REPORT OF THE PHOTO-ID AND NEW TECHNOLOGIES TASK FORCE AT ITS 1ST MEETING

28-29 APRIL 2019
GLAND, SWITZERLAND

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CONTENTS

ACRONYMS

ATC	Air Traffic Control
BAI	Body Area Index
Company	Sakhalin Energy Investment Company Ltd.
GPNS	Gazprom-Neft Sakhalin, LLC
IR	Infrared
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
Panel	Western Gray Whale Advisory Panel
PCFG	Pacific Coast Feeding Group [of gray whales]
Photo-ID	Photo-identification
PHIDNT	Photo-ID and New Technologies Task Force
RGWP	Russia Gray Whale Project
Sakhalin Energy	Sakhalin Energy Investment Company Ltd.
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System(s)
WGWAP	Western Gray Whale Advisory Panel

1 INTRODUCTORY ITEMS

1.1 Opening remarks and objectives

Under chairmanship of David Weller, the 1st meeting of the Photo-ID and New Technologies Task Force (hereafter PHIDNT or Task Force) took place on 28-29 April 2019, at SUMAS Sustainability Management School and IUCN Headquarters, in Gland, Switzerland.

In addition to those attending in person, Jane Alcock and Andrey Samatov from Sakhalin Energy and Olga Sychenko from the Russia Gray Whale Project (RGWP) joined parts of the meeting remotely. The list of participants is given as Annex A.

Recognizing that information derived from photo-identification (photo-ID) studies, complemented by genetic data when possible, is critical for assessment of western gray whales, this Task Force is aimed at, among other things: (a) planning efficient and effective uses of existing datasets, (b) providing advice on the design of future field efforts and (c) evaluating the effectiveness of using drones to supplement or replace traditional photo-ID approaches (boat-, vessel-, shore-based). Regarding this last-mentioned aim, the recent 'blending' of the photo-ID and distribution/density monitoring aspects of the Joint Programme raises particular concerns as outlined in the WGWAP-19 report (items 6.1.1.4 and 6.1.2.2)[1]. These concerns were addressed to a limited extent during the meeting.

The primary objectives of the meeting were to: (a) identify and determine the status of existing photo-ID and genetic datasets from the western North Pacific (Sakhalin, Kamchatka, Okhotsk Sea, etc.), (b) identify and consider the opportunities and challenges of ongoing and future work including incorporation of new and emerging technologies that are already or potentially applicable to gray whale research (note the concerns related to the 'blending' of photo-ID and distribution/density monitoring with drones as noted above), (c) consider opportunities for synergies including the concept of a shared catalogue/database and (d) produce a workplan for the Task Force through at least the 2019 calendar year.

In the absence of participation by Sakhalin Energy during much of the meeting, the Task Force attempted to address as many issues as was feasible using the expertise present. However, no attempt was made to address a number of items on the original agenda and several of the items could only be considered in a cursory manner.

1.2 Adoption of agenda

The adopted agenda is given as Annex B.

1.3 Available documents/materials

The list of documents is given as Annex C.

[1] https://www.iucn.org/western-gray-whale-advisory-panel/panel/meetings/a-glance-meeting-reports

2 REVIEW OF PHOTO-ID AND BIOPSY FIELD WORK AND DATA FROM SAKHALIN AND KAMCHATKA

Weller began the meeting by reviewing several maps of north-eastern Sakhalin Island, including depictions of the nearshore and offshore feeding areas and oil and gas infrastructure. The overarching aims of this agenda item were to: (a) identify and assess the status of the existing photo-ID images and datasets from the western North Pacific (Sakhalin, Kamchatka, Okhotsk Sea, etc.), (b) develop a workplan for cross-comparison of the existing (Joint Programme and RGWP) images and datasets as has previously occurred, (c) determine the utility, scope of effort and methods needed for updated or new analyses regarding cross-basin matching, scarring from fishery interactions, vessel strikes and killer whale attacks, body condition and calf determinations[2] and (d) further the development of a workplan for combining the Joint Programme and RGWP catalogues and datasets (e.g. sighting histories, sexes, calving histories) under the auspices of the International Whaling Commission (IWC) and its data availability agreement.

2.1 Russia Gray Whale Project

Associate Scientist Alexander Burdin began his presentation on the long-running RGWP (formerly called the Russia-US Programme) by explaining that the core objectives of the study are to better understand and monitor the status of western gray whales through use of photo-ID and tissue sampling of individuals. Between 1997 and 2018, funded in large part by the International Fund for Animal Welfare (IFAW), photo-ID surveys have been conducted annually during the summer feeding season. Some data from 1994 and 1995 are included in the RGWP dataset, including photographs obtained between 7-12 September 1994 during the filming of a wildlife documentary by H. Minakuchi (for description see Weller et al., 1999) and from 14-20 August 1995 during a pilot study to determine the feasibility of conducting boat- and shore-based research in the study area. In order to perform inter-annual comparisons, this project has maintained an overall consistency in research design, data collection techniques and data analysis.

Between 1994 and 2018, 3,901 groups were approached during 485 boat-based surveys off north-eastern Sakhalin Island and 276 individual whales have been identified. In the period 1995 to 2010, 147 skin/blubber biopsy samples were collected (archived at the U.S. National Oceanic and Atmospheric Administration’s Southwest Fisheries Science Center, NOAA/SWFSC) and in the 2011 to 2018 period 18 genetic samples were collected (archived at the A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences).

All photo-ID data are stored on hard drives with redundant copies of the data stored at different locations. Photographs collected on film during the early years of the study have been digitized. Image processing has been conducted using *ACDSee* and *Photoshop* software. Most recently, the research software *Discovery*[3] has been used as the primary system to process and manage images and related data collected between 2011 and 2018. Other related data and information are stored in two main formats: *Microsoft Access* and *Microsoft Excel*. The RGWP database is managed in *Microsoft Access* and data from 2016-2018 are presently being checked for quality assurance and quality control.

The RGWP has also conducted field efforts off south-eastern Kamchatka, in Avachinsky Gulf and Kronotsky Gulf, where gray whales have been reported since the mid-1990s. The main area of gray

[2] Decisions as to whether a given individual is a calf-of-the-year
[3] http://www.cetaecoresearch.com/research-software-discovery.html

whale observations in Kronotsky Gulf is Olga Bay in the northern part of the gulf. This is a very limited area – only about 20 km long and mainly close to shore.

