Online ISSN: 0718-1957
RBMO

Revista de Biología Marina y Oceanografía
Vol. 57(3): 181-191, 2022
<https://doi.org/10.22370/rbmo.2022.57.3.4062>

ARTICLE

Effectiveness of Marine Wildlife Rescue and Rehabilitation Centers in Chile in relation to strandings of sea turtles, penguins, sea lions, and sea otters

Efectividad de los centros de rescate y rehabilitación de fauna marina en Chile ante varamientos de tortugas, pingüinos, lobos marinos y nutrias

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Resumen.- Los Centros de Rescate y Rehabilitación de Vida Silvestre Marina (CRRVSM) son cruciales para la rehabilitación de especies marinas en peligro de extinción, como pingüinos, tortugas marinas, lobos marinos y/o nutrias marinas. En Chile, el rescate de fauna marina es coordinado por el Servicio Nacional de Pesca y Acuicultura (SERNAPESCA). Esta organización se encarga de asistir a los animales varados y transportarlos para su rehabilitación a 6 de los 13 CRRVSM que existen a lo largo de los 6.345 km de costa del país. Este estudio analizó los varamientos de dos especies de pinnípedos (*Otaria flavescens* y *Arctocephalus australis*), dos especies de pingüinos (*Spheniscus humboldti* y *Spheniscus magellanicus*), dos especies de quelonios (*Chelonia mydas* y *Lepidochelys olivacea*) y una especie de nutria marina (*Lontra felina*) varados en la costa de Chile durante el periodo 2009-2019. También examina el éxito en la rehabilitación y posterior liberación en el medio natural de los individuos. Se registraron un total de 2.818 varamientos con un total de 3.198 animales varados, correspondientes a *O. flavescens* (52,9%), *S. humboldti* (20,4%), *S. magellanicus* (17,9%) y *L. olivacea* (4,3%). De los 3.198 animales varados, 721 individuos fueron enviados a CRRVSM y solo 136 fueron liberados después de su rehabilitación. Esto mostró una tasa de un 18,8% de éxito en la liberación de especies de fauna marina post-rehabilitadas en centros de rescate tras su varamiento. Por tanto, es necesario mejorar la comunicación y los acuerdos entre SERNAPESCA y los CRRVSM en Chile para incrementar la tasa de liberación y aumentar el número de CRRVSM para recuperar especies marinas amenazadas que varan en las costas del país.

Palabras clave: Vertebrados marinos, rehabilitación, especies amenazadas, liberación, rescate

Abstract.- Marine Wildlife Rescue and Rehabilitation Centers (MWRRCs) are crucial for the rehabilitation of endangered marine species, such as penguins, sea turtles, sea lions, and/or sea otters. In Chile, rescue of marine fauna is coordinated by the National Fisheries and Aquaculture Service (SERNAPESCA). This organization is responsible for assisting stranded animals and transporting them to 6 of the 13 MWRRCs that exist throughout the 6,435 km coastline of the country. Stranding events were analyzed for two species of pinnipeds (*Otaria flavescens* and *Arctocephalus australis*), two species of penguins (*Spheniscus humboldti* and *Spheniscus magellanicus*), two species of chelonians (*Chelonia mydas* and *Lepidochelys olivacea*), and one species of sea otter (*Lontra felina*) found stranded at the coast of Chile during 2009-2019 period. Success in post-rehabilitation release of individuals was also examined. A total of 2,818 stranding events were recorded with a total of 3,198 stranded animals, corresponding to *O. flavescens* (52.9%), *S. humboldti* (20.4%), *S. magellanicus* (17.9%) and *L. olivacea* (4.3%). Of the 3,198 stranded animals, 721 specimens were referred to MWRRC, and only 136 were released post-rehabilitation. This shows 18.8% of success rate in the release of marine fauna species post-rehabilitated in rescue centers after their stranding. It is necessary to improve coordination between SERNAPESCA and MWRRCs in Chile to improve the release rate and to increase the number of MWRRCs to recover endangered marine species that strand along the country's coast.

Key words: Marine vertebrates, rehabilitation, endangered species, release, rescue

INTRODUCTION

A stranding event is defined by Wilkinson (1991) as "any irregular activity of one or more marine animals, found dead or alive on the beach, being trapped in shallow waters that make it impossible to resume their normal life or approach the coast due to external injuries, environmental disturbances or health problems". Various threats affect higher marine vertebrate species worldwide and may cause stranding events. These include habitat deterioration, overexploitation, invasive alien species, environmental pollution, climate change,

increased ultraviolet radiation, damage (direct or indirect) of anthropogenic origin, and emerging diseases (Schipper *et al*. 2018). These events are used by the scientific community as part of monitoring strategies since such events provide valuable information regarding the biology and population status of higher marine vertebrate species (Schlatter *et al*. 2009). Most of the species susceptible to suffer strandings are listed as "endangered" by the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN) or as "data deficient" due to the lack of scientific information regarding their abundance and/or population trends (IUCN 2019). For example, the seven species of sea turtles and five of the seven species of penguins are listed as endangered or critically endangered (IUCN 2019). Strandings (*i.e.*, stranded marine animals) directly affect the survival and population abundance of these species since they may cause death of individuals, thereby reducing their abundance. Marine Wildlife Rescue and Rehabilitation Centers (MWRRCs) play a crucial role in the conservation of higher marine vertebrate species. Rehabilitation of wildlife is understood to be the (temporary) treatment and care of wild animals, which arrive at MWRRCs due to trauma (injuries), orphaned specimens, or are seized by the concerned authority in cases of illegal possession, to be later released in their natural environments (Trendler 1995). The final success of the rehabilitation process implies that the released animal survives, rejoins the social hierarchy, and finally reproduces itself since the latter is the greatest indicator of a successful rehabilitation process (Carr 1995). It is necessary to rehabilitate the specimens of endangered species that manage to reach the coast alive, to recover the sick animals, and to release them back into their natural habitat, thereby preventing reduction in their abundance due to death.

