SC/68C/ASI/02

Sub-committees/working group name: ASI

HUMPBACK WHALE BREEDING STOCK G: UPDATED POPULATION ESTIMATE BASED ON PHOTO-ID MATCHES BETWEEN BREEDING AND FEEDING AREAS

Fernando Félix1, Jorge Acevedo2, Anelio Aguayo-Lobo3, Isabel C. Ávila4, Natalia Botero-Acosta5, Andrea Calderón6, Benjamín Cáceres7, Juan Capella8, Romina Carnero9, Cristina Castro10, Ted Cheeseman11, Luciano Dalla Rosa12, Natalia Dellabianca13, Judith Denkinger14, Ari Friedlaender15, Héctor Guzmán16, Ben Haase17, Daniela Haro18, Rodrigo Hucke-Gaete19, Martha Llano20, Lenin Oviedo21, Aldo Pacheco22, Juan Pacheco21, Daniel M. Palacios23, José Palacios-Alfaro24, Logan Pallin15, María José Pérez25, Kristin Rasmussen26, Cristina Sanchez-Godinez27, Luis Santillán28, Eduardo Secchi12, Mónica A. Torres13, Edgar Vásquez29

HUMPBACK WHALE BREEDING STOCK G: UPDATED POPULATION ESTIMATE BASED ON PHOTO-ID MATCHES BETWEEN BREEDING AND FEEDING AREAS

Fernando Félix[1], Jorge Acevedo[2], Anelio Aguayo-Lobo[3], Isabel C. Ávila[4], Natalia Botero-Acosta[5], Andrea Calderón[6], Benjamín Cáceres[7], Juan Capella[8], Romina Carnero[9], Cristina Castro[10], Ted Cheeseman[11], Luciano Dalla Rosa[12], Natalia Dellabianca[13], Judith Denkinger[14], Ari Friedlaender[15], Héctor Guzmán[16], Ben Haase[17], Daniela Haro[18], Rodrigo Hucke-Gaete[19], Martha Llano[20], Lenin Oviedo[21], Aldo Pacheco[22], Juan Pacheco[21], Daniel M. Palacios[23], José Palacios-Alfaro[24], Logan Pallin[15], María José Pérez[25], Kristin Rasmussen[26], Cristina Sanchez-Godinez[27], Luis Santillán[28], Eduardo Secchi[12], Mónica A. Torres[13], Edgar Vásquez[29]

[1] Pontificia Universidad Católica del Ecuador (PUCE). Av. 12 de Octubre y Roca, Quito, Ecuador.
[2] Centro de Estudios del Cuaternario de Fuego-Patagonia y Antártica (CEQUA). Av. España 184, Punta Arenas, Chile.
[3] Instituto Antártico Chileno (INACH). Plaza Muñoz Gamero 1055, Punta Arenas, Chile.
[4] Universidad del Valle. Ciudad Universitaria Meléndez, Calle 13 N°100-00, Cali, Colombia.
[5] Fundación Macuáticos. Calle 27 N°79-167, Medellín, Colombia.
[6] Biology Department, City College of New York, New York, New York 10031, USA.
[7] Museo de Historia Natural de Río Seco. Punta Arenas, Chile.
[8] Whalesound Ltda. Lautaro Navarro 1163, Punta Arenas, Chile.
[9] Pacific Adventures-Manejo Integral del Ambiente Marin S.A.C. Los Órganos, Perú.
[10] Pacific Whale Foundation. Malecón Julio Izurieta y Abdón Calderón, Puerto López, Ecuador.
[11] Happywhale, Columbia St, Santa Cruz, California, USA and Southern Cross University, Lismore, Australia.
[12] Universidade Federal do Rio Grande (FURG). Av Itália km 8 s/n, Campus Carreiros, Río Grande, Brasil.
[13] Centro Austral de Investigaciones Científicas (CADIC). Bernardo Houssay 200, Ushuaia, Argentina.
[14] Universidad San Francisco de Quito. Calle Pampite e Interoceánica, Quito, Ecuador.
[15] Institute of Marine Science, University of California Santa Cruz, Santa Cruz, A, USA.
[16] Smithsonian Tropical Research Institute. PO Box 0843-03092, Panamá, Panamá.
[17] Museo de Ballenas. Av. Enríquez Gallo entre calles 47 y 50 Salinas, Ecuador.
[18] Centro Bahía Lomas, Facultad de Ciencias,Universidad Santo Tomás. Avenida Costanera 01834, Punta Arenas, Chile.
[19] Universidad Austral de Chile (UACH). Valdivia, Chile.
[20] Proyecto Resiliencias. Tv 46 c #42 a este 480, Vía amor y amista # 645, Medellín, Colombia.
[21] Centro de Investigación de Cetáceos de Costa Rica (CEIC). San José, Costa Rica.
[22] Universidad de Nacional Mayor de San Marcos, Av. Universitaria s/n, Lima, Perú.
[23] Marine Mammal Institute, Oregon State University, Newport, Oregon USA.
[24] Fundación de Investigación y Conservación Marina-Costera (KETO). Mariposario, Uvita, Osa, Puntarenas, Costa Rica.
[25] Centro de Investigación Eutropia. Valparaíso, Chile.
[26] Panacetacea. 1554 Delware Ave, St Paul, MN 55118 USA.
[27] Fundación MARVIVA. Rohrmoser San José, Costa Rica
[28] Centro Peruano de Estudios Cetológicos. Lima, Perú.
[29] Fundación Omacha. Calle 84 No. 21-47, Bogotá, Colombia.

ABSTRACT

We report a new mark-recapture-based population estimate for the humpback whale Breeding Stock G (BSG), defined by breeding grounds on the northwestern coast of South America and southwestern Central America and feeding grounds around the Antarctic Peninsula and southern Chile. Photographic fluke catalogs from 23 research groups working in both breeding and feeding areas were compiled in the largest photo-ID matching effort ever made for this stock. A total of 6,354 unique individuals including 1,698 (26.7%) from feeding areas and 4,656 (73.3%) from breeding areas covering the period 1991-2018 were used for this purpose. The dataset was fitted to closed population models to estimate population size and Jolly-Seber models to estimate apparent survival, both implemented in the software Mark. Mixture models with two different data types, full likelihood and conditional likelihood, produced similar results of 11,784 and 11,786 (SE = 266 for both estimates) whales, respectively. In both cases, a model with two mixtures {M_{th2}} provided the best fit. Two Cormack-Jolly-Seber with Pledger mixtures models produced apparent survival estimates for the two mixtures (0.924 and 0.959, SE = 0.003 and 0.008; respectively). The new population estimate is 181% higher than a previously obtained in 2006. The annual rate of increase in the 27-year study period was 5.07%. Sources of bias were associated with effort heterogeneity, population stratification and the time scale. These and other sources of bias should be considered in future modeling estimates.

