WESTERN GRAY WHALE ADVISORY PANEL | **WGWAP:**
Photo-ID Task Force
Task Force Workshop | **12-14 October 2007**
Vancouver, Canada

REPORT OF THE TASK FORCE

CONVENED BY IUCN - THE WORLD CONSERVATION UNION

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1 INTRODUCTION

Two research groups have ongoing western gray whale (WGW) photo-identification (photo-ID) programmes centred on the northeastern Sakhalin Shelf. The Russia-US programme has been working there since 1995, and the Institute of Marine Biology (IBM) group has been working there since 2002. At its first meeting in 2006, the Western Gray Whale Advisory Panel (WGWAP) agreed to establish a task force to review and cross-match the two programmes' photo-ID catalogues.

Objectives

The objectives of the Task Force, as stated in its terms of reference (Annex 1), were to:

1. Compare the Russia-US and IBM catalogues[1] and arrive at an agreed list of known individuals;

2. Suggest appropriate further collaboration, taking into account the need for annual updating of the comparison, and for consistency in: (i) identification of new individuals; (ii) identification of re-sightings; and (iii) classification of photograph quality; and

3. Consider ways to reduce photo-ID-related disturbance to whales, while maintaining sufficient data collection for population assessment and for addressing other important scientific questions.

Programme of Work

The methods to be used to meet those objectives were to:

1. Cross-match the two existing catalogues. The cross-matching was to be carried out by the people involved in the development, compilation and curation of the catalogues as well by one or more experienced external matchers to:
   - determine, for each whale in each catalogue, which whale, if any, it matches in the other catalogue;
   - resolve doubtful cases, if necessary by examining all available photographs of the whales involved at a Task Force workshop;
   - review and discuss the report of the independent expert.

2. Hold a three-day workshop to discuss and, if possible, make recommendations concerning further work, including:

[1] By catalogue here we mean the reference set of photographs (best) for each individual. This differs from a database that includes the complete sightings history for each individual along with the photograph(s) used for each agreed resighting and the quality rank assigned to those photographs.

- consistent protocols for the assessment of photograph quality, matching of individuals, and inclusion of definite and candidate new whales in the catalogues (including field methods and “laboratory” procedures);
- arrangements for annual updating (cross-matching of new additions to each catalogue each year);
- matching of photographs submitted by third parties;
- scientific questions that could be addressed using the photo-ID data (including examples of analyses conducted to date – such as population assessment – and potential analyses that could be performed);
- facilitation of collaborative analyses, taking into account questions of protection for data owners.
- consideration of ways to reduce photo-ID-related disturbance to whales, while maintaining sufficient data collection for population assessment and for addressing other important scientific questions.

3. Report back to the WGWAP at its 3rd meeting on the results of the cross-matching, including summary statistics of the matching process, recommendations for further collaboration, and any outstanding issues or problems.

The first item in the above list was addressed in three steps. First, CD’s of the two catalogues were exchanged by the teams (completed in January 2007). Second, each team conducted an initial in-house cross-matching of the catalogues and the results, including comments and questions and indication of all matches considered uncertain was submitted to the chairs of the Task Force. Finally, by agreement of all parties, an external, independent expert reviewed the results of each team’s cross-matching exercise and provided comments and advice, particularly with respect to inclusion and matching criteria, and uncertain matches. The expert’s final report was provided to the Task Force in September 2007.

The second item was fulfilled by a workshop held in Vancouver, Canada, 12-14 October 2007. As specified in the Task Force terms of reference, persons actively engaged in the photo-ID work attended the workshop and provided access to their respective full sighting histories and photo archives. Also in attendance were members of the WGWAP, consultants representing industry sponsors of the IBM group, the aforementioned external expert and representatives of IUCN (Annex 1).

The third item will be covered by submission of the present report to the WGWAP for consideration at its 3rd meeting in Lausanne, Switzerland, 10-13 November 2007.

The rest of this Task Force report follows the workshop agenda (Annex 2).

2 CROSS-MATCHING EXERCISE

2.1 Presentation of report of independent expert and cross-matching results

Rowntree summarised her report, which the Task Force judged to be excellent in all respects. It was decided that the report should be finalised by Rowntree and included in final form as an annex to this report (Annex 3).

The Task Force expressed its appreciation to Rowntree for the professionalism and clarity of her report and thanked her for participating in the workshop.

2.2 Resolution of doubtful cases, and, if appropriate, matching of temporary whales

The six unresolved matches were discussed by members of both research teams in a working group chaired by Rowntree. It was decided that for the purposes of this exercise, temporary whales would be removed and sightings only through the year 2005 (as presently available on CD from each team)would be considered. Both teams agreed that whale # IBM KOGW 135 is a match to # R-US 099. Therefore, the final tally (summarized in Table 1) was agreed by all to be 155 whales, including 130 matches and 25 individuals that are unique to one catalogue or the other.

Table 1. Results of resolution exercise

Catalogue	Individuals in catalogue	Agreed Matches	Unique to catalogue
IBM	135	130	5
Rus-US	150	130	20

3 PRESENTATION OF EACH TEAM'S WORK

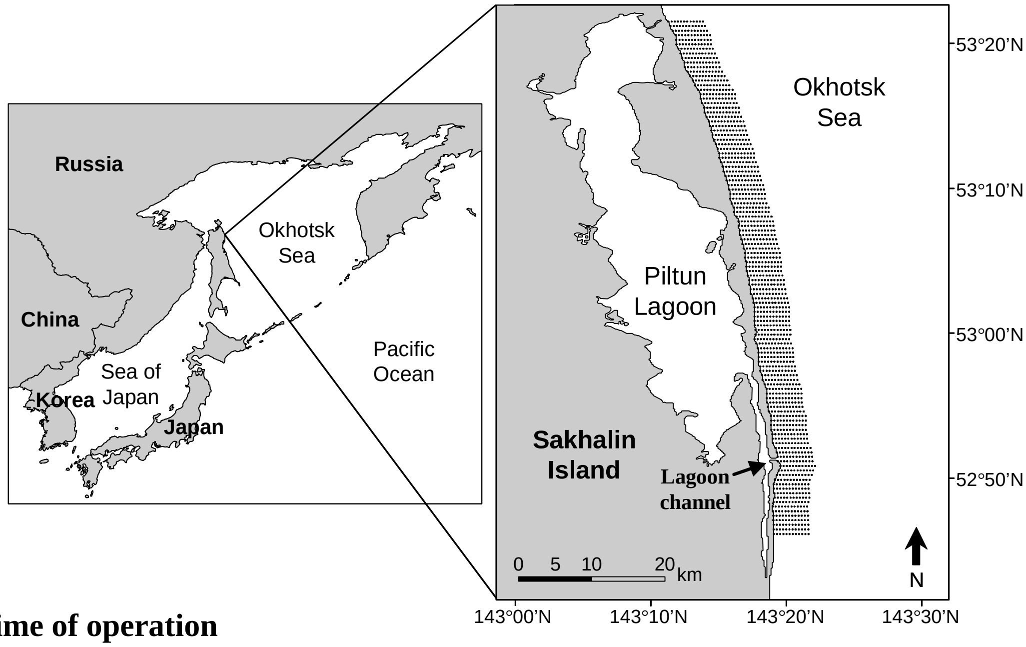
Tyurneva and Bradford provided presentations of the field methods and laboratory procedures used by the IBM and Russia-US programmes, respectively. The information from each team is summarised in the following sections.

3.1 Field methods

3.1.1 Russia-US team

Area of operation

Surveys are conducted off the northeastern coast of Sakhalin, in near proximity to Piltun Lagoon (see maps below). Research effort is concentrated within 5 km of shore and extends approximately 60 km north and 10 km south of the lagoon channel (hashed area within detailed map).



Time of operation

Photo-identification surveys have been conducted between 1995 and 2007 during summer and autumn months (see following table for summary through 2006). Data included from 1994 were obtained opportunistically (see Weller *et al*., 1999 for description).

Table of annual survey effort, groups encountered and whales identified 1994 to 2006.

Year	Sampling Period (mm, dd)	Number of Surveys	Hours of Direct Observation	Groups Encountered	Whales Identified
1994	09/07 - 09/12	1			10
1995	08/15 - 08/19	5	10.1	23	28
1997	07/09 - 09/08	22	33.4	114	47
1998	07/06 - 09/29	35	50.5	125	54
1999	06/29 - 10/13	56	122.0	434	69
2000	06/25 - 09/16	40	56.5	365	58
2001	06/25 - 09/25	49	101.8	448	72
2002	06/25 - 09/25	36	75.6	411	76
2003	07/15 - 09/13	22	41.7	219	75
2004	07/29 - 09/12	21	33.8	194	93
2005	07/04 - 09/09	20	40.9	160	93
2006	07/23 - 08/25	10	24.1	96	79
Overall		317	590.4	2590	158

Platform photographs taken from

All surveys are conducted from a 4.5 m Zodiac equipped with a four-stroke outboard motor. The research team consists of a boat driver, data recorder, digital video camera operator, and digital SLR camera photographer.

How whales are located

Systematic visual search by observers on the survey vessel is maintained until a whale sighting is made. Whales are also located via observers stationed on the Piltun lighthouse when the research vessel is within visual range. Dedicated surveys are characterized by a single line transect about 1 km from shore.

Methods to obtain photographs

Upon initial sighting of a group, the survey vessel is slowed to low speed, and moved to a vantage point approximately 50 m from the whale(s). From this position, observations on group location (as determined by GPS), time, behaviour, and number of whales are recorded. Whenever possible, approach is initially from behind and to the side of whales at low to idle speed.

Photographs are optimally obtained from about 15-30 m. In cases of poor weather or unpredictable whale behaviour, the distance from which photos are collected is occasionally increased to no more than 50 m. Film and digital SLR cameras using zoom-telephoto lenses ranging between 200 mm and 400 mm have been used over the years. Most recently, Nikon D1X and D2X cameras coupled with 200, 300 and 400 mm lenses have been used. In addition, digital camcorders (mini DV and HD formats) are used in tandem with still photography for all group encounters.

The photo-identification catalogue is based on right-side dorsal flank markings (see description in Weller *et al*., 1999, 2006, as well as image below). Attempts are made to simultaneously photograph and videotape the right dorsal flank of each whale, followed then by photos of the left dorsal flank and flukes. However, the majority of whales identified to date now have images of right and left dorsal flanks, as well as the ventral surface of flukes, in the photo-identification catalogue, thereby allowing for useful identification images to be collected from nearly any body region.

Sufficient time is spent with each group to comprehensively photograph a whale(s). When the whale(s) is visually recognized, effort is directed at obtaining good quality images of either the right or left flank. If the whale(s) is not visually recognized effort is directed at obtaining right dorsal flank images as the priority.

Data collected for each group encounter includes: group size and composition (i.e., mother-calf, subadult, adult), catalogue ID number if known, behaviour, and affiliation and disaffiliation. During the photographic effort, a running commentary regarding the image frame and video counter number as related to particular whales is recorded onto data sheets. Measures of water depth (as determined by digital depth sounder), location (as determined by GPS), and environmental conditions are recorded every 3-5 min throughout each photographic session. Other auxiliary data collected include notation of other marine mammals, seabirds and presence of any nearby vessels or helicopters. In addition, water temperature and salinity are recorded at least once per survey. Data collected in the field are entered electronically in raw form, as well as summarized in an Access database, on a daily basis and backed up on multiple hard drives.

