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At-Sea Associations In An Upper-Trophic Level Predator, The Grey Seal (*Halichoerus Grypus*)

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Introduction

Observing grey seals at sea is challenging, leaving their potential associations due to shared resources or stable social groups largely unexplored [1]. Using acoustic detection and GPS location data, this study explores previously inaccessible at-sea associations among grey seals on the Eastern Scotian Shelf and in the Gulf of St. Lawrence.

Research Question

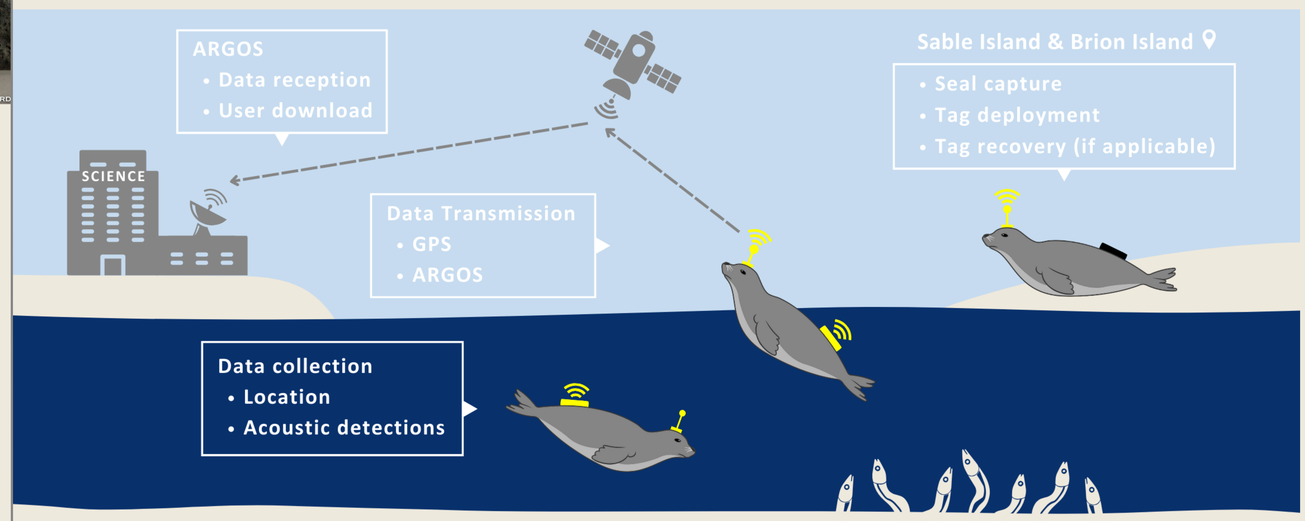
Do seals form associations with other seals at sea?

Hypotheses

1. The Supermarket Hypothesis: the large population size allows for random associations among seals at foraging hot spots.
2. Male-female interactions at foraging hot spots will occur less frequently when compared to same-sex associations.
3. There will be an increase in the number of associations leading up to, and immediately following, the breeding season in Dec/Jan.

Methods

Land-deployed tags collected seven years of fine-scale movement and acoustic detection data while seals were at sea.



Tags

- The Argos-linked MK10-AF Fastloc™ GPS tag archives and transmits the seals' location and time-at-depth.
- The VHF transmitter is used to locate the seals on the island from close range.
- The Vemco Mobile Transceiver (VMT) is an archival acoustic transceiver that transmits and records acoustic codes.

Seals on Brion Island were deployed with tags that included a Bluetooth connection between the VMT and a Satellite Relay Data Logger which enabled the transmission of data collected by the VMT to the user through the ARGOS satellite system.

Analysis

- A hidden Markov model (HMM) was used to estimate the probability of Area Restricted Search (pr(ARS)) behaviour [2, 3]. Slow movement, where the pr(ARS) is >0.5, is associated with foraging or resting behaviours [4].
- R software [5] was used for conducting exploratory and descriptive analyses, in addition to generating graphical figures.
- Generalized linear mixed models will be used to examine the significance of variables in relation to seal-seal associations at sea.

An association between two individuals was characterized as a series of acoustic detections where the time between detections was >35 min.

Results

Table 1 Number of grey seals tagged and recovered on Sable Island and Brion Island from October 2009 to January 2016.

Mean (±SE) deployment (days)	Number of seals tagged (recaptured)		Number of seals with associations	
	Male	Female	Male	Female
164 (± 50.23)	46 (33)	97 (90)	20	66

1. Summary statistics revealed a high mean probability of Area Restricted Search (pr(ARS)) behaviour during associations.

Table 2 Details associations between grey seals deployed on Sable Island from October 2009 to January 2016. Pr(ARS) is a continuous measure of the probability (0 to 1) of exhibiting area-restricted search behaviour as determined by the hidden Markov model.

Association	Median duration of association (min)	Mean (±SE) bathymetry during association	Mean (±SE) pr(ARS) during association
Male-male	8.11	-49.05 (±21.93)	0.73 (±0.41)
Female-female	5.25	-51.01 (±35.37)	0.73 (±0.38)
Male-female	3.07	-33.84 (±23.44)	0.67 (±0.43)

Table 3 Total number of associations recorded between grey seals deployed on Sable Island from October 2009 to January 2016. Seal$_f$ is the seal that recorded the detection(s) during the association.

