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ABSTRACT

While gray whales (*Eschrichtius robustus*) have traditionally been considered to be separated in two populations, one in the western North Pacific (WNP) and the other in the eastern North Pacific (ENP), we provide recent sightings of WNP gray whale in Baja California, Mexico during the winter breeding season. Historical evidence indicates that the South China Sea may have been used as a wintering ground in the WNP while for ENP the Baja California Peninsula, Mexico is the main breeding and calving area during the winter. In recent years , research including: photo-identification, telemetry and genetics has shown some degree of mixing between populations. Here, we present an update from a multinational effort to show the movements of gray whales identified in WNP feeding grounds and ENP breeding ground in Mexico. Images of 378 whales identified on the summer feeding grounds off Russia (229 from Sakhalin; 63 from Kamchatka and 86 registered in both areas), were compared to 11,000 individuals (right flank photo-ID images) photographed in the wintering lagoons of Baja California, Mexico (1540 from Laguna Ojo de Liebre; 5857 from Laguna San Ignacio; and 3603 from Bahia Magdalena). A total of 48 matches of WNP and ENP gray whales were found, including 21 females, 14 males, and 13 whales of unknown sex: matches included 13Sakhalin/Kamchatka-Mexico, 28 Sakhalin-Mexico, and 7 Kamchatka-Mexico. Movements between the WNP and ENP represents 12.6% of gray whales identified off Sakhalin Island and Kamchatka, and the 0.4% of the gray whales identified in the breeding lagoons of Baja California peninsula Mexico. From the 48 gray whales that have migrated between WNP and Mexico, 16 of them have migrate to Mexico at least twice in different years (range from 2 to 5 migrations).

INTRODUCTION

The gray whale (*Eschrichtius robustus*) has been historically considered to consist of two extant populations, the western North Pacific (WNP) and eastern North Pacific (ENP) populations (Reilly et al., 2008). The ENP population ranges from calving areas off Baja California, Mexico, to feeding areas in the Bering, Beaufort, and Chukchi Seas. The WNP population feeds in the Okhotsk Sea off Sakhalin Island, Russia, and in nearshore waters of the southeastern Kamchatka Peninsula. Historical evidence indicates that areas in the South China Sea were used by the WNP whales as wintering grounds (Weller et al. 2002). The WNP population is listed as critically endangered whereas the ENP population has recovered and numbers between 20,000-25,000 individuals, and is of least concern (Reilly et al., 2008). Both populations were extensively harvested during commercial whaling (Henderson 1984, Weller et al. 2002, Reeves et al. 2010). The ENP population is currently estimated at 19,126 (cv= 0.071) individuals (Laake et al. 2009. The most recent assessment of the WNP population in the Okhotsk Sea (Sakhalin Island + east coast of Kamchatka), using a Bayesian individual-based stage-structured model, resulted in a median 1+ (non-calf) estimate of 321-412 individuals, and 130-170 individuals for the Sakhalin feeding whales in 2016 (95% confidence interval) (Cooke et al. 2016).

Research on gray whales in the WNP has been ongoing since 1995, predominantly on the primary feeding ground off northeastern Sakhalin Island, including the Piltun area (52°20' N–53°30' N), stretching 120 km along the shore of Piltun Bay, and the Offshore area, located further offshore from Chayvo Bay (51°40' N–52°20' N) (Weller et al. 1999, 2012; Bradford et al., 2008; Yakovlev et al., 2009; Lang et al. 2011), and more recently off southeastern Kamchatka (Vertyankin et al. 2004, Tyurneva et al. 2010, Burdin et al. 2011). These studies monitor gray whales using photoidentification methods, as gray whales are individually identifiable based on unique, permanent pigmentation features (Darling 1984). Researchers have documented a pronounced seasonal site fidelity and inter-annual return of known individuals in the Sakhalin coasts (Weller et al. 1999, 2002, Bradford 2011); as well as movements of individuals, including reproductive females and calves, between the coastal waters off Sakhalin and the southern and eastern coast of Kamchatka (Tyurneva et al. 2010, 2018; Burdin et al. 2011).

Current data from the historical migratory corridor(s) of the WNP are limited, and data from the presumed wintering area(s) are essentially unavailable (Weller et al. 2012). There is only one known photographic match of a fatally entrapped female in set nets along the Pacific coast of Honshu, Japan in January 2007 that was photographed as a calf in Sakhalin feeding ground in July and August 2006 (Weller et al. 2008). Lang (2010) reported that two adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes of 2 whales sampled off Santa Barbara, California, USA. This report was the first to suggest that some level of interchange might be occurring between the WNP and ENP.