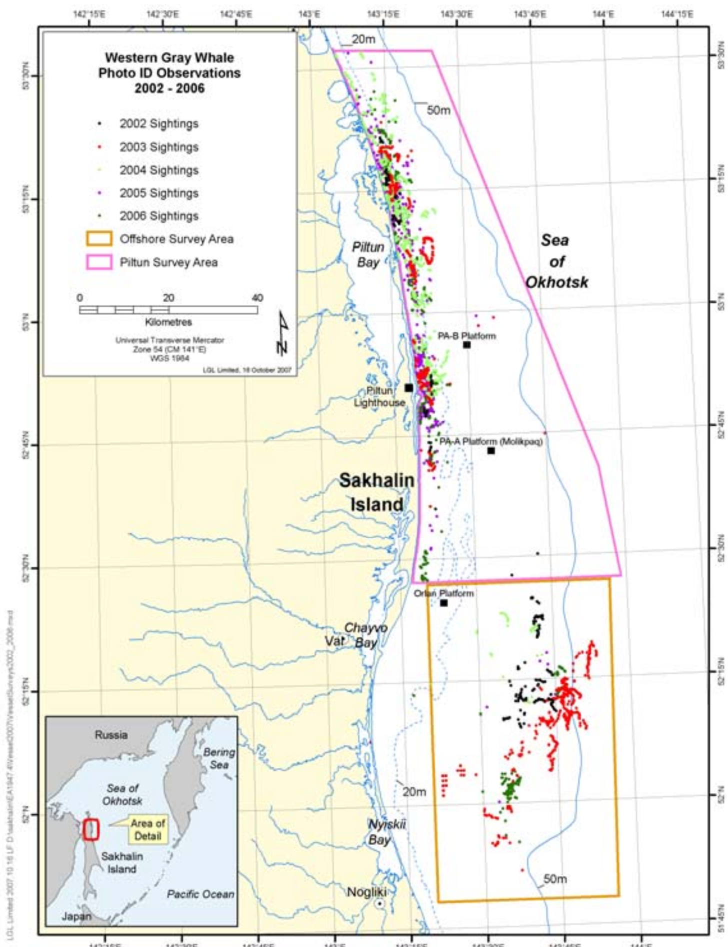
Summary of field effort

See table above.

3.1.2 IBM team

Study area

The study area covers the entire northeastern coast of Sakhalin Island including the Piltun feeding area (52°27’ N to 53°32’ N) stretching along the shore of Piltun Bay, and the Offshore feeding area located offshore of Chaivo Bay (51°48’ N to 51°27’ N). Photo-identification, or Photo-ID, effort was concentrated in these two areas, but whales were also photographed opportunistically if encountered outside these regions. In 2006, whales were encountered in the Chaivo Bay area. The base vessel, from which the inflatable (hereafter “zodiac”) is launched, covers an area out to 20 nm (37.04 km) from shore with most effort concentrated within 15 nm (27.78 km) of shore.



Area of photo-ID coverage and locations of whales photographed in the Piltun and Offshore areas. These are the main areas covered by the photo-ID vessel, although some whales have been photographed outside these areas opportunistically.

IBM photo-ID effort 2002-2006

Year	Dates	No. of missions (Number of Zodiac Surveys)	Hours on Group Total (Pil/Off/Chaivo)	No. Group Sightings from Zodiac	Number of Whales Identified*
2002	30.08-25.10	24	40.7 (10.1/30.6/0)	72	45
2003	21.07-27.09	35	52.4 (19.8/32.6/0)	86	82
2004	30.07-07.10	27	31.7 (30.6/1.1/0)	113	95
2005	12.07-07.10	56	61.3 (59.5/1.8/0)	186	117
2006	03.08 - 14.10	26	36.8 (27.1/7.2/2.5)	109	120

* Individual whales identified not including temporary whales, or whales identified by researchers other than the IBM photo-ID team. Effort is calculated based on the latest available data from the Photo-ID database at the time this report was written, these data are subject to revision as the database is updated.

Platform from which photographs are taken

Photo-ID of gray whales was conducted from a zodiac equipped with a 4-stroke outboard motor on dedicated photo-ID days, when weather and sea conditions permitted. Visual observations of marine mammals were maintained continuously from the main vessel during daylight hours, allowing the photo-ID team to travel directly to whale aggregations, reducing zodiac search time. Gray whales were located by vessel and land-based observers (shore-based teams) in addition to marine mammal observers (MMOs) stationed on other industry-related vessels. Photo-ID was also conducted from the main vessel opportunistically.

Photo-ID data from other teams

Photographs and associated sightings histories are also collected from teams other than the IBM photo-ID research team. The shore-based behavioral team has contributed information and data, especially valuable for cows and calf identification. Vladimir Vertyankin has contributed a number of photographs of gray whales from the Kamchatka area. Data from these teams were compared to the IBM catalogue, and are planned to be incorporated into the main photo-ID database.

How whales are located

(See above section on Platform from which Photographs Are Taken)

Methods to obtain photographs

When whales are approached for a photograph, the zodiac decreases speed at a distance of ~ 1 km from the whale group. At ~ 500 m from the group, conditions and group behaviour are assessed. Groups are approached at slow speed at an oblique angle until the zodiac is either behind or parallel to the focal animal (at appropriate angle and distance for ID photography). Photos from the zodiac are generally taken from 50-100m from a whale. This distance is optimal for photographic quality, however, photographs taken from greater distances are usable as well especially when enhanced using photo-editing software such as Photoshop. Nikon D1X and D2X digital cameras with 300mm and 80-400mm VR Nikkor lenses are used. A 2x teleconverter is occasionally used with a monopod from the main vessel opportunistically, resulting in a 800mm effective focal distance.

Priority is given to obtaining a right flank photo if light and other conditions permit. An attempt is made to photograph all aspects. Priority is given to photographing groups containing mother-calf pairs. A time limit of ~ one hour per individual and ~ 30 minutes per mother-calf pair is followed to minimize potential disturbance from the zodiac. Group size, mother-calf pairs, behaviour, field-ID, plumes, body and skin conditions, and unusual markings (e.g. entanglement scars, wounds, etc.) are recorded. Time, position, bearing and distance to the whale, whale sighting ID, effort, environmental variables, nearby vessels, and the presence of feeding birds or other marine mammals are also recorded. This information is recorded on paper sheets in the field and entered into a computer database on the main vessel at the end of each survey day. The database is backed up both in the field and laboratory on multiple external hard drives and DVDs. Backups are maintained at the IBM lab, the home of the principal investigator in Vladivostok, at the LGL Limited office in Sidney, B.C., Canada, and at the home of Christina Tombach Wright in Santa Barbara, California. Video of the whales is taken simultaneously along with the still photographs and serves as another tool for identification, and as a way of assessing behaviour and other phenomena.

Mean number of days spent in areas where gray whales have been photographed.

Year	Piltun	Offshore	North	Chaivo
2002	4	9	-	-
2003	7	10	-	-
2004	21	4	-	-
2005	28	2	2	-
2006	26	7	-	3

3.2 Laboratory methods

3.2.1 Russia-US team

Note that the following methods are based on the use of digital photography and processing, which was adopted by the Russia-U.S. Program in 2002. If these methods represent relevant departures from the film-based procedures, such is noted in the text.

Pre-processing

After the completion of each survey, all digital images obtained are reviewed to preliminarily assess field identifications. This review does not influence the matching procedure and the associated individual sighting histories, but is used to inform the field recognition process. That is, several surveys may occur before there is sufficient time for image processing. Given that individual recognition allows for some flexibility in image collection (i.e., perhaps a good quality left-side sequence of images is sufficient for a previously identified whale) and biopsy sampling, a preliminary review of the images post-survey for field identification validation is highly useful. Prior to the collection of digital images, the simultaneous digital video footage was used for this purpose.

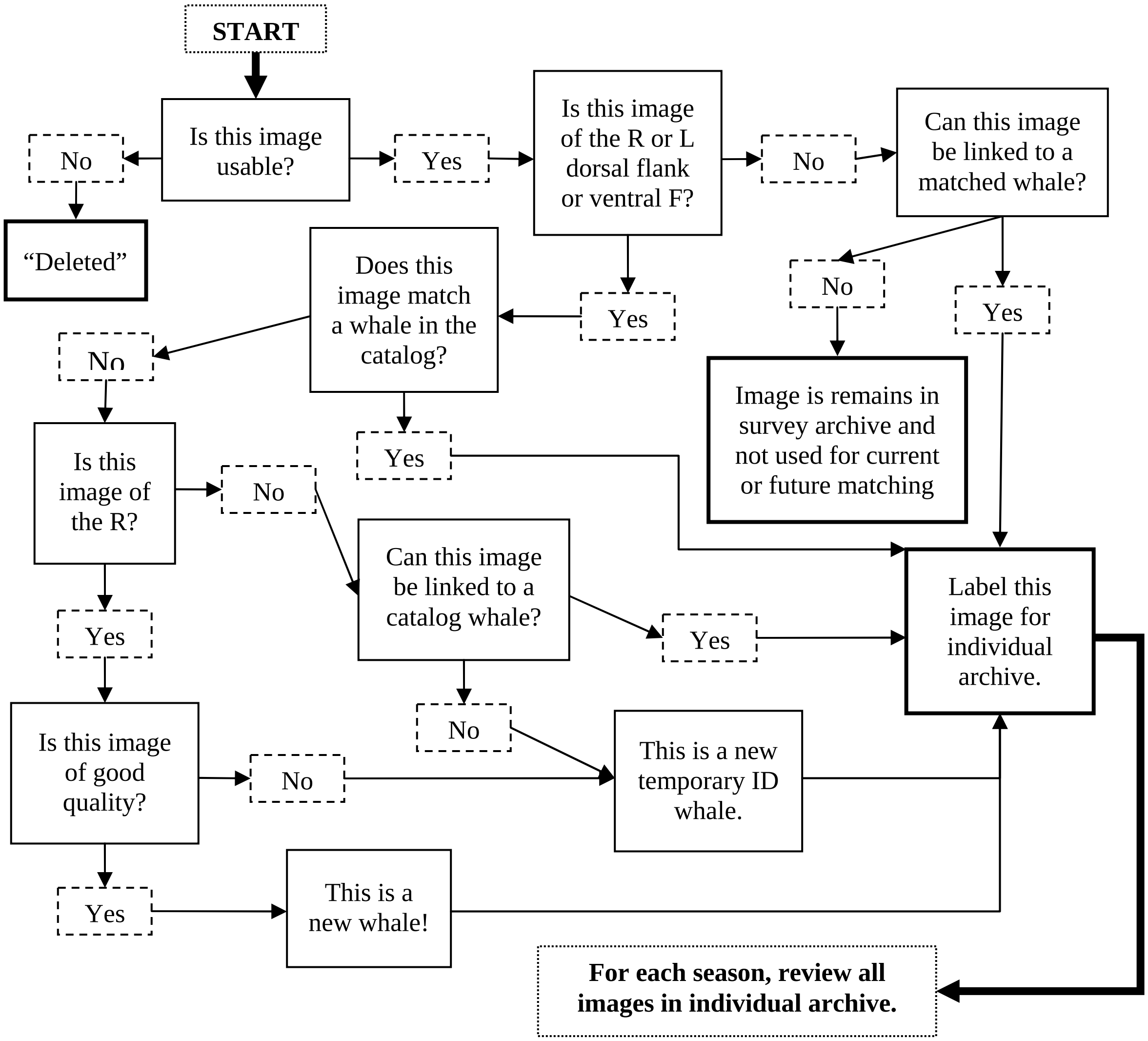
Once time is available for image processing, all images taken during a survey are labelled by the date, image card number, group number, and image number corresponding to that image. Unusable images are then "deleted" (i.e., moved to a separate folder). An image is considered unusable if it is characterized by poor photographic quality (e.g., out of focus) and/or highly compromised whale position (e.g., little of body visible), such that reliable matching is not possible.

Image enhancing software such as Adobe Photoshop is used sparingly during pre-processing, as well as during the general matching process. Image enhancing is laborious when dealing with large numbers of images and lowers the resolution of the enhanced JPEG files. Further, while image enhancing can help elucidate features used for matching, it cannot repair an inherently unusable image. Instead, every effort is made in the field to collect images that are usable with little or no image enhancement.

Matching process

All usable images taken during a survey are considered in the matching process, as opposed to only considering the best image or a subset of images of each whale sighted. Since gray whales are individually identifiable from every aspect of their body, it is desirable to archive and update images forming a composite view of all parts of the body shown when a whale surfaces. Such images: 1) allow known whales to be identified from photographic sightings of any aspect, and 2) ensure that visual based analyses requiring more extensive body coverage (e.g., scarring and body condition assessments) can be conducted.

A schematic of the image matching process is shown below. Individual matching is based primarily on natural pigmentation patterns, which are permanent, and secondarily on scars from barnacles and other sources (e.g., killer whales, entanglement), which can be transitory. The specific features used to make a given match are not documented. Although photo quality is considered during the matching process, a photo quality (or distinctiveness) rating is not assigned. Members of the data collection team are involved in the matching process. Further, digital photography enables all matching to be conducted while still in the field. Images are viewed and processed using ACDSee, which allows image metadata to be edited and exported. These exported metadata are compiled to form the individual sighting histories.