In Chile, the rehabilitation of hydrobiological species is regulated by the National Fisheries and Aquaculture Service (SERNAPESCA), organization under the jurisdiction of the Ministry of Economy, Development, and Tourism. The Fisheries and Aquaculture Law No. 18,892, in its 5th paragraph refers to the protection, rescue, rehabilitation, reintegration, observation, and monitoring of mammals, reptiles, and hydrobiological birds. Specifically, Article 13 B states "After the rescue of a specimen, in case these specimens cannot be returned to their natural environment, they should be sent immediately to a hydrobiological species rehabilitation center". The Marine Mammal Center in Sausalito, California (USA) is one of the world's leading MWRRCs. This center has hired 49 people, including scientists, educators, doctors, and veterinary technicians, as full-time staff, in addition to having more than 1,000 volunteers per year. During the 1984-1990 period, the Marine Mammal Center received 768 California sea lions (*Zalophus californianus*), of which 46.3% (n= 356) were successfully released to their natural habitat post-rehabilitation (Gage *et al.* 1993). However, MWRRCs in Chile differs among other countries in terms of having small infrastructure, scarce equipment, and funding shortage, which can have a significant impact on the response to stranding events (Soto-Azat 2017). Furthermore, the number of strandings of marine megafauna such as penguins that increase during El Niño events may force Chilean MWRRCs to be ready to react in certain decadal periods (Toro-Barros *et al*. 2017). Out of the total of 23 MWRRCs in Chile, 13 centers allow species of marine fauna. Of these, two are defined as Primary Care Centers (PCCs), six as Rehabilitation Centers (RCs), and three as Rescue Centers (Soto-Azat 2017). The remaining two centers 'Chiloé Silvestre' and 'Unidad de Rehabilitación de Fauna Silvestre' of Universidad Andrés Bello of Chile (UFAS-UNAB) were not included in Soto-Azat (2017) study but were defined in their social networks as Rehabilitation Centers. PCCs have basic infrastructure, so they serve only for short term stabilization and maintenance of the specimens, while RCs maintain rapid diagnostic equipment such as hematocrit, blood glucose, and some imaging tests (*e.g.*, ultrasound and radiography). The 13 centers that received marine fauna such as marine mammals, seabirds, chelonians and mustelids are distributed along nine of the 16 Chilean regions. It is noteworthy that only two centers (Metropolitan Region-RM and Coquimbo Region) are exclusive for marine species, while six centers receive stranded animals rescued by SERNAPESCA due to collaboration agreements (Soto-Azat 2017).

Currently, to implement a MWRRC suitable for the reception of marine fauna in Chile there is a mandatory protocol that rescue centers must implement such as the treatment of the waters, medical treatments, and other vital characteristics. These requirements are documented in the technical report "Definition of standards for the certification of centers for the rescue and rehabilitation of mammals, reptiles and hydrobiological birds in Chile", prepared by the Research Center for Sustainability, Facultad de Ecología y de Recursos Naturales, of Universidad Andrés Bello. The report has been approved by Subsecretaría de Desarrollo Regional y Administrativo (SUBDERE, Ministerio del Interior, Gobierno de Chile)[2] (Soto-Azat 2017). However, there are no studies related to MWRRCs effectiveness in Chile. Hence, the objective of this study was to evaluate stranding events of sea turtles (*Chelonia mydas* and *Lepidochelys olivacea*), penguins (*Spheniscus humboldti* and *S. magellanicus*), sea lions (*Otaria flavescens* and *Arctocephalus australis*) and one threatened species of sea otter (*Lontra felina*) in Chile during the period 2009-2019, analyzing MWRRCs effectiveness in the rehabilitation and release of these species.

[1]<https://www.iucnredlist.org/>

[2]SUBDERE. 2018. División política-administrativa de Chile: Regiones, provincias y comunas. Subsecretaría de Desarrollo Regional y Administrativo. Gobierno de Chile, Santiago. <https://www.bcn.cl/siit/nuestropais/div_pol-adm.htm>

Materials and methods

Study area

The study area included coasts of Continental Chile, Insular Chile, and Chilean Antarctic territory, with a total length of 6,435 km (Diaz-Navea & Frutos 2010). The coastline was divided according to the political-administrative division of Chile (SUBDERE 2018). It considers 15 regions and excludes the Metropolitan Region (RM) since it lacks access to the coast (Fig. 1). For this study, strandings were analysed in those regions that National Stranding Registration of SERNAPESCA acts in response to marine fauna stranding events. There are 13 MWRRCs in Chile that admit hydrobiological species, but these are not distributed equally along the country, considering that there are centers in only nine (I, II, IV, V, RM, VIII, XIV, X, and XII) of the 16 Regions (Table 1, Fig. 1).

