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Elephant Seal Research Group

Environmental research at Sea Lion Island, Falkland Islands

Field work report 2015/2016

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Summary

Between 1995 and 2016 our research team carried out various research projects on wildlife and environment of Sea Lion Island (Falkland Islands; SLI hereafter), including a long term study of southern elephant seals (*Mirounga leonina*), a study of killer whales (*Orcinus orca*) begun in 2013, a study of skuas (*Stercorarius antarctica antarctica*) begun in 2014, and a general environmental monitoring project, carried out opportunistically along the years but gradually intensified from 2013. Sea Lion Island is a Falklands wildlife hotspot, a National Nature Reserve, a RAMSAR convention site, an Important Bird Area, and a premier location for nature-oriented tourism. In this report we briefly outline the work done during the 2015/2016 field work season, and the data processing and analysis that is ongoing.

The first goal of the field work was to carry on the data collection for our long term research project on the behaviour and ecology of elephant seals. We collected data on: 1) the demography of the population, that will be used to estimate its long-term trend and status; 2) the breeding history of the marked individuals, that will be used to estimate vital statistics of the population, and to study the individual breeding strategies; 3) the behaviour of breeding individuals, that will be used to study mating and breeding tactics, the individual variation of behaviour, social communication, and the mother-pup bond; 4) various aspects of individual phenotype, including age, size and morphology, that will be used to understand the effect of structural phenotype on behaviour, reproductive success and survival; 5) the weanling behaviour, that will be used to study the effect of anthropogenic stressors; 6) weaning weight, that will be used to study the long term effect of oceanographic and climate on elephant seal access to food resources. There were no apparent detrimental effects of the research on the seals, and there were no complaints about our research procedures by other visitors of the island.

For the killer whale research project: 1) we increased our database of pictures of identified resident and transient killer whales; 2) we spent in the field a large amount of time to observe killer whales, and determine their activity pattern in time and space, the effect of environmental conditions on the likelihood of sighting, the association among individuals and their social system; 3) we studied killer whale hunting tactics trough direct observations and video-recording of predation events, counts of potential pinniped preys, and necropsies of the pinnipeds found dead on the beaches.

For the skua research project: 1) we carried out nest identification and mapping using survey-grade GPS receivers; 2) we estimated reproductive success by visiting the nests and monitoring chick survival to fledging; 3) we recorded skua vocalizations to carry out a study of their vocal communication, and individual recognition. This project was low invasive, we did no

capturing or marking of skuas, we located nest by GPS positions and unobtrusive flags, and we did just a maximum of three recording sessions for each nest or pair.

For the general environmental monitoring project: 1) we carried on the monitoring of two-banded plovers (*Charadrius falklandicus*), that were ringed during a previous research (Woods and Szekely, 2006); 2) we carried out regular counts of southern sea lions (*Otaria byronia*), in particular to determine the net productivity and timing of breeding events of the small Sea Lion Island colony of this rare species; 3) we carried out counts and mapping of nests, eggs, and chicks of various species of birds, including striated caracaras (*Phalcoboenus australis*), kelp gulls (*Larus dominicanus*), dolphin gulls (*Leucophaeus scoresbii*), and South American terns (*Sterna hirundinacea*). All these field activities were totally non invasive and required only counts, taking of pictures and mapping of positions using GPS receivers. Our final goal is to aggregate all this information into a dedicated GIS for Sea Lion Island, that we are currently developing. We are also trying to aggregate to this GIS the information available from past opportunistic surveys and mapping efforts, which results have never been properly reported, and that are at risk to be lost.

We plan to follow up our field work during the next season, August 2016 to April 2017, if our research licences will be confirmed.

1. The southern elephant seal study

1.1 Introduction

In 1995 our research team began a long term research project on southern elephant seals (*Mirounga leonina*) of Sea Lion Island (Falkland Islands, SLI hereafter). SLI shelters a small and localized population of elephant seals of about 600 breeding females (Fig. 1), is the main breeding colony of elephant seals in the Falklands, and is a hotspot for moulting of alien elephant seals coming from various populations of the South Georgia stock. In this report we describe the field work carried out between August 2015 and March 2016, we summarize the data processing and analysis that is ongoing, and we discuss the follow up of the research. A separate report on the trend in population size and status is available from our website, www.eleseal.org (Galimberti & Sanvito, 2016). Our plan is to carry on the study of elephant seals during the 2016 elephant seal breeding season and the 2016/2017 moulting season, if our research licences will be confirmed. More information on the research project is available online on the web site of the research team (www.eleseal.org).

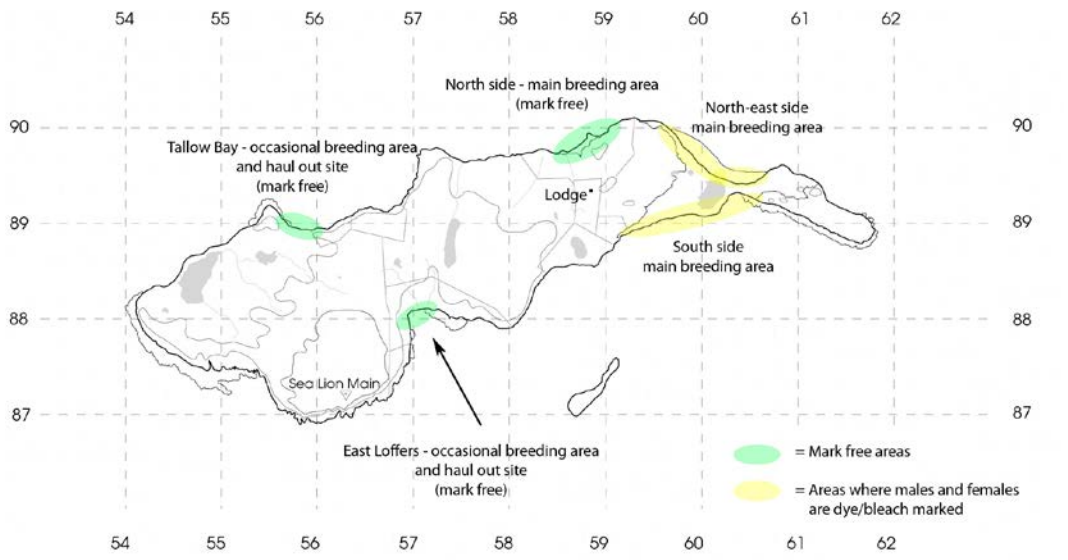

Fig. 1 - Map of Sea Lion Island, with the elephant seal breeding areas.

1.2 Field work activities and methods

The field work was carried out by two PIs and four to six field helpers for the whole length of the elephant seal breeding and moulting season, including the arrival on land and departure to sea of all breeding seals, and the moulting of the various sex and age classes. The only period that we are not covering is the "winter" haul out of younger individuals, which is anyway a difficult process to predict, which ecological significance is almost unknown.

All together field work was carried out from 31/08/2015 to 28/03/2016 (211 days, 108 during the breeding season and 103 during the moulting season). The number of field helpers

fluctuated slightly during the field work, but we had a minimum of seven operators (PI or helpers) in the field during the breeding season, and a minimum of four during the moulting season. We have been able to collect all the planned data, with a very good coverage of both the elephant seal breeding and moulting. We carried out a total of 11904 hours of effective field work, 7681 during the breeding season (mean = 9.6 hours per operator and day), and 4223 hours during the moulting season (mean = 8.6 hours). Data collection and processing was carried out using a fully digital workflow, including: 1) data collection in the field using palmtop computers (iPaq, HP) and relational databases and entry forms (HanDBase, www.ddhsoftware.com); 2) daily integration of new data on a custom relational data management system (programmed in LiveCode, www.livecode.com); 3) quality control of the collected data; 4) automated reporting and preliminary analysis of the collected data. Our goal is to streamline the data collection and processing, reducing operator errors and improving reliability.

