NORTH ATLANTIC RIGHT WHALE (*Eubalaena glacialis*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Individuals of the western North Atlantic right whale population range from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and presumed mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Knowlton *et al*. (1992) reported several long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland, indicating an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described. Likewise, a calving and wintering ground has been described for coastal waters of the southeastern USA; sightings from the Gulf of Mexico (Moore and Clark 1963; Schmidly *et al*. 1972), are either geographic anomalies or indicate a more extensive historic range. Whichever the case, 85% of the population is unaccounted for during the winter. A small offshore survey effort in February 1996 reported three sightings in waters east of northeastern Florida and southeastern Georgia: a mother/calf pair, a single individual, and a group of four juveniles. These sightings suggest a distribution further offshore than previously reported.

Research results to date suggest five major habitats or congregation areas (southeastern United States coastal waters, Great South Channel, Cape Cod Bay, Bay of Fundy, and Scotian Shelf) for western North Atlantic right whales. However, movements within and between habitats may be more extensive than sometimes thought. Results from a few successfully attached satellite telemetry tags suggest that sightings separated by perhaps two weeks should not be assumed to indicate a stationary or resident animal. Instead, telemetry data have shown rather lengthy and somewhat distant excursions, including into deep water off the continental shelf (Mate *et al*. 1997). These findings cast new light on movements and habitat use, and raise questions about the purpose or strategies for such excursions.

New England waters are a primary feeding habitat for the right whale, which appears to feed primarily on copepods (largely of the genera *Calanus* and *Pseudocalanus*) in this area. Research suggests that right whales must locate and exploit extremely dense patches of zooplankton to feed efficiently. These dense zooplankton patches are likely a primary characteristic of the spring, summer, and fall right whale habitat (Kenney *et al*. 1986). Acceptable surface copepod resources are limited to perhaps 3% of the region during the peak feeding season in Cape Cod and Massachusetts Bays (Mayo and Goldman, pers. comm.). While feeding in the coastal waters off Massachusetts has been better studied, feeding by right whales has been observed elsewhere over Georges Bank, in the Gulf of Maine, in the Bay of Fundy, and over the Scotian Shelf. The characteristics of acceptable prey distribution in these areas are not well known. New England waters also serve as a nursery for calves and, in some cases, for mating.

Genetic analyses of tissue samples are providing insights into stock definition. Schaeff *et al*. (1993) used Restriction Fragment Length Polymorphism (RFLP) analysis to suggest that western North Atlantic right whales represent a single breeding population that may be based on as few as three matrilines. However, more recent analyses based upon direct sequencing of mitochondrial DNA (mtDNA) have identified five mtDNA haplotypes (Malik, 1997). Schaeff *et al*. (1997) compared the genetic variability of northern and southern (*E. australis*) right whales, and found the former to be significantly less diverse. They suggested that this might be indicative of inbreeding in the population, but no definitive conclusion can be reached using current data. Additional work comparing modern and historic genetic population structure in right whales, using DNA extracted from museum specimens of baleen and bone, is also underway (Rosenbaum *et al*. 1997). Preliminary results suggest that the eastern and western North Atlantic populations were not genetically distinct (Rosenbaum *et al*., submitted). However, the virtual extirpation of the eastern stock and its lack of recovery this century strongly suggests population subdivision over a protracted (but not evolutionary) timescale.

To date, skin biopsy sampling has resulted in the compilation of a DNA library of more than 200 North Atlantic right whales. When work is completed, a genetic profile will be established for each individual, and an assessment provided on the level of genetic variation in the population, the number of reproductive individuals, reproductive fitness, the basis for associations and social units in each habitat area, and the mating system. Tissue analysis has also aided in sex identification: the sex ratio of the photo-identified and catalogued population (through December of 1995) is 137 females and 132 males (1.04:1), not significantly different from parity ($P<0.001$) (M.W. Brown, pers. comm.). Analyses based on sighting histories of photographically identified individuals also suggest that, in addition to the Bay of Fundy, there exists an additional and undescribed summer nursery area utilized by approximately one-third of the population. As described above, a related question is where individuals other than calving females

and a few juveniles overwinter. One or more additional wintering and summering grounds may exist in unsurveyed locations, although it is also possible that "missing" animals simply disperse over a wide area at these times.