Table 1. Description of the Marine Wildlife Rescue and Rehabilitation Centers in Chile, type of marine vertebrate species they receive, region in which they are found and number of inhabitants at each region / Descripción de los centros de rescate y rehabilitación de fauna marina en Chile, especies de vertebrados superiores que reciben, región donde se encuentran y número de habitantes por región

	Name	Type of marine vertebrates	Region	N° Inhabitants / Region
1	CIREMAR Iquique	Penguins, pinnipeds, sea turtles and otters	I	330,558
2	CRRFS Univ. Antofagasta	Penguins, pinnipeds, sea turtles and otters	II	607,534
3	CRFM Univ. Católica del Norte	Penguins, pinnipeds, and sea turtles	IV	757,586
4	Foundation Ñamku	Penguins, pinnipeds, sea turtles and otters	V	1,815,902
5	CRFS San Antonio	Penguins, pinnipeds, sea turtles and otters	V	1,815,902
6	Foundation Sea World	Penguins, pinnipeds, sea turtles and otters	RM	7,112.808
7	UFAS Univ. Andrés Bello-Buin Zoo	Penguins and otters	RM	7,112,808
8	CRFS Univ. de Concepción	Penguins	VIII	1,556,805
9	CRFS Univ. SS Concepción	Penguins, pinnipeds, sea turtles and otters	VIII	1,556,805
10	CEREFAS Univ. Austral	Penguins, pinnipeds, sea turtles and otters	XIV	384,837
11	CRFS USS Puerto Montt	Penguins, pinnipeds, sea turtles and otters	X	828,708
12	CRFS Chiloé Silvestre	Penguins, pinnipeds, sea turtles and otters	X	828,708
13	CR Aves Leñadura	Penguins, pinnipeds, sea turtles and otters	XII	166,533

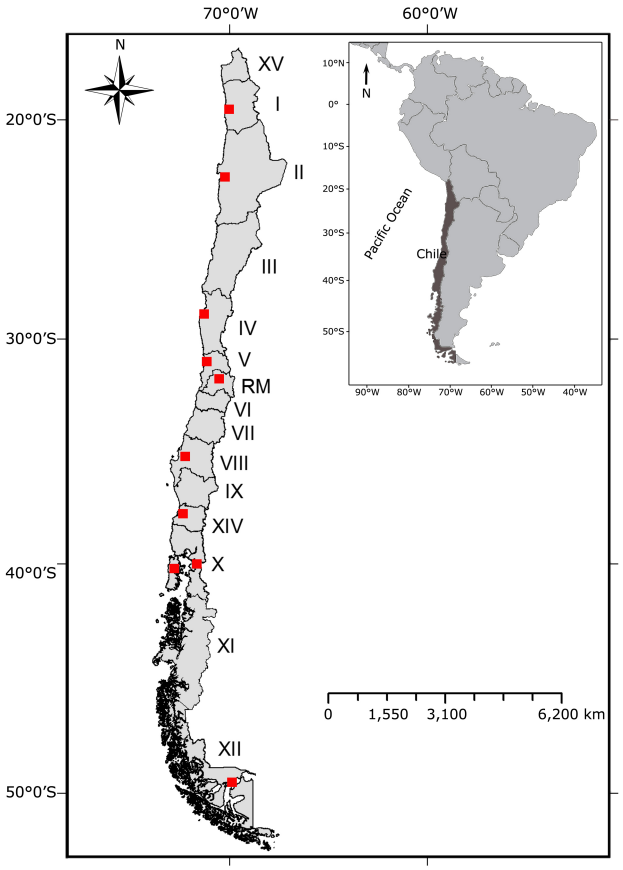

Figure 1. Distribution of the Marine Wildlife Rescue and Rehabilitation Centers throughout Chile. Red dots indicate presence of a MWRRC / Distribución de los centros de rescate y rehabilitación de fauna marina en Chile. Puntos rojos indican la presencia de estos centros

Data recording

Stranded animals were found, alive or dead, along the coast of Chile with help of telephone calls from tourists, individuals, fishermen, and/or businessmen, who channeled information about these events through SERNAPESCA National Stranding Registration during the period 2009-2019 (SERNAPESCA 2020). These records were tabulated in an Excel® spreadsheet designed by SERNAPESCA according to species, month, year, region, condition (alive or dead), age class (adult, sub-adult, juvenile, pup/hatchling), transported to primary care or rehabilitation center, and post-rehabilitation release. Unfortunately, underlying causes of the stranding events in Chile were not determined by SERNAPESCA, hence this data is lacking in this study. The age class was established through the visual inspection of feather coloration for the case of penguins and through the measure of individuals size for the case of mustelids, chelonians and pinnipeds (Garshelis 1984, Weise & Costa 2007, Wallace *et al.* 2008).

Data analysis

Four groups of higher marine vertebrates (pinnipeds, chelonians, mustelids, penguins) stranded along the Chilean coast were analyzed. From each group, the two most frequently stranded species were chosen for the study (Chelonians: *Lepidochelys olivacea* and *Chelonia mydas*; Pinnipeds: *Otaria flavescens* and *Arctocephalus australis*; Penguins: *Spheniscus humboldti* and *S. magellanicus* and Mustelidae: *Lontra felina*). In the case of mustelids, only *Lontra felina* was considered since the strandings of *Lontra provocax* (other mustelid species present in Chile) were very rare in SERNAPESCA database (<10 specimens in ten years). Cetaceans were not considered because their rehabilitation is more complex for the limited capacity of the rehabilitation centers in Chile (Soto-Azat 2017).

