may indicate fairly high neonatal mortality (Wang[32])

Human-related Mortality

As noted above, the primary factor influencing the recovery of the right whale involves their occurrence in coastal habitats. This aspect of their distribution places them in direct contact with shipping traffic, fishery operations, coastal oil and gas development, and other human activities. The five factors influencing the recovery of North Pacific and western North Atlantic right whale stocks are summarized in Table 7.

Fisheries Interactions

The magnitude and nature of fisheries interactions on right whales is not completely known. Apparently, some whales survive an entanglement, but in some cases, injuries not initially lethal may result in gradual weakening of entangled individuals, making them more vulnerable to some other direct causes of mortality (Kenney and Kraus, 1993).

Data are scant for North Pacific right whales: two fishery-related mortalities have been reported from Russian waters (Anonymous, 1991a; Kornev, 1994).

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[26] Kraus, S. D., R. D. Kenney, A. R. Knowlton, and J. N. Ciano. 1993. Endangered right whales of the southwestern North Atlantic. Rep. to Minerals Manage. Serv., 1110 Herndon Pkwy., Herndon, VA 22070. Contr. 14-35-0001-30486.

[27] Hamilton, P. K., A. R. Knowlton, M. K. Marx, and S. D. Kraus. 1998. Age structure and longevity in North Atlantic right whales (*Eubalaena glacialis*). Rep. submitted to Mar. Ecol. Prog. Ser.

[28] Cooke, J. G., R. Payne, and V. Rowntree. 1998. Updated estimates of demographic parameters for the southern right whales (*Eubalaena australis*) observed off Peninsula Valdes, Argentina. Unpubl. doc. SC/M98/RW12 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

[29] Best, P. B., A. Branadao, and D. Butterworth. 1998. Demographic parameters of southern right whales off South Africa. Unpubl. doc. SC/M98/RW16 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

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Table 7.—Factors possibly influencing the recovery of right whale stocks under the ESA (1973) § 4 (a)(1),1992 Amend. (eastern North Atlantic data is not available).

Factor	North Pacific	Western North Atlantic	Southern Hemisphere
1. Present or threatened destruction or modification of habitat	Offshore oil and gas development (e.g. noise disturbance, oil spills)	Offshore oil and gas development; pollution; channel dredging	Offshore oil and gas development; pollution; channel dredging
2. Overutilization for commercial, recreational,scientific, or educational purposes	Unknown	Whale watching and scientific research vessel traffic	Whale watching vessel traffic
3. Disease or predation	Unknown	Unknown	Unknown
4. Inadequacy of existing regulatory mechanisms	Unknown	Current vessel traffic and fisheries regulations	Unknown
5. Other natural or man-made factors	Entanglement in fishing gear (e.g. drift gillnets)	Vessel collisions; entanglement in fishing gear (e.g. gillnets, lobster pots, seines, weirs)	Vessel collisions

In the western North Atlantic, an estimated 57% of right whales bear scars and injuries indicative of fishing gear entanglement (Kraus, 1990). Gillnets, lobster pots, seines, and fish weirs are the primary gear types that entangle right whales (Anonymous, 1991a; Anonymous[33]). Entanglement in fixed gear was estimated to account for 7% of the known mortality in right whales in the western North Atlantic from 1970 through early 1993 (Kenney and Kraus, 1993). Fisheries monitored by the NMFS from 1991 through 1995 had a mean annual mortality rate of 0.4 (CV = 0.33) right whales (Waring et al., 1998). However, a review of sighting data outside the observed fisheries (from records maintained by the New England Aquarium and the NMFS Northeast Regional Office) for the years 1991 through parts of 1996, indicated an estimated annual mortality rate (due to fisheries interactions) of 1.1 right whales (Waring et al., 1998). These rates are in contrast to the IWC conclusion in 1996 that approximately one right whale dies per year worldwide as a result of fishing gear entanglement. In response to this high level of mortality (relative to the current population level), Take Reduction Teams have been established. These teams develop take reduction plans which include measures to reduce incidental take of marine mammals in North Atlantic fisheries to below the current calculated removal level (Anonymous, 1997). In the 1996 plan, the Atlantic Offshore Cetacean Take Team recommended prohibiting pair trawl, driftnet, and longline fisheries from operating in designated critical right whale habitat (i.e. Cape Cod Bay, the Great South Channel, and southeast U.S. calving grounds) and during periods of peak right whale occurrence (Anonymous, 1997). In addition, the Atlantic Large Whale Take Reduction Team recommended gear modifications to gillnets and lobster pot lines, as well as time-area fishing closures in known right whale habitat (Anonymous, 1997). As a result of stranding and entanglement records of large whales from 1990 to 1994, the NMFS changed the classification of the Gulf of Maine and U.S. Atlantic lobster pot fisheries from Category III to Category I.[34]