POPULATION SIZE

Based on a census of individual whales identified using photo-identification techniques, the western North Atlantic population size was estimated to be 295 individuals in 1992 (Knowlton *et al*. 1994). Because this was a nearly complete census, it is assumed that this represents a minimum population size estimate. However, no estimate of abundance with an associated coefficient of variation has been calculated for this population and its status remains uncertain (IWC 1998). Calculation of a reliable point estimate is likely to be difficult given the known problem of heterogeneity of distribution in this population.

Historical Population Estimate

An estimate of pre-exploitation population size is not available. Basque whalers may have taken as many as 200 right whales a year at times during the 1500s in the Strait of Belle Isle region, and the stock of right whales may have already been substantially reduced by the time whaling was begun by colonists in the Plymouth area in the 1600s (Reeves and Mitchell 1987). A modest but persistent whaling effort along the eastern USA lasted three centuries, and the records include one report of 29 whales killed in Cape Cod Bay in a single day during January 1700. Based on incomplete historical whaling data, these authors could only conclude that there were at least some hundreds of right whales present in the western North Atlantic during the late 1600s. In a later study (Reeves *et al*. 1992), a series of population trajectories using historical data and an estimated present population size of 350 were plotted. The results suggest that there may have been at least 1,000 right whales in this population during the early to mid-1600s, with the greatest population decline occurring in the early 1700s. The authors cautioned, however, that the record of removals is incomplete, the results are preliminary, and refinements are required. Based on back calculations using the present population size and growth rate, the population may have numbered fewer than 100 individuals by the time that international protection for right whales came into effect in 1935 (Hain 1975; Reeves *et al*. 1992; Kenney *et al*. 1995).

Minimum Population Estimate

The western North Atlantic population size was estimated to be 295 individuals in 1992 (Knowlton *et al*. 1994), based on a census of individual whales identified using photo-identification techniques. A bias that might result from including catalogued whales that had not been seen for an extended period of time and therefore might be dead, was addressed by assuming that an individual whale not sighted for five years was dead (Knowlton *et al*. 1994). It is assumed that the census of identified and presumed living whales represents a minimum population size estimate. The true population size in 1992 may have been higher if: 1) there were animals not photographed and identified, and/or 2) some animals presumed dead were not.

Current Population Trend

The population growth rate reported for the period 1986-92 by Knowlton *et al*. (1994) was 2.5% (CV = 0.12); this suggested that the stock was showing signs of slow recovery. However, work by Caswell *et al*. (1999) has suggested that crude survival probability declined from about 0.99 in the early 1980's to about 0.94 in the late 1990's. The decline was statistically significant, a finding which (if confirmed) is of grave concern. The impact of heterogeneity of capture on survival estimates remains unclear, and further research is urgently required; in addition, ongoing work by Caswell and colleagues, as well as by NMFS scientists, is incorporating age-specific factors into the survival analysis. As noted by the IWC (1998), determination of the status of this population is a high priority, notably in light of the known high levels of anthropogenic mortality in this population. The status and trends of the western North Atlantic right whale population will be addressed in an IWC workshop in October 1999.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

During 1980-1992, 145 calves were born to 65 identified cows. The number of calves born annually ranged from 5 to 17, with a mean of 11.2 (SE = 0.90). There was no detectable trend in the number of calves produced per year. The reproductively active female pool was static at approximately 51 individuals during 1987-1992. Mean calving interval, based on 86 records, was 3.67 years. There was an indication that calving intervals may be increasing over time, although the trend was not statistically significant (P = 0.083) (Knowlton *et al*. 1994). Since that report, total reported calf production in 92/93 was 6; 93/94, 9; 94/95, 7; 95/96, 21; and 96/97, 19. The total calf production was reduced by reported calf mortalities: 2 mortalities in 1993, 3 in 1996, and 1 in 1997. Of the three calf mortalities in 1996, available data suggested one was not included in the reported 20 mother/calf pairs, resulting in a

total of 21 calves born. Eleven of the 21 mothers in 1996 were observed with calves for the first time (i.e., were "new" mothers) that year. Three of these were 10 years old or younger, two were 9 years old, and six were of unknown age. In 95/96, more mothers gave birth after a 5-year interval than in previous years (L. Conger, pers. comm.). An updated analysis of calving interval through the 95/96 season suggests that calving interval is increasing ($P<0.001$) (R. Kenney and A. Knowlton, pers. comm.).

