Final report – Hungry Humpbacks Land Team

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Our team settled at King Edward Point station in the South Georgia Islands from November 18, 2023 to January 14, 2024. During this approximately 2-month period, the 2-person team conducted land-based field research activities and explored various possibilities to effectively study whales on the islands from land. The following document provides details on the sampling effort, field hours and results, as well as incident reports, troubleshooting and recommendations.

Working area

The explored fieldwork area was the cliffs near the entrance of Cumberland Bay in the northernmost part of the Thatcher Peninsula.

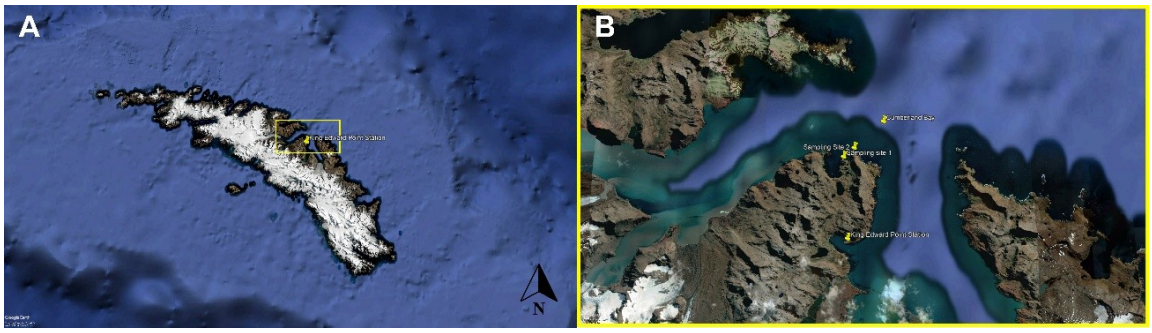

***Figure 1**. Satellite image of the South Georgia Islands with details of the working area (A), entrance to Cumberland Bay and sampling sites (B).*

The path from the station to the working area is approximately 7 kilometres. Along the way, steep hills, snow, loose rocks on slopes, streams, peat bogs, ridges, and Tussock grass fields with gullies are found. Wild animals are present on the path. It's common to come across Gentoo Penguins as there is a colony nesting 400 metres off the coast of Maiviken Bay. It's crucial to avoid blocking their path as they are in the breeding period during the sampling months. Skuas and Terns are also frequently encountered, and they tend to protect their nests by attacking the heads of those who approach. Most importantly, the path is populated with Antarctic Fur Seals, particularly the areas with Tussock. These animals are in their mating and breeding season during these months and may exhibit aggressive behaviour. Prior to starting fieldwork, the team received training on how to handle encounters, potential aggressive approaches, and even how to treat injuries from bites.

Halfway along the path, there is a shelter, "Maiviken Hut," commonly used as a recreational area by the station residents. Our team used the shelter as a base of operations when weather conditions allowed. A generator was available for charging batteries, and part of the heavier equipment was left there during days of bad weather

On each outing, the team had to carry work materials (drone, batteries, tablets, tablet batteries, and various items), safety equipment (first aid kit, seal bite kit, satellite phone, CO metre, among others), and personal gear, including food and water for several days on some occasions.

At times, the team opted to camp at the sampling sites for logistical convenience. This helped reduce travel time but required including additional personal safety items and camping equipment.

During the first month of work, our team used Sampling Site 1 (Fig. 1.B.). The 30-metre-high cliff provided a panoramic view of part of Cumberland West Bay, although a significant portion of the bay's entrance was obscured by a much taller cliff. Due to logistical and safety considerations, climbing the 160-metre-high cliff was ruled out. However, after a month of sampling with little success, our team decided to relocate to higher ground on the cliff (Sampling Site 2).

