University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Publications, Agencies and Staff of the U.S. Department of Commerce

U.S. Department of Commerce

2002

The western gray whale: a review of past exploitation, current status and potential threats

David Weller
Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037-0271, USA, dave.weller@noaa.gov

Alexander Burdin
Kamchatka Institute of Ecology and Nature Management, Russian Academy of Sciences, Kamchatka, 683000, Russia

Bernd Wursig
Texas A&M University, Marine Mammal Research Program, 4700 Avenue U, Building 303, Galveston, TX 77551, USA

Barbara Taylor
Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037-0271, USA

Robert Brownell, Jr.
Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037-0271, USA

Follow this and additional works at: http://digitalcommons.unl.edu/usdeptcommercepub

Part of the Environmental Sciences Commons

Weller, David; Burdin, Alexander; Wursig, Bernd; Taylor, Barbara; and Brownell, Jr., Robert, "The western gray whale: a review of past exploitation, current status and potential threats" (2002). *Publications, Agencies and Staff of the U.S. Department of Commerce.* Paper 96.
http://digitalcommons.unl.edu/usdeptcommercepub/96

This Article is brought to you for free and open access by the U.S. Department of Commerce at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Publications, Agencies and Staff of the U.S. Department of Commerce by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

The western gray whale: a review of past exploitation, current status and potential threats

DAVID W. WELLER[*†], ALEXANDER M. BURDIN[+], BERND WÜRSIG[†], BARBARA L. TAYLOR[*] and ROBERT L. BROWNELL, JR.[*]

Contact e-mail: dave.weller@noaa.gov

ABSTRACT

Gray whales (*Eschrichtius robustus*) occur along the eastern and western coastlines of the North Pacific as two geographically isolated populations and have traditionally been divided into the eastern (California-Chukchi) and western (Korean-Okhotsk) populations. Recent molecular comparisons confirm, based on differences in haplotypic frequencies, that these populations are genetically separated at the population-level. Both populations were commercially hunted, but only the eastern gray whale has returned to near pre-exploitation numbers. In contrast, the western population remains highly depleted, shows no apparent signs of recovery and its future survival remains uncertain. Research off Sakhalin Island, Russia between 1995 and 1999 has produced important new information on the present day conservation status of western gray whales and provided the basis for the World Conservation Union (IUCN) to list the population as 'Critically Endangered' in 2000. The information presented here, in combination with potential impacts from anthropogenic threats throughout the range of this population, raises strong concerns about the recovery and continued survival of the western gray whale.

KEYWORDS: GRAY WHALE; PACIFIC OCEAN; NORTHERN HEMISPHERE; CONSERVATION; OKHOTSK SEA; EXPLOITATION; POPULATION STATUS

INTRODUCTION

Gray whales (*Eschrichtius robustus*) are known to occur along the eastern and western margins of the North Pacific (Andrews, 1914; Rice and Wolman, 1971); they have been extinct in the North Atlantic for several hundred years (Mead and Mitchell, 1984). Recent genetic studies show that animals from the eastern (California-Chukchi) and the western (Korean-Okhotsk) Pacific should be recognised as geographically and genetically separated at the population level (LeDuc *et al.*, 2002). Although both populations were greatly reduced by commercial whaling, only the eastern gray whale has returned to numbers approaching the suspected pre-exploitation population size (IWC, 1998). In contrast, the western gray whale was thought to be extinct as recently as the early 1970s (Bowen, 1974), but later published reports confirmed that the population was extant (Berzin, 1974; Brownell and Chun, 1977). Today, the western gray whale population remains highly depleted and shows no apparent signs of recovery (e.g. Weller *et al.*, 1999; IWC, 2002b). Information regarding the life history and biology of the western population is sparse (Andrews, 1914; Rice and Wolman, 1971) and only recently has it come under concerted study (e.g. Brownell *et al.*, 1997; Weller *et al.*, 1999).

Historic records and recent data suggest that summer feeding grounds for the western population are in the Okhotsk Sea, but the location(s) of the winter breeding grounds, suspected to be along the coast of southern China, remain unknown (Wang, 1984; Henderson, 1990). Contemporary findings from an ongoing US-Russia mark-recapture photo-identification project between 1995 and 2001 suggest that the total population size is < 100 individuals (e.g. Weller *et al.*, 1999; IWC, 2002b). Low-level human-related mortality south of the Okhotsk Sea (Brownell and Kasuya, 1999; Baker *et al.*, 2002), and the onset of large-scale multinational oil and gas development programmes within Okhotsk waters, pose potential new threats to the continued survival of this population.

Serious concern over the status of this population has been expressed by the World Conservation Union (by assigning it 'Critically Endangered' - Hilton-Taylor, 2000) and by the International Whaling Commission (IWC, 2002b).