During the summers of 2010 and 2011, seven adult gray whales were radio (satellite?) tagged in Sakhalin Island, and three of the tags transmitted long enough to document the whales' migration routes. These three whales went across the Bering Sea to the Gulf of Alaska, one of them, "Varvara," traveled south within 103 km of Cabo San Lucas, Baja California Sur, México, and return to Sakhalin Island after 172 days of tagging (Mate et al., 2015). Using comparison of photo-

identified gray whales, Weller et al. (2012) reported the first ten matches between the WPN and ENP; six between whales photographed in Sakhalin Island and Vancouver Island, Canada, and four between Sakhalin Island and San Ignacio Lagoon, Mexico. Following a recommendation of the Scientific Committee of the International Whaling Commission, Urbán et al. (2012; 2013) reported the results of a collaborative North Pacific wide study on population structure and movement patterns of North Pacific gray whales that identified 23 photographic matches between the WNP and the breeding lagoons from the Baja California Peninsula, Mexico. Here we present an update on trans-Pacific movements of gray whales photo-identified in WNP and the whales' Mexican breeding grounds.

METHODS

The catalogues from WNP were merged and compared to identify all the individual whales from that area.

Similarly, the catalogues from the three breeding areas in Mexico, were compared by area (among years) to identify the total number of whales identified in each area, however, photographs from each area were not compared with each other (Ojo de Liebre Lagoon, San Ignacio Lagoon, and Bahia Magdalena-Bahia Almejas complex were analyzed separately). Therefore, there are individual whales that are contained in more than one catalogue (recaptures between breeding areas), and thus the total number of individual whales in Mexico is overestimated.

For this project we only used images of the whales' right flanks. Comparison of images was facilitated by the use of the matching software "Hotspotter" (http://www.cs.rpi.edu/hotspotter/). All of the comparisons conducted twice: first Mexican vs Russian, and then Russian vs Mexican photographs, because sometimes this software cannot always find match in each one way comparison, depending on the photo-id quality.

The comparison was made based on the following sources: Russia:

Sakhalin Island:

• Burdin, M.A., Weller W. D., Sychenko, A.O. and Bradford, L.A. Western gray whales off Sakhalin Island, Russia: A catalog of photo-identified individuals. (1994-2016) 261 individuals. (WGW)

• Tyurneva. Y.O. and Yakovlev, M.Y. The Western Pacific gray whales of Sakhalin Island Photo Identification Catalogue (2002-2017). 283 individuals. (KOGW)

Kamchatka Peninsula:

• Tyurneva, O. and Vertyankin, V. The North Pacific Master gray whale catalogue (2004-2011). 150 ids. 149 individuals. (KamGW)

Mexico (Fig 2):

▪ *Conner. L. and Hillman E. Studies Field School Gray whale photo ID catalog (1998- 2010). Bahía Magdalena. 233 individuals.*

▪ *Catalogues from Bahía Magdalena and Bahia Almejas. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2012- 2022). 3603 individuals.*

▪ *Catalogues from Laguna San Ignacio. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2005-2022). 5857 individuals.*

▪ *Catalogues from Laguna Ojo de Liebre. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2001-2003, 2013-2015). 1540 individuals.*

RESULTS

The comparison among the three catalogs from Russia (315 from Sakhalin; 149 from Kamchatka) result in: 229 individual whales from Sakhalin, 63 from Kamchatka, and 86 from both Sakhalin and Kamchatka, with a total of 378 photo-identified individual whales from Russia. These 378 whales from Russia were compared to 11,000 individuals' photo-identified in the wintering lagoons of Baja California, Mexico (1540 from Laguna Ojo de Liebre; 5857 from Laguna San Ignacio; and 3603 from Bahia Magdalena-Bahia Almejas). A total of 48 matches were found, and consisted of 21 females, 14 males, and 13 whales of unknown sex (Table 2).

From the total of matches, 13 were between Sakhalin/Kamchatka-Mexico, 28 Sakhalin-Mexico, and 7 Kamchatka-Mexico. In addition, there were matches between the two feeding areas from the WNP, and between the three breeding areas in Mexico, except between Kamchatka and Ojo de Liebre Lagoon (Table 1).

Of the 48 whales marched between WNP and the Mexican breeding grounds, 32 have been confirmed migrating to Mexico at least once; 8 migrating twice (different years); 5 migrating 3 times; 2 migrating 4 times and one migrated to Mexico in 5 times in different years (Table 2).

During the last 23 years, 18 female whales from the Western Pacific have been seen with a calf in the breeding grounds in Mexico, and they represent an important proportion of the reproductive capacity of the WNP population (Table 2). Of these, 10 females have been seen with one calf, 4 females with two different calves, and 3 females with three different calves, resulting in a total of 28 calves, increasing the recruitment of new individuals into that population.

The oldest confirmed record of a migration between the WNP and Mexico reported in this paper is from a1999 sighting, however the catalog from that year was not included for this update; this record came from a recapture data base belong to PRIMMA-UABCS.

In 2022, we photographed 6 whales from WNP in Mexico; 2 of them in Laguna San Ignacio, and 4 in Bahía Magdalena-Bahia Almejas, two of which were documented in Mexican waters for the first time.

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Tables and Figures

Table 1. Number of recaptures between WNP feeding areas: Sakhalin (SAK) and Kamchatka (KAM) and Mexican breeding and calving areas: Ojo de Liebre lagoon (LOL), Laguna San Ignacio (LSI) and Bahia Magdalena-Bahia Almejas complex (BM).