2.2 Joint Programme

In the absence of a representative from the Company, the Task Force reviewed a presentation (PHIDNT-1/6) provided by Sakhalin Energy about the Joint Programme on Gray Whale Monitoring off northeast Sakhalin Island with details on the 2002-2018 photo-ID and genetic database. Additional information contained in the report by Yakovlev et al. (2019) on the 2018 results of Joint Programme photo-ID component was also used by the Task Force as a basis for the following summary. It should be noted that there are minor discrepancies between the timeline in the presentation and what is stated in the aforementioned report. In such cases, the information in Yakovlev et al. (2019) was used.

The overarching objectives of the photo-ID component of the Joint Programme have been: (a) individual identification, including documentation of mother-calf pairs, (b) assessment of body and skin condition, and (c) examination of habitat use and movements between the nearshore and offshore feeding areas by individual whales.

Photo-ID surveys have been conducted by the Joint Programme off north-eastern Sakhalin Island since 2002. In 2018, Gazpromneft-Sakhalin (GPNS) joined Sakhalin Energy and Exxon Neftegas Limited (ENL) in the Joint Programme and managed the surveys in the offshore feeding area. Between 2002 and 2013, photo-ID data were collected primarily from small boats (i.e. rigid-hulled inflatable boats/RHIBs) launched from larger vessels. In 2014 and 2015, a second small-boat team stationed on land and deploying the vessels from Piltun Lagoon was used to survey the nearshore feeding area. Also, in 2014 the feasibility of shore- and vehicle-based photo-ID was initiated and tested. Small-boat effort in the nearshore feeding area was terminated after 2017 but shore-based effort was continued and this was supplemented in 2017-2018 by the use of small handheld drones (see item 7.6 below). As of 2018, photo-ID in the offshore feeding area was primarily carried out from small boats launched from a larger vessel, although photographs were also opportunistically collected from the large vessel, while in the nearshore area it was carried out by shore-based teams and drones.

Between 2002 and 2018, 297 individual whales were identified. This includes 290 whales observed in the nearshore feeding area. Of these 290, 143 have never been sighted in the offshore feeding area while 147 individuals have been sighted in both the offshore and nearshore areas. Only four individuals have been sighted exclusively in the offshore feeding area. Over the period 2012-2018, 77 skin/blubber samples of 65 individual whales were collected by the Joint Programme. A separate Kamchatka gray whale catalogue of images obtained off south-eastern Kamchatka in 2004, 2006-2012 and 2018 contains 174 individual whales and out of that number, 95 have been recorded off Sakhalin.

2.3 Discussion of Presentations

On behalf of the task force, Weller thanked Burdin and the Joint Programme for providing presentations and their willingness to share this information. In general, the Task Force was pleased to learn that the datasets and photo-ID catalogues appeared to be in good order and are contemporary in terms of inclusion of data from the past year (2018). Additionally, the Task Force was encouraged by the fact that both photo-ID programmes are centralizing their respective datasets using the *Discovery* platform. Weller reiterated the long-standing goal of creating a common dataset and identification catalogue under the auspices of the IWC (see item 4 below) and that using a common database and catalogue platform such as *Discovery* would result in efficiencies towards reaching this goal.

In discussion, the Task Force noted that the RGWP conducts surveys only in the nearshore feeding area while surveys by the Joint Programme cover both the nearshore and offshore feeding areas. Despite these differences in survey coverage, the number of individuals in each of the catalogues is quite similar. Weller noted that this was due, at least in part, to the relatively high degree of movement by the whales between the two feeding areas (Yakovlev et al., 2019). That being said, in any given year the amount of exchange between the two areas varies. Most recently, the number of whales in the offshore area has exceeded the number in the nearshore area and the level of exchange may be decreasing. This pattern or trend could be related to the decline in benthic prey in the nearshore area that has been ongoing since at least 2012[4]. In addition, the Task Force was reminded that the RGWP catalogue began in 1997 while the Joint Programme catalogue began in 2002, indicating that the Joint Programme is likely to have more whales included in its catalogue as a result of greater survey coverage. The Task Force highlighted, as has the Panel repeatedly in the past, the benefits that could be realized if the RGWP and Joint Programme were to coordinate their survey efforts. This would reduce redundancy and increase efficiency, particularly if there were a common dataset and catalogue, as discussed under item 4 below.

In response to a question concerning how photographs collected outside of the Sakhalin area are archived and managed, Sychenko explained that the RGWP catalogue currently contains only whales photographed off Sakhalin. She added that the RGWP is considering how the images and data from all the existing catalogues and databases can be integrated. Burdin stressed the importance of photographs taken and data collected off Kamchatka and in other areas of the western North Pacific and emphasized the point that centralization of the information from all sources, including creation of a common catalogue, should the end goal for conservation of these whales.

3 SUMMARY OF PHOTO-ID TASK FORCE WORK IN 2007-2009

Photo-ID of individual gray whales has been a core element of both the industry-sponsored Joint Programme and the non-industry RGWP since 2004 when IUCN convened its first independent gray whale panel. At its first meeting in November 2006, WGWAP established a Photo-ID Task Force (see report of WGWAP-1, Annex 4 for the Task Force's Terms of Reference). That meeting (item 5 of its report) stressed the importance of ensuring consistency in how identifications of individuals are determined (e.g. 'new' animals vs. re-sightings) and the goal of combining the datasets of the two research groups in the expectation that this would "enable more precise and accurate estimation of population characteristics and hence quicker detection of possible negative trends." It was assumed that integration of data from the two programmes would not only "enhance" population monitoring but also "reduce duplication of field efforts and minimise disturbance to the whales."

The Photo-ID Task Force met three times between 2007 and 2009. Its main tasks focused on reconciling the two catalogues, following an independent review by an expert (Vicki Rowntree). A comparison of data through the 2007 season revealed a total of 178 different whales, of which about 85% were common to both catalogues. A few discrepancies were detected but these were fairly quickly resolved.