RANGE AND DISTRIBUTION

Western gray whales occur off Russia, Japan, the Democratic People's Republic of Korea (North Korea), Republic of Korea (South Korea) and People's Republic of China (China). Although historic sighting and whaling records indicate that gray whales occurred in areas north of the presently described Okhotsk Sea feeding ground, the present day population range appears to be largely confined to the region between the west central Okhotsk Sea off the northeastern coast of Sakhalin Island (summer-autumn) and the South China Sea (winter). Individuals remain in shallow, mainly nearshore waters, year-round; except when crossing the La Perouse and Tartarskiy Straits off the southern end of Sakhalin Island or during north-south migrations in the Sea of Japan, and the Yellow and East China Seas. Although few records of gray whales are available south of Hong Kong (Wang, 1984; Zhu, 1998), it is presumed that they maintain a nearshore affinity throughout the southern portion of their range.

Main habitat

Gray whales are known for their long-distance migrations between sub-tropical calving and mating grounds near continental coasts and high-latitude feeding grounds in the Arctic and sub-Arctic (e.g. Rice and Wolman, 1971; Swartz, 1986). As bottom-feeding specialists, gray whales aggregate during summer and autumn in shallow shelf waters and offshore banks where benthic and epibenthic invertebrate communities are concentrated (Nerini, 1984; Oliver *et al.*, 1984; Kim and Oliver, 1989). Traditional nearshore migratory routes connect high-latitude feeding areas with warm-water coastal and inshore wintering grounds. Today, the primary summer-autumn feeding habitat for western

[*] *Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037-0271, USA.*
[+] *Kamchatka Institute of Ecology and Nature Management, Russian Academy of Sciences, Kamchatka, 683000, Russia.*
[†] *Texas A&M University, Marine Mammal Research Program, 4700 Avenue U, Building 303, Galveston, TX 77551, USA.*

This article is a U.S. government work, and is not subject to copyright in the United States.

gray whales is located off the northeastern coast of Sakhalin Island (Weller *et al.*, 1999; 2002). The calving and mating grounds for this population are unknown, but records from sightings, strandings and whaling catches from 1933-1996 indicate that at least some western gray whales occur in coastal waters off China in the South China Sea (Wang, 1984; Zhu, 1998).

Distribution

Key areas of distribution include the summer feeding grounds off northeastern Sakhalin Island (~52°50'N 143°20'E). Known portions of the north-south migratory route include regions off the eastern shore of Sakhalin Island in the Okhotsk Sea and along the eastern shores of mainland Russia near Peter the Great Bay and along the Korean peninsula in the Sea of Japan (Andrews, 1914; Brownell and Chun, 1977; Berzin, 1990). It is thought that prior to the 20th century, two groups of gray whales may have migrated to coastal waters off Japan (Omura, 1984). One of these groups was thought to travel along the eastern (Pacific) shore of Honshu during their southbound migration while en route for a supposed calving ground in the Seto Inland Sea (Omura, 1984). The other group was suspected to migrate along the eastern shore of Korea, cross the Korean Strait near Ulsan, and ultimately arrive at southwest Honshu and northwest Kyushu (Omura, 1984). Although gray whales were once hunted by net fishermen off the eastern shore of Honshu (Omura, 1984), present-day sightings of the species off Japan are very rare (Kato and Tokuhiro, 1997).

The winter distribution of this population is unknown. Whaling records indicate that peak gray whale numbers off southern Korea occurred in two seasonal pulses, one during the southward migration between December and January, and the other between March and April during the northward migration (Andrews, 1914; Kato and Kasuya, 2002). Whalers working off Ulsan, South Korea found that a majority of adult females taken between December-January were carrying near-term foetuses and were thought to be within two to three weeks of parturition (Andrews, 1914). Based on these observations, and his own measurement of one 4.76m foetus, Andrews suggested that calves were probably born somewhere off the southern end of the Korean Peninsula, and that this region represented the probable southern terminus of the winter migration (Andrews, 1914).

The idea that western gray whales overwinter off the southern coast of Korea, as suggested by Andrews (1914), was largely speculative (Rice, 1998). Several lines of evidence suggest that Andrews miscalculated the true position of the wintering grounds. Rice and Wolman (1971) reported an average near-term foetus size of 4.62m for eastern gray whales taken off central California between December and January. Thus, the observed foetus size, seasonal timing and latitudinal position (about 34°N) reported for Korea and central California closely corresponded. However, eastern gray whales migrate to breeding areas as far south as 20°-27°N off Baja California (Rice and Wolman, 1971; Swartz, 1986). Although Andrews suspected that western gray whales terminated their southern migration off southern Korea, a location approximately 7°-14° north of the eastern gray whale wintering grounds, historical records indicate that they occur as far south as the Yellow Sea, East China Sea and South China Sea (Henderson, 1972; 1984; 1990; Wang, 1978; 1984; Omura, 1988; Zhu, 1998; Kato and Kasuya, In press). Some evidence is available that western gray whales range at least as far south as 20°N off Hainan Island in southeastern China (Wang, 1984; Zhu, 1998). In addition, several unverified sighting reports led Omura (1974) to suggest that an alternative or additional calving and mating area was in the Seto Inland Sea (34°-35°N) off southern Japan, but little direct evidence is available to support this idea.