A description of the field research activities and methods follows. For each activity, we indicate the short or long term research goals. More details on the goals of the project can be found online on the website of the research team. Field work activities were carried out in accordance with research licence R10/2013, a five year licence to study elephant seals granted by the Environmental Planning Department of the Falkland Islands Government. See section 1.2.9 for guidelines compliance.

1.2.1) Marking of elephant seals

Goals: long term study of individual breeding strategies; estimation of vital statistics and life tables; population viability analysis; estimation of number of moulters immigrating from other populations; study of inter-population movements.

Long term marking is obtained with numbered tags (Figure 2, left), while short term marking is obtained with hair dye (Figure 2, right). The protocol used was the same of the past seasons (Galimberti and Boitani 1999), with the following exceptions: a) we used mostly Dalton (www.daltontags.co.uk) Jumbo tags (used from the beginning of the research) to mark adults and pups at birth during the breeding, and all seals during the moulting; we are still using Jumbo tags on adults, notwithstanding the decrease in quality observed along the years, because they are currently the only tags that can be deployed on adults by surprise and without restrain; unfortunately Jumbo tags are not produced anymore, and, therefore we are testing alternatives; b) we used mostly Caisley (www.caisley.de) Primaflex tags (used for the first time in 2009) to mark pups at weaning, because they proved to be better than Jumbo tags, at least in the short term; this new tag model is very similar in size and shape to the Dalton Jumbo, but, unfortunately, due to the shape of the tag applicator these tags are difficult to deploy on unrestrained adults; c) we tested laser printed Caisley Primaflex tags, in addition to the usual hot foil printed tags. The comparison of different brands, models, and printing methods of tags is of paramount importance,

because we need to determine a new optimal tag model now that Dalton Jumbo has been discontinued. Our preliminary impression is that Caisley laser printed tags can be an ideal model if the applicator can be modified to let us deploy the tags on unrestrained adults.

Fig. 2 - Marking of elephant seals. Left: tagging of a weaned pup; right: dye marking of a female.

We tagged all pups with two tags, the first usually within 24 hours from birth, to be able to surely identify the mother, and the second at or after weaning (Fig. 2, right). We deployed a total of 2598 tags, 42.3% of which were used to double-tag the pups. Of the other tags (1370), 22.7% were deployed on breeding seals and 87.3% on moulting seals (see below). The tags placed on breeders (males and females) were deployed in order to: a) double tag individuals that received just one tag at birth/weaning; b) double tag individuals that lost one of their tags; c) double tags the very few individuals that lost both tags; and d) add a new readable tag to individuals that had tags that were so worn out to be difficult to read. For already tagged individuals, each new tag was cross-referenced to at least one of the old tags in all cases, to avoid identity duplication. We tagged almost the whole new cohort: 625 pups were tagged, 96.5% of them with two tags. The mother was surely identified at first tagging for 531 pups (84.5%); field notes and behavioural observations usually permit to attribute the mother to all pups, even when she is not identified at tagging. The identification of mothers is of paramount importance to build up pedigrees and complement the molecular data for our genetic studies. We identified the sex of almost all tagged pups.

We marked breeding males and females with hair dye. Dye marks were made on four possible sides: left flank, right flank, back near to the caudal area, and belly. We made a total of 1924 one to three sides dye marks, 79.3% on females and the rest on males. All breeding males and about 90% of the breeding females had at least one side mark. No dye marks were put on pups, weanlings or moulting individuals. We estimated that toward the end of the breeding season (mid-November) less than 5% of the seals present on land did bear dye marks. Dye marks fade during the post-breeding aquatic phase, and are completely lost during the moult. We calculated the relative size of marks by taking pictures of a sample of side marks and measuring the relative size of the marks (on the size of the body) using image analysis software (ImageJ, http://imagej.nih.gov/ij/). The median relative size of marks was 13.9% of the body size on the horizontal axis and 18.9% of the body size on the vertical axis.

A great effort was put in tagging alien moulting individuals that arrived to SLI from other populations, and in re-sighting of tags of alien moulting seals that were tagged during previous moulting season. The final goal of this tagging effort on moulters is to estimate the number of alien seals coming to SLI for the moult using mark-recapture models (McCrea and Morgan 2014). This is a compelling needing for SLI, and should be extended to the rest of the Falklands, because there are clear evidences that seals from various populations of the South Georgia stock use the Falklands as moulting ground. Alien seals tagged at Sea Lion Island during the moult were observed as breeders in the Valdés Peninsula, at King George Island, in the South Shetland Islands and at South Georgia (unpublished data). Moreover, there are anecdotal evidences that number of alien seals moulting in the Falklands can be great, much greater than number of local breeders, and particularly relevant from an ecological and conservation point of view. All together we deployed 1059 tags on alien moulters: 9.6% on adult females, 9.9% on yearling of both sexes, 18.0% on two year old individuals of both sexes, 42.1% on juvenile males (3-5 year old), 19.0% on sub-adult males (6-9 year old), and 1.4% on adult (10 year old or older) males.

1.2.2) Counts and identification of elephant seals

Goals: long term monitoring of the population and trend estimation; timing of breeding; study of individual breeding strategies; timing of moulting; estimation of haul out models for the moulters.

We used the same protocol of the past seasons (Galimberti and Boitani 1999). During the breeding season, the main study area, i.e., the sandy beaches of the eastern part of the island, where usually 95% or more of the elephant seals breed, was counted daily, and we obtained 100 daily counts of the breeders, including 81 counts in which there were females hauled out. The rest of the island coastline counted every week (breeding) or every other day (moulting). We carried out a total of 22 counts of the whole island coastline during the breeding season. A total of 14 females breed outside the main study area, 9 at Tallow Bay (near the diesel storage area), in small harems (2-3 females) or isolated, and 5 at East Loafers in a small harem. These are the only

places outside our main study area in which breeding females and pups have been observed in the past.

We identified all the breeding individuals, males and females that hauled out, and all of them were individuals of known age, born at SLI and tagged as pups, bearing tags or, in very few cases, signs of lost tags. We carried out daily sessions of identification of males and females, to study their breeding strategies, and of weaned pups, to study weaning and the following dispersal phase. In all, we obtained 5133 identifications of males (mean = 50.3 per day), 17122 of females (206.3 per day), and 14641 of weaned pups (244.1 per day). During each day of the elephant seal breeding season we identified at least 85% of the breeding females, and all breeding males.

During the moulting season, we carried daily counts of the main study area, that was the same main study area of the breeding season plus three extensions: 1) the East Point, that is not occupied by seals during the breeding, but is a moulting hotspot, in particular for females; 2) the beach of the Small Pond, that is also much used by moulting seals; and 3) the west ridge of Cow Bay, that is also an moulting hotspot for females. We carried a total of 101 daily counts during the moult. We carried a whole island census every other day, surveying the whole coastline, obtaining a total of 51 full counts. We obtained 28820 identification of moulting individuals, to study temporal and spatial distribution, individual timing of the moult, and moulting habitat preference.

1.2.3) Observation of elephant seal behaviour

Goals: long term study of social system, communication, mating tactics and breeding strategies.