[4] WGWAP Open Statement of Concern on decline of the amphipod prey base in the nearshore feeding area of gray whales near Piltun Lagoon, Sakhalin Island, Russian Far East, 11 July 2019, https://www.iucn.org/sites/dev/files/final_statement_from_wgwap_on_benthos_11july2019_en-ru.pdf

In addition, efforts were made to reconcile mother-calf designations. In some instances, the Joint Programme team reported an individual as a calf in one season when the Russia-US team had identified the same whale at Sakhalin in the previous season. Such discrepancies were noted and addressed, using Bradford et al. (2010) as an authoritative guide to calf determinations, and both programs have been applying similar criteria for the last decade or so. It proved possible to cross-check and rework the Joint Programme data on mother-calf pairs back to 2003 and for unaccompanied animals identified as calves of the year back to 2006.

By December 2009, when the Photo-ID TF met for the last time, a process had been established whereby the catalogues of the two teams were submitted to IUCN for double-blind cross-validation. This practice continued for several years, by which time the catalogues were essentially in full agreement. In its final (third) report (item 6.1), the Task Force stated that catalogue cross-matching was expected to continue on an annual basis, "with data exchange managed by IUCN and regular reporting on progress at Panel meetings." However, from 2012 the Joint Programme stopped participating in the data exchange process.

One of the main purposes of the photo-ID research effort was, in part, to support periodic population assessments and these have been conducted every 1-2 years since 2010. Cooke reported that regardless of which team's data are used, results are basically the same, i.e. they indicate a steadily increasing population.

In response to a question concerning juvenile survival rates, Cooke reported that survival of calves from their first season at Sakhalin (they are around half a year old on arrival) to their second season is about 80% or higher, depending on the dataset used in the analysis. If analysed over a broader area, the rate is somewhat higher because individuals are sometimes identified at Kamchatka but not Sakhalin in their second year or later.

In his annual population analyses, Cooke has found some evidence suggesting a lagged effect on the calving rate (or at least calf survival from birth to arrival off Sakhalin at around half a year of age) from (acoustic) disturbance on the feeding ground (e.g. WGWAP-16 report, item 8.3). Also, there is evidence from the eastern North Pacific suggesting that first-year survival of gray whales is affected by ice cover on the feeding ground, with lower ice cover correlated to higher survival (Perryman and Lynn, 2002)

Besides regular population assessment, photo-ID (especially in combination with biopsy sampling to determine sex) proved to be extremely valuable (actually essential) for the 'real-time' identification of individuals for tagging, as was carried out at Sakhalin in 2010 and 2011 (see Weller et al. 2009, 2010).

4 PROGRESS TOWARDS A COMMON CATALOGUE/DATABASE UNDER THE IWC

Those involved in western gray whale research and conservation have expected for a number of years that a common (joint) western gray whale photo-ID catalogue and database would be available 'soon', to be controlled and managed under the auspices of the IWC. According to Donovan, who serves as IWC Head of Science, all the parties have agreed in principle to make their photographs, biopsies and data available under a data-sharing agreement. The software being used by the two teams is compatible, and there should be no technical impediment to moving ahead without further delay. Those present understood that new data will continue to be shared regardless. Also, it was expected that the data and photographs obtained by GPNS in and near the offshore feeding area would be shared under the same terms as agreed by the other Joint Programme partners.

Sakhalin Energy's response to Recommendation WGWAP-19/19, however, raised concerns on the part of some participants that no formal agreement is yet in place and that the Company is unwilling or unable to share any of the Joint Programme data without explicit consent of the other partners.

5 USES OF PHOTO-ID (AND GENETICS) DATA FOR WESTERN GRAY WHALE SCIENCE AND CONSERVATION

The Task Force discussed this agenda item only briefly, noting the recently completed five-year range-wide review undertaken by the IWC Scientific Committee. Photo-ID and genetic data from whales off Sakhalin were used extensively during that review to help develop hypotheses regarding gray whale stock structure in the Pacific Ocean.

6 REVIEW OF WGWAP COMMENTS, ADVICE AND OPEN RECOMMENDATIONS REGARDING RELEVANT TOPICS

Considerable attention was devoted to four 'open' WGWAP recommendations at this meeting: 17/04, 18/06, 19/16 and 19/17. In each case, a new or updated response from Sakhalin Energy had been received and posted on the public WGWAP Recommendations Database online in mid-April 2019.[5]

All four of these recommendations relate to 'integrated' studies of gray whale feeding ecology and behaviour that take advantage of the rich and relatively long time series of data collected under the Joint Programme. As discussed at some length in the Panel reports where these recommendations were initially explained and set forth, a major underlying concern is the apparently steep decline in benthic biomass in the nearshore (Piltun) feeding area between 2013 and 2016. The benthic sampling element of the Joint Programmewas discontinued following the 2016 season. As discussed at some length in the report of the last Panel meeting (WGWAP-19, item 6), other changes have been made in methods used under the Joint Programme to monitor whale numbers and distribution. All such changes were reported to the Panel only after the fact, that is, without advance notice and without any consultation.

The evidence available from both the Joint Programme and the RGWP point to a recent decline in usage by gray whales of the nearshore (Piltun) feeding area and a shift in distribution away from waters near the lagoon mouth where mother-calf pairs, in particular, have been known to concentrate since at least the early 21st century. This trend has been broadly coincident with the decline in amphipod biomass near shore and an apparent increase in time spent by whales (other than mother-calf pairs) in the still highly productive offshore feeding area.

The discussion at this meeting of the Task Force provided a basis for Panel comments in response to the Company's responses concerning the four recommendations, and those 'responses to

[5] With follow-up responses provided by the Company in June 2019, which have also been posted on the database and are accessible via https://www.iucn.org/western-gray-whale-advisory-panel/recommendations or directly at https://portals.iucn.org/wgwap.

responses' were posted on the WGWAP Recommendations Database in mid-May 2019[6]. In addition, it was agreed at this meeting that the Panel would issue a public Statement of Concern regarding the major apparent changes in the benthos and in whale distribution in recent years and the importance of reinstating benthic sampling as part of the Joint Programme[7]). Most participants assumed that it would be in the interest of the companies operating off north-eastern Sakhalin to resume and continue, perhaps even re-design and/or ramp up, the benthic sampling work, and to ensure that the time series of data on whale distribution is maintained (using consistent, or at least compatible, methods, as discussed below).

The meeting also considered recommendation WGWAP-19/20 which concerns the methods used by the Joint Programme to collect data on whale distribution and numbers from shore-based platforms. The companies apparently switched in 2017 from a reliance on daily visual surveys by observers to a reliance on drones deployed from shore to monitor gray whale usage of the nearshore feeding area. Again, this change was made without giving the Panel advance notice and without soliciting its advice.