EXPLOITATION

Groups of Koryak natives (Kamentsy, Parentsy and Itkantsy) living along the northeastern shores of the Okhotsk Sea hunted whales, although the particular species killed by these aboriginal whalers were not well documented (Krupnik, 1984); the author, however, believed that gray whales were hunted until the early 20th century. Whaling by Japanese hand-harpoon whalers was underway by at least the 16th century and Japanese net-whalers continued to take whales during the 17th-19th centuries (Omura, 1984). European and American whalers operating in the western North Pacific (mainly in the Okhotsk Sea) took gray whales from the late 1840s to perhaps the start of the 20th century (Henderson, 1984; 1990). Russian steam whalers took gray whales in the coastal waters of the Far East at the end of the 19th century (Andrews, 1914; Brownell, unpublished data). Japanese and Korean whalers continued to hunt gray whales until as recently as 1966 (Kasahara, 1950; Mizue, 1951; Brownell and Chun, 1977; Omura, 1984).

The reduction in the western Pacific gray whale population can be attributed largely to modern commercial whaling off Korea and Japan between the 1890s and 1960s. The population has been protected from commercial whaling since 1946, under the International Convention for the Regulation of Whaling. The Soviet Union and Japan joined the International Whaling Commission (IWC) in 1948 and 1951, respectively. The Republic of Korea and China, however, did not join until 1978 and 1980, respectively. Prior to their IWC membership, at least 67 gray whales were killed in the period 1948-1966 off the Republic of Korea (Brownell and Chun, 1977). Although no capture records are available from 1967 to the time that either the Republic of Korea or China joined the IWC, it cannot be assumed that gray whale catches did not occur during this period. Kasahara (1950) summarised whaling operations off northern Korea prior to 1945. Today, the Democratic People's Republic of Korea is not a member of the IWC and nothing is known about whaling in its waters since the end of World War II.

Western gray whales were probably never as numerous as their eastern counterparts. While pre-exploitation numbers for the western population are unknown, it has been speculated that they once may have numbered between 1,500-10,000 individuals (Yablokov and Bogoslovskaya, 1984). Berzin and Vladimirov (1981) estimated that only 1,000-1,500 gray whales remained in the population by 1910, after some commercial exploitation had already occurred. However, details of how these pre-exploitation and 1910 estimates were derived are not provided.

Kato and Kasuya (In press) estimated that some 1,800-2,000 whales (including 44 individuals killed by net whaling in the 1890s) were taken in the period 1891-1966, mostly off Korea and Japan. Peak annual catches of 100-200 whales began as early as 1907, but occurred primarily between 1911 and 1919 (no data were available for 1910) during which time at least 1,034 whales were killed, with a mean annual take of 115 whales. In the period 1920-1929, 289 whales were killed, with a mean annual take of 29 whales. By the 1930s, gray whale captures had greatly declined, with only 48 whales killed between 1930 and 1934

for a mean annual take of 10. No known additional catches occurred until 1942. Based on these catch data, it is apparent that by the early 1930s gray whales were far less abundant off the coasts of Korea and Japan and had likely reached commercial extinction. Continued low-level hunting between the 1940s and 1966, including the 67 whales captured in waters off South Korea, resulted in at least 71 whales killed. Kato and Kasuya (In press) hypothesise that the continued, albeit low-level, whaling pressure during this time is responsible for hindering the recovery of the western population. If the projected population size in 1910 was between 1,000-1,500, as estimated by Berzin and Vladimirov (1981), the removal of at least 1,442 whales recorded in the period 1911-1966 lends support to the above hypothesis offered by Kato and Kasuya (In press).

By the 1930s, the western gray whale was considered by many to be extinct (Mizue, 1951; Bowen, 1974). Nishiwaki and Kasuya (1970), believing the western population to be extinct and unaware of the Korean catches and sightings in the 1960s, suggested that sightings of two gray whales, one in about 1959 and one in 1968 off the coast of Japan, represented strays from the eastern population. However, Brownell and Chun (1977) described the probable existence of the western population based on catch records from the Korean coast during a nearly 20-year period between 1948 and 1966. These catch records, combined with the observation of four gray whales in the western Okhotsk Sea in 1967 (Berzin, 1974) and the sighting of a female gray whale and her calf in Korean waters in May 1968 (Brownell and Chun, 1977) indicated that western gray whales continued to survive in small numbers and that the observations reported by Nishiwaki and Kasuya (1970) were likely to be of western rather than eastern gray whales.