KEYWORDS: humpback whale, breeding grounds, feeding grounds, abundance estimate, apparent survival, Southeast Pacific, Antarctic Peninsula.

INTRODUCTION

The humpback whale (*Megaptera novaeangliae*) Breeding Stock G (BSG) also referred to as the Southeast Pacific Stock, is one of the seven stocks of this species in the Southern Hemisphere recognized by the International Whaling Commission (IWC, 2006). BSG whales breeding off the northwestern coast of South America between northern Peru and southern Nicaragua in Central America (Flórez-González, 1991, Félix et al., 2001a, Rasmussen et al., 2007, Pacheco et al., 2009, DeWeerdt et al., 2020) are connected to three discrete feeding areas (Acevedo et al., 2013) located around the Antarctic Peninsula (e.g., Stevick et al., 2004, Acevedo et al., 2017, Rasmussen et al., 2007) and central and southern Chile (e.g., Acevedo et al., 2007, 2017; Hucke-Gaete et al. 2013). The BSG is the most genetically differentiated stock in the Southern Hemisphere (Olavarría et al., 2007; Amaral et al., 2016), despite some connections found through photo-ID and genetic studies with other stocks breeding off Brazil and Oceania (Stevick et al., 2013; Steel et al., 2017; Félix et al., 2020), suggesting complex migratory and connectivity dynamics among the southern stocks.

The first attempts to estimate the size of the BSG with mark-recapture models date from studies in the mid-1990s, based on local studies on the central coast of Colombia (Capella et al., 1998; N =1,120-2,190), Ecuador (Scheidat et al. 2000; Felix and Haase, 2001b; N = 405, 95% CI 221-531, and N = 2,683 (95% CI = 397-4,969), respectively), Panamá (Guzmán et al., 2015; N = 221, 95% CI = 170-290) and around the Antarctic Peninsula (Stevick et al., 2006; N = 3,851, 95% CI 3,666-4,036). Efforts continued in Ecuador, where most of the research effort of this whale population has been concentrated for many years. Off Ecuador, based on a 16 years dataset, the population of the BSG was estimated at 6,504 individuals (95% CI 4,270-9,907) in 2006 with the Petersen model modified by Chapman (Félix et al., 2011a). During that time, an attempt was also made to estimate the survival rate using the Jolly-Seber model for open populations, obtaining lower than expected values due to different sources of heterogeneity in the dataset. Such heterogeneity would be related not only to an irregular effort between years but also to aspects associated with the whales´ migratory behavior and repeated monitoring in the same area (Félix et al., 2011a).

Recent satellite tagging studies in Ecuador and Panama showed that the BSG is highly spatially structured on the breeding grounds (Guzmán and Félix, 2017), supporting previous findings through genetic studies (Félix et al., 2012) and photo-ID (Acevedo et al., 2007, 2013, 2017, Valdivia et al., 2017). This structure is also consistent with lower population estimates from central and northern sites of the breeding grounds, from Colombia north (e.g. Flórez-González, 1991, Guzmán et al., 2015) compared to those obtained in Ecuador, which is both a breeding ground and migratory corridor. A more reliable population estimate of the BSG should integrate information from multiple sites, both in the breeding and feeding areas, to deal with spatial structure.

IWC-SC 66 recommended a collaborative photo-ID approach to humpback whales in the Southeast Pacific, integrating data from multiple research programs across the full range of the BSG (Jackson et al., 2016). This is now possible through the integration of datasets gathered over the last 25 years – some based on whale-watching tourism – along the west coast of Central and South America and around the Antarctic Peninsula. During the biennial meeting of the Latin American Society of Aquatic Mammals, SOLAMAC, in December 2016, a workshop on a collaborative approach to carrying out a new abundance estimate on the BSG was convened (IWC, 2017a, b). In this context, we report preliminary BSG abundance and survival estimates resulting from these efforts.

MATERIALS AND METHODS

Data sources

Humpback whale monitoring programs have been established in all countries throughout the Southeast Pacific region since 1990, comprising from 11°N to 65°S (Figure 1). Throughout 2017 and 2018, we compiled, reconciled, and compared photo-ID catalogs and capture-recapture histories from 23 research groups (see Appendix 1). A total of 8,451 fluke images taken between 1991 and 2018 were collated, of which 1,961 (23.2%) came from the three feeding areas and southern migratory corridor off central Chile and 6,490 (76.8%) from breeding areas. The number of images of unique whales received per year from each research group is shown in Table 1.

Image selection

Images were graded as a high-, medium- or low-quality for the analysis based on five criteria: 1) exposure/contrast/illumination; 2) angle of the fluke in relation to the surface of the water; 3) lateral angle of the fluke with respect to the photographer; 4) focus and sharpness; and 5) visible proportion of the flukes. Both high- and medium-quality images were included in the analysis. After selection, 6,474 images (76.6% of the total compiled photographs) were selected. Each photograph was pre-treated (lighting and contrast) and trimmed, leaving only the fluke.

Matching process

The process of image matching within and among the photo-identification catalogs started with the post-treatment images by the use of the HotSpotter recognition software version 1.0 (Crall et al., 2013), scoring the likelihood of potential matches based on a combination of the SIFT algorithms of Wild-ID (Lowe 2004) and a "local naïve Bayes nearest-neighbor algorithm". To reduce bias, both the selection and the matching process were carried out by the same person, who was experienced in matching humpback whale photographs (JA). First, the photographs within each catalog were compared internally to eliminate potential duplicate whales (N = 120 individuals). Then, the catalogs were compared to each other, allowing us to build capture-recapture histories. A second comparison process was carried out later using the automated image recognition algorithm hosted at the Happywhale web-based platform (https://happywhale.com/home, Cheeseman et al., in press), which allowed the detection of additional matches not found in the first comparison process.