Catalogue

The photo-identification catalogue is the set of best images (i.e., type specimen images) for each identified individual and is used as a reference when resighting individual whales. At a minimum, a catalogue entry should contain a good quality image of the right dorsal flank (see below), but would ideally also include a good quality image of the left dorsal flank and ventral fluke surface, although fair quality images of these latter aspects will be incorporated if good quality images are not available. An image is considered good quality if it is characterized by good photographic quality and appropriate whale position, such that pigmentation patterns in the target feature are undistorted and can be clearly distinguished from barnacle and other scars, enabling matching over the long-term (i.e., on the order of years to decades). An image is viewed as fair quality if it is characterized by fair photographic quality and/or compromised whale position. While skin pigmentation in these images may be somewhat distorted and not clearly distinguishable from scars, the overall pattern of the markings can be discerned, enabling matching over the short-term (i.e., on the order of months to years).

The searchable catalogue can contain multiple images of an aspect for a given individual (particularly when that individual has been sighted over many years), although one image per aspect per individual is flagged as the 'best' image (generally the most recent image of good quality). These 'best' images are viewed first during the matching process, and the supporting images referred to if additional confirmation is needed. Left dorsal flank and ventral fluke images are linked to their corresponding right dorsal flanks primarily by the use of overlapping images, but can also be inferred from instances when the whale was sighted singly.

A whale is considered new if a good quality right dorsal flank image is obtained that does not match other whales in the catalogue. The next available identification number is assigned to the new whale. All new whale designations are confirmed by two researchers. The date a given whale was considered new is known and can be retrieved from the database. Resightings of previously identified individuals can be made from either good or fair quality images, as long as the aspect being matched is represented in the record of the individual in the catalogue. If a right dorsal flank image does not match other whales is in the catalogue, but is only of fair quality, then this image is considered to represent a temporary whale. Likewise, if good or fair quality images of the left dorsal flank and ventral fluke do not match other whales in the catalogue, then these images also represent temporary whales. Thus, it is possible that temporary whales include both new whales and new aspects of previously identified whales. Temporary whales are uniquely labelled and are kept in the searchable catalogue to facilitate resighting and eventual identification of the represented individuals. A temporary whale record generally contains only one aspect, but can contain all three aspects depending on the images that were collected and the ability to link these images. The sighting histories of temporary whales are not considered in any photo-identification analyses. The number of temporary whales in the catalogue has consistently numbered less than five.

An identified whale is regarded as a calf if it was of small body size (i.e., about one-third the size of a mature adult) and in constant and close association with a particular adult whale, who is considered the mother of the calf. In some cases, an identified whale can be considered a calf when not accompanied by a mother (i.e., a calf of the year first sighted post-weaning) if that whale is sighted with a known calf of the year and is of a similar size. Mother-calf pair designations are made in the field when the size and behaviour of the pair can be observed, but most designations are confirmed using genetic analyses. An identified whale is considered male or female based on genetic analyses, although in one case a female was designated such solely by her association with a calf.

Sighting histories

The individual sighting histories comprise one table within the Access database. This table contains the whale identification number, the sighting date and group number, the aspect photographed (right, left, and/or fluke), and the type of image obtained (film, digital, and/or video). All matched photographs are associated with individual sightings, although the images are not physically linked within the database. It is possible to trace when an individual was first identified and when retrospective identifications were made (i.e., when temporary whales became identified whales). Although new whales are only established from good quality digital or film images, resightings of previously identified whales can also be made from video sightings. The Russia-U.S. database and all collected images are backed up on multiple hard drives and duplicate copies of digital video tapes are made.

References

Weller, D. W., B. Würsig, A. L. Bradford, A. M. Burdin, S. A. Blokhin, H. Minakuchi, and R. L. Brownell, Jr. 1999. Gray whales (*Eschrichtius robustus*) off Sakhalin Island, Russia: Seasonal and annual patterns of occurrence. Marine Mammal Science 15:1208-1227.

Weller, D.W., Bradford, A.L., Tsidulko, G.A., Ivashchenko, Y.V., Lang, A.R., Kim, H.W., Rickards, S.H., Burdin, A.M. and Brownell, R.L., Jr. 2006. Western gray whales off Sakhalin Island, Russia: A catalog of photo-identified individuals. Paper SC/58/BRG2 presented to the IWC Scientific Committee.

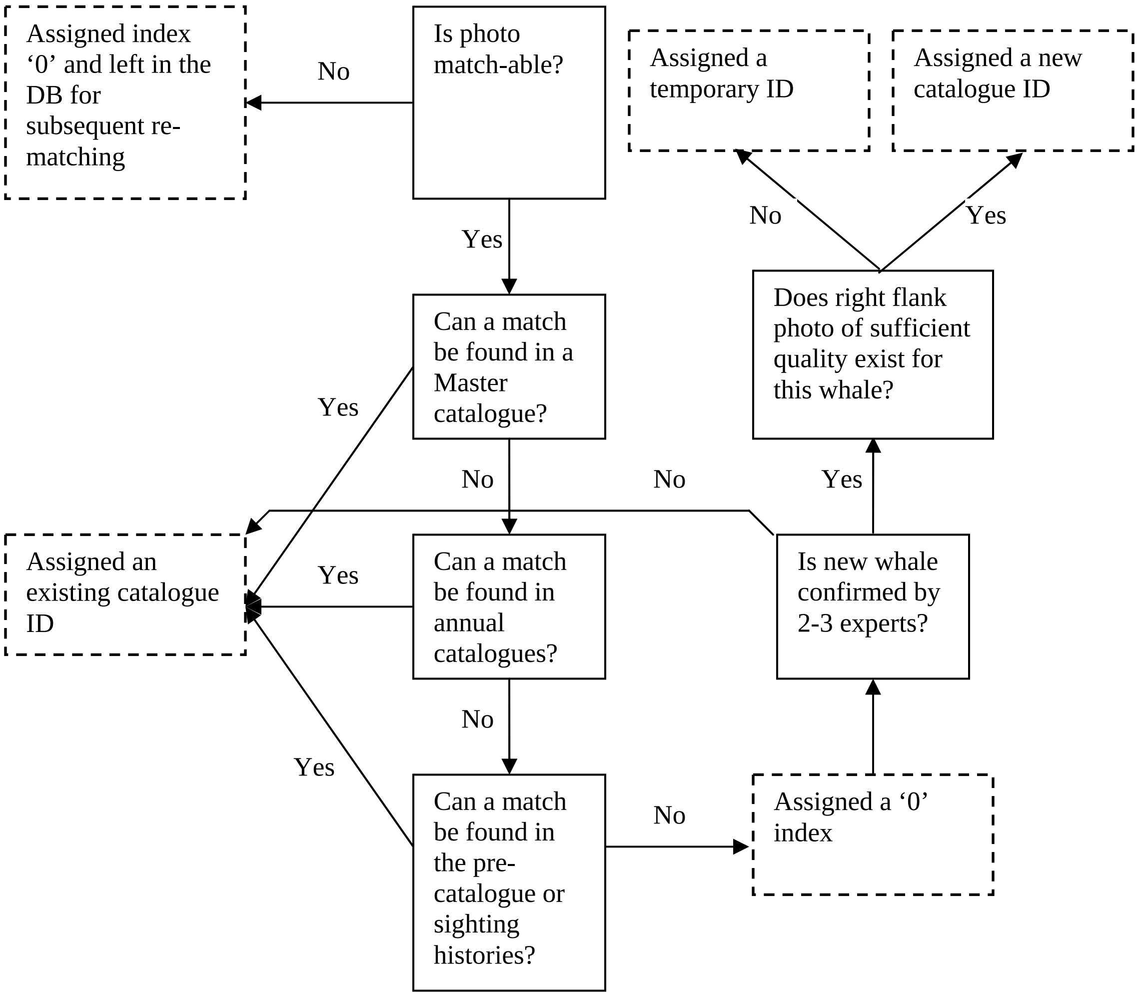
3.2.2 IBM team

Matching process

Photos are not pre-processed in the field and no matching occurs in the field. Photos are enhanced in Adobe Photoshop during the matching process as needed. This is done for nearly all of the type-specimen “best” photographs for each sighting, and for supplementary photographs within a sighting if needed to aid in identification. Features used for matching include natural and permanent pigmentation patterns such as spots and mottling, followed by scars from predation, barnacles and other sources. These scars may persist for years, but are not reliable permanent identifiers. Tertiary features, such as whale knuckles, can be useful not only for individual identification, but also for aspect association. Other markers, such as skin condition (e.g. sloughing events, lice, etc.), can both help and hinder identification (as they occasionally cover permanent reliable markings), and can transition rapidly, even within one feeding season.

The “type-specimen” photographs of each individual per sighting become the sighting or “pre-catalogue”. These are noted in the photo-ID database, but features other than the best-quality photographs used to make the match are not recorded. All sighting catalogue photographs are currently not rated for photo quality.

All photographs in the Photo-ID database have been scored for “match-ability” (i.e. True/False). The photographs are compared to the existing series of catalogues to see if they can be matched to existing whales or if they can be determined to represent a “new” individual. Photographs of insufficient quality to determine a reliable match are labelled as “trash” photos for that year, but are retained in the database.



Catalogue

The IBM Master catalogue provides a 1-page reference set of photographs for quick and easy visual identifications. These data are supplemented by the searchable database during the matching process. Individual whales can be sorted by photo qualities (namely the hierarchy of catalogue qualities). The best photos of each individual are organized within the database via a series of catalogues, starting with daily sighting “pre” catalogue(s), then annual catalogues, followed by a master catalogue which displays the best-quality photograph(s) of each available aspect (right and left side flanks, ventral and dorsal flukes), for all identified individuals.

The minimum requirements to designate a new whale are (1) a sufficient-quality right side flank photo, (2) a match confirmed by two to three lab matching experts, and (3) the photo is compared to the current Master catalogue and additional photographs of the whale housed in the searchable digital photo-ID database (this includes all other available catalogue-quality photographs of the whale). If a match is not found and the photo meets the above requirements and is of matchable quality, the whale is given a new sequential catalogue identification number and classified as a new individual. Re-sighting photographs are confirmed by one to two lab-matching experts, depending on the quality and distinctiveness of the photograph(s).

A fair to good matchable-quality right side flank photograph is required for a whale to be designated as new and issued a sequential catalogue ID number. If these criteria are not satisfied, and a poor-quality right flank photograph or other matchable-quality aspects are captured which cannot be matched to existing known catalogue whales, the photos are given temporary ID number(s). These temporary IDs are preserved in the case histories of the whale even after a sufficient-quality right side flank photo is obtained and the whale can be issued a catalogue ID number. Temporary ID numbers are issued sequentially and not re-used. The database allows for tracking any whale by both its permanent catalogue ID number and its temporary ID number (if available) and the year each of these was issued.

A minimum catalogue entry consists of a photo of the right flank. A full catalogue entry consists of photos of all four aspects (right and left flanks, ventral and dorsal flukes), and possibly additional photos if they contain information important or helpful for matching. Photographs are taken as surfacing series from ventilation to dive. This is useful for documenting all regions of the body and assessing body condition, and for aspect linkage (see Appendix 1). Whale knuckle height and spacing on the back and caudal region can also be used to assist in linking right and left side aspects. Occasionally, when available, views of the back (e.g. from the rear), showing both left and right flanks simultaneously, can help in aspect linkages and can support previously established associations. Re-sightings also confirm previously made aspect linkages.

When a whale is first added to the catalogue, its data are recorded and so the time at which it was added to the database can be determined based on annual catalogues, temporary whale ID's, and sighting dates. This information can be tracked within the database itself.

The sex of an individual whale can only be determined (a) if it is seen in close association with a calf or (b) via a detailed ventral view photograph. The criteria/methods for determining mother-calf pairs include:

- Whale is not recorded in the current catalogue
- Looks like a possible calf (based on size) and demonstrates playful calf behaviour
- Encountered multiple times near shore (at shallow depths) in close association with the same adult, and is significantly smaller than the adult
- Can be encountered within groups of other calves from the same year
- Calf identification is confirmed by field data notes

- Calf identification is confirmed by the shore-based observers (teams).

Database (sightings histories, etc.)

