Report of the Western Gray Whales Rangewide Workshop

Western Gray Whales:
Status, Threats And The Potential For Recovery

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CONTENTS

1. WELCOME AND OPENING REMARKS

Since 1998, the Scientific Committee of the International Whaling Commission (IWC) has reviewed the status of western gray whales annually and made various recommendations for research and conservation. In October 2002, the IWC held a workshop in Ulsan, Republic of Korea, to review knowledge and to stimulate and guide research in all range states of this population (IWC, 2004). In 2004, the International Union for Conservation of Nature (IUCN) established an Independent Scientific Review Panel (ISRP) with a mandate to evaluate scientific aspects of western gray whale conservation in the context of Sakhalin-II Phase 2, a large offshore oil and gas project in close proximity to the population's primary summer feeding area off northeastern Sakhalin Island, Russia (Reeves *et al.* 2005). Among other things, the ISRP noted the need for a comprehensive, international strategy for studying and conserving this population, which is listed as Critically Endangered on the IUCN Red List of Threatened Animals. Following completion of the work by the ISRP and a series of expert workshops on Sakhalin issues, IUCN established a standing Western Gray Whale Advisory Panel (WGWAP) which has met regularly since 2006 (http://www.iucn.org/wgwap/). Given the limited nature of the WGWAP mandate, which focuses on oil and gas activities on the northeastern Sakhalin shelf, IUCN recognised the need to address other known and potential threats to the western gray whale population elsewhere in its range (see Fig. 1). Therefore, the present Workshop was organised as a step towards development of a comprehensive, rangewide strategy, as anticipated by the Ulsan workshop in 2002 and the ISRP in 2005. Most attention focussed on areas of the western gray whale range outside the Sakhalin shelf area given the extensive work of the WGWAP on that region.

1.1 Welcome, introduction of participants

The Workshop was held at the National Museum of Nature and Science, Tokyo, Japan, from 21-24 September 2008. A list of participants is given in Annex A.

Lundin and Larsen welcomed participants on behalf of the IUCN Global Marine Programme (GMP) and thanked Yamada and the National Museum of Nature and Science for hosting the Workshop. For their efforts in planning the Workshop, Lundin thanked Brownell, Donovan, Kato, Reeves and Yamada; other members of the steering group who were unable to attend the meeting were Andrew Hurd of the GMP and Jean-Christophe Vié of the IUCN Species Programme. François Simard of IUCN provided helpful advice concerning logistics. Financial support was provided by Sakhalin Energy Investment Company via a contract with the GMP.

1.2 Logistics, rapporteur assignments, reporting

Bannister chaired the meeting and Gotheil and Reeves served as rapporteurs. They received valuable assistance from Donovan and Weller in preparation of the report. The Conclusions and Recommendations section (Item 6) was reviewed and agreed before adjournment. The rest of the report was drafted after the meeting, reviewed by participants via e-mail, and revised before final issuance.

1.3 Adoption of agenda

The agenda, as adopted, is given in Annex B.

1.4 Documents available

A list of documents available to the Workshop is given in Annex C. Attention was drawn to additional information to be found in the reports of meetings of the IWC Scientific Committee (annual supplements to the *Journal of Cetacean Research and Management*) and the reports of the various IUCN western gray whale panels (all available at http://www.iucn.org/wgwap/).

1.5 Development of an effective conservation plan for western gray whales

Donovan suggested that one appropriate outcome of the Workshop would be to provide the scientific basis for the development of a conservation plan for western gray whales and a mechanism for the future development of such a plan. He introduced Donovan *et al.* (2008) that proposed an approach towards developing conservation plans that should optimise the likelihood that such plans are effective. The authors concluded that well-developed conservation plans represent one important component of effective cetacean conservation. The development of conservation plans involves integrating information on the population of interest with information on threats in a co-ordinated and quantitative manner with respect to prioritised quantifiable objectives. Whilst a sound scientific basis and continuing scientific programme are essential, consideration of the appropriate legal framework and the involvement of a broad range of stakeholders throughout the development and implementation process are also critical for success. A key component of a conservation plan is a series of focussed, costed actions with timelines and quantified targets. These may cover a variety of areas including: research, management/legislation, compliance, monitoring, capacity building/public awareness and co-ordination. Conservation plans should be seen as living documents and an appropriate monitoring programme to evaluate whether objectives are being met and a strategy for regular evaluation and if necessary updating must be integral parts of the plans.

The Workshop **agreed** to the approach suggested and this is discussed further under Item 5 and in Annex D.

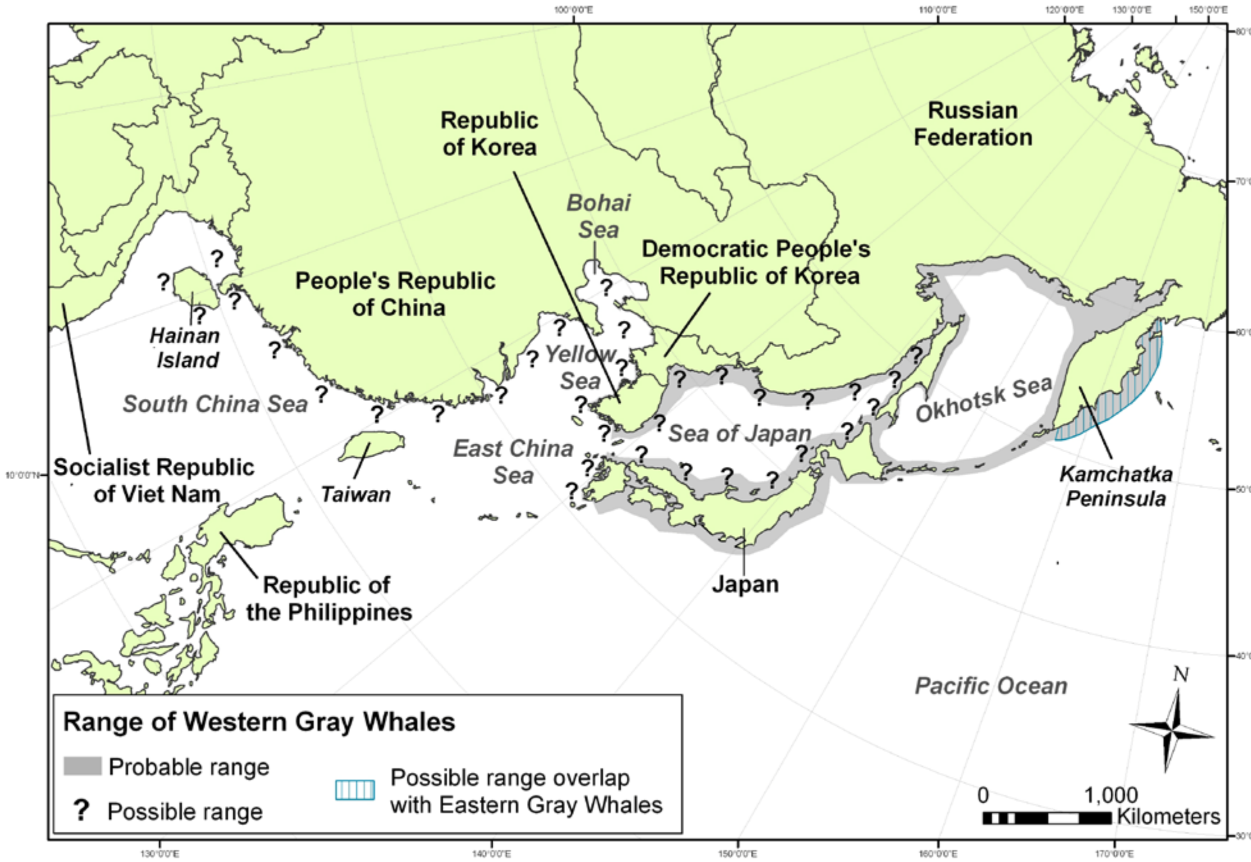

Fig. 1. Map showing the range of the western gray whale and the possible overlap with the eastern gray whale.

2. POPULATION BIOLOGY

2.1 Population structure

2.1.1Differences between eastern and western populations

Lang presented RW2008-2 on genetic differentiation between eastern and western gray whale populations using microsatellite markers. Within the North Pacific Ocean, gray whales occur as distinct eastern and western populations. Although both populations were severely reduced by whaling, the eastern one has recovered while the western one remains severely depleted. Previous studies have documented genetic differentiation between the two populations on the basis of mtDNA haplotype frequencies (LeDuc *et al.*, 2002). Since mtDNA represents only maternal inheritance patterns, RW2008-2 used bi-parentally inherited microsatellite markers (n=14) to measure differentiation between the populations as well as to compare levels of nuclear genetic diversity retained in each of them. Mean levels of genetic diversity were similar for the two populations, suggesting that significant amounts of nuclear genetic diversity have not been lost in the small western population. Comparison of microsatellite allele frequencies confirmed that the eastern and western populations are genetically distinct ($p<0.001$). Although highly significant, the level of differentiation between them is relatively low, which may reflect recent divergence or indicate that a limited degree of dispersal or gene flow is occurring.

The Workshop welcomed this study, noting that it confirmed previous assumptions and conclusions.

2.1.2 Structure within the western population

Lang presented RW2008-1, which addressed *inter alia* the question of whether there is evidence of substructure within the western gray whale population. Much of what is known about western gray whales has been derived from studies of whales observed or sampled in the near-shore feeding area off northeastern Sakhalin Island (Russia), where mating does not occur. There is little information on contemporary migratory routes or wintering areas of western gray whales but it has been suggested that more than one route was used in the past (see Item 2.3). Any segregation of whales during the period when breeding occurs (winter to early spring) could result in population substructure. Three types of analyses were used to explore the possibility of substructure. Firstly, a clustering method was used to assess whether genetic markers could detect structure within the samples collected in the Sakhalin feeding area. Secondly, paternities of whales first observed as calves off Sakhalin were assessed to provide information on the proportion of successfully breeding males that has been sampled. Thirdly, genetic assignment tests were used to evaluate potential dispersal between the eastern and western populations.

The cluster analysis found no strong signal to indicate substructure within the western population although the authors cautioned that this possibility could not be entirely ruled out on the basis of their results.

The paternity assessment was successful in assigning putative fathers to only 26 (47%) of the 55 calves. Given that 84% of the photo-identified individuals from Sakhalin had been genetically sampled, the authors found this low rate of paternity assignment surprising. They concluded that the most likely explanation was that at least some individuals ('missing fathers') range more widely during the summer (*e.g.* to Kamchatka Peninsula, Russia) and have not been sampled in the Sakhalin feeding area. It was also noted that not all whales observed off Sakhalin had been sampled and that adult males, in particular, might have been under-sampled in the biopsy programme.

The genetic assignment tests identified a small number of animals sampled off Sakhalin as potential dispersers from the eastern population – four males and one female. None of the four males had been identified as a putative father of a Sakhalin calf and the female had never been sighted with a calf. It is also of interest that the genotype of a female sampled off eastern Kamchatka had a higher probability of belonging to the western population than to the eastern.

In discussion, the Workshop **agreed** that it was important to examine whether the low rate of paternity assignment obtained by the authors really was unexpected. This can be achieved by determining the expected percentage of paternities assuming a null hypothesis that the population is closed and mating is at random. It was also suggested that it could be informative to compare the results of the present study with similar analyses on another whale population.

2.2 Population biology

Weller presented RW2008-8, a summary of what is known about life history parameters of the western gray whale population. As part of the ongoing Russia-U.S. research programme, a preliminary analysis was conducted to examine birth intervals and sex composition of western gray whales summering off northeastern Sakhalin Island. A total of 23 mothers and 68 calves were identified in the Sakhalin feeding area between 1995 and 2007. The annual number of calves recorded ranged between 2 and 11. The number of calves observed with a given mother ranged from 1 to 5. A total of 38 birth intervals for 19 (83%) of the 23 reproductive females had been documented. The number of intervals available to be calculated per female ranged from 0 (for females that were sighted with only one calf) to 4 (for females that were observed with five calves). Of the observed birth intervals, 50% (n = 19) were 2 years, 34% (n = 13) 3 years, 10.5% (n = 4) 4 years and the remainder consisted of one interval of 5 years and one of 6 years.

For the subset of 12 females in which more than one birth interval could be calculated, the interval remained stable for 6 (50%), decreased for 5 (42%) and increased for 1 (8%). In general, most females appeared to be maintaining stable intervals of 2 years (n = 5) or 3 years (n = 1) or to have experienced a shortening of the birth interval (n = 5).

Of the 68 western gray whale calves observed between 1995 and 2007, none had yet been observed to produce a calf of its own. However, in 2007 a whale first observed as a yearling in 2001 was sighted accompanied by a calf, and the parent-offspring relationship was subsequently confirmed through genetic analysis. Based on the presence of a full year of barnacle growth and associated scarring, which allows a clear visual distinction to be made between calves and yearlings, the age at first birth recorded for this female was 7 years. Assuming this whale conceived as soon as she was sexually mature, her age at sexual maturity was 6 years.

For all individuals (n = 142) sampled between 1995 and 2007, males predominated (58%). This was also true for the subset of whales sampled as calves (n = 59) of which 66% were male. The sex ratio of calves as a function of year was also biased; in 9 (75%) of 12 years males predominated.

The overall sex ratio of calves born to the 17 reproductive females that produced at least two calves of known sex during the study varied. Ten (59%) of these females had more males, including 5 individuals that produced only male offspring. In comparison, 3 females (18%) had more females, including 2 individuals that produced only female offspring. Finally, 4 females (23%) had an equal male to female calf ratio.

Workshop participants welcomed this updated summary of reproductive biology and noted that the male-biased sex ratio was both biologically interesting and deserving of closer investigation, particularly given the suggestion of male bias in historical catch data (Andrews, 1914; Mizue, 1951). All of the data summarised in RW2008-8 are incorporated in the population model described in RW2008-12 (see Item 2.9, below).

2.3 Phenology and distribution

This section includes information on past and present distributional limits, migration timing and routes, and locations of summer feeding areas and winter breeding/calving areas.

Three Workshop papers and several presentations addressed this topic. The papers by Uni (RW2008-11) and Nambu *et al.* (RW2008-18) provided information on gray whale occurrence and movements around Japan; that by Brownell and Weller (RW2008-19) provided a rangewide synthesis of distribution and movements. In addition, Vladimirov and Vertjankin gave presentations on occurrence and movements in the Sea of Okhotsk and along the eastern coast of the Kamchatka Peninsula.

RW2008-11 used historical and recent records of sightings, strandings, bycatches and whaling catches to evaluate hypotheses regarding migratory routes. The Sea of Japan was a freshwater lake during the last ice age and therefore gray whales could only have migrated along the Pacific coast of the Japanese islands at that time. The 'Pacific route' (along the Pacific coast of Japan) is not just an occasional route or a route used by 'strays' but rather a regular route for at least part of the western gray whale population; most recent sightings, entrapments and strandings in Japan have been along the Pacific coast. Japanese whaling for western gray whales (over the past 400-500 years) occurred mainly in the Sea of Japan.

Fig. 2. Japanese place names referred to in the text of the report.

The author concluded that the available evidence was best explained by the following hypotheses:

(1) gray whales migrate from the Sea of Japan into the Sea of Okhotsk through Soya (La Pérouse) Strait;

(2) gray whales travel from the East China Sea to the Pacific Ocean by passing around Kyushu and past the Ohsumi Islands;

(3) if gray whales enter the Inland Sea, they do so through the Bungo Channel or the Kii Channel, and not the Kan-mon Strait;

(4) gray whales enter the Sea of Okhotsk from the Pacific coast, via the Kunashir Strait (southern Kuriles) or other passes in the northern Kuriles (*i.e.* they do not use the Nemuro Strait);

(5) some gray whales using the Pacific route visit feeding areas off Kamchatka.

If the author is correct in assuming that some gray whales use the waters around Kyushu, mitigation measures to reduce the potential risks from vessel traffic, particularly high-speed ferries, should be a priority. Uni suggested that an observation tower at Cape Shionomisaki on the southern tip of Honshu would be a good place to look for gray whales using the Pacific coast migratory route. He expressed the view that gray whales pass particularly near the Japanese coast in areas where there is a steep depth gradient near shore.

In discussion it was noted that the use of multiple migratory routes by western gray whales is consistent with eastern gray whales along the coasts of Washington, British Columbia and Alaska. However, eastern gray whales also often cross open bights with deep water, so it should not be assumed that western gray whales always keep close to shore during migration.

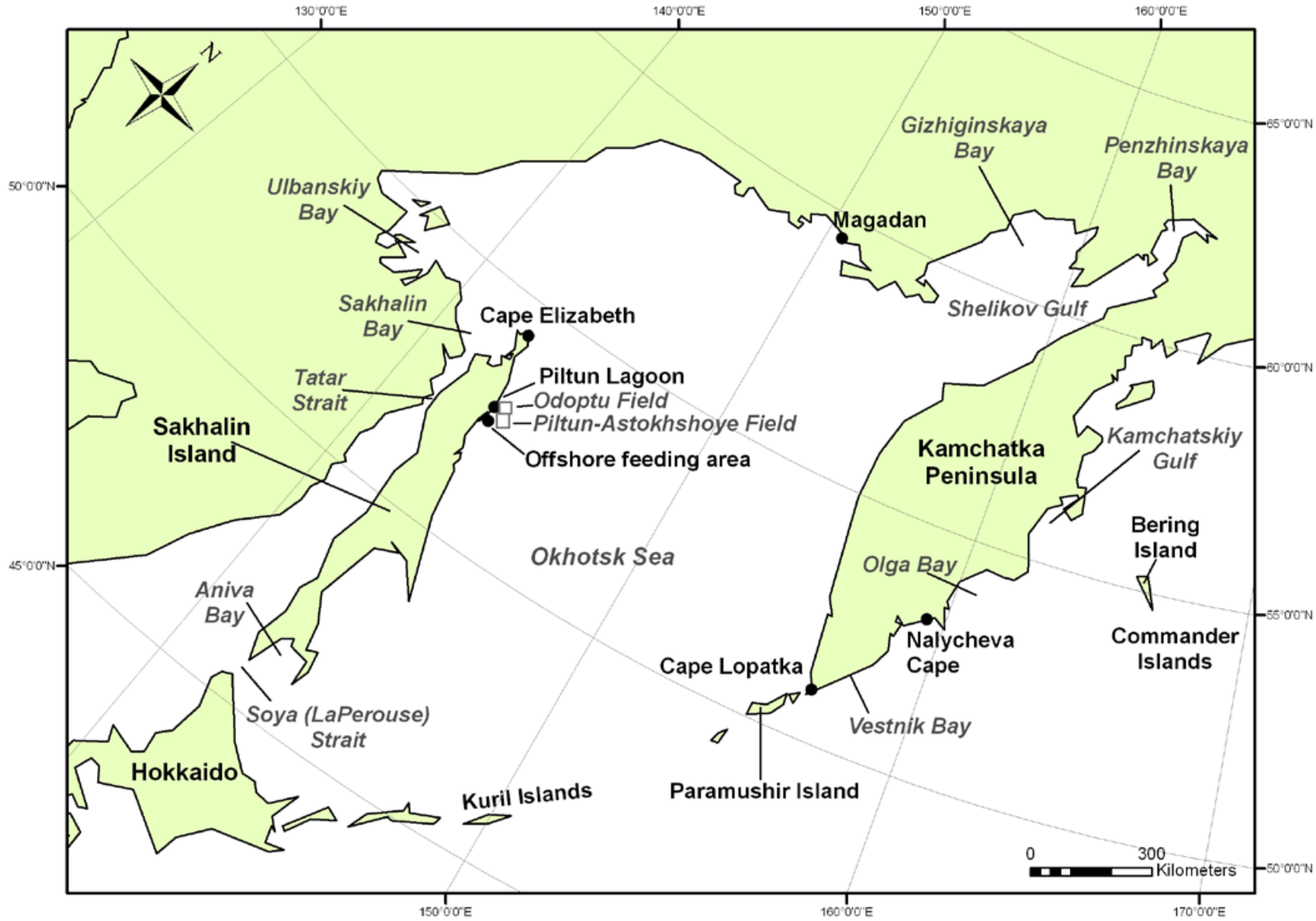

Fig. 3 Sakhalin and Kamchatka regions showing place names mentioned in the text.