The annual population growth rate during 1986-1992 was estimated to be 2.5% (CV = 0.12) using photo-identification techniques (Knowlton *et al*. 1994). A population increase rate of 3.8% was estimated from the annual increase in aerial sighting rates in the Great South Channel, 1979-1989 (Kenney *et al*. 1995). The current estimated population growth rate of the western North Atlantic stock is lower than that of the four stocks of southern-hemisphere right whales for which data are available: western Australia, 12.7%; Argentina, 7.3%; east and west Africa, 6.8% (Best 1993). This difference could be attributable in part to reproductive females in the population--only 38% of the females in the North Atlantic population are known to have given birth compared with 54% in the western South Atlantic population (Brown *et al*. 1994). In addition, as noted above recent work has suggested that the population may be in decline (Caswell *et al*. 1999).

The relatively low population size indicates that this stock is well below its optimum sustainable population (OSP); therefore, the current population growth rate should reflect the maximum net productivity rate for this stock. The current population growth rate reported by Knowlton *et al*. (1994) of 2.5% (CV = 0.12) was assumed to reflect the maximum net productivity rate for this stock for purposes of this assessment. This rate is no longer current and may reflect underlying methodological problems; nonetheless, it is used here in the absence of better information because a risk-averse approach is appropriate for this critically endangered population. The alternative default rate of 0.04 is not species-specific and, being higher, is less conservative.

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) was specified as the product of minimum population size, one-half the maximum net productivity rate (½ of 2.5%), and a "recovery" factor for endangered, depleted, threatened stocks, or stocks of unknown status relative to OSP (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The recovery factor was 0.10 because this species is listed as endangered under the Endangered Species Act (ESA). PBR for the northern right whale is 0.4 whales. If confirmed by ongoing work, the suggestion by Caswell *et al*. (1999) that the population is in decline will warrant a resetting to zero of the recovery factor in future SARs.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 1993 through 1997, the total estimated human-caused mortality and serious injury to right whales in USA waters is estimated as 2.0 per year. This is derived from two components: 1) non-observed fishery impact records, 1.0; and 2) ship strike records, 1.0. Note that in past stock assessment reports, a six-year time frame was used to calculate these averages. A five year period was used for this report to be consistent with the time frames used for calculating the averages for other species. It is also important to stress that serious injury determinations are made based upon the best available information; these determinations may change with the availability of new information.

Background

Approximately one-third of all right whale mortality is caused by human activities (Kraus 1990). Further, the small population size and low annual reproductive rate suggest that human sources of mortality may have a greater effect relative to population growth rates than for other whales. The principal factors believed to be retarding growth, and perhaps recovery, of the population are ship strikes and entanglement with fishing gear. An updated summary of right whale mortalities reports a total of 30 mortalities (29 if one eliminates a record with some doubt about species identification) for the period 1970 to early 1993 (Kenney and Kraus 1993). Eight (27%) were due to ship collisions, and two (7%) were due to entanglement with fishing gear. (Note that this report corrects one of the published records from the Kraus 1990 report, where a fishing vessel caught an already-dead carcass, making the actual cause of death unknown and possibly unrelated to fishing activity. Further, there was uncertainty about the species identification.) Both entanglements involved fixed fishing gear, and there was no evidence for right whale mortality from encounters with mobile fishing gear. The total of ten confirmed anthropogenic mortalities is one-third of all known mortalities for the period addressed. Young animals, ages 0-4 years, are apparently the most impacted portion of the population (Kraus 1990). Finally, entanglement or minor vessel collisions may not kill an animal directly, but may weaken or otherwise affect it so that it is more likely to become vulnerable. Such was apparently the case with the two-year old right whale killed by a ship off Amelia Island, Florida, in March 1991 after having carried gillnet gear wrapped around its tail region since the previous summer (Kenney and Kraus 1993).

For waters of the northeastern USA, a present concern, not yet completely defined, is the possibility of habitat degradation in Massachusetts and Cape Cod Bays due to a Boston sewage outfall now under construction. Timetables for levels of treatment are under discussion.

