

Project: TEMPORAL VARIATION IN FORAGING BEHAVIOR OF SYMPATRIC OTARIID SPECIES, *Arctocephalus australis* AND *Otaria flavescens*, AND THEIR TROPHIC OVERLAP IN URUGUAY

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1. Level of achievement of the project's original objectives

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Determine the seasonal utilization of food resources by sex of <i>Arctocephalus australis</i> and <i>Otaria flavescens</i> .		X		At this stage we can only make preliminary conclusion about the variation in seasonal utilization of food resources by sex from our results. Final conclusion can be made after we have obtained the whisker growth rate from ongoing field experiment (see below for more details about trial).
Assess the trophic overlap of both species along the year.			X	
Study the diving behaviour and attendance patterns of lactating South American fur seal.			X	Ten adult lactating fur seals were captured at Isla de lobos during the austral summer 2010. Individual females were fitted with time-depth recorders to obtain diving behaviour. Mean dive depth was 23.5 ± 19.5 m (max 186.0m) and the dive depth ranged between 10 and 40m (88%). Mean dive duration and bottom time accounted for 1.2 ± 0.8 and 0.68 ± 0.6 min, with a maximum of 5.3 and 3.5 min, respectively. Most frequent dive duration ranged 0.5 to 2.0 min (72%). The mean ratio of bottom time/total dive duration (0.48 ± 0.25) indicated that lactating fur seals spend nearly 50% of their dive time at the bottom. These results suggest that lactating fur seals perform benthic and epi-pelagic dives.
To compare diving behaviour and attendance pattern of South American sea lions and fur seal.			X	Lactating sea lions (69%) had a higher proportion of dives Intra-Depth-Zone index (index to determine the tendency to repeatedly dive to a given depth) dives than fur seals (64.3%); however, suggesting than in both species most of the dives were benthic. Notwithstanding, in the later species, the mean bottom times, the depth range, the dive profiles and the ratio of bottom time to dive duration indicated that they were also performing epi-pelagic dives.

				Lactating sea lion foraged during any time of the day whereas lactating fur seals had a diel pattern. Fur seal dove for longer periods and deeper during the night than during the day. Furthermore, on average, lactating fur seals dove deeper than sea lion. Sea lion dove to the benthic zone at depths ranging from 17 to a maximum of 78 m and fur seal dove to the benthos and pelagic zone to depth ranging 84-187m. Despite that lactating fur seals dove deeper, sea lions dove for longer period of time (mean 1.9 ± 0.7 min) and spend more time at the bottom of the dive (mean 1.1 ± 0.6 min) than fur seals (mean 0.7 ± 0.7 min; 0.3 ± 0.4 min, respectively).
controlled feeding trial to estimate whisker growth to interpret isotope variations along the vibrissae		X		Initially, a permit to conduct the feeding trail at the local zoo was granted but one of the animals died prior to commencing the study. Under this scenario, the veterinarians denied any manipulation with the animals. Thereafter, we had difficulties obtaining new permits but, finally, the permits were obtained in November, 2010. Due to this delay we decided to conducted the trail with six free-ranging lactating fur seals (inject labelled glycine that served as whiskers growth rate calculation) that were captured in December the same year. These females will be captured between July and September (2011) and a whiskers will be sample for analysis. Although, at first glance it seemed like a problem, doing the trail with wild animal will produce more realistic results than with captive animals that are feed on a daily basis and have different metabolic rate.

One of the mayor difficulties that arose during the project was that we had to delay the stable isotope analysis of the vibrissae samples at the CICIMAR Lab (La Paz, Mexico) due to family health issues. This problem was notified immediately to Jane Raymond on the 14th of October 2010; and a permission to delay the submission of the final report was requested, and thereafter conceded.

