Underwater calls of Weddell seals in the Weddell Sea, Antarctica

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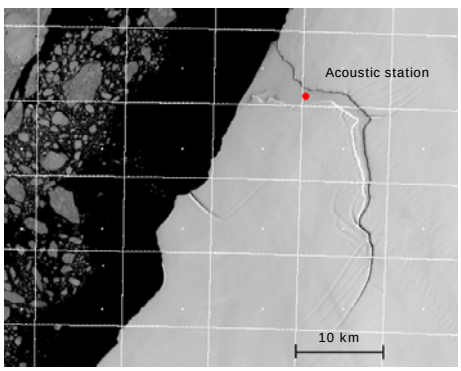
Background & Objectives

Weddell seals, like other marine mammals have evolved to use sound and hearing as their primary means of communication and sensing their surroundings. Similarly, oceanographers, geophysicists, biologists and navigators rely on sound to measure ocean currents and bottom topography, to locate schools of fish by acoustic fish finders, and to navigate vessels. For tackling research on possible effects of man-made sound on marine mammals, the AWI recently established the project group "Ocean Acoustics". The interdisciplinary projects involve: (1) identifying marine mammal vocalizations in long term acoustic recordings of high resolution, (2) developing techniques to minimize impacts of sound emissions on the marine environment, (3) constructing computer algorithms for automated call detection and classification, and (4) using the detected calls to understand the seasonal presence and behaviour of the animals. Here we summarize our initial analyses of acoustic recordings collected during a recent field campaign at the eastern Weddell Sea coast. The study aimed at examining the characteristics of Weddell seal calls and at identifying ambient sounds to find out how quiet or noisy the underwater habitat of Weddell seals actually is.

Material & Methods

During the 2003/04 Weddell Sea cruise of RV *Polarstern,* 242 hours of acoustic data were recorded from 17 Dec. to 2 Jan. in the Drescher Inlet (72°50'S, 19°02'W), a 25-km-long crack in the Riiser Larsen Ice Shelf. According to bathymetric surveys of RV *Polarstern*[1] the depth of the seabed inside the inlet ranges from 380 to 430 m. The acoustic station, a cabin sledge, was placed on solid sea ice at 6 km distance from the open sea. Three hydrophones were lowered 100 m down through ice holes drilled in a 100 m baseline triangle. The system was calibrated to obtain absolute sound pressure levels, and operated with a sampling rate of 48 kHz/16 bit to record frequencies up to 24 kHz. Two recording periods of 84.1 h (21 Dec. – 25 Dec.) and 55.6 h (30 Dec. –2 Jan.) were analyzed. The analysis based on a subjective auditory and visual differentiation of prominent sound patterns roughly corresponding to the classification scheme developed by other investigators[2,3]. This allowed a fast manual grouping of similar calls resulting in simplified phonetic categories clearly separable by the human ear and eye (spectrograms). Focusing on the principal call features (duration, initial and final frequency, frequency devolution, and number of call elements), we intend to develop automated detection and classification methods.

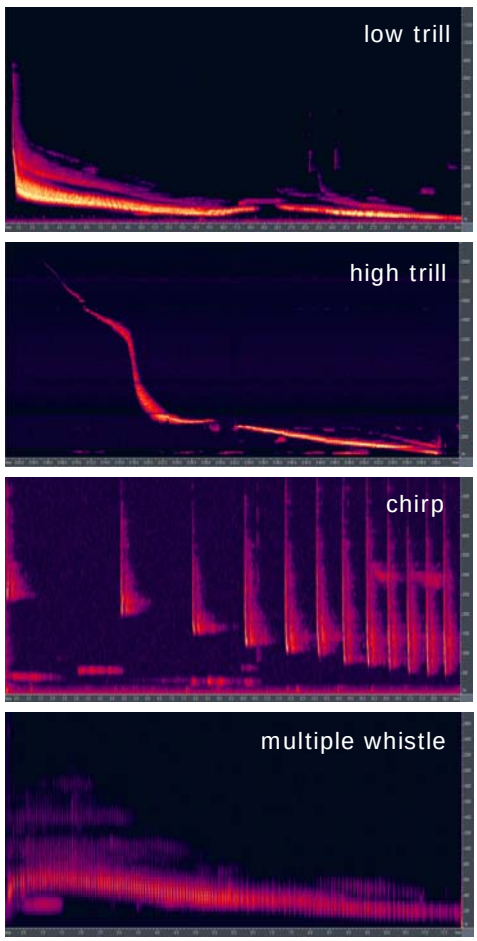


Drescher Inlet, Riiser Larsen Ice Shelf (2 Jan. 2002)
Landsat image kindly provided by the AWI Bathymetric Group

Acoustic station in the Drescher Inlet

Results

This is the first documentation of Weddell seal calls from the Weddell Sea. A total of 19414 calls was analyzed to describe the seals' acoustic repertoire.