Vessel Collisions

The greatest known cause of mortality among right whales in the North Atlantic is collision with ships. Out of 27 documented mortalities in the North Atlantic from 1970 through 1991, 22% were caused by ship propellers severing the tail stock, spine, or causing mortal wounds to the head region (Anonymous, 1991a). From 1991 through the beginning of 1993, an additional three mortalities were reported in the North Atlantic as a result of collisions with vessels (Kenney and Kraus, 1993). From 1991 to 1996, the reported average mortality and serious injury rate due to vessel collisions was three per year (Waring et al., 1998). The low incidence (7%) of photographically identified whales showing scars and wounds from ship propellers compared to the high rate of ship propeller wounds in stranded animals indicates that most interactions between ship and whale are fatal to the whale (Kraus, 1990). Increased monitoring and warning of vessels operating in the presence of right whales, particularly in areas of high calf density, such as in southeastern U.S. coastal waters, may be important components in efforts to reduce this form of mortality (Anonymous, 1997). Such monitoring has begun in the western North Atlantic, where a real-time aerial warning system, educational pamphlets, and delineation of critical right whale habitat on nautical charts are all part of the effort to reduce ship strikes (Slay et al.[35]). Vessel-related mortality rates for stocks in the North Pacific are unknown.

In the Southern Hemisphere, three fatal ship strikes were reported from Brazil from 1989 to 1993, and 10 fatal ship strikes were reported from South Africa from 1983 to 1997 at the IWC Comprehensive Assessment Workshop[14]. The Workshop concluded that

[33] Anonymous. 1992. Proposed regime to govern interactions between marine mammals and commercial fishing operations: draft legislative environmental impact statement. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Off. Protected Resour., Silver Spring, MD 20910.

[34] A Category III fishery classification is assigned to those fisheries in which it is highly unlikely that marine mammals will be incidentally taken during a 20-day period, while a Category I fishery classification is assigned to a fishery that has documented frequent incidental take and in which it is highly likely that more than one marine mammal will be incidentally taken by a randomly selected vessel of the fishery during a 20-day period. See also Federal Register (1997), Taking of marine mammals incidental to commercial fishing operations; Atlantic Large Whale Take Reduction Plan regulations. Fed. Regist. 62(140), 50 CFR pt. 229.

[35] Slay, C. K., S. D. Kraus, P. K. Hamilton, A. R. Knowlton, and L. A. Conger. 1998. Early warning system 1994-1997. Aerial surveys to reduce ship/whale collisions in the North Atlantic right whale calving ground. Unpubl. doc. SC/M98/RW6 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

many of the problems faced by right whales in the North Atlantic with regard to ship traffic may also be faced by right whales in the Southern Hemisphere. Therefore, recommendations were made regarding the control of shipping activity in areas where the density of right whales is known or critical right whale habitat has been designated (IWC[14]).

Habitat Destruction

A continued threat to the coastal habitat of the right whale in both the North Atlantic and North Pacific is the undersea exploration and development of techniques for mining mineral deposits, as well as the dredging of major shipping channels. Offshore oil and gas activities have been proposed off the U.S. middle and south Atlantic coasts and are currently being conducted in the Bering Sea and in eastern North Pacific waters (Anonymous, 1991a). Right whales also frequent coastal waters where dredging and its associated disposal operations occur on a regular basis, such as along the southeastern U.S. coast. It is unknown to what extent these activities affect right whales. It appears that their level of sensitivity to noise disturbance and vessel activity is related to the behavior and activity in which they are engaged at the time (Watkins, 1986; Anonymous, 1991a), but further study is necessary.

Pollution

Relatively low levels of organochlorine contaminants have been found in right whale blubber, most notably PCB and DDT (Woodley et al., 1991). Contaminant levels are low because baleen whales feed lower on the food web than odontocetes and follow seasonal migration patterns that decrease their exposure to localized contaminants. The levels at which these contaminants occur in baleen whales are likely too low to be linked to any direct mortality or impaired reproductive functioning, and therefore they are not considered primary factors in slowing the recovery of any stocks of large whales (O'Shea and Brownell, 1994). However, some contaminants affect phytoplankton and zooplankton density and distribution, and therefore the energetics and distribution of right whales may be affected (Anonymous, 1991a).