Another difficulty that arose during the project was related to the delays to obtain permits to conduct a trail with captive fur seal at the local zoo. The problem was tackled by conducting the same trail with six wild fur seal that were captured in December, 2010. There is an advantage of conducting the trail with captive animals; you can recapture the animal at any time. In contrast, a trail with wild animal reduces the chances of recapture; however, wild animals are under natural conditions and this will be reflected in their metabolic rates that differ from animal in captivity.

2. Briefly describe the most important outcomes of your project.

a- Firstly, the analysis of stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) from whiskers showed that there was a sexual feeding segregation in sea lions and fur seals. Female fur seals, on average, had more preference for foraging in the pelagic zone than males ($\delta^{13}\text{C}$: $T=-5.227$, $df= 208$, $p<<0.001$); and prey choice and trophic level of female fur seals was different from that of males ($\delta^{15}\text{N}$: $T=-2.677$, $df= 208$, $p=0.008$). Further, males fur seals showed greater niche area than females (8.77 vs. 6.85) suggesting that some males migrate to feeding areas located south (Buenos Aires Province or Patagonia) or north (south of Brazil) of Uruguay). Female sea lion foraged more on the coastal continental water than males ($\delta^{13}\text{C}$: $T= 6.16$, $df= 202$, $p<<0.001$) but had on average similar prey trophic level from that of males ($\delta^{15}\text{N}$: $T= 1.99$, $df= 202$, $p=0.047$). Isotopic variation among female sea lions was relatively large ($F= 2.44$, $p< 0.001$), suggesting that females consumed in a great range of trophic levels (include smaller). Despite these differences female and males sea lion foraged on the same diversity of areas (niche amplitude: female = 3.50, males = 3.73).

b- Secondly, we found a lack of trophic overlap between fur seals and sea lions along the year. Previous studies have reported same results but these researches were limited to breeding females and the period prior and post partum (Franco-Trecu, 2010). Contrary to these results, another study using traditional method to determine the diet of seals (scat analysis) demonstrated a high degree of trophic overlap between species (Szteren et al., 2004). Metabolically inert tissues that grow continuously, such as whisker, can be used to study the feeding habits of animals for long period (1-6 years). The current study showed that female ($\delta^{13}\text{C}$: $T= -48.5$, $df= 254$, $p<0.01$; $\delta^{15}\text{N}$: $T= -26.2$, $df= 254$, $p<0.01$) and males ($\delta^{13}\text{C}$: $T=-24.83$, $df= 156$, $p<0.001$; $\delta^{15}\text{N}$: $T=-18.44$, $df= 156$, $p<0.001$) fur seal and sea lion did not have a trophic overlap (2 to 4 years period). During the year sea lion forage on coastal areas and a higher trophic level than fur seals that forage mostly on the pelagic zone. The niche area of in both female and male fur seals doubled in size compared to sea lions. These results suggest the food resource competition between sympatric otariid species may not be playing a role in the decline of the sea lion population.

c- Third, we found that fur seals and sea lion have different foraging strategies. In addition, our data indicated that the diving behavior of lactating sea lions is benthic, which was also supported by diet studies. Whereas the diving records of lactating fur seal indicated that they are benthic and epi-pelagic divers. This result suggests that lactating fur seals may have different dive behavior than sea lions and that their foraging strategy may allow them explore different habitat. Further, the isotope and scat analysis results support this argument and suggest that fur seals have a range of feeding tactics and have the capacity to explore different niches and therefore consumed prey from different trophic levels. It is very likely that fur seals are less vulnerable to changes in the distribution and availability of preferred prey caused by natural or anthropogenic factors. The contrasting population trend between fur seals (increasing) and sea lion (declining) may be related to their foraging strategies. Is possible that the diversity of foraging strategies of fur seals may allow them continue to have a positive population rate by being able explore trophic resources more efficiently but also been able to response to changes in prey availability.

