

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; Rice¹²), 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; Rice¹²). 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* Muller 1776, and the Southern Hemisphere right whales will be referred to as *E. g. australis* Desmoulin 1822 after Rice¹² and IWC designations.

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.

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.



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 As-

essment Workshop¹⁴, 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 (IWC¹⁴).

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.

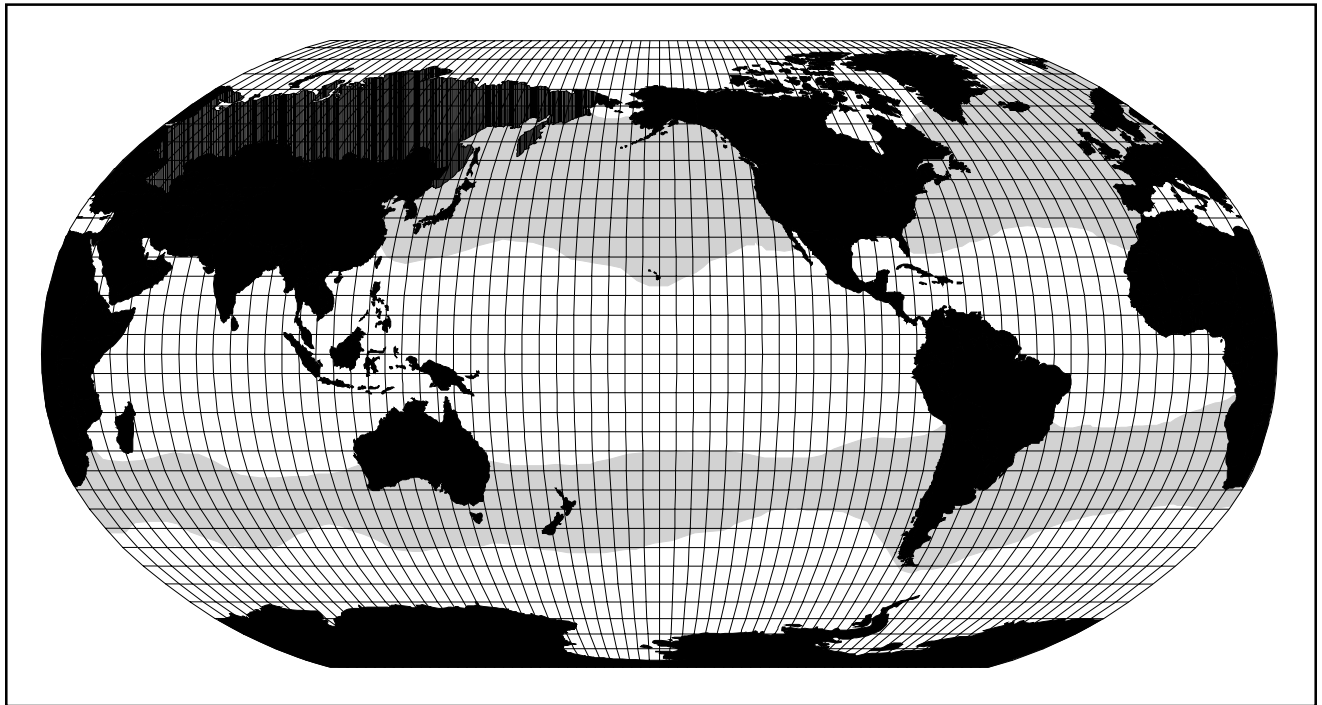


Figure 3.—Historic worldwide right whale distribution. Adapted from Braham and Rice (1984).

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 (Carretta¹⁵). In July 1996, a group of right whales was sighted in western Bristol Bay (Fig. 4) (Goddard and Rugh, 1998). The group consisted

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

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

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 habitat¹⁷ due to their importance to the reproductive and feeding activities of the species (Kraus

and Kenney¹⁸). 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.