RW2008-18 reviewed the migration routes of western gray whales suggested by various Japanese scientists and considered these in the context of historical and recent records from Toyama Bay, Sea of Japan. They noted two catches in set nets[1] in the bay, one in March 1955 and one in April 1970. They also reported two other records: a broken skull of an adult gray whale found at Kashiwazaki, Niigata Prefecture, in March 1997; and a carcass found drifting off Suttsu-cho in 1996 (Brownell and Kasuya, 1999; Uni and Kasuya, 2002). Those are the only four records of gray whales from the Sea of Japan coast of Japan since 1950. The authors of RW2008-18 concluded that the Sea of Japan coast was still used at least occasionally by a few individuals and Nambu urged, therefore, that this route's potential importance to the population not be discounted.

Vladimirov (RW2008-21) summarised data on the feeding distribution and movements of gray whales along the eastern coast of Sakhalin Island, primarily as a result of the co-funded programme by SEIC and Exxon-Neftegas. This information has been, and continues to be, of central interest to the WGWAP and therefore it was discussed only briefly at the Workshop. The general pattern observed from 2001-2007 was for the numbers of gray whales off Sakhalin to increase in July and into August, become relatively stable during the second half of August and through September, and decline after September. Nearly all of the whales (*ca* 97%) have been observed within 5 km of shore while they were in the Piltun (near-shore) feeding area. Vladimirov stated that very few whales were observed in the 'offshore' feeding area in 2004. After 2004, and at least from 2005 - 2007, it appeared that the numbers of whales using that area returned to previous levels. Vladimirov suggested that the anomalous situation in 2004 had been related to a seismic survey carried out by Rosneft in late September that year, a time when gray whale densities in the region are normally relatively high. Vladimirov also noted that survey effort had been reduced in 2006 due to poor weather conditions and that in 2007 the density of whales was very low in the northern part of the Piltun feeding area. He stressed that, when comparing the albeit sparse information available on gray whale occurrence and distribution in the Sakhalin region between 1984-1991 (helicopter surveys by the research institute TINRO, late May to early November) with that

[1] These correspond to the FAO category 'stationary uncovered pound net' http://www.fao.org/fishery/geartype/search

obtained by relatively intense monitoring between 2001-2007, in his view there was no qualitative indication of a change in distribution despite the extensive oil and gas exploration and development activity there.

Vertjankin (RW2008-22) reported that after a long period starting in the early 20th century with virtually no information on gray whales off Kamchatka, sightings began to be reported in the late 1970s (a single animal was seen off Cape Lopatka in 1979). Gray whales have been seen with increasing frequency off southern Kamchatka in recent years, mainly in Vestnik and Olga Bays. Effort to look for whales has also increased in recent years.

He noted that the whales are seen mainly within 3 n.miles (5.5 km) of shore. Sightings in Vestnik Bay began in 1983 and reached a peak in 1994, then declined somewhat. By the early 2000s, individual gray whales were being seen near Nalycheva Cape (250 km to the north) and in Olga Bay (510 km north). Seven whales were seen near Nalycheva Cape in 2002 and two or three were present in Olga Bay in 2001. In 2002, 11 different individuals were seen in Olga Bay and in 2006, 15. By 2004, as many as three gray whales were observed in Kamchatskiy Gulf (350 km north of Olga Bay). Overall, there appears to have been a tendency for the numbers to increase and for the range to expand northwards along the Kamchatka coast with time. Vertjankin estimated that gray whales had extended their range northwards by about 1000 km along the Kamchatka coast over the last 30 years. He stated that sighting effort in the two main bays was consistent from year to year because regular monitoring is an aspect of management of the protected areas within which both Vestnik and Olga bays are located (see Item 4.2.4).

In August 2006, 12 individuals were photo-identified in Olga Bay. Photographs of these whales, together with photographs of one whale seen in Vestnik Bay in early July 2006 (by V.N. Burkanov) and three whales seen near Nalycheva Cape in July and August 2004 (by Burkanov and Vertjankin) were compared to the IBM catalogue (by Olga Tyurneva). It was confirmed that six of the 16 whales photo-identified off eastern Kamchatka in 2004 and 2006 had also been documented off Sakhalin. Five of these had been photographed off Sakhalin between 2002 and 2005, while the sixth was first photo-identified off Kamchatka in August 2004 and was then photo-identified for the first time off Sakhalin in September 2006. Two animals photographed off Kamchatka, in Vestnik and Olga bays, on 5 July and 22 August 2006 were observed off Sakhalin, nearly 1000 km away, 50 and 39 days later, respectively (23 August and 28 September). These findings demonstrate that some whales move between the two areas within a single summer feeding season.

Whales photo-identified off Sakhalin have now been documented off Kamchatka and Magadan (northern Sea of Okhotsk), both during the same season and between seasons. Of seven whales identified in Vestnik Bay in 2007, six had been identified off Sakhalin in previous years. All six were also seen off Sakhalin in 2007. The seventh individual was new to the records from both Sakhalin (IBM catalogue) and Kamchatka. Among the 30 gray whales identified in Olga Bay in 2007, 12 have also been identified off Sakhalin, six during the same season. Two were 'new' to the IBM Sakhalin catalogue. Of the three individuals identified off Magadan in 2006, two were observed in Olga Bay in 2007.

It is Vertjankin's view that the whales seen off southeastern Kamchatka arrive from the south and move north along the Kamchatka coast. He also has the impression that the period of occupancy by the whales in the region is lengthening. Feeding behaviour and defecation have been observed in Olga Bay. None of the whales observed off Kamchatka has been characterized as 'skinny'. The season of occurrence off Kamchatka is prolonged, with the first individuals appearing in late May and the last observations being in late December or early January. In 2004, the whales did not leave the Kamchatka coast until early February. Vertjankin suggested that feeding conditions are favourable for gray whales in the bays along the Kamchatka coast. Moreover, sea ice is generally absent through the winter and killer whales are uncommon in the near-shore parts of bays where the gray whales concentrate. In addition, there is no human economic activity in the bays where the whales are seen. Even research activity is limited, with special permits required to enter these legally protected areas.

Vertjankin reported that about half of the whales seen off Kamchatka in August in 2006 and 2007 were young, judging by their relatively small size and comparatively small blow profiles. In total, 22 of the 44 individuals photo-identified thus far off southeastern Kamchatka have also been photo-identified off Sakhalin. Four individuals first identified as calves off Sakhalin have been seen later off Kamchatka. Two of four whales photo-identified in Olga Bay on 22 August 2006 were identified from the IBM Sakhalin catalogue as calves born in 2003 and 2004; they had not been re-identified off Sakhalin after their initial sightings there. In 2008, a mother-calf pair was sighted off Kamchatka in August. This mother had been photo-identified off Sakhalin in 2006 and off Kamchatka in 2007 without a calf.

Vertjankin offered three hypotheses that could explain the occurrence of some gray whales off Kamchatka that have not been photo-identified off Sakhalin: (1) they move north along the Sakhalin coast in early summer (June to early July) and south again in the late autumn or early winter (November-December), which means they are not observed during the field season for photo-identification effort from mid-July to early October; (2) they migrate along the Kuril chain to and from Kamchatka, without visiting Sakhalin coastal waters; and (3) at least some of them are eastern gray whales.

It was noted during discussion that the lighter ice conditions off Kamchatka represented a significant, recent change, possibly triggered or enhanced by a pivotal, very extreme El-Niño event in 1998. Vertjankin stated that the last time sea ice arrived in southeastern Kamchatka from the north was about ten years ago.

Following on from the information provided by Vertjankin, Brownell noted that the Russia-U.S. programme had made earlier matches of whales photo-identified off Sakhalin to other areas in the Okhotsk Sea and in the Bering Sea. The first related to a single animal photographed on 13 June 2000 off Bering Island, near Nikolskaya Bay, in the western Bering Sea and subsequently matched to the Sakhalin Island catalogue. It had first been identified as a calf in 1997 off northeastern Sakhalin Island, but not photographed there again until 2002 (Weller *et al*., 2003). The second related to a gray whale sighted on 2 July 2000 in the Okhotsk Sea off the southwestern end of Paramushir Island, Russia (50° 16' N 155° 12' E), one of the most northern Kuril Islands. This whale, observed to be feeding near shore, was videotaped and the resulting fluke images were matched to whale No. 021 from the Sakhalin catalogue (Weller *et al*., 2002). It was seen again on 2 September 2000 off Ulbanskiy Bay in the Shantar Island Archipelago, Russia (53° 58' N 137° 51' E), travelling rapidly and frequently displaying fluke-up dives in water approximately 25m deep (Weller *et al*., 2002).

The Workshop was pleased to receive the considerable amount of new information on the links between the known and suspected feeding areas.

RW2008-19 was a synthesis of information on distribution and migration of western gray whales based on all available published and unpublished records (including those gleaned from museum specimens, strandings, captures and sighting observations). Records from all of the range states were covered and where possible, details of the records were provided.

In summary, the list of records reviewed for the 19th, 20th and 21st (up to 2007) centuries support the idea that western gray whales mainly summer and feed in the Okhotsk Sea. These data also suggest that during the southbound migration from the feeding grounds to the wintering grounds, segments of the population used routes along (1) the Korean Peninsula, (2) the western coast (Sea of Japan) of Hokkaido and Honshu, Japan and/or (3) the eastern (Pacific) coast of Japan. It is presumed that the winter destination of these whales was the East China Sea. However, it has been speculated that whales migrating off the Pacific coast of Japan may have used the Seto Inland Sea as a calving area.

There are no historical or recent records to suggest that western gray whales ever used the southern Korean Peninsula as a wintering or calving area. The last known observation in Korean waters was in 1977 although a 12 m female stranded in northern Korea Bay in early December 1996, just west of the China-North Korea border (RW2008-11). There are no confirmed records of gray whales from Taiwan although American whalers in the 19th century reported seeing them in the middle of Taiwan Strait and off the northern coast of Taiwan (Henderson 1990). One region that still needs to be investigated for the current presence of western gray whales is the northeastern Okhotsk Sea (Shelikhov Gulf, Gizhiginskaya Bay and Penzhinskaya Bay) where 19th century American whalers hunted gray whales and bowhead whales (Reeves *et al.* in press).

Almost all reports of western gray whales outside of the Okhotsk Sea since the 1970s have come from the Pacific coast of Japan. This finding, in combination with the recent fatal set net entrapments of four whales off the Pacific shores of Japan, clearly demonstrates the critical need for implementation of the conservation and protection measures in this area.

In discussion, it was noted that additional effort is needed to search for historical data on the various whaling stations on and near the Korean peninsula that took gray whales (Kato and Kasuya, 2002). Additionally, the Workshop stressed the importance of knowing more about the migration route(s), wintering area(s) and summering areas of western gray whales so that mitigation efforts can be appropriately designed and focussed. These information gaps highlight the need for telemetry work to be carried out (see Item 2.11.1) as well as the need for improvements in reporting and response networks so that strandings, sightings and bycatches have a higher likelihood of being investigated and verified.

2.4 Feeding ecology

This section includes information based on studies of this population (historical and recent) and analogies with the eastern population.

VanBlaricom provided a brief presentation summarising current knowledge on the foraging ecology of gray whales – much of the information on western gray whales has been discussed in the WGWAP. The traditional understanding (‘classic model’) of gray whale foraging comes primarily from observations of eastern gray whales during summer months in the Bering Sea. In this region the whales are thought to feed primarily on benthic crustaceans, particularly amphipods of the genus *Ampelisca*. Ampeliscid amphipods are relatively large (up to 2cm in length) and high in lipid content, and they typically occur in dense patches on the Bering Sea floor. They are tube-dwelling filter-feeders and are relatively sessile. In areas with dense patches of benthic amphipods, gray whales are observed to roll on their right side and to force the rostral area into the sediment, engulfing large quantities of sediment, water and prey in their mouth. Engulfed materials are then filtered through the baleen in the manner of other baleen whales, with prey retained on the inside of the baleen and subsequently swallowed. Foraging activity of gray whales can be detected readily from the air because of mud plumes associated with benthic disturbances. Such disturbances initiate patch-specific successional responses in the benthic infaunal community, with some species specializing in opportunities for foraging or space exploitation as a result of the disturbances. The interaction of disturbance and subsequent succession creates a temporal-spatial mosaic on the sea floor, likely enhancing spatial and temporal variance, diversity and productivity in the ecosystem.

Feeding activities that do not conform to the above model have been observed off the coasts of Washington and British Columbia. In some areas there, gray whales feed primarily on hypoplanktonic mysids that swarm adjacent to rocky reefs and kelp forests. In such cases, the feeding activity of the whales is much like that of other baleen whale species, with filtering and ingestion of prey occurring in the water column, without ingestion of sediment or disturbance to the sea floor. Gray whales also have been seen feeding at the sea surface on dense patches of minute crab larvae, with filtration and ingestion occurring at the sea surface.

Foraging by western gray whales has been observed primarily in the feeding area adjacent to Piltun Lagoon, generally in waters < 20 m deep. All foraging activity observed to date has involved benthic prey and disturbance to the benthos. Foraging activity in the southern part of the Piltun feeding area likely focuses on patches of the dominant benthic species, the amphipod *Pontoporeia affinus*. *P. affinus* is a mobile detritivore that does not form tubes on the sea floor. The ecosystem-level significance of predation on *P. affinus*, and of the associated disturbance to benthic habitats in the Piltun area, is unknown. There is circumstantial evidence indicating that western gray whales may feed on sandlance (*Ammodytes hexapterus*) in the northern portion of the Piltun feeding area during some years. The sandlance is a forage fish common in the coastal North Pacific and adjacent coastal seas. These fish bury themselves in benthic sediments when at rest, and they may be vulnerable to ingestion by foraging gray whales. V. Fadeev has reported a positive correlation between gray whale feeding activity in the northern part of the Piltun feeding area and indices of sandlance abundance.

Western gray whales also forage in an 'offshore' feeding area southeast of the Piltun feeding area. Benthic habitats there are deeper (40-50 m) and are dominated by ampeliscid amphipods. Such habitats may be similar ecologically to those of the well-known feeding grounds of eastern gray whales in the Bering Sea.

Selection of prey species by western gray whales has been inferred primarily from abundance patterns of benthic species considered likely prey. Confirmation of details concerning their diet is lacking. Faecal material from western gray whales is rarely observed and is said to be difficult to collect. Prey ingestion has not been observed directly, and biochemical methods for dietary characterization have not been applied.

Studies of carbon and nitrogen stable isotope patterns in benthic organisms from the Piltun feeding area were conducted (by Fadeev and colleagues) to test the hypothesis that detrital export in tidal effluents from Piltun Lagoon subsidises the diets of benthic invertebrates, thus enhancing system productivity and the value of the area immediately outside the lagoon to foraging whales. The stable isotope data do not support the hypothesis, and this finding argues against models in which Piltun Lagoon is considered to provide subsidies beneficial to gray whales. However, two other mechanisms for lagoon-based subsidisation of the productivity of the Piltun feeding area remain untested. Exports of basic nutrients for primary producers, such as nitrate or phosphate, could enhance water column and benthic productivity in the feeding area and improve feeding conditions for gray whales. Likewise, export of living phytoplankton from Piltun Lagoon could benefit benthic species in the feeding area and increase the productivity of the food base for gray whales.

Western gray whales may forage in locations other than those thus far identified on the northeastern Sakhalin shelf. Gray whales have been seen in recent years near the Kurile and Commander Islands, off the mainland coast of Kamchatka and in the northern Sea of Okhotsk. Vertjankin described observations of feeding behaviour and defecation by gray whales in Olga Bay (Kamchatka) but otherwise little information was available to the Workshop on foraging by western gray whales in areas outside Sakhalin.

2.5 Causes of natural mortality

This section refers to information on predators, disease risks, susceptibility to harmful algal blooms and ice entrapment.

Topics of disease, harmful algal blooms and ice entrapment were reviewed by the ISRP (Reeves *et al.*, 2005) and therefore they were not discussed in detail at the Workshop. Harmful algal blooms are becoming a major issue in China, Korea and Japan and thus cannot be ignored as a potential problem for western gray whales. Vertjankin reported a case of ice entrapment of a young gray whale in Kamchatka in December 2003. The whale had passed under ice to get into a harbour where it was then limited to a small (40-50 m diameter) open-water area. As the weather got colder and the ice heavier, the whale had tried to swim free but failed until an icebreaker fortuitously created a lane allowing the whale to reach open water.

Weller presented RW2008-09, a preliminary analysis of the incidence of killer whale tooth rakes on western gray whales identified by the Russia-U.S. research programme between 1995 and 2007 off Sakhalin. Of the 169 photo-identified individuals examined, 74 (43.8%; 39 males, 26 females, 9 of unknown sex) were found to have survived at least one killer whale encounter based on the presence of visible scarring. It was possible to confirm that at least 22 of these whales (29.7%; 14, 6, 2) had been attacked during the course of the study. These male and female whales included both calves and non-calves, although relatively few attacks on calves were inferred from the scarring analysis. Weller reported that killer whale marks on the whales seen off Sakhalin generally are not fresh and he assumes that most of the attacks occur elsewhere.