Some of the species considered in this study are listed as endangered according to the IUCN Red List of Threatened Species. Pinnipeds (*O. flavescens* and *A. australis*) are listed as "Least Concern" (Cárdenas-Alayza *et al*. 2016a, b); penguins (*S. humboldti* and *S. magellanicus*) are listed as "Vulnerable" and "Least Concern", respectively (BirdLife International 2020a, b); chelonians (*L. olivacea* and *C. mydas*) are listed as "Vulnerable" and "Endangered" (Abreu-Grobois & Plotkin 2008, Seminoff 2004), respectively; the sea otter (*L. felina*) is listed as "Endangered" (Mangel *et al.* 2022). Stranding data of these species registered by SERNAPESCA (2009 to 2019) were organized according to species, month, year, region, condition (alive or dead), and age class (adult, sub-adult, juvenile, pup/hatchling), transported to primary care or rehabilitation center, and post-rehabilitation release in an Excel® spreadsheet. Descriptive statistics using Rstudio software (R Core Team 2018) were performed to determine region-wise stranding patterns. To analyze the relationship between number of strandings and inhabitants in different regions of Chile, linear regression analysis and nonparametric Spearman's correlation test were performed in Rstudio software.

Results

During the 2009-2019 period, a total of 2,818 stranding events involving 3,198 stranded animals were documented for the marine species analyzed in this study (Table 2). The pinniped *O. flavescens* (52.9%) was the most commonly stranded species, followed by penguins *S. humboldti* (20.4%) and *S. magellanicus* (17.9%), and sea turtle *L. olivacea* (4.3%) (Fig. 2A). Regarding age classes, most of the stranded penguins were juveniles, while *O. flavescens* were pups and the sea turtles *L. olivacea* were adults (Fig. 2B).

Table 2. Summary of species of higher marine vertebrates stranded in Chile showing group, species, number of individuals, number of events, conservation status according to the IUCN Red List of Endangered Species, and number of individuals per stranding (Min= minimum; Max= maximum) / Resumen de vertebrados marinos superiores varados en Chile mostrando grupo, especie, número de individuos, número de varamientos, estado de conservación de la lista roja de especies amenazadas de la IUCN y número de individuos por varamiento (Min= mínimo; Max= máximo)

Group	Species	Conservation status (IUCN Red LIST)	Alive stranded specimens	Events	N° individuals per stranding (Min and Max)
Pinnipeds	*Otaria flavescens*	Least Concern	1,693	1,357	1 - 70
	Arctocephalus australis	Least Concern	63	63	1 - 1
Penguins	*Spheniscus humboldti*	Vulnerable	652	633	1 - 13
	Spheniscus magellanicus	Least Concern	571	546	1 - 13
Chelonians	*Lepidochelys olivacea*	Vulnerable	138	138	1 - 1
	Chelonia mydas	Endangered	46	46	1 - 1
Mustelids	*Lontra felina*	Endangered	35	35	1 - 1
Total			3,198	2,818	