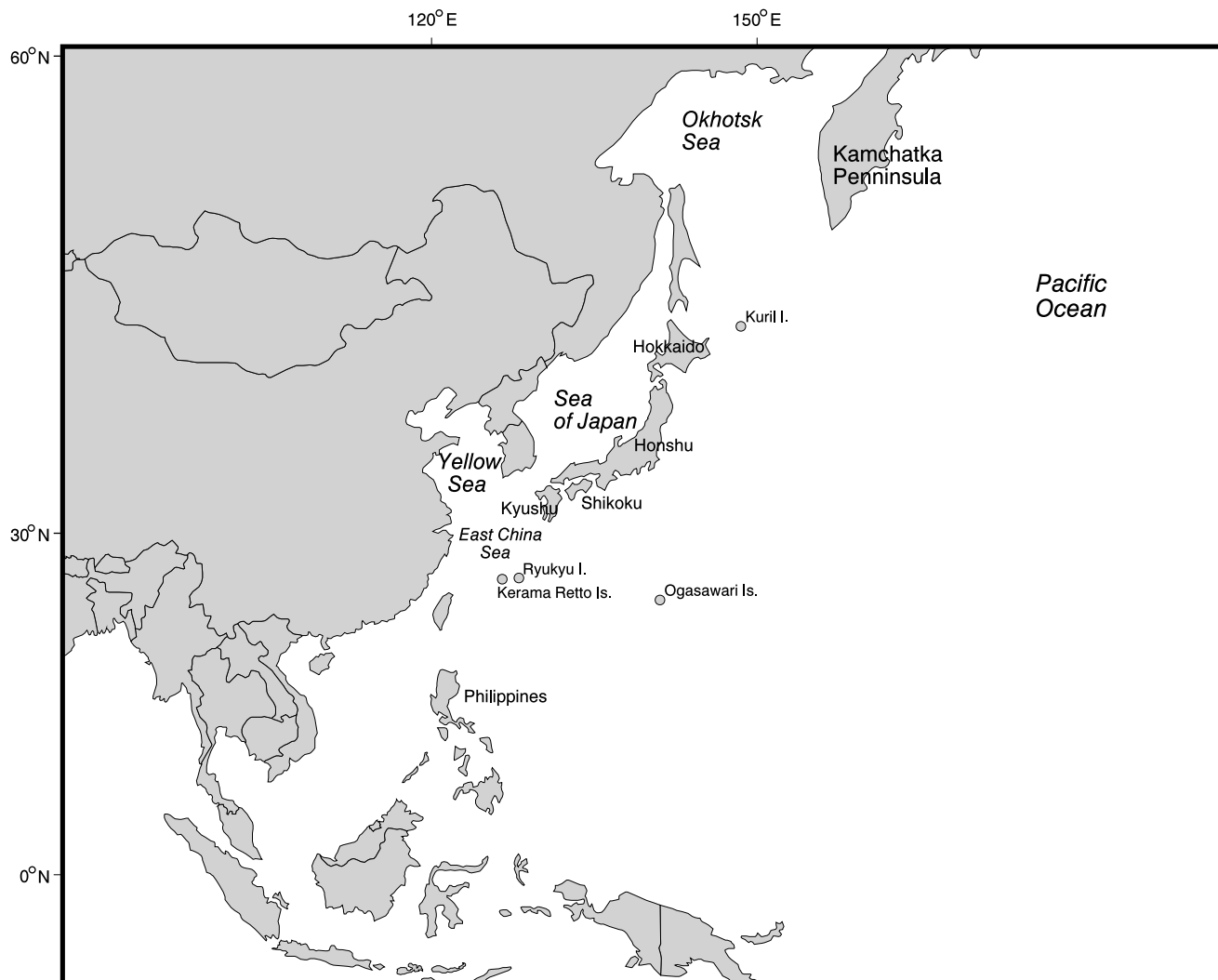


Figure 5.—Western North Pacific region.

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; Winn¹⁹). 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,

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.

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-

²¹ Mate, B. R., S. Nieuwkerk, 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 (IWC¹⁴). 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 mov-

ing 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,

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].

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 (Brownell²³). This estimate has wide confidence intervals and may be negatively biased (IWC¹⁴).

North Atlantic

In the western North Atlantic, the current best estimate of 300 right whales

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

(Knowlton et al., 1994) is based on photographic identification. Despite uncertainty surrounding this estimate (IWC¹⁴), 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 (IWC¹⁴). During the 1998 Compre-



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).

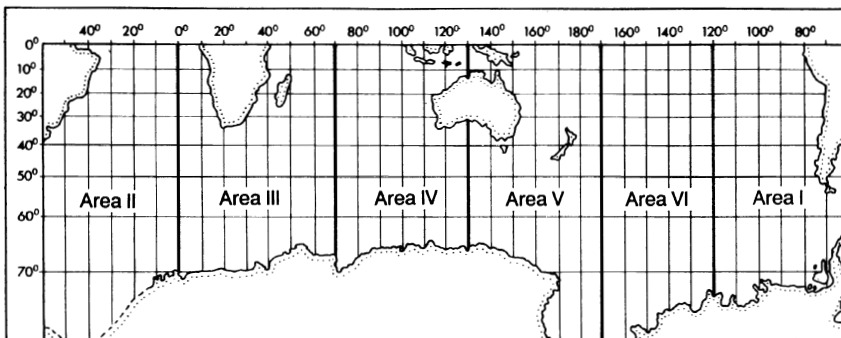


Figure 9.—IWC Southern Hemisphere stock “Area” designations for all endangered baleen whales (Donovan, 1991).

lation simulation using various estimated rates of growth (IWC¹⁴).