CURRENT POPULATION STATUS

The western gray whale population survives as a small remnant population (Blokhin *et al.*, 1985; Weller *et al.*, 1999). Aerial and ship-based sighting records in the Okhotsk Sea between 1979 and 1989 indicated that gray whales aggregated predominantly along the shallow-water shelf of northeastern Sakhalin Island and were most common offshore of the southern portion of Piltun Lagoon (Blokhin *et al.*, 1985; Berzin *et al.*, 1988; 1990; 1991; Berzin, 1990; Blokhin, 1996). Two non-quantitative population estimates have been reported in the Russian literature (Vladimirov, 1994; Blokhin, 1996). An estimate of 250 by Vladimirov (1994) was derived from cetacean sighting records collected between 1979 and 1992 in the Okhotsk Sea; these records were collected from a variety of observation platforms, during different seasons, and employed mostly non-systematic sampling strategies. Although counts may be inflated by repeated observations of the same individuals, the highest number reported by Vladimirov (1994) during any sampling period was 34 gray whales observed in 1989 off northeastern Sakhalin Island. The author does not explain the origin of the estimate 250. An estimate of 100 by Blokhin (1996) was based on eight shore counts and one helicopter survey conducted between July and August of 1995 along the northeastern Sakhalin Island coast. The highest number of whales counted on any one day during that period was 42 but again, the author did not explain the origin of the estimate of 100. Therefore, both of these estimates must be considered unreliable.

Recent photo-identification studies conducted between 1994 and 1999 on the primary feeding ground off northeastern Sakhalin Island (Weller *et al.*, 1999; 2000; Würsig *et al.*, 1999; 2000) have identified a total of 88 individual whales (Table 1). These photo-identification data indicate high levels of annual return and pronounced seasonal site fidelity for most whales (Table 2). While new individuals continue to be identified annually, the rate at which this is occurring is low. Only 18 previously unidentified whales (excluding calves) were photographed during 91 days of effort between 1998 and 1999. This finding suggests that a majority of the population had been identified in the period 1994-1997 (Weller *et al.*, 2000). Between 1995 and 1999, 11 reproductive females and their

Table 1

Annual survey effort, number of groups encountered and whales identified in the period 1994-1999.

Year	Sampling period	No. of surveys	Hours of direct observation	Rolls of film used	Groups encountered	Whales identified
1994	7 Sep. - 12 Sep.					10
1995	15 Aug. - 19 Aug.	5	10.1	15	23	27
1997	9 Jul. - 8 Sep.	22	33.4	72	114	47
1998	6 Jul. - 29 Sep.	35	50.5	91	125	54
1999	29 Jun. - 13 Oct.	56	122.0	160	434	70
Overall		118	216.0	338	696	88*

*The number of whales identified annually includes resightings of individuals from previous years, resulting in a total of 88.

Table 2

Annual sighting trends and resighting percentages of whales photo-identified in the period 1994-1999.

Year	Whales identified	Calves/non-calves identified (crude birth rate)	New non-calves	Non-calves identified from previous years
1994	10		10	
1995	27	2/25*	20	20.0% ($n = 5$)
1997	47	2/45 (4.3%)	25	44.4% ($n = 20$)
1998	54	8/46 (14.8%)	5	89.1% ($n = 41$)
1999	70	3/67 (4.3%)	13	80.6% ($n = 54$)

* Insufficient data available to calculate crude birth rate.

15 calves were observed (Weller *et al.*, 2000). Two calves were observed in each of 1995 and 1997, eight in 1998 and three in 1999. Crude birth rates ranged between a low of 4.3% in 1997 and 1999, to a high of 14.8% in 1998. Of the 12 calves identified between 1995-1998, seven (58.3%) have not been resighted on the Sakhalin feeding grounds subsequent to their birth year.

Mature population size[1]

Estimating the number of whales inferred to be capable of reproduction or 'number mature' is problematic for western gray whales because there are limited direct data, and demographic estimates depend on the population growth rate, which is currently unknown. Two approaches are used here to estimate plausible, albeit conservative, numbers mature. The first uses information from Rice and Wolman (1971), who found that 24% of the eastern gray whales in their sample were sexually immature and from this suggested that the total proportion of immature animals in the population was more likely to be 44%-61%. Using the minimum estimate of 88 western gray whales (Weller *et al.*, 1999; 2000) and using the estimated proportion immature from Rice and Wolman (1971), the number of mature whales in the western population ranges between 34 and 49.

However, the eastern gray whale population was growing at the time Rice and Wolman conducted their study and would therefore be expected to consist primarily of immature animals; this would not be the case for a stable population. The second method used here is based on the premise that the proportion mature for a stable population can be estimated using age-specific birth and mortality rates. Rice and Wolman (1971) reported the mean age of sexual maturity for eastern gray whales to be eight years (range = 5-11 years). Reilly (1992) estimated adult survival to be 0.95. Although there are no data for first year survival in gray whales, it is assumed here that survival does not differ strongly from that for humpback whales (*Megaptera novaeangliae*), which is 0.875 (Barlow and Clapham, 1997). For a stable population, therefore, the estimated proportion mature is 63%, which for the estimate of 88 whales in the present case results in 55 mature animals.

In addition to the uncertainty surrounding the estimated values of the population parameters, this estimate assumes that all mature adults are capable of reproduction. If, as suspected, the western population is not growing, then it is plausible that reproduction has been compromised because the population is so small. Data from another small population that has failed to recover provide a pessimistic comparative scenario. Only 70% of North Atlantic right whale (*Eubalaena glacialis*) females known to be mature are reproductively active (IWC, 2001). If it is assumed that all males reproduce but only 70% of the females do, then 85% of the sexually mature animals are capable of reproduction. Thus, of the 55 mature western gray whales estimated using this approach, only 47 would meet the IUCN definition of mature (see below).

