Anna-Maria Seibert, Lars Kindermann, Holger Klinck and Olaf Boebel

PALAOA: Ross seal presence and calling patterns

Introduction

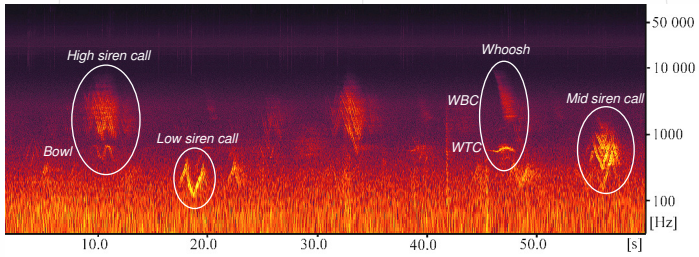
The Southern Ocean is largely unaffected by anthropogenic noise. It, therefore, provides the ideal location for long-term underwater recordings. These are obtained from PALAOA (**Perenni**AL **A**coustic **O**bservatory in the **A**ntarctic Ocean) located at Atka Bay, eastern Weddell Sea. Passive acoustic observations are a powerful tool to investigate inconspicuous species e.g. the Ross seal (*Ommatophoca rossii*).

The Ross seal exhibits a typical head-up posture when approached

Although Ross seal sightings are scarce around Atka Bay, their distinct siren-like calls[3,6] temporarily dominate the underwater soundscape.

Results

- 4 different call types, distinguishable by a combination of min & max frequency
- Acoustic presence of Ross seals at Atka Bay between December and February
- Distinct diurnal calling pattern with peak calling rates around midnight
- Approx. 3-8 animals vocally active simultaneously



Spectrogram of a PALAOA sound-file: According to their spectral structure, four Ross seal call types were identified, as shown below:

Discussion

For the first time, Ross seal underwater vocalizations are characterized in detail, which provides the basis for any further investigation in the bioacoustics of Ross seals. Neither the production and the purpose of these intense siren-like sounds are explained yet, nor are the existence of geographic variation, or patterns of communication known. The results will help to develop automatic pattern recognition algorithms which, together with acoustic localization, will allow for remote monitoring and more detailed population censuses[4].

The acoustic presence of Ross seals in Atka Bay between December and February matches recent findings on the migratory behavior of these animals derived from satellite tags[1]. An increase in calling rate in mid January is probably caused by the arrival of seals[4], that were pelagic before. The striking drop at the end of January might correspond with the migration of most Ross seals northwards[1].

The nocturnal peaks in calling rates are similar to those of other Antarctic seal species[2,5].

Call types

High siren call

Alternating up- & downsweeps
36% (n=5064) of all calls counted
Sweep rates: UP.....3.02 oct s^{-1} (±0.59)
DOWN....2.12 oct s^{-1} (±0.41)
Min frequency:.....592.18 Hz (±145.47)
Max frequency:.....7129.38 Hz (±1803.55)
Duration:.....3.37 sec (±0.68)
4-10 strong harmonics at relatively constant rate
40% of calls with attached Bowl component

Mid siren call

Alternating up- & downsweeps
21% (n=2919) of all calls counted
Sweep rates: UP.....2.40 oct s^{-1} (±0.42)
DOWN....2.29 oct s^{-1} (±1.06)
Min frequency:.....168.42 Hz (±35.45)
Max frequency:.....2010.38 Hz (±596.62)
Duration:.....3.29 sec (±0.42)
4-9 strong harmonics at relatively constant rate
98% with distinct edges at upsweeps

Low siren call

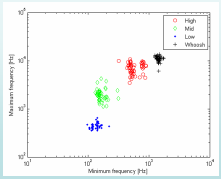
Alternating up- & downsweeps
29% (n=4031) of all calls counted
Sweep rates: UP.....2.13 oct s^{-1} (±0.33)
DOWN....2.89 oct s^{-1} (±0.43)
Min frequency:.....132.54 Hz (±21.69)
Max frequency:.....449.14 Hz (±60.85)
Duration:.....2.00 sec (±0.46)
Mostly only 1 harmonic visible

Whoosh

7% (n=945) of all calls counted

Broadband Component (WBC)
Diffuse downsweep at relatively constant rate
Max frequency:.....10 996.54 Hz (±1305.36)
Min frequency:.....1439.26 Hz (±104.70)
Duration:.....2.51 sec (±0.30)

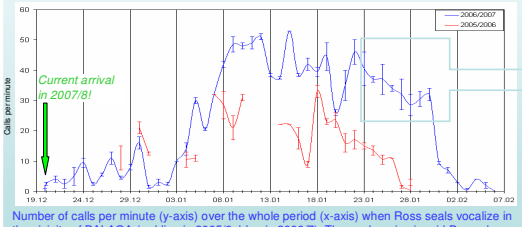
Tonal Component (WTC)
Single tonal sound ascending & descending at the end
Sweep rate:.....0.60 oct s^{-1} (±0.17)
Min frequency:.....574.18 Hz (±11.42)
Max frequency:.....591.50 Hz (±47.31)
Duration:.....2.33 sec (±0.44)
Always associated with WBC



Cluster analysis of min frequency (x-axis) plotted against max frequency (y-axis) precisely separates the four call types (here shown in different colours).

