Exploiting the Unexploited: A Smart Panel System for In-situ Detection of Adult Sea Lamprey

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ABSTRACT:

This project focused on the design, development, and testing of low-cost portable smart panel system for detecting the suction and attachment of sea lampreys. Several sensing principles and approaches were explored. First, a soft capacitive pressure sensor, made with a convenient and low-cost screen-printing process, was developed. With a unique approach that accommodated air gaps in the dielectric layer, the sensor was able to detect both positive and negative pressures from –60 to 20 kPa. While the sensor exhibited repeatable response for thousands of cycles and a 12 × 12-pixel sensor array demonstrated the capability of mapping pressure profiles in air and under water for abiotic stimuli, experiments with sea lamprey attachment did not yield clear suction patterns, likely due to the capacitive interference from the lamprey body. A manuscript describing this work (Shi et al., 2019, Appendix 1) has been published by *Advanced Functional Materials*. Second, several novel (rigid) sensing panels were constructed using commercially available pressure sensors, and experiments were conducted to measure the suction pressure dynamics of sea lampreys. Results showed that the suction pressure fluctuated between –0.6 kPa and –26 kPa with a leakage time of 20 s to 200 s for adult lampreys at rest, and increased to –8 kPa to –70 kPa before lampreys were manually disengaged. In addition, the suction pressure distribution was largely uniform across the mouth. These results offer valuable insight for the design of soft sensor systems for attachment detection. A manuscript describing this work (Shi et al., 2020, Appendix 2) is currently under review by *PLOS One*. Third, a soft resistive pressure sensor array was developed using piezoresistive films (Velostat) and a 10 × 10-pixel sensor array showed resistance change patterns associated with suction by sea lampreys. A least-square algorithm with regularization was further developed to decouple the

measured pixel resistances to obtain the individual pixel resistances, and the latter demonstrated more clear change patterns corresponding to lamprey suction. Finally, another lamprey attachment sensor was developed based on interdigitated electrodes that could be easily fabricated and probed. Experiments showed that the voltage output of the device exhibited a distinct exponential decay following the attachment of a lamprey mouth. The decay characteristics were found to have correlation with weight and mouth size of the lamprey. Overall this project not only resulted in significant knowledge about suction pressure behavior of sea lampreys, but also at least two sensor technologies for detecting the lamprey suction that, with further development, hold promise for field deployment. These technologies will help address critical gaps in sea lamprey life history and ecology (e.g., understanding of their refuge-seeking behavior and habitat characteristics, and stream-entry timing) and have broad-ranging applications to sea lamprey assessment and control (e.g., new trapping system design).