Pupil dilation in the spiny dogfish, *Squalus acanthias*

Stephen M. Kajiura[1] and Shelly M.L. Tallack[2]
[1]Department of Biological Sciences, Florida Atlantic University, Boca Raton, FL 33431
[2]Gulf of Maine Research Institute, Portland, ME 04101

The spiny dogfish, *Squalus acanthias*, spans a large depth range from the surface to 600m regularly and maximally to 1460m[1]. Because this species spans such a large depth range, it is subjected to a wide range of light intensities from bright surface waters to the aphotic zone. Therefore, we predicted that *S. acanthias* would demonstrate a correspondingly large range of pupillary apertures to facilitate visual function across the wide range of light intensities that the shark could encounter.

To quantify pupil dilation, a total of 6 sharks were anaesthetized, secured to a stage in a glass aquarium and ventilated through the mouth with aerated seawater. A digital camera mounted on a tripod was focused upon the eye. The eye was illuminated for 5 minutes with a 75W incandescent bulb and photographed under these light conditions then all lights were extinguished. A dim red LED torch briefly illuminated the eye to permit photographing at 1, 2, 3, 5, 10, 20 and 30 minutes as the shark was dark-adapted. After 30 minutes, the lights were switched on and the eye was photographed at 1, 2, 3 and 5 minutes as the shark readapted to the bright light. The pupil and total eye areas were quantified using ImageJ software and the pupil area expressed as a percentage of the total eye area.

The light-adapted pupil was 22.9% ±2.23 (SEM) of the total eye area (Figure 1). The pupils gradually dilated in the dark to 35.3% ±1.61 (SEM) of the total eye area after 30 minutes. Upon light exposure, the pupils rapidly constricted to an area of 24.1% ±2.45 (SEM) within 5 minutes at which point the pupil area approached, but was still greater than, the pre-dark-adapted state (paired *t*-test, p = 0.003).

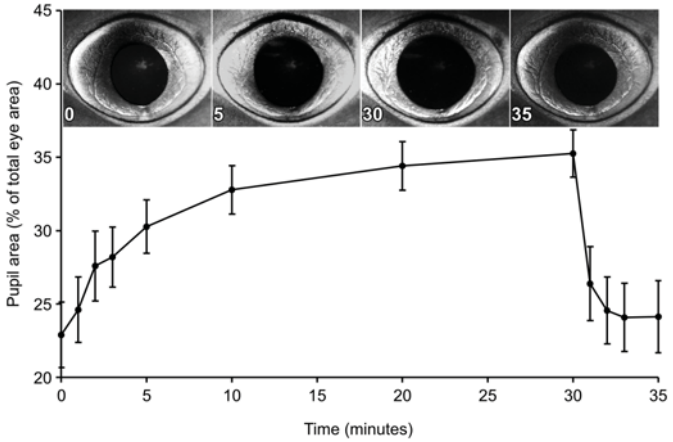

Fig. 1. Pupil dilation in the spiny dogfish, *Squalus acanthias*. The pupil area, expressed as a percentage of the total eye area, is plotted against time for dark adaptation (0-30 minutes) and light adaptation (30-35 minutes). The pupil area increased by 12.4% over 30 minutes of dark-adaptation and constricted dramatically within the first minute of light exposure eventually returning to near the light adapted size within 5 minutes of light exposure. Insets show photographs of the eye at time 0 (light), 5 (dark), 30 (dark), and 35 (light) minutes.

Unlike most fishes, elasmobranchs are characterized by a highly mobile pupil. At the end of 30 minutes, the pupil of *S. acanthias* had expanded dramatically and the dilation rate was approaching an asymptote, although a longer period of dark adaptation would have likely yielded a slightly greater maximum pupil area. Other studies have expressed pupil size in various ways confounding direct comparison and precluding determination of whether the 12.4% increase in dark-adapted pupil area differs from exclusively shallow water species. Applying the same methodology to other species will resolve whether the dilation range of *S. acanthias* is exceptional. This work was supported by a MDIBL New Investigator Award to SMK and SMLT and by NSF IOS-0639949 to SMK.

1. **Compagno, LJV, Dando, M, and Fowler, S.** Sharks of the World. Princeton, Princeton University Press, 2005.