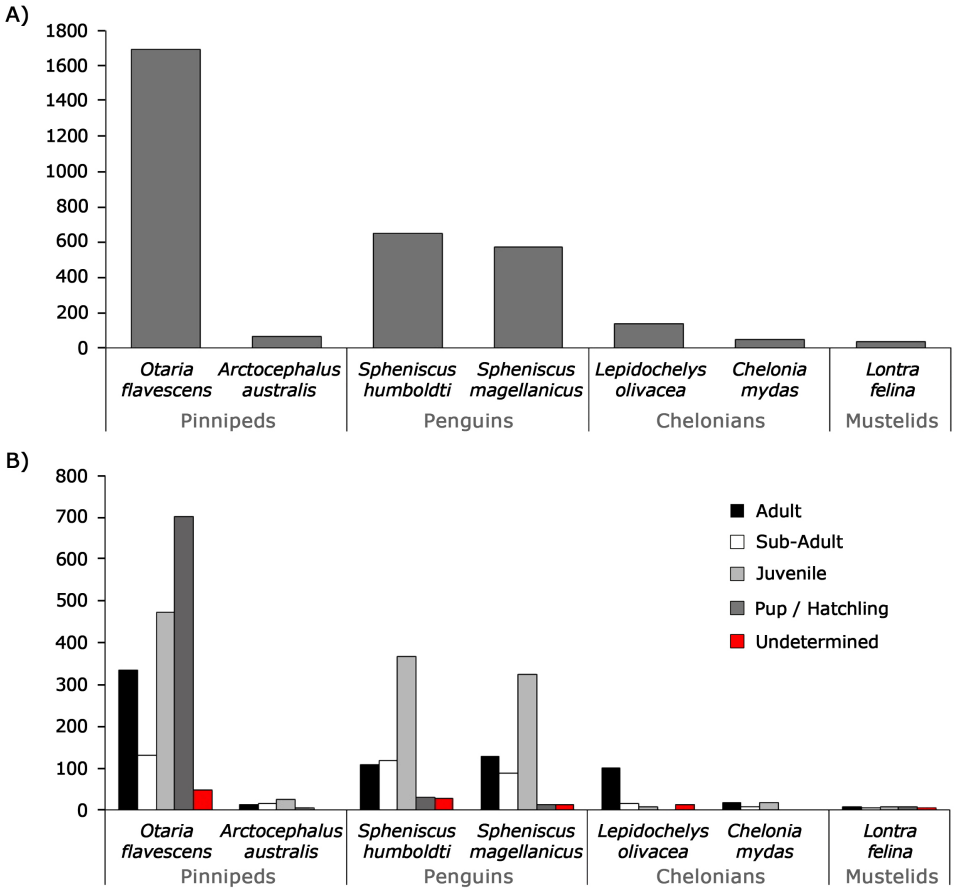

Figure 2. A) Number of stranding events of pinnipeds, penguins, chelonians, and mustelid species analyzed in this study, B) Age group of stranded penguins, pinnipeds, chelonians, and mustelids in Chile during the 2009-2019 period / A) Número de varamientos de especies de pinnípedos, pingüinos, chelonios y mustélidos analizados en este estudio, B) Edad de pingüinos, pinnípedos, quelonios y mustélidos varados en Chile durante el período 2009-2019

The year 2019 presented the highest number of pinnipeds and mustelids strandings; 2016 witnessed the highest number of penguins strandings, and 2017 presented the highest number of sea turtles strandings (Fig. 3A). The months of January and February presented the highest number of strandings for all species, corresponding to the Southern Hemisphere austral summer (Fig. 3B).

The Regions with the highest number of stranding events were Valparaíso with 743 (23.2%), Biobío with 494 (15.4%), and Los Lagos with 409 (12.8%). Valparaíso Region presented the highest number of stranding events of the pinniped, penguin, and mustelid groups with 370, 331, and 19 specimens, respectively. The highest number of strandings of chelonians (n=35) was concentrated in Coquimbo Region. Linear regression analysis and Spearman's

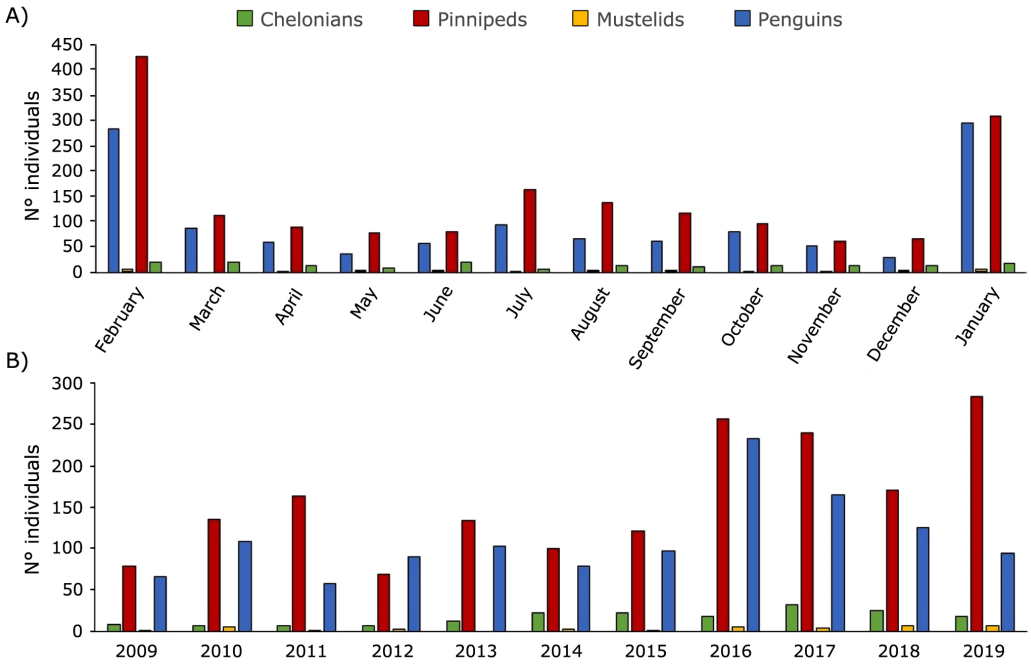

Figure 3. A) Monthly stranding frequency of penguins, mustelid, pinnipeds, and chelonians during study period (2009-2019). B) Year-wise total number of strandings in Chile during the study period (2009-2019) / A) Número de varamientos distribuidos mensualmente de pingüinos, mustélidos, pinnípedos y quelonios durante el período de estudio (2009-2019). B) Número total de varamientos anuales durante el período de estudio (2009-2019) en Chile

correlation test showed significant differences between number of inhabitants and number of strandings (R^2= 0.533, F= 17.01 (13); *P*-value= 0.001). Thus, regions with the highest number of inhabitants, mainly Valparaíso, Biobío, and Los Lagos, had the highest number of strandings (Fig. 4B) The most frequent species transported to MWRRCwas *O. flavescens*, with 274 (16.2%) specimens derived from the 1,693 stranding events. It was followed by *S. magellanicus* with a total of 594 stranded animals, of which 207 (28.7%) animals were transported to MWRRC and a total of 654 *S. humboldti* stranded animals, 167 (23.2%) were transported to MWRRC (Fig. 5). Unfortunately, there is no information in SERNAPESCA data sheet regarding animals found dead or released right after the stranding.