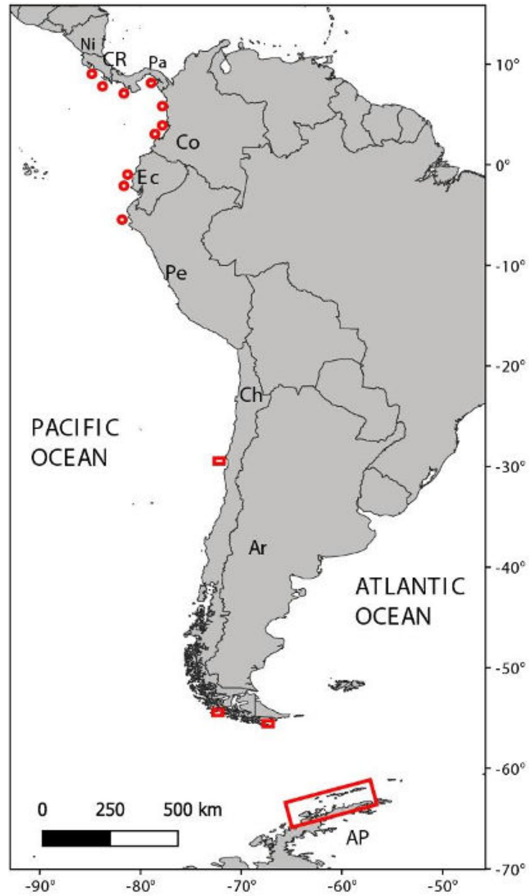

Figure 1. Area of distribution of the Breeding Stock G and sampling sites. Red circles are breeding sites and red squares feeding areas.

Recapture rates

Recapture rates for each sampling area in both breeding and feeding grounds were calculated for those datasets with more than 100 individuals by dividing the number of different recaptured individuals by the total number of individuals identified. Individuals with low-quality images were excluded.

Population abundance

Two different modeling approaches to estimate abundance open and closed populations are commonly used with data from mark-recapture studies. Open population models allow gains from immigration and births and losses from emigration and mortality, while closed population models consider the population to be constant during the study period (Seber and Schwarz, 1999). Both approaches assume conditions of equal and consistent capture probability across all sampling periods, such as unique, permanent correctly recorded marks that do not affect catchability (Hammond, 2010). The violation of such assumptions may lead to biased estimates.

For the analyses, capture-recapture histories of the 5,197 individuals were constructed using the binary sequence "1" and "0", where "1" indicates that the individual was observed during that sampling period and "0" indicates that the individual was not observed in that sampling period (Cooch and White, 2009). The complete dataset corresponds to 28 sampling periods (1991-2018). Individuals recorded at breeding and feeding grounds in the same year were included in the same sampling period to achieve a larger sample. Because of the small effort with few identified individuals in the first five years (1991-1995), data were pooled in one single period. Thus, 24 annual periods were used for the analysis. Open and closed population models were fitted to estimate abundance using program Mark 9.0 (White and Burnham, 1999).

The fourteen models for closed populations implemented in Mark are divided into two main data types "full likelihood" (Otis et al, 1978) and "conditional likelihood" (Huggins, 1989). Full likelihood models take into account the probability of an individual not being observed or captured, that is, the scenario "000" is given, while the conditional likelihood models eliminate this scenario from their calculations. Full likelihood models are based on the parameterization of three types of parameters: 1) p = the probability that an animal in the population is captured and marked for the first time; 2) c = the probability that an individual has been captured at least once before; and 3) f_0 = the number of individuals in the population that have not been counted. Conditional likelihood models are restricted to the number of animals detected; therefore, f_0 is not taken into consideration and only includes the parameters p and c. An advantage of the conditional likelihood approach is that covariates can be used to model the encounter process.

Four of the fourteen models belonged to a group called heterogeneity models, which contain an additional parameter to p and c called mixture parameter pi (π), which calculates the heterogeneity that exists between individuals at the time of capture. The following six models incorporated another parameter that considers the probability of identifying an individual correctly in its first observation "α". Finally, there were the four Huggins models with parameters "p" and "c" with random effects that use numerical integrations to add individual differences in the match probabilities.

Closed population models in Mark used the following notations:

M_0: probability that an animal is captured and marked for the first time (p) remains constant.
M_t: probability that an animal is captured and marked for the first time (p) varies with time.
M_b: response of the behavior of individuals.
M_h: probability that an animal is captured and marked for the first time (p) is heterogeneous.
M_{h2}: probability that an animal is captured and marked for the first time (p) is heterogeneous, and the population comprises a mixture of two types of animals.

Mark chooses the most parsimonious model based on the Akaike information criterion (AIC), where the model with the lowest value (AICc or AICweight) is the one that best fits the data (Freitas and Marino 2012). Since AICc values between full likelihood and conditional likelihood models are not comparable, the analyses were conducted separately.

Apparent survival

Apparent survival Phi (φ) was estimated using Jolly-Seber models for open populations implemented in Mark. We fitted 105 different models to the data using the different formulations implemented in Mark: *POPAN*, Link-Barker, Pradel-recruitment, Burnham JS, and Pradel-λ. The difference among such formulations is the way they parameterize new entrants to the population.

Table 1. Information compiled in this study of the different research groups in the Southeast Pacific and Antarctic Peninsula, number of fluke images per site and sampling period (year), for the period 1991-2018. Numbers in the table indicate new individuals discovered in the season by each research group.

Contributor	Site	Total	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Feeding ground																														
INACH	Antarctic Peninsula	276					23	40	46	19	38							55	10	45										
PROANTAR	Antarctic Peninsula	766				2				53	60	21	65	106	51	17	22	13	21	1	53	18	26		57	54	51	75		
AF	Antarctic Peninsula	256																			21	33		10	38	69	85			
CEQUA_ANT	Antarctic Peninsula	38																				38								
MHNRS	Antarctic Peninsula	17																										6	11	
OTROS_ANT	Antarctic Peninsula	105																	2	7	28	11			55			2		
MBS_ANT	Antarctic Peninsula	9		1																							8			
ACMA	Antarctic Peninsula	35																											35	
CHAC	Chañaral - Chile	10																					2		1	5	1		1	
EUTROPIA	Chañaral - Chile	15															1		2	3	1					4	2		2	
CBA	Corcovado Gulf - Chile	41													2	1	2	15	3	2	4	4	1	7						
CEQUA	Magellan St. - Chile	177													11	27	29	16	10		3	8	10	24		2	21	16		
EMA	Magellan St. - Chile	178									18	3	6	7	12	10	7	12	17	10	8	10	7	11	9	5	14	12		
CADICCB	Beagle Ch.- Argentina	37																							3		2	3	8	21
Breeding ground																														
KETO	Osa Pen.- Costa Rica	130															2	11	13	1	7	19	9	9	37	22				
PAN	Costa Rica	41			1		1				3		10	9	1	1			15											
CEIC	Dulce G.- Costa Rica	30																				8	1	2	13	1	1	4		
PAN	Chiriqui G.- Panama	552												5	8	4		4	34	28	34	12	35	79	106	126	77			
PMA-LP	Las Perlas Arch.- Panama	173													12	8	22	51	31		2		4	8	6	2	7	9		11
PAN-CONT	Panama	18																					18							
ICA	Solano and Malaga Ba.- Colombia	42															6	11		4	3	8	4	3	3					