Weather

Sampling was conducted considering the following meteorological conditions based on a combination of forecasts and actual conditions:

- Winds up to 14 knots
- Gusts up to 35 knots
- Rainfall up to 0.2 mm/h
- Cumulative rainfall <5 mm / 6 hours

On several occasions, the team encountered adverse weather conditions different from those forecasted. Waterproof and snow protection materials for the equipment, multiple layers of insulation, raincoats, and windbreakers were always carried. Temperature, precipitation, and wind speed, including gusts, seemed to change unpredictably, deviating from the forecast. Due to the glaciers' location relative to the sampling sites, katabatic winds were common. These winds could be detected before their arrival by observing the sea water surface. For operational safety reasons, under no circumstances were drone flights conducted during strong gusts, rain, heavy snow, or fog.

Sampling effort and fieldwork

From land

22 field outings were conducted accounting for 205.5 hours of fieldwork and 110.25 hours of observation (see **Table A1** in annex section).

Due to the requirements of photogrammetry techniques, the only useful images of whales are those where the individual is photographed from a zenithal view, without arching its body, and where its contour is visible. Whales were sighted during four outings, yet data collection was only feasible on one occasion (See **Table A2** in annex section) when one whale was successfully measured. This limitation arose from the distant and inaccessible positions of the observed individuals on three separate occasions, rendering successful drone operations unattainable.

From boat

The land-based team embarked on the fishing patrol "Pharos" to access a broader range from December 5 to December 10. The methodology involved continuous observation from the vessel's bridge when weather conditions allowed and drone deployment upon potential whale encounters. Weather conditions on December 7, December 8, and December 10 were mostly unfavourable for sampling (winds between 40 and 70 knots). Additionally, the vessel was conducting fixed transects at a speed of 9 knots with immovable schedules, reducing the

opportunity for whale encounters. On December 9, two humpback whales were sighted under favourable weather conditions during a fixed transect. The team decided to deploy the drone and obtained aerial images of the two individuals. These were the only images obtained during the 6 days aboard.

Incident report, troubleshooting and recommendations.

Signal booster

Having considered the range limitations of the drones, a signal booster for the remote controller was acquired prior to the project's commencement to enable long-range operations. This would extend the signal from 4 kilometres to at least 6 kilometres, crucial for covering the area at the entrance to Cumberland Bay. On November 24, the first long-range test flight was conducted in the field, revealing that, despite using the signal amplifier, the drone's range did not exceed a few hundred metres. Back on station, an exhaustive equipment analysis was conducted with the help of the electrician on station. The problem was traced directly to the amplifier, which could not be fixed on-site, limiting the flight range to no more than 4000 metres from the sampling point.

On December 9, five humpback whales were observed. The drone's flight range was insufficient to reach the whales, which were roughly at about 4,500 metres.

It is advisable for forthcoming projects to conduct preliminary test flights before dispatching the equipment, employing the signal booster. Given the potential risk of damage during transit, it is recommended that, if deemed of paramount importance, a spare amplifier be dispatched as a precautionary measure. Conducting these test flights can also detect other issues in advance. One of the drones had an internal fault that prevented it from deploying the landing gear properly. While this did not affect its functionality, it could be an early indication of other failures.

Range Finder

To conduct photogrammetry effectively, it is imperative to have a laser altimeter (Range Finder) on the drone to ensure precise height measurements. The Range Finder model utilised for the drones in this project is external and connects to the drone's battery. Initially, the suggestion was to affix the altimeter to the camera to minimise measurement errors. Following the installation of the devices, short test flights were conducted without encountering any issues. However, during field flights at speeds exceeding 60 km/h and flights in gusts of 20 knots, it became apparent that the altimeter was destabilising the camera. This was attributed to the altimeter’s installation, which includes a counterweight, resulting in increased wind resistance. The degree of destabilisation was such that not only was it impossible to capture zenithal images, but also to manoeuvre the aerial vehicle using the camera's vision. Consequently, our team opted to relocate the Range Finder to the underside of the drone, ensuring that operational safety and flight performance were not compromised. Following this modification, no further issues were detected.