According to SERNAPESCA stranding records, no specimens of *C. mydas*, *L. olivacea*, or *L. feline* were released. In respect to *O. flavescens*, *S. humboldti*, and *S. magellanicus*, only 74, 32, and 29 specimens, respectively, were released, which corresponded to 27% of *O. flavescens*, 11.7% of *S. humboldti* and 10.6% of *S. magellanicus* specimens, from the total of specimens admitted to rehabilitation (Fig. 5). The regions with the highest number of animals released post-rehabilitation were Biobío (46 specimens), Los Lagos (29 specimens), and Los Ríos (19 specimens).

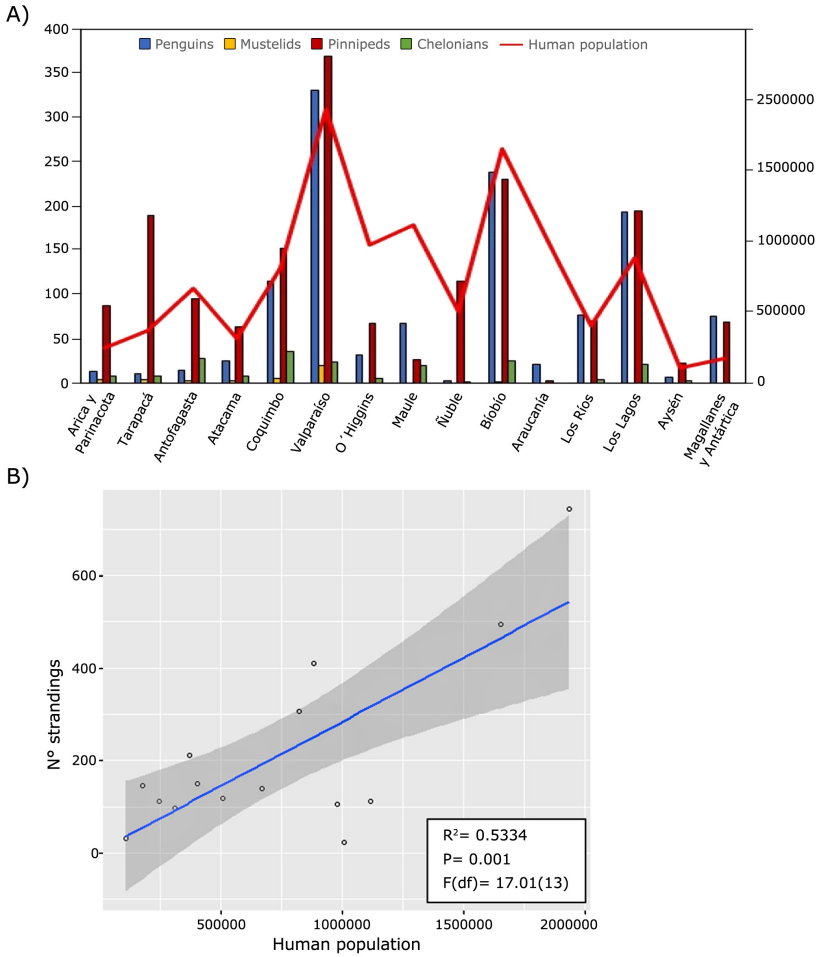

Figure 4. A) Stranding distribution of penguins (*S. humboldti* and *S. magellanicus*), mustelids (*L. felina*), pinnipeds (*O. flavescens* and *A. australis*), chelonians (*C. mydas* and *L. olivacea*) along Chile regions (2009-2019 period). Red line indicates human population at each region. B) Linear regression analysis and Spearman's correlation test of the relationship between human population and stranding events throughout Chilean regions / A) Distribución regional de varamientos de pingüinos, mustélidos, pinnípedos y quelonios en las diferentes regiones de Chile (período 2009-2019). Línea roja indica la población humana de cada región, B) Análisis de regresión linear y prueba de correlación de Spearman de la relación entre población humana y varamientos registrados en cada región de Chile

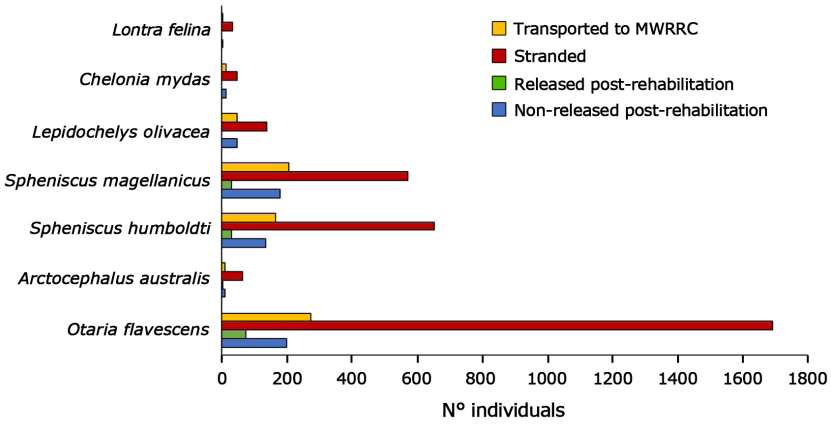

Figure 5. Number of stranded sea turtles, pinnipeds, penguins, and sea otters, transported to rescue centers, released post-rehabilitation and not released during the study period (2009-2019) in Chile / Número de tortugas, pinnípedos, pingüinos y nutrias varadas, transportados a centros de rescate, liberados pos-rehabilitación y no liberados durante el período de estudio (2009-2019) en Chile