Details of the observation protocol can be found in Galimberti et al. (2000; Fig. 3). We carried out a total of 1518.5 hours of observation of seals behaviour. We did 469 observation periods focused on males, each one of the standard duration of two hours, to study male fighting behaviour, dominance and mating success. We also did 1161 observation periods focused on females, each one of the standard duration of 30 minutes, to study mother-pup communication, suckling, and aggression between females. The average number of observation periods per day of work was 26.7, with more intense effort around and after peak haul out, when male interaction rate and copulation rate are higher. In all, we recorded data for 4208 male *vs.* male interactions, 3933 male *vs.* female interactions, and 2249 female *vs.* female interactions. We observed a total of 851 copulations by 46 males. Average number of copulations per male was 18.5 but range was 1 to 155, and only 13 males, all of them harem holders, did 15 copulations or more. During female observation periods we collected data on time budget using scan sampling at 1 minute intervals. In all we carried out 358 scan sampling sessions.

To study the timing of the breeding events we carefully recorded all observed arrival to land of females (180 records), births (257 records), return to sea of females (111 records), and weaning (236 records).

Fig. 3 - Video-recording of an elephant seal fight.

1.2.4) Recording of seal vocalizations

Goals: long-term study of acoustic communication (see Sanvito et al. 2007 a); individuality and phenotypic correlates of female vocalizations; feasibility of a sound based identification system for females.

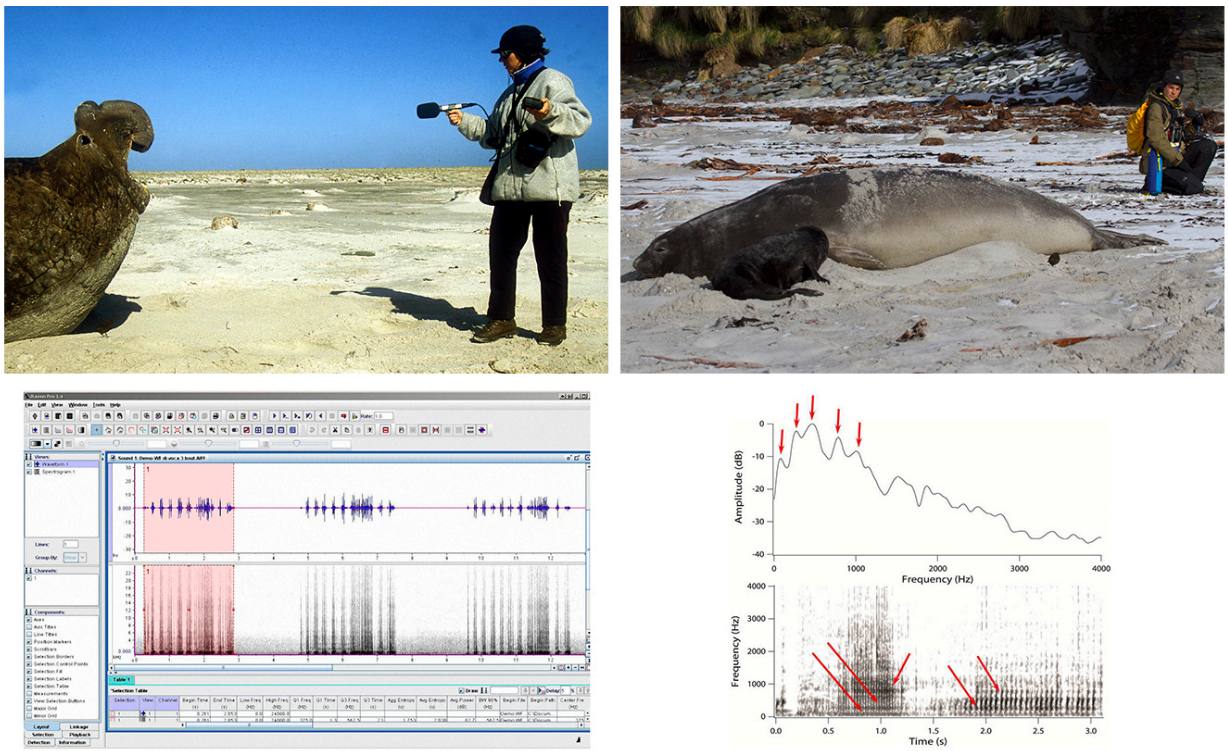

Fig. 4 - Recording and processing of elephant seal vocalizations. Top left: male recording; top right: mother and pup recording; bottom left: sound analysis software, bottom right: spectral analysis of sound.

Recordings were obtained opportunistically during the whole breeding season. In days with good conditions (low wind, low swell) operators walked along the breeding beaches and recorded vocalizations using digital solid state recorders (Marantz PMD-660, en.wikipedia.org/wiki/Marantz_PMD-660) and super-cardiod dynamic microphones (Sennheiser MD-441, en-us.sennheiser.com/dynamic-studio-microphone-condenser-md-441-u). Ultra-directional shotgun microphones (Sennheiser ME-67) were used the least possible, due to their limited dynamic range. Sounds were visualized and checked after recording sessions using dedicated animal sound analysis software (Raven Pro, version 1.4, Cornell Laboratory of Ornithology, http://www.birds.cornell.edu/brp/raven/RavenOverview.html). After the end of the field season all recordings were reviewed, selected, and analyzed using sound analysis software (Raven Pro; Praat, http://www.fon.hum.uva.nl/praat/). Main steps of sound recording and processing are shown in Figure 4. We obtained 195 recordings of 82 males, 907 recordings of 182 females; 122 females were recorded two or more times. Of the female recording, 502 were aggressive vocalizations.

1.2.5) Measurement of elephant seal size and morphology

Goals: development of non-invasive methods of size estimation; study of male and female growth; effect of male size and morphology on dominance and mating success; effect of female size on maternal investment; development of secondary sexual traits; use of face morphology for individual recognition.

Size is a fundamental aspect of the biology of any species. In elephant seals size has deep effects on behavioural strategies, maternal investment, foraging at sea, and breeding strategies. The measurement of size in large animals often involves invasive methods. From the very beginning of our elephant seal study we tried to devise methods to reduce invasiveness, and we did the same also for size and morphology (Sanvito et al 2007 b).

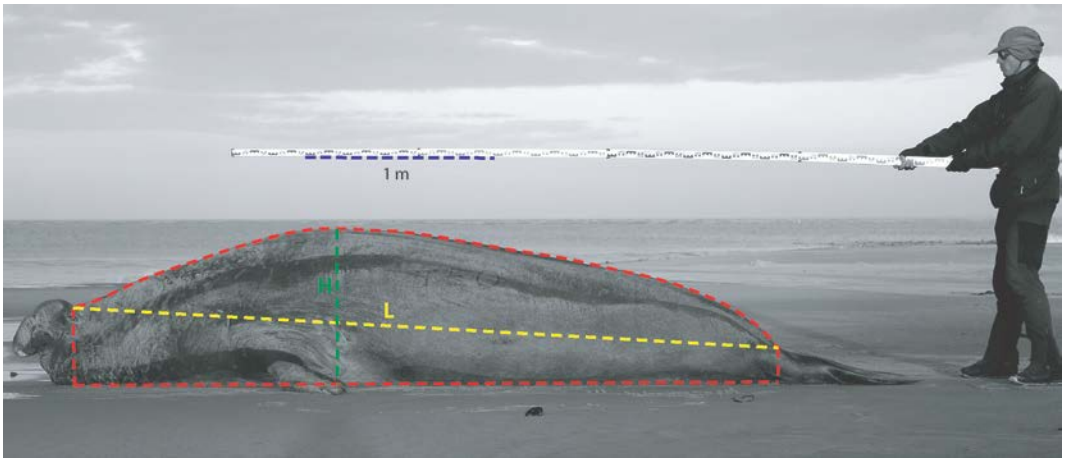

Fig. 5 - Photogrammetric measurement of a male elephant seal.