Operating on moving vessels

From December 5 to December 10 our team worked from a vessel that was conducting fixed transects. These poses added challenges. The vessel constantly moves away from the whale sighting point and moves straight regardless of the waves. This implies that in case of any emergency or system failure and activation of emergency landing systems, the vessel is unable to assist in the flight manoeuvre, diminishing risk mitigation capabilities. Moreover, fixed transect routes usually result in more pronounced waves than during free routes. The increased wave level poses a risk to the team during drone launch and landing. The inclined level of the platform resulted in a failure in the calibration of internal drone systems (gyroscopes and accelerometers), leading to destabilisation. On December 9, during a landing on the helicopter landing platform, total destabilisation occurred, resulting in autonomous movement that broke all four propellers and the camera's anti-vibration mount.

Analysing potential risks and benefits of sampling whales during fixed transects, conducting flight manoeuvres during this type of route is considered not recommended. If drone launches and landings from the vessel are carried out, it is recommended to always do so using the "hand-release" and "hand-catch" method, with appropriate safety gear (helmet and protective gloves). Communication during such manoeuvres between the pilot and the team is key to a safe operation.

Following with the issue, our team proceeded to triangulate the problem with the rest of the team in Cambridge and with technical support in Argentina, in addition to the assistance of the electrician at station. A potential problem with the camera was identified, and the replacement of the anti-vibration mount was suggested. After obtaining a spare part in Buenos Aires, sent to Ushuaia and then to the station in South Georgia via cruise ship, the team proceeded to replace the mount with technical assistance. The installation was successful, but the issue persisted due to an undetectable underlying error. This meant that fieldwork was subsequently carried out without a spare drone.

Equipment in the field

At the outset of planning the first field trip, the team encountered the issue of safely transporting the equipment. Although a backpack model was acquired during project planning to carry a drone and some batteries, the way the Range Finder was installed did not allow for the removal of the drone's camera, making it impossible for the drone to fit into the backpack. The team proceeded, with the assistance of the station leader, to construct a box-type backpack with internal foam material to transport the drone safely. Although it was later decided to remove the Range Finder from its location on the camera, the team chose to continue using this box backpack as it offered better protection against impacts and water. The purchased backpack was used to transport batteries and tablets. This way, the team was able to divide the total weight to be carried. While the box-type backpack served its purpose, it is recommended that for future projects, if the same drone model is to be used again, consideration be given to constructing or adapting a backpack with appropriate back protection to prevent injuries.

Additional recommendations

Building good relationships

Building good relationships with people at the station was key not only for productive coexistence but also for receiving assistance in detecting and resolving some issues. Without the necessary help, it would have been very difficult to build the box-backpack that allowed the team to safely transport the drone and distribute the weight. Without assistance from the electrician, it would have been difficult or impossible to detect the source of the signal booster and anti-vibration mount issues. Government officials would inform the team if cruises spotted whales on their way to Cumberland Bay. Boatmen would inform in case of water operations that would allow the team to go onboard and expand the possibilities of sampling from inside the bay, thus extending the range of coverage. And everyone on station provided detailed weather updates, when necessary, sometimes necessary for personnel and equipment safety.

Real conditions and drone operations

Given the drone model used in this project, it is important to maintain constant monitoring of real meteorological conditions. The equipment can withstand strong winds of over 35 knots. However, it is crucial to detect the arrival of katabatic winds in advance. For this, it is essential for the pilot assistant to maintain constant situational awareness, not only of the drone's location but also of the actual local weather conditions. Strong winds are often easily detectable after observing changes in the water surface, becoming turbulent with more white caps.

Water visibility at Cumberland West's entrance is low, estimated at no more than 3 or 4 metres on some days and no more than 1 metre on others. High concentrations of sediment, possibly glacial sediment, are observed within Cumberland West.

Out in the field, exposure to the elements is harsh. Although the project was carried out during the summer months, temperatures generally did not exceed 3 degrees Celsius, accompanied sometimes by breeze, wind, drizzle, and/or snow. Our team always carried water protection gear to keep all equipment safe. Sometimes, when attempting to launch the drone, they had to wait for the batteries to warm up as they were very cold. As this issue had been foreseen during the planning of this project, the drone model used has a self-heating system after ignition, so the waiting time was short. However, on occasions when the generator was used to charge the batteries at Maiviken Hut, the team had to warm the used batteries with body heat. Otherwise, the environment was too cold and the batteries would not charge.