Discussion

During the 2009-2019 period in Chile, a total of 3,198 specimens of chelonians, pinnipeds, penguins, and mustelids were stranded; of them, 721 were transported to MWRRC, and 136 were released post-rehabilitation. These results show a success rate of only 18.8% in the release of charismatic marine fauna stranded along the coast of Chile. There is a need to increase the number of MWRRCs in Chile due to low success rate of post-rehabilitation procedures. Furthermore, there is a lack of MWRRC in six Chilean Regions (III, VI, VII, IX, XI, XV) (Soto-Azat 2017). This is a serious concern in Northern Chile (Arica and Parinacota, Iquique, Antofagasta, and Atacama Regions) with a total area of 126,049 km^2 and only one MWRRC located in Antofagasta city. For example, in Arica and Parinacota Region occurred 111 strandings events, but there are no MWRRCs.

Chile has a low success in post-rehabilitation releases. Such as 2,970 live sea turtles (*Caretta caretta* and *Chelonia mydas*) stranded during the period 1996-2013 in Queensland (Australia), of which 39% (n= 1,173) were released post-rehabilitation (Flint *et al.* 2017). In Chile, 184 specimens of *L. olivacea* and *C. mydas* were stranded during the 2009-2019 period, and 0% of the specimens were released post-rehabilitation. Regarding pinnipeds, 786 sea lions were stranded in the USA during a 7-year period (1984-1990), of which 34.5% (n= 272) were released post-rehabilitation (Gage *et al.* 1993). While Chile, registered during the 2009-2019 period, 1,693 specimens of stranded sea lions, of which only 4.4% (n= 74) were released post-rehabilitation. Parsons *et al.* (2018) evaluated the success in South African penguins' rehabilitation (*Spheniscus demersus*) and concluded that 83.3% of the 3,657 stranded specimens between 2002-2013 were successfully released (305 on average per year) (Parsons *et al.* 2018). The current study shows that in Chile, during the 2009-2019 period, a total of 1,223 penguins were beached, considering *S. humboldti* and *S. magellanicus* species (122 penguins on average per year), of which only 5% were released. Nicholson *et al.* (2007) indicated that sea otters rehabilitation process depends primarily on human care, since 67% of animals tended to fail in their subsequent release and insertion into their natural habitat. This is due to the imprinting process when orphan otters see human rehabilitator as a parent during the critical period of their development. After this imprinting they will be identified with human species for life. To overcome this issue, orphan pups were paired with captive adoptive mothers, increasing survival rate from 31% to 71%. This study showed that from a total of 35 stranded sea otters (*L. felina*) during the 2009-2019 period (8 adults, 5 subadults, 7 juvenile, 9 pups and 6 undetermined), only five individuals were transported to MWRRC and no individual was released post-rehabilitation. These findings indicate that marine charismatic fauna rehabilitation in Chile is just beginning when comparing to other countries that have progressed better in terms of post-rehabilitation released specimens.

Rehabilitation of these species assumes importance in the wake of their declining population. *S. humboldti*, a species classified as "Vulnerable", has 32,000 mature individuals in their natural state, and their numbers have decreased significantly from 1980 to 2008 by 51% in Peruvian colonies (Vianna *et al.* 2014). 80% of the *S. humboldti* population lives in the Chilean territory. Therefore, efforts to recover and conserve this species should be intensified in the country (Birdlife International 2020a, b). Regarding sea turtles, *L. olivacea* is categorized into "Vulnerable" (Abreu-Grobois 2008) and *C. mydas* "Endangered" (Seminoff 2004) and their population has a decreasing trend. The sea otter, *L. felina*, an "Endangered" species with a population of 800 to 2,000 individuals, is found on the coast of Peru showing also a population decreasing tendency (Valqui 2012, Mangel *et al.* 2022). *O. flavescens* and *A. australis*, classified into "Least Concern", have a population of 222,500 and 109,500 mature individuals, respectively in the wild (Cárdenas-Alayza *et al.* 2016a, b). These species were one of the most hunted during the nineteenth and twentieth centuries. In 1995, the Subsecretaría de Pesca y Acuicultura (SUBPESCA) imposed a ban on their capture in Chile due to the ecological damage that can be caused by indiscriminate hunting (SUBPESCA 1995)[3].

Although data regarding stranding cause of sea lions, sea otters, sea turtles and penguins were not registered in the current study, historical decline of these marine fauna species in the South East Pacific has been associated with bycatch, habitat degradation, and boat strikes (De Paz *et al.* 2002, Kelez*et al.* 2003, Alfaro-Shigueto *et al.* 2011, Quiñones & Quispe 2017). The main threats faced by sea lions are bycatch, as artisanal and industrial fisheries fish the same species that sea lions eat such as the Peruvian anchovy (*Engraulis ringens*) in northern Chile (Sepúlveda *et al.* 2007, IMARPE 2013, Gonzales *et al.* 2015). In Chile, a study revealed that 56% of fishermen have observed sea lions killed during fishing operations due to entanglements (Sepúlveda *et al.* 2007). This problem has been enhanced during El Niño Southern Oscillation (ENSO) years when prey is scarce (Culik *et al.* 2000). The current study shows that most of the stranded sea lions were pups (n= 700). Sea lions pups are most susceptible to die during coastal storms when wave power exceeds 100 m^2s^{-1} (Sepúlveda *et al.* 2020). Penguins are also susceptible to die during strong ENSO events due to depletion of prey inducing nest abandonment and chick mortality (Paredes & Zavalanga 1998, Simeone *et al.* 2002). Bycatch, invasive species in nesting colonies and oil spills may also cause death of penguins in Chile (García-Borboronglu *et al.* 2008, Simeone & Luna-Jorquera 2012).

