SnotBot: Developing an innovative platform for cetacean research

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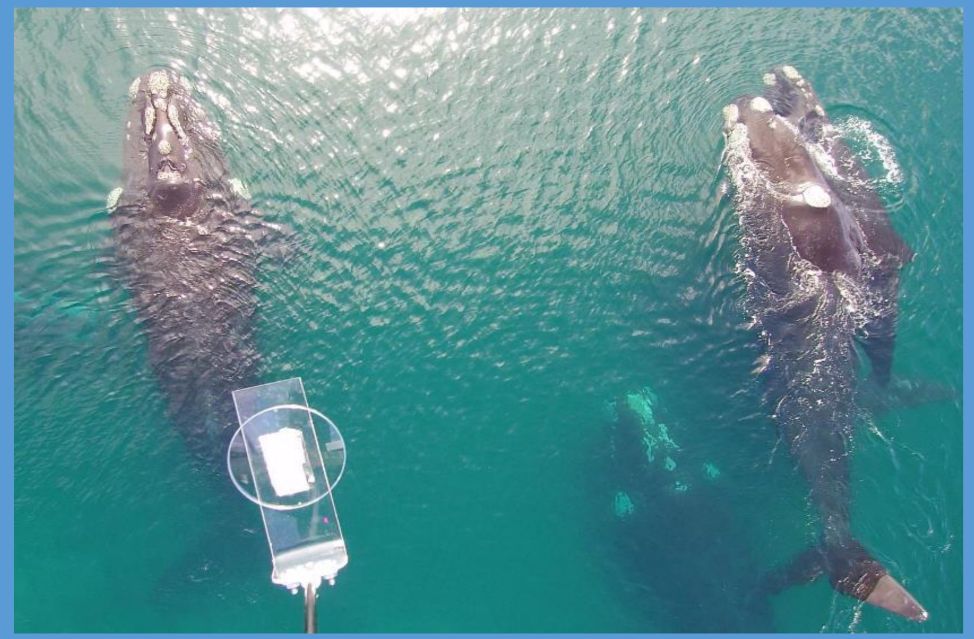
INTRODUCTION

There are many challenges associated with obtaining robust data on the physiology of large whales. Dropping costs and technological advancements are advancing the case of 'small unmanned aerial systems' (sUAS), as highly adaptable, practical and cost-effective research tools.

Along with our partners at Olin College of Engineering, we have spent the last four years developing the SnotBot program, through several of stages of evolution including testing prototypes in playing fields, in controlled situations such as test tanks at Olin and offshore in the Gulf of Mexico. In September 2015, we took SnotBot to our field station in Patagonia to collect our first 'Snot' data from Southern right whales. This field season was run in partnership with Instituto de Conservación de Ballenas & WHOI. We met or exceeded our goals and demonstrated that drones like SnotBot are an important emerging tool in marine mammal research.



PHOTOGRAMMETRY

Ocean Alliance is committed to collaboration in our mission to advance our knowledge of marine mammals and the threats they face. As part of the Patagonia field season we flew a APH-22 Hexacopter belonging to Dr's Moore & Durban. They are using this sUAS to assess size and body condition of whales using photogrammetry. We captured 1,220 images of 57 right whales. Dr. Moore and Dr. Durban developed this program & protocols and they will be analysing the images/data we collected.

DISCUSSION POINTS

This is a new field, using an emerging and rapidly evolving technology, and the most effective ways of utilizing sUAS have yet to be fully determined. This field season raised as many questions as it answered. Some of the on going challenges we faced are discussed below.

- There was a trade-off between sUAS stability, size and quantity of blow collected. Angling the rotors outwards stabilised the sUAS, but with the rotors facing vertically down more EBC seemed to be blown back down on to a collection petri dish that was pointing up (away from the whale).

- Perhaps counter-intuitively windier conditions were optimal. Surprising variability in the angle of the whale's blow meant that potential samples were sometimes lost due to poor positioning of the drone. However, in windier conditions, we found that hovering the sUAS slightly downwind from the blowhole, increased our success rate.

- Waterproof sUAS were tested, as an insurance against 1) the vehicle falling into the ocean, 2) the blow interfering with internal mechanisms. They were found to be less effective being heavier, less adaptable and created more downwash, interfering with blows and possibly irritating the whales. Their advantages were nullified by lighter units reliability, stability & sensors prohibiting them from descending beneath a pre-set height.

DEVELOPMENT

As they are already being flown in close proximity to cetaceans, we thought it important to try and better understand the potential impacts of sUAS flight over whales. With a long history of developing benign research techniques, we felt a responsibility to approach this project as methodologically as possible.

With our partners at Olin College of Engineering we developed this program systematically. Olin students created 'SnotShot' a whale blow simulator, even using different species 3D-printed blow-holes. After tests on land and in a test pool, SnotShot was put onto SnotYacht-our mechanical whale analogue. SnotYacht was also equipped with an array of sensors including anemometers, hydrophones (above and below the water) and pressure plates in an effort to determine what a whale might feel and hear from an approaching drone. We conducted SnotYacht field tests in Gloucester and in the Gulf of Mexico.