Awareness and mitigation programs for reducing anthropogenic injury and mortalities to right whales have been set up in two areas of concern. The first was initiated in 1992 off the coastal waters of the southeastern USA, and it has been upgraded and expanded annually. It involves both government and non-government organizations, including the Navy, Army Corps of Engineers, US Coast Guard, and Florida and Georgia state agencies. In 1996, a program was established in the northeastern USA, largely in cooperation with the US Coast Guard and the State of Massachusetts.

Fishery-Related Serious Injury and Mortality

Reports of mortality and serious injury relevant to calculation of PBR as well as total human impacts are contained in records maintained by the New England Aquarium and the Northeast Regional Office/NMFS (Table 1). From 1993-97, 5 of 10 records of mortality or serious injury involved entanglement or fishery interactions. The reports often do not contain the detail necessary to assign the entanglements to a particular fishery or location. However, based on re-examination of the records for the right whale observed entangled in pelagic drift gillnet in July 1993, which included the observer's documentation of lobster gear on the whale's tail stock and subsequent entanglement reports of this whale, the suspected mortality of this whale was reassigned to the Gulf of Maine and USA Mid-Atlantic lobster pot fisheries In this case, the pre-existing entanglement of lobster gear was judged to have been sufficient cause of eventual mortality independent of the drift net entanglement. Although some drift net gear was left on the tail by the fishing vessel, the entanglement in the drift net gear would likely not have occurred had the lobster gear not compromised the whale's mobility. In another instance, a 2 year-old dead male right whale with lobster line through the mouth and deeply embedded at the base of the right flipper beached in Rhode Island in July 1995. This individual had been sighted previously, entangled, east of Georgia in December 1993, and again in August 1994 in Cape Cod Bay. In this case, the entanglement became a serious injury, and, directly or indirectly, the cause of the mortality.

In January 1997 (62 FR 33, Jan. 2, 1997), NMFS changed the classification of the Gulf of Maine and USA Mid-Atlantic lobster pot fisheries from Category III to Category I based on examination of stranding and entanglement records of large whales from 1990 to 1994 (including the right whale records of 9 July 1993 and 17 July 1995, shown in Table 1).

Fishery Information

Data on current incidental takes in USA fisheries are available from several sources. In 1986, NMFS established a mandatory self-reported fisheries information system for large pelagic fisheries. Data files are maintained at the Southeast Fisheries Science Center (SEFSC). The Northeast Fisheries Science Center (NEFSC) Sea Sampling Observer Program was initiated in 1989, and since that year, several fisheries have been covered by the program. In late 1992 and in 1993, the SEFSC provided observer coverage of pelagic longline vessels fishing off the Grand Banks (Tail of the Banks), and currently provides observer coverage of vessels fishing south of Cape Hatteras. By-catch has been observed by NMFS Sea Samplers in the pelagic drift gillnet fishery, but no mortalities or serious injuries have been documented in either the pelagic longline, pelagic pair trawl, or other fisheries monitored by NMFS. The only documented by-catch of a right whale by NMFS Sea Samplers was a 1½ year-old female that was released from a pelagic drift gillnet along the southern edge of Georges Bank (mentioned above). At the time of the release, it was discovered that the animal was also entangled in lobster gear. After recent review of the evidence, the serious injury to the whale has since been attributed to the non-observed Gulf of Maine and USA Mid-Atlantic lobster pot fisheries (see above).

In a recent analysis of the scarification of right whales, a total of 61.6% of the whales bore evidence of entanglements with fishing gear (Hamilton *et al*. 1998). Entanglement records maintained by NMFS Northeast Regional Office (NMFS, unpublished data) from 1970-1996, included 42 right whale entanglements or possible entanglements, including right whales in weirs, entangled in gillnets, and trailing line and buoys. An additional record (M. J. Harris, pers. comm.) reported a 9.1-10.6 m right whale entangled and released south of Ft. Pierce, Florida, in March 1982 (this event occurred in the course of a sampling program and was not related to a commercial fishery). Incidents of entanglements in groundfish gillnet gear, cod traps, and herring weirs in waters of Atlantic Canada and the USA east coast were summarized by Read (1994). In six records of right whales becoming entangled in groundfish gillnet gear in the Bay of Fundy and Gulf of Maine between 1975 and 1990, the right whales were either released or escaped on their own, although several whales have been observed carrying net or line fragments. A right whale mother and calf were released alive from a herring weir in the Bay of Fundy in 1976. For all areas, specific details of right whale entanglement in fishing gear are often lacking. When direct or indirect mortality occurs, some carcasses come ashore and are subsequently examined, or are reported as

"floaters" at sea; however, the number of unreported and unexamined carcasses is unknown, but may be significant in the case of floaters. More information is needed about fisheries interactions and where they occur.