In its formal response to recommendation 19/20, Sakhalin Energy indicated that the Joint Programme would "conduct standard distribution survey[s] on a weekly basis in the 2019 field season." The English version of the final 'main' report on the Joint Programme's 2018 field season was received by IUCN and distributed to the Panel on 10 April 2019, but this report contained no details on methods. To the best of meeting participants' knowledge, the frequency of shore-based distribution surveys changed from daily up to 2017, when the use of drones for monitoring was emphasized, and then in 2018 reverted back to reliance on visual observations by shore-based observers which were, however, conducted weekly rather than daily.

In conclusion it was suggested that for future planning, an analysis should be undertaken to determine, among other things, how the results from daily surveys compare to those from weekly surveys and how this might affect the companies' ability to follow trends in the whale population and its use of the Sakhalin feeding areas through time. This point is reflected in the Panel's response to the Company's response for recommendation 19/20.[8]

7 USE OF 'NEW' TECHNOLOGY (E.G. DRONES) FOR PHOTO-ID, DISTRIBUTION/DENSITY MONITORING AND OTHER PURPOSES

Two of the primary aims of this Task Force meeting were to: (a) evaluate the effectiveness of using drones for supplementing and/or replacing 'traditional' photo-ID approaches (boat-, vessel-, shore-based), including provision of advice on the use of images and data obtained from drones in combination with existing 'traditional' datasets and studies and (b) evaluate the feasibility of using drones to assist in new/additional studies (e.g. evaluating risk of ship strikes, killer whale attacks; feeding and other behaviour; assistance with seismic survey monitoring and mitigation).

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[6] Accessible via https://www.iucn.org/western-gray-whale-advisory-panel/recommendations or directly at https://portals.iucn.org/wgwap

[7] See https://www.iucn.org/sites/dev/files/final_statement_from_wgwap_on_benthos_11july2019_en-ru.pdf

[8] Accessible via https://www.iucn.org/western-gray-whale-advisory-panel/recommendations or directly at https://portals.iucn.org/wgwap

7.1 Presentations and reporting

Two presentations were given regarding the use of drones to study large whales. Associate Scientist Lars Bejder (University of Hawaii) presented an overview entitled “Unoccupied Aerial Systems (UAS/Drones) in Cetacean Research” and Panel member Leigh Torres (Oregon State University) provided a presentation entitled “Applications of Drones to study Oregon Gray Whales”. A third presentation by Peter van der Wolf (Geocon) on the use of drones to study gray whales off Sakhalin was expected, either in-person or remotely. However, van der Wolf was unable to participate in either manner. In his absence, the Task Force reviewed and discussed an earlier presentation he had prepared for the 10th International Conference on Marine Mammals of the Holarctic (2018) and a presentation by Sakhalin Energy at the WGWAP-19 meeting entitled “Use of Unmanned Aerial Vehicle (UAV) During Western Gray Whale Joint Program – Onshore Photo-ID”.[9]

For this report, given the degree of overlap in some aspects of the presentations, general discussions of equipment, operational considerations and methods have been combined and generalized below. Specific methodologies and areas where field operations or research approaches differ, however, are attributed to the particular presenter.

7.2 Unmanned aerial systems (UAS)

Unmanned aerial systems (UAS) also referred to as unmanned aerial vehicles (UAV) or drones are increasingly being used to study marine mammals. With technological advancement, the versatility and functionality of these systems has expanded. In parallel, ‘prosumer’ or off-the-shelf UAS models have become more sophisticated in terms of their capabilities and have become more affordable. Advancements include miniaturization of components, increased battery life, larger payload capacity and the ability to record accurate and repeatable measurements. Drones now commonly carry an array of high-tech processors and sensors that obtain a suite of measurements and high-resolution imagery. With their decreasing cost, increasing flight time and relative ease of use on land and at sea, drones are poised to become a methodological staple of marine mammal science.

At a minimum, drones consist of an aircraft, a ground control station and a communication link between the two. Presently, there are two basic systems in use by scientists: fixed-wing and multirotor. Fixed-wing drones provide a viable alternative to more expensive manned aircraft in that they can carry larger payloads (i.e. sensors), are relatively fast and have reasonably long flight times which, in combination, allows them to cover large distances. Using this type of aircraft, however, requires substantial operator training and they are only capable of horizontal flight and cannot hover. Therefore, fixed-wing drones are most commonly used in wildlife science for conducting line transect surveys of terrestrial and marine animals (Hodgson et al. 2013, 2017; Linchant et al. 2015).

In contrast to fixed-wing systems, multirotor aircraft are small and lightweight, easy to launch and retrieve on land or at sea and can hover over a target, making them particularly well-suited for research reliant on photographic imaging. Flight times for these systems are limited by battery technology; while improving, presently flights are limited to only about 15-20 minutes. In their presentations, Bejder and Torres discussed their respective research using multirotor drones to address a number of questions, including: photo-identification, body condition, growth, age structure, behaviour and prevalence of scarring from fishing gear and killer whales. In both of these case studies, the primary data being collected are gleaned from photo/video images. Photogrammetry of this type is commonly used to measure whales (or other organisms). A central challenge when collecting scientifically useful images from small drones is the establishment of scale (Dawson et.

[9] See document WGWAP-19/33 at https://www.iucn.org/sites/dev/files/wgwap19_33_en.pdf (English) and https://www.iucn.org/sites/dev/files/wgwap19_33_ru.pdf (Russian)

al. 2017). More specifically, the precision and accuracy of measurements from photographs can be affected by: (a) body position of the target animal not being horizontal/flat at the surface, (b) light refraction at the air-water interface, (c) image selection and digitization error introduced by an analyst, (d) camera orientation over the target being non-vertical as well as (e) measurement error of the altitude of the UAS when collecting photographs. Some of these issues can be corrected for by use of custom and/or off-the-shelf computer programs that conduct or assist with image digitization and measurement. Nevertheless, the collection of proper meta-data from the UAS in combination with the skill of an analyst remains inherently important with respect to selecting images best suited for precise measurement.

In addition, a number of approaches to measuring altitude have been tested. In some cases, error in this measurement has been overcome by way of laser altimeters and similar technologies. Bejder reported that his system has a precision error of less than 2 cm when flying at an altitude of 100 m above sea level. That being said, the importance of collecting calibration images – photographs of an object of known length that is floating on the surface of the water – was highlighted as a simple method to ground-truth the more advanced systems.