Spectrograms of selected Weddell seal calls

Eight call categories were identified:

Trill: Downsweeps of distinctive long duration up to 60 sec. The initial frequency varied between either around 5 kHz (low trill) or a high frequency sometimes exceeding our recording limit of 24 kHz (high trill).

Chirp: Appears typically in a 20 sec-long series of 12 repetitions at about 4 kHz. The inter element interval decreased towards the end of the call.

Multiple Whistle: A series of discrete 10 kHz upsweep whistles with de- and increasing inter element intervals often followed by a final chug.

Single Whistle: A single-element, brief-duration upsweep from about 2 to 10 kHz.

Growl: Two tones of equal length and frequency usually at 1 or 4 kHz and lasting for about 3 sec.

Whoop: A two-element vocalization of about 15 sec and a constant frequency of about 400 Hz, ending with a slowly rising 1 kHz upsweep.

Chug: Beginning with an abrupt 1 kHz downsweep followed by a brief 500 Hz tone.

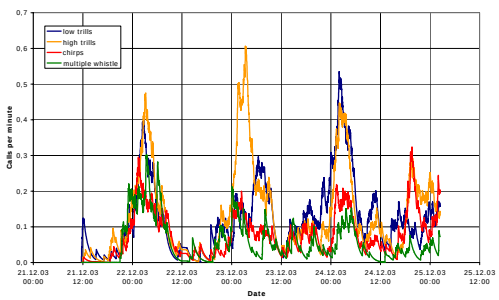
Grunt: A series of discrete 1 kHz grunts at constant intervals.

Ambient sounds: Our records featured permanent undulating background noise identified as ice reaming. Sound artefacts were caused by tidal currents interfering with the hydrophone moorings. During the 84.1 h-period of recording the ambient noise level was around 50 dB re 1 µPa @ 1kHz (100 dB RMS) enabling us to detect 3.67 seal calls/min. During the following 55.6 h-period RV *Polarstern* was audible (via hydrophone) while approaching the acoustic station from 59 to 6 km. During this time the noise level raised above 85 dB @ 1 kHz (130 dB RMS) so that only 0.26 calls/min. were detectable. Assuming a similar vocalization rate of Weddell seals as in the period before, the vessel's propeller noise masked about 93 % of the detectable seal calls.

Weddell Seal calls recorded in the 1st period from 21-25 Dec. (84.1 h) and in the 2nd period from 30 Dec. – 2 Jan. (55.6 h)

Call category	1st Period n	1st Period %	1st Period min^{-1}	2nd Period* n	2nd Period* %	2nd Period* min^{-1}	Masked* %
Growl	8886	47.93	1.76	348	39.73	0.10	68.0
Single Whistle	4846	26.14	0.96	156	17.81	0.05	74.0
Whoop	2449	13.21	0.49	2	0.23	0.0006	94.1
Trill	1341	7.23	0.27	284	32.42	0.09	95.1
Chirp	408	2.20	0.08	70	7.99	0.02	95.3
Multiple Whistle	290	1.56	0.06	9	1.03	0.003	99.9
Chug	143	0.77	0.03	5	0.57	0.001	94.7
Grunt	175	0.94	0.03	2	0.23	0.0006	98.3
Total	18538	100.00	3.67	876	100.00	0.26	92.9

* Period when RV *Polarstern* was present



Diurnal variation in the emission rate of selected Weddell seal calls

Discussion

Our records were made close to a large ice crack where adult Weddell seals and also still nursed and recently weaned pups hauled out. Trills, in particular, are thought to function in territorial advertisement during the mating period and are surmised to be exclusively used by males[2]. Innovative animal-mounted acoustic loggers in tandem with systems for determining 3D underwater movement of seals are required to provide new insights into the ecological implications of acoustics in seal foraging behaviour.

With respect to variations in Weddell seal calls from geographically distant breeding populations studied elsewhere in Antarctica[4,5,6,7] our acoustic data remain unanalyzed because we focus on automated methods to detect and identify the principal call features of a variety of marine mammal species. Standardization of the description and terminology used to represent the vocal peculiarities of Weddell seals in our study area may serve as a basis for further investigations on developing new techniques aimed at minimizing man-made sound emissions and their impact on the aquatic life of seals and whales.

References

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