Other Mortality

Ship strikes are a major cause of mortality and injury to right whales (Kraus 1990). Records from 1993 through 1997 have been summarized in Table 1. For this time frame, the average reported mortality and serious injury to right whales due to ship strikes in USA waters was 1.0 whales per year.

In the period January to March 1996, an 'unusual mortality event' was declared for right whales in southeastern USA waters. Five mortalities were reported, at least one of which (on 1/30/96) was attributable to ship strike. A second mortality (on 2/22/96) showed evidence of barotrauma but no proximate cause of death could be determined. Of the remaining three mortalities, two were calves (1/2/96 and 2/19/96), one of which may have died from birthing trauma (inconclusive). The third (2/7/96) was decomposed and could not be towed in for examination. The five mortalities in the southeast were followed by a sixth at Cape Cod, Massachusetts (3/9/96); this involved an animal killed by ship strike, with the possibility that an existing entanglement (first reported in 1995) may have impeded its mobility.

Table 1. Summarized records of mortality and serious injury likely to result in mortality, North Atlantic right whales, January 1993 - December 1997. This listing includes only records related to USA commercial fisheries and/or USA waters. Causes of mortality or injury, assigned as primary or secondary, are based on records maintained by NMFS/NER and NMFS/SER.

Date	Report Type	Sex, age, ID	Location	Assigned Cause: P=primary, S=secondary			Notes
				Ship strike	Entang./ Fsh.inter	Unknown uncertain	
1/5/93	mortality, offshore	calf	St. Augustine, FL	P			vessel reported striking whale, carcass recovered 1/8/93, deep propeller gashes
7/9/93	serious injury	1 y.o. female #2233	120 miles SE of Nantucket		P		lobster gear constricted on tail stock, subsequently became entangled in pelagic drift gillnet
12/6/93	mortality, offshore	female	offshore VA	P		S	photos show gash
2/22/94	serious injury	calf #2404	offshore NE FL	S	P		deep wounds from line or cable on head, probable propeller gashes on flukes
11/17/94	serious injury	3 y.o. juv., #2151	nr. Plum I., MA		P		line tightly wrapped around rostrum and deeply embedded in gums
7/17/95	mortality, beached	2 y.o. male #2366	Middletown, RI		P		lobster line through mouth, embedded deeply into bone at base of right flipper
8/13/95	serious injury, offshore	adult female, #1045	S. Georges Bank	P		S	large head wound exposing bone
1/30/96	mortality, offshore	adult male, #1623	offshore GA	P		S	shattered skull, broken vertebrae and ribs
3/9/96	mortality, beached	adult male #2220	Cape Cod MA	P	S		3.3 meter gash on back, broken skull, lobster line through mouth and around tail
8/5/96	serious injury	unknown	SE of Gloucester, MA		P		unknown type of gear entangled around head

The details of a particular mortality or serious injury record often require a degree of interpretation. The assigned cause is based on the best judgement of the available data; additional information may result in revisions. When reviewing Table 1, several factors should be considered: 1) a ship strike or entanglement may occur at some distance from the report location, 2) the mortality

or injury may involve multiple factors--struck and entangled whales are not uncommon, 3) the actual vessel or gear type/source is often uncertain, and 4) in entanglements, several types of gear may be involved.

The serious injury determinations are the most susceptible to revision. There are several records where a struck and injured whale is re-sighted later, apparently healthy, or, an entangled or partially disentangled whale is re-sighted later free of gear. The inverse of this may also be true--a whale initially appearing in good condition after being struck or entangled is later re-sighted and found to have been seriously injured by the event. Entanglements of juvenile whales are typically considered serious injuries because the constriction on the animal is likely to become increasingly harmful as the whale grows.