BGT	Tribuga G.- Colombia	543																				16			127	98	66	236		
SENTIR	Tribuga G.- Colombia	36												7	3	26														
EC	North/Central Ecuador	628						24		7	8	14	82	96	65	143	57	4		10	7	3	4	26	4	12	39	23		
PWF	Machalilla- Ecuador	1468						20	12	26	23	13	60	88	111	237	258	159	178	283										
MBS	Salinas- Ecuador	2157	8	13	1	15	29	79	70			3		69	88	132	183	266	284	252	158	229	37	48	65	56	38	34		
MBS	Perú	2																2												
MBS	Panama	2																							2					
PAO	Los Órganos - Perú	650																			13	34	16	96	111	84	131	165		
CEPEC	Sechura - Perú	18																1			13	4								
TOTAL		**8451**	**8**	**14**	**2**	**17**	**53**	**163**	**128**	**105**	**150**	**54**	**223**	**387**	**364**	**606**	**589**	**620**	**620**	**646**	**355**	**455**	**174**	**323**	**637**	**540**	**543**	**585**	**57**	**32**

RESULTS

Recapture rates

Recapture rates were highly variable within the dataset in both feeding and breeding areas (Table 2). Major datasets from Antarctic Peninsula (n=3) ranged between 0.025 to 0.048 and the number of recaptures per individual between 1.0 and 1.16, but in the continental feeding area (Magellan Strait), the recapture rate was six times higher on average (0.645 and 0.765, CEQUA and Whalesound, respectively). High variability was also found in the breeding grounds datasets where the recapture rate ranged between 0.026 to 0.194 and the number of recaptures per individual between 1 and 1.38.

The overall comparison process resulted in 5,197 unique individuals. A total of 2,329 recaptures of 1,176 whales across catalogs were found. The overall recapture rate was 0.226 and the number of recaptures per individual was 1.98 (range 1-16) on average.

Table 2. Calculated recapture rates of individual datasets from feeding and breeding areas containing more than 100 individuals.

Research group	No. Individuals	No. Recaptured individual	Recapture rate	No recaptures/ individual
<u>Feeding areas</u>				
INACH	227	6	0.026	1.00
Proantar-Furg	608	29	0.048	1.07
Institute of Marine Science UCSC	255	6	0.025	1.16
Fundación CEQUA-Magallanes	169	109	0.645	4.09
Whalesound	161	121	0.765	6.22
<u>Breeding areas</u>				
Panacetacea	485	80	0.165	1.33
KETO	112	3	0.026	1.33
MBS	1541	173	0.112	1.21
Macuático	425	15	0.035	1
Pacific Adventure	551	26	0.047	1.07
UFSQ	257	50	0.194	1.38
Héctor Guzmán	135	4	0.029	1.25
Pacific Whale Foundation	1045	86	0.082	1.24

Population abundance estimates

Abundance estimates obtained with open population models did not reach numerical convergence or produced unrealistic estimates due to the spatial and temporal structure of the data and high heterogeneity resulting from uneven sampling effort along a large geographic region. Estimates obtained with closed population models were considered more suitable with the current data structure. Results obtained with two different closed population data types are shown in Table 3. In both cases, the model that best fitted the data allowed capture probability to vary by time with heterogeneity in capture probability with two mixtures (M_{th2}). The population size obtained with both models was similar (11,784 and 11,786, respectively; SE= 266 in both cases).

Table 3. Population abundance estimates for the BSG obtained with the two data types using information from breeding and feeding areas of the period 1991-2018, fitted using closed population models in program Mark 9.0.

Data type	Model	N-hat	SE	Lower	Upper
Full likelihood	{M_{th2}}	11,784	266	11,282	12,326
Conditional likelihood	{M_{th2})}	11,786	266	11,284	12,328

Apparent survival estimates

Two CJS models with heterogeneous capture probabilities (Cormack-Jolly-Seber model with Pledger mixtures) resulted in the same AICc value and model likelihood best fitted the data: 1) constant survival and heterogeneity and time-dependent capture probability; and 2) constant survival and time-dependent heterogeneity and capture probability. These models incorporate a mixture parameter (pi) to model heterogeneity in both phi and *p*. Thus, two *g*roups with different variation in both parameters are reported for each model. Both models produced the same values of survival in the two mixtures 0.924 and 0.959, with marginal differences in the standard errors (Table 4).

Table 4. Survival estimates obtained with the Cormack-Jolly-Seber with Pledger mixtures models.

Model	Mixture	Estimate	Standard error	Lower	Upper
{pi(.) Phi(.) p(t)}	1	0.924	0.003	0.916	0.978
	2	0.959	0.008	0.938	0.973
{pi(t) Phi(.) p(t)}	1	0.924	0.006	0.911	0.936
	2	0.959	0.008	0.937	0.973

DISCUSSION

These updated abundance estimates of the BSG resulted from the collaborative effort of research groups working throughout the entire distribution range (~11°N to 65°S), allowing the integration of data from breeding and feeding areas for the first time. However, it is recognized that different sources of bias persist, particularly those associated with the effort heterogeneity and the time scale that models most probably were unable to depict completely (see Table 1). Likewise, the low rate of recaptures, despite the enormous research effort, precluded the use of models for open populations. In such a long-term data series, closed population models could introduce an important downward bias affecting the estimate, and therefore our estimates should be considered conservative. The enormous extent of the distribution range, its high level of population structure in the breeding (Guzmán and Félix, 2017) and feeding areas (Acevedo et al., 2013), and even during migration (Félix and Guzmán, 2014) are aspects difficult to quantify but should be considered in future population modeling attempts.

In both abundance and apparent survival estimates, mixture models fitted the data best, which confirms the heterogeneity within datasets. An example of such heterogeneity can be found in the two subsets from Magellan Strait (CEQUA and EMA). These two datasets include 15 years of sampling from small population units with a high level of annual philopatry and therefore with a different capture probability when compared to the full range of BSG breeding, feeding and transit areas. Recent estimates for Magellan Strait using a robust design Bayesian framework estimated humpback whale abundance at 204 (95% CI 199-210) for the period 2004-2016 (Monnahan et al., 2019), which presents the highest confidence estimate for any population unit in the full dataset. By contrast, some datasets accounted for once or few years of effort with low recapture probabilities. Furthermore, breeding areas were disproportionately more frequently sampled than feeding areas (3.3:1; see Figure 1 and Table 1).