The downwash created by the SnotBot at a height of 2 metres, averaged 3 metres per second (6.7mph), similar to a very mild ocean breeze, and thus likely negligible to the subject whale. The sound created was well within parameters of ocean noise, and far quieter than motor boats used in traditional cetacean data collection. Additionally, current knowledge of cetacean hearing suggests that few species even have a hearing range which could detect SnotBot (see TePRA reference below).

PATAGONIA EBC (EXHALED BREATH CONDENSATE) COLLECTION

We found that the major advantages of sUAS revolve around their practicality, adaptability and cost-effectiveness. These were demonstrated well by our EBC collection efforts in Patagonia.

- Off-the-shelf models were modified with a simple arm for holding the petri dish Snot Collectors
- sUAS were launched and recovered by hand, both from the research vessel and the beach.
- Flight time was restricted to approx. 18 minutes, though this was a conservative effort, some of our units had a maximum flight time of 35 minutes.
- We had a 3 person crew, pilot, launch/retrieval, sample processor.

There are many challenges associated with collecting physical samples/data from whales. Small, unpredictable sample sizes (sloughed skin/faecal matter), invasive (biopsy/close approach) procedures and expensive and or dangerous (survey plane) methodology compound efforts to obtain this information. We believe that sUAS technology can be a major player in meeting these and future challenges.

EBC Collection Protocol

- Collection devices: Yuneec Typhoon/Tornado sUAS equipped with a collection arm holding up to four either 160mm or 100mm sterile petri dishes and sterile glass wool
- sUAS & collection arm wiped down with alcohol before flight,
- Scientist and sUAS launcher wearing masks and gloves
- Launcher retrieves sUAS, EBC either pipetted using sterile, filter pipette tips and/or petri dish wiped with a sterile supor filter.
- Samples frozen in liquid nitrogen or transported in a cooler to be processed on land
- Video data collected during any flight in the presence of whales
- Flight data/video shown on pilot's screen including: height over water, distance from pilot, mode of flight, direction of drone, flight time remaining.
- Flight lasted for full battery length whenever possible. In circumstances where it seemed a robust sample had been collected, sUAS would return immediately to vessel.
- Full meta data collected.
- Sample collection arm easily removed and could be swapped out if a rapid turnaround was required.

THE FUTURE

We see an extraordinary future for sUAS in cetacean & oceanographic research. The potential applications of sUAS are vast, diverse and exciting; avenues we are currently exploring include:

- Using video to detect, track and study whales; there is an opportunity here to significantly improve data sets whilst drastically dropping costs. The possibilities of studying movement/distribution/population data/inter-species interactions and sociality/predator-prey interactions are enormous. Even more so, they could potentially yield new insights into the behaviour of whales undisturbed by noisy ships/planes in close proximity.

- Summer 2015 we tested a FLIR InfraRed camera aboard the RV Odyssey in the Gulf of Mexico, consequently we know that mounted on a sUAS a FLIR system offers enormous potential to collect unique behavioural data at night. There is also the possibility of detecting & gauging the severity of infections or wounds on individual animals.

- By providing rapid and cost effective live aerial footage during whale disentanglement sUAS could reduce the resources required and the duration & safety of the procedure, and ultimately reduce the stress and physical damage to the animal.

- Telepresence, offering live-stream video footage of animals from remote locations, the collaborative possibilities are enormous. Different researchers from round the world could monitor a live-feed and communicate with & potentially direct the on-site pilot and researchers.

sUAS/DRONES

- APH-22 Hexacopter. Designed and built by Aerial Imaging Solutions. Weight=4lbs, Measurements=32' from propeller to propeller. Max. flight time=35mins. A small VTOL UAS used to collect digital images with Olympus OLEPM2S camera payload.
- Tornado hexacopter. Developed by Yuneec. Weight=10.5lbs. Max. flight time=40mins. A medium VTOL UAS.
- Typhoon hexacopter. Developed by Yuneec. Weight=10.5lbs. Measurements=36' from propeller to propeller. Max. flight time=45mins. A medium VTOL UAS used primarily to obtain EBC samples.

RESULTS

Typically a remote location and new technology do not go hand in hand. We are pleased to report then that our first expedition to collect blow samples & meta data from whales was a success at all levels (22 EBC samples & 1,220 photographs of 57 whales). While we were very focused on blow collection, we were also keen to document the unforeseen challenges of actively collecting samples from whales which our controlled testing could not identify. To this end, we learnt a lot and are now working to perfect our methodology & upgrade our equipment.

	APH-22 flights	Typhoon flights	Tornado flights	Photogrammetry images	Breath Samples
Day 1	2	0	0	10	0
Day 2	2	0	0	83	0
Day 3	7	4	0	313	0
Day 4*	0	6	0	0	3
Day 5	5	4	1	213	3
Day 6	6	7	0	258	4
Day 7*	0	0	2	0	0
Day 8	8	14	0	343	7
Day 9*	0	0	2	0	0
Day 10	0	8	0	0	5
Total	30	43	5	**1220**	**22**

***= Limited effort due to 15 to 25 knot winds**

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