With these caveats, the total estimated annual average human-induced mortality and serious injury within USA waters (including fishery and non-fishery related causes) was 2.0 right whales per year. As with entanglements, some injury or mortality due to ship strikes, particularly in offshore waters, may go undetected. Decomposed and/or unexamined animals (e.g., carcasses reported but not retrieved or necropsied) represent 'lost data', some of which may relate to human impacts. For these reasons, the 2.0 estimate must be regarded as a minimum estimate.

While this assessment relates to USA fisheries and/or USA waters, there are additional records for Canadian waters within the same time frame. Six records are noteworthy: 1) whale #1247 was sighted 21 September 1994 in the Bay of Fundy entangled with line of an unknown gear type tightly wrapped around its tail stock and has not been sighted since--this is considered a serious injury (A.R. Knowlton, pers. comm.); 2) whale #2250 was found dead on Long Island, Nova Scotia, probably the result of a ship strike–it had a large gash on its back and broken vertebral disks; 3) whale #2220, which came ashore on Cape Cod on 9 March 1996, was entangled in Canadian lobster gear set in the Bay of Fundy and noticed missing in mid-December 1995--while the primary cause of death was probably a ship strike, the entanglement may have played some role in the whale's death; 4) whale #2450 was found dead in the Bay of Fundy on 19 August 1997--ship strike was identified as the cause; 5) whale #2212 was initially reported entangled in the Bay of Fundy on 23 August 1997, was mostly disentangled on 24 July 1998, but considered seriously injured due to subsequent evidence of it having ingested gear; and 6) whale # 2557, sighted on 29 August 1997, which was considered seriously injured due to line being tightly wrapped on the body, its emaciated appearance, and evidence of a necrotic left flipper.

In addition to these records, there was one Canadian record examined this year for which there was insufficient information to make a serious injury determination. This animal, #1705, was initially seen in mid-July 1997 in the Bay of Fundy with a small amount of line with several small, oval black buoys attached coming out of the right side of its mouth. The whale was also seen on 7/18/97, 8/25/97, and 9/6/97, still trailing the line and floats in each sighting. Although the injury resulting from the gear appeared minimal, it may have the potential to impair the animal's feeding. Future observations of the whale may provide an indication of whether the gear has resulted in serious injury.

Lastly, there was one USA record of a right whale serious injury that did not fall into the 1993-97 time frame, but is mentioned here since it was neglected in previous stock assessment reports. The whale was a juvenile sighted off the southeastern USA on 11 January 1992, apparently the victim of an entanglement. It had a long, deep gash on its fluke and entanglement scars on its tail. It appeared emaciated and in poor health.

STATUS OF STOCK

The size of this stock is considered to be low relative to OSP in the USA Atlantic EEZ, and this species is listed as endangered under the ESA. A Recovery Plan has been published and is in effect (NMFS 1991). Three critical habitats, Cape Cod Bay/Massachusetts Bay, Great South Channel, and the Southeastern USA, were designated by NMFS (59 FR 28793, June 3, 1994). The NMFS ESA 1996 Northern Right Whale Status Review concludes that the status of the western North Atlantic population of the northern right whale remains endangered. The total level of human-caused mortality and serious injury is unknown, but reported human-caused mortality and serious injury has been a minimum of 2.0 right whales per year since 1993. The total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching a zero mortality and serious injury rate. This is a strategic stock because the average annual fishery-related mortality and serious injury exceeds PBR, and because the North Atlantic right whale is an endangered species. Relative to other populations of right whales, there are also concerns about growth rate, percentage of reproductive females, and calving intervals in this population.

REFERENCES

Best, P. B. 1993. Increase rates in severely depleted stocks of baleen whales. *ICES J. Mar. Sci. 50: 169-186.*

Brown, M.W., S.D. Kraus, D.E. Gaskin, and B.N. White. 1994. Sexual composition and analysis of reproductive females in the North Atlantic right whale, *(Eubalaena glacialis)*, population. *Mar. Mamm. Sci. 10(3): 253-265.*

Caswell, H., Fujiwara, M. and Brault, S. 1999. Declining survival probability threatens the North Atlantic right whale. *Proc. Natl. Acad. Sci. USA* 96: 3308-3313.

Hain, J.H.W. 1975. The international regulation of whaling. *Marine Affairs J. 3: 28-48.*

Hamilton, P.K., M.K. Marx, and S.D. Kraus. 1998. Scarification analysis of North Atlantic right whales (*Eubalaena glacialis*) as a method of assessing human impacts. Final report to the Northeast Fisheries Science Center, Contract No. 4EANF-6-0004.