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

hensive Assessment Workshop, population models were constructed applying this preliminary current estimate and catch history data to a back-calcu-

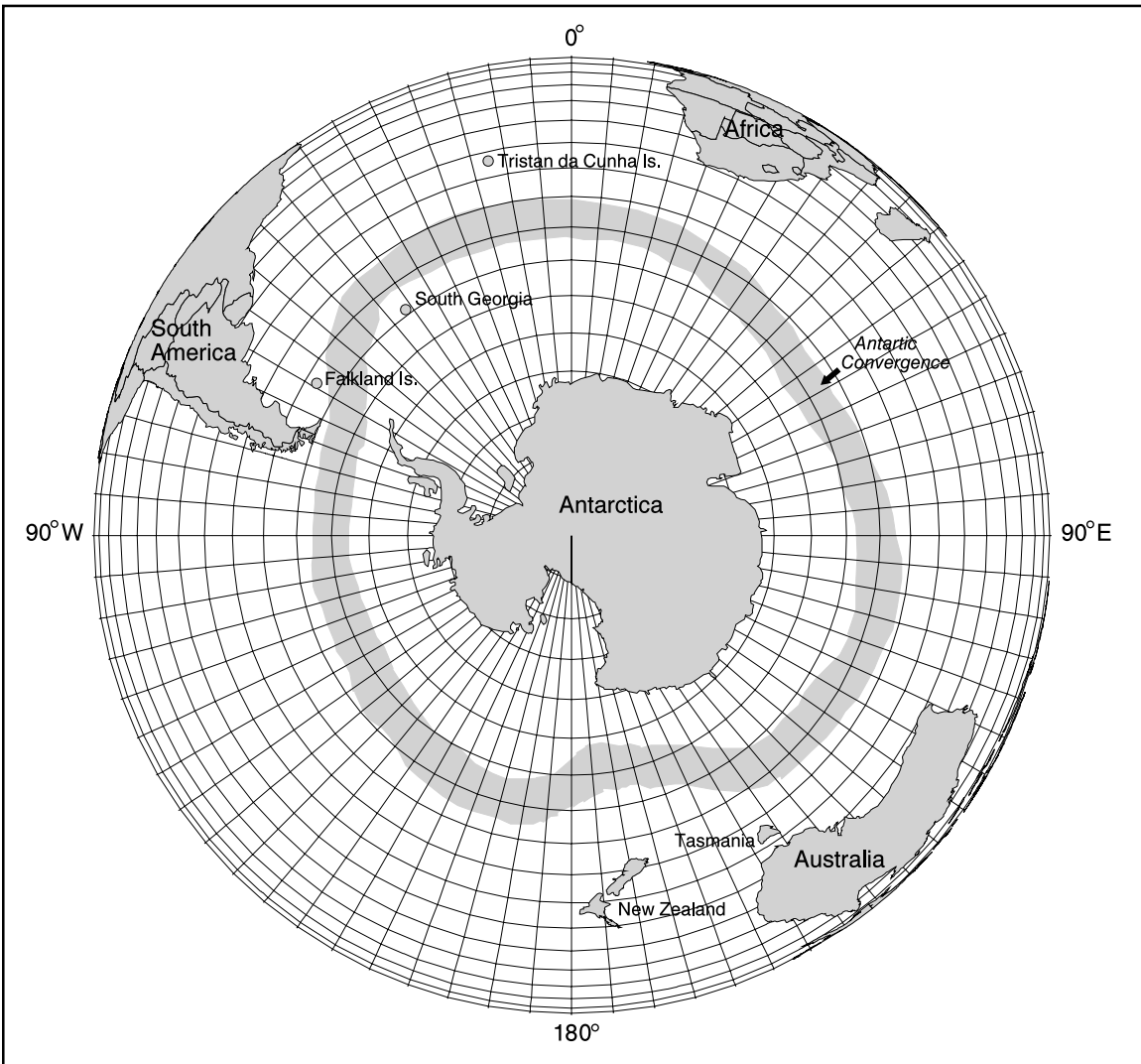


Figure 10.—Antarctic region; shaded area represents approximate location of Antarctic Convergence.

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

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.

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 capac-

ity. 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 (IWC¹⁴).