[3]Subsecretaría de Pesca. 1995. Decreto Exento N°225 de Veda para los recursos hidrobiológicos que indica. Diario Oficial de la República de Chile, 09 de noviembre de 1995, pp. 1-3. <http://www.subpesca.cl/portal/615/articles-6623_documento.pdf>

There is a lack of stranding data records at national level as not all the MWRRCs inform about the strandings to SERNAPESCA and there is a underestimation of the number of stranded, rescued a rehabilitated animals. It is suggested to standardize data collection protocols for stranding events, since the current spreadsheet data that SERNAPESCA uses present some inconsistencies, causing trouble in the data analysis and statistics. Variables without information or with contradictory information were found in the database. For example, it was observed that an animal was not transported to an MWRRC but was released, which indicates that either the animal was not transported to a center and released directly in nature or relocated, or SERNAPESCA was wrongly informed about release or transport. It is also possible that this animal was relocated to avoid tourists or predators from the stranding area. Tourism can have both positive and negative effects on marine fauna strandings. Tourist can disturb penguin or sea lions colonies by altering newborn nursing behavior but they can also visualize stranded animals and contact local authorities about injured marine fauna in the coast (Simeone & Schlatter 1998, Newcomb *et al.* 2021). Increase in strandings during recent years may be due to the expansion of tourists during holidays. The enforcement of the stranding network with skilled professionals and economic resources, documenting strandings including information on spatio-temporal patterns of occurrence, anthropogenic activities or associated climate events are actions suggested to respond quickly to strandings and improve the information provided by the database. It is suggested to implement an interdisciplinary work between different entities (SERNAPESCA, NGOs, and the MWRRC) and corroborate agreements among them in order to improve the rehabilitation procedure of marine fauna species in Chile. As there are few rescue centers to cover the large extension of the Chilean coast, this study shows a low success in the release of marine species stranded alive along the coast of Chile and underlines the need to improve the action protocol and coordinated work between the organizations involved. Hence, it is suggested that the Chilean government should improve the infrastructure of rescue centers along the country's coastline and establish an action protocol against stranding of marine megafauna endangered species. Lack of funding and deficient infrastructure presented in Chilean MWRRCs is affecting the number of specimens that can be released post-rehabilitation (Wimberger *et al.* 2010, Soto-Azat 2017).

As post-release monitoring of rehabilitated animals is not standardized in Chile, some centers have implemented their own techniques for marking penguin with paint, chips, or rings. For example, 64% of the MWRRCs indicated that they did not use any post release monitoring system (Soto-Azat 2017). Post-release monitoring is essential for the development and refinement of marine fauna rehabilitation and release practices as the first month after release is the critical period in which it will become evident whether the animal is thriving, capturing sufficient prey and being accepted for conspecifics for example in the case of sea lions. It is recommended that after completion of the rehabilitation process, all released animals should be marked with ear tags, rings, chips, or using photo identification (*e.g.*, ventral spots in penguins of the genus *Spheniscus*) to guarantee the monitoring of released animals and continue on a regular basis via field observations, radio or satellite linked monitoring for up to one full year (Whaley 2009). Post-release marking is necessary to investigate the success rate of the rehabilitation process and, in turn, join efforts for the benefit of conservation programs for those endangered species (Soto-Azat 2017).

The results obtained in this study show a low release rate of stranded sea lions, penguins, sea otters and sea turtles after rescue and rehabilitation in Marine Wildlife Rescue and Rehabilitation Centers in Chile. This low rate decreases the possibilities to recover populations of endangered species in the South East Pacific. The lack of MWRRCs along the Chilean coast hindered the rehabilitation process in addition to the lack of collaboration among SERNAPESCA authorities, NGOs and Rescue Centers. To improve this situation Chilean Government should standardize marine fauna stranding network in the country and the protocol to rescue and rehabilitate marine fauna should be improved in terms of stranded animals follow up from the finding at the coast to their transport to rescue centers, treatment, recovery and release post-rehabilitation. These steps are scarce in marine fauna stranding records provided by SERNAPESCA which reflects the poor effectiveness release rate of stranded animals. The causes of stranding remain unknown as there is no standardized protocol for the rehabilitation and rescue centers do not share this information. Cause of stranding is important information in terms of knowing if strandings are produce due to anthropogenic factors or climate change in order to search for prevention strategies, provide proper medical care and to better understand the health status of Chilean marine ecosystem. Moreover, there is a need to improve and standardize the protocol for the tracking of released animals in order to understand whether the rehabilitation process was successful or not.

Acknowledgments

N Allende-Marín thanks Ana M. García-Cegarra for her unconditional dedication to this process. We would like to thank the support extended by the SERNAPESCA for provide the necessary data to carry out this study.

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Received 10 November 2021
Accepted 9 September 2022