The incidence of killer whale tooth scars on western gray whales is markedly high (43.8%) when compared to similar estimates (Metha *et al.*, 2007) made for other populations of large whales. Given the small size of the western gray whale population, even low levels of mortality related to killer whale attacks could hinder its recovery. The authors concluded that by this view, the reportedly high incidence of killer whale scars may represent a previously under-appreciated potential threat to the population.

In discussion it was suggested that a comparative study of scarring on western and eastern gray whales could be informative since the eastern population also has a high rate of scarring and calves are known to experience substantial mortality from killer whale predation.

2.6 Population status in 2007

The collaborative Russia-U.S. research programme on western gray whales summering off northeastern Sakhalin has been ongoing since 1995 and has produced important new information on the population's conservation status that has been reported annually to the IWC Scientific Committee and more recently also to the WGWAP. Weller presented RW2008-10, a summary of the programme's results from 2007 and a synthesis of findings from its inception in 1994.

Photo-identification work off Sakhalin in 2007 resulted in the identification of 83 whales, including 9 calves and 2 previously unidentified non-calves. When the new photographs were combined with data from 1994-2006, the Russia-U.S. programme's photo-ID catalogue totalled 169 individual whales, not all of which were assumed to be alive. Of the 169 whales, 142 (84%) had been biopsy-sampled. From genetic analysis of biopsies collected through 2007 (n = 142), an overall sex ratio of 58% male and 42% female was determined. When the subset of whales sampled as calves (n = 59) was examined, 66% were male and 34% female. A minimum of 24 reproductive females had been documented since 1995. Of the 83 whales recorded in 2007, 7% (n = 6) were classified as 'skinny'.

2.7 Health assessment of population

Bradford presented RW2008-14, an effort to assess the body condition of individual western gray whales. A premise of this study was that, along with other natural limiting factors and anthropogenic threats, western gray whales are susceptible to nutritional stress, as witnessed by regular observations of individual whales in compromised body condition. Thus, a method is needed to quantify the relative body condition of free-ranging western gray whales and evaluate how their condition varies seasonally and annually. A photo-ID study in the feeding area off northeastern Sakhalin from 1994 to 2005 by the Russia-US research team produced a large data set of digital, film and video images of 150 identified individuals. These images were used for a visual assessment of body condition categories (*i.e.* good, fair, poor) by evaluating the relative amount of subcutaneous fat in three body regions presumed to reflect body condition. Multinomial logistic regression for ordinal responses was used to evaluate the effects of year, month, whale class and sex on body condition. Although the correlation between observations of individual whales had not yet been accounted for, the preliminary analysis indicated that: (1) body condition varied annually and seasonally; (2) body condition improved as each feeding season progressed; and (3) lactating females were in relatively poor body condition and associated (but near to weaning) calves were in comparatively good body condition. Additional work is needed to refine the statistical analysis. Investigating the causes and consequences of compromised body condition is important for understanding the health and viability of the western gray whale population.

The Workshop welcomed this paper and encouraged further work to continue including refined statistical analysis. It was also noted that annual and seasonal variation in body condition, improvements in body condition as the feeding season progresses and the relatively poor condition of lactating females are not unexpected results.

In response to a suggestion that it was important to validate the assumption that whales classified as in 'poor' body condition are stressed or under-nourished, Bradford cited the difficulty of comparing the appearance of a live, swimming whale to that of a dead, stranded one. To validate the assumption, it probably would be necessary to use something other than morphometrics, such as parasite loads or physiological parameters, as the basis for comparisons.

Given that this potential tool for monitoring body condition is now available, it was suggested that efforts be made to correlate annual population-scale health indices with environmental conditions and human activities (*e.g.* noise events on the feeding grounds). However, it was acknowledged that distinguishing between natural and anthropogenic effects would be very difficult. It was also suggested that an effort be made to compare body condition of pregnant and non-pregnant females (determined retroactively by the presence or absence of a calf accompanying a given female one year later).

2.8 Health assessment of individuals taken as bycatch

Yamada presented information on two gray whales necropsied by him and his team. The presentation was supplemented by two submitted documents on the parasites collected from these carcasses (RW2008-4 and RW2008-6).

The first of the two whales was a young female that became entrapped and died in a set net in Tomiyama-machi, Chiba, along the Pacific coast of Japan in May 2005. The animal was 7.8 m long and in poor physical condition ('skinny'). The carcass had a fresh, deep rope mark around the caudal peduncle behind the anus. This whale had been seen swimming awkwardly in Tokyo Bay (and exhibiting feeding behaviour according to Kato) about two weeks before the entrapment. Yamada considered that the awkward swimming may have been caused by severe hyperostosis of the caudal vertebrae (*Spondylitis deformans*) (Ca4-6 and Ca7-9 were fused), a condition possibly linked to a virus or bacterium, or perhaps hereditary. The condition was judged unlikely to have been linked to an injury or advanced age since the animal was estimated to be a young adult. It was generally agreed that the whale had become entangled and died while inside the set net, probably of acute suffocation. The Workshop noted that the whale's compromised health condition could have resulted in death even without entrapment.

The second specimen described by Yamada, also a female, was found stranded and in a fairly advanced state of decomposition at Nishiki-oka, Tomakomai-shi, Hokkaido, in early August 2007. There was no clear evidence of rope or net marks on the carcass. In a still image from video footage taken on the day the animal was found, what appear to be rope marks are present on the chest, and these gave reason to suspect that entrapment or entanglement had been involved in the death. Upon viewing the image, Mattila commented that if this carcass were on a beach in the United States, the rope marks would have been a sufficient basis for classifying the death as associated with entanglement or entrapment. However, Yamada and his colleagues who conducted the necropsy concluded that the rope marks and bleeding shown in the video image were more likely caused by post-mortem handling of the carcass. They found no evidence to suggest that entanglement or ship strike was implicated in the whale's death.

2.9 Abundance, trends and population modelling

Cooke presented RW2008-12, which is summarised as appropriate under the relevant Items below.

2.9.1. Research programmes and data

Throughout much of the range of western gray whales, sightings are very rare. However, the regular occurrence of gray whales in the summer months in the feeding areas off northeastern Sakhalin permit the collection of sufficient data to allow population assessment and monitoring. Due to their extensive skin markings and small population size, western gray whales lend themselves to population analyses based on identification and re-identification of individual whales.

There are two currently ongoing photo-identification research programmes, the Russia-US programme, which has operated since 1995 (see RW2008-10), and the IBM (Institute of Marine Biology, Vladivostok) programme, which has been running since 2002. In addition, photographs of whales have been collected off Kamchatka since 2004 and these are sent to Vladivostok for comparison with the IBM catalogue.

2.9.2. Population assessments

A population assessment, using photo-ID data collected by the Russia-U.S. team up to and including the 2003 season, was conducted by the ISRP (Reeves *et al.*, 2005).

A stage-structured population model was fitted to the photo-identification data (supplemented with sex determinations from biopsies). The model divided the population into the following components for each year: male calves, female calves, immature females, calving females, resting females (mature but not calving in the current year), and other males. By fitting the model to the data, estimates of several population parameters of interest were obtained, including total population size and annual trend, numbers of whales in each population component, annual survival rate of yearlings and older animals, and inter-calf intervals. The model was also used to project the population into the future under a range of scenarios. Uncertainty was taken into account by formulating the model in probabilistic terms and considering several sources of uncertainty, *e.g.* gaps in the data (including animals absent in some years, missed calvings, calves with unknown mothers), demographic stochasticity (exacerbated by the small population size), environmental variability affecting reproduction, and sampling variability of parameter estimates.

An update of the population assessment using data collected up to and including the 2007 season was presented in RW2008-12. Median estimates of key population parameters (with 90% Bayesian confidence intervals) were 0.98 (0.97 - 0.99) for the non-calf annual survival rate; 0.78 (0.69 - 0.86) for the survival rate from 'calf' (~6 mo age) to 'yearling' (~18 mo age); 2.5% (1.6% – 3.5%) for the average annual rate of population increase over 1994-2007; and 130 whales (120 - 142) for the 1+ (non-calf) population size in 2008. There remained an unexplained significant male:female bias of about 2:1 in the sex ratio of calves ($p < 0.01$). The number of mature females alive in 2008 was estimated at 27 (22-31).

2.9.3. Forward projections: prospects for recovery

The assessment results indicated that the population had been increasing, at least up to 2005. Forward projections of the model to 2050, assuming no additional mortality or disturbance to reproduction, indicated a high probability (>99%) of continued population increase.

Five whales (all female) were caught or found dead on the Pacific coast of Japan during 2005-2007 (RW2008-7), including four deaths in fishing nets; a further possible entanglement/entrapment-related death is discussed under Item 2.8. One of the dead animals (found in 2007) had also been identified off Sakhalin in 2006 (Weller *et al.*, 2008b).

Projections of the female population incorporating this same level of 'extra' mortality (5 females per 3 years), on the assumption that all dead individuals are from the population that feeds off Sakhalin, and are not included in the estimated background levels of 'natural' mortality, indicated a high probability (~25%) of population decline and a substantial risk (~10%) of extirpation by 2050.

The Workshop emphasised that this projection is only an example scenario. However, it does illustrate the point that even a very small number of additional deaths, particularly of females, could jeopardize the recovery of the population.

During the Workshop discussion, it was clarified that (a) the calving interval was estimated by reference to the calves successfully brought to the feeding area, and not necessarily to all calves born in a given year (some of which may have died prior to the mother's arrival in the feeding area) and (b) the actual number of whale deaths implied by the estimate of natural mortality would be, on average, 2-3 adults and 2 calves per year.

2.9.4. Uncertainties in the population assessment

The updated population assessment is slightly more optimistic than the assessment in Reeves *et al.* (2005), mainly due to a reduced average calving interval. Among calving intervals ending during 2003-2007, 2-year intervals predominated, while for intervals ending in 2000-2002, 3-year intervals predominated. This may have been related to improved feeding conditions. The possible influence of environmental factors (including El Niño events) on food species and body condition of western gray whales was examined in document RW2008-17 (see item 3.5) and an analysis of the relationship between body condition and reproductive success is planned, as recommended by the WGWAP (WGWAP, 2008a).

Environment-related variability in reproductive success is incorporated into the population model and is reflected in the range of forward projections. An assumption is that the years for which data have been collected (1995-2007) reflect typical environmental conditions. If average conditions worsen in the future (*e.g.* more frequent occurrence of El Niño years), the situation may be less promising than the model projects.

The current population assessment assumes that all western gray whales use the Piltun feeding area but not necessarily every year. If some of the whales (*e.g.* some of those seen off Kamchatka, see Item 2.3) never visit the Piltun area where they would be 'captured' photographically, then this component of the population would not be included in the population estimate and the total number of western gray whales would be higher than estimated.

2.9.5. Use of additional data

It was noted that a cross-comparison of the Russia-U.S. and IBM catalogues (up to and including the 2005 season) had been carried out under the auspices of the WGWAP in early 2007 (WGWAP, 2008b). The comparison had shown that there was substantial agreement between the two catalogues. One hundred and thirty whales were common to both catalogues, while 5 whales occurred in the IBM catalogue only and 20 in the Russia-U.S. catalogue only. The greater number in the Russia-U.S. catalogue was likely due mainly to whales that had been seen early in the Russia-U.S. programme but died before they could be included in the IBM catalogue.

A Workshop was held by a WGWAP Task Force to examine further issues related to the collection and analysis of photo-identification data from the two research programmes (WGWAP, 2008b). Based on a preliminary inspection of the two data sets, the Task Force noted that many of the gaps in each team's sighting record for each individual whale were filled by the other team, suggesting that the combined data set could provide a more nearly complete picture than each data set individually. To date, only data from the Russia-U.S. catalogue have been made available for population analysis, but the WGWAP recommended that a combined analysis using both data sets should be performed eventually. This would require permission from the sponsors of the IBM catalogue. The Workshop endorsed the WGWAP recommendation (see Item 2.9.6 below).

2.9.6. Conclusions and recommendations

The population is very small (~130-150 animals, of which <30 are mature females) and at a small fraction of its pre-whaling level (probably at least 1,000 at the beginning of the 20th century – Bradford, 2003). It is encouraging, however, that it appears to have been slowly increasing, at least up to 2005. Based on the data for 1995-2007, it appears that if current conditions persist, and in the absence of additional mortality, the population stands a good chance of continuing to increase.

However, projections show that even small levels of additional mortality, particularly of females, could substantially reduce the prospects for recovery. The recent (2005-2007) level of additional mortality, according to some projections, may be unsustainable. The Workshop accordingly **emphasised** the importance of reducing anthropogenic mortality to as near zero as possible, and **recommended** that this be a core goal of the conservation plan for western gray whales (see Item 5).

The Workshop emphasised the importance of continued monitoring of the population and regular update of the population assessment, and **strongly recommended** that this work continue. This is an essential component of any conservation plan. It is important that any adverse demographic changes, should they occur, be detected as soon as possible, while there is still time for remedial action.

The Workshop expressed hope that the proposed joint analysis of the Russia-U.S. and IBM photo-ID data would proceed, and **recommended** that the sightings from Kamchatka be included in that analysis.

2.10 Information from 2008 field season

This topic was not addressed given the timing of the Workshop (the field season at Sakhalin generally continues into October).

2.11 Information needs and methods to address these

The Workshop identified the following major information needs with regard to the population biology of western gray whales and suggested possible ways to address these.

(a) *Improved understanding of migration routes and timing, including movements of the animals within a season and between feeding areas.* This could be addressed by the continuation and geographical expansion of photo-ID work (and associated biopsy sampling). Although such work will add to our understanding, satellite tagging would contribute at broader and finer scales and at a much quicker pace (see Item 2.11.1, below).

(b) *Improved understanding of population status in addition to the current estimates of abundance and trend.* Further development and application of the health assessment approach described in RW2008-14 could be explored in this context.

(c) *Improved knowledge of the calving history of individual females in relation to their health status, which is probably affected by environmental factors, both natural and anthropogenic.* Without knowing more about the whales' locations and activities while away from Sakhalin and Kamchatka (see above), it was difficult to see how this knowledge might be obtained. However, here again satellite tagging could be helpful in directing attention to other areas that may be used by adult females seasonally or in different years and thus where, for example, calves might be observed that either do not survive long enough to reach the northern feeding grounds or go with their mothers in the summer to areas other than Sakhalin or Kamchatka.

(d) *Improved information on the health status of gray whales that becomes available from necropsy of stranded or bycaught animals.* This will require a more efficient system of detection and reporting of carcasses, a mechanism for rapid deployment of skilled personnel, and a standardised necropsy protocol.

2.11.1 Satellite tagging

The issue of using telemetry data to obtain information on the migration and movements of western gray whales to inform mitigation of threats (see Item 3) throughout the population's range has been considered by the IWC Scientific Committee and various IUCN panels (*e.g.* IWC 2006a; 2007; 2008; WGWAP 2006; 2007; 2008). Weller summarised the discussions and relevant work on telemetry undertaken prior to the present Workshop, including the final report of the U.S. Marine Mammal Commission-sponsored large whale tagging workshop that had included an addendum on western gray whales as a case study (Weller, 2008).

As noted under Item 2.3, knowledge of the migratory routes and breeding grounds of western gray whales is very limited and there is no doubt that additional information on these would be valuable for developing appropriate mitigation measures. Discussions on tagging of western gray whales have often centred on the potential for injury or compromised health of individuals due to tagging, given that the population is very small with only 25 or so reproductive females (see Items 2.6 and 2.9). However small the risk, the need to undertake a thorough cost-benefit analysis (from the perspective of the population) has been emphasised on a number of occasions; such an analysis must also examine the chances of success with the current technology. It is for this reason that the IWC Scientific Committee recommended that any tags should first be tested on eastern gray whales (IWC, 2004).

Two studies (both funded by SEIC and Exxon-Neftegas) have been carried out in keeping with this recommendation: one on the breeding grounds and one on the feeding grounds of the eastern North Pacific population.

Mate and Urbán-Ramirez (2006) reported the results of a tagging study on eastern gray whales conducted in San Ignacio Lagoon, Baja California, Mexico. In March 2005, satellite-monitored radio tags were attached to 17 adult gray whales (16 females with calves and one unaccompanied adult). The tagging was carried out approximately six weeks after the usual peak time of calving. All tags transmitted data: four whales for > 200 days, six for > 100 days and seven for < 30 days (including two explained below). The whales were tracked for 86,059 km (average 5,059 km and 102 days). One single, unaccompanied individual was determined from transmitted data to be on shore (i.e. un-moving beach location, no dives and continuous transmissions) 18 days after tagging. An experienced stranding response team, including an expert marine mammal histopathologist from Sea World in San Diego, was deployed to find the whale and assess its condition. They arrived 11 days post-mortem and found no evidence of tag site infection (e.g. infectious tracks, swelling or purulent material) or that the death was tag-related. As mentioned by Weller (2008), there is some uncertainty as to whether evidence of tag effects would have been discernible, given the carcass's state of decomposition. A local resident had pulled the tag from the whale's carcass and taken it home, where it was recovered. One whale lost its tag while entangled in a gillnet outside the lagoon 23 days after tagging (fishermen reported that the animal had broken free of the net and the tag was left behind). Local hunters killed one whale 202 days post-tagging in the aboriginal subsistence hunt off Chukotka in Russia; the whale was noted to have mild swelling within 2-4 cm of the tag site. All three of the recovered tags showed no signs of corrosion or distortion. Another tagged whale was resighted 41 days post-tagging off the central Oregon coast and no adverse effects at the tag site were observed. Despite considerable effort for follow-up observations, no information was obtained on the other whales.

The tags were attached primarily to mothers with calves (94%) on the wintering grounds where the close tactile relationships of the pairs may have led to some or all of the early tag losses. No other deaths besides that of the single, unaccompanied adult were reported in the lagoon where the lost tags last reported locations. None of the tagging occurred in the feeding grounds, where bottom contact may have been expected to dislodge tags. However, a number of tags continued to function throughout the northward migration and on the feeding grounds. Of the six tags that exceeded 100 days of operation, all went through the Bering Strait and lasted an average of 223 days, during which it can be assumed that the whales were feeding. Thus, the tags demonstrably withstood typical feeding behaviour. The posterior/dorsal tag attachment site may not get rubbed during bottom feeding. Four whales' tags lasted through the entire summer feeding season in the Bering and Chukchi Seas, and three began the southward migration in unison. One whale reached Monterey Bay 322 days after tagging. In some cases, distances of more than 17,000km were recorded. Importantly, the average tracking period of all tags was 102 days and the average of those lasting over 30 days (n=11) was 146 days. Data return of 100+ days would be sufficient to determine the southern migratory destination for western gray whales if swim speeds are similar between eastern and western gray whales. Moreover, if the feeding behaviour of eastern gray whales in the deeper-water habitat of the Bering and Chukchi Seas is comparable to that of western gray whales in the shallow waters off Sakhalin, the persistence of tag attachments throughout an entire feeding season bodes well for tag duration on the Sakhalin feeding ground and for identifying additional summer foraging habitats as well as individual home ranges for western gray whales.