The database is divided into two components. A field component is implemented in MS Access and stores all information gathered in the field, associating each record with a specific digital photograph frame and time. The matching component is based on the iMatch photo cataloguing software, which stores all photographs and associates each with the matching data (including whale ID, aspect, body and skin condition, etc.). At the end of each matching season, the information from both components is joined and final working tables are created. Every photograph is associated with all available sightings information.

It is possible to trace when an ID was first made and when retrospective identifications were made based on annual catalogue and temporary catalogue records maintained by the database. Re-sightings do not include information based on materials other than photographs (e.g. video, or field identifications).

Data are systematically backed up on external hard drives at the end of the season's matching process and routinely throughout the year. Copies of the data are sent and stored in the three locations specified above in Vladivostok; Sidney, and Santa Barbara. Additional back-ups are created as a side-effect of the development of daily catalogue photos. These files are copied and organized in mission-base and whale-base folder structures.

3.3 Conclusions and recommendations

The Task Force **agreed** that the presentation of each team's field and laboratory procedures was clear and thorough, and that it now had a good understanding of each team's work and the differences between them. It does not rule out that there may be further questions over specific details.

The Task Force thanked the teams for these detailed descriptions. Although much of the information has already been presented in other documents and publications, it is very useful to have compact and comparable descriptions in one place.

3.3.1 Field Procedures

The Task Force noted that there are quite a few differences between the two teams both in the collection and analysis of the data, and furthermore that even within teams practices have evolved over time. Especially in recent years, the bulk of the effort of the Russia-US team has been in inshore waters and earlier in the season, while the IBM team has had more coverage further offshore and later in the season. As discussed under section 5, this has resulted in some complementarity in the results of the two teams, with each team tending to sight whales missed by the other team.

Field procedures differ in subtle ways between the teams. For example, the Russia-US team often recognise whales on sight (although photographs are always collected nonetheless), and tend to spend more time photographing potential new whales, including calves, rather than known whales, for which fewer photos are taken on an encounter to confirm their identity. The IBM team tend to treat all encountered groups in a more uniform way, without identifying them in the field.

Some of the differences relate to the research conducted in conjunction with photo-id. The base for the IBM team's zodiac is the research vessel, whose itinerary is determined primarily by the programme for collection of benthos samples and other data. The Russia-US team's zodiac departs from a fixed shore base, and while the research programme is dedicated to photo-ID of whale, the deployment of effort is partly directed towards the collection of biopsy samples.

Based on the descriptions of the two teams' field procedures, the Task Force **agreed** that it was not appropriate or necessary to attempt to standardise field procedures between the two teams, although it was important to understand them fully. The two teams were urged to report any changes to procedures after each season.

Issues where field procedures may need to be reviewed are: (i) judgement of cow-calf pairs and (ii) judgement that unaccompanied whales are calves. These are discussed in section 5.

3.3.2 Laboratory procedures

The Task Force noted that identification of whales is not generally based on a single photo, but usually on a sequence of photos, and **agreed** that a quality grading of individual photos is not a high priority. For the published catalogues, the teams tend to include the best single photos of each aspect of the whale, but identification of re-sightings of whales is not based solely on the catalogue photo.

The Task Force **agreed** that, given reasonable photos or photo sequences of the right side, all whales in this population are clearly distinguishable, and that classification of the distinctiveness of individuals was, therefore, not necessary.

The Task Force noted that both teams had found that it is easier to confirm a re-sighting of a catalogued whale than it is to confirm a new whale. Therefore, there exist photos or sequences that have not been matched to a known whale, but which cannot definitely be designated as a new whale. This is the usual situation in photo-id studies, and it can potentially cause some bias in population analyses based on photo-id data. In order to bound the potential for bias, it is important that the number of such uncertain whales be known.

Both teams have partially addressed this problem through the designation of "temporary whales". Temporary whales include whales, for example, where only a left-side photo is available, and where there are some whales in the catalogue which lack a left-side photo. A whale may also be considered temporary if right-side photos are available, but are of insufficient quality to qualify as a type specimen (e.g. not enough body is visible). As more photos are obtained, temporary whales may later be matched with catalogue whales, or become new catalogue whales themselves.

The Task Force **recommends** that all current temporary whales be clearly designated as such, and appended to the respective catalogues. In the case of former temporary whales whose identity has since been clarified (either as a match or as a new whale), the entries in the data files should be such that it can be traced (retrospectively) which whales had been temporary and for how long.

The Task Force emphasised that the four categories: (new whale; match; temporary whale; unusable image) should be exhaustive. There should be no hidden reserve of images which contain insufficient information to assign an image to a whale at the current time, but which are held in reserve for potential future matching. The Russia-US team confirmed that they have no such reserve.

4 PROCEDURES FOR REGULAR UPDATING OF CATALOGUES AND CROSS-MATCHING

The Task Force was pleased that the results of the comparisons of the two catalogues described above showed such a high level of agreement. Only six unresolved matches had been identified during the review by the independent expert and these were resolved at the workshop (see Item 2.2).

As discussed under Items 5, 6 and 7, considerable benefits arise from being able to undertake analyses of combined datasets. The Task Force **recommends** that the cross-matching of catalogues is updated each year.

For a number of reasons, including the small size of the population and the fact that all animals in the population appear to be identifiable, it was agreed that it was not necessary to develop a single catalogue, nor was it necessary to categorise all photographs for photo quality and/or distinctiveness. However, in order to undertake analyses of combined datasets with confidence, it is important to ensure that: (1) all aspects of the whales included in the catalogues are correct and should any changes be identified, the implications of these changes for existing sightings histories be examined and if necessary corrections made; (2) identification of calves and assignments of calves to mothers are correct and consistent; and (3) resightings are being identified correctly and consistently.

With respect to (1), the work carried out before and at the workshop completed the initial part of this process. The Task Force **recommends** that the checking of the resightings in the light of this be undertaken as soon as possible, ideally before the next WGWAP meeting.

With respect to (2), the Task Force **recommends** that the final (current) versions of the two datasets be compared to assess levels of agreement. It was agreed that the Russia-US data be treated as the ‘master’ since that team (a) has genetic evidence to confirm most of its field assignments and (b) generally begins its work earlier in the season before most weaning is believed to take place.

As discussed under Item 5, a preliminary analysis using one non-final dataset was undertaken. This analysis, along with the obvious importance of having accurate calf and mother data for many analyses, suggests that it would be valuable to review the criteria used to identify calves and their mothers and also to establish a scoring system to assess reliability of particular cases. As a first step, it could be useful, prior to undertaking the above comparison, for each team to grade their cow-calf pairs as definite, probable, or possible, based on the strength of the evidence.

The Task Force also **agreed** that the existing photographic and video data should be further examined to determine the extent to which characteristics such as scarring (e.g. from killer whale attacks, barnacles), barnacle occurrence and behaviour can be used to assist in identifying calves and their mothers. This could be extended to see if such characteristics can be used to identify juveniles.

Finally, with respect to (3), the Task Force **agreed** that the level of agreement in the exercises described under Item 2 (above) and Item 5 (below) suggested that correctness and consistency of resightings was unlikely to be a major problem. In order to confirm this preliminary conclusion, it is not necessary to cross-check all resightings for both catalogues but it would be wise to undertake a comparison exercise for a subset of the resightings. The Task Force therefore **recommends** that a small group works to design such an exercise. This exercise would not need to be undertaken annually but could perhaps be undertaken every few years.

5 SIGHTINGS HISTORY DATABASE STRUCTURE

5.1 Introduction

For a variety of possible population-related analyses, such as the population assessment considered by the WGWAP to date, the key data are the annual sightings histories of each whale, i.e. the years in which it was identified or re-sighted.

The specific structures of the databases of each team are detailed under section 3.2. For the purpose of this section, each 'entry' in the annual sightings history is a record of a whale being seen by one or both teams in that year, regardless of how many times within the year it was seen. Where possible, entries are categorised as: (a) mother with calf, (b) calf, or (c) neither. Entries for calves are subdivided where possible into: (b1) calf of known mother or (b2) unaccompanied calf.

5.2 Inspection of sightings histories

In accordance with its terms of reference, the Task Force inspected tabulations of the sightings histories from each team. The purposes were (1) to get an impression of how the sightings data correlate between the two teams (for example, the extent to which they duplicate or complement each other), (2) to enhance understanding of their scope and limitations, especially with respect to potential analytical uses, and (3) to resolve any discrepancies that might be found.

The tabulations themselves are not appended to this report, since this would have required permission from the teams and their sponsors. However, the inspection yielded some useful insights as discussed below. Because the data examined were not necessarily the most up-to-date versions of each team's data, it is possible that subsequent tabulations would differ to a small extent from the findings reported here.

Sightings histories were compiled from the data from each team for the period 2002-06, when both teams were operating. Because the inter-team matching was based on the catalogues through 2005, whales seen for the first time by a team in 2006 were not included in the tabulation, but re-sights in 2006 of previously identified whales were included. Whales not seen at all during 2002-06 were not included. This left about 140 whales, of which over 90% were in both teams' catalogues.

5.3 Extent of overlap between the two datasets

Of a total of more than 500 sightings history entries during 2002-06 (where an entry means that an identified whale was recorded in the given year), around 60% involved sightings by both teams, and the remainder by just one team or the other.

To examine further the degree to which the two teams' results complement each other, the Task Force examined the gaps in the sightings histories. A 'gap-year' is any year in which a whale is not seen by one or both teams, but where the whale has been seen by at least one team both prior to and subsequent to that year (and thus is known to have been alive in that year).

Of well over 100 gap-years (i.e. counting a 2-year gap as 2 gap-years, etc.) in the combined data, a whale was missed by just one team (and not the other) in more than 80% of the gap-years, and by both teams in less than 20% of the gap-years. Therefore, most of the gaps in the sighting histories would be filled by combining the two datasets.

The Task Force **concluded** that the data sets complement each other to a considerable extent. Combining the datasets eliminates most of the gaps in the sightings histories, and thus would potentially improve the precision of population analyses based on these data. The Task Force therefore **recommends** that specifications for population analyses using the combined data be drawn up (see section 6), and that permission be sought from the relevant parties to enable these to be conducted.

5.4 Examination of mother-calf pairs

Observations of mothers and calves are of especial importance for assessment of the reproductive rate in the population.

Of the combined sightings history entries that were recorded by one or both teams as mothers with calves, less than half were recorded as such by both teams. As described in section 3.1., the Russia-US team concentrated its field effort in inshore areas and earlier in the season; as could be expected, this team saw more mother-calf pairs during 2002-06.

Comparison of the data showed that animals recorded as calves by one team were not always recorded as calves by the other team even when seen in the same season. Identification of calves seems to be particularly problematic after a calf has separated from its mother, which is more common later in the season.

The Task Force **concluded** that identification of unaccompanied calves was not straightforward, and **recommends** that the criteria for calf identification be reviewed.

Photogrammetric methods to measure whale size might be useful both for calf identification and for studying WGW growth more generally, and therefore should be considered.

Care is also needed with respect to the assignment of calves to mothers.

Weller reported that of the recorded mother-calf pairs in the Russia-US dataset that were sampled genetically, the genotypes were consistent with a mother-calf relationship in all but one case, which is being further investigated. This suggested that field criteria used by the Russia-US team to determine mother-calf relationships had been sufficiently strict to control the risk of false positives.

Rowntree reported on a scoring system used for identifying calves and mother-calf linkages in southern right whales. That system is based on the number of days in the year that the suspected mother is seen with a calf, or with the same calf, whether the adult/calf pair is by itself (i.e. not near other whales) or two adults are with the calf. A combined score is computed based on all the available evidence. At the analysis stage, identifications with low score can be excluded as a sensitivity test.

The Task Force **recommends** that the field criteria for judging mother-calf pairs be reviewed, and that, if appropriate, a scoring system be developed, along the lines of that used for southern right whales.

The population analyses considered by the WGWAP to date (e.g. Cooke et al. 2007) make the following assumptions:

(1) whales recorded as mothers in a year really did have a calf in that year;
(2) whales not recorded as mothers in a year may or may not have had a calf in that year;
(3) whales recorded as calves really are calves; and
(4) whales recorded as non-calves really are non-calves.