d- Lastly, I contributed in the process of implementation of the National System of Protected Areas by participating in Workshops organized by DINAMA (National Administration of Environment) as marine mammal experts and putting forward information collected in this work that was aid in the decision making process (Attached file – SNAP Letter). I bring essential information for the selection of focal conservation objects in this area, viability / ecological integrity and determination of critical areas for focal objects. The products resulting from this process was essential inputs for the design of

management strategies, zoning and monitoring of the area. As a result of my participation, through sharing information about South American fur seals (*Arctocephalus australis*) and sea lion (*Otaria flavescens*) biology and ecology, both species were selected as conservation focal objects. The data were partially obtained in this project and also from previous research during my education (Bachelor and Master thesis) and project with team members. Conservation's focal objects are species, systems / ecological habitats or specific ecological processes selected to represent and encompass the full range of biodiversity in a project area. They are the basis for setting conservation goals and objectives, strategic actions and measure the effectiveness of conservation process. These workshops identified gaps in information such as research that is needed to estimate the current and the future status of the fur seals and sea lions populations in Uruguay. In this context, the later was declared as priorities by the National System of Protected Areas.

3. Involvement of local communities

Seal Flipper Tag network

All the coastal local communities have been involved in the project by collaborating with the Seal Flipper Tag Network. Posters referring to Seal Flipper Tag Network have been placed in local stores, social centers and institutions (educational institutions, government's agencies). The poster invites people to participate and report animals with flipper tags. The advertising of the Seal Flipper Tag Network commenced in November 2010 and since then there has been several reports of animal tagged. (Attached file - Seal Flipper Tag Network)

Community-based participatory research

Marine Biodiversity

In October 2010 I participated in the project entitled "Participatory research of the marine biodiversity in the Uruguayan prawn fisheries" financed by Conservation Leadership Program and carry out by the Research and Development Organization and the National Museum of Natural History. The main aim of the project is to involve the local communities, in particular the artisanal fishermen, in the monitoring and conservation of marine biodiversity. One of the objectives is to diffuse the knowledge of the local marine biodiversity richness at schools y cultural centers in Valizas town (Rocha, Uruguay). I participated by given a talk to 6th, 7th and 8th graders about the general characteristic of South American fur seal and sea lion. The talk was about how to identify the species based on their morphological differences, the role of these in the marine ecosystem and the importance of their conservation and value as natural resources. In addition, the talk also included the differences in their behavior (reproduction, feeding, etc) and the objectives of the current project and their importance. (Attached file – Marine Biodiversity Letter)

Sea lions interactions with artisanal fisheries

In April 2011, I was invited to participate in a community-based participatory research process (to be conducted till December 2011) about the interaction between sea lions and artisanal fisheries. This project is carried out by the Science & Development Unit from the Faculty of Sciences (University of the Republic) in coordination with the Natural Resources Institute of the University of Manitoba (Canada). The project aims to investigate the role of participatory research in the creation of suitable conditions that could facilitate the emergence of co-management of fisheries resources. The interaction between the fisheries and sea lions is one of main concerns of the artisanal fishermen since sea lions take fish from their fishing nets and long-lines, and damage the gear but also reduces their catch. The

participatory research project team is composed by, artisanal fishermen with DINARA (National Administration of Aquatic Resources - management agency), local NGOs, and researchers from the Faculty of Sciences (as myself). In May, the participatory research project team met in a workshop, aiming to agree on an understanding of the problem between the artisanal fisheries and the sea lions. In the workshop there were contrasting opinions between artisanal fishermen and researchers about sea lion diet and their population trend. At the workshop, I was able to present the result of my sea lion research since 2004. In the next meeting, the team will aim to define a research question of common interest that will be addressed collectively. The artisanal fishermen will greatly benefit from the participatory research project because it gives them an opportunity to collaborate with a multidisciplinary team, and together they can address the questions and problem that are of their main concern.