Clearly, both these approaches are somewhat crude and are based on assumptions that may not be valid. However, both suggest a mature population size of less than 50 mature individuals, including only 11 known calf-bearing females documented between 1995 and 1999.

[1] In terms of evaluating the western gray whale population under 'Criterion D' (population estimated to number less than 50 mature individuals) of the World Conservation Union (IUCN), the definition of 'mature individuals' in this context is defined as 'the number of individuals known, estimated or inferred to be capable of reproduction' – see section on 'International concern and conservation measures'.

Potential threats to the population

Although there is some evidence that an undetermined level of hunting may occur (e.g. Brownell and Kasuya, 1999; Baker *et al.*, 2002), it seems likely that the major threats for this population may stem from indirect mortality (e.g. bycatches and ship strikes) and habitat pollution and degredation.

Gray whales are known to be vulnerable to incidental catches in fisheries (e.g. IWC, 1994) and there are extensive coastal net fisheries off southern China, Korea and Japan (Zhou and Wang, 1994; Kato, 1998; Kim, 2000). The substantial nearshore industrialisation and shipping congestion throughout the migratory corridor(s) of this population also represent potential threats by increasing the likelihood of exposure to chemical pollution and ship strikes. Present and planned large-scale offshore gas and oil development in the South China Sea and in close proximity to the only known feeding ground for western gray whales off northeast Sakhalin Island in the Okhotsk Sea is of particular concern (e.g. see Brownell *et al.*, 1997; Brownell and Yablokov, 2001; IWC, 2002b). Activities related to oil and gas exploration, including high-intensity geophysical seismic surveying, drilling operations, increased ship and air traffic, and oil spills all pose potential threats to gray whales (e.g. Moore and Clarke, 2002). Disturbance from underwater industrial noise may displace whales from critical feeding, migratory and breeding habitat (e.g. Bryant *et al.*, 1984; Richardson *et al.*, 1995; Brownell and Yablokov, 2001). Physical habitat damage from drilling and dredging operations, combined with possible impacts of oil and chemical spills on benthic prey communities, also warrant concern.

A recent concern is the deterioration in physical condition of numerous individuals; during 1999, 2000 and 2001 whales have been observed that appeared to be unusually thin ('skinny') while on the summer feeding grounds (Weller *et al.*, 2000; authors' data). Morphological attributes correlated with this description varied among individuals, but consisted of at least one of the following: (1) an obvious sub-dermal protrusion of the top edge of the scapula from the body with associated thoracic depressions at the anterior and posterior insertion points of the flipper; (2) the presence of depressions near and posterior to the blowholes and head; and (3) a pronounced depression along the neural/dorsal spine of the lumbar and caudal vertebrae resulting in the appearance of a 'bulge' along the lateral flank.

While the causal mechanism(s) for the observed deterioration in physical condition and apparent health status of some whales is unknown, any of the following alone or in combination may be contributing factors: (1) natural or human produced changes in prey availability or habitat quality; (2) physiological changes related to stress; or (3) disease. Regardless of the cause, the loss of even a few whales (especially reproductive females) due to this deterioration in physical condition will greatly hinder population growth and ultimately prevent its recovery. Therefore, it is essential that this situation is carefully monitored and that all anthropogenic activities be reduced to an absolute minimum.

Although a natural occurrence, predation by killer whales (*Orcinus orca*) may also pose an additional threat to the recovery of this population at its currently reduced number. Killer whales are known to kill eastern gray whales, especially calves, off central and northern California (Rice and Wolman, 1971; Baldridge, 1972). Andrews (1914) found killer whale tooth raking on the flukes and flippers of a majority of the gray whales killed off Korea and

documented numerous accounts of killer whales attacking both living and already captured gray whales. Although killer whales are somewhat common off the Sakhalin Island gray whale feeding ground, no aggressive interactions between the two species have been observed (Weller *et al.*, 2000). However, of 69 gray whales photographically identified between 1997 and 1998 on the feeding ground off Sakhalin, over 33% had tooth rakes from killer whales on their flukes, flippers or bodies (authors' data). This finding suggests that killer whales are at least threatening, and perhaps killing, western gray whales somewhere within their range but any associated mortality related to these observations is currently unknown.

Other factors, for which the cause is unknown but which give rise to concern for this population include low calf survival estimates (<42%) between 1995 and 1998; a male bias (59.4% males, 40.6% females; $n=64$) in the [biopsy] sampled population and a more pronounced male bias (77.8% males, 22.2% females; $n=9$) in sampled calves.

INTERNATIONAL CONCERN AND CONSERVATION MEASURES

Largely on the basis of the recent information provided by the joint USA-Russia research programme (1995-2001) initiative and summarised here, the World Conservation Union (IUCN) listed the western gray whale population as 'Critically Endangered' in 2000 (Hilton-Taylor, 2000). In particular, this was due to the criterion that the population is estimated to have less than 50 mature individuals.