With respect to camera specifications, there is great variation in the systems being used. However, gimball-mounted stabilized cameras, capable of taking high-resolution images, either still or video or both, are required for the purposes of photogrammetry. Ideally, a flat glass lens is used on the camera. This type of lens provides distortion-free imaging in comparison to traditional curved-glass lenses which can introduce differing levels of ‘barrel’ distortion, resulting in the edges of a photo appearing to be curved and, in turn, an inability to take straight-line measurements of the target animal. In situations where a flat lens is not available or proves to be cost-prohibitive, there are both custom and off-the-shelf software routines that allow lens distortion to be quantified and corrected for (Dawson et al. 2017, Burnett et al. 2018). In addition, limiting images used for analysis to those in which the target animal is positioned in the centre of the frame helps to minimize distortion caused by curved-glass lenses. Image analysis programs and computer code, as well as an instructional video and related publications are available on the Marine Mammal Institute of Oregon State University website[10].

7.3 Body condition

Torres performed a direct comparison between traditional visual assessment of gray whale body condition (following the methods of Bradford et al. 2012) to drone-based photogrammetry assessment of body condition with gray whales in the Pacific Coast Feeding Group (PCFG). While both methods determined similar results at the population level, the drone-based assessment is less subjective in that quantitative measurements, as opposed to a qualitative score, are determined.

Acknowledging the important contribution of his collaborator Fredrik Christiansen, Bejder described measurement protocols used in his laboratory to assess body condition of baleen whales, including gray whales (methods described in Christiansen et al. 2016a). The broader goal of this work is to relate body condition to survival and reproductive success at both the individual and population level. This system takes measurements (in pixels) of length from the tip of the rostrum to: (a) the notch of the tail flukes, (b) the end of the dorsal fin, (c) the position of the eyes (measured along the body axis of the whale) and (d) the beginning of the tail flukes. Subject-animal width is measured perpendicular to the body axis at 5% intervals along the entire body of the whale. These

[10] See https://mmi.oregonstate.edu/gemm-lab/research-projects/application-unmanned-aerial-systems-uas-%E2%80%9Cdrones%E2%80%9D-assess-whale-body

relative measurements of the whale are converted to absolute measurements in centimetres, using the scale of photographs obtained for each animal.

With southern right whales (*Eubalaena australis*) off Australia as an example, Bejder reported that he and his colleagues (Christiansen et al. 2018) used a UAS to collect repeated morphological measurements of mothers and their calves. The aim of this research was to evaluate how maternal body size and condition influenced the growth rates of calves during the 3-month period on the wintering ground in South Australia. During this time, mothers are nursing their calves while at the same time, fasting. By estimating body volume from body width and length measurements, calf growth was found to be positively related to the rate of loss in maternal body volume, indicating that maternal volume loss is proportional to the energy investment into her calf. Lactating females lost on average 25% of their body volume over the 3-month winter breeding season.

Torres's laboratory developed and uses the 'Body Area Index' (BAI) to describe gray whale body condition off the coast of Oregon. She noted that this index is applicable to all species of baleen whales as well as sperm whales. The BAI estimates the flat dorsal surface area of a whale by assuming a parabolic shape for approximately 40% of a whale's total length and combining the area under parabolas representing each side of a whale (see Burnett et al. 2018). This index is scale-invariant, unitless and independent of body length. Even when aerial images have no accompanying altitude data and there is no scaling object in the frame, it is still possible to calculate BAI for comparison across populations (e.g. western vs PCFG vs eastern gray whales) and time periods. Torres suggested that calculations of BAI from drone-based images of whales at Sakhalin and elsewhere in the western Pacific for comparison with her team's BAI values for the PCFG whales would be of interest.

Torres demonstrated how her lab used the BAI metric to describe changes in body condition of PCFG gray whales on their foraging grounds as a function of time, age/size class and reproductive status and how these changes can be correlated with environmental parameters (e.g. sea surface temperature, upwelling).

7.4 Behaviour

Studies of gray whale behaviour have benefited from the use of drones to collect high-resolution 4K video. In her studies off the coast of Oregon, Torres reported that the use of drones tripled the observation time in comparison to comparable boat-based observations of behaviour (Torres et al. 2018). Analysis of these data refined the previously described 'foraging' behaviour of gray whales off the coast of Oregon by providing insight into a number of novel behavioural events and feeding strategies that had not been described previously when a boat was used as the observation platform. In addition, new information on the behaviour of mother-calf pairs, including nursing, was obtained.

7.5 Photo-ID

Finally, the use of drones for individual identification has proven to be useful in several respects including: (a) the ability to link 'traditional' boat-based images to UAS images, (b) the creation of UAS-based catalogues that incorporate aspects of the body such as 'back' and 'dorsal fluke surface' and (c) inspection of individual whales for signs of interactions with fisheries. The work of Bejder and colleagues in the lagoons of Mexico provides an example of the ability to link UAS images with traditional photographs. That being said, it was emphasized that when efforts of this nature are underway it is important to collect traditional boat- or shore-based photo-ID images at same time as collecting drone-based images to help link photographs taken from the two very different perspectives. Bejder cautioned that it had not been determined whether drone-based images can be matched to the entirety of an existing photo-ID catalogue. Also, it is important to note that the drone-based images being referred to here are, for the most part, taken directly overhead of the target subject given the overarching objective of conducting morphometric analyses. It is possible, however, to collect flank images, more in keeping with a traditional photographic perspective, if the drone is flown to the side of the target animal.

7.6 Joint Programme presentation

The Task Force reviewed and discussed a presentation first made available at the WGWAP-19 meeting in November 2018. The discussion (to the best of the Task Force's ability in the absence of a Company representative) was centred on evaluating UAS operations currently in use by the Joint Programme and, in turn, providing advice to the Company. Of particular interest to the Task Force was how the Joint Programme has or will: (a) integrate the use of drones for photo-ID purposes into its present research programme, (b) integrate UAS-based images with the existing catalogue based on 'traditional' boat- and shore-based methods, (3) replace existing components of the annual field effort (e.g. boat-based photo-identification) by using drones and (4) further expand the use of drones into its annual monitoring (e.g. use of fixed-wing systems for distribution surveys).