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 (Brownell²⁵). 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

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

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

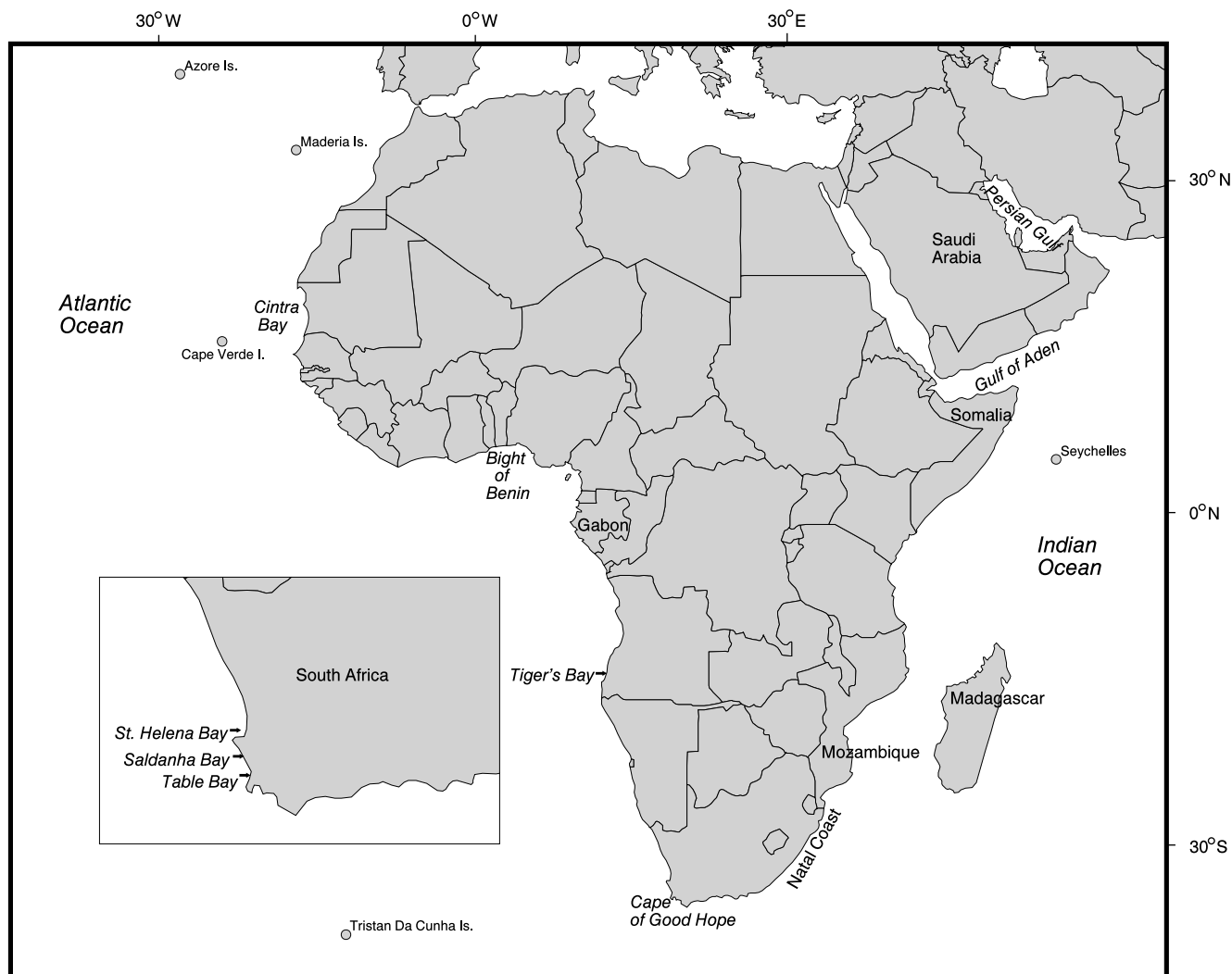


Figure 12.—Eastern South Atlantic/Western Indian Ocean region.

(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 whalers, 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 south-