We used a photogrammetric method, in which one operator place a calibrated survey bar over the seal, and another operator take pictures (Figure 5). The bar is then used as a scale, and pictures are measured using image analysis software (ImageJ, http://imagej.nih.gov/ij/). We obtained pictures to estimate body size for 76 males, and pictures to measure morphology for 65 of them.

Close-range photogrammetry proved to be very useful for male elephant seals (Galimberti et al. 2007), but it is somehow more problematic with females, that being aggregated in harem are more difficult to approach. We are currently testing a new method based on simple trigonometry, in which distances are measured using a high accuracy laser rangefinder (Leica Disto A8, www.leica-geosystems.com/en/index.htm), and angles are measured using a digital protractor (WR418; http://wixey.com/digitalprotractor/). We obtained a total of 1151 measures for 134 females, including 122 females with 3 or more measures. The most common length measure, the median axis length from the tip of the nose to the point of attack of the rear flippers, had an overall repeatability of 0.91 (95% confidence interval = 0.86-0.95). All together, our trigonometric measurement system looks very promising, permitting a fast and accurate estimation of size.

The study of facial morphology for individual recognition of animals is a new area of research, which is getting momentum from the recent developments in biometrical system for human face recognition (Kumar and Kumar Singh 2014). The idea is to use facial features for the automated recognition of individual animals. There is a previous study carried out on southern elephant seals (Caiafa et al 2005), but its results are severely limited by flaws in the methodology (small sample size, lack of a really independent validation sample, lack of external validation through artificial marking, use of a rather outdated face recognition algorithm). We are currently developing a new approach based on: 1) the taking of standardized pictures of faces of elephant seals; 2) the identification of landmarks on pictures and the registration of picture using these landmarks; 3) the application of state of the art face recognition algorithms (http://scikit-learn.org); 4) the customization of the chosen algorithm to suit the specific problem of elephant seal recognition (e.g., extreme variation in lighting conditions). Although we are at a very preliminary stage, this seems to be a promising area of research, because it can effectively complement artificial marking of seals. We are currently working on a set of 156 images of 26 females and on a set of 240 images for 10 males. We obtained good repeatability of the first phase of the procedure, the placement of facial landmarks.

1.2.6) Weighing and measurement of weanlings

Goals: study of maternal investment; assessment of female access to resources; evaluation of population health.

The weighing protocol was the same used in the past, and is described in Galimberti and Boitani (1999; Fig. 6). We weighed 232 weanlings, 56.0% of which were males. During the weighing

operations we also measured the standard body length, the curvilinear ventral length and the girth circumference of the subjects. During handling we collected various measures of reaction to assess the impact of the procedure on the subject welfare and stress, including a qualitative index based on the behavioural modules shown, distance and timing of movements after the release, and presence of urination and defecation. Total handling time, that included weighing, measuring, and tagging lasted on average just 6 ' 30". Average weaning weight was 132.6 kg (range = 77-203.6 kg), similar to the long term average.

Fig. 6 - Weighing of a weaned pup.

1.2.7) Collection of environmental data

Goals: study of the relationship between microclimate and elephant seals behaviour during the breeding and the moulting.

We deployed a total of 15 data loggers, 5 Hobo Pro with air and ground probes (Onset Computers, www.onsetcomp.com) and 11 Thermochron of various models (Maxim Integrated, http://www.maximintegrated.com/en/products/ibutton/ibuttons/thermochron.cfm). Data loggers were programmed to collect temperature data at 5 minutes intervals. During the breeding phase dataloggers were deployed close to traditional areas of formation of main harems. During the moulting phase some were moved to place of moulters concentration. Data collected by dataloggers were downloaded at weekly intervals (Fig. 7). We had full coverage of the elephant seal breeding and moulting season. Dataloggers data will be combined with data collected by the SLI weather station operated by the British Atmospheric Data Centre (badc.nerc.ac.uk). Environmental data collected in the field will be augmented by climatic, oceanographic, sea condition and tide data obtained from various Internet sources.

Fig. 7 - Downloading of environmental data from a datalogger.

1.2.8) Collection of GIS data

Goals: study of the spatial ditribution of the wildlife; collection of baseline data about SLI topography; development of an integrated GIS for SLI.

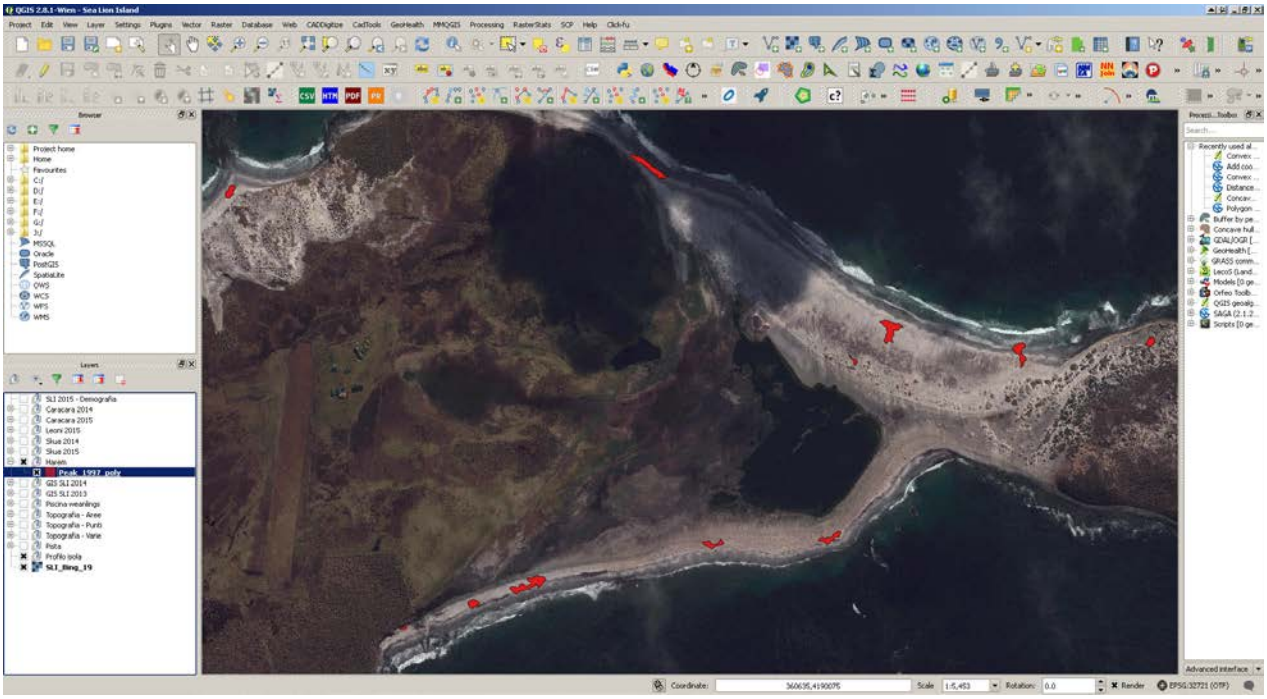

Fig. 8 - Profiles of elephant seal harems, shown in GIS software.