Serious concern over the status of the population has also been expressed by the Scientific Committee of the International Whaling Commission (IWC, 2002b). As a result of this, the Commission itself passed a Resolution in 2001 calling for concerted action by range states and others to pursue actions to eliminate anthropogenic mortality and disturbances on this population (IWC, 2002a). The IWC also strongly endorsed a continuation and expansion of the current research programme.

CONCLUSION

It is apparent that long-term research and monitoring efforts of the western gray whale population need to be continued and expanded. The extensive past exploitation of this population, in combination with potential new threats from anthropogenic activities throughout its range, raises questions about the potential recovery and continued survival of the western gray whale. Future measures to protect this population will require international research collaboration between all range state countries and development of effective conservation measures and dedicated cooperation between science, industry and government.

ACKNOWLEDGEMENTS

In the field we were fortunate to work with S. Blokhin, A. Bradford, Y. Ivashchenko, S. Reeve-Rickards, Y. Shvetsov, G. Tsidulko and Y. Zhalinsky. Thanks to P. Clapham, J. Darling, D. DeMaster, T. Kasuya, S. Reilly, S. Swartz, W. Perryman and A. Yablokov for their excellent advice and willingness to serve as scientific advisors. A. Dizon and R. LeDuc conducted genetic analyses of the tissue samples to determine the sex of individuals. R. Reeves and the Editor provided quality advice and comments on earlier drafts of this manuscript. Financial support for studies conducted between 1997-1999 were provided by Sakhalin Energy Investment Company (1997-1999) and Exxon Neftegas Ltd. (1997-1998). This project was conducted as part of the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves within the US-Russia Agreement on Cooperation in the Field of Environmental Protection. This represents contribution no.75 of the Marine Mammal Research Program, Texas A&M University.

REFERENCES

Andrews, R.C. 1914. Monographs of the Pacific Cetacea. I. The California gray whale (*Rhachianectes glaucus* Cope). *Mem. Am. Mus. Nat. Hist.* 1(5):227-87.

Baker, C.S., Dalebout, M.L. and Lento, G.M. 2002. Gray whale products sold in commercial markets along the Pacific coast of Japan. *Mar. Mammal Sci.* 18(1):295-300.

Baldridge, A. 1972. Killer whales attack and eat a Gray whale. *J. Mammal.* 53(4):898-900.

Barlow, J. and Clapham, P.J. 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. *Ecology* 78(2):535-46.

Berzin, A.A. 1974. Practical problems in studying cetaceans (following the example of Pacific cetaceans). *Zool. Pozv.* 6:159-89. [In Russian].

Berzin, A.A. 1990. Gray whales of the Okhotsk-Korean population in the Sea of Okhotsk. Paper SC/A90/G28 presented to the IWC Scientific Committee Special Meeting on the Assessment of Gray Whales, Seattle, April 1990 (unpublished). 5pp. [Paper available from the Office of this Journal].

Berzin, A.A. and Vladimirov, V.L. 1981. Changes in the abundance of whalebone whales in the Pacific and the Antarctic since the cessation of their exploitation. *Rep. int. Whal. Commn* 31:495-9.

Berzin, A.A., Vladimirov, V.L. and Doroshenko, N.V. 1988. Results of aerial surveys to study the distribution and abundance of cetaceans in the coastal waters of the Sea of Okhotsk in 1986-1987. pp. 18-25. *In:* N.S. Chernysheva (ed.) *Nauchno-issledovatel'ski ra'oty po morskim mlekopitayushchim severnoi chasti Tikhogo okeana v 1986-1987.* VNIRO, Moscow. [In Russian].

Berzin, A.A., Vladimirov, V.L. and Doroshenko, N.V. 1990. Aerial surveys to determine the distribution and number of polar whales and beluga whales in the Sea of Okhotsk in 1985-1989. p. 112. *In:* A.A. Berzin (ed.) *Questions Relating to the Rational Exploitation of Marine Mammals in the Far Eastern Seas.* TINRO, Vladivostok, USSR. [In Russian; Translated by Environment Canada, translation no. 4083779, 109pp.].

Berzin, A.A., Vladimirov, V.L. and Doroshenko, N.V. 1991. Results of aerial surveys to study the distribution and abundance of whales in the Sea of Okhotsk in 1988-1990. pp. 6-17. *In:* L.A. Popov (ed.) *Nauchno-issledovatel'ski ra'oty po morskim mlekopitayushchim severnoi chasti Tikhogo okeana v 1989-1990.* VNIRO, Moscow. [In Russian].

Blokhin, S.A. 1996. Distribution, abundance and behavior of gray whales (*Eschrichtius robustus*) of American and Asian populations in regions of their summer location nearshore of the Far East. *Izv. TINRO* 121:36-53. [In Russian].

Blokhin, S.A., Maminov, M.K. and Kosygin, G.M. 1985. On the Korean-Okhotsk population of gray whales. *Rep. int. Whal. Commn* 35:375-6.

Bowen, S.L. 1974. Probable extinction of the Korean stock of the gray whale (*Eschrichtius robustus*). *J. Mammal.* 55(1):208-9.