ern 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

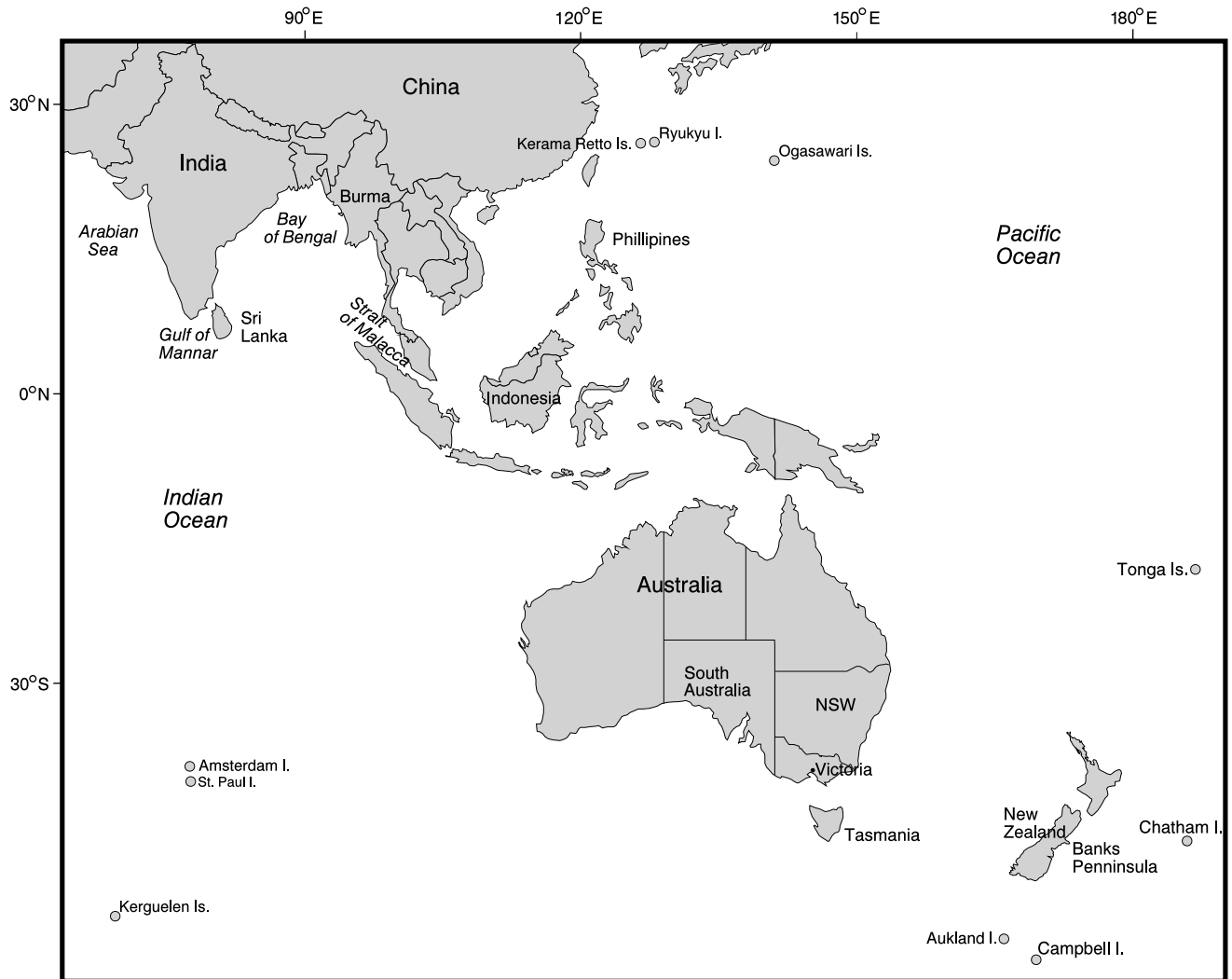


Figure 14.—Eastern Indian Ocean/Western South Pacific region.

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 south-

ern 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 temper-

ate 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* (Braham³).

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 sand lance, *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% CI²⁸; Best et

al.²⁹; Burnell³⁰). 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 Kraus³¹).

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 (Wang³²).

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).

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.

³⁰ Burnell, S. R. 1998. Aspects of the reproductive biology and behavioral ecology of right whales off Australia. Unpubl. doc. SC/M98/RW19 submitted to the IWC Workshop on the Comprehensive Assessment of Right Whales, Cape Town, South Africa, May 1998.

³¹ Knowlton, A. R., and S. Kraus. 1989. Calving intervals, rates and success in North Atlantic right whales (Abstr.) In Proceedings of the eighth biennial conference on the biology of marine mammals. Soc. Mar. Mammal., Lawrence, Kan.

³² Wang, K. 1998. Fishery biologist, NMFS Southeast Region, Protected Resources Division, 9721 Executive Center Drive N., St. Petersburg, FL 33702.

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; Anonymous³³). 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

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.

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 ad-

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.

ditional 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 Workshop¹⁴. The Workshop concluded that

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 (IWC¹⁴).

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 distri-

bution 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 Register³⁶).

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 cur-

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

rent 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 (Brownell²³).

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 (IWC¹⁴). 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 (IWC¹⁴). Also, mortality and serious injury from human activities continue to slow recovery. In this regard, the potential biological removal (PBR) level³⁷ 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-

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.