In the cliffs of Maiviken Bay, there is a large population of petrels and albatrosses, along with some gulls, skuas, and terns. It is crucial to keep track of their presence to avoid potential collisions or disturbances to the wildlife. Therefore, it is important for the assistant to promptly inform the pilot about the presence of birds along the operational route or near the drone when stationary.

As a final recommendation in this matter, it is important to constantly check not only the actual conditions but also the configuration of the equipment. Particularly, the automatic return-to-home setting should always be enabled when operating from land, and the return altitude should be consistent with the terrain obstacles. When covering long distances to fly over cetaceans, signal loss is common, and knowing how to react correctly and having the configuration properly set is crucial.

Fur Seals

As mentioned earlier, the route from the station to the sampling sites is a common resting area for Antarctic Fur Seals during their mating and breeding season. It is important to know how to handle potential aggressive encounters with these animals. Due to the uneven terrain and the amount of equipment team members had to carry, avoiding these encounters is not always feasible, and straying too far from the least inconvenient path is also not advisable. In addition to conducting the necessary training, using walking sticks during the journey to the sampling point is recommended to maintain distance from wildlife and balance on uneven terrain.

Safety

In addition to the presence of Fur Seals, the rugged terrain makes the path to the sampling sites particularly treacherous, particularly when carrying heavy equipment. Bogs, river crossings after heavy snowfall, and gullies between Tussock clumps with steep slopes are notable hazards. Hence, it is important to have appropriate safety and first aid equipment for possible contingencies, as well as constant assessment of terrain conditions and the best traversal routes. In cases of very steep slopes, such as the one to climb to sampling site 2, it is recommended to climb with only one pack. Thus, the team had to climb it twice on each sampling outing. For future projects, it is recommended to reassess the drone model to be used. Consideration should be given to the potential advantages of employing a smaller drone, which could mitigate risks and facilitate easier access to sampling locations. Nevertheless, it is worth noting that the current drone model employed in this project offers superior capabilities, including the capture of high-resolution imagery, precise measurements, as well as good wind resistance.

Final words

The Hungry Humpbacks Land Team's expedition to the South Georgia islands has concluded, and about 110 hours of observation were conducted, accounting for whale encounters on four separate occasions from land. Only on one occasion was it possible to obtain significant data. Additionally, two whales were recorded from a vessel. Despite not having collected an abundance of data and encountering numerous challenges, from unpredictable weather to technical equipment issues, the team demonstrated resilience and adaptability in overcoming obstacles. Through collaborative efforts, meticulous planning, and a commitment to safety, they conducted comprehensive fieldwork, contributing valuable data to the study of whale populations in the region. As the project concludes, the team's achievements underscore the importance of interdisciplinary collaboration and proactive problem-solving in advancing scientific knowledge and conservation efforts in remote and challenging environments. It is also important to remember that the land-based component of this project was the first attempt to conduct land-based photogrammetry research on humpback whales in South Georgia. While this method has worked well in other locations, we did not know if whales would approach the coast within the distance that the drone could operate. The small sample size obtained during the land-based component shows that land-based work is challenging in South Georgia and will need further discussions about future work.