These new abundance estimates show a population increase of 181% with respect to a previous estimate made with information only from the breeding area off Ecuador in 2006 (Felix et al., 2011a), yielding an annual average growth rate of 5.07% in 12 years (2006-2018). This annual growth rate is low compared with other southern hemisphere humpback whale populations, ~ 10% in the Western Australian population (Bannister and Hedley, 2001) and 7.4% in the Southwestern Atlantic population (Ward et al., 2011). The maximum plausible rate of increase (ROI) for this species is estimated at 11.8% (Zerbini et al., 2010). Differences between estimates with data from one breeding area and the estimate obtained in this study including a combined dataset of breeding and feeding areas could be caused, among other factors, by the following: 1) a previous overestimation; 2) the dataset from the feeding areas included whales from an area not sampled in the breeding zone; and 3) the datasets from the feeding areas included whales sampled in Antarctica that do not belong to the BSG. In the first case, the estimate made in 2006 has a wide range of confidence (95% CI 4,270-9,907) (Félix et al., 2011a), so in a strict sense, the new estimate could be considered consistent with such calculation. In the second case, unmonitored areas may persist in the Southeast Pacific such as the Galapagos Islands, where one female was identified to belong to the BSG through molecular studies (Felix et al., 2011b) but no fluke images were available, as well as in other oceanic islands such as Malpelo in Colombia (Herrera et al., 2011, Palacios et al. 2012) and perhaps Cocos Island in Costa Rica (Acevedo-Gutierrez and Smultea, 1995). Lastly, in the third factor above, a certain degree of mixing exists between humpback whales from different Southern Hemisphere stocks in Antarctic waters (Dawbin, 1964, Amaral et al., 2016; Steel et al., 2017), so it cannot be ruled out that some whales photographed in the Antarctic Peninsula and included in the new dataset do not belong to the BSG.

The current analyses also showed an improvement regarding apparent survival estimates. The former average survival estimated at 0.919 (Félix et al., 2011a) is lower than the value obtained for the mixture with the lowest value (0.924). The apparent survival values are also higher than the recent estimate in the Magellan Strait feeding aggregation (0.892, CI: 0.871–0.910) which also showed an annual increasing rate of 55% lower than the whole BSG (2.3%: CI 2.1%-3.1%) (Monnahan et al., 2019). The mixture with the highest apparent survival value (0.959) is within the range reported in other humpback whale populations (Zerbini et al. 2010).

The population increase rate of the BSG could be influenced by anthropogenic factors such as the high rate of whale entanglement in fishing gear reported in waters of Ecuador and Colombia (e.g., Capella et al. 2001, Félix et al., 2011c) and ecological factors such as the increase in the predation rate, suggested by an increase of scars from killer whale *Orcinus orca* in the flukes of BSG individuals over time (Capella et al., 2018; Testino et al., 2019). Other threats of anthropogenic origin include vessel collision (Van Waerebeek et al., 2007) and vessel disturbance (Scheidat et al., 2004; Ávila et al., 2015), as well as emergent issues with a potential effect on cetaceans such as marine litter (Panti et al., 2019) and climate change (Askin et al., 2017), particularly, changes in the extent of sea coverage/pack mass influencing food availability in Antarctic (Ávila et al., 2020).

ACKNOWLEDGEMENTS

AF research was supported by the National Science Foundation of Polar Programs, WWF and the Southern Ocean Research Partnership. CC thanks Pacific Whale Foundation and Yaqu Pacha for financial support. FF and BH thanks tourist operators in Puerto López and Salinas, Ecuador. CETACEA project in norther and central Ecuador is funded by research grants of the University San Francisco de Quito, Rufford Grant and support of the local fishermen. DH thank Luis González of Turismo Orca, Chile. Fundación Keto thanks ASOTU and ASOGUIBA from Uvita de Osa and financial aid by CMS Small Funds Program (2012-13). ICA is grateful with Pacífico Extremo (Colombia) and Oscar Rocha for collaboration in collecting some data. NAD and MAT are grateful to Ushuaia tourist boats and crews to share records and logistic assistance, the Consejo Nacional de Investigaciones Científicas y Técnica (CONICET), and the Wildlife Conservation Society for their financial support. Pacífico Adventures thanks their crew; skippers, tour guides, volunteers for collecting photographs every year. Panacetacea was supported by the Moore Charitable Foundation and the Islas Secas Foundation. GP and MJPA Thanks to Asociación Turística Chañaral de Aceituno, Turismo Arca de Noé, Turismos Orca and Aurelio Aguirre. Samples from the Brazilian Antarctic Program (PROANTAR) were obtained with financial aid from the National Council for Research and Technological Development (CNPq), the Brazilian Navy and the Secretariat of the Interministerial Commission for the Resources of the Sea (SECIRM). The Research group Ecologia e Conservação da Megafauna Marinha − EcoMega/CNPq of the Federal University of Rio Grande-FURG contributed to this study. LS thanks Rufford Small Grants supported surveys in Sechura By in Perú. AAL thanks to Carlos Olavarría, Antonio Larrea and Jordi Plana for assisting in the field with photo-identification and organizing the INACH catalogue. AAL funding research was supported by INACH-08-93 and INACH-163 projects of the Chilean Antarctic Institute. JA thanks all crew members of Chonos yacht and M/N Forrest, as well as the field assistants and CEQUA for logistical support in the Magellan Strait, Chile. JA funding have been supported by the National Commission for Science and Technology, Regional Government of Magallanes and BIOMAR Foundation project. NBA would like to thank all funding agencies well as whale watching companies, community councils and the local communities within the Gulf of Tribugá, northern Colombian Pacific. A significant acknowledgement to Colciencias in relation to NB's doctoral fellowship.

REFERENCES

Acevedo, J., Rasmussen, K., Félix, F., Castro, C., Llano, M., Secchi, E., Saborío, M. T., Aguayo-Lobo, A., Haase, B., Scheidat, M., Dalla-Rosa, L., Olavaria, C., Forestell, P., Acuña, P., Kaufman, G., and Pastene, L. A. 2007. Migratory destinations of the humpback whales from Magellan Strait feeding ground, Chile. *Marine Mammal Science*, 23(2): 453-463. doi: 10.1111/j.1748-7692.2007.00116.x.

Acevedo J., Haro, D., Dalla-Rosa, L., Aguayo-Lobo, A., Hucke-Gaete, R., Secchi, E., Plana, J., and Pastene, L. A. 2013. Evidence of spatial structuring of eastern South Pacific humpback whale feeding grounds. *Endangered Species Research,* 22: 33-38. doi: 10.3354/esr00536.