Brownell, R.L., Jr. and Chun, C. 1977. Probable existence of the Korean stock of the gray whale (*Eschrichtius robustus*). *J. Mammal.* 58(2):237-9.

Brownell, R.L., Jr. and Kasuya, T. 1999. Western gray whale captured off western Hokkaido, Japan. Paper SC/51/AS25 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 7pp. [Paper available from the Office of this Journal].

Brownell, R.L., Jr. and Yablokov, A.V. 2001. Endangered Sakhalin gray whales face cumulative threats on their feeding ground during summer 2001. Paper SC/53/BRG22 presented to the IWC Scientific Committee, July 2001, London (unpublished). 6pp. [Paper available from the Office of this Journal].

Brownell, R.L., Jr., Blokhin, S.A., Burdin, A.M., Berzin, A.A., LeDuc, R.G., Pitman, R.L. and Minakuchi, H. 1997. Report of the Scientific

Committee, Annex F, Appendix 4. Observations on Okhotsk-Korean gray whales on their feeding grounds off Sakhalin Island. *Rep. int. Whal. Commn* 47:161-2.

Bryant, P.J., Lafferty, C.M. and Lafferty, S.K. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. pp. 375-87. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale,* Eschrichtius robustus. Academic Press, Inc., Orlando, Florida. xxiv+600pp.

Henderson, D.A. 1972. *Men and Whales at Scammon's Lagoon. Baja California Travels Series No. 29.* Dawson's Book Shop, Los Angeles. 313pp.

Henderson, D.A. 1984. Nineteenth century gray whaling: grounds, catches and kills, practices and depletion of the whale population. pp. 159-86. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale*, Eschrichtius robustus. Academic Press, Inc., Orlando, Florida. xxiv+600pp.

Henderson, D. 1990. Gray whales and whalers on the China coast in 1869. *Whalewatcher* 24(4):14-6.

Hilton-Taylor, C. 2000. *2000 IUCN Red List of Threatened Species.* IUCN/SSC, Gland, Switzerland and Cambridge, United Kingdom. i-xviii+64pp.

International Whaling Commission. 1994. Report of the Workshop on Mortality of Cetaceans in Passive Fishing Nets and Traps. *Rep. int. Whal. Commn* (special issue) 15:1-71.

International Whaling Commission. 1998. Report of the Scientific Committee. Annex J. Report of the Sub-Committee on Aboriginal Subsistence Whaling. *Rep. int. Whal. Commn* 48:237-48.

International Whaling Commission. 2001. Report of the Workshop on Status and Trends of Western North Atlantic Right Whales. *J. Cetacean Res. Manage.* (special issue) 2:61-87.

International Whaling Commission. 2002a. Chairman's Report of the Fifty-Third Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:In press.

International Whaling Commission. 2002b. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.

Kasahara, A. 1950. Whaling and whale resources in the adjacent waters of Japan. *Nippon Suisan K.K. Kenkyuhoukoku* 4:1-103. [In Japanese].

Kato, H. 1998. Japan. Progress report on cetacean research May 1996 to April 1997. *Rep. int. Whal. Commn* 48:329-37.

Kato, H. and Kasuya, T. 2002. A note on the modern whaling catch history of the western North Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.*:In press.

Kato, H. and Tokuhiro, Y. 1997. A sighting of gray whale off Kochi, southwest Japan in 1997, with some notes on its possible migration in adjacent waters of Japan. Paper SC/49/AS17 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 8pp. [Paper available from the Office of this Journal].

Kim, S.L. and Oliver, J.S. 1989. Swarming benthic crustaceans in the Bering and Chukchi Seas and their relation to geographic patterns in gray whale feeding. *Can. J. Zool.* 67(6):1531-42.

Kim, Z.G. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 4. Bycatch of minke whales in Korean waters, 1998. *J. Cetacean Res. Manage. (Suppl.)* 2:103-4.

Krupnik, I. 1984. Gray whales and the aborigines of the Pacific Northwest: the history of aboriginal whaling. pp. 103-20. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale,* Eschrichtius robustus. Academic Press Inc., Orlando, Florida. xxiv+600pp.

LeDuc, R.G., Weller, D.W., Hyde, J., Burdin, A.M., Rosel, P.E., Brownell, R.L., Jr., Würsig, B. and Dizon, A.E. 2002. Genetic differences between western and eastern gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):1-5.

Mead, J.G. and Mitchell, E.D. 1984. Atlantic gray whales. pp. 33-53. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale*, Eschrichtius robustus. Academic Press, Orlando, FL. xxiv+600pp.

Mizue, K. 1951. Gray whales in the east sea area of Korea. *Sci. Rep. Whales, Res. Inst., Tokyo* 5:71-9.

Moore, S.E. and Clarke, J.T. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):19-25.

Nerini, M. 1984. A review of gray whale feeding ecology. pp. 423-50. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale,* Eschrichtius robustus. Academic Press, Inc., Orlando, Florida. xxiv+600pp.

Nishiwaki, M. and Kasuya, T. 1970. Recent record of gray whale in the adjacent waters of Japan and a consideration on its migration. *Sci. Rep. Whales Res. Inst., Tokyo* 22:29-37.