The second study took place on the feeding grounds. In September 2006 off Chukotka, 13 tags (different to those employed in the Mate and Urbán-Ramirez study) were deployed of which 4 failed to provide information (Heide-Jørgensen *et al.* in prep.). The remaining nine provided locations for an average of 39 days (range = 12-81 days). No information was provided regarding the behavioural, physical or physiological effects of tagging on individual whales in that study. The investigators conducting the study suggested that attachment problems and the limited data return from some tags were probably due to whales making contact with the bottom during feeding. They recommended (1) that smaller tags be designed and tested on eastern gray whales on their feeding grounds and (2) the development of a new or modified tag delivery system to allow longer-range deployment because whales were difficult to approach closely (the average approach time for tag deployment in their study was 45 min).

Both the IWC Scientific Committee and the WGWAP have recognised the value of telemetry studies provided that suitable safeguards are in place to minimise risks to whales (WGWAP, 2006; 2007; 2008; IWC, 2008; In Press). These include:

(a) the work should be carried out by experienced investigators using tested techniques;

(b) the work should be restricted to known males (from photo-id studies) and 'non-skinny' individuals;

(c) field protocols to minimise risks and limit the time spent with individuals should be developed and presented for review in advance of fieldwork;

(d) follow-up work on the potential effects of tagging should be a key part of any programme;

(e) data should be available in near real-time.

An important component of this was the establishment of a co-ordination group (Brownell, Donovan, Gales, Reeves, Weller plus a Russian scientist yet to be decided) to provide scientific advice and to ensure consistency in advice from the IWC Scientific Committee and the WGWAP.

In addition to the review of Weller (2008) and the previous IWC Scientific Committee and WGWAP reports, the Workshop received information from Mate on a recently developed Argos-GPS-TDR tag designed for use on large whales during controlled-exposure experiments. He provided a brief overview of a sperm whale tagging study conducted during spring 2007 in the Gulf of California. Thirteen tags were successfully deployed, producing novel information on surface-dive patterns and particularly detailed location information via GPS (as compared to less precise ARGOS derived locations). This summary was brought to the attention of the Workshop to (1) outline how such tags might be used to learn more about the reactions of whales to anthropogenic sounds (*e.g.* seismic survey operations) during controlled-exposure experiments and (2) describe how findings from work with eastern gray whales could be of direct relevance to better understanding noise-related impacts on western gray whales. The Argos-GPS-TDR tags have a shorter life (60 days) than the location-only Argos tags and must be recovered after they are jettisoned to download the highly detailed TDR information.

As in previous discussions within the IWC Scientific Committee and the WGWAP, consideration at the present Workshop focussed on the great potential value of the telemetry data to assist in development of mitigation measures and the need to balance this against potential risks to the health of individuals. The Weller (2008) report, which was valuable in this regard, had summarised the information on the three available follow-up studies for large whale species. In one case, resighting rates of tagged versus untagged North Atlantic right whales were found to be the same, suggesting no tagging effect on the survival of tagged whales. In another case, it was concluded that tagging had no major effect on the reproductive success of adult female southern right whales or (by inference) the survival of their calves. In the third case, humpback whales that had been tagged with implantable tags in the 1970s were resighted many years and even decades (> 30 years) later, including one reproductive female that continued to produce calves at regular intervals.

The Workshop **agreed** that telemetry data were the most efficient and perhaps only way in the short term to assist with:

(1) identification of all feeding habitats of western gray whales in the expectation that this would (a) lead to photographic identifications of whales in feeding areas other than Sakhalin and Kamchatka, allowing improved population assessment, and (b) point to additional areas in need of protection from potentially harmful human activities;
(2) identification of migratory timing and routes between summer feeding and winter breeding areas to improve assessment of potential threats along the migration routes and identify where mitigation is most critically needed; and
(3) identification of the winter breeding area(s) so that potential threats there can be identified and mitigated.

The results from the Mate and Urbán-Ramirez (2006) study in terms of tag retention and transmission life were encouraging in this regard although the Workshop agreed with the conclusions of the WGWAP that the tags used in the Heide-Jørgensen *et al.* study, which were difficult to deploy (mean approach time for tag deployment: 45 min) and provided locations for an average of only 39 days (range = 12-81 days), would need further development and testing before use on western gray whales.

With respect to potential risks of tagging, most attention was paid to the results from Mate and Urbán-Ramirez (2006) and in particular to the animal that was found dead on the beach. Mate provided additional information (and the WGWAP had received the field notes from the examining veterinarian, Judy St. Leger). Despite the difficulties due to the long post-mortem time, histopathology and the presence of a prolapsed uterus suggested that the most probable cause of death was birthing problems. The Workshop agreed but noted that it was not possible to make an unequivocal statement regarding the cause of death. It **concluded** that the available information pointed to the need for further targeted studies into the potential health effects of tagging (see recommendation below).

There was also some discussion about whether it was appropriate to recommend that animals entangled or entrapped alive in fishing gear and then released should have telemetry devices attached. The Workshop **concluded** that for a number of reasons, primarily related to the desire to avoid additional stress to animals which may be females, entangled/entrapped and released western gray whales should **not** have telemetry devices attached to them. However, as noted elsewhere (see Item 6.3.1), the collection of skin samples (and photographs) was strongly encouraged.

In conclusion, the Workshop **strongly endorsed** the previous recommendations by the IWC Scientific Committee and various IUCN panels that a satellite tagging programme be designed and undertaken, with due consideration for the need to minimise risks to the health of individual animals and to the population’s recovery. It **agreed** that the co-ordination group established at the 2008 IWC Scientific Committee should oversee the field effort. It is important that initiation of the satellite-tagging programme not be further delayed, and the Workshop **recommended** that every effort be made to attempt tagging at the end of the 2009 field season whilst recognising the potential logistical problems (including finance, available personnel and permit requirements). It emphasised that much of the information expected from the programme is urgently needed – *e.g.* identification of winter breeding areas and migratory routes and their spatio-temporal overlap with various threat factors such as fishing, vessel traffic and industrial activities. Moreover, the potential for achieving a key precautionary element of the tagging effort, *i.e.* selecting candidate whales for tagging based on their sex, relative age, health status and other factors, is diminishing with time as it depends on the Russia-US team’s availability (in practice, the presence of Amanda Bradford as part of the tagging team) and ability to keep current with the individual whales. The Workshop **agreed** that a small group comprising Weller, Donovan, Larsen and Reeves should work intersessionally to provide a discussion document on a way forward for presentation to the co-ordination group and ultimately to the 2009 IWC Scientific Committee meeting.

Noting the concern about potential effects of satellite tagging on the health of individual whales and the need for follow-up data on tagged individuals, the Workshop also **recommended** that a study be undertaken as soon as possible to evaluate such effects on eastern gray whales. A candidate population would be the well-studied Pacific Coast Feeding Aggregation off Washington and British Columbia in which resightings of the same individuals are frequent (Weller, 2008).

3. IDENTIFICATION AND QUANTIFICATION OF ACTUAL AND POTENTIAL THREATS TO THE POPULATION

3.1 Mortality as a direct result of human activity

3.1.1 Entanglement or entrapment in fishing gear
Immediately prior to the present Workshop, a small subset of participants (Brownell, Larsen, Lundin, Mattila, Simard, Weller) visited the town of Himi, a fishing port on the Sea of Japan coast of Honshu. The purpose of the visit was to observe a Japanese-type set net (locally known as ‘fixed shore nets’ in Toyama Prefecture) of the same kind that has been involved in incidental catches of western gray whales in order to learn more about the construction and use of these nets and the circumstances surrounding catches of large cetaceans.

Two types of set nets are in use along this coast: a small-type set net set in waters < 27m depth and a large-type set net set in waters > 27m. This distinction is governed by fisheries regulations. The set nets are found along all Japanese coasts and number in the thousands. In the Toyama Prefecture, *ca* 70% of the total fish catch comes from set nets.

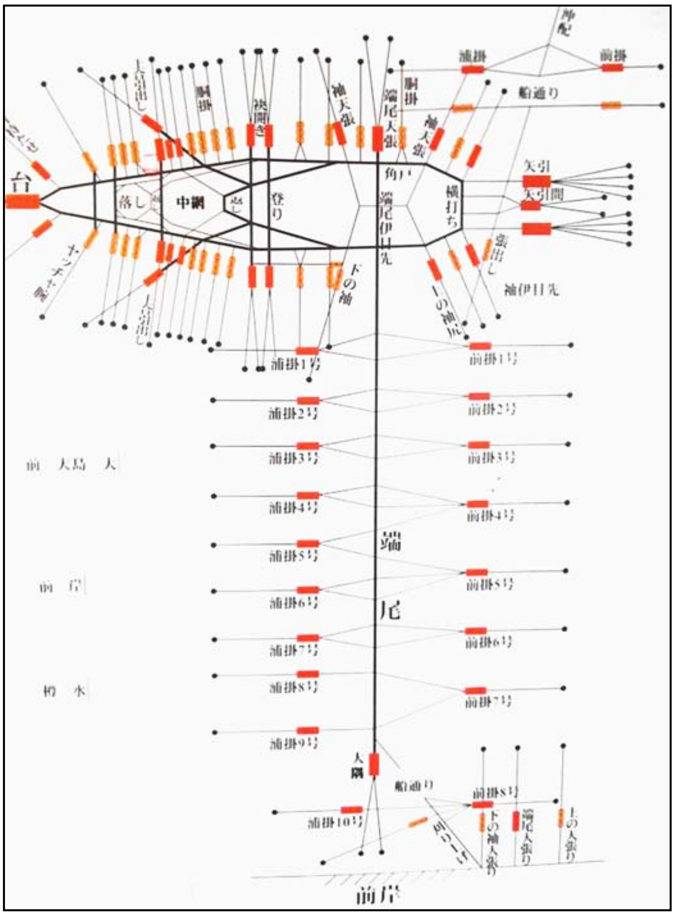

Fig. 4. Diagram of the 'set net' at Himi (see text)

Dr. Hisao Nambu of the Toyama Science Museum kindly arranged a meeting with Mr. Eiichi Hamamoto, the head of the group of fishermen that owns one of the large-scale set nets at Himi. This particular set net (Fig. 4) had caught one gray whale in March 1955 and another in April 1970. The net is about 1km long including the lead net. It consists of a trap with three consecutively smaller chambers and a lead net extending shoreward. The trap net is *ca* 50m at the widest point, and the length of the trap is *ca* 250m. The net is anchored at a depth of 85 to 135m using *ca* 50,000 anchors made from bags of gravel. Mesh size of the netting in the lead net and in the trap part of the set net is 30 to 50mm. A number of horizontal lines crossing inside each compartment of the set net are used to help the net maintain its shape. These lines do not create an obstacle to the fish caught inside the nets but could entangle a whale.

The nets are used year-round. Each net is tended every day, weather permitting, usually before dawn. This particular net was equipped with an underwater camera inside the trap-end. The camera could be accessed by mobile phone, allowing the fishermen to assess the species composition and magnitude of the catch before setting out to sea. Since the fish caught can swim around freely and are usually not caught in the meshes, they tend to survive for several days. The main catches in the Himi area are yellowtail (*Seriola quinqueradiata*) tuna (*Thunnus spp.*) and other schooling fish, but the nets catch a large variety of other species including squids.

Due to adverse weather conditions, it proved impossible to see the set net in the water or watch it being emptied. Instead the Workshop participants visited Mr. Eiichi Hamamoto at his home, where they were shown models and plans of the large-type set nets and had the opportunity to ask questions concerning normal catching operations and bycatch of cetaceans.

Mr. Eiichi Hamamoto stated that in his opinion it was certainly possible to release large whales from the nets, as they were usually largely motionless once trapped. However, it should be noted that the fishermen's experience is mostly with common minke whales; gray whales may behave differently when trapped. These nets are large enough (except in the trap-end) for a gray whale to swim around inside the compartments unless it becomes entangled in the lines crossing the compartments. Therefore, releasing a non-entangled whale should be possible by lowering the float line and herding the animal towards this opening. Nonetheless, lowering the float line to a sufficient depth to allow a gray whale to swim across would not be trivial.

The Workshop thanked Dr. Nambu and Mr. Eiichi Hamamoto for their co-operation, noting that the visit had provided valuable background information on the topics of entanglement and mitigation measures.

Koya presented RW2008-20, a summary of administrative actions taken by the Japan Fisheries Agency with regard to conservation of western gray whales and a review of gray whale observations in Japan since 1955.

Following IWC resolutions in 2001, 2004 and 2005 (IWC, 2002, p. 55; 2005, p. 66; 2006b, p. 67), the Government of Japan implemented a series of amendments to ministerial ordinances, with associated administrative guidance, leading to the present regulatory regime intended to promote the release of any gray whale bycaught in a set net or stranded alive, and to reinforce the prohibition on deliberate capture (and bycatch) of gray whales. Effective from 1 January 2008, the sale or possession of products from gray whales is explicitly prohibited. In addition, in August 2008, the Government of Japan hosted a meeting, with all prefectural governments invited to participate, to ensure that coastal fishermen are aware of the current legal situation and have been given guidance on how to release live gray whales found in their gear.

During discussion, it was noted that the regulatory language did not differentiate explicitly between gray whales found alive or dead in the set nets. Koya explained that the prohibition against selling the whale or its products was an incentive to release live gray whales from fishing gear. Asked if fishermen were instructed or required to contact a biologist for assistance in identifying whales caught in their set nets, Koya indicated that the training of fishermen was a responsibility of local or prefectural governments.

Kasuya cautioned there was a risk that the new regulations could create an incentive for non-reporting of gray whale entanglements/entrapments, noting that this happened with minke whales after a change in the regulations in 2001. Koya responded that in his opinion, non-reporting is unlikely to increase because gray whales are much larger and rarer than minke whales, and any capture of a gray whale would attract media attention and be widely publicised. Asked if a reward was being offered to encourage reporting, Koya responded that rewarding fishermen for their cooperation was an option under consideration.

All confirmed ‘entanglements/entrapments’ except the one in Tokyo Bay in May 2005 have been in large-scale set nets (*i.e.* trap nets set in water ≥ 27m deep). The adult gray whale found dead at Suttu, Hokkaido, in May 1996 was ‘entangled’ in harpoon lines from the Dall’s porpoise hunt and therefore its death was not accidental. The vast majority of the 22 records since 1955 have been on the Pacific coast rather than the Sea of Japan coast. Of the six instances on record of gray whales dying in Japanese set nets, four have occurred since 2005.

Fig. 1 of RW2008-20 showed the trend in number of large-scale set nets in Japanese waters between 1957 and the present. Koya explained that this did not include salmon nets which, in any event, are present only in Hokkaido. In the late 1950s and early 1960s the number declined dramatically from more than 2000 in those times to 757 in 2004. According to RW2008-20, the sizes and locations of set nets are rarely changed.

During discussion, it was noted that most of the sighted, stranded or ‘entangled’ gray whales reported in Japan since 1955 had been judged to be ‘juveniles’. However, adults, including adult females, had also died in the set nets. It was further noted that although most occurrences had been in the winter or spring months (January to May), there were also records for June, July and August. The set nets remain in place and are ‘active’ year-round on the Pacific coast of Japan. Koya stated that the set net fishery is closed in the winter in the Sea of Japan, except in the area where the gray whales have been bycaught.

There was further discussion of RW2008-18 under this agenda item (see Item 2.3 for a summary). It was noted that the 1955 capture had taken place in water 50m deep and that the gray whale had been removed alive from the set net. Unfortunately, no one present at the Workshop was able to provide details on how such removal had been accomplished and therefore nothing about how to extricate whales safely from these structures could be learned from that experience. It was noted that in 1955, the netting was made from natural fibres but synthetic material has been used for approximately the last 30 years.

Both of the records reported in RW-2008-18 came to the attention of the document’s authors as a result of a chance event; these records were unknown to science as recently as the early 2000s (*cf.* Kato and Kasuya, 2002). A photograph of the 1955 whale was seen recently in a British publication, it was brought to Nambu’s attention, and this led him to investigate local sources where he was able to collect further details on the 1955 event and also discovered the 1970 event. Given this example, there is reason to suspect that some, perhaps many, additional similar events have occurred without being reported.

In discussion, it was noted that although set nets were the focus of the presented information and indeed nearly all documented bycatches of gray whales in Japan in recent decades had been in such nets, other types of gear, such as drift gillnets used to catch salmon in the northern parts of the western gray whale population’s range, also deserve consideration and are a further cause for concern. Participants were not aware of a single observation of a western gray whale trailing gear or with gear attached to its body.

It was agreed that it would be easier to interpret the bycatch data if monitoring and reporting effort were better characterised and quantified, and if characteristics of the fishery data were better described. In addition, the importance of engaging stakeholders, in this case fishermen, was noted. Finally, it was recognised that investigations of strandings and entanglement/entrapment events, including detailed necropsies of carcasses as soon after death as possible, is crucial to improve understanding of the bycatch problem as well as to improve knowledge of the natural history and behaviour of western gray whales.

RW2008-15, presented by Bradford, examined the magnitude of anthropogenic interactions as inferred from the types and incidence of scars on western gray whales. This study used the multi-year (1995-2007) data set of digital and film images of 169 individuals photo-identified during the Russia-U.S. programme's long-term study of the whales off Sakhalin. The images were reviewed and scored for anthropogenic scarring by recording the presence of visible scars from fishing gear entanglement and vessel collisions in 21 defined body regions. Of the 169 whales, 42 (24.9%; 21 males, 19 females, two of unknown sex) were assigned at least one anthropogenic scar code in at least one body region from 1995 to 2007, with 41 (24.3%; 21, 18, 2) presumed to have been previously entangled in fishing gear at least once and 3 (1.8%; 1, 2, 0) presumed to have survived at least one vessel collision. Of the 41 whales with entanglement scars, at least 12 (29.3%, 8, 3, 1) were 3 years of age or younger when their scars were acquired (none of the individuals with vessel scars are of known age). These figures are likely negatively biased given the nature of the photo-ID data set, but they show that both male and female western gray whales are exposed to entanglements and ship strikes. While various biases are associated with the scar analysis (*e.g.* it only provides information about survivors), it suggests that interactions with fishing gear are common.