Acevedo, J., Aguayo-Lobo, A., Allen, J., Botero-Acosta, N., Castro, C., Dalla Rosa, L., Denkinger, J., Félix, F., Flórez-González, L., Frank Garita, F., Guzmán, H. M., Haase, B, Kaufman, G., Llano, M., Olavarría, C., Pacheco, A. S., Plana, J., Rasmussen, K., Scheidat, M., Secchi, E. R., Silva, S., and Stevick, P. T. 2017. Migratory preferences of humpback whales between feeding and breeding grounds in the eastern South Pacific. *Marine Mammal Science,* 33(4): 1035-1052. doi: 10.1111/mms.12423. https://doi. org/10. 1111/mms. 12423.

Acevedo, A. and Smultea, M.A. 1995. First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of northern and southern hemisphere populations. *Marine Mammal Science*, 11: 554-560. https://doi.org/10.1111/j.1748-7692.1995.tb00677.x.

Amaral, A. R., Loo, J., Jaris, H., Olavarría, C., Thiele, D., Ensor, P., Aguayo, A., Rosembaum, H. R. 2016. Population genetic structure among feeding aggregations of humpback whales in the Southern Ocean. *Marine Biology*, 163:132. https://doi.org/10.1007/s00227-016-2904-0.

Askin, N., Belanger, M., and Wittnich, C. 2017. Humpback whale expansion and climate change: Evidence of foraging into new habitats. *Journal of Marine Animals and Their Ecology*, 9(1): 13-17.

Ávila I.C., L. M. Correa & E.C.M Parsons. 2015. Whale-watching activity in Bahía Málaga, on the Pacific coast of Colombia, and its effect on humpback whale (*Megaptera novaeangliae*) behavior. Tourism in Marine Environments 11 (1): 19-32.

Ávila, I.C., C.F.Dormann, C. García, L.F. Payán & M.X. Zorrilla. 2020. Humpback whales extend their stay in a breeding ground in the Tropical Eastern Pacific. ICES Journal of Marine Science 77(1): 109–118. doi:10.1093/icesjms/fsz251.

Bannister, J. L., and Hedley, S. L. 2001. Southern Hemisphere Group IV humpback whales: their status from recent aerial survey. *Memoirs of the Queensland Museum,* 47: 587-598.

Blount D., Holmberg, J., and Minton, G. 2018. Flukebook – A tool for cetacean photo-identification, data archiving and automated fluke matching. Report SC/67b/PH03 of the International Whaling Commission. 10 p.

Capella, J., Florez-Gonzalez, L., Falk, P. and Celis, G. A. 1998. Population size of southeastern Pacific humpback whale stock. Is it recovering? pp.23. *Abstracts of the World Marine Mammal Science Conference, Monaco, 20–24 January 1998*. 159 pp.

Capella, J. J., Gibbons, J., Flórez-González, L., Llano, M., Valladares, C., Sabaj, V., and Vilina, Y. A. 2008. Migratory round-trip of individually identified humpback whales at the Strait of Magellan: clues on transit times and phylopatry to destinations. *Revista chilena de historia Natural*, *81*(4): 547-560. https://dx.doi.org/10.4067/S0716-078X2008000400008.

Capella, J. J., Flórez-González, L. and Falk-Fernández, P. 2001. Mortality and anthropogenic harassment of humpback whales along the Pacific coast of Colombia. *Memoirs of Queensland Museum,* 47(2): 547–53.

Capella, J., Félix, F., Flórez-González, L., Gibbons, J., Haase, B. & Guzmán, M. 2018. Geographic and temporal patterns of non-lethal attacks on humpback whales by killer whales in the eastern South Pacific and the Antarctic Peninsula. *Endangered Species Research*, 37: 207-2018.. https://doi.org/10.3354/esr00924.

Cheeseman, T., and Southerland, K. 2018. Happywhale Progress Report 2017-2018. Report SC/67b/PH WP02 of the International Whaling Commission. 3 p.

Cheeseman T, Southerland K, Park J, Olio M, Flynn K, Calambokidis J, Jones L, Garrigue C, Frisch A, Howard A, et al. (in press). Advanced image recognition: a fully automated, high-accuracy photo-identification matching system for humpback whales. *Mammalian Biology*.

Cooch, E., and White, G. 2019. Program Mark, A gentle introduction. Cornell University and Colorado State University Cooperative Wildlife Unit, 1-52.

Crall, J., Stewart, C., Berger-Wolf, T., Rubenstein, D., and Sundaresan, S. 2013. Hotspotter- patterned species instance recognition. Pp. 230-237 in IEEE Workshop on Application of Computer Vision.

Dawbin, W. H. 1964. Movements of humpback whales marked in the southwest Pacific Ocean 1952-1961. *Norsk Hvalfangst Tidente*, 53:68-78.

De Weerdt, J, Ramos, EA, Cheeseman, T. Northernmost records of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) migrating from the Antarctic Peninsula to the Pacific coast of Nicaragua. *Mar Mam Sci*. 2020; 36: 1015– 1021. . https://doi.org/10.1111/mms.12677.

Félix, F., and Haase, B. 2001a. The humpback whale off the coast of Ecuador, population parameters and behavior. *Revista de Biología Marina y Oceanografía*, 36(1):61-74.

Félix, F., and Haase, B. 2001b. Towards an estimate of the Southeastern Pacific humpback whale stock. *Journal of Cetacean Research and Management*, 3(1):55-58.

Félix, F., Castro, C., Laake, J., Haase, B., and Scheidat, M. 2011a. Abundance and survival estimates of the Southeastern Pacific humpback whale stock from 1991-2006 photo-identification surveys in Ecuador. *Journal of Cetacean Research and Management*, Special Issue 3: 301-307.

Félix, F., Palacios, D., Salazar, S. K., Caballero, S., Haase, B., and Falconí, J. 2011b.The 2005 Galápagos humpback whale expedition: a first attempt to assess and characterize the population in the archipelago. *Journal of Cetacean Research and Management*, Special Issue 3: 291-299.

Félix, F., Muñoz, M., Falconí, J., Botero, N., and Haase, B. 2011c. Entanglement of humpback whales in artisanal fishing gear in Ecuador. *Journal of Cetacean Research and Management*, Special Issue 3: 285-290.

Félix, F., Rodrígues, D., Cheesemen, T., Haase, B., D'Arc, J., Marcondes, M. C., Southerland, K., and Acevedo, J. 2020. A New Case of Interoceanic Movement of a Humpback Whale in the Southern Hemisphere: The El Niño Link. *Aquatic Mammals*, 46(6):578-583. doi: 10.1578/AM.46.6.2020.578

Flórez-González, L. 1991. Humpback whales *Megaptera novaeangliae* in the Gorgona Island, Colombian Pacific breeding waters: population and pod characteristics. *Memoirs of Queensland Museum,* 30(2):291-295.

