Passive Health Assessment of Sea Mammals (PHASM)

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Introduction

Marine mammals face increased threats due to human activities. Current health monitoring strategies include dangerous pole captures, skin biopsies, or catch-and-release procedures.

Uncrewed aerial systems (UAS) can collect blow mucus without the animal needing to stay close to a boat, providing a less invasive health assessment option.

Blow samples can be analyzed for reproductive health and stress levels, indicating animal fitness.

Multi-rotor UAS have been used to collect blow in larger whales. But propeller downwash blows away samples from Small cetaceans with a smaller blow-field (Abele, 2021).

Figure 1: Modified Heewing T2 Cruza, PHASM prototype used in successful sample collection

For this project, a fixed-wing system named PHASM or Passive Health Assessment of Sea Mammals (Figure 1) was designed to collect blow even from small animals like dolphins or porpoises.

Methods

Visual Impacts: Dolphin Field of Vision
We established the effective field of vision (FOV) in bottlenose dolphins (*Tursiops truncatus)* to determine the blind spots and achieve visual stealth with the close approach UAS.

Three bottlenose dolphins from Dolphin Quest Bermuda (DQB) were asked to swim into a Hoberman sphere apparatus and whistle when they saw any of the lights turn that were affixed to and encircling the sphere. This process allowed us to generate 3D images of their FOV, as shown in Figure 2.

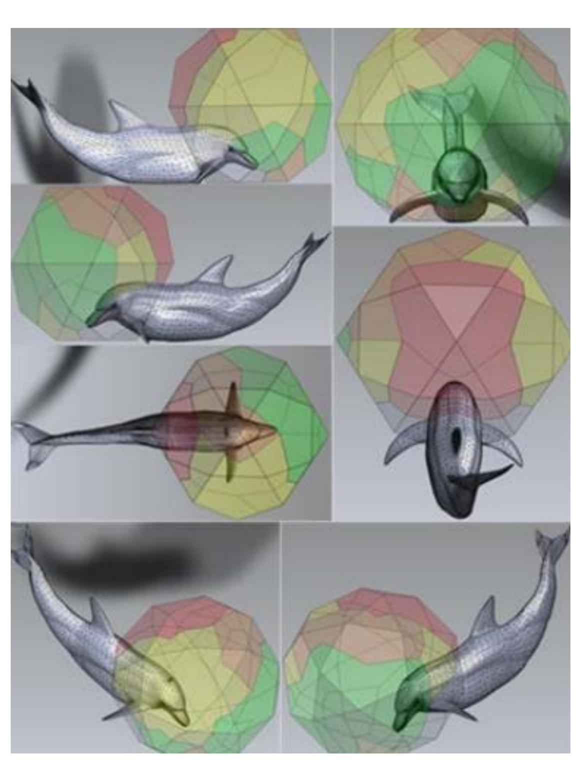

Figure 2: 3-D images of dolphin field of view. Green visible, yellow likely visible, orange likely not visible, Red not visible

Acoustic Impacts: Dolphin Response to UAS Noise and Profile
Seven UAS platforms were used to assess bottlenose dolphin responses to UAS noise level.

Each UAS was flown in decreasing height vertically to evaluate behavioral responses via number of looks and submersion time.

Figure 3: Three examples of drones tested: DJI Mini 2, DJI Mavic 2 Enterprise Advanced, DJI Inspire 2

Methods cont.

Chuff Simulator
Combining flow visualization and 3D models of dolphin nares, the "Chuffsim" was developed to emulate a dolphin's blow field, allowing us to test close approach UAS collection before the UAS's use in real animals.

PHASM Development
An Electric Ducted Fan (EDF) was used as a suction device to pull the blow into a fine mesh or filter paper (soaked in pH indicator for system tests) where the sample would be used for health assessment, as shown in Figure 4.