In accordance with assumption (2), it is not an ‘error’ to fail to record a whale as a mother in a year when it had a calf. Indeed, it is to be expected that some mothers will first be observed after their calf has separated, especially when research occurs later in the season. In view of the above discussion, the Task Force considered that assumption (4) should perhaps be relaxed. It cannot be ruled out that some calves might separate early from their mothers, and fail to be recognised as calves by either team, pending further development of the criteria to identify unaccompanied calves.

6 SCIENTIFIC QUESTIONS THAT CAN BE ADDRESSED BY ANALYSES OF WGW PHOTO-ID DATA

6.1 Examples of analyses conducted to date

The two research teams prepared summaries of the analyses they have conducted to date using photo-ID data.

6.1.1 Russia-US Project Photo-ID Analyses To Date

The Russia-US program photo-ID dataset has been used to establish the seasonal and annual occurrence patterns of WGWs off Piltun Lagoon on the northeastern coast of Sakhalin Island (Brownell *et al.*, 1997; Weller *et al.*, 1999, 2006, 2007). These data have also been used for WGW population assessment and parameter estimation, including an individual-based modeling population assessment (Cooke *et al.*, 2007) and a mark-recapture estimation of survival (Bradford *et al.*, 2006) and abundance (Wade *et al.*, 2003). Visual-based analyses of the photo-ID data have examined anthropogenic scarring of WGWs (Bradford *et al.*, In Revision), as well as seasonal and annual variation in WGW body condition (Brownell and Weller, 2001; Kim, 2006; Bradford *et al.*, 2007). Finally, these data have been used to investigate the relationship between WGW calving interval and nutritional stress (Brownell and Weller, 2002), as well as to photographically link WGWs feeding in other parts of the Okhotsk Sea and elsewhere to whales identified off Piltun Lagoon (Burdin *et al.*, 2003; Weller *et al.*, 2002, 2003).

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6.1.2 IBM Team Photo-ID Analyses to date

Since 2002, the IBM Western Gray Whale Photo-Identification team has conducted photo-ID along the northeast coast of Sakhalin Island, Russia. Photo-ID was conducted in primarily the coastal Piltun and the more recently discovered offshore feeding area, located in 2001 (Maminov and Yakovlev 2002, Meier et al. 2007). Whales were also photographed in other regions along the northeast coast of Sakhalin Island when encountered. Other industry-sponsored teams have conducted photo-identification of WGW from shore on Sakhalin Island and during vessel-based surveys along SE Kamchatka. This work is helping to determine the size, structure and status of the population as a whole by examining the number of cow/calf pairs, the number of repeated sightings of individuals, annual return of animals to feeding habitats, seasonal movement of animals between feeding areas the attachment of identified individuals to specific waters, and seasonal change in physical condition. Some studies were also performed to determine how transient markings (scars, etc.) change over time. Photo-ID was conducted from a zodiac deployed from a larger research vessel, allowing a large spatial area of the northeast coast of Sakhalin Island to be covered each year. The photo-ID program is part of a larger multi-disciplinary industry-sponsored research program examining WGW feeding ecology including shore and vessel-based distribution surveys, prey sampling, shore-based behavior studies and acoustics.

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6.2 Other potential questions, and analyses that could be performed

Two features of the WGW population are that, like the North Atlantic right whale population, (a) it is small and (b) almost all individuals are known – this is relatively unusual in cetacean photo-ID studies and allows for certain analyses that would not be possible for larger populations where only a proportion of the individuals are known.

This allows researchers to address certain questions in a manner not normally possible. For example, the mechanism(s) behind a change in a certain population parameter (e.g. average calving interval) can be investigated in more detail by following the histories of all individual females that make up the average and determining whether the change is a result of problems with specific individuals or reflects a more widespread problem. This is important because it can provide insights not only into problem(s) but also into its cause(s) and possibly mitigation measures.

In such a small population, photo-ID data also provide the potential to relate problems with regards to health and fitness (e.g. ‘skinny’ whales) directly to responses at the population level (e.g. declines in reproduction or survivorship). To this end, the Task Force **recommends** that databases continue to include information on skinny whales and that the two teams compare their criteria for determining such whales so as to ensure a level of consistency that would allow analyses of combined datasets (see Item 7). This is particularly important with respect to following the reproductive histories of females and their calves over time (e.g. Weller and Brownell, 2002). In addition to looking at skinny whales, it is worth considering other factors that may reflect health (e.g. barnacle loads).

In addition to identifying and mitigating threats on the feeding grounds (the present focus of the WGWAP process), it is clear that the survival of the WGW population depends on the mitigation of threats throughout its range. This makes it extremely important to try to identify animals found outside the feeding grounds. In recent years, deaths due to bycatches in fishing gear have been documented to be a serious problem. Identifying the dead animals by comparing photographs (or DNA profiles) is extremely important but has proved difficult. There are a number of reasons for this, including the orientation of the carcass while on the beach; obtaining suitable photographs for comparison with those in the existing databases can be problematic. The Task Force **recommends** that a small group be established to develop an advisory protocol that could be provided to the appropriate authorities in range states for distribution to fishermen to maximise the chance of comparisons. This group should also design a protocol to be sent to whalewatching operations in range states. It was further **agreed** that both field teams should take any opportunities that arise to photograph parts of a whale’s body (or angles) not normally used for photo-identification; this can be expected to increase the chances of making matches with bycaught or stranded animals.

It is well known that the value of analyses using photo-ID data increases considerably with the length of the time series. The Task Force **recommends** that analyses of, for example, within-season site fidelity, feeding, and distribution, as presented in annual progress reports of the respective teams, be expanded to combined season analyses.

Whilst recognising the difficulties of determining cause and effect, the Task Force noted that efforts to relate the behaviour and responses of individuals to anthropogenic factors such as vessels and noise will require further investigation. Such investigation will depend on within-season resighting rates. The Task Force **recommends** that a small group be established to evaluate the potential for such analyses, particularly with respect to integrated analyses with data from other studies (e.g. of feeding and behaviour).

At a more fundamental level, the Task Force notes the value of examining variation in the marks used to identify individual gray whales, their origins, and their reliability as identifiers over time. In stating this, the Task Force recognised that the high information content in the mottling, which appears to remain constant over time, makes this work slightly less important than it would be for some other species.

7 ISSUES RELATED TO UNDERTAKING ANALYSES INVOLVING BOTH DATASETS

7.1 Scientific benefits

The preliminary analysis presented under Item 5 illustrates that the two teams’ work is complementary to a considerable degree. In particular, annual sightings histories and within-season histories are much more informative when data from the two teams are combined. Thus, major benefits with respect to population modelling, estimation of population parameters, and focal animal-based studies, as discussed under Item 6, are likely to be realized when both datasets are used in combination.

7.2 Practical issues

The Task Force had relatively little time to discuss practical issues. It noted that a mechanism will need to be developed to determine the specifications for combined analyses. Also, it will be necessary to decide who will undertake such analyses and under what conditions – e.g. see Item 8 regarding the issues of data ownership and publication.

8 PRACTICAL ISSUES OF COMBINING BOTH DATASETS

8.1 Data ownership

The Task Force did not have time to discuss this issue in detail. It also recognised that the issue is broader than simply the photo-ID data (it was, for example, discussed at the last WGWAP meeting in the context of the multivariate analyses). The Task Force **agreed** that the basis for discussions at the next WGWAP meeting should be the data availability agreement of the IWC Scientific Committee.

8.2 Other

Again, the Task Force did not have time to discuss this issue in detail and recognised that it is broader than simply the photo-ID data. The main additional issues that need to be considered relate to such things as confidentiality, use at WGWAP and other meetings, and use for scientific publications

9 CONSIDERATION OF WAYS TO REDUCE DISTURBANCE TO WHALES, WHILE MAINTAINING SUFFICIENT DATA COLLECTION FOR POPULATION ASSESSMENT AND OTHER IMPORTANT SCIENTIFIC QUESTIONS

The Task Force noted that there is currently no evidence that the scientific research causes detrimental disturbance to the whales. However, the WGWAP at its 2nd meeting had noted that shore-based tracking had revealed a significant correlation between small boat traffic and certain aspects of whale behaviour. Therefore, precaution dictates that each team be alert to the possibility that field research may disturb the whales, and be open to ways to limit the numbers and durations of encounters, especially where this can be achieved without significantly compromising the amount of data collected, in terms of their information content. The Russia-US team noted that they had already reduced their field effort substantially in recent years, such that any further reduction would likely cut into the numbers of whales identified each year.

9.1 Optimisation of photo-ID effort

The preliminary review of the photo-id data (section 5), indicated that while there is some overlap in the data, the two data sets complement each other to a high degree: each team's data fill in most of the gaps in the other team's data. Therefore, it is not the case that the efforts of the two teams simply "duplicate" each other.

The Task Force **agreed** that the primary way in which the photo-ID research effort should be optimized, is to allow analyses of the combined data to be performed (see recommendations under section 8) such that advantage can be taken of the complementary relationship between the two data sets.

Each team reported that they tended to avoid working in the immediate area when the other team was sighted. The Task Force further noted that differences in the timing and area of operation also tended to reduce the overlap in research effort. Task Force nevertheless **agreed** that the extent of overlap of the research effort in the field be examined more closely, with a view to determining whether the combined effort could be rationalized. This requires a more detailed comparison of the data than was possible in the time available to the Task Force.

The Task Force **requests** that each team first prepare a broad graphical summary of the deployment of their research effort. This could, for example, involve plotting the hours of photo-id research effort by square (of suitable size) by 2-week period. Where the boundaries of the research area are well-defined, these should be shown.

Inspection of these plots would reveal whether a more detailed overlap analysis is necessary. Such an analysis would probably require data files giving, for each photo-id encounter: date, position, start and end times of the encounter; estimated number of whales present; and catalogue numbers of whales identified during the encounter (if any).

The Task Force **recommends** that the WGWAP consult with the relevant parties with a view to facilitating the required analyses.

9.2 Optimisation of collection of other data in conjunction with photo-ID

Each research team collects other data in addition to conducting photo-ID, some related to the whales themselves and some to food availability and other aspects of their environment.

Regarding non-whale data, such as benthic sampling, the Task Force **recommends** that, where possible, data be collected at times when whales are not in the immediate vicinity of the sample point. The Task Force noted that this is already being practised to some extent. However, it is also desirable to avoid additional vessel transits through the WGW feeding ground; the Task Force recognised that these competing considerations need to be taken into account when deciding when to collect samples.

The Russia-US team, which collects biopsies from whales, explained that they already take steps to minimise their invasiveness. This includes the identification of whales in real time, to avoid sampling the same whale a second time. The field team has the catalogue, and the list of previously sampled whales, to hand at all times. These precautions will also be taken if and when tagging of whales is initiated (this is subject to further discussion by the WGWAP and other bodies). The Task Force noted the value of biopsies for sex determination and for the confirmation of mother-calf relationships. Further analyses that are either underway or being considered, such as paternity analyses, may also yield useful information.

10 CONCLUSIONS AND RECOMMENDATIONS

The key conclusions and recommendations have been extracted from each section of the report and listed here for ease of reference. For more details on each item, the corresponding section should be consulted, where additional recommendations can be found.

Cross-matching of catalogues and related data (see sections 2, 6)

1. The Task Force **concludes** that the cross-matching of the catalogues up to 2005 has been completed successfully, and that all doubtful cases remaining after the initial matching exercise have been resolved satisfactorily. The great majority of identified whales are common to both catalogues, and there is agreement that all the remaining whales in each catalogue represent valid individuals.

2. The Task Force **agrees** that a single catalogue is not necessary. It notes that the publication of both catalogues, coupled with the fact that the whales are so clearly identifiable, implies that, in effect, a joint catalogue already exists.

3. The Task Force **recommends** that the cross-matching be updated each year, through exchange of the updated catalogues.

4. The Task Force **agreed** that the correctness and consistency of resightings was unlikely to be a major problem. In order to confirm this preliminary conclusion, it would be wise to undertake a comparison exercise for a subset of the resightings. The Task Force therefore **recommends** that a small group works to design such an exercise.

5. The Task Force notes the scientific value of matching dead whales, such as by-caught whales, with the whales in the catalogues, and **recommends** that an advisory protocol be developed to help ensure that identifiable photos are obtained from dead whales.

Field and laboratory procedures (see sections 3, 5, 6)

6. The Task Force **agrees** that the presentation of each team's field and laboratory procedures is clear and thorough, and that it now has a good understanding of each team's work and the differences between them. It does not rule out that there may be further questions over specific details.