With regard to the equipment being used by the Joint Programme, it appears to include (based on the aforementioned WGWAP-19 presentation) use of *DJI-Phantom 4 Pro* drones equipped with low-noise propellers and capable of collecting 4K video and JPEG/RAW still images. Flight distances of as much as 2-3 km and durations of 25 mins were reported. The benefits of this system are that each drone is relatively low-cost (about 1,200 USD) and it is easy to assemble and operate, making the system well suited for both shore- and boat-based deployment. The disadvantages noted were flight operations in wind >10 m/s (20 kts) as well as rain, fog and humidity.

The presentation highlighted the importance of: (a) training for the UAV teams, (b) real-time monitoring of whale behaviour to try and minimize and mitigate disturbance and (c) obtaining necessary permits, permissions and clearances for flight operations.

The Joint Programme UAV team consists of a pilot and spotter. The spotter assists with locating target animals and guiding the drone into proper position for photography. The minimum flight altitude for operations over whales is 9 m. UAV deployments follow a pre-flight protocol that begins with a visual/binocular scan of the area for the presence of whales. At this time, the distance from shore, general behaviour and approximate swim speed is estimated for the whales detected. Additionally, flocks of birds and other aircraft operations are searched for and recorded. The following criteria for the deployment of a UAV are used by the Joint Programme:

- A drone is not deployed if: (a) whales are >1000 m from shore and moving > 5 km/hr, (b) flocks of birds are in the area of target whales or (c) helicopters or other aircraft are in the area of operation.
- A drone is deployed if: (a) whales are relatively stationary and at a distance < 2,500 m and (b) operational conditions such as visibility, wind speed/direction and sea state are suitable for flight operations.

With respect to potential impacts on whales from UAS operations, the presentation noted the work by Christiansen et al. (2016b) to assess noise levels of multirotor drones and the implications for potential underwater disturbance. The observers of the Joint Programme reported that: (a) reactions to UAVs vary as a function of age and behaviour of the target animal(s) - 'congregations of whales actively engaged in playing seem less bothered by sound', and (b) 10-15% of their UAV approaches at altitudes of 10-15 m elicited 'avoidance behaviour' by the target animals. This behaviour was described as high-speed swimming away from the UAV and tail slapping.

Finally, the legal requirements of operating UAVs in the Sakhalin study area were provided. These included: (a) registration of a UAV with Russian Federation authorities and Air Traffic Control (ATC), (b) flight permits and approvals to operate in the study area, (c) daily contact with ATC and evaluation and update of air-space use and (d) submission of photographic and video data to Russian Federation authorities for approval of use.

The Task Force was interested in obtaining more information on the long-range flights given that 2-3 km is a considerable distance for the type of small drone being used. Also, the group was interested to learn more about how the 25 min flight times were being achieved given that most similar systems have shorter air-time capabilities.

The Task Force discussed the utility of adding overhead images to the existing traditional catalogues. Overhead images are clearly useful for photogrammetry. In addition, the images being collected by the Joint Programme at variable horizontal distances are also of value for photo-identification. While these later images do not allow photogrammetric measures to be obtained, they are useful for photo-ID purposes in that they provide a perpendicular view of the lateral flank of a whale similar to the perspective obtained with traditional methods. Despite the usefulness of low altitude overpasses for photo-ID work, approaches at these heights limit the ability to use images and video for other purposes. For instance, in cases where a flat lens is not being used (as appears to be the current situation for the UAVs in use by the Joint Programme), images taken at low altitudes will place more of the whale in the outer edges of the image where lens distortion is the greatest. In contrast, higher altitude ensures that the entire body of a target animal can remain in the centre of the image where lens distortion is least.

After 2017, the Joint Programme moved away from boat-based photo-ID efforts in the nearshore (Piltun) area and have, instead, focused on using shore- and UAV-based images. The Task Force was interested in learning more about the overall effectiveness of the UAV approach and suggested that a direct comparison of the earlier traditional methods compared to the new drone methods should have been conducted (and perhaps was) prior to changing field operations.

7.7 Discussion

The utility of fixed-wing UAS systems for distribution work was discussed in the context of the Sakhalin area. Bejder cautioned that in his experience this type of work was highly challenging, requiring extensive forethought, planning, and feasibility trials in advance of being able to successfully implement this method.

Vedenev asked if drones could be used in non-optimal weather conditions commonly experienced off Sakhalin (e.g. fog, wind) and if the use of onboard infrared (IR) cameras should be considered as a research tool. The use of IR cameras had been discussed in other contexts (e.g. shore-based IR monitoring of the ENL sealift operation) and it was noted that weather conditions, especially fog and humidity, greatly hinder the ability of IR cameras to 'see'. Bejder confirmed this to be the case for trials he ran using IR cameras off Alaska. Torres and her team have used drone-mounted IR cameras, with mixed results, to look for heat signatures around injuries and infections on gray whales off Oregon.

In summary, the Task Force agreed that UAS methods, when properly implemented, can be an excellent addition to many research programmes including those focussed on gray whales off Sakhalin. In addition to aiding photo-ID efforts, drones can be used to assess body condition, entanglement and killer whale scarring, behaviour and possibly distribution (if fixed-wing aircraft were used). In addition, drones can be used to scout for derelict fishing gear and survey beaches for stranded whales.

8 NEXT STEPS

The Task Force agreed on the following priority actions: (a) work with Donovan to draft and formalize an agreement template related to the common catalogue concept under IWC auspices, (b) subject to progress at IWC, liaise with IUCN to support efforts to compile the 'final' datasets and photo-ID images maintained by the RGWP and Joint Programme and (c) subject to progress at IWC, draft terms of reference for a new cross-comparison of the RGWP and the Joint Programme catalogues.

Additionally, the Task Force and Panel may provide advice on the relevant elements of the 2020-2021 Scope of Work for planned field work.

9 ADOPTION OF REPORT

Weller and Reeves, with help from Berzina-Rodrigo, assumed responsibility for drafting the meeting report for circulation and review by participants.