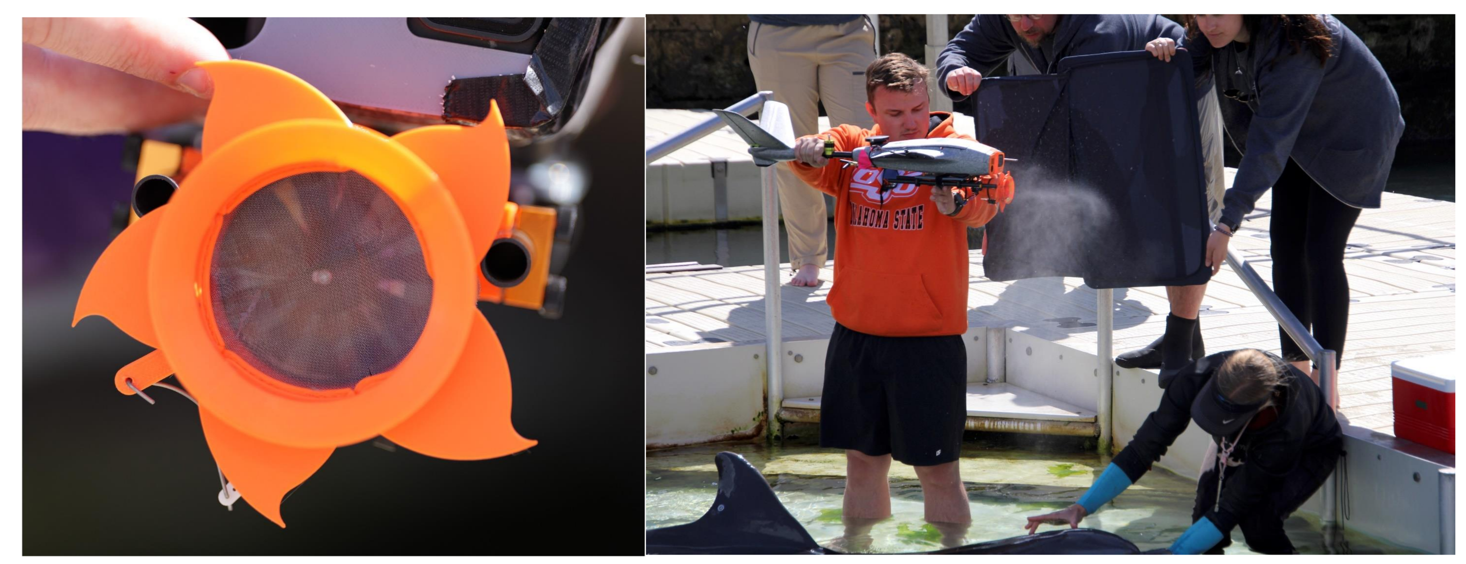

Figure 4: A) Open Iris of Electric Ducted Fan
B) EDF effectiveness tested at Dolphin Quest Bermuda with static chuffs (forced strong exultation of air)

Test flights occurred in May of 2024 at Dolphin Quest Hawaii (DQH). As shown in Figure 5, the collection phase of each PHASM flight occurred 1-2m behind the dolphin as the UAS flew through the blow field and the EDF was activated.

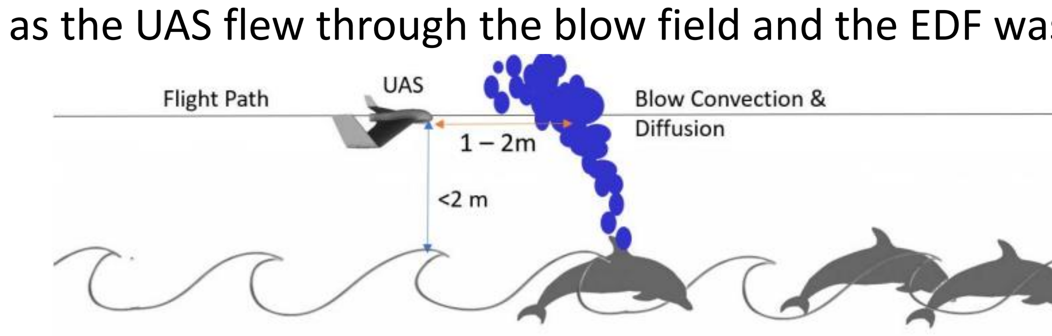

Figure 5: Collection Phase of Operation

Results

Initial PHASM prototypes were deemed too noisy given animal looks and submerge time compared to other off the shelf systems ($F(6, 1469) = [6.364]$, $p < 0.001$), Figure 6). As such we shifted to a modified Heewing T2 Cruza.