Oliver, J.S., Slattery, P.N., Silberstein, M.A. and O'Connor, E.F. 1984. Gray whale feeding on dense ampeliscid amphipod communities near Bamfield, British Columbia. *Can. J. Zool.* 62(1):41-9.

Omura, H. 1974. Possible migration route of the gray whale on the coast of Japan. *Sci. Rep. Whales Res. Inst., Tokyo* 26:1-14.

Omura, H. 1984. History of gray whales in Japan. pp. 57-77. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale*, Eschrichtius robustus. Academic Press Inc., Orlando Florida. xxiv+600pp.

Omura, H. 1988. Distribution and migration of the western Pacific stock of the gray whale. *Sci. Rep. Whales Res. Inst., Tokyo* 39:1-9.

Reilly, S.B. 1992. Population biology and status of eastern Pacific gray whales: recent developments. pp. 1,062-74. *In:* D.R. McCullough and R.H. Barrett (eds.) *Wildlife 2001: Populations.* Elsevier Applied Science Publishers, London. xv+1,163pp.

Rice, D.W. 1998. *Marine Mammals of the World. Systematics and Distribution.* Special Publication No. 4. The Society for Marine Mammology, Lawrence, Kansas. 231pp.

Rice, D.W. and Wolman, A.A. 1971. *The Life History and Ecology of the Gray Whale* (Eschrichtius robustus). American Society of Mammalogists, Special Publication No. 3, Stillwater, Oklahoma. viii+142pp.

Richardson, W.J., Greene Jr, C.R., Malme, C.I. and Thomson, D.H. 1995. *Marine Mammals and Noise.* Academic Press, San Diego. 576pp.

Swartz, S.L. 1986. Gray whale migratory, social and breeding behavior. *Rep. int. Whal. Commn* (special issue) 8:207-29.

Vladimirov, V.L. 1994. Recent distribution and abundance level of whales in Russian Far-Eastern seas. *Russian J. Mar. Biol.* 20:1-9.

Wang, P. 1978. Studies on the baleen whales in the Yellow Sea. *Acta Zool. Sin.* 24(3):269-77.

Wang, P. 1984. Distribution of the gray whale (*Eschrichtius gibbosus*) off the coast of China. *Acta Ther. Sinica* 4(1):21-6. [In Chinese with English summary].

Weller, D.W., Würsig, B., Bradford, A.L., Burdin, A.M., Blokhin, S.A., Minakuchi, H. and Brownell, R.L., Jr. 1999. Gray whales (*Eschrichtius robustus*) off Sakhalin Island, Russia: seasonal and annual patterns of occurrence. *Mar. Mammal Sci.* 15(4):1208-27.

Weller, D.W., Würsig, B., Burdin, A.M., Reeve, S.H. and Bradford, A.L. 2000. Gray whales off Sakhalin Island, Russia: June-October 1999. A joint US-Russian scientific investigation. Unpublished contract report submitted by Texas A&M University and the Kamchatka Institute of Ecology and Nature Management, June 2000, 70pp. [Available from the author].

Weller, D.W., Reeve, S.H., Burdin, A.M., Würsig, B. and Brownell, R.L., Jr. 2002. A note on the spatial distribution of western gray whales (*Eschrichtius robustus*) off Sakhalin Island, Russia in 1998. *J. Cetacean Res. Manage.* 4(1):13-17.

Würsig, B., Weller, D.W., Burdin, A.M., Blokhin, S.A., Reeve, S.H., Bradford, A.L. and Brownell, R.L., Jr. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint US-Russian scientific investigation. Unpublished contract report submitted by Texas A&M University and the Kamchatka Institute of Ecology and Nature Management, February 1999, 101pp. [Available from the author].

Würsig, B., Weller, D.W., Burdin, A.M., Reeve, S.H., Bradford, A.L., Blokhin, S.A. and Brownell, R.L., Jr. 2000. Gray whales summering off Sakhalin Island, Far East Russia: July-September 1998. A joint US-Russian scientific investigation. Unpublished contract report submitted by Texas A&M University and the Kamchatka Institute of Ecology and Nature Management, February 2000, 133pp. [Available from the author].

Yablokov, A.V. and Bogoslovskaya, L.S. 1984. A review of Russian research on the biology and commercial whaling of the gray whale. pp. 465-85. *In:* M.L. Jones, S.L. Swartz and S. Leatherwood (eds.) *The Gray Whale,* Eschrichtius robustus. Academic Press Inc., Orlando, Florida. xxiv+600pp.

Zhou, K. and Wang, X. 1994. Brief review of passive fishing gear and incidental catches of small cetaceans in Chinese waters. *Rep. int. Whal. Commn* (special issue) 15:347-54.

Zhu, Q. 1998. Strandings and sightings of the western Pacific stock of the gray whale *Eschrichtius robustus* in Chinese coastal waters. Paper SC/50/AS5 presented to the IWC Scientific Committee, April 1998, Oman (unpublished). [Paper available from the Office of this Journal].