A preliminary study of the effect of seismic air-gun surveys on glass sponges

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I. Background

Oil and gas exploration in the Queen Charlotte Basin will involve the use of air-gun surveys that will insonify the sea floor with broadband, high intensity sound. Air-gun arrays have dominant energy at low frequencies, which can propagate for great distances with little attenuation in deep water environments. Previously, researchers have investigated acoustic harassment of marine mammals through effects on behavior and tissue integrity (Goold and Fish, 1998, McCauley et al., 2003). Recently, the related issue of whether the sound pressures produced by a small, surface operated air-gun alter the normal feeding activities (pumping behavior) of glass sponges (*Aphrocallistes vastus*) was examined experimentally in a research cruise. The experiment used an underwater measurement system that was designed to study glass sponge ecology (Leys, Yahel, Reiswig and Tunnicliffe, in prep.)

II. Experiment

The study was carried out from the Canadian research vessel CCGS *John P. Tully* in July 2005 using the remotely operated submersible ROPOS. The sponges were located in the Fraser Ridge sponge reef (about 1.5 m high) in the Strait of Georgia (49º10'N 123º 20'W) at about 160 m depth. Since all flow from these animals exits through a large ex-current aperture (osculum), measurement of the exiting flow from the osculum of the sponge should provide a good proxy of its pumping behavior. Sponge pumping rate was documented using Acoustic Doppler Velocimeters (ADCPs), which are non intrusive instruments that measure 3-dimensional velocities within a controllable sampling volume of few cm^3 located above the osculum (Yahel, Leys and Tunnicliffe, in prep.). Independent current meters measured the ambient current flow speed in the area.

The primary sound source was a single 164 cm^3 Bolt air gun that was deployed from the stern of the *Tully* and operated using a pressure cylinder on the ship. The air gun generated average sound exposure levels of 151 dB re μ Pa^2s^{-1} at the sponge location. The air-gun pressure signal was distinct from background noise below 300 Hz. Sixteen sequences of 3 or 5 air-gun shots were transmitted between 1800 and 2400h (UTC) 16 July 2005.

As hexactinellid sponges lack a true neural system (Mackie 1980, Mackie et al. 1983, Leys & Mackie 1997, Leys et al. 1999), we expect a slow response to external stimuli. Moreover, *Aphrocallistes vastus* pumping is particularly robust to disturbance. Therefore, a response of the sponge was predefined as a 20% or 0.5 cm/s reduction of the excurrent flow initiated within 3 minutes from the last shot of a sequence and lasting for at least 2 minutes.

III. Results

In this section a methodology to determine whether the sponge responds (measured by the particle flow through the osculum) to the pressure signals from the air-gun shots is presented and applied to the experimental data. The excurrent speed data were filtered with a two-minute moving average, and the time series was analyzed for the predefined response. The filtered data are

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plotted in Fig. 1 for the portion of the time in the experiment when the air-gun test was carried out. The times of the air-gun shot sequences are noted by the triangles and vertical lines in the figure. There were three responses to the 16 air-gun shot sequences, following shots 2, 5 and 6.

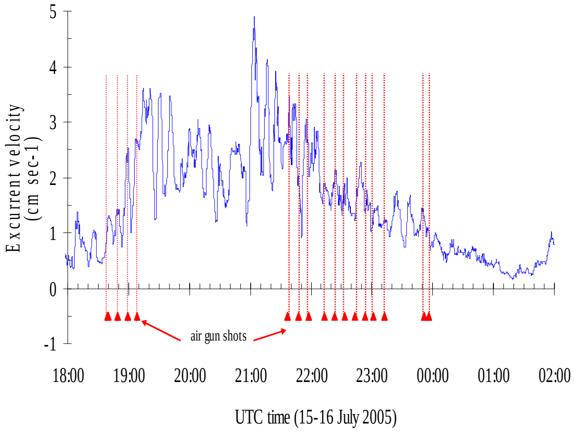

Fig1. Excurrent speed from the osculum of the experimental sponge recorded in situ at 160 m depth during the air-gun experiment. Air-gun shot times are denoted as triangles and vertical lines.

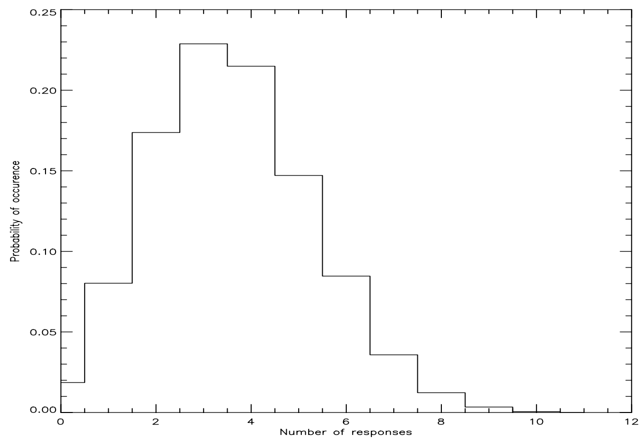

Fig. 2. Frequency distribution of number of responses obtained for the 53,000 virtual start times of the sixteen shot air-gun experiment.

To determine whether the observed result of three responses was statistically significant, a histogram of the number of similar excurrent reduction events (i.e., virtual responses) was calculated for all the ambient conditions in the six-day experiment. First, the time differences between the first air-gun shot and all the other shot sequences were determined. Next, the number of responses was calculated for all possible virtual starting times in the experiment, i.e., assuming that the first air-gun shot was fired at each observation time and it was followed by shots at the appropriate delays for all the other 15 shot sequences. The number of such events ranged from 0 to 11, with a mean of 3.99 and standard deviation of 1.76. These values appeared randomly throughout the six-day experiment time. The histogram of the virtual responses is shown in Fig. 2. Since the number of responses from the experiment at the true air gun times was only three, there is no evidence that the sponge is responding to the air-gun from these data.

IV. Conclusions

For this single sample of 16 air-gun shots, the statistical analysis indicated that there was no evidence to support the hypothesis that the acoustic pressure from the air-gun influenced the pumping behavior. The experimental work carried out was very challenging, and many factors were difficult to control. First, since the ambient flow speed in the water was related to the sponge excurrent flow, it was impossible to separate this factor from the analysis. Second, the complexity of the approach constrained the sample size and duration of the observations. Daylight hours, marine mammal intrusion, preparation time for the ROV (Remote Operated Vehicle) and instrument malfunction all became confounding factors. Nonetheless, the study is novel and the techniques can be refined. Further studies are necessary that should focus on more realistic sound levels, sponge recovery times, animal habituation and longer term effects (e. g., on tissue and skeletal integrity) before final conclusions are drawn.

V. References

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