4. Plans to continue my work

The results of this project showed a low degree of trophic overlap between fur seals and sea lions. These results have led to new questions and to suggest that it appears that other factors may be responsible for the sea lion population decline such as the interaction with commercial fisheries. One important aspect of the present work is that it is focused on the trophic overlap between species. Therefore, it must be taken into account that the potential interaction between seal species and the commercial fisheries could be playing an important role in the decline of sea lion population, and consequently this, could mask the effect of the trophic overlap between fur seal and sea lions.

The results of the current project, jointly with other research conducted by our working group, will give clues to identify some of the natural or anthropogenic factors that are responsible for the sea lion population decline and the recovery of the fur seal population post exploitation, and therefore making a significant long lasting contribution to the management and conservation plans for both species. We will continue investigating the foraging ecology of sea lions and fur seals in order to explain the population trend of these species.

Diet data obtained from the analysis of fecal samples and isotope and the data on diving behavior of both species (this project) support the argument that female fur seals have greater variety of foraging strategies than female sea lions. Female fur seals forage in coastal (on the shelf) and oceanic (off the shelf) water and have benthic and epi-pelagic diving behavior suggesting that they have widened their feeding range to diminish the intraspecific competition in response to the population increase. It is likely that certain phylogenetic restraints are operating resulting in less plasticity in the foraging behavior of sea lions. Therefore it is crucial to continue with this work and fit satellite tags on female fur seals and sea lions to track their movement at sea and assess the overlap in space and identify exclusive foraging areas.

5. Share my results with others

Workshop

I will contribute in the decision making process of implementation of the National System of Protected Areas by participating in workshops organized by the National Administration of Environment (DINAMA) as marine mammal expert and putting forward crucial information obtained in the current project.

Community-based participatory research

I have recently joined a project that aims to address some of the questions regarding the sea lion and fisheries interaction. The team is integrated by artisanal fishermen, DINARA (National Administration of

Aquatic Resources - management agency), local NGOs, and researchers from the Faculty of Sciences. I will share the results of this project in the meeting and workshops framed in the participatory research.

Report, scientific publications, conferences

A report will be submitted to government agencies such as the National Administration of Aquatic Resources (DINARA) of the Ministry of Livestock, Agriculture and Fisheries.

The results of this project will be presented at regional and international conferences.

I foresee that 2 research articles will be published in peer review journals.

6. Next steps

One of main objectives of our research is to share the finding with the decision makers and government agencies that are responsible of managing the marine resources. Further, one of our main activities will continue, as we have done in the past, participating in the specialist workshop organized by the National System of Protected Areas contributing with pertinent biological data. In addition, through community-based participatory research we will collaborate with the artisanal fishermen in the process of understanding and finding solutions to the conflict between the fisheries and the sea lions.

In addition, we will continue researching, aiming to answers the questions that emerged from our results, on the ecology and biology of both species and the factor that are affecting the population trends. The next objectives are to test whether there are inter-annual differences in individual foraging strategies by fitting satellite tag of females that were capture previous summer. Further, we will continue attaching flipper tags to estimate population parameters using Mark-Recapture techniques and conducting aerial surveys to monitor the population trend.

We used de Yaqu-Pacha logo in:

- Poster presented at the 8th Latin-American Meeting of Aquatic Mammals Specialists. Latin-American Society of Aquatic Mammals (SOLAMAC). Florianópolis (SC), Brazil. October 24th - 28th, 2010.
- In teaching activities in the project entitled “Research on Biodiversity in Uruguayan (ROBIN) artisanal red-shrimp fisheries” funded by Conservation Leadership Program.
- Talk presented at the Sea Mammal Research Unit, St. Andrews University, St. Andrews, Scotland. 18th November, 2010.
- Poster to promote the Seal flipper Tagging Network: poster informing about the flipper tagging of sea lion and fur seals since 2004 (Attached file - Seal flipper Tagging Network Poster)
- At the research group Cetáceos Uruguay web page www.cetaceos.org.uy (see link)

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