The location of each isolated seal or seals group was mapped daily with navigation-grade GPS receivers (GPS60 and GPS60Map, Garmin). In all, we collected 10941 valid GPS fixes. We

mapped the coastline and the topography of the breeding areas, and the profile of harems using survey-grade GPS (ProMark3, Spectra Precision), and we post-processed these data using fixes from a reference station to achieve sub-metric accuracy (Figure 8). Mapping surveys were carried out in 30 days during the breeding and moulting season. GPS tracks of each operator, collected using automated GPS loggers (Canmore GT-730F-S, 1421 daily logs), were used to estimate the effective time spent in the field, and the km walked in the study areas. These two measures will be used to standardize data on the research effort.

1.2.9) Research guidelines

Our research project strictly follows the following field research guidelines:

- Guidelines for the treatment of animals in behavioural research and teaching (Association for the Study of Animal Behaviour, 2012).
- Guidelines of the American Society of Mammalogists for the use of wild mammals in research (Sikes et al., 2011)
- Guidelines for the treatment of marine mammals in field research (Gales et al., 2009).

1.3 Impact of the research on elephant seal welfare and on Sea Lion Island visitors

None of the research activities mentioned above seems to have produced short or medium term detrimental effects on the animals. A full account on the matter, and on the ethical background of the research, is available online in PDF format (http://www.eleseal.it/pdf_vari/ethic.pdf). We have an ongoing project to evaluate the impact of research disturbance, and human disturbance at large, on elephant seals. In particular, we are collecting data on elephant seal reaction and behaviour toward approaching humans and vehicles, and on physiological and behavioural effects of pups handling. We obtained data on elephant seal behaviour during FIGAS approach and landing, helicopter approach and landing, and lodge vehicles transit.

We had no direct complaints about the research by visitors of SLI. The Lodge Manager reported to us no verbal complaint related to the dye marking of seals. The vast majority of the reactions of visitors to our research work were positive.

1.4 Conclusions and goals for the future

The field work produced a large amount of data that improved our understanding of the Sea Lion Island elephant seal population. In particular, the follow up of the demographic monitoring, the re-sight of tags, and the weighing of weanling augmented our base of data to determine population health. We look at the following improvements for the next season of field work (2016/2017):

- stabilize at six the number of field helpers for the breeding season, and four for the moulting season, keeping turn over to the minimum, to reduce the workload per each helper, and improve the quality of the data that we are collecting
- experiment with tag models to replace the Dalton Jumbo model, that is not produced anymore, and be able to use the same tag for all age classes of elephant seals
- increase the tagging and re- sighting effort for moulters
- use of the non-invasive trigonometric approach to measure seal size, that was tested in the current season, to greatly improve our database of seal measurements, in particular for females and moulters
- set up of full featured GIS for Sea Lion Island, using QGIS and Python scripts, to integrate the vast amount of spatial data that we are collecting on elephant seals, killer whales and other species.

2. The killer whale study

2.1 Introduction

Our killer whale (*Orcinus orca*) project has three main goals: 1) the study of the behavioural ecology of killer whales, including space use, temporal distribution, social structure, and hunting techniques; 2) the determination of the impact of killer whale predation on the local pinniped populations, and on elephant seals in particular; 3) the long term study of killer whale life history using mark-recapture methods through photo-identification of individuals. The following is a brief outline of the field work carried out. A full report of the results obtained for the three seasons of study (2013-2016) is currently in preparation. The killer whale research is carried out under licence R15/2014, granted by the Environmental Planning Department of the Falkland Islands Government.

2.2 Field work and methods

2.2.1) Photo-identification

Goals: identify the killer whales; collect data on killer whale life history; collect data on killer whale movements around Sea Lion Island, in the Falklands, and elsewhere.

Photo-identification is possibly the most important tool in the study of killer whales. At SLI killer whale photo-identification is carried out mostly using features of the saddle patch (scars and scratches) and the dorsal fin. Pictures were taken using digital cameras (Canon EOS 7D) fitted with long zoom lenses (100-500mm). Digital pictures were processed using established guidelines (Mizroch 2007), and matching to know individuals was done by experienced operators using a

reference catalogue (www.eleseal.org/pdf_vari/KW_SLI_catalogue.pdf; Fig. 9). Manual match of saddle patch features was complemented by automated dorsal fin matching carried out using the DARWIN software (darwin.eckerd.edu/?page=photo_identification.html). Processing of the pictures is currently ongoing. Intra- and inter-operator reliability of identification on good pictures was 100%. We also collected killer whale pictures from wildlife photographers, tourists and the general public, to augment our picture base and to identify individuals observed elsewhere in the Falklands. Although these pictures are often problematic due to reduced frame coverage and resolution, they are of paramount importance to obtain data on killer whale movements around the Falklands. An updated version of the photo-identification catalogue is available on our website.

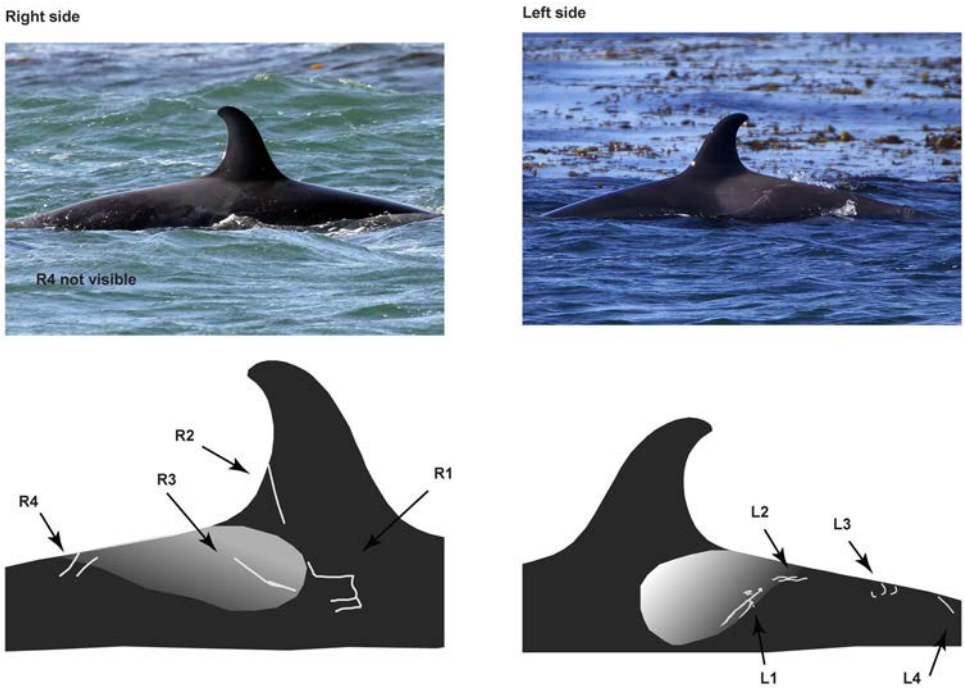

Fig. 9 - An example of killer whale photo-identification using the saddle patch.

During the 2015/2016 season of field work we observed 24 of the 31 individuals previously identified, and we identified two new individuals, a calf (Didi) and an adult male (Poldo). One of the resident female, Lola, returned without her calf Ale, so we can assumed the he died. As in the past season, Lola was associated to various killer whale groups, including individuals that appeared only once or for few days. This seems to confirm our hypothesis that there might be a rather large pool of KW inhabiting Falklands waters, just a small proportion of which is regularly visiting the coastline.

2.2.2) Surveys and observations

Goals: temporal and spatial distribution; effect of environmental factors; general activity and social behaviour; association and social system.

Daily surveys of the coastline were carried out to monitor killer whale presence and count their potential pinniped preys. A total of 2731 periods of observation of one-hour standard length were carried out from vantage points known to be hotspots of killer whale presence, or moving along the beaches. Operators carrying out survey had 10x42 binoculars, GPS receivers to get approximate positions of the killer whales, and GPS loggers to track their movements (used to calculate measures of effort and standardize data).