	LOL	LSI	BM	LSI/BM	LSI/LOL	BM/LOL	LOL-LSI-BM	MEXICO
SAKHALIN	6	15	5	2	---	---	---	28
KAMCHATKA	0	4	3	0	---	---	---	7
SAK-KAM	1	8	2	2	---	---	---	13

Tabla 2. Recaptures between WNP feeding areas and Mexican breeding and calving areas (ENP). Mc: Mother with calf, S: Single (Male or Female without a calf). Sex codes are M (Male); F (Female); --- (unknown). Letter with black color (year columns) are from San Ignacio lagoon; blue color for Bahia Magdalena-Bahia Almejas and red color for Ojo de Liebre lagoon.

UABCS-LSIESP (Mexico) 2001-2022 and SFS 1998-2010	Burdin-Weller et al (Sakhalin 1994-2016)	lTyurneva y Yakovlev (Sakhalin 2002-2017)	Id. Tyurneva y Yakovlev (Kamchatka 04-11)	SEX	1999	2001	2002	2003	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
99-0186-D-LSI	WGW-052	KOGW 026	---	M	S						S			S											S	
01-0517-D-LOL	WGW-076	KOGW 062	---	F		S																					
02-0336-D-LOL	WGW-027	KOGW 002	---	M			S																				
03-0195-D-LOL-M	WGW-087	KOGW 040	Kam GW 113	F				Mc																			
03-0291-D-LOL-M	WGW-030	KOGW 008	---	F				Mc																			
05-0446-D-LSI	WGW-082	KOGW 025	Kam GW 132	M					S																		
06-0131-D-LSI	WGW-028	KOGW 059	Kam GW 122	M						S																	
06-0132-D-LSI	WGW-094	KOGW 057	---	---						S																	
06-0176-D-LSI	WGW-069	KOGW 113	---	M						S																	
06-0209-D-LSI	WGW-020	KOGW 080	---	M						S																	
SFS182	WGW-033	KOGW 116	---	M							S																
07-0457-D-LSI	WGW-103	KOGW 119	---	F							S				Mc												
08-0051-D-LSI-M	WGW-085	KOGW 051	---	F								Mc		S		Mc			Mc				S				
08-0107-D-LSI-M	WGW-063	KOGW 047	Kam GW 013	F								Mc										Mc/Mc					
09-0022-D-LSI	WGW-084	KOGW 029	---	M									S					S							S		
09-0506-D-LSI	---	KOGW 166	Kam GW 015	---									S														
09-0696-D-LSI-M	WGW-042	KOGW 090	Kam GW 001	F									Mc			S						S					
10-0739-D-LSI-M	WGW-029	KOGW 028	Kam GW 045	F										Mc									Mc				Mc
11-0267-D-LSI	WGW-207	KOGW 212	---	F											S		Mc				Mc						S
11-0273-D-LSI	WGW-091	KOGW 137	Kam GW 042	M											S								S				
11-0308-D-LSI	---	---	Kam GW 036	---											S												
11-0362-D-LSI	---	---	Kam GW 134	---											S												
11-0416-D-LSI	WGW-110	KOGW 132	Kam GW 002	M											S												S
11-0505-D-LSI-M	WGW-003	KOGW 114	---	F											Mc												
12-0272-D-BM	---	---	Kam GW 114	---												S	S										
12-0229-D-LSI-M	---	---	Kam GW 117	F												Mc											
12-0436-D-LSI	WGW-047	KOGW 009	---	M												S											
12-0551-D-LSI	WGW-200	KOGW 191	---	---												S											
13-0096-D-LOL-M	WGW-107	KOGW 108	---	F													Mc										
14-0013-D-LOL-M	---	KOGW 122	---	F														Mc									
14-0039-D-LOL	WGW-050	KOGW 100	---	---														S									
14-0734-D-LSI-M	---	---	Kam GW 106	F														Mc			Mc						

15-0397-D-LSI-M	WGW-092	KOGW 015	---	F	Mc							
15-0482-D-LSI-M	WGW-116	---	---	F	Mc							
15-0560-D-LSI-M	WGW-206	KOGW 204	---	F	Mc							
16-0043-D-BM-M	WGW-038	KOGW 064	Kam GW 060	F		Mc			Mc			
17-0201-D-BM	WGW-252	---	---	---			S					
17-0282-D-LSI	WGW-112	KOGW 081	---	M			S					
17-0628-D-LSI-M	WGW-001	KOGW 007	---	F			Mc		Mc			
18-0086-D-LSI	WGW-135	KOGW 095	Kam GW 008	F				S				
19-0197-D-BM	WGW-181	KOGW 172	---	---					S			
19-0466-D-LSI	WGW-068	KOGW 043	Kam GW 118	M					S		S	
20-0467-D-LSI	WGW-202	KOGW 201	---	---						S		
21-0014-D-BM	WGW-037	KOGW 048	Kam GW 071	---							S	S
21-0253-D-BM	WGW-096	KOGW 087	---	M							S	
21-0394-D-BM	WGW-019	KOGW 063	---	F							S	
22-0113-D-BM	---	---	Kam GW 073	---								S
22-0589-D-BM	---	---	Kam GW 017	---								S