In discussion, it was suggested that if feasible it would be useful to compare entanglement rates (as inferred from scarring) between age classes, *e.g.* between animals thought to be < 3 years old and all others. Beyond the findings reported in RW2008-15, it is important to consider how these data might be used in the development of mitigation strategies and/or in the evaluation of effectiveness of such strategies once implemented. In addition, it is important to obtain more information on the nature of the scars and on where and when they are acquired, and to determine whether they are linked in any way to set nets in Japan. Russian participants stated that there is relatively little net fishing in Sakhalin coastal waters.

Mattila provided a brief summary of what is known about large whale entanglement worldwide, focusing on those aspects likely to inform discussions of this particular threat to western gray whales. He drew from IWC documents, published papers, NOAA Fisheries data, advice of experts from the United States, Australia and Canada, and his personal experience directing disentanglement networks in the United States.

Since entanglements of large whales are rarely observed in 'fisheries observer' programs, most of the data come from less direct sources. Three examples were given where entanglement was the known or likely cause of a substantial percentage (20-30%) of the whale strandings in which cause of death was investigated – humpback whales along the U.S. Atlantic coast and Ecuador (Alava *et al.,* 2005) and eastern gray whales in Canada (Baird *et al.,* 2002). In addition, studies of entanglement scarring have shown high levels of interaction with fishing gear in North Atlantic right whales (Hamilton *et al.,* 1998) and humpback whales (Robbins and Mattila, 2001). The latter study found that juvenile humpbacks were at greatest risk, but that all age and sex classes continued to accumulate entanglement scars throughout their lives. Indeed, in the western North Atlantic up to 22% of the humpback whale population acquires new scars each year. Preliminary analysis of scarring in North Pacific humpback whales indicates that all subpopulations interact with gear at high rates. Mattila reiterated that scarring studies refer only to survivors of entanglements, but he noted that an attempt to link scarring rates to mortality rates in western North Atlantic humpback whales would be presented at the next IWC Scientific Committee meeting.

Opportunistic reports are another source of information about entanglements in a given area, but they can vary in reliability and depend on mariners knowing that they should report their observations, and to whom. Entanglement reports generally increase by an order of magnitude in areas with established outreach and reporting networks (NOAA Fisheries, unpublished data), but a review of information about whales known to be entangled and towing telemetry buoys revealed only one report in more than 21,000 km of tracked movement (Landry *et al.,* 2007). This suggests that the actual number of entangled large whales is much higher than the number of reports received. It is also consistent with an analysis of new entanglement scars on known individuals in a given year indicating that fewer than 10% of the entanglement events were reported in that year (Robbins and Mattila, 2001).

All species of large whales can become entangled, but some appear to be at higher risk, depending on, amongst other things, the extent of overlap of their distribution with gear, their morphology and their behaviour (especially feeding). Because their propensity to feed near the bottom and their highly coastal migratory routes put them in close contact with high concentrations of fixed fishing gear, gray whales are likely at high risk of entanglement, and data from eastern gray whales appear to support this (Heyning and Lewis, 1990). Analyses of gear removed from entangled whales in the U.S. to date indicate that whales can become entangled in any type of fixed ('passive') rope and/or net in the water column (Johnson *et al.,* 2005). In the eastern Pacific, gray whales have been found entangled in salmon gillnets and seines, herring gillnets, and net pens, longlines and traps (Baird *et al.*, 2002). While whales may be at greatest risk of entanglement in feeding areas due to their behaviour and the overlap with fishing gear, they do also become entangled while migrating and on breeding grounds (*e.g.* humpback whales in Australia, both eastern and western gray whales).

In concluding, Mattila reviewed some of the ways that an entanglement can kill a large whale if it does not drown immediately. These include starvation as a result of compromised feeding ability, infection from a chronically irritated wound, and even the eventual severing of a limb or an artery, or creation of an opening to the body cavity. He gave examples where the wrap of a single, small-diameter (synthetic) line eventually killed the entangled whale.

During discussion it was noted that only perhaps 3-10% of entanglements or entrapments of whales (including those that result in relatively minor injuries) get reported. Mattila emphasized that the absence of reports of entanglement, *e.g.* in gear other than set nets, should not be interpreted to mean it does not happen. A strategy and an effort to encourage reporting are essential for assessing the significance of entanglement/entrapment. Also, it was noted that a major gap is the lack of population-level data on entanglement/entrapment or scarring rates of eastern gray whales. It might be informative to compare such rates between the eastern and western populations.

Russian participants reported that there had been no reports of entangled or entrapped western gray whales in Russia. The fact that an entanglement of a bowhead whale was reported, however, shows that there is at least some chance that such an event involving a gray whale would be reported in Russia. Over the last ten years, enforcement of fishery regulations in the Russian Far East has deteriorated and the inspectors who formerly controlled the activities of fishermen are no longer being deployed. With enforcement responsibility left to the coast guard, reporting of things like whale entanglements is less reliable than it once was.

In China, there have only been records of strandings, deliberate kills (historical) and sightings of gray whales. Although entangled gray whales have not been reported, entanglement of cetaceans in Chinese waters is considered a major problem, given China's long coastline and high fishing effort in coastal waters. Marine mammals are legally protected in China but most fishermen see no economic benefit in reporting bycatch and therefore little information is available on the subject. Also, species identification is unreliable.

As mentioned earlier, there have been no recent reports of sightings or bycatches of gray whales in Korean waters. The gray whale is a protected species and therefore cannot be 'used' if found or bycaught in the Republic of Korea. The government there offers a reward for reporting gray whales – $5000 for a dead animal, $10,000 for a live animal. A booklet was produced for fishermen to help them identify the species. Kim advised the Workshop that the size of the reward is less than the amount that could be realised from utilisation of a whale. Therefore, he felt that there was little or no risk of the reward providing an incentive for capturing a gray whale.

3.1.2 Vessel strikes

Kato presented RW2008-16, an initial evaluation of the magnitude of the threat of ship strikes on western gray whales in Japanese waters. The authors compiled available data on ship strikes on whales in Japan. A total of 15 vessel strikes on large-sized marine animals had been reported since 2003 when the Ministry of Land, Infrastructure and Transportation of Japan (MLIT-J) began to collect information related to ship collisions in a systematic way. All 15 of the reported incidents involved hydrofoils and four of the 15 were confirmed to have involved cetaceans. On one occasion the whale was identified as a common minke whale based on DNA analysis of a piece of flesh recovered from the vessel's hull. On two other occasions the circumstances led the authors to conclude that the whales were probably common minke whales and on the fourth occasion the captain of the hydrofoil identified the whale as a sperm whale. Total frequency of such collisions in Japanese waters was calculated to be 0.04×10^{-5} n.miles (total number of collisions/total cruising distance) with some regional variation from 0.06×10^{-5} n.miles in the Sea of Japan to 0.02×10^{-5} n.miles in the Pacific Ocean. Seven of the 15 collision records with 'large animals' (not necessarily all of them cetaceans) came from the Tsushima Strait, which may be regarded, relative to other areas, as 'collision-prone' although the absolute frequency of reported collisions there was still very low (0.23×10^{-5} n.miles). Judging from available evidence on the frequency of occurrence of collisions and what is known from systematic sightings programmes regarding the occurrence of western gray whales relative to other cetaceans, the authors of RW2008-16 judged the probability of vessel strikes on gray whales in Japan to be extremely low or negligible.

Despite the infrequency of reported ship strikes in Japanese waters, a working group had been established by the Councillor of MLIT-J to investigate how such events can be prevented. This working group was created in direct response to an accident in the mouth of Kagoshima Bay in April 2006 where the officially reported object struck was 'driftwood?' (RW2008-16, Table 2). The group is expected to include representatives of various committees of the Fisheries Agency, academic experts, the manufacturers of high-speed hydrofoils and officials from the ferry companies.

Ongoing and planned projects include: (1) further efforts to identify species that are at risk of ship strikes, through use of both independent and onboard observers on the hydrofoils/car ferries; (2) development of 'avoidance systems' that incorporate such things as scanning sonar and improvements or modifications in underwater speaker systems according to the hearing abilities of at-risk species; and (3) establishment of surveillance systems that take account of the developments mentioned above and all relevant information available. Kato has been requested by the working group to provide advice on this initiative.

The Workshop welcomed this information.

Kim reported that in Korea, 4 cases of ship strikes had been reported, three involving minke whales and one an ocean sunfish (*Mola mola*).

In discussion the Workshop agreed that special attention should be given to any area where heavy ship traffic intersects a migration route or passes through a whale feeding area. This point was emphasised in the ISRP report and in other

IUCN panel reports, *e.g.* in relation to large tankers that will increasingly be transiting La Perouse Strait between Hokkaido and Sakhalin (the ISRP report (Reeves *et al.,* 2005) had reviewed the problem of ship strikes on western gray whales in some detail). Calambokidis drew attention to observations in the eastern North Pacific showing large and conspicuous increases in ship strikes on blue and fin whales when ship traffic passes through high-density whale feeding areas.

The Workshop did not consider the use of passive acoustics to be promising for ship strike mitigation for western gray whales although it has been suggested elsewhere. Regarding the use of active acoustics (*e.g.* underwater warning systems such as those apparently being considered in Japan; RW2008-16), it was noted that such approaches could have undesired effects. For example, a startling or aversive sound stimulus could cause whales to move towards the surface, where the risk of collision increases rather than decreases.

In the case of this critically endangered population, the absolute number of ship strikes is more important than the probability of strikes. Therefore, it is essential to identify areas of overlap between migration routes and high levels of ship traffic and to establish precautionary mitigation measures there. Noting that there are limits to the effectiveness of onboard observers (especially during sub-optimal viewing conditions and at night) and no satisfactory technological approach to ship strike risk reduction has been developed, the most effective mitigation measure is probably to slow vessel speeds.

The IWC maintains a ship-strike database as part of the work of its Scientific and Conservation Committees[2].

3.1.3 Deliberate killing
The most recent deliberately caused death of a western gray whale was that of a whale found off the west coast of Hokkaido in May 1996 (Brownell and Kasuya 1999; Uni and Kasuya 2002).

Kasuya reported that the Democratic People's Republic of Korea had issued postage stamps showing images of an operating whaling catcher boat. The dates of issuance were 1964, 1972 and 1974. The 1974 issue was accompanied by presidential encouragement of the operation. Presumably the North Korean whalers hunted any species they encountered, including gray whales.

3.2 Disease, harmful algal blooms, ice entrapment
Item 2.5 (above) covers these issues in the context of 'natural' mortality.

It was noted that the problems of harmful algal blooms and ocean 'dead zones' are becoming much more prominent, with mounting evidence not only that the scale and frequency of such phenomena are increasing but also that human activity is a directly contributing cause (Van Dolah, 2005; Diaz and Rosenberg, 2008). Although there is no basis for believing, on presently available evidence, that either algal blooms or dead zones are having an impact on western gray whales, these are potential problems that deserve consideration, particularly in areas where the whales may feed outside the Sea of Okhotsk (*cf.* RW2008-11).

It was further noted that disease-related involvement has not been ruled out as a potentially relevant factor in the 'skinny' whale problem (see Item 2.7).

3.3 Information needs and methods to address these
As under Item 2, the Workshop **agreed** that knowing more about the timing and location(s) of western gray whale migration, as well as the location(s) where the animals spend the winter (and give birth and mate), is a high priority for improved understanding of threats. Satellite telemetry is the most efficient method for obtaining this information (see Item 2.11.1).

Another major information need is knowledge of where and when the occurrence of western gray whales coincides with a high density of threat factors. Specifically, it is important to know more about the distribution (and regional characteristics) of fishing gear and ship traffic for comparison with what is known about gray whale occurrence (and what will come from future telemetry work) to assess the relative risks from these threats. Some key information is already available. For example, it is known that some of the existing population of western gray whales migrate along the Pacific coast of Japan and the times and locations of a number of entrapment/entanglement events are well known.

It is also important to discover as much as possible about cause of death whenever a western gray whale carcass becomes available (see Item 2.8). This reinforces the need, as noted under Item 2.11, for more efficient systems of detection and reporting of carcasses, mechanisms for rapid deployment of skilled personnel, and development and use of a standardised necropsy protocol.

There is also a need for more work of the kind presented in RW2008-15 to improve understanding of where and when harmful interactions occur between western gray whales and human activities.

[2] http://www.iwcoffice.org/sci_com/shipstrikes.htm

There is a clear need for information on vessel activity, fishing and other anthropogenic factors that could put gray whales at risk in China and Korea. Among other things, it would be useful to know if there are set nets in those countries similar to those used in Japan.

3.4 Human activities that indirectly affect the ability of the population to recover (habitat degradation)

3.4.1 Noise and other related disturbances

Moore summarised and updated the relevant information in Moore and Clark (2002). The coastal habits of gray whales often bring them into direct contact with human activities in coastal waters. During their annual migrations, whales in both the eastern and western populations pass through military training ranges, oil and gas exploration/development areas and shipping lanes that converge at large port cities. Western gray whales are exposed to noise associated with oil and gas activities in their feeding areas near Sakhalin Island and likely in their breeding area(s) as well (although the location/s is/are unknown). The potential impacts of anthropogenic noise associated with oil and gas development have been the focus of concern and discussions of the various IUCN panels since 2004.

Noise associated with oil and gas development was the focus of extensive research during the 1980s. Marine dredging and platform construction are often the noisiest aspects of such development, whereas seismic survey work is the most controversial aspect. The overall findings of experimental and other research in the 1980s have been used to set maximum ‘safe’ exposure thresholds for gray whales of 120 dB for continuous noise and 170 dB for impulsive noise (*i.e.* from airguns) (Moore and Clarke, 2002, Table 1). However, it is impossible to model 120 dB and 170 dB (or, any other) isopleths with a high degree of accuracy, especially in shallow water, and this complicates the use of such values for mitigation. The problem of setting and applying maximum sound exposure criteria has been addressed in detail by the IUCN panels (see http://www.iucn.org/wgwap/). Also, the specific problem of mitigating the noise from seismic surveys has been addressed by a WGWAP task force (see http://www.iucn.org/wgwap/).

Published reports show that commercial shipping has caused a doubling of background (ambient) noise levels in the ocean every decade since the mid-1900s. Because the habitat of western gray whales includes busy shipping corridors, these whales are routinely exposed to elevated noise levels that can mask their sounds (including con-specific calls) and thus impair their ability to navigate and communicate efficiently (empirical evidence on blue whales and fin whales is available to demonstrate this). Low frequencies (between about 10 Hz and 1 kHz) are of greatest concern because the large whales, including the gray whale, are low-frequency specialists. Commercial shipping in the United States is expected to double again by 2030 and noise from this source is certain to increase in other areas as well. Ships are becoming larger and louder and the volume of commercial ship traffic tends to increase with gross domestic product (GDP). Reduction in ship noise will require new ship designs and retrofitting, so reductions are likely to occur only over a fairly long timescale. The goal should be to reduce the noise produced by existing fleets (through better maintenance and retrofitting) while incorporating quieter design features into new ships as they are being built.

In December 2007, the impact of noise from shipping on marine mammals was recognized by the Marine Environment Protection Committee of the International Maritime Organization (IMO), and an initial goal of reducing noise from commercial shipping by 3 dB in ten years and by 10 dB in 30 years was proposed at an International Workshop on Shipping Noise and Marine Mammals in April 2008. This goal was endorsed by the IWC Scientific Committee at its annual meeting in June 2008 (IWC, in press [Annex K]) and participants in the present Workshop expressed their support for the goal as well. It was noted that the IWC is co-operating with IMO with respect to ship strikes *e.g.* via the database referred to under Item 3.1.2. It was suggested that it might be useful to add shipping noise to the documentation work shared by the IWC and IMO.

The Workshop was advised that IMO processes tend to be prolonged and slow, and therefore that additional avenues for reducing the risks of noise and ship strikes should be considered. It was suggested that a ship classification system might be useful, and also that direct engagement with the shipping and/or ship insurance industries could be worth pursuing. For example, there might be strong economic arguments for quieter ships, and this would appeal to both industries.

In discussion, the Workshop noted that there are good reasons to minimise noise exposure on the feedings grounds (*i.e.* reduce stress and ensure that the whales obtain optimal nutrition during this phase of their annual cycle). The point was made that most mothers in the western gray whale population bring their calves to the near-shore feeding area off Sakhalin during the summer. Until approximately a decade ago, this area would have been relatively quiet; it is only in the last ten years that significant underwater noise has become a feature of this area.

It may also be important to prevent noise disturbance on the migration route(s) so that the whales are not forced to adjust their movements in ways that place them at greater risk of entanglement/entrapment or ship strike. For example, it is possible that gray whales off Japan are staying inshore of shipping routes, and this might place them at greater risk of encountering set nets. On the other hand, in some situations it may be desirable for the whales to respond to noise as it could keep them away from areas of high risk. How gray whales navigate during migration is unknown. Assuming that audition plays at least some role, their ability to obtain auditory clues may be critical for detecting ‘signposts’ and allowing the whales to cross bays or bights efficiently. Apart from the possibility of masking, desensitisation as a result of prolonged exposure to noise could increase the whales’ vulnerability and impair their navigational efficiency.

In view of the fact that so little is known about the breeding behaviour and breeding habitat of western gray whales, it is unclear how noise disturbance might be a factor affecting this phase of their annual cycle. However, Zhu pointed out that China is certain to continue the exploration and development of coastal resources, including oil and gas deposits in the South China Sea. He also drew attention to a planned bridge linking Hong Kong, Macao and the mainland that will involve a great deal of construction noise and ship traffic and could have implications for gray whales on migration.

Playback studies of the effects of low-frequency active (LFA) sonar on migrating eastern gray whales showed that the whales changed their swimming trajectory in response to this type of noise. It was noted that in the United States, discussions concerning where LFA sonar should be permitted have been ongoing since 2003 between the Navy and the Natural Resources Defense Council (NRDC). Because of the potential for LFA deployment in parts of the western North Pacific, it is important that these discussions include consideration of western gray whales. The Navy has insisted on being able to continue the use of LFA off the Korean Peninsula and Japan, as part of a settlement that includes restrictions on LFA use in shallow-water areas.