During killer whale observations we collected data on the individuals (number, size classes, identity), on the time and place (area name, GPS position), on the meteorological and sea conditions, and on the general activity and behaviour using a standard ethogram (Casoli 2014). We also took pictures for photo-identification (see above). We obtained a total of 263 killer whale observations, and a total of 526 direct killer whale identifications during the observations. Direct identification will be merged with identifications from pictures, to study association and social structure using a social network approach (Krause et al. 2009; Fig 10). The average number of killer whales observed was 3.85. We obtained 3673 records of killer whale activity.

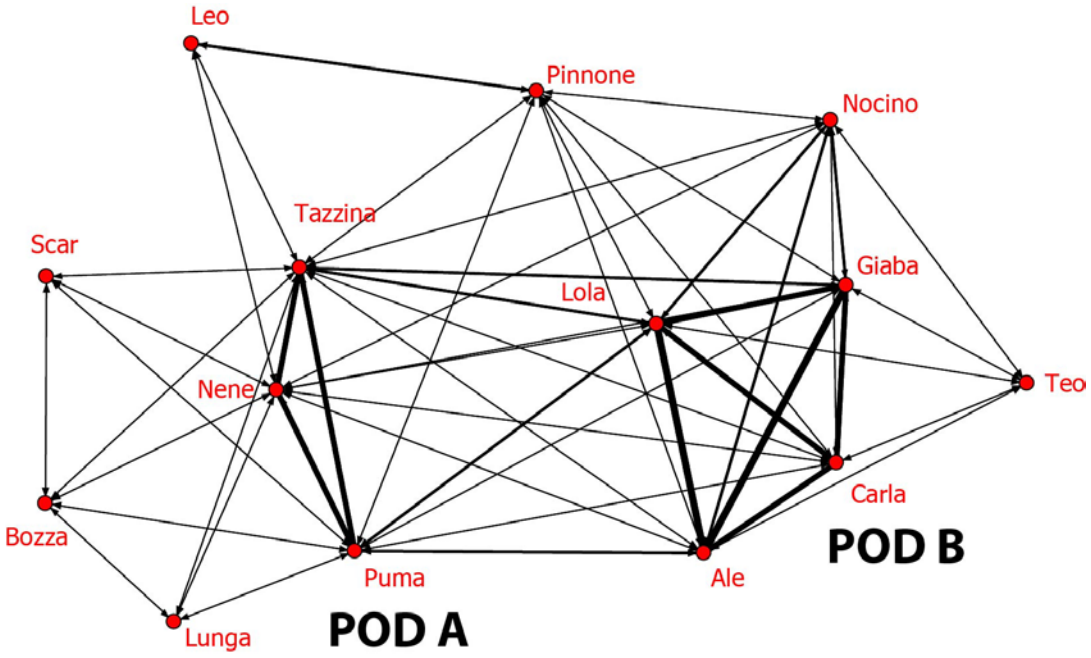

Fig. 10 - Social network graph of the two main killer whale pods observed at SLI.

2.2.3) Study of predation

Goals: study of hunting behaviour; cultural transmission of hunting tactics; impact of killer whale predation on pinniped prey demography.

Predation attempts were observed with particular care, possibly by more than one observer, using the same approach detailed above. Moreover, predation attempts were filmed were possible, and a particular effort was placed in trying to identify marked elephant seals in the pictures and videos

of predation attempts. We observed a total of 48 predations attempts, mostly on weaned elephant seal pups (Figure 11). We carried out necropsies of elephant seals and sea lions found on the beaches, trying to determine the cause of death. We also collected skulls and examined skeletons of fresh carcasses to try to estimate the sex and age classes by skull and/or bone measurements.

Fig. 11 - Predation of an elephant seal weaned pup.

2.3 Conclusions and perspective for the future

The study of killer whales at SLI is difficult because it is a land based study in which data can be collected only when killer whales are close to the coast. The lack of a boat is problematic, and in particular hampers the full observation of predation events, that usually begin close to the coastline, but may have a follow up in deeper waters. Moreover, the lack of any data about killer whale movements at sea makes particularly difficult to integrate the accurate data on time and space collected at SLI in a broader perspective. Notwithstanding these negative aspects, the study is producing using useful information, and is suggesting that studying killer whales at large in the Falklands may be worth, due to the likely presence of a large pool of killer whales actually using Falklands waters, but just rarely approaching the coastline. We are currently exploring funding options to deploy satellite-linked tracking devices on the killer whales, and we are planning for the next to make some trial observations from a kayak, to improve our capability to observe killer whales when they are distant from the coastline.

3. The skua project

3.1 Nest identification and mapping

Goals: to study the spatial distribution of skuas; to determine the timing of skua breeding.

The Falklands skua (*Stercorarius antarctica antarctica*) is a very interesting subspecies on which limited investigation has been carried out (Catry et al 2011). We searched for skua nests in the whole Sea Lion Island, we identified and mapped each nest with GIS-grade GPS receivers (ProMark 3, Ashtech), and we marked nests using a number red flag placed at about 5 meters from the nest; the flag was low on the ground and visible only at close distance. Most skua nests were clustered in two areas, one around Sea Lion Lodge, and one at the west end of the island (Figure 12). We located a total of 125 nests. Only one of these nests was isolated, while the others were clustered (mean = 14 nests per cluster, range = 2-33). Of the clustered nests, 62.1% were located at the west end of the island. Field work was carried out under research licence R10/2015, granted by the Environmental Planning Department of the Falkland Islands Government.

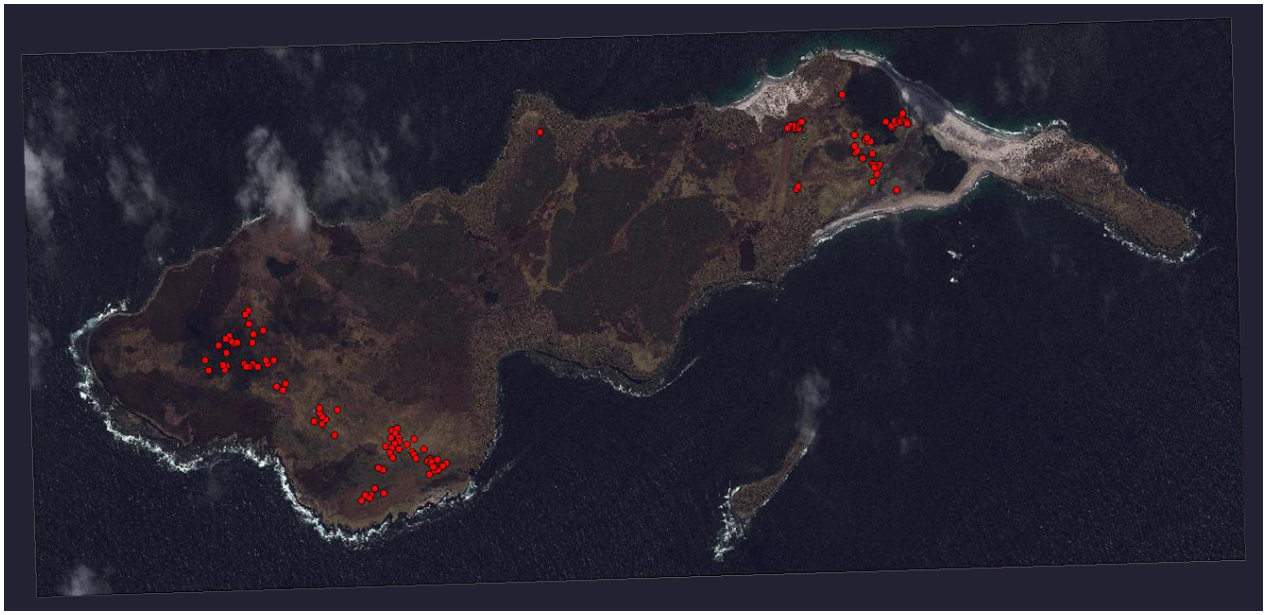

Fig. 12 - Map of the skua nests located at SLI during the 2015/2016 breeding season.