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WGWAP Joint Programme Task Force meeting reports, https://www.iucn.org/western-gray-whale-advisory-panel/panel/task-forces/joint-programme-task-force

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ANNEX A – LIST OF PARTICIPANTS

Jane Alcock (Sakhalin Energy, remotely, Day 2)
Lars Bejder (Associate Scientist)
Alexander Burdin (Associate Scientist)
Justin Cooke (WGWAP)
Jon Hancox (Ramboll)
Leslie New (WGWAP, Day 1)
Doug Nowacek (WGWAP, Day 1)
Randall Reeves (WGWAP)
Andrey Samatov (Sakhalin Energy, remotely, Day 2)
Olga Shpak (WGWAP)
Greg Silber (WGWAP)
Olga Sychenko (Associate Scientist, remotely)
Leigh Torres (WGWAP)
Alexander Vedenev (WGWAP)
Dave Weller (WGWAP)
Karen Westley (Shell, Day 1)

IUCN

Ulrika Aberg (Rapporteur, Day 2)
Anete Berzina-Rodrigo
Giulia Carbone
Leigh Ann Hurt (Rapporteur, Day 1)

Interpreters

Alexander Danilov (Day 1)
Grigory Shkalikov

ANNEX B – AGENDA

1. INTRODUCTORY ITEMS
1.1 Opening remarks and introductions
1.2 Chair and rapporteurs
1.3 Adoption of Agenda
1.4 Documents available

2. REVIEW OF PHOTO-ID AND BIOPSY FIELD WORK AND DATA FROM SAKHALIN AND KAMCHATKA
2.1 Russia Gray Whale Project (formerly Russia-US Programme) (Burdin, Sychenko, Weller)
2.1.1 Chronology and description of field efforts
2.1.2 Status of data archive (photo and genetic) including description of software format(s) in use
2.1.3 Status of photo-id catalogue including description of software format(s) in use
2.2 Joint Programme (Weller on behalf of Sakhalin Energy)
2.2.1 Chronology and description of field efforts identifying any changes
2.2.2 Status of data archive (photo and genetic) including description of software format(s)
2.2.3 Status of photo-id catalogue including description of software format(s)

3. SUMMARY OF PHOTO-ID TASK FORCE WORK IN 2007-2009
3.1 Overview of accomplishments and related recommendations (Cooke, Reeves)

4. PROGRESS TOWARDS A COMMON CATALOGUE/DATABASE UNDER THE IWC
4.1 Description of concept, scope and value; status of intra-/inter-party agreement (Weller, Reeves)

5. USES OF PHOTO-ID (AND GENETICS) DATA FOR WGW SCIENCE AND CONSERVATION
5.1 Individual movements within and between seasons and cross-basin (Weller)
5.2 Body condition, health, scarring/wounding (Weller)
5.3 Population dynamics (abundance, trends, life history) (Cooke)
5.4 Healing of telemetry tag wounds (Weller)

6. REVIEW OF WGWAP COMMENTS, ADVICE AND OPEN RECOMMENDATIONS REGARDING RELEVANT TOPICS

7. USE OF 'NEW' TECHNOLOGY (e.g. drones) FOR PHOTO-ID, DISTRIBUTION/DENSITY MONITORING AND OTHER PURPOSES (Bejder, Torres, Weller)
7.1 Off-the-shelf and customized drone technology and its use for scientific purposes (including advantages and limitations and use in poor visibility conditions) (Bejder)
7.2 Description of current drone use and technology off Mexico, Oregon, Sakhalin and elsewhere (Bejder, Torres, Weller on behalf of van der Wolf, Weller)
7.3 Photo-ID and compatibility with existing photo-ID data and methods (Bejder)
7.4 Photogrammetry (e.g. relative age composition of population, changes in body condition through time, pregnancy, scarring) and technical requirements (Bejder)
7.5 Use of drones to monitor whale distribution/density (and compatibility of results with data from 'traditional' methods involving visual observation from shore, vessels, or manned aircraft)
7.6 Behaviour/feeding studies including use of videography
7.7 Breath sampling
7.8 Other uses

8. CONCLUSIONS AND DEVELOPMENT OF A WORKPLAN TO IDENTIFY AREAS OF OVERLAP, PRIORITIZATION OF EFFORT(S) AND POTENTIAL COLLABORATIONS

ANNEX C – LIST OF DOCUMENTS

#	DOCUMENT	LANGUAGE	STATUS
WGWAP-19/REPORT	Report from the 19th meeting of the Western Gray Whale Advisory Panel	English/ Russian	Public
WGWAP-19/19	2019 Scope of Work for Gray Whale Monitoring Off the North-East Coast of Sakhalin Island	English / Russian	Public
WGWAP-19/33	Presentation delivered at the 10th International Conference on Marine Mammals of the Holarctic 2018 and presented by Sakhalin Energy at WGWAP-19: Use of Unmanned Aerial Vehicle (UAV) during Western Gray Whale Joint Programme - Onshore Photo-ID, Sakhalin Energy – Exxon Neftegaz Limited, Chayvo - South-Piltun - Odoptu, Sakhalin, Russian Federation 2016 - 2018, Prepared by Peter van der Wolf, environmental consultant Geocon	English / Russian	Public
WGWAP-19/INF.2	Presentation on Gray whale research off north east Sakhalin in 2018 delivered at WGWAP-19 (by A.Burdin and M.Mamaev, Russia Gray Whale Project)	English	Public
PHIDTF/ REPORTS	Reports from the previous Photo-ID Task Force meetings held between 2007 and 2009	English	Public
JPTF/ REPORTS	Reports from the Joint Programme Task Force meetings held between 2013 and 2016	English	Public
PHIDNT-1/1	Joint Programme Report on Gray Whale Monitoring Program off the Northeast Sakhalin Island in 2018 (incl. Appendix 1. Joint Program Publications)	English	Public
PHIDNT-1/2	Photo-IDof Gray Whales (*Eschrichtius robustus*) off the Northeast Coast of Sakhalin Island in 2018 (Appendix II to the Joint Programme 2018 report, doc 1/1)	Russian (English translation expected at a later stage)	Public
PHIDNT-1/3	Distribution and abundance of gray whales in shelf waters of Sakhalin during July-October 2018 (Appendix III to the Joint Programme 2018 report, doc 1/1)	Russian (English translation expected at a later stage)	Public
PHIDNT-1/4	Olga Yu. Tyurneva, Yuri M. Yakovlev, Vladimir V. Vertyankin, Peter van der Wolf, and Michael J. Scott (2018). Long-term photo-ID studies of gray whales (*Eschrichtius robustus*) offshore northeast Sakhalin Island, Russia, 2002-20217. IWC SC Paper SC/67B/ASI/04	English	Public
PHIDNT-1/5	Alexander M. Burdin, Olga Sychenko, Matvey M. Mamaev (2018). Gray whale research off northeasern Sakhalin Island and Eastern Kamchaka, Russia, in 2017. IWC SC Paper SC/67B/CMP/07	English	Public
PHIDNT-1/6	Summary slides of Photo-ID / Genetic Data Base (GW Joint Program) provided by Sakhalin Energy	English	For internal use only