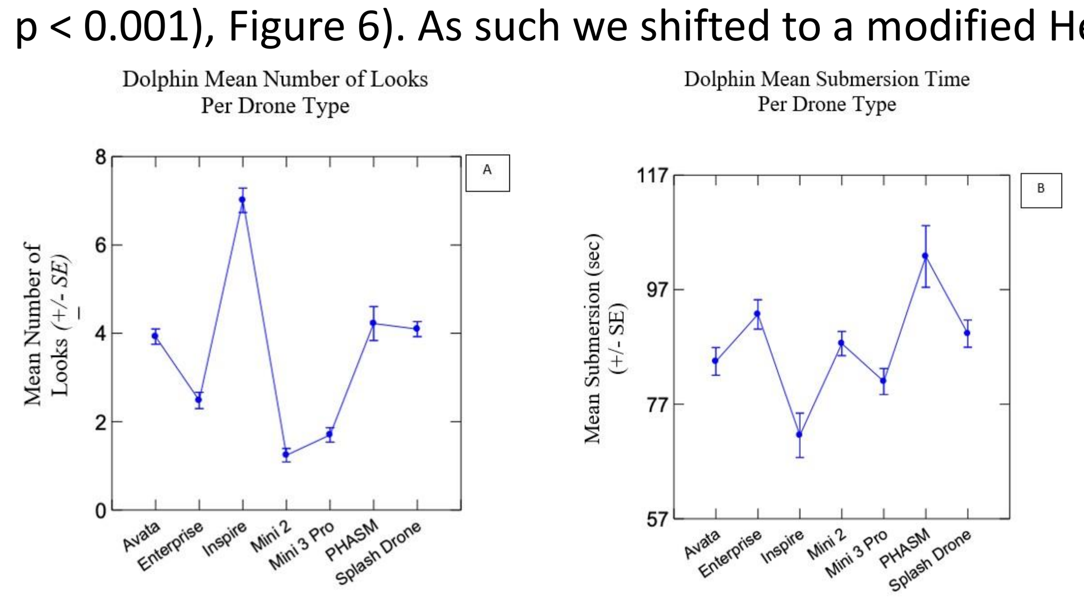

Figure 6: (A) The mean (+/- SE) number of dolphin looks per UAS type for all UASs. (B) The mean (+/- SE) duration of dolphin submersion time as a function of UAS type.

The first successful collection occurred on June 4th, 2024, with fruitful blow captures on each of the three subsequent flights, demonstrating improvement in the process/ timing, pilot capability, and system reliability.

Results cont.

PH indicator filter paper from within the EDF identified when successful collection occurred, as shown in Figure 7.

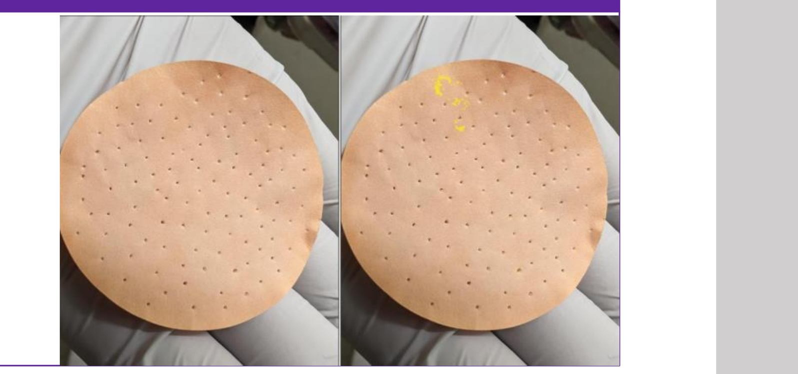

Figure 7: Photo of filter paper with mucus (left), false color mucus with image processing (right)

Discussion

Aiming to show the feasibility of using a UAS to collect blowhole mucus samples from bottlenose dolphins, our flight tests confirmed that a fixed-wing UAS can approach/follow dolphins undetected within 2 meters (Figure 8).

As the dolphins swam along the routes shown in Figures 9, 10 (DQH) and 11 (DQB), they may have been sent too early, too late, swam at inconsistent speeds, or may not have surfaced to breathe in consistent locations. These issues will likely be less of an issue in the wild.

Figure 8: Side view of first successful blow capture at DQH June 4th, 2024. UAS is visible just behind a swimming dolphin breaking the water's surface to breathe

The blow samples could be sufficient for DNA extraction, like humpback whale samples obtained by Pirotta et al. (2017).

Figure 9: Flight Plan at DQH depicted by thin red line. Large green area depicts collection area in flight path

Figure 10: Overview of PHASM Flight at DQH

Figure 11: Flight Path (A to B swim route) at DQB

Narrated video summary of each stage of the PHASM project

Future Directions

In the next phase of our project, we plan to attempt breath sample capture from wild dolphin populations in the Gulf of Mexico near Galveston where analysis labs are present.

References

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DOLPHIN QUEST