7. The Task Force **agrees** that standardisation of field procedures is not necessary, but **requests** that each team report any changes in its operations after each season.

8. The Task Force further **agrees** that common standards for grading the quality of photographs and the distinctiveness of whales are not needed in this case.

9. The Task Force **recommends** that the field criteria for judging mother-calf pairs be reviewed, and that, if appropriate, a scoring system be developed for the degree of evidence of the relationship, along the lines of that used for southern right whales.

10. The Task Force **concludes** that identification of unaccompanied calves is not straightforward, and **recommends** that criteria for calf identification be reviewed.

11. The Task Force **recommends** that each database continues to include information on skinny whales and that the two teams compare their criteria for determining such whales so as to ensure a level of consistency that would allow analyses of combined datasets

12. The Task Force **recommends** that entries for temporary whales be clearly labeled as such and appended to the catalogues, and that the history of each temporary whale (with the designation that it was a temporary whale) be retained in the databases even after the whale's permanent identity has been established. Apart from the temporary whales, there should be no reserve of photos or photo sequences that cannot currently be definitively determined to be a match or a new whale, but which are kept in reserve as candidates for future matches.

Relationship between data sets, and joint analysis (sections 5, 6, 7)

13. Based on a preliminary comparison of the sightings histories, the Task Force **concludes** that the data sets complement each other to a considerable extent. Combining the datasets eliminates most of the gaps in the sightings histories, and thus would potentially improve the precision of population analyses based on these data.

14. The Task Force therefore **recommends** that specifications for population analyses using the combined data be drawn up, and that permission be sought from the relevant parties to enable these to be conducted.

15. The Task Force **recommends** that a small group be established to evaluate the potential for analyses using photo-ID and other data that could help measure the effects of anthropogenic disturbance on the whales.

Optimization of data collection with a view to minimising research-related disturbance (see section 9)

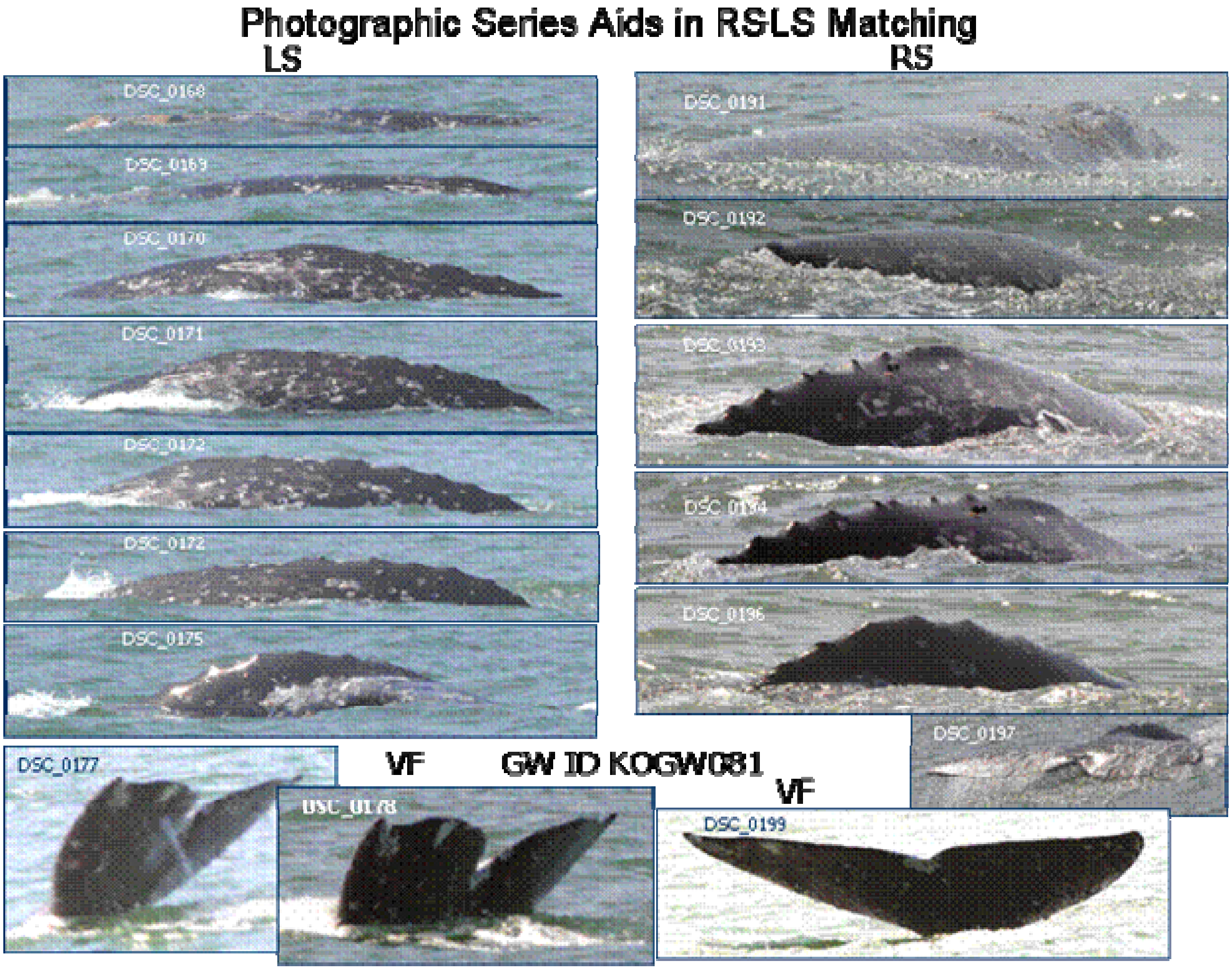
16. The Task Force **agrees** that the primary way to optimize the photo-ID research would be through combined analyses of the two data sets.

17. The Task Force **agrees** that the extent of overlap in the research effort in time and space should be examined, and **requests** that each team prepare a broad graphical

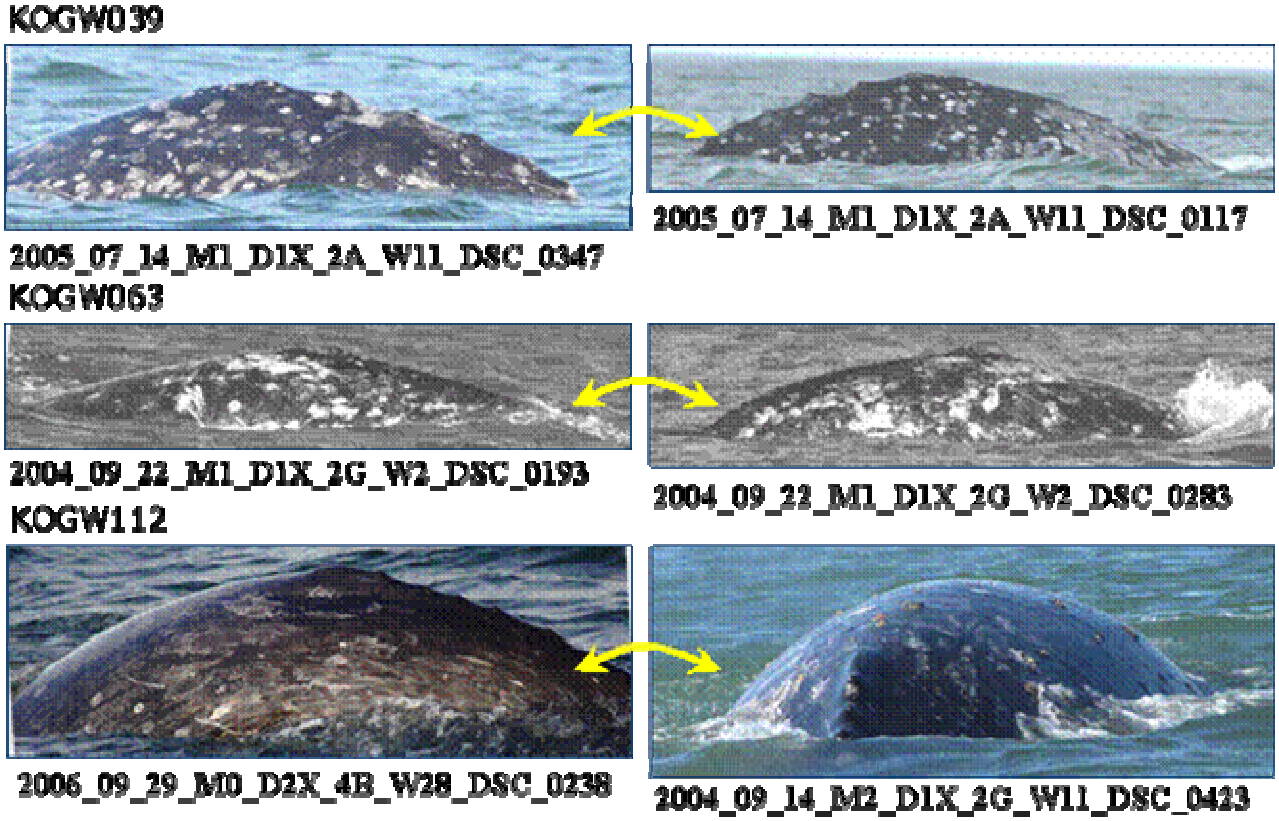
summary of their hours of photo-ID research effort by square and time period. Based on this, the need for a more extensive analysis can be assessed.

18. The Task Force **recommends** that, where possible, non-whale data be collected at times when whales are not in the immediate vicinity.

APPENDIX 1


Photographic Series Aids in RSLS Matching
LS
RS
DSC_0168
DSC_0169
DSC_0170
DSC_0171
DSC_0172
DSC_0173
DSC_0175
DSC_0191
DSC_0192
DSC_0193
DSC_0194
DSC_0196
DSC_0197
DSC_0177
VF
GW ID KOGW081
VF
DSC_0178
DSC_0199

Knuckles and Back Photos Aid in RS-LS Matching



ANNEX 1

Terms of Reference and Work Plan for Photo-ID Task Force

Background

Photographic and genetic data for individual identification represent the single most important basis for assessment of the western gray whale population. The value of such data in obtaining *inter alia* estimates of abundance and other population parameters and in elucidating social structure and movements is well known. At present two groups are working on photo-identification of western gray whales: the Russia-US programme that has been working since 1997; and the Institute of Marine Biology (Vladivostok) group that has been working under industry sponsorship (Sakhalin Energy and Exxon Neftegas Ltd) since 2002.

Experience from around the world has shown that results from collaborative work by groups with photo-identification data are of considerably greater scientific value than simply the sum of the results from the individual groups working alone. In the case of such a small, critically endangered population as that of western gray whales, collaboration also provides the opportunity to minimise the disturbance to whales caused by research boats. The Western Gray Whale Advisory Panel (WGWAP), at its first meeting in 2006, agreed to establish a Task Force to review and cross-match the two catalogues. The following terms of reference have been prepared to guide the work of the Task Force.

Objectives

The Task Force will:

1. Compare the catalogues[2] of the Russia-US programme and the Institute of Marine Biology (Vladivostok) programme to arrive at an agreed list of known individuals; and

2. Suggest appropriate further collaboration, taking into account the need for annual updating of the comparison, and for consistency in: (i) identification of new individuals; (ii) identification of re-sightings; and (iii) classification of photograph quality.

3. Consider ways to reduce photo-ID-related disturbance to whales, while maintaining sufficient data collection for population assessment and other important scientific questions.

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[2] By catalogue here, we mean the reference set of photographs (best) for each individual. This differs from a database that includes the complete sightings history for each individual along with the photograph(s) used for each agreed resighting and the quality rank assigned to those photographs.

Task Force Composition
The task force will consist of the following individuals:

WGWAP
Justin Cooke (Chair of the Task Force)
Greg Donovan (Co-Chair of the Task Force)
Grisha Tsidulko
Randall Reeves
Bob Brownell

SEIC
Doug Bell
Christina Tombach-Wright
Olga Tyurneva
Tatiana Sapozhkova

Associate Scientists
Dave Weller
Amanda Bradford
Victoria Rowntree

IUCN
Julian Roberts
Sarah Gotheil

Task Force Focal Points
- Julian Roberts – IUCN, Programme Officer
- Doug Bell, SEIC, Environmental Manager

Methods

1. Conduct a cross-matching of the two existing catalogues, involving: (a) the people involved in the development and matching of the individual catalogues; and (b) additional experienced matchers:
- determine, for each whale in each catalogue, which whale, if any, it matches in the other catalogue;
- resolve doubtful cases, if necessary by examining all available photographs of the whales involved at a task force workshop;
- Review and discuss the report of the independent expert.