PHIDNT-1/7 (rev)	Presentation by Burdin A.M., Sychenko O. and Mamaev M.S. on Russia-US -> RGWP (Russia Gray Whale Project) gray whale research off Sakhalin 1995-2018 (updated)	English	For internal use only
PHIDNT-1/8	Relevant WGWAP recommendations with responses and current status[11] - WGWAP-16/017 on definitive IBM dataset - WGWAP-16/020 on assessment of tag injury from photos - WGWAP-17/04 on Companies' analysis of complete dataset to determine 'core use' areas etc. - WGWAP-18/07 on RGWP continuation - WGWAP-18/08 on cross-matching photo-ID catalogues 2012-2016 - WGWAP-19/15A on entanglement and other scarring - WGWAP-19/21 on drone based distribution	English	Public
PHIDNT-1/9	Presentation by J.G.Cooke on Photo-ID Task Force to date	English	For internal use only
PHIDNT-1/10	Presentation by L.Bejder on Unoccupied Aerial Systems (UAS; drones) in cetacean research	English	For internal use only
PHIDNT-1/11	Presentation by L.Torres on Applications of drones to study Oregon gray whales (excluding unpublished data)	English	For internal use only

For information documents

PhID/NT-1/INF.1	Bibliography on applicability of drone technology to wildlife research	English	Public
PhID/NT-1/INF.2	Aniceto, A. S., Biuw, M., Lindstrøm, U., Solbø, S. A., Broms, F., & Carroll, J. (2018). Monitoring marine mammals using unmanned aerial vehicles: quantifying detection certainty. Ecosphere, 9(3).	English	Public
PhID/NT-1/INF.3	Apprill, A., Miller, C. A., Moore, M. J., Durban, J. W., Fearnbach, H., & BarrettLennard, L. G. (2017). Extensive Core Microbiome in Drone-Captured Whale Blow Supports a Framework for Health Monitoring. MSystems, 2(5), e00119–17.	English	Public
PhID/NT-1/INF.4	Burnett, J.D., Lemos, L., Barlow, D., Wing, M.G., Chandler, T. and Torres, L.G. (2018) Estimating morphometric attributes of baleen whales with photogrammetry from small UASs: A case study with blue and gray whales. Marine Mammal Science., 35 (1): 108: https://doi.org/10.1111/mms.12527. This paper comes with a suite of three programs (in Matlab and R) to conduct the morphometric analysis. The zip file containing the code is available. A 'how to' video is available at https://mmi.oregonstate.edu/gemm-lab/research-projects/application-unmanned-aerial-systems-uas-%E2%80%9Cdrones%E2%80%9D-assess-whale-body	English	Public

[11] Available on the public WGWAP Recommendations Database, accessible via https://www.iucn.org/western-gray-whale-advisory-panel/recommendations or directly at https://portals.iucn.org/wgwap

PhID/NT-1/INF.5	Christiansen, F., Rojano-Doñate, L., Madsen, P. T., & Bejder, L. (2016). Noise levels of multi-rotor unmanned aerial vehicles with implications for potential underwater impacts on marine mammals. Frontiers in Marine Science, 3, 277.	English	Public
PhID/NT-1/INF.6	Colefax, A. P., Butcher, P. A., Kelaher, B. P., & Browman, H. editor: H. (2017). The potential for unmanned aerial vehicles (UAVs) to conduct marine fauna surveys in place of manned aircraft. ICES Journal of Marine Science, 75(1), 1–8	English	Public
PhID/NT-1/INF.7	Dawson, S.M, Hamish Bowman, M., Leunissen, E. and Sirguey, P. (2017). Inexpensive Aerial Photogrammetry for Studies of Whales and Large Marine Animals. Front. Mar. Sci. 4:366. https://doi.org/10.3389/fmars.2017.00366	English	Public
PhID/NT-1/INF.8	Durban, J. W., Fearnbach, H., Barrett-Lennard, L. G., Perryman, W. L., & Leroi, D. J. (2015). Photogrammetry of killer whales using a small hexacopter launched at sea. Journal of Unmanned Vehicle Systems, 3(3), 131–135	English	Public
PhID/NT-1/INF.9	Hodgson, A., Kelly, N., & Peel, D. (2013). Unmanned Aerial Vehicles (UAVs) for Surveying Marine Fauna: A Dugong Case Study. PLOS ONE, 8(11), e79556. https://doi.org/10.1371/journal.pone.0079556	English	Public
PhID/NT-1/INF.10	Hodgson, A., Peel, D., & Kelly, N. (2017). Unmanned aerial vehicles for surveying marine fauna: assessing detection probability. Ecological Applications, 27(4), 1253–1267	English	Public
PhID/NT-1/INF.11	Koski, W. R., Thomas, T. A., Funk, D. W., & Macrander, A. M. (2013). Marine mammal sightings by analysts of digital imagery versus aerial surveyors: a preliminary comparison. Journal of Unmanned Vehicle Systems, 01(01), 25–40. https://doi.org/10.1139/juvs-2013-0015	English	Public
PhID/NT-1/INF.12	Nowacek, D.P., Christiansen, F., Bejder, L., Goldbogen, J.A. & Friedlaender, A.S. (2016). Studying cetacean behaviour: new technological approaches and conservation applications. Animal Behaviour 120: 235-244	English	Public
PhID/NT-1/INF.13	Torres, L.G, Nieukirk, S.L, Lemos, L. & Chandler, T.E. (2018). Drone Up! Quantifying Whale Behavior From a New Perspective Improves Observational Capacity. Front. Mar. Sci. 5:319. doi: 10.3389/fmars.2018.00319 Note from L.Torres: the supplementary material includes a video compilation of examples of the gray whale behaviors we documented using the drone. This can be viewed here: https://oregonstate.app.box.com/folder/51786638610	English	Public