Freitas, M., and Marino, S. 2012. Estimación de abundancia por captura-recaptura de los delfines Guiana en el sureste de Brasil. *Ciencias Marinas*, 38(3):529-541.

Guzmán, H., Condit, R., and Pérez-Ortega, B. 2015. Population size and migratory connectivity of humpback whales wintering in Las Perlas Archipelago, Panama. *Marine Mammal Science*, 31(1):90-105. doi: 10.1111/mms.12136.

Guzmán, H., and Félix, F. 2017. Movements and habitat use by Southeast Pacific humpback whales satellite-tracked at two breeding sites. *Aquatic Mammals,* 43(2):139-155. http://dx.doi.org/10.1578/AM.43.2.2017.139.

Hammond, P. S. 2010. Estimating the abundance of marine mammals. P42-97. In Boid, I.L, Bowen, W. D., and Iverson, S. J. (Eds). Marine Mammal Ecology and Conservation, a handbook of Techniques. Oxford University Press. New York.

Herrera, J. C., Capella, J. J., Soler, G. A., Besudo, S., García, C. and Flórez-González, L. 2011. Ocurrencia y tasas de encuentro de mamíferos marinos en las aguas de la isla Malpelo y hacia el continente. *Boletín de Investigaciones Marinas y Costeras* (Suplemento Especial), 40:57-78.

Hucke-Gaete R, D Haro, JP Torres-Florez, Y Montecinos, F Viddi, L Bedrigaña-Romano, MF Nery & J Ruiz. 2013. A historical feeding ground for humpback whales in the eastern South Pacific revisited: the case of northern Patagonia, Chile. Aquatic Conserv: *Marine and Freshwater Ecosystem*, 23(6): 858-867. https://doi.org/10.1002/aqc.2343.

Huggins, R. M. 1989.On the statistical analysis of capture experiments. *Biometrika*, 76: 133-140.

International Whaling Commission (IWC). 2006. Report of the Scientific Committee. Annex H, report of the Sub-Committee on other Southern Hemisphere whale stocks. Saint Kitts, June 2006. 24p.

International Whaling Commission (IWC). 2017a. Report of the Scientific Committee. *Journal of Cetacean Research and Management*, 18 (Suppl): 1-109.

International Whaling Commission (IWC). 2017b. Report of the Workshop on Southern Hemisphere blue, fin and humpback whale photo-identification catalogues from the Central and Eastern South Pacific and the Antarctic Peninsula. Document SC767A/REP/03 Rev1, 17 p.

Jackson, J., Zerbini, A., Findlay, K., Ross-Gillsipie, A., Weinrich, M., Collins, T., Kaker, C. D., Butterworth, D. S., Clapham, P., and Rosenbaum, H. 2016. Southern Hemisphere humpback whale in depth assessment: Priorities for future assessments. Report SC/66b/SH01 of the International Whaling Commission. 12 p.

Lowe, D. 2004. Distinctive image features from scale-invariant keypoints. *International Journal of Computer Vision*, 60: 91-110.

Monnahan, C. C., Acevedo, J., Hendrix, A. N., Gende, S., Aguayo-Lobo, A., and Martínez, F. 2019. Population trends for humpback whales (*Megaptera novaeangliae*) foraging in the Francisco Coloane Coastal-Marine Protected Area, Magellan Strait, Chile. *Marine Mammal Science*, 35(4):1212-1231. doi: 10.1111/mms.12582.

Olavarría, C., Baker, C. S., Garrigue, C., Poole, M., Hauser, N., Caballero, S., Flórez-González, L., Brasseur, M., Bannister, J., Capella, J., Clapham, P., Dodemont, R., Donoghue, M., Jenner, C., Jenner, M. N., Moro, D., Oremus, M., Paton, D., Rosenbaum, H. and Russell, K. 2007. Population structure of South Pacific humpback and the origin of the eastern Polynesian breeding grounds. *Marine Ecology Progress Series*, 330:257-268.

Otis, D. L., Burnham, K. P., White, G.C., and Anderson, D. R. 1978. Statistical inference from capture data on closed animal populations. *Wildlife Monographs*, 62:3-135.

Pacheco A. S., Silva, S., and Alcorta, B. 2009. Winter distribution and group composition of humpback whales (*Megaptera novaeangliae*) off northern Peru. *Latin American Journal of Aquatic Mammals*, *7*(1-2): 33-38. https://doi.org/10.5597/lajam00131.

Palacios, D.M., J.C. Herrera, T. Gerrodette, C. García, G.A. Soler, I.C. Avila, S. Bessudo, E. Hernández, F. Trujillo, L. Flórez-González, and I. Kerr. 2012. Cetacean distribution and relative abundance in Colombia's Pacific EEZ from survey cruises and platforms of opportunity. Journal of Cetacean Research and Management 12(1):45-50.

Panti, C., Baini, M., Lusher, A., Hernandez-Milan, G., Bravo Rebolledo, E.L., Unger, B., Syberg, K., Simmonds, M. P. and Fossi, M. C. 2019. Marine litter: One of the major threats for marine mammals. Outcomes from the European Cetacean Society workshop. *Environmental Pollution,* 247:72-79. https://doi.org/10.1016/j.envpol.2019.01.029.

Rasmussen, K., Palacios, D. M., Calambokidis, J., Saborio, M. T., Rosa, L. D., Secchi, E. R., Steiger, G. H., Allen J. M. and Stone, G. S. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. *Biology Letters,* 3(3):302-305. doi: 10.1098/rsbl.2007.0067.

Scheidat, M., Castro, C., Denkinger, J., González, J. and Adelung, D. 2000. A breeding area for humpback whales (*Megaptera novaeangliae*) off Ecuador. *Journal of Cetacean Research and Management*, 2(3):165-171.

Scheidat, M., Castro, C., González, J., & Williams, R. 2004. Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. Journal Cetacean Research Management, 6, 63–68.

Seber, G. A. F., and Schwarz, C. J. 1999. Estimating Animal Abundance: Review III. *Statistical Science*, 14(4):427–456. doi:10.1214/ss/1009212521.

Steel, D., Anderson, M., Garrigue, C., Olavarría, C., Caballero, S., Childerhouse, S., … Baker, C. S. 2017. Migratory interchange of humpback whales (*Megaptera novaeangliae*) among breeding grounds of Oceania and connections to Antarctic feeding areas based on genotype matching. *Polar Biology,* 41(4): 653–662. doi:10.1007/s00300-017-2226-9.