2. Hold a three-day workshop including relevant task force members, in order to discuss, and if possible make recommendations concerning, further work, including:

- consistent protocols for the assessment of photograph quality, matching of individuals, and inclusion of definite and candidate new whales in the catalogues (including field methods and "laboratory" procedures);
- arrangements for annual updating (cross-matching of new additions to each catalogue each year);
- matching of photographs submitted by third parties, if any;
- scientific questions that could be addressed using the photo-id data (including examples of analyses conducted to date – such as population assessment – and potential analyses that could be performed);
- facilitation of collaborative analyses, taking into account questions of protection for data owners.
- Consideration of ways to reduce photo-id-related disturbance to whales, while maintaining sufficient data collection for population assessment and other important scientific questions.

  Experience with other catalogues (e.g. North Atlantic humpback whales, Europhlukes) should be taken into account where relevant.

3. Report back to the WGWAP at its 3rd meeting on the results of the cross-matching, including summary statistics of the matching process, recommendations for further collaboration, and any outstanding issues or problems.

Work Plan & Timing

Task	Description	Completion	Notes
1	Exchange catalogue CD's between the two teams.	January 2007	Completed
2	Each team conducts an initial in-house cross-matching of the catalogues. Results are reported back to the Task Force, including any comments or questions and indication of any matches considered to be uncertain	February 2007	Completed
3	External expert reviews results of each team's cross-matching exercise and provides comments and advice, particularly with respect to inclusion and matching criteria, and uncertain matches	October 2007	Final draft completed and circulated to task force members
4	3-day workshop in Seattle/Vancouver, including persons from each team actively engaged in the photo-id work, plus the external expert under item 3, plus additional task force members as appropriate. The workshop shall resolve any questions arising during steps 1-3 and in particular resolve any doubtful or uncertain identifications. The workshop shall have access to the full sighting histories and photo archives of each team, so that any outstanding matching uncertainties can be resolved. It will consider, and if possible make recommendations, on a future process or processes	October 2007	Scheduled for 12-14 October

5	Report of the Task Force, including the workshop report, submitted to WGWAP	November 2007	Scheduled for 10-13 November

Safeguards
Data providers' rights will be protected. No use of the data will be made without the express permission of the data providers. Any use of the data by the WGWAP will protect the data providers' rights in accordance with paragraph 3(e) of the WGWAP terms of reference. Any other use of the data will be subject to agreement between the scientists and institutions providing and using the data. The rights of any third parties contributing additional data will be similarly respected. Any external experts engaged to assist with the matching shall assent to these conditions. "Data" includes both photographs and auxiliary information, such as time, date and location of photographs.

FINAL WORKSHOP PARTICIPANTS

WGWAP
Justin Cooke (Chair of the Task Force)
Greg Donovan (Co-Chair of the Task Force)
Grisha Tsidulko
Randall Reeves
Bob Brownell

SEIC
Christina Tombach-Wright
Olga Tyurneva
Yury Bychkov
Stephen R. Johnson
Sonya Meier

Associate Scientists
Dave Weller
Amanda Bradford
Victoria Rowntree

IUCN
Julian Roberts
Sarah Gotheil

ANNEX 2

Final Annotated Agenda for the Photo-identification Workshop

Vancouver, Canada, 12 to 14 October 2007

The meeting will start at 9:00 am and end at 5:30 pm on October 12 and 13. Coffee breaks will take place at 10:30am and 3pm, and lunch break from 12:30 to 1:30pm. The evenings will be available for tasks assigned to individuals or small groups, as needed.

The order of the items to be discussed, as well as the time allocated to each item will be decided by the Task Force at the beginning of the meeting. The schedule of October 14 will also be agreed upon during the meeting.

Note: Comments in italics are explanatory notes that are not part of the agenda itself.

1. Introductory items

2. Cross-matching exercise

2.1. Presentation of report of independent expert and cross-matching results
Dr Victoria Rowntree has reviewed the cross matching exercises and prepared a report, which will respect the rights of the data owners and be circulated to participants well in advance of the Workshop.

2.2. Resolution of doubtful cases, and, if appropriate, matching of temporary whales
Based on results received from each team to date, there remains only a very small number of doubtful cases which the workshop will need to examine. The Teams will be encouraged to bring all available photos of these whales together with these sighting histories in case these are needed.

3. Presentation of each team's work, including:

3.1. Field methods (e.g. locating and approaching whales; obtaining photographs, including multiple aspects [left/right/flukes]; auxiliary field data collected)

3.2. 'Laboratory' procedures (criteria/procedures for): (a) designating new whales; (b) identifying re-sights; (c) linking different aspects; (d) designating temporary whales; (e) dealing with undetermined/pending cases (if any); (f) photo quality rating or other procedure for acceptance/rejection of photos; (g) permanent archiving of photos.
A general understanding of the field and laboratory procedures followed to date is important to interpret the data and to ensure that any analyses to be conducted are based on assumptions that are consistent with the way the data were collected.

3.3. Conclusions and recommendations

This item is a placeholder in case the participants develop any agreed conclusions and recommendations. Recommendations contained in the independent expert's report can also be considered under this item.

4. Procedures for regular updating of catalogues and cross-matching (incl. matching 3rd party photos)

5. Sighting history database structure

Analyses of the data to address demographic and related issues typically require not merely the catalogue but the records of annual sighting history of each whale. Under this item, it would be helpful to view tabulations of these data and some example histories in order to aid understanding of their scope and limitations with respect to particular analytical techniques. This opportunity can also be used to resolve any discrepancies in the histories that are found.

6. Scientific questions that can be addressed by analyses of WGW photo-id data

After resolution of doubtful cases it would probably be worthwhile to brainstorm on the analysis that could be conducted from various perspectives (there will/can be overlap of certain analysis for each driver):
- conservation relevance
- company driven motivation
- scientific motivation

6.1. Examples of analyses conducted to date (e.g. WGWAP population assessment)

6.2. Other potential questions, and analyses that could be performed

The obvious scientific questions of conservation relevance relate to demography (survival rates, birth intervals, age at first reproduction, population trend), but there may be further relevant questions that could be addressed using photo-id data.
These identified analyses could be categorized according to the above perspectives.

7. Issues related to undertaking analyses involving both datasets

7.1. Scientific benefits

More nearly complete coverage of the population, and expanded sighting histories, are obvious benefits of a combined analysis, but there may be others.

7.2. Practical issues (incl. safeguards for data owners and facilitation of permission to use)

8. Practical issues of combining both datasets

8.1. Data ownership

8.2. Other

9. Consideration of ways to reduce disturbance to whales, while maintaining sufficient data collection for population assessment and other important scientific questions

9.1. Optimisation of photo-ID efforts

The excellent agreement found during the cross-catalogue comparison and the work demonstrating short-term responses of whales to close approaches by boats, suggests that the current (largely duplicative) level of photo-identification research effort needs to be reviewed in terms of minimising disturbance without compromising data collection and the ability to answer relevant scientific questions.

9.2. Optimisation of collection of other data incidental to photo-ID

Due to the close coupling of other types of data, such as biopsy samplings, with photo-ID, it is desirable that the Task Force considers this issue in the framework of minimizing duplication of efforts and disturbance to whales. It is however not envisioned that the Task Force will come to some kind of agreement or discuss the issue thoroughly, but rather flag it and define the best way to discuss it further at another meeting or workshop.

10. Conclusions & recommendations

11. Adoption of report to be submitted to WGWAP

ANNEX 3

A comparison of two western gray whale catalogues, with suggestions for future work

VICTORIA J. ROWNTREE,

Whale Conservation Institute/Ocean Alliance, Lincoln, Massachusetts,
Department of Biology, University of Utah, rowntree@biology.utah.edu

INTRODUCTION

This report is a result of a request from the WGWAP (western gray whale advisory panel) via IUCN arising from the first WGWAP meeting under the Terms of Reference it established for its Photo-ID Task Force (appended to this document). The primary task of this report was to examine and review the results of the cross-matching exercise undertaken by the teams involved in the production of the two extant catalogues of western gray whales. One catalogue was created by researchers in the Russia-US (Rus-US) Program, covering the years 1994-2005. The other was created by researchers at the Institute of Marine Biology (IBM, Vladivostok), covering the years 2002-2005. Researchers in each group had been asked to compare their catalogue to the other group's catalogue and report all inter-catalogue matches, including any comments or questions and indication of any matches considered to be uncertain. In the reports I received, the Rus-US Team had also scored the quality of the photographs used to determine matches and suggested a system for selecting identifications for use in catalogues, i.e. to establish the basis of an individual record.

In addition to providing an independent comparison of the two catalogues, the present report makes some suggestions for scoring catalogue photos, developing protocols for matching photographs and dealing with variations in image quality and the distinctiveness of identifying marks on individual whales. These ideas are offered in the context of the Terms of Reference given in the Appendix. I hope that they will aid ongoing efforts to optimally integrate information from the two catalogues, toward the goals of assessing the status of the western gray whale population and better understanding its ecology and current needs.

SUMMARY OF RESULTS OF THE CROSS-MATCHING EXERCISE

I searched independently for 80 of the whales and agreed with the decisions made by both research teams. I also checked and agreed with all matches found by each team. The IBM catalogue contains 135 individuals and two candidate whales. The Rus-US catalogue contains 150 individuals and two candidate whales. IBM and Rus-US teams independently agreed to 129 matches between catalogues, 3 unique whales in the IBM catalogue and 19 unique whales in the Rus-US catalogue for a total of 151 different individual whales.

Catalogue	Individuals in catalogue	Temporary Whales	Agreed Matches	Unique to catalogue
IBM	135	2	129	3
Rus-US	150	2	129	19

The results show an excellent level of agreement (see table above).
In fact, there are only six unresolved matches (see table below) that need to be discussed by the two teams before determining the final number of individually identified whales. Two of the 'between-catalogue' matches (5 and 6) could only have been found by one team because they involved candidate or temporary whales that were not included in the catalogues that were exchanged.

1	IBM TempGW1 (RS)	=?	R-US 108 (RS)
2	IBM TempGW2 (LS)	=?	R-US 099 (LS)
3	IBM KOGW 135 (RS)	=?	R-US 099 (RS)
4	IBM KOGW 135	=?	IBM TempGW2 (via LS R-US 099)
5	IBM KOGW 086	=?	R-US T99A pics yet to be seen by IBM
6	IBM KOGW 129	=?	R-US 155 pics yet to be seen by IBM

I agree with the internal match (4 above) and the suggested five additional matches. If my views are accepted at the Workshop, then the catalogues through 2005 will have 133 whales in common and 22 whales that are unique to one or the other catalogue, for a total of 155 western gray whales that were individually identified from 1994 to 2005 (depending on how the Workshop decides to deal with temporary whales). Of course, not all identified whales will still be alive today. The catalogues themselves do not contain all the information required to estimate the number of whales alive in a specific year. This requires an analysis of the full sighting histories of the identified whales (as discussed in Reeves *et al*. 2005).

ADDITIONAL THOUGHTS THAT MAY BE OF VALUE TO THE WORKSHOP

The ToR of the Task Force also included the possibility of further collaboration to develop consistency in '(i) consideration identification of new individuals; (ii) identification of re-sightings; and (iii) classification of photograph quality. In the light of my comparison of the catalogues and the reports from the two teams then I would offer the following thoughts, noting that general issues surrounding collaboration and consistency must be seen in the context of the uses to which the photo-identification data are to be put.

The International Whaling Commission's *Report of the Workshop on Individual Recognition and the Estimation of Cetacean Population Parameters* noted that photo-identification data are valuable for estimating abundance and population parameters such as survivorship, age at sexual maturity, calving intervals etc. For certain types of analyses, such as estimating abundance using mark-recapture methods, it is important to use only photographs of excellent or good quality in carrying out the matching, regardless of the distinctiveness of the animal, to try to meet the assumption of equal catchability (IWC 1990). The report also noted that in some cases where that assumption is not important, "poor photographs of distinctively marked individuals" can be used "to maximize the amount of available data" in determining "parameters such as calving intervals and survivorship" (IWC 1990).