International Whaling Commission. 1999. Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison. *Rep. int. Whal. Commn. (in press)*.

Kenney, R. D., M. A. M. Hyman, R. E. Owen, G. P. Scott, and H. E. Winn. 1986. Estimation of prey densities required by western North Atlantic right whales. *Mar. Mamm. Sci. 2(1): 1-13*.

Kenney, R. D. and S. D. Kraus. 1993. Right whale mortality — a correction and an update. *Mar. Mamm. Sci. 9:445-446.*

Kenney, R. D., H. E. Winn, and M. C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979-1989: right whale (*Eubalaena glacialis*). *Cont. Shelf Res. 15: 385-414.*

Knowlton, A. R., J. Sigurjonsson, J. N. Ciano, and S. D. Kraus. 1992. Long-distance movements of North Atlantic Right whales (*Eubalaena glacialis*). *Mar. Mamm. Sci. 8(4): 397-405.*

Knowlton, A. R., S. D. Kraus, and R. D. Kenney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Can. J. Zool. 72: 1297-1305.*

Kraus, S. D. 1990. Rates and potential causes of mortality in North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mamm. Sci. 6(4): 278-291.*

Malik, S. 1997. Assessment of genetic structuring and habitat philopatry in the North Atlantic right whale (*Eubalaena glacialis*). M.Sc. thesis, McMaster University, Hamilton, Ontario. 133 pp.

Mate, B.M., Nieukirk, S.L. & Kraus, S.D. 1997. Satellite-monitored movements of the northern right whale. *J. Wildl. Manage. 61: 1393-1405*.

Moore, J. C. and E. Clark. 1963. Discovery of right whales in the Gulf of Mexico. *Science 141(3577): 269.*

NMFS. 1991. Recovery plan for the northern right whale (*Eubalaena glacialis*). Prepared by the Right Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland, 86 pp.

Read, A. J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. *Rep. int Whal. Commn Special Issue 15: 133-147.*

Reeves, R. R. and E. Mitchell. 1987. Shore whaling for right whales in the northeastern United States. Contract Report No. NA85-WCC-06194, SEFSC/NMFS, Miami, FL, 108 pp.

Reeves, R. R., J. M. Breiwick, and E. Mitchell. 1992. Pre-exploitation abundance of right whales off the eastern United States. Pages 5-7. *In*: J. Hain (ed.), The right whale in the western North Atlantic: A science and management workshop, 14-15 April 1992, Silver Spring, Maryland. Northeast Fisheries Science Center Reference Document No. 92-05. NEFSC/NMFS, Woods Hole, Massachusetts, 88 pp.

Rosenbaum, H.C., Egan, M., Clapham, P.J., Brownell, R.L. Jr. & DeSalle, R. 1997. An effective method for isolating DNA from non-conventional museum specimens. *Mol. Ecol. 6: 677-681*.

Rosenbaum, H.C., Egam M.G., Clapham, P.J., Brownell, R.L. Jr., Malik, S., Brown, M., White, B. Walsh, P. and DeSalle, R. Submitted. Levels of historic genetic diversity and population structure in North Atlantic right whales detected by an effective technique to isolate DNA from museum specimens. *Rep. int. Whal. Commn. (in review)*.

Schaeff, C.M., S.D. Kraus, M.W. Brown, J. Perkins, R. Payne and B.N. White. 1997. Comparison of genetic variability of North and South Atlantic right whales (*Eubalaena*) using DNA fingerprinting. *Can. J. Zool. 75: 1073-1080.*

Schaeff, C. M., S. D. Kraus, M. W. Brown, and B. N. White. 1993. Assessment of the population structure of the western North Atlantic right whales (*Eubalaena glacialis*) based on sighting and mtDNA data. *Can. J. Zool. 71: 339-345*.

Schmidly, D. J., C. O. Martin, and G. F. Collins. 1972. First occurrence of a black right whale (*Balaena glacialis*) along the Texas coast. *Southw. Nat. 17(2): 214-215*.

Wade, P.R., and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop, April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12. U.S. Dept. of Commerce, Washington, D.C. 93 pp.