Stevick, P., Aguayo, A., Allen, J., Avila, I.C., Capella, J., Castro, C., Chater , K., Engel, M. H., Félix, F., Flórez-González, L., Freitas, A., Haase, B., Llano, M., Lodi, L., Muñoz, E., Olavarría, C., Secchi, E., Scheidat, M., and Siciliano, S. 2004. A note on the migrations of individually identified humpback whales between the Antarctic Peninsula and South America. *Journal of Cetacean Research and Management,* 6(2):109-113.

Stevick, P.T., Aguayo-Lobo, A., Allen, J.M., Castro, C., Chater, K., Dalla Rosa, L., Felix, F., Haase, B., Llano, M., Olavarria, C., Rasmussen, K. and Secchi, E. 2006. Estimated abundance of humpback whales off the west coast of central and South America (Group G). Paper SC/A06/HW56 presented to the IWC Workshop on Comprehensive Assessment of Southern Hemisphere Humpback Whales, Hobart, Tasmania, 3–7 April 2006 (unpublished). 9pp.

Stevick, P. T., Allen, J. M., Engel, M. H., Félix, F., Haase, B., and Neves, M. C.. 2013. Inter-oceanic movement of an adult female humpback whale between Pacific and Atlantic breeding grounds off South America. *Journal of Cetacean Research and Management*, 13(2):159-162.

Testino, J.P., Petit, A., Acorta, B., Pacheco, A.S., Silva, S., Alfaro-Shigueto, J., Sarmiento, D., Quiñones, J., More Eche, A., Mota, E., Fernandez, S., Campbell, E., Carrillo, G., Epstein, M., Llapapasca, M., and González-Pestana, A. 2019. Killer whale (*Orcinus orca*) occurrence and interactions with marine mammals off Peru. *Pacific Science* 73(2), 1-13. https://doi.org/10.2984/73.2.7.

Valdivia, C. A., Pacheco, A. S., Félix, F., Haase, B., Rasmussen, K., Santillán, L., Alcorta, B. and Silva. S. 2017. Movements of humpback whales (*Megaptera novaeangliae*) within the breeding region of the Southeast Pacific. *Aquatic Mammals,* 43(3), 324-330. https://doi. org/10. 1578/AM.43.3.2017.32.

Van Waerebeek, K., Baker, A. N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G. P., Secchi, E., Sutaria, D., van Helden, A., and Wang, Y. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, and initial assessment. *Latin American Journal of Aquatic Mammals*, 6(1):43-69.

Ward, E., Zerbini, A. N., Kinas, P., Engel, M. H., and Andriolo, A. 2011. Estimates of population growth rates of humpback whales (*Megaptera novaeangliae*) in the wintering grounds off the coast of Brazil (Breeding Stock A). *Journal of Cetacean Research and Management* (Special Issue) 3:145–149.

White, G., and K. Burnham. 1999. Program Mark: Survival estimation from populations of marked animals. *Bird Study*, 46:120-139.

Zerbini, A. N., Clapham, P. J., and Wade P. R. 2010. Assessing plausible rates of population growth in humpback whales from life-history data. *Marine Biology*, 157:1225–1236. doi 10.1007/s00227-010-1403-y.

Appendix 1.

		Research group	Study area	Primary contact person	Email address
BREEDING GROUND	1	Fundación de Investigación y Conservación Marina-Costera (Keto)	Osa Peninsula – Costa Rica	José David Palacios	pala1611@gmail.com
	2	Centro de Investigación de Cetáceos de Costa Rica (CEIC)	Dulce Gulf – Costa Rica	Juan Diego Pacheco	dpachecop@gmail.com
	3	Panacetacea	Osa Peninsula – Costa Rica (past) Chiriqui Gulf – Panama (current)	Kristin Rasmussen	panamakristin@gmail.com
	4	Smithsonian Tropical Research Institute (STRI – Panama)	Panama Gulf – Panama Las Perlas Archipelago – Panama	Héctor Guzmán	guzmanh@si.edu
	5	Anonymous contributor	Panama Gulf – Panama	--	--
	6	Fundación Macuáticos	Tribuga Gulf – Colombia	Natalia Botero	natalia.botero@eagles.usm.edu
	7	SENTIR/ Proyecto Resiliencias	Tribuga Gulf – Colombia (past)	Martha Llano	marthaelenallano@gmail.com
	8	Universidad del Valle	Solano Bay – Colombia Malaga Bay – Colombia	Isabel Cristina Ávila	isabel_c_avila@yahoo.com
	9	Universidad San Francisco de Quito	Esmeralda Bay – Ecuador	Judith Denkinger	judenkinger@gmail.com
	10	Pacific Whale Foundation	Machalilla – Ecuador	Cristina Castro	cristinacastro@pacificwhale.org
	11	Museo de Ballenas Salinas	Salinas –Ecuador	Fernando Félix	fefelix90@hotmail.com
	12	Pacific Adventure	Los Órganos – Peru	Aldo Pacheco	babuchapv@yahoo.com
	13	Centro de Estudios del Pacífico	Secchura – Peru	Luis Santillán	lsantillancorrales@yahoo.com
FEEDING GROU	14	Centro de Investigación Eutropia	Chañaral de Aceituno – Chile	María José Pérez	mjose.perez@gmail.com
	15	Universidad Santo Tomás	Chañaral de Aceituno – Chile (past)	Daniela Haro	daniela.haro.diaz@gmail.com
	16	Universidad Austral de Chile	Corcovado Gulf – Chile	Rodrigo Hucke-Gaete	rhucke@uach.cl
	17	Whalesound Ltda	Magellan Strait – Chile	Juan Capella	jjcapella@yahoo.com
	18	Fundación CEQUA	Magellan Strait – Chile Antarctic Peninsula	Jorge Acevedo	jacevedo@cequa.cl
	19	Centro Austral de Investigaciones Científicas (CADIC)	Beagle Channel – Argentina	Natalia Dellabianca	ndellabianc@gmail.com
	20	Instituto Antártico Chileno (INACH)	Antarctic Peninsula	Anelio Aguayo-Lobo	aaguayo@inach.cl
	21	Universidade Federal do Rio Grande (FURG)	Antarctic Peninsula	Luciano Dalla Rosa	l.dalla@furg.br

N	22	Institute of Marine Science UCSC	Antarctic Peninsula	Ari Friedlaender	Ari.friedlaender@ucsc.edu
D	23	Museo de Historia Natural de Río Seco	Antarctic Peninsula	Benjamín Cáceres	benjamincaceresm@gmail.com
	24	Fundación Omacha	Antarctic Peninsula	Edgar Vásquez	ragdeadrian@gmail.com
	25	Other contributors	Antarctic Peninsula	--	--