Association	Number of associations while seal$_f$ was traveling (pr(ARS) <0.5)	Number of associations while seal$_f$ was foraging or resting (pr(ARS) >0.5)	Total number of associations
Male-male	97	219	316
Female-female	389	736	1125
Male-female	241	307	548

2a. GPS movement tracks from 2010 revealed that grey seals from Sable Island frequently visited shallow offshore banks on the Eastern Scotian Shelf.

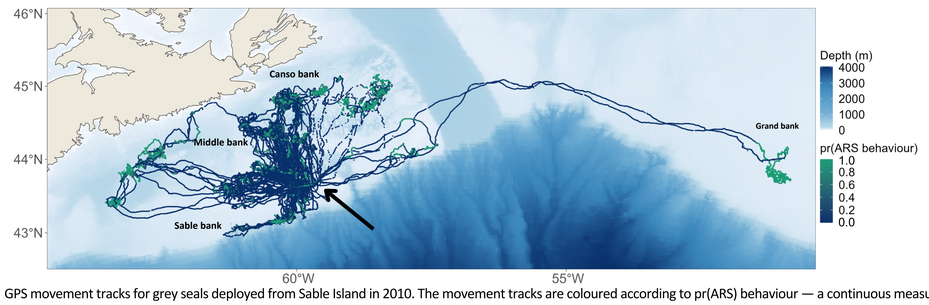


Figure 1 GPS movement tracks for grey seals deployed from Sable Island in 2010. The movement tracks are coloured according to pr(ARS) behaviour — a continuous measure of the probability (0 to 1) of exhibiting area-restricted search behaviour as determined by the hidden Markov model. The location of Sable Island is indicated by the black arrow.

2b. In 2010, observations of grey seals encountering each other above shallow offshore banks confirmed our hypothesis about associations related to foraging.

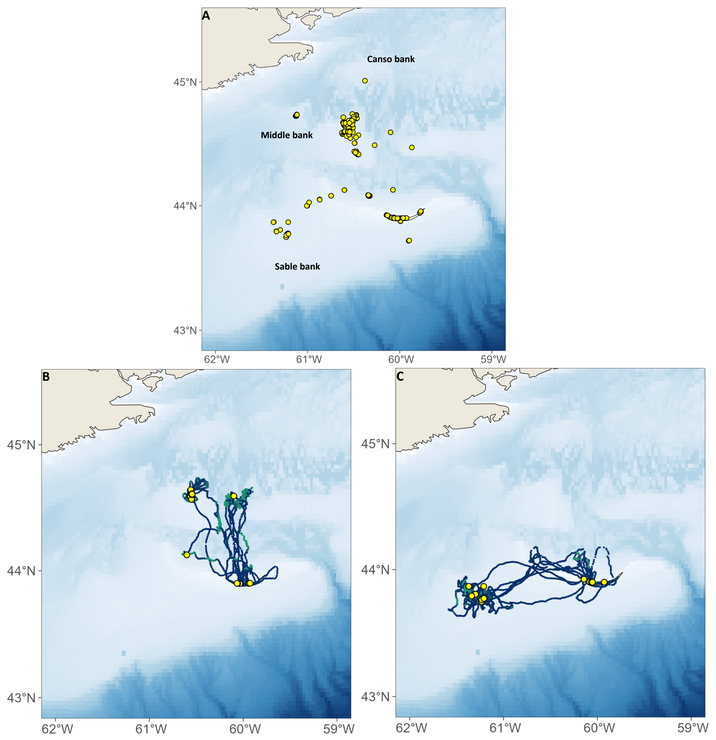


Figure 2 Location of associations between grey seals for A) all seals deployed from Sable Island in 2010, B) seal 9934 and C) seal 9937 (n = 15). Figures B) and C) are examples to show the correlation between location of associations, bathymetry and seal behaviour. See Figure 2 for the pr(ARS) and depth scale legend.

3. Temporal variability in associations with peaks in the frequency of associations around day 230 (August) and 290 (mid-October)

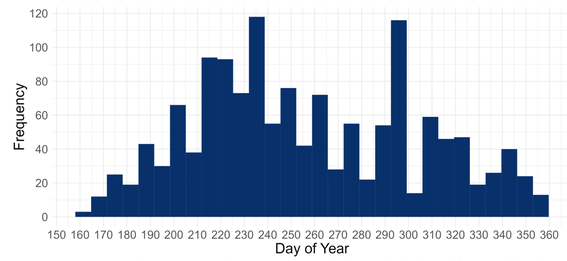


Figure 3 Frequency of associations between grey seals (n = 58) deployed from Sable Island from June 2011 to January 2016.

Conclusions

1. Out of 123 recovered grey seals, 86 (69.92%) recorded associations with other grey seals while at sea.
2. Same-sex associations seem to occur more frequently during foraging bouts, while male-female associations between appear to be less common.
3. During encounters, grey seals exhibited high pr(ARS) behaviour, suggesting that associations are more likely to occur while foraging.

References

[1] Lidgard et al. 2012. PLOS ONE. 7(11): e48962
[2] Zucchini & MacDonald. 2009. Chapman and Hall/CRC.
[3] Patterson et al. 2009. J Anim Ecol. 78(6): 1113–1123
[4] Barraquand & Benhamou. 2008. Ecology. 89(12): 3336–3348
[5] R Core Team. 2023. R Foundation for Statistical Computing.

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