It was emphasized with regard to seismic surveys that, particularly in view of the fact that so little is known about response thresholds for gray whales, it is vital, whenever such surveys occur in areas used by gray whales, to make every effort to collect meaningful data on exposure and response. This is one way to increase the knowledge base and improve mitigation measures. Vladimirov again drew the Workshop's attention to the situation off Sakhalin (see also Item 2.3, above). An August-September 2001 seismic survey of the Odoptu field (the northern end of the Piltun or near-shore feeding area off Sakhalin), conducted on behalf of Exxon-Neftegas Limited, had been considered at the Ulsan workshop in 2002 (IWC, 2004) and during detailed discussions within the various IUCN panels and the WGWAP Seismic Survey Task Force (http://www.iucn.org/wgwap/). Also, the journal *Environmental Monitoring and Assessment* devoted a special section of its November 2007 issue (Volume 134, pp. 1-136) to papers on this subject, including the overall industry-sponsored western gray whale monitoring program off Sakhalin.

According to Vladimirov, another episode of disturbance occurred during a seismic survey for Rosneft between 23 September and 12 October 2004. Vladimirov stated that the noise from this seismic survey appeared to have displaced some gray whales southward from the Piltun feeding area. However, no detailed analysis had been carried out to evaluate this impression.

A planned 4-D seismic survey of the Astokh portion of the Piltun-Astokhshoye oil and gas field off Sakhalin in summer 2009 is the subject of ongoing work by the WGWAP Seismic Survey Task Force to develop a gray whale mitigation and monitoring programme (http://www.iucn.org/wgwap/).

In response to remarks by Vladimirov that there appeared to be a positive correlation in June-July 2006 between the local density of gray whales and dredging activity associated with pipeline burial (*ca* 20 vessels present, of which 10-12 were engaged in dredging), it was suggested that the whales could have been taking advantage of the bottom disturbance as an assist to their own foraging. This possibility, however, could only be considered as speculation in the absence of relevant data and analysis.

The Workshop acknowledged the great difficulty of identifying, measuring and separating the influences of different variables and therefore determining whether noise disturbance (or any other anthropogenic factor) did or did not affect gray whale behaviour and distribution. Also, it is very difficult to judge whether short-term effects on individuals are or are not significant on a long-term basis and at the population level. Multivariate analyses of gray whale distribution and behaviour during the two main construction seasons for the Sakhalin II Phase 2 project (2005 and 2006) have been underway for several years and initial results have been reviewed by the WGWAP (http://www.iucn.org/wgwap/). That panel has proposed that an expert workshop be convened, with participation of industry-sponsored and independent scientists, to consider the entire suite of potentially relevant data (whales, acoustics, benthic sampling *etc.*) and develop an appropriate analytical framework.

3.4.2 Chemical contamination including oil

As summarized in the ISRP report (Reeves *et al.*, 2005; and see Moore and Clarke, 2002), there is much uncertainty surrounding the question of how oil spillage can affect baleen whales in general and gray whales in particular. Specific issues related to oil from SEIC operations have been reviewed extensively by the WGWAP oil spill task force (http://www.iucn.org/wgwap/).

VanBlaricom provided a summary of conservation issues relating to potential chemical contamination of western gray whales, their prey and their habitats. His presentation focused on spilled petroleum and persistent organic pollutants.

Spillage of petroleum can occur in either a chronic or an acute manner. Chronic spills include continuous, low-rate leakage from pipelines and frequent small spills from offshore production and transportation infrastructure. Acute spillage typically comes in the form of sudden, large-volume events associated with human error or failure of infrastructure such as drilling and production platforms, sub-sea pipelines and tank vessels. Once oil has been spilled, a large number of factors (*e.g.* the properties of the oil type) influence patterns of dispersal, degradation and persistence of the lost product.

Potential effects of spilled oil on gray whales may be direct or indirect. Direct effects involve contact of spilled product with individual whales, potentially leading to skin damage, fouling of baleen, damage to pulmonary and thoracic structures from inhalation of volatile components, and toxicity resulting from ingestion. Indirect effects would involve contact of spilled petroleum with prey populations and habitats. Potential acute impacts are those associated with direct contact of spilled oil with individual prey animals. Potential chronic impacts are those that develop over time when spilled oil is incorporated into benthic sediments where key prey populations dwell. Direct and indirect effects of spilled oil on gray whale prey will almost certainly be exacerbated by application of dispersants to floating components of spilled oil on the sea surface.

The gammaridean amphipod *Pontoporeia affinus* is a dominant benthic invertebrate in the primary feeding areas of the western gray whale population off northeastern Sakhalin Island. Although difficult to verify, *P. affinus* is probably an important prey species for gray whales there (see Item 2.4). *P. affinus* is common in boreal marine sedimentary habitats, including the Baltic Sea. In the aftermath of the *Tsesis* oil spill in the Baltic, populations of *P. affinus* declined significantly in the most heavily oiled areas. It follows that prey populations in the feeding areas used by western gray whales would be highly vulnerable to damage from a large oil spill.

A key dilemma for management of oil spills relates to spatial and temporal scales of spill occurrence and fate. Ecologically damaging oil spills are rare events, often separated by decades and involving large volumes of spilled product concentrated into discrete portions of marine environments with resident species highly vulnerable to oil contamination. The extreme spatial and temporal patchiness of large damaging spills poses major challenges with regard to investment in appropriate measures for spill prevention and response. In such circumstances, prevention is technically and economically onerous, which means that industry, in the absence of legal requirements, may be tempted to avoid or circumvent measures most likely to be effective. The scenarios for effectively responding to and controlling large spills are discouraging. Thus, there is good reason to argue that effective control of catastrophically large oil spills at sea is impossible.

Persistent organic pollutants (POPs) typically are incorporated into an animal's tissues by ingestion and digestion of prey. POPs are generally lipophilic and tissue levels are magnified across trophic levels of marine food webs. In marine mammals, POPs concentrate in the blubber layer and may be mobilised in milk during periods of lactation. The major categories of POPs of concern in marine ecosystems include the polychlorinated biphenyls (PCBs), the dichloro-diphenyl-trichloroethanes (DDTs), the chlordanes, the hexachlorocyclohexanes (HCHs) and the polybrominated diphenyl ethers (PBDEs). PCBs were developed for use in a number of industrial applications, including insulation of electrical transformers. DDTs, chlordanes and HCHs are pesticides. PBDEs are a relatively new category of POP used as flame retardants in a number of commercial products.

Understanding patterns of exposure and contamination by POP categories in marine mammals requires knowledge of several key variables. These include the histories and spatial distributions of production and application, the characteristics, histories and locations of environmental reservoirs, and the pathways of large-scale transport within and among oceanic and atmospheric strata and regions. Of particular concern to marine mammals is the tendency for POPs stored in blubber to be mobilised metabolically during lactation. The result is that offspring receive a substantial inoculum of POPs as a transfer from their mothers during nursing. This process introduces several key patterns in POP body burdens of marine mammals that link to age and sex. For example, the firstborn offspring of a given female generally receives a larger dose of POP contamination pre-weaning than subsequent offspring. Because adult females can 'offload' POP burdens during lactation, adult females typically carry lower POP concentrations than males of comparable age, once the age of first reproduction has been reached.

The nature of dose-response relationships of POPs in marine mammals is not well known. Although contaminant levels can be readily measured if blubber biopsies can be obtained in the field, the physiological consequences of observed POP body burdens generally are unknown in marine mammals.

In discussion, Calambokidis noted that even though gray whales are benthic foragers, they are not known to accumulate what are considered dangerously high fractions of conventional contaminants in their body tissues (O'Shea and Brownell 1994; Krahn *et al.* 2001). Aluminium levels are elevated in their tissues but this is suspected to be the result of naturally high concentrations in sediments.

3.4.3 Reduction of prey availability

3.4.3.1 SMOTHERING (OR MODIFICATION AND DEGRADATION) OF PREY PATCHES

This subject was addressed in detail by the ISRP (Reeves *et al.*, 2005) and no new information was available for the Workshop to consider. It was noted that the potential effects of dredging, in particular, on bottom communities that form the food base for western gray whales need to be evaluated through retrospective analyses now that offshore pipeline construction, at least for Sakhalin II Phase 2, is finished. The multivariate analyses mentioned above under Item 3.4.1 may address those effects to some extent. In addition, a long-term environmental monitoring task force established by the WGWAP is expected to consider 'smothering' and other mechanisms associated with industrial activity that might influence the food base of western gray whales (see report of WGWAP-4 at http://www.iucn.org/wgwap/).

3.5 Changing environmental conditions related to climate change and other processes

Ragen summarised this topic and prepared an initial draft of Table 1. Climate change may affect in the future, or already may be affecting, western gray whales through three mechanisms: changes in the physical and chemical properties of the marine environment; secondary changes in marine ecology; and secondary changes in human activities. Although much remains to be learned about such effects, present knowledge allows the development of some reasonably well-informed hypotheses. In many cases, the nature of the effect, and even if it will be positive, neutral or negative, is difficult to ascertain.

Table 1.

Potential effects of long-term environmental change on western gray whales.

Potential effect	Mechanism
Chemical and Physical	
Increasing temperature	Altered prey habitat with secondary changes in prey distribution, density, composition, productivity; increased exposure to disease and parasites
Decreasing sea ice	Earlier and longer access to foraging grounds; expanded area available for foraging
Increasing sea level	Altered nearshore and onshore topography; altered lagoon configuration and dynamics
Altered precipitation patterns	Altered freshwater and brackish water flow and correspondingly altered input of nutrients into nearshore foraging areas
Altered nearshore ocean conditions (*e.g.* currents)	Altered distribution of nutrients leading to changes in nearshore productivity patterns
Biological and ecological	
Prey distribution, productivity, density, composition	Possible changes in prey communities for various reasons, *e.g.* changes in temperature, nutrient input, current patterns and, possibly, introduction of new species.
Interactions with other baleen whales	Possible movement of western gray whales into parts of the Okhotsk and/or Bering Sea where they could compete or otherwise interact with bowhead whales
Harmful algal blooms	Increased incidence and severity due to higher water temperatures, greater nutrient loads, and additional chemical/nutrient input from oil and gas activities.
Disease and parasites	Increased exposure secondary to changing temperatures.
Human-related[1]	
Contaminants	Altered chemical and biological activity of various pollutants.
Noise	Increased vessel activity in or near whale habitat, increasing their exposure to noise.
Fishing	Altered distribution of fish stocks, causing increased fishing (and thus risk of entanglement) in areas used by gray whales.
Shipping	Increased shipping in high latitudes (*e.g.* via Bering Strait), leading to increased risks to gray whales from ship strikes, noise and contaminants.

[1] Human activities may have an increasing influence on the western gray whale population. The possible effects listed here are limited to those that may result from climate change specifically.

It was noted during discussion that ocean acidification is a global concern related to carbon emissions and that it, in addition to climate change *per se*, should be borne in mind as a potential factor affecting the long-term prospects of western gray whales. Although it is impossible to predict exactly how and how much climate change will affect western gray whales, it was agreed that monitoring both the whale population and relevant environmental indices is important.

Kim presented RW2008-17, an examination of body condition of western gray whales in relation to environmental change in the North Pacific. Following the 1998 North Pacific El Niño event, the number of skinny whales observed on the nearshore feeding area off northeastern Sakhalin Island increased in 1999, peaked in 2000, and returned to 1999 levels again in 2001. This pattern suggests that a relationship between climate events, in this case El Niño, and body condition of western gray whales.

The Workshop welcomed this study and encouraged the authors to extend it over additional years if possible, noting that El Niño events are expected to become more frequent in the immediate future. It was suggested that additional variables might be incorporated. For example, age at first reproduction, not just calving interval, might be expected to change in response to foraging conditions (this has been shown in humpback whales in the North Atlantic).

Although it was recognised that amphipod populations have high population turnover rates and thus are likely to show fairly rapid responses to changes in environmental conditions, it was not obvious why western gray whales would be so 'sensitive' to such localised changes in food supply, given that their population size is assumed to be far below the environmental carrying capacity (K). Are the whales fixated on limited food patches (site-tenacious) and are they slow in looking for and discovering alternative patches? Is the whale population using the near-shore Piltun feeding area actually near K? Cooke pointed out that one would expect some individual variability in foraging strategy and behaviour, and therefore corresponding variability in condition of individuals (from robust to skinny) would be expected even at population sizes far below K.

During 1999 and 2000 the eastern gray whale population experienced unusually high mortality of immature/adult whales, with annual stranding rates approximately ten times greater than reported during the previous decade (LeBoeuf *et al.*, 2000; Moore *et al.*, 2001). Coincident with the high mortality, estimates of calf production in 1999, 2000 and 2001 were the lowest recorded in an eight-year time series of data (Perryman and Rowlett, 2003). Although the causal mechanism(s) responsible for this event is (are) poorly understood, some researchers have hypothesised that benthic prey biomass for eastern gray whales had been depleted due to the combined influence of increased annual water temperatures in the Bering Sea and overuse of the feeding grounds by a whale population at or even above pre-exploitation levels (LeBoeuf *et al.,* 2000; Moore *et al.,* 2001). While such an explanation regarding the eastern population may be plausible, observations of skinny western gray whales between 1999 and 2001 are less readily explained.

The Workshop concluded that although intriguing and worthy of further exploration, the correlations identified and discussed in RW2008-17 need closer scrutiny. The ‘skinny whale’ phenomenon may or may not be a valid index of habitat quality, the effectiveness of mitigation actions, or broad-scale biophysical processes (*e.g.* El Niño events). Causal links and mechanisms are likely to be complex.

3.6 Other indirect human effects

Changes in the physical structure and morphology of the shoreline in areas used by western gray whales might affect their reproductive or foraging success. For example, the whales’ access to bays or lagoons may be compromised by urban development in southern China. However, there is no clear evidence that western gray whales depend (or depended historically) on coastal subtropical lagoons as calving and nursery areas in the same way as eastern gray whales do.

3.7 Synergistic effects

The status of the western gray whale population is determined by the whales’ natural vital rates (survival and reproduction) as altered by various human activities. Throughout their range, gray whales are subject to a variety of definite and potential threats, including entrapment or entanglement in fishing gear, ship strikes, chemical contaminants, noise, coastal development and factors that affect ecologically related species, particularly prey.

The total impact of human activities on the population is the sum of the effects of each threat factor together with the interactions among them. For example, the potential impact of oil and gas development on the Sakhalin shelf includes the individual effects of (a) noise during the construction of offshore platforms and pipelines, drilling, and long-term operations, (b) vessel strikes and (c) habitat degradation from spillage of oil or other contaminants (*e.g.* drilling waste). These factors may be independent of each other, in which case their effects are additive, or they may be related, in which case their combined influence will be determined by the nature of their interaction (either synergistic or countervailing). Another example would be where whales already compromised in some way (*e.g.* entangled in fishing gear, injured, diseased) are disproportionately susceptible to such things as ship strikes and bycatch. Such whales also may be less able to withstand periods of poor nutrition caused by natural or anthropogenic processes.

Research and management efforts are usually tailored to specific threats. To be comprehensive, however, conservation programmes need to address the range of threats and their potential interactions. The purpose of this Workshop was, in part, to engage researchers and managers from multiple countries to ensure that risk factors are being addressed throughout the western gray whale population’s range. As information becomes available on region-specific threats, that information must be evaluated (for example, in the gray whale population model; Item 2.9, above) to determine the significance of threats and the advisability of possible management measures to address them. Such a process is essential to the development of a truly comprehensive conservation effort.

Although the cumulative or synergistic effects of some threats are at least partially incorporated into the population assessment model developed by Cooke and colleagues (Item 2.9), it would be desirable to make such incorporation more explicit and to specify the uncertainties associated with resulting trajectories.

3.8 Information needs and methods to address these

The various IUCN panel reports have identified some information needs and methods to address them, particularly with regard to the Sakhalin shelf. The Workshop emphasised here, and at other points in the agenda, the critical importance of continuing the population monitoring work in the summer feeding areas. Improved understanding of the nature of threats and their consequences is one output of population monitoring through photo-identification and biopsy sampling.

The Workshop identified the following information needs and methods for addressing them (in no particular order).

- *Better understanding of effects (preferably dose-based) of noise on gray whales as well as the thresholds of responsiveness*. Lack of good data on the effects of noise has been highlighted by the WGWAP. Controlled exposure experiments (CEEs) to investigate sensitivity to particular types of noise, such as that from airguns used in seismic surveys, would improve understanding of effects and facilitate approaches to mitigation. CEEs should be undertaken only with eastern gray whales and a premium should be on experiments involving feeding rather than migrating whales. In addition, it is important to take full advantage of any opportunity to monitor gray whale behaviour and movements before, during and after seismic surveys and other potentially disturbing events. This can be a learning tool in its own right and also allow validation of theoretical or experimental assumptions and findings – contributing to an understanding of effects and to the development of approaches to mitigation. Empirical studies require a multivariate analytical framework to measure and tease apart multiple independent variables. Development of such a framework will require one or more expert workshops as recommended previously by the WGWAP.

- *Better understanding of the 'skinny whale' phenomenon*. It is desirable to use all the relevant data acquired by the various research groups off Sakhalin in a collaborative context and to link these data (through modelling) to environmental indices and indices of population status and trend.
- *Further information and data on potential threats in southern and southeastern Kamchatka*, which has only recently been recognised as a possibly significant part of the summer feeding range of western gray whales. This will require continuation and preferably expansion of the monitoring work there.
- *Better information, obtained in a timely manner, on potentially harmful activities in areas where gray whales are present*. Although detailed information is available on the activities of Sakhalin Energy (SEIC) on the Sakhalin shelf, this is not the case for other oil and gas operators in the region even though several are pursuing large development projects in or near whale feeding areas. Such information is required, well in advance of potentially harmful activities, to ensure appropriate mitigation and monitoring. Similar information is needed on oil and gas activities in other parts of the Sea of Okhotsk where gray whales either occurred in the past (and may recolonise) or are known to occur at least occasionally today (*e.g.* Magadan and western Kamchatka). Given that existing mechanisms for obtaining this kind of information have not been successful (except in the single case of Sakhalin Energy), either a new mechanism needs to be created or existing mechanisms (*e.g.* WGWAP) need to expand their scope or approach.
- *Better characterisation of threats in China and Korea*. Two specific methods to address this need were identified. One was to strengthen networks for reporting and investigating strandings. The other was to compile and analyse data on fishing effort, particularly in near-shore waters (*e.g.* types, amounts and locations of gear, seasonal aspects of deployment), and ship traffic, again especially in near-shore waters and at times when gray whales would be expected to be present. It was understood that gathering such information would not be easy but also that some welcome progress had been made in this regard in Japan (*e.g.* IWC 2007; RW2008-16). Vertjankin suggested that one approach for getting insights on whale interactions with fisheries would be to solicit records of damage to nets caused by whales.
- *Better information on fishing in Russia*. Although entanglement/entrapment is not considered a significant threat to gray whales in the Sakhalin feeding areas, there is a need for better information on fisheries in Russian waters that could put gray whales at risk. For example, there are concerns related to Japanese salmon fishing with drift nets in the Russian EEZ – these nets, even after being abandoned, would be capable of entangling gray whales. Vertjankin called the Workshop's attention to three whale entanglements off Kamchatka of which he was aware, one involving a humpback whale, one a common minke whale and one a sperm whale.
- *Better understanding of causes of mortality*. As noted under Item 2.11, improved systems are needed for detecting, reporting and investigating strandings and bycatch events. Learning about causes of mortality is essential, and it depends on the rapid deployment of skilled personnel who can conduct necropsies following rigorous, standardized protocols.