3.2 Monitoring of reproductive success

Goals: to estimate the reproductive success, and its trend.

Skua nest were visited once per week, trying to reduce disturbance to the minimum. Skua reactivity was different between the two main nest areas: skuas of the lodge areas, being more accustomed to human beings, were less reactive. Therefore, great care was placed in checking nests of the west end area. While field helpers were allowed to do the weekly census of the lodge area nests, only the PIs checked nests of the west end area. Skua nests were located using mapped

positions on GPS receivers. The following information was recorded for each nest: area, substrate, and vegetation class; number of attending adults, eggs or chicks; colour, size and condition of the adults and chick; prey remains; reaction of adults and chicks to the operator. We carried out 20 weekly census of the skua nests.

3.3 Skua acoustic communication

Goals: to describe skua vocalizations; to measure individuality of vocalizations of adults and chicks; to assess the feasibility of individual recognition using recordings of vocalizations for management and conservation purposes.

There are no studies on vocal communication of Falklands skuas. During the 2015/2016 we opportunistically recorded adult, subadult and chicks using digital solid state recorders (Marantz PMD-660, en.wikipedia.org/wiki/Marantz_PMD-660), super-cardiod dynamic microphones (Sennheiser MD-441, en-us.sennheiser.com/dynamic-studio-microphone-condenser-md-441-u) and ultra-directional shotgun microphones (Sennheiser ME-67; Figure 13).

Fig. 13 - Recording of skua vocalizations.

We tried to obtain recordings from both individuals of the nesting pair, and to have at least three different calls of each individual. We also recorded opportunistically the chick calls. All together, we obtained 303 recordings. Sounds were recorded in optimal wind and noise conditions, so about 95% of the recording are actually of good quality, and can be used for the acoustic-identification study. During the recording sessions we took pictures of the individuals of the pair to photo-identify them. A separate report on this skua communication study is currently in preparation.

4. General environmental research

4.1 Demography and phenology of southern sea lions

Goals: estimation of pup productivity; determination of the timing of breeding; estimation of population trend.

The southern sea lion (*Otaria byronia*) is a rare species in the Falklands, with many small colonies scattered around. The species had a significant demographic crash and, although it is slowly recovering, its total size is still very small if compared to the numbers reported in the past (Thompson et al. 2005). The species has not been studied intensively in recent years, although an excellent whole island census as been carried out in 2014 and a tracking-at-sea project is currently ongoing (Dr. Al Baylis, pers. comm.). The SLI colony is a very small colony that has a single localized breeding site. This site is close to the SLI settlement and, therefore, can be regularly monitored, providing valuable information about the demographic variation, timing of breeding events, and breeding behaviour of sea lions. From 05/12/2015 to 21/02/2016 we carried out 23 full census of the colony counting the individuals of the different sex and age classes, taking pictures to validate the counts, and mapping the position of territorial males and female groups. The maximum number of sea lion counted all together in the breeding colony was 234 (29/01/2016). We observed a 24% increase in pup production from 2015 (75 pups) to 2016 (93 pups). We carried out opportunistic visits to the colony to observe sea lion behaviour, and check for the presence on new pups. We also counted and mapped sea lions observed in the rest of the coastline during elephant seal surveys (weekly September to November, every other day December to March).

4.2 Demography of striated caracara

Goals: mapping of nests; estimation of breeding success.

We located 17 caracara nests observing territorial behaviour of the breeding pairs (Figure 14). Most of nests were distributed along the coastline, in the tussock grass; two nests were located on open grass close the gentoo penguin colonies and Sea Lion Lodge, while one nest, the only unsuccessful one, was located on the sand dunes toward the East Point of the island. Nests were mapped using GIS grade GPS receivers (ProMark 3, Ashtech). Nest were visited irregularly to check for the presence of eggs and chicks. We tried to minimize disturbance to the nests, and only PIs carried out nest checking, field helpers were not involved in this activity. We estimated reproductive success by counting chicks just after fledging. Nest had 1-3 eggs, but 2 eggs were more common (mean = 2.19). Breeding pairs produced 1-3 fledglings, with a mean reproductive success of 1.88. There is some information about caracara nests from opportunistic surveys

carried out in the past. Although reliability of this information is dubious, there has been an apparent increase in the number of caracara pairs nesting at Sea Lion Island.

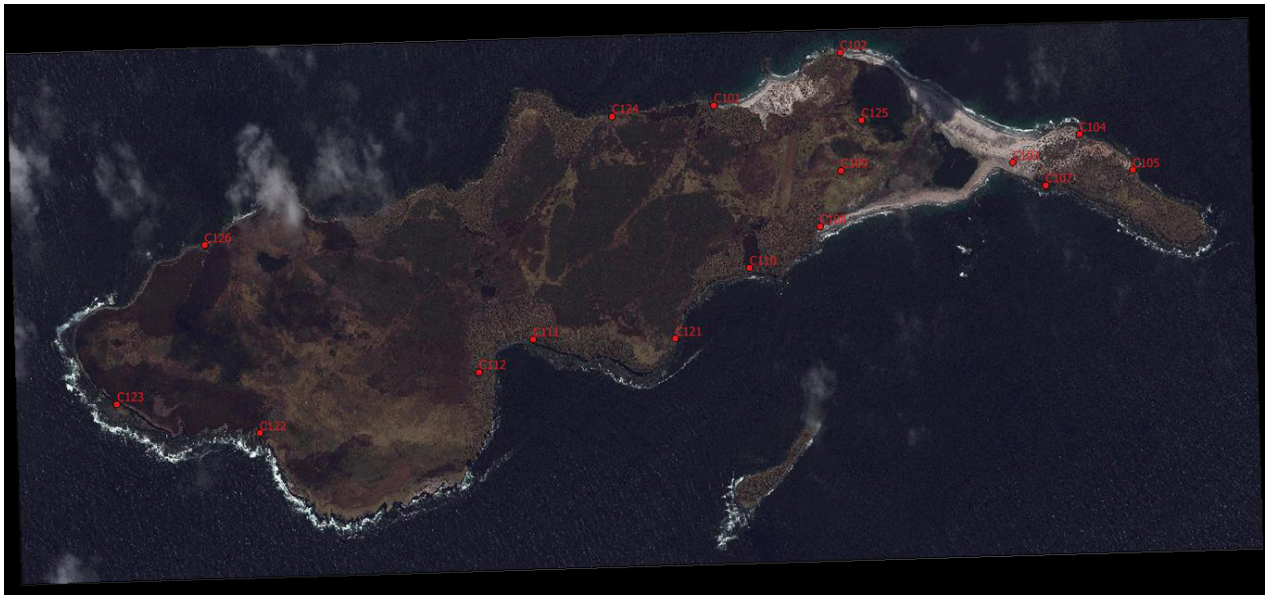

Fig. 14 - Map of the caracara nests located at SLI during the 2015/2016 breeding season.