Ross seal presence

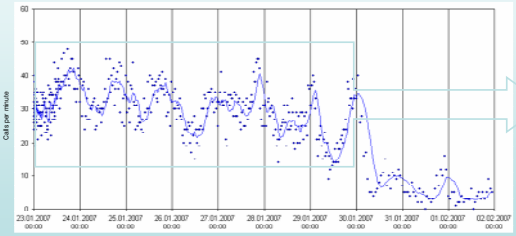
Seasonal calling pattern: Ross seal presence at Atka Bay, eastern Weddell Sea



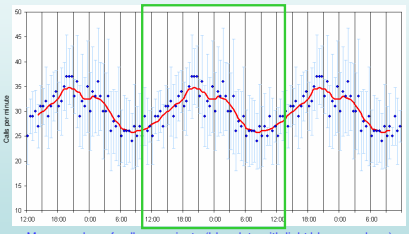
Number of calls per minute (y-axis) over the whole period (x-axis) when Ross seals vocalize in the vicinity of PALAOA (red line in 2005/6, blue in 2006/7). The seals arrive in mid December and leave the area in the beginning of February. In December 2007, their arrival day coincides exactly(!) with the arrival date of the previous year (as indicated by the green arrow).

Calling patterns

Diurnal calling pattern of Ross seals at Atka Bay, eastern Weddell Sea, Antarctica

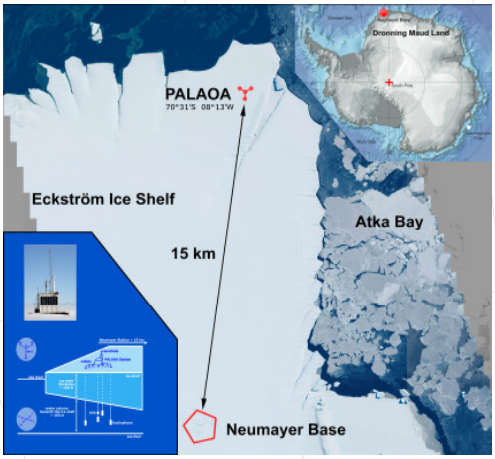


Number of calls per minute (blue dots) between 23 Jan and 1 Feb, 2007. The blue line represents the moving average. Diurnal calling peaks occur around midnight (r = -0.18, p < 0.005).



Mean number of calls per minute (blue dots with light blue error bars) averaged over seven consecutive days and plotted into one 24-hour-interval (green frame). The red line represents the moving average.

Location of PALAOA on the Ekström Ice Shelf, eastern Weddell Sea, Antarctica



The autonomous recording station consists of an array of up to four hydrophones (300m apart) deployed through the ice shelf (~170m depth). The ice shelf edge is at a distance of 1-3km.

Ross seal habitat at Atka Bay: pack ice at the shelf edge (ca.15m in height)

Materials & Methods

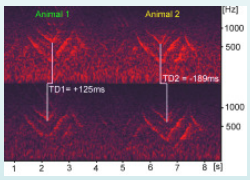
PerenniAL Acoustic Observatory in the Antarctic Ocean (PALAOA):

- located at 70.5°S, 8.2°E on the Ekström Ice Shelf at the eastern Weddell Sea
- in operation since December 2005
- designed for perennial, autonomous operation
- broad-band (15 Hz - 96 kHz), and high resolution (up to 24 bit) recordings
- real-time data access via satellite transmission
- multiple hydrophones deployed through ice shelf

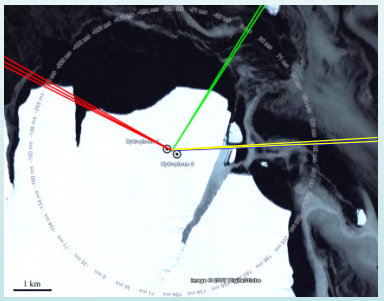
Call measurements:

- visual and aural analysis using Adobe Audition 2.0
- 50 samples of each call type characterized in detail
- ~14.000 calls counted for diurnal call rate
- ~3.000 calls counted for seasonal call rate

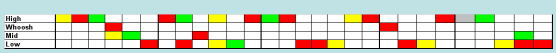
Acoustic localization of vocalizing Ross seals



Sound arrives at the two hydrophones (hydrophone 1, at top; hydrophone 2, at bottom) with a time delay (TD1 and TD2) which corresponds to the direction of the incoming call, as shown on the right image.



The three different directions of sound sources propose a minimum of three vocal active Ross seals at that time. The distance, however, cannot be predicted with two hydrophones only.



The temporal structure of a typical Ross seal "conversation" with calls of all four call types coming from the three distinct directions shown above.

References

(1) Blix A.S., Nordøy E.S. (2007) Ross seal (*Ommatophoca rossii*) annual distribution, diving behaviour, breeding and moulting, off Queen Maud Land, Antarctica. Polar Biology 30(11): 1449-1458.
(2) Green K., Burton H.R. (1988) Annual and diurnal variations in the underwater vocalizations of Weddell seals. Polar Biology 8: 161-164.
(3) Ray G.C. (1981) Ross seal *Ommatophoca rossi* Gray, 1844. *in* Handbook of Marine Mammals, Vol. 2, edited by S.H. Ridgway and R.J. Harrison (Academic, London), pp. 237-260.
(4) Rouget P.A., Terhune J.M., Burton H.R. (2007) Weddell Seal underwater calling rates during winter and spring near Mawson Station, Antarctica. Marine Mammal Science 23(3): 508-523.
(5) Thomas J.A., DeMaster D.P. (1982) An acoustic technique for determining diurnal activities in leopard (*Hydrurga leptonyx*) and crabeater (*Lobodon carcinophagus*) seal. Canadian Journal of Zoology 60: 2028-2031.
(6) Watkins W.A., Ray G. C. (1985) In-air and underwater sounds of the Ross seal, *Ommatophoca rossi*. The Journal of the Acoustical Society of America 77(4): 1598-1600.

Acknowledgements
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Alfred Wegener Institute for Polar and Marine Research,
Am Handelshafen 12, 27570 Bremerhaven, Germany

www.awi.de/acoustics

Contact:
Anni_Seibert@hotmail.com
Lars.Kindermann@awi.de