4. THREAT ELIMINATION AND MITIGATION

4.1 Prioritisation of actual and potential threats identified under Item 3

Whilst acknowledging that the list of potential threats facing this very small, critically endangered whale population is long, and that understanding of the whales' movements and activities outside the relatively well-studied feeding areas off Sakhalin Island is extremely poor, the Workshop proposed a provisional ranked list of threats, broken down into two categories – directly lethal threats and sub-lethal ('indirect') threats. These are summarised in Table 2.

The list for the first category is as follows:

(1) entrapment in set nets in Japan (usually the whales are alive when they become entrapped and remain so for a considerable time);

(2) entanglement in other types of fishing gear (*e.g.* gillnets, trap and pot gear) in all parts of the range of western gray whales where fishing with entangling gear occurs;

(3) ship strikes in all areas where ship traffic overlaps the distribution of western gray whales.

Table 2

Known and potential threats to western gray whales, with priority levels for action.

Actual/potential threat	Activity	Evidence	Possible impact	Priority for action
Directly lethal threats				
Entrapment in set nets	Set-net fishing	Strong	Mortality, especially of adult females	High
Entanglement in other types of fishing gear	Fishing with gillnets (set or drifting), gear that includes lines in the water column (*e.g.* crustacean traps)	Moderate (circumstantial)	Mortality, serious injury, impairment of ability to feed efficiently or to undertake other vital processes	High
Ship strikes	Ship traffic, particularly at speeds higher than 10 knots	Moderate (circumstantial)	Mortality, serious injury	Moderate
Sub-lethal threats				
Noise in feeding areas	Offshore construction (*e.g.* oil platforms, pipeline burial), seismic surveys	Strong	Impaired efficiency of feeding, leading to compromised health. Possible abandonment of feeding area	Moderate to High
Contamination of prey	Offshore oil and gas production, oil transport	Weak or Moderate	Reduced food availability, leading to compromised health	Low
Noise in migratory routes	Shipping primarily	Weak	Whales forced to change routes, increasing their energy needs or forcing them into high-risk areas	Low
Physical disturbance of prey	Offshore construction that mobilises sediment, onshore construction or development that increases runoff or discharge	Weak	Reduced quantity or quality of feeding habitat	Low
Physical modification of coastal zone	Urban development (*e.g.* land reclamation), bridge, causeway or dam construction	Weak	Degradation or elimination of habitat for key life functions	Low

These threats are common to most otherwise-protected populations of baleen whales, the North Atlantic right whale being the best-known example where mortality from ship strikes and interactions with fishing gear have long been regarded as the chief impediment to population recovery. Although available information suggests that the risk to western gray whales from ship strikes is relatively low (see Item 3.1.2), it must be recognised that in much of their range, monitoring and reporting of such events are lacking.

The list for the second category is as follows (also see ISRP report; Reeves *et al.*, 2005).

(1) noise from industrial activities that, by displacing the whales away from optimal foraging areas, could reduce individual fitness and therefore compromise survival and reproduction;

(2) contamination of key prey populations from spillage of oil and other contaminants;

(3) noise from shipping and other human activities that forces western gray whales to vary their migratory movements, causing them to expend extra energy or placing them in high-risk contexts that they would otherwise avoid;

(4) physical disturbance of prey populations caused by industrial activity such as dredging;

(5) physical modification of the coastal environment (*e.g.* land reclamation) that eliminates or degrades habitat for western gray whales (*e.g.* for calf nursing, breeding, feeding).

4.2 Potential and actual mitigation measures (including research needs)

4.2.1 Fishing-related mortality and disturbance

Mattila presented an overview of efforts to mitigate large whale mortality from entanglements in fishing gear in the United States. This began with a review of currently established ‘disentanglement networks’ around the world (*e.g.* in Australia, Canada, Mexico, New Zealand, South Africa, United Kingdom) with a focus on those in the United States. If a whale does not drown immediately, there is almost always ample time to prepare appropriate resources for a successful release attempt. Therefore, virtually all disentanglement networks have adopted an ‘emergency team’ approach. Such a team consists of trained individuals who have access to specially designed equipment and who are transported to the scene, often by the national Coast Guard or Navy, to work with local fishermen to release the whale. Members of the team generally have expertise in whale behaviour and anatomy as well as experience handling ropes and small vessels under heavy load and stress. For example, a team often includes at least one biologist and at least one fisherman.

In the United States, the teams routinely use telemetry buoys to track free-swimming, entangled whales. This allows the rescuers to gather resources and wait for optimal conditions (*e.g.* good weather, close proximity to shore), thus improving the chances of a safe and successful outcome. In some of the U.S. networks, several buoys are cached at strategic locations along the coast so that a minimally trained or under-resourced responder is able to attach a buoy and wait for back-up support.

One of the techniques used for disentanglement is akin to what open-boat whalers called ‘kegging’. For this technique, a line is attached to gear already on the swimming whale, and buoys are then added to that line in order to slow the animal and keep it from diving. Mattila stressed that disentanglement tools and techniques are designed to make it unnecessary for rescuers to enter the water; experience has shown that doing so with an entangled whale is extremely dangerous. He also emphasised that because a single wrap of line can kill a whale, it is wrong to assume that releasing a whale with ‘only a little gear left on it’ can be considered a successful rescue.

The difficulty of releasing large whales varies by species. Some are more prone to ‘complex’ entanglements (*e.g.* right whales tend to get entangled in the mouth more frequently than other species). The innate responses to entanglement and release efforts appear to vary, with some species (*e.g.* minke whales) tending to be more passive and others more violent and even aggressive (*e.g.* right whales). Humpback whales and gray whales appear to lie somewhere between those extremes; that is, some individuals are more passive while others react violently.

In the United States, the disentanglement work is both authorized and funded by government. Mattila very roughly estimated that the main equipment (inflatable boat, telemetry devices, knives *etc.*) costs in the order of $50,000 per team.

During discussion, it was suggested that in Japan, it might be feasible to equip set nets with video cameras that transmit cellular telephone images and thus would allow ‘real time’ notification and consultation concerning whale entrapments. However, given that the set nets are checked daily by the fishermen, and the entrapped whales normally remain alive inside the net traps, notification should not require remote surveillance. If the fishermen are sufficiently motivated to release gray whales, it should be possible to do so in most if not all instances.

Mattila noted that mitigation through prevention is preferable to mitigation through disentanglement. In the United States, several ideas for gear modification are being pursued to reduce the incidence of whale entanglement – *e.g.* ‘weak links’, sinking ground lines, remotely releasing buoy lines, pingers (not promising for baleen whales) and glowing ropes. Also, studies are underway to improve understanding of how various kinds of fixed fishing gears ‘behave’ when deployed on the sea bottom or in the water column, and how the behaviour of the whales can increase or decrease the risk of entanglement. In the case of set nets in Japan, the goal should be to prevent whales from entering in the first place, although it was also noted that investment in this approach needs to be balanced against investment in disentanglement/release efforts.

Currently, there are no well-established disentanglement teams in the range states of western gray whales. The Workshop **agreed** that development of a disentanglement capacity in the region is desirable, and that this would need to involve *inter alia* planning, procurement (and maintenance) of equipment and training, all of which would require funding. Kato advised the Workshop that he had been involved in a successful effort to release a minke whale from a set net off Taiji in February 2008. He stressed that the cooperation of the fishermen is key to getting the whales out of the set nets alive.

It was noted during discussion that the amount of time that elapses between a whale’s entrapment or entanglement and its death is a key factor in determining the feasibility of disentanglement (or release in the case of entrapment). Mattila stated that in the United States it is not unusual for whales to survive for months whilst entangled in gear as long as they can gain access to the surface. As noted above, set nets are a special case because whales trapped in them are normally releasable, *i.e.* can remain alive in the nets for at least several days. It was noted that in some circumstances, it is actually less damaging to the gear if the whale is released alive than if it is killed – this needs to be addressed in education and awareness work with fishermen.

Several of the items listed and described under Item 3.1.1 are relevant here. Mattila stressed that better information on where, when and how much of various types of fishing gear are deployed, in combination with better information on the distribution and movements of western gray whales, would facilitate the identification of ‘hotspots’ where entrapment/entanglement risk is particularly high and thus where mitigation effort, including public and targeted awareness/education campaigns and capacity building (*e.g.* workshops with fishermen), should focus. In this regard, Kato commented that when the gray whale was initially observed in Tokyo harbour in the spring of 2005 (see Item 2.8), television coverage prompted some fishermen to go out in their boats and try to prevent it from entering set nets.

Good information on the distribution of set nets and other gear that entangles or entraps whales in Japan is important and during the Workshop, Funahashi showed participants detailed charts of the Japan coastline showing locations of set nets as well as salmon driftnets. Koya confirmed that he could provide, on request, details on set nets including numbers and locations. The Workshop **agreed** that this information should be requested by IUCN from Japan, noting its value for the development of the conservation plan (see Item 5). It was noted that having such information in a GIS format would be optimal for using it to develop conservation measures.

Although the recent entanglements have occurred in Japanese waters, the Workshop recognised that the potential for such entanglement exists in all range states. It was pleased to learn that three rescue (response) teams had been established in the Republic of Korea and that these teams are designated to release any marine animals, including gray whales, either live-stranded or accidentally caught in fishing gear.

4.2.2 Vessel-related mortality and disturbance

The Workshop acknowledged and commended the initial analysis of ship traffic and ship strikes in Japan presented by Kato (RW2008-16; summarised under Item 3.1.2). He and his group were encouraged to consult and collaborate with other groups elsewhere in the world working on the same problem. It was noted that, as with the fishing data discussed under Item 4.2.1, having vessel traffic data in a GIS format would greatly facilitate efforts to assess collision risk and identify potential 'hotspots'.

4.2.3 Chemical-related effects, including oil

The Workshop deferred to the WGWAP and other efforts carried out under the IUCN aegis to address issues related to oil as they pertain to western gray whales (Stevens and Aurand, 2008; http://www.iucn.org/wgwap/).

There is, at present, no basis for assessing the nature and degree to which chemical contaminants other than oil represent a threat to western gray whales. No baseline data on tissue levels in western gray whales are available and no sampling programme is in place to obtain such data. The necropsy work reported by Yamada and colleagues (see Item. 2.8) is expected to provide some contaminants data. As noted elsewhere (see Items 2.11, 3.8), it is important that such work be encouraged, supported and carried out in a rigorous, standardised fashion. Particularly in the case of contaminants, it is crucial that carcasses are as fresh as possible and strict protocols for tissue sampling and preservation are followed. The procedures used for chemical assays need to meet international standards and the reporting of results, and their interpretation (*e.g.* whether the sampled tissues are representative, health implications), requires due consideration for methodological differences, sampling bias etc. (*e.g.* Geraci and Lounsbury, 1993; O'Shea, 1999). Clearly, more research and monitoring are needed before effective, targeted mitigation measures can be developed and recommended to the responsible government agencies and international bodies.

4.2.4 General approaches (e.g. MPAs)

The Workshop briefly considered marine protected areas (MPAs). The MPA concept differs within and among countries. As Donovan *et al.* (2008) note, MPAs targeted at identified threats are a potential tool to be considered as part of a conservation plan and this issue should be considered further in that context (see Item 5). Vertjankin pointed out that the areas used by gray whales off southern and southeastern Kamchatka are already within protected areas and that the management of those areas (no human activity allowed except under permit) is beneficial to the whales (*e.g.* low or non-existent risk of entanglement, minimal underwater noise). It was also noted that WWF-Russia and other groups have been seeking to establish MPA status for the nearshore (Piltun) feeding area off Sakhalin Island (see WGWAP reports at http://www.iucn.org/wgwap/).

Mattila called attention to a major international conference on MPAs that he is co-organising, scheduled for Hawaii in March 2009. Participation by scientists and managers from the range states of western gray whales would be useful.

4.3 Monitoring of effectiveness of mitigation measures (including consideration of enforcement issues)

The importance of monitoring for compliance and, where necessary, imposing sanctions for non-compliance, is self-evident. The Workshop made no attempt to develop this further but pointed to the need for engagement by relevant authorities and stakeholders in any attempt to do so in the future. The Conservation Plan discussed under Item 5 would address the subject in some detail.

5. STRUCTURE AND COMPONENTS OF A CONSERVATION PLAN FOR WESTERN GRAY WHALES

Based upon the agreement under Item 1.5, Donovan *et al.* (2008) and the discussions at the Workshop, Donovan provided an initial outline of a Conservation Plan for Western Gray Whales (Annex D). He noted that the Workshop discussions had provided a good scientific basis for such a plan, for developing some initial actions and for determining a way to involve more stakeholders. He further noted the value of the reports of the WGWAP (and its predecessors) for those sections related to Sakhalin and specifically the value of the ISRP report; those reports contain much of the scientific background needed for an initial draft (with appropriate updating). The plan should be free-standing and self-explanatory, with a clear indication that it is a living document to be modified with time and experience.

The Workshop adopted Donovan's outline as the basis for future work and it was expected that plan development would proceed under the auspices of the IUCN Global Marine Programme, assuming that adequate staff and funding are available. The initial draft of the plan will:

- include a clear explanation of why the conservation plan is needed and a statement of its goals and objectives;
- incorporate assistance from the relevant programme(s) within IUCN with respect to the 'legal framework' portion of the plan;
- accompany any references to 'hunting' by a clear explanation (possibly in the form of footnotes) of the legal status, recognising that all range states, with the possible exception of the Democratic People's Republic of Korea have complete prohibitions against the direct, intentional taking of western gray whales;

- include examples of mitigation measures taken elsewhere in the world to protect whales (regardless of species) from the same or similar threats;
- include a separate section, in addition to specific actions, devoted to public awareness and education;

The drafting group will take into account the lessons learned from other similar plans (*e.g.* see Donovan *et al.* 2008) and the work on conservation plans recently undertaken by the IUCN Species Survival Commission.

It was agreed that the first draft of the plan would be prepared by Donovan, Larsen and Reeves, and then sent to a larger drafting group to consist of Brownell, Kato, Rock, Mattila, Vladimirov, Weller and Zhu. Larsen would be responsible for overall coordination of the process. The goal would be for the draft to be circulated to the wider group in sufficient time to allow at least one round of revision prior to presentation of the document at the 2009 annual meeting of the IWC Scientific Committee.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Status and monitoring

As reported under Item 2.9, the population[3] of western gray whales is extremely small (around 130-150 animals, of which fewer than 30 are mature females) and remains at only a small fraction of its pre-whaling level, although it is encouraging that the population appears to have been increasing, at least up to 2005. Based on the data from 1994-2007, it is projected that if current environmental conditions persist, and in the absence of additional mortality, the population will continue to increase. However, such an extremely small population is vulnerable and the projections also indicate that even low levels of additional mortality, particularly of females, could substantially reduce the prospects for recovery. According to model projections, the recent (2005-2007) level of additional mortality may be unsustainable and, if continued, could cause the population to decline.

The Workshop accordingly **emphasises** the importance of reducing human-caused mortality to zero and **recommends** that such reduction be a core goal of the conservation plan being developed for western gray whales.

The importance of continued population monitoring to determine if mitigation measures are working cannot be over-emphasised. A fundamental requirement is that annual monitoring effort in the field, using both photo-identification and the collection of biopsies from new animals, be maintained at a level adequate to support analyses using an appropriate population assessment model (*e.g.* that of Cooke *et al*.). Any adverse demographic changes must be detected as early as possible, and preferably while there is still time for remedial action. The Workshop therefore **strongly recommends** that research effort off Sakhalin Island, in support of annual population assessment through modelling, be continued as the highest-priority monitoring tool for this population.

The recent observations of gray whales along the southeastern and southwestern coasts of Kamchatka and in the northern Sea of Okhotsk demonstrate the importance of obtaining photo-identification data from other areas in addition to the northeastern Sakhalin Shelf. Therefore, the Workshop **recommends** that photo-identification effort be continued or expanded in other areas where western gray whales are known to occur, such as off Kamchatka and Magadan. It further **recommends** that all photographs from Kamchatka be compared to the Sakhalin catalogues maintained by the Institute of Marine Biology (IBM) and the Russia-US program.

Photo-identification studies form an essential component of a number of elements of the conservation effort for western gray whales. The Workshop **strongly endorses** the recommendations made previously by the WGWAP and the IWC Scientific Committee concerning joint analyses of the Russia-US and IBM catalogues. It further **recommends** that the photographs from Kamchatka and other parts of the population's range be included in any such joint analyses and notes the importance of continuing efforts to identify additional feeding areas of western gray whales.

6.2Threats and improved mitigation

6.2.1 Essential scientific knowledge for mitigation

A good spatial and temporal understanding of the migratory routes, breeding areas and movements of western gray whales is essential if effective conservation measures are to be developed and implemented to protect them from anthropogenic threats throughout their range, particularly entanglement and entrapment in fishing gear, vessel traffic and industrial activities. At present, there is a severe shortage of such information. The Workshop **stresses** that the most efficient (and probably only) way to achieve the necessary knowledge is to undertake a carefully planned satellite tagging programme. A successful programme will provide essential insights on threats (*e.g.* what they are, their spatio-temporal character and severity), reveal new information about the biology and behaviour of the animals to allow the development of effective mitigation measures, and better inform research and conservation planning.

In short, satellite tagging of western gray whales will address the following critical objectives:

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[3] Genetic analyses have confirmed that the western population is discrete from the eastern population of gray whales. Despite its low absolute abundance, it appears that the western population has retained sufficient genetic diversity to allay concerns about inbreeding.

(1) *Identification of all feeding habitats of western gray whales*. This would (a) lead to photographic identifications of whales in feeding areas other than Sakhalin and Kamchatka, allowing improved population assessment, and (b) point to additional areas in need of protection from harmful human activities.
(2) *Identification of migratory timing and routes between summer feeding and winter breeding areas* to improve assessment of threats along the migration routes and identify where mitigation is most critically needed.
(3) *Identification of the winter breeding area(s)* so that threats there can be identified and mitigated.