Consistent protocols need to be developed so that the two catalogues can be maintained independently but combined for analyses. Combining catalogues requires that catalogue holders develop and use consistent protocols for (1) identifying matches, (2) declaring new whales, (3) encoding the quality of photographs and the distinctiveness of features used in identifications and (4) recording errors in matches. In what follows I mention some issues that should be considered in the design of protocols that will ensure the consistency of information in each catalogue.

Searching catalogues for whales

- Gray whales have an extraordinary abundance of individually identifying marks on their bodies. How long do the different types of marks persist over time? It would be good for the researchers to create a list of the identifying features with descriptions (where possible) of their causes, permanence, and any available information about the length of time each type of mark can be used for individual identification.
- What are the most important and consistent marks actually used when searching for a whale? What marks should be used first, second or third in searches (*e.g.,* gray marbling, white marks, barnacles, barnacle scars, scrapes, scars, the most unusual or outstanding marks, vertebral groupings and sharpness of vertebral projections)?
- How extensively should different types of marks be compared before a match is declared? Should matching requirements differ for different kinds of marks? Marks can be matched by location, size, placement, edge patterns and distinctiveness. Can the amount of information required for a match be quantified according to the mark type, or different combinations of mark types, in a way that would make all catalogue users feel confident about each others' matches (for example, should matching of three different sets of marks in each view be required, or should gray marbling be matched over several regions of a lateral view)?
- It might be important to include codes for the features that were used in declaring a match in the information recorded with each sighting.
- Does confirmation of a match require that all views (right lateral, left lateral, ventral fluke) of the potential match be compared and that multiple features in

each view should match? Can a match be confirmed from only the right lateral view?

- Is there a protocol for combining the lateral and fluke photos of the same whale and assessing how confident a researcher is that the three views are of the *same* animal?
- Some matches between the IBM and Rus-US catalogues provide independent three-surface views of the matched whales. These cases are of special importance for several reasons, including that they provide duplicate “type” photographs of the individuals involved. It might be of value to highlight these cases, and in particular, to use them in training and in studies of the reliability of identification from one-surface and two-surface views. Can future matches of these individuals be made with high certainty when only one good-quality image of any of the three views is available?
- What is the white covering that obscures identifying marks and scars (for example, on the body of KOGW#22=RU#036 and the fluke of KOGW#068=RU#032? Does it change with time and thus make identification difficult?

Declaring new whales

- How much information is required to say that a whale is unmatched and therefore should be added to a catalogue as a “new” individual? Is validation by a “second person” required to confirm a new whale, as suggested in IWC (1990)?
- Do the right, left and ventral views of a whale all need to be obtained before a whale can be considered a new addition to a catalogue? Or can a whale be considered new if its right lateral view does not match any right lateral photos in the existing catalogue?
- When a whale has no right lateral photograph, how are its left lateral and/or ventral fluke photographs stored and reviewed?
- What are the criteria used to give a whale a temporary whale number? How are photos of temporary whales stored and when are they searched? Are they reviewed at regular intervals as suggested by the IWC Photo-ID Workshop (IWC 1990)?

Coding of photo quality and distinctiveness of identifying marks

As noted earlier, the coding of photo quality and the distinctiveness of markings is essential in determining which photographs are appropriate for use in the various types of analyses that can be carried out to obtain unbiased estimates (IWC 1990, 2001; Hammond 1986) and to establish the level of confidence in matches or to quantify the risk of missing matches. A number of possible coding categories can be defined: the most important feature is that they must be consistently scored within and between catalogues.

IWC (1990) had recommended that photo quality and distinctiveness be judged separately and scored in three categories: excellent, good and poor (IWC 1990; Hammond 1986). This was further developed at the IWC Right Whale Workshop (IWC

2001) where it was recommended that a *photo quality* rating with grades 1-4 meaning good, medium, poor and unmatchable be assigned to a number of factors:

- Visibility of identifying marks due to water or glare
- Focus/image size
- Angle/foreshortening
- Viewpoint

Three categories were assigned to distinctiveness:

- Good (1) even in poor quality photographs, the marks are distinctive enough to match.
- Average (2) with average quality photographs, the marks are distinctive enough to match.
- Poor (3) a generic/indistinct animal, with high quality photos, confirming match is difficult.

The Russia-US program in their report on comparing the gray whale catalogues described their system for scoring the quality of photographs of each view (right and left lateral and ventral fluke) of gray whales included in the catalogue. They presented results of their scoring system only for the IBM catalogue, and not for their own catalogue; thus the exercise is still only one-sided at this stage. They used three categories:

- Good (3) Image is characterized by good photographic quality and appropriate whale position (despite a slight parallax) and can be used as a type specimen in photo-ID catalogue.
- Fair (2) Image is characterized by fair photographic quality and/or compromised whale position (including a pronounced parallax) and, ideally, would be used for short-term matching, but not as a type specimen in photo-ID catalogue.
- Poor (1) Image is characterized by poor photographic quality and/or highly compromised whale position (including pronounced parallax and, ideally, should not be used for short-term matching or as a type specimen in photo-ID catalogue.

Their coding system combines photo quality with obliqueness of view to determine whether a photograph should be used as a “type” specimen in a catalogue, or for short-term matching only, or neither. Every view (right lateral, left lateral, ventral fluke) was scored separately. The scores for right lateral images were used to determine whether an image of a whale should be included as a “type” specimen in the catalogue. Photos scored as good were assigned to the ‘stringent’ category and photos scored as ‘good’ or ‘fair’ were assigned to the more inclusive ‘flexible’ category.

In examining the results in their report, I found that their photo quality assessments were reasonably consistent. However, photographs with fair and even some with poor ratings appeared to have enough information to determine that a whale was new to the catalogue or that it was a match. In my opinion, the Rus-US categories may be too strict and the categories not fine enough (for example, even using the ‘flexible’ category would exclude 11% of the animals in the IBM catalogue; using ‘stringent’ would remove well over half). This view is somewhat supported by the extremely high level of agreement reached by the two teams when comparing catalogues, which seems inconsistent with the ‘stringent’ category alone being considered.

If this view is accepted, an alternative set of criteria could be established to score the “catchability” of gray whales. The identifying marks on gray whales are so plentiful and cover such a large portion of the whales’ bodies that enough detail can be seen in different portions of a whale’s patterns to allow individual identification even when photos are slightly out of focus. An alternative for judging catchability could be that a whale be declared individually distinctive if the photograph has a large enough portion of the pattern area visible, an angle that is not too shallow and light and contrast good enough to examine a pre-determined number (3-5) of fairly large sub-areas with distinctive patterns that do not change over time. It would be useful to estimate the number of gray whales with no identifying marks. If it is very low, perhaps they could be dealt with separately and the remaining gray whales could be considered equally catchable.

It is important that the Workshop considers these issues in some detail and reaches some agreement on appropriate classification categories that are sufficiently well defined to ensure consistency in classification within and between teams. Provided the system is well defined and the number of categories sufficiently fine, analysts can then select appropriate datasets for the questions they are addressing (and examine uncertainty in assumptions). It is important that categories are ‘suitable for purpose’ and do not result in unnecessarily excluding data/photographs that could be used to provide unbiased estimates or in including photographs that will lead to biased estimates. For example, using too strict a criterion for photo quality may result in the exclusion of most photographs/whales and also result in it taking a long time to obtain photographs with the required scores for view and focus to significantly reduce the number of whale excluded, time that the population may not have.

Working as a group to decide agreeable scores of a subset of photographs might be a good way to arrive at a scoring system that would be more inclusive and meet the criteria necessary for modeling population size and growth rate. To ensure consistency over time in coding photo quality and distinctiveness within and between groups that are comparing catalogues, the IWC Right Whale Workshop recommended that sample photographs representing each grade of photo quality and distinctiveness be shared among individual researchers (IWC 2001).

In this context, it should be remembered that there are photo enhancement programs available (e.g. Adobe Photoshop) that can be used to improve the ability to match photographs e.g. by adjusting the brightness and contrast of images to create the best exposure for viewing the identifying features on a whale. Dark photographs make identifying features difficult to see and compare and may be inadvertently passed over in searches involving hundreds of photos.

In addition, the year a photo was taken should be included on catalogue photos to assist in interpreting marks, such as scars, that can appear or disappear with time.

Matching errors such as missing a match or falsely identifying a match.
Estimating the probability of these two kinds of matching errors is important in determining the biases that could affect population estimates (e.g. see Stevick *et al*, 2001).

- How do catalogue holders search for matches *within* their catalogues (when two whales become one)? Are catalogues pre-sorted by type of identifying feature (IWC 1990) to speed the matching process? If not, can catalogues be coded and sorted by particular identifying features to help find internal matches (*e.g.* if easy-to-find marks indicate a match, do other marks in other views of the same whale also match)? Searches that require a reordering of a catalogue can be helpful in finding internal matches. Perhaps independent searches using VF, RS and LS are already helping to find internal matches.
- Is there a method for finding falsely identified matches (situations when photographs of "one" whale are actually of two whales)? In confirming a re-sighting, are other photographs viewed in addition to the ones included in the catalogue when making a match? Can multiple photos of the same view of a whale be examined on the same screen at one time? Reviewing multiple photographs of the same marks on the same whale can greatly increase the probability of identifying photos that may have been wrongly matched.
- The IWC workshop on the Individual Recognition of Cetaceans (IWC 1990) recommended that catalogue holders keep a record of matching errors that includes:
    - The date of the discovery of the matching error;
    - The date of entry of each photograph involved in error entry into the catalogue; and if possible
    - The number of photographs entered into the catalogue between the photographs involved in the error; and
    - The number of times the two photographs were compared before the error was discovered.

Matching of third-party photos
Third-party photos will be sent to researchers from time to time. A stable address should be established and well advertised so people will know where to send their photos. The person who matches third-party photos should be someone who maintains a research catalogue and who can reply promptly to the senders.

Annual updating of catalogues
Annual updating of catalogues including sharing of "type photos" of new whales will be important for the rapid assessment of variations in the status of the population. Updates could be done electronically and then followed up with a meeting if making decisions at a distance becomes difficult.

Scientific questions that can be addressed from photo-ID data
Scientific questions that can be addressed from photo-ID data (in addition to the topics listed on page 4 of the Report of the First Meeting of the Western Gray Whale Advisory Panel) include:

- Changes in scarring over time, do killer whale marks increase every year or do whales learn how to avoid attacks? At what age are the gray whales most vulnerable to orca attacks? Can scars be used to distinguish juveniles from adults?
- Variation in the marks used to identify individual gray whales, their origins and reliability as identifiers over time.
- Can scarring (by barnacles or orcas) be used to distinguish juveniles from adults and thus be useful in understanding survivorship of different age classes?
- Are there inter-annual and inter-individual differences in barnacle loads? Could these differences be related to the health of individuals? Are barnacles debilitating in terms of their weight?

CONCLUSIONS AND RECOMMENDATIONS

(1) The results of the comparisons of the two catalogues show an excellent level of agreement. In fact, there are only six unresolved matches need to be discussed at the Workshop before determining the final number of individually identified whales. If my views on these are accepted at the Workshop, then the catalogues through 2005 will have 133 whales in common and 22 whales that are unique to one or the other catalogue, for a total of 155 western gray whales that were individually identified from 1994 to 2005 (depending on how the Workshop decides to deal with temporary whales).

(2) Consistent protocols need to be developed so that the two catalogues can be maintained independently but combined for analyses. Combining catalogues requires that catalogue holders develop and use consistent protocols for (1) identifying matches, (2) declaring new whales, (3) encoding the quality of photographs and the distinctiveness of features used in identifications and (4) recording errors in matches.

(3) In determining standard protocols for updating the catalogues and for carrying out matching to enable the estimation of population parameters, one of the most important elements is for the Workshop to reach agreement on a catagorization scheme for photographs that considers (1) photo quality and (2) distinctiveness of animals.

(4) The Report of the First Meeting of the Western Gray Whale Advisory Panel points out that the combination of information in both western gray whale catalogues will be of greater value than the information found in either catalogue alone. I agree. Collaborative research between the catalogue holders will also reduce the amount of boat-induced disturbance needed to assess the status of this critically endangered population and maximize the value of the information that is gathered during the limited period when the whales are accessible for observation.

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