Whale Watching and Small-boat Regulations

Concern has been raised over the impacts of whale-watching activities and scientific field research on right whale aggregations, particularly in the western North Atlantic (i.e. Cape Cod Bay and lower Bay of Fundy) (Anonymous, 1991a). These activities, like the industrial shipping activities discussed above, have the potential to disturb right whales or disrupt their activities. The effect of these human activities on right whales is not known. Nonetheless, to diminish the likelihood of vessel disturbance and to reduce the risk of a vessel striking a whale, the NMFS issued regulations in 1997 that prohibit the approach of any vessel, not in possession of a special NMFS permit, within 500 yards of a right whale in waters off the U.S. east coast (Anonymous, 1987; Federal Register[36]).

Classification Status

The northern right whale was listed as endangered under the ESA in 1973 and designated depleted under the MMPA. This status applies to all stocks in U.S. waters (Anonymous, 1994b). Worldwide, all right whale stocks are designated as "Protected Stock" by the IWC. Under this designation, the IWC recognizes that all stocks of right whales are 10% or more below their MSY level (IWC, 1995b).

Threats to right whales continue to exist (Table 7); however, there is incomplete information regarding potential threats in the eastern North Atlantic. Any reevaluation of northern and southern right whale status awaits collection of more reliable information on abundance, distribution, and threats from human activities in the North Pacific, eastern North Atlantic, and Southern Hemisphere, as well as the development of objective delisting criteria.

The eastern North Pacific right whale stock clearly remains severely depleted. Virtually nothing is known about its current size, trends in abundance, distribution, or migration patterns. The size of this stock is thought to be very small, but there are no reliable estimates of abundance. The classification of this stock should not change at this time and is not likely to change in the foreseeable future. Preliminary survey data from 1989, 1990, and 1992 in the western North Pacific yields a preliminary estimate of only a few hundred animals (Brownell[23]).

As noted above, the size of the western North Atlantic stock is estimated at about 300 individuals. This number has not increased significantly since the species received international protection in 1935. It is generally agreed that the current rate of population increase is low, about 2.0–2.5% annually (IWC[14]). In addition, the western North Atlantic population has exhibited annual oscillation in recruitment, a near-failure of calf production from 1993 to 1995, and a significant increase in calving intervals between 1985 and 1997 (IWC[14]). Also, mortality and serious injury from human activities continue to slow recovery. In this regard, the potential biological removal (PBR) level[37] for the North Atlantic right whale, estimated at 0.4 whales per year (Waring et al., 1998), has been exceeded for each of the last 5 years. From 1991 to September 1996 the estimated average annual human-induced mortality and serious injury rate (both from fishery and nonfishery related activities) was three whales (Waring et al., 1998).

The northern right whale recovery plan (Anonymous, 1991a) stated that recovery was likely to be slow and estimated that even under the best conditions, it would likely take more than 100 years for the species to recover to preexploitation levels in both the Pacific and Atlantic Oceans. Therefore, with regard to the western North Atlantic stock, the plan's interim goal was to outline a strategy for changing the sta-

[36] Federal Register. 1996. Regulations governing the taking and importing of marine mammals. Fed. Regist. 50 CFR pt. 216.

[37] Under the 1994 MMPA reauthorization, PBR is defined as the product of minimum population size (N_{min}), half the maximum productivity rate, and a specified "recovery" factor. For endangered species, the recovery factor is typically 0.1. And for cetaceans, the default maximum net productivity rate is 4%, if a current, statistically reliable maximum productivity rate is not available.

tus of the population from endangered to threatened. This strategy recommended that a classification change should only be considered after:

1) The size of the population recovered to a level of 6,000 individuals,
2) The population increased steadily over a period of 20 years or more at an average annual net recruitment rate of at least 2% per year, and
3) An effective program was in place to reduce human-related mortality and ensure that deterioration of essential habitat was not likely to occur, thereby allowing abundance to increase to the optimum sustainable population level.

New data on population size and trends in abundance have been collected since the 1991 recovery plan and should be used in revising Criteria 1 and 2. Criteria 3 should also be reevaluated, since programs are in place to facilitate the recovery of this population, but threats from human activities remain (Table 7). Given existing and continuing threats to northern right whales and little or no evidence of moving toward attaining population increase criteria, the endangered status of the western North Atlantic right whale stock should remain unchanged for the foreseeable future.

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