As noted by other groups that have considered the need for such information, the Workshop **stresses** the importance of an extensive cost-benefit review of telemetry studies in terms of how they would be expected to contribute to conservation versus how they might pose risks to individual western gray whales. After a full discussion of the work of other international groups, and especially a careful consideration of the review of telemetry studies and potential health effects commissioned by the US Marine Mammal Commission (the 'Weller report'), the Workshop **strongly endorses** the previous recommendations by the IWC Scientific Committee and various IUCN panels that a satellite tagging programme be designed and undertaken as soon as possible. It **stresses** that initiation of the satellite-tagging programme should not be further delayed, and the Workshop **recommends** that every effort be made to attempt tagging at the end of the 2009 field season. That being said, it is essential that every safeguard be undertaken to minimise risks to the health of individual animals and to the population's recovery (see Item 2.11.1) and it **endorses** the approach and recommendations of the IWC Scientific Committee and the WGWAP in this regard. It **emphasises** that the potential for achieving a key precautionary element within the tagging effort, *i.e.* selecting candidate whales for tagging based on their sex, relative age, health status and other factors, is diminishing with time as it depends on the Russia-US team's availability and that team's ability to keep current with the individual whales.

In parallel with the telemetry programme on western gray whales, and in view of the general need to obtain further data on any potential effects of satellite tagging on the health of individual whales (see Item 2.11), the Workshop also **recommends** that an evaluation study be undertaken as soon as possible using the well-studied Pacific Coast feeding aggregation of eastern gray whales regularly seen off Washington and British Columbia in which resightings of the same individuals are frequent (Weller, 2008).

6.3 Entrapment and mortality

6.3.1 Release of entangled whales

Entrapment in set nets in Japan has caused several deaths of western gray whales in recent years. Given the critically endangered status of the population, the Workshop **strongly recommends** that every effort be made to release entrapped animals as expeditiously as possible. In order to encourage this, the Workshop **recommends** that a suitable reward scheme be introduced for all gray whales that are released alive and free of fishing gear. This scheme would be expected to involve a requirement for appropriate documentation to confirm species identification and that the release was successful. It would also ensure the collection of basic information, such as approximate length of the animal, date, location, photographs, skin samples *etc*. Such information is important in helping to fill gaps in information on migration timing and routes. Information on such releases should be reported to the IWC Scientific Committee annually.

In this regard, the Workshop**,** welcoming the measures that have already been implemented by Japan, also **encourages** the appropriate Japanese authorities to initiate a campaign immediately to educate all set-net fishing cooperatives concerning (a) the critically endangered status of western gray whales, (b) the historical role of set nets in bycatches of gray whales and (c) the need to make every effort to release any entrapped or entangled western gray whale.

In addition, the Workshop **encourages** authorising agencies to identify appropriate individuals who can make up a rapid-response team to assist fishermen in the event that a badly entangled gray whale is found and specialised assistance is needed to release it. The team should consist of individuals with experience in whale biology and behaviour, handling ropes under stress, and small vessel safety, and be trained and equipped with custom-designed tools. The team should receive training and equipment from appropriate, established disentanglement experts (*e.g.* from either North America or Australia) who have extensive experience dealing with free-swimming, entangled whales or with otherwise complicated entanglements of large whales. Such a team could be used to release entangled, but free-swimming, gray whales if any are reported.

When safe and appropriate, the scientific members of the team could help to collect specific information from such events (*e.g.* photographs for use in photo-identification, tissue samples, estimates or measurements of animal size, health assessment *etc.*). They could also be involved in specialised necropsy work (see below).

Although the recent entanglements have occurred in Japanese waters, the Workshop recognised that the potential for such entanglement exists in all range states. It was pleased to learn that three rescue (response) teams had been established in the Republic of Korea and that these teams are designated to release any marine animals, including gray whales, either live-stranded or accidentally caught in fishing gear. The Workshop **encourages** the further development of these teams through communication with experienced response teams elsewhere in the world.

The Workshop **recommends** that the appropriate authorities in the other range states (Russia, Democratic People's Republic of Korea and China) initiate educational campaigns specifically targeted at fishermen who use the types of fishing gear that could entrap or entangle western gray whales. These campaigns should explain the critically endangered status of the population, the risks of entrapment or entanglement, and the necessity to report any gray whale found in gear (alive or dead) and to release any live gray whales found.

The Workshop noted that the results of the recommended telemetry programme will greatly assist in focussing the above efforts on areas where gray whales are most likely to occur.

6.3.2 Necropsy data

The Workshop was pleased to receive from Japanese scientists, detailed information from their examinations of dead gray whales, either in set nets or found stranded, and it commended those investigators for their efforts in this regard. It noted that necropsies conducted in an expeditious manner by experts have great value in determining cause of death, assessing pre-mortem animal health, and improving mitigation measures. The Workshop **recommends** that facilitation of such necropsies be made a priority in all range states, involving all relevant qualified individuals and organizations. It also **recommends** that a detailed protocol be developed by IUCN (under Larsen), taking due account of experience elsewhere in the world (*e.g.* with North Atlantic right whales), and distributed widely to maximise the amount of data and information obtained from dead western gray whales. The Workshop **endorses** previous recommendations by the IWC Scientific Committee that range states should submit necropsy reports on western gray whales to the IWC Scientific Committee for review.

6.4 Improved information from outside the known feeding grounds

Although a great deal of new information on western gray whales has become available since the previous workshop in 2002 (IWC, 2004), almost all of it has come from the feeding grounds near Sakhalin Island. In addition to the work carried out there, some recent photo-identification data has been collected from the southern Kamchatka region in Russia and there is recent information on sightings, bycatches and strandings in Japan. Despite dedicated research effort to find gray whales in waters of the Republic of Korea since 2003, no sightings have been made and no new bycatches or strandings have been reported. There is very little new information of any kind on gray whales in China, where research and monitoring remains a major challenge. No information of any kind is available from the Democratic People's Republic of Korea.

The Workshop therefore **recommends** that arrangements for detecting, reporting and investigating occurrences of gray whales, for example through stranding and sighting networks, be enhanced in all range states and particularly in China. It **emphasises** that this should be accompanied by efforts to improve the capacity and ability of researchers in the range states to investigate and validate reports of gray whales, *e.g.* through photography or tissue sampling. Importantly, as recommended by the IWC Scientific Committee, any tissue samples should be made available for genotype matching with the biopsy archive of the Russia-US programme.

Recognising the difficulty of detecting individuals away from the known concentrations on the feeding grounds, and given that the total number of animals is so small and information on breeding grounds and migration is so poor, the Workshop **recommends** that high priority be given to developing accurate and effective public awareness campaigns in the range states, involving use of *inter alia* the internet, newspapers, radio and, if possible, television. The Workshop **encourages** IUCN and IWC to assist relevant authorities in each of the range states in this regard.

7. ADOPTION OF THE REPORT

The Chair of the Workshop thanked all of those responsible for its planning, especially the Steering Group, Larsen and Gotheil from IUCN and Yamada and the staff of the National Museum of Nature and Science. He also thanked Donovan for his guidance in developing the Conservation Plan, and the rapporteurs and interpreters for their hard work. The group thanked the Chair for his expert handling of the Workshop. The final report was adopted by email.

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Annex B
Agenda

1. Welcome and opening remarks

1.1 Welcome, introduction of participants
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1.3 Adoption of agenda
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1.5 Development of an effective conservation plan for western gray whales

2. Population Biology

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2.9.6 Conclusions and recommendations
2.10 Information from 2008 field season
2.11 Information needs and methods to address these
2.11.1 Satellite tagging

3. Identification and quantification of actual and potential threats to the population

3.1Mortality as a direct result of human activity
3.1.1 Entanglement or entrapment in fishing gear
3.1.2 Vessel strikes
3.1.3 Deliberate killing
3.2 Disease, harmful algal blooms, ice entrapment
3.3 Information needs and methods to address these
3.4 Human activities that indirectly affect the ability of the population to recover (habitat degradation)
3.4.1 Noise and other related disturbances
3.4.2 Chemical contamination (including oil) on feeding and breeding grounds and migratory routes
3.4.3 Reduction of prey availability
3.5 Changing environmental conditions related to climate change and other processes
3.6 Other indirect human effects
3.7 Synergistic effects
3.8 Information needs and methods to address these

4. Threat Elimination and Mitigation

4.1 Prioritisation of actual and potential threats identified in Item 3
4.2 Potential and actual mitigation measures (including research needs)
4.2.1 Fishing-related mortality and disturbance
4.2.2 Vessel-related mortality and disturbance
4.2.3 Chemical-related effects, including oil
4.2.4 General approaches (e.g. MPAs)
4.3 Monitoring of effectiveness of mitigation measures (including consideration of enforcement issues)

5. Structure and components of a conservation plan for western gray whales

6. Conclusions and Recommendations

6.1 Status and monitoring
6.2 Threats and improved mitigation
6.2.1 Essential scientific knowledge for mitigation
6.3 Entrapment and mortality
6.3.1 Release of entangled whales
6.3.2 Necropsy data
6.4 Improved information from outside the known feeding grounds

7. Adoption of the report

Annex C

Number	First author	Title
RW2008-1	Lang	Population structure of western gray whales: Insights from genetic analyses.
RW2008-2	Lang	Genetic differentiation between western and eastern gray whale populations using microsatellite markers
RW2008-3	Yamada	Further report of the health assessment of a young gray whale caught in a set net along the Coast of Minami-Boso City, Chiba, the Pacific coast of Japan.
RW2008-4	Kuramochi	Helminth Parasites Collected from the Gray Whale Caught in a Set Net along the Coast of Minami-Boso City, Chiba, the Pacific coast of Japan.
RW2008-5	Tajima	Report of a physical examination on a gray whale stranded at Tomakomai City, Hokkaido, Japan.
RW2008-6	Asakawa	Collection records of parasitic crustaceans obtained from a western gray whale (*Eschrichtius robustus*) stranded on Tomakomai, Hokkaido, Japan
RW2008-7	Yamada	Summary of the recent western gray whale mortalities in the Japanese waters during the year 2005 and 2007.
RW2008-8	Weller	Birth-Intervals and Sex Composition of Western Gray Whales Summering off Sakhalin Island, Russia
RW2008-9	Weller	The Incidence of Killer Whale Tooth Scars on Western Gray Whales off Sakhalin Island, Russia
RW2008-10	Weller	Status of western gray whales off northeastern Sakhalin Island, Russia, in 2007
RW2008-11	Uni	Past Feeding Ground, Migration route and new records of the Western Gray Whale off Japan
RW2008-12	Cooke	Population assessment of Western Gray Whales based on data from Piltun, Sakhalin Island
RW2008-13	Mate	The Spring Northward Migration and Summer Feeding of Mother Gray Whales in the Eastern North Pacific Ocean, Bering Sea and Chukchi Sea.
RW2008-14	Bradford	Seasonal and annual variation in body condition of western gray whales off northeastern Sakhalin Island, Russia.
RW2008-15	Bradford	Anthropogenic scarring of western gray whales (*Eschrichtius robustus*).
RW2008-16	Kato	Current status of vessel collision with cetacean in coast waters off Japan.
RW2008-17	Kim	Study on skinny western gray whales (*Eschrichtius robustus*) in relation to environmental changes in the North Pacific
RW2008-18	Nambu	Records of gray whale, *Eschrichtius robustus*, in Toyama Bay, central Japan: an evidence of migration route along Sea of Japan in Japan.
RW2008-19	Brownell	Rangewide records of western gray whales and their migration routes
RW2008-20	Koya	Summary of administrative actions on conservation of the western gray whales by the Fisheries Agency MAFF/GOJ, with some associated information.
RW2008-21	Vladimirov	Distribution and abundance of the western gray whale feeding aggregation in the coastal waters of northeastern Sakhalin Island in the summer-fall season, 2004-2007
RW2008-22	Vertjankin	New Western Gray Whale (*Eschrichtius robustus*) Feeding Area Offshore Eastern Kamchatka, Russia

Annex D

Draft outline for the development conservation plan

GREG DONOVAN

As noted in Donovan *et al.* (2008), a conservation plan is a living document and one that must evolve with input from a variety of stakeholders. The present Workshop provides a good foundation for beginning the process, particularly with respect to the scientific basis of a plan, for developing some initial actions and for determining a way forward that begins to involve more stakeholders. The primary purpose of the Workshop was to build upon the work done off Sakhalin by the WGWAP and its predecessors – an important component of the conservation plan for those waters can be taken from those reports. Similarly, much of the scientific background summary of the ISRP report can be used, updated where appropriate with information from the Workshop.

Section I: Introduction

This needs to contain a concise summary of the need for a conservation plan for western gray whales – it probably needs to be no more than a few paragraphs. The concluding paragraph needs to specify the general **objective** of the Conservation Plan.

Section II: Legal framework

Scientists are not the appropriate people to draft this section. This is something that IUCN could assist with. It needs a concise summary of the relevant national and international legal situation for western gray whales within each range state and, where appropriate, high seas with respect to *e.g.* :

(a) The management of human activities concerning the actual and potential threats identified in section IV below (including existing protection measures such as MPAs);

(b) Permits required to undertake any of the research actions that may be identified.

Section III: Biology and status of western gray whales

(a) Baseline information
This section needs to contain a summary of the biology (and where appropriate baseline data) of western gray whales, including:

(1) Stock identity

(2) Distribution, migration and movements

(3) Basic biology

(4) Abundance and trends (include description of modelling framework – also valuable for evaluating threats)

It should highlight the major information gaps with a focus on those that have implications for conservation management. The highest priority gaps should also be the subject of draft actions (see Section VIII). Perhaps the highest priority information gap relates to obtaining a better understanding of migration routes, timing and the location of the breeding ground(s), and the best method to achieve improved understanding is through satellite telemetry (an action). The importance of exchange of samples/photographs should be emphasised (an action) as being important in establishing links. An appropriate necropsy protocol is valuable both for investigation of natural and anthropogenic-related causes of mortality and should be the subject of an action. Public awareness/education could also be important here with respect to areas outside the feeding grounds, especially.

(b) 'Attributes' to monitor
Particularly in light of the draft objective, the primary attribute (*i.e.* quantifiable characteristic of a population) to monitor is abundance and trends. This section should include a short power analysis showing the ability to detect trends given present estimation methods. The monitoring programme must be the subject of a high priority action. It would also be appropriate to emphasise the need for effort in other areas such as Kamchatka and to reflect the WGWAP's views on co-operation/collaboration.

It may also be appropriate here to consider other attributes that may be valuable for monitoring – such as an indication of health status (*e.g.* the photographic approach wrt 'skinny' whales). Further work to investigate its suitability as an indicator (*e.g.* of habitat quality and the success of mitigation activities) and the likelihood of detecting significant trends should they occur, might be the subject of a 'research' action.

Section IV: summary of actual and potential anthropogenic threats

(a) Baseline information, evaluation and priorities

This section needs to summarise the direct and indirect threats facing western gray whales throughout its known and suspected range beginning with direct threats (bycatch, hunting, ship strikes) and moving on to habitat-related threats. It needs to identify where these are known or suspected and include at least a qualitative indication of the extent of the activities and the possible impact, and an indication of priorities. In addition to brief text on each, the information could be summarised in the form of a table such as that indicated below (see also Table 2 of the main report). Knowledge gaps should be highlighted and the highest priority gaps may be the subject of actions. It may be that for some, it is better to wait until a better understanding of the breeding ground(s) becomes available. Note that some activities may contribute to several threats (for an example see Table 2 in Donovan *et al.* (2008)). With respect to the feeding grounds off Sakhalin the WGWAP reports provide a good basis.

One possible action that has been mentioned was to improve our baseline knowledge of the presence/effort of set nets, particularly along known or suspected migration routes or in feeding areas and to have such information available in GIS format. The value of a necropsy protocol action has already been noted in the previous section and is relevant here and below. Actions related to the WGWAP recommendations are also appropriate (incl. obtaining good information from other operators as well as SEIC).

Threat	Anthropogenic activity/ies	Evidence	Possible impact	Priority for action

(b) Monitoring

This section needs to begin to discuss how to monitor human activities leading to threats to determine if there are changes over time (this will be particularly important if the population does not increase as we expect in order to help explain changes and perhaps change priorities for action).

Section V: Mitigation measures

In many ways this is the most important component of the conservation plan. Actual and potential mitigation measures should be identified in accordance with the priorities identified in Section IV and priorities for research into mitigation measures highlighted. Again a tabular summary similar to that given in Table 3 of Donovan *et al.* (2008) would be useful.

The highest priority action could be one aimed at the release of entrapped gray whales in set nets (this must have a public awareness/education component – it must be developed in conjunction with those familiar with the prevailing local situation *e.g.* the fishermen who have been involved in such cases). Other actions could include the establishment of an expert group capability within range states. The need for co-operation with those working on similar problems elsewhere in the world should be emphasised (*e.g.* with respect to mitigation against ship strikes, disentanglement) and could ultimately be encapsulated in actions.

Section VI: co-ordinator(s) and steering committee

As noted in Donovan *et al.* (2008), conservation plans have little or no chance of success without at least one full-time co-ordinator and a broadly-based steering committee that should at least:

- Promote/co-ordinate the plan including funding – involve stakeholders
- Collate information on implementation (results, difficulties)
- Communicate to the public
- Conduct regular evaluation and update of the conservation plan
- Attract funding

It is suggested that IUCN might take a lead with respect to co-ordination and with the appointment of a co-ordinator and initial funding, at least. A co-ordination action may be appropriate. An initial discussion of possible funding opportunities would be valuable as well as a discussion as to the nature of the membership of a steering committee.

Section VII: Public awareness and Education

There is great difficulty of detecting individuals away from the known concentrations on the feeding grounds, particularly with the small total number of animals and the lack of information on breeding grounds and migration. Given this, the importance of accurate and effective public awareness campaigns in the range states is particularly important. Actions could be developed using of *inter alia* the internet, newspapers, radio and, if possible, television. It is essential that these be developed in conjunction with local stakeholders.

Section VIII: Actions

These can fall under six general categories although there may well be overlap:

- Research
- Management/legislative
- Compliance
- Monitoring
- Capacity building and public awareness
- Co-ordination

In this working paper I have indicated where even at this stage, the drafting of actions may be/is appropriate. The structure of actions should follow the general outline of Table 4 of Donovan *et al.* (2008):

Short description

Relevant objective
Threat
Target
Rationale
Method
Expected results
Timeline
Budget

Legal framework
If necessary

Actors
Relevant authorities
Co-ordinators
Undertakers
Stakeholders
Evaluators

Priority
Importance/feasibility

Evaluation
Indicators/monitoring tools