

Topic Areas:

Fluid Dynamics, Fluid Logic

Advisor:

Nikola Velimirović,
velimirovic@iams.uni-stuttgart.de

Responsible Professor:

Prof. C. David Remy

Prerequisites/Prior Knowledge:

Matlab, System Dynamics

In the field of marine biology, the use of non-invasive data collection methods is crucial for the study of marine mammals. A potential means of attaching sensors to whales and dolphins ("Whale Tags", Fig. A) are simple suction cups. Their biggest advantages are that they work passively without the need for energy supply and that they can be detached without damaging the animal, their biggest challenges are related to water leakage and premature detachment.

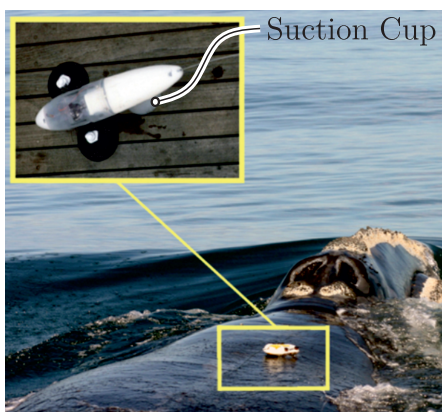
This Simulation Study Project aims to address the aforementioned issues through the introduction of a passive pumping mechanism. This mechanism integrates two fluid-driven membrane valves [1], which are set up as check valves, in conjunction with a pneumatic membrane pump (Fig. B). The primary function of this arrangement is to pump out leaked water from the cup to maintain a good seal

between the suction cup and the skin of the whale. This is accomplished without the need for external electronics; the pumping is fueled directly by the periodic diving motion of the whales which causes a periodic displacement of the membrane in the membrane pump.

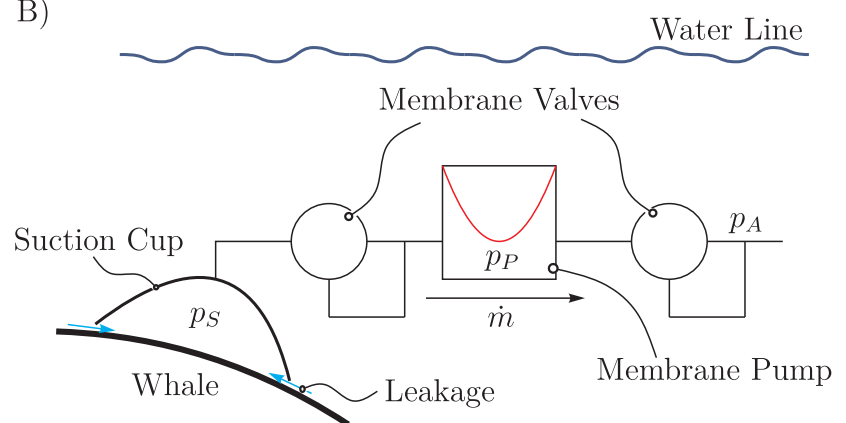
The initial phase of this project involves a comprehensive simulation study of the pump setup utilizing MATLAB / Simulink. This study will serve as the foundation for understanding the passive pumping dynamics and the role of the check valves.

Additionally, the project proposes the exploration of a new system design aimed at actively controlling the pressure within the suction cups through the use of *fluid logic*. In contrast to uncontrolled pumping, this will minimize the potential discomfort to the whales and will thus reduce the risk of the whales trying to remove the tags.

A)



B)



A) Whale Tag in operation (Doug Nowacek/Duke University) B) General setup of the passive pumping mechanism, consisting of 2 membrane valves and a membrane pump

[1] Dai, Velimirović et al. *Modeling and Experimental Validation of High-Flow Fluid-Driven Membrane Valves for Hyper-Actuated Soft Robots*, 2024, *Advanced Intelligent Systems*