4.3 Breeding success of bird populations

Goals: monitoring of breeding success of lees known bird species.

Although some penguin species are counted every year by Falklands Conservation (www.falklandsconservation.com/projects/seabirds) to estimate reproductive success and populations trends, most SLI bird species are not regularly monitored, and only few opportunistic surveys have been carried out in the past (unpublished data). Therefore, we are trying to carry out a regular monitoring of bird species, focusing on the ones that are less studied and known. This is currently an unfunded project that we do opportunistically, when time is available, but we are increasing the effort put into it. We are focusing in particular on kelp gulls (*Larus dominicanus*), dolphin gulls (*Leucophaeus scoresbii*), and South American terns (*Sterna hirundinacea*; Fig 15). During the 2015/2016 we located and opportunistically counted nests, eggs and chicks, in particular to obtain an estimate of total productivity.

In the previous season kelp gulls nested only at the west end of the island, near the Beaver Pond, a site already used by them in the past, which is rarely visited, and, therefore, presents a low level of human disturbance. In 2015/2016, they nested there again, but they also nested close to the gentoo penguin colonies and Sea Lion Lodge, a place with much higher disturbance level. Previous attempts to nest in the lodge area were unsuccessful, due to the high level of skua predation of eggs and chicks, triggered by human disturbance (unpublished data). This time, on the contrary, fledging success was rather good. All together, kelp gulls produced 99 fledglings,

67.7% in the lodge area nesting site. Two of these fledglings were produced by one of the three pairs that had isolated nests on the west coast, between Tallow Bay and the Beaver Pond. On the contrary, the reproductive success at the Beaver Pond was rather low, just 30 fledglings were produced. All together there was a significant decrease in success compared to the previous season, in which 338 fledglings were produced. Dolphin gulls begun nesting in the same location of the past year, on the west end of Tallow Bay, but that nesting site was abandoned during a few days of storm and heavy seas. They moved to the same nesting site of the kelp gulls at the Beaver Pond, and produced 230 fledgling, a 14.3% increase compared to the previous season. The low kelp gull productivity was possibly related to the joint nesting with dolphin gulls. South American terns were observed at Tallow Bay, close the previous season nesting ground that they shared with dolphin gull, but they did not actually nest there. We observed only one nesting pair this season, that had the nest close to sand beaches on the south east coast of the island, compared to the 63 nests and 21 fledgling of the previous season.

Fig. 15 - Monitoring of gull and tern nesting.

We opportunistically mapped nests of some species of ducks and geese, including kelp goose (*Chloephaga hybrida malvinarum*), flightless steamer duck (*Tachyeres brachypterus*), and Patagonian crested duck (*Lophonetta specularioides specularioides*). Processing of information regarding these species if currently ongoing. Our first goal is to establish a data collection

protocol for these species, that will permit an accurate estimation of reproductive success in the short term, and of population trends in the long term.

4.4 Implementation of the Sea Lion Island GIS

Goals: development of a GIS for Sea Lion Island, to aggregate all spatially-referenced environmental information that we collected in the past, recover scattered data collected by other researchers and conservation wardens, and establish a standardized collection protocol for the future.

We are developing a GIS for Sea Lion Island that may help to streamline the aggregation, processing and analysis of data that has a spatial reference. We have three goals: 1) improve the access to the spatial data that we collected for our past research projects, and that we are collecting now; 2) make a better use of scattered data that was collected in the past by other researchers (e.g., vegetation distribution study, waders study) and by conservation wardens (e.g., bird surveys); 3) improve the collection on data about local environmental changes. Although the implementation is progressing slowly, due to lack of funding and dedicated personnel, we have digitized the coastline and subdivided it in areas with homogeneous topography, we have classified coastline habitats, and we are integrating in the system our elephant seal spatial data. Moreover, we are integrating the data of our more recent projects, including killer whale sightings and bird nest locations. Our next goals are to acquire high resolution imagery, to study past variations in landscape, and implement a landscape/vegetation classifier.

5. Ongoing data processing and analysis

The following is a brief list of the sub-projects for which there is a current ongoing effort to process and analyze the data, in most case connected to a thesis project:

Elephant seals

- Effect of body size on female breeding biology; completed MSc thesis
- Peri-natal behaviour and establishment of the mother pup bond; ongoing BSc thesis
- Mother-pup acoustic communication and individual recognition; ongoing MSc thesis, close to completion
- Female aggressive communication, and its relationships with age and body size; ongoing MSc thesis
- Elephant seal communication as honest signalling in males and females; combined project involving two ongoing BSc thesis and one ongoing MSc thesis
- Sociality of elephant seal females studied by social network analysis; ongoing MSc thesis

- Structure and function of the proboscis studied using the geometric morphometry approach, ongoing BSc thesis
- Weanling behaviour, and its potential use to evaluate stress; joint project involving one ongoing BSc thesis and one ongoing MSc thesis
- Moulters temporal and spatial distribution, including habitat choice; ongoing MSc thesis

Killer whales

- Killer whale behavioural ecology; completed BSc thesis
- Killer whale predation tactics; complete BSc thesis
- Killer whale photo-identification to study sociality; ongoing MSc thesis

6. Dissemination of information about our research projects

The dissemination of information about what we do in the field, and the results that we are producing, is a very important component of our research effort. The following is a summary of some activities related to the research project that we carried out during the span of the field work season to disseminate information about our research projects:

- we updated the poster that describe our elephant seal research project and that is located in the Sea Lion Lodge lounge
- we updated all our information material that is provided to Sea Lion Lodge guests, and Sea Lion Island visitors at large, to take into account the recent developments of the research
- we updated our collection of printout of research papers to include the new ones; this collection is made available to lodge guest in the lounge
- we deployed new material related to the killer whale project, including a new leaflet on the project that includes a summary of killer whale biology, a dedicated guest book for killer whale observations, and a printed killer whale photo-identification catalogue
- we carried out informal talks and lectures in the lodge to increase the guest awareness about our research projects
- we held a public talk at the Stanley Community School, focused the various environmental monitoring projects that we are running at Sea Lion Island
- we are preparing a report on the elephant seals population status, that updates our past reports with the information collected during the current field work season
- we are preparing a detailed report on the killer whales project and on the skua project
- we are maintaining a web site on the project carried out by the research team, www.eleseal.org, and we are developing a new general web site on SLI environment.

The PDF of all new reports will be made available on our website. On the same sites we have PDF of all the booklet, leaflet, and information material.

7. Overall conclusions and perspective for the future

The ESRG has carried out field work at Sea Lion Island during the past 21 years. Although our original focus was the collection of data about the breeding tactics of elephant seals during the land phase of their life cycle, we gradually expanded our interest to other areas of the elephant seal biology, and to other species. We now see the ESRG field work at SLI as a wonderful opportunity to study not just elephant seals but also their interaction with other species (killer whales) and with human beings. Moreover, we are trying to make the best use of the time we spend in the field by collecting data on other species, that can be used to establish baseline information, to improve our understanding of wildlife populations, and to permit detection of changes. Due to easy access, logistical feasibility of surveys, and abundant availability of previous data, SLI can be an ideal place for long term monitoring of environmental changes. We are planning to increase our effort to collect long-term data not only on elephant seals but also on other species, and in particular we would like to increase our effort to count and assess breeding success of marine birds, focusing on non-penguin species, that are usually less known and studied than penguins in the Falklands. Moreover, we would like to integrate all the information that we are collecting on the various species of our research project in a full features GIS for SLI, that is currently under development.

Acknowledgements

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Our research projects are dedicated to our beloved son Leonardo, that recently passed away at Sea Lion Island.

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