Annex

Date	Time out of station/hut	Starting monitoring time	Weather at beginning	Ending monitoring time	Weather at end	Time back on station/hut	Hours of observation	Hours in the field
21-Nov	10:00:00	N/A	N/A	N/A	N/A	18:00:00	00:00:00	08:00:00
24-Nov	06:00:00	10:55:00	Calm, cloudy	15:30:00	Calm, cloudy	18:00:00	04:35:00	12:00:00
25-Nov	07:30:00	10:40:00	Calm, sunny	17:00:00	Calm, sunny	19:40:00	06:20:00	12:10:00
28-Nov	09:00:00	N/A	N/A	N/A	N/A	12:00:00	00:00:00	03:00:00
05-Dec	08:50:00	N/A	N/A	N/A	N/A	11:30:00	00:00:00	02:40:00
09-Dec	05:30:00	08:45:00	Breeze, sunny	17:00:00	Breeze, cloudy	18:00:00	08:15:00	12:30:00
10-Dec	05:00:00	07:00:00	Calm, sunny	13:00:00	Windy, cloudy	18:00:00	06:00:00	13:00:00
13-Dec	05:00:00	08:30:00	Calm, cloudy	13:00:00	Windy, fog, rain	14:00:00	04:30:00	09:00:00
14-Dec	08:00:00	10:00:00	Calm, fog	14:30:00	Calm, sunny	18:00:00	04:30:00	10:00:00
15-Dec	06:00:00	09:00:00	Calm, fog and rain	16:00:00	Calm, cloudy	18:00:00	07:00:00	12:00:00
18-Dec	05:30:00	07:50:00	Calm, sunny	18:30:00	Calm, sunny	21:00:00	10:40:00	15:30:00
22-Dec	12:30:00	15:30:00	Windy	18:00:00	Windy	20:00:00	02:30:00	07:30:00
23-Dec	06:30:00	09:05:00	Calm, cloudy	13:00:00	Breeze, cloudy	15:00:00	03:55:00	08:30:00
29-Dec	17:00:00	N/A	N/A	N/A	N/A	18:00:00	00:00:00	01:00:00
30-Dec	05:30:00	07:40:00	Heavy snow, fog	17:00:00	Calm, cloudy	N/A	09:20:00	11:30:00
31-Dec	N/A	07:30:00	Calm, cloudy	16:00:00	Calm, cloudy	19:00:00	08:30:00	11:30:00
02-Jan	10:30:00	13:20:00	Calm, cloudy	18:00:00	Calm, cloudy	19:30:00	04:40:00	09:00:00
03-Jan	05:30:00	08:00:00	Calm, sunny	17:30:00	Calm, sunny	19:00:00	09:30:00	13:30:00
04-Jan	05:30:00	08:00:00	Calm, cloudy	15:00:00	Calm, cloudy	18:00:00	07:00:00	12:30:00
07-Jan	07:20:00	11:00:00	Calm, cloudy	18:45:00	Calm, rainy	20:15:00	07:45:00	12:55:00
08-Jan	12:00:00	13:00:00	Calm, cloudy	18:15:00	Calm, fog	19:45:00	05:15:00	07:45:00
09-Jan	11:00:00	12:15:00	Breeze, rain	12:45:00	Breeze, rain	17:00:00	00:30:00	06:00:00
						TOTAL	**110:15**	**205:30**

Table A1. *Detail of each field outing: schedules, weather conditions, and hours spent in the field and hour of observation.*

Date	Whales observed	Data collected
21-Nov		
24-Nov		
25-Nov		
28-Nov		
05-Dec		
09-Dec	✓	
10-Dec		
13-Dec		
14-Dec		
15-Dec		
18-Dec	✓	
22-Dec		
23-Dec		
29-Dec		
30-Dec	✓	✓
31-Dec		
02-Jan		
03-Jan		
04-Jan	✓	
07-Jan		
08-Jan		
09-Jan		

Table A2. *Detail of the occasions when whales were sighted and data were collected.*

Supplementary material for the final report – Hungry Humpbacks Land Team

Here we share pictures that complement the final report and help interpret aspects of life at the station and fieldwork in South Georgia.

Image 1. Discovery house, our land team's home during the project. Some of its most common neighbors outside on a typical summer day.

Image 2. A view of Maiviken Hut and Maiviken Lake. Maiviken Hut was used by our land team on several occasions for overnight stays during stretches of good weather suitable for fieldwork, making it their second home.

Image 3. Tussock grass field filled with Antarctic Fur Seals, 200 metres away from sampling site 1.

Image 4. One of our team members carry the equipment through the valley between Maiviken Hut and Maiviken Bay.

Image 5. The team awaits a weather window to continue work at sampling site 2

Image 6. The team wakes up on the cliff at the sampling site 2 after a snowy night camping,ready to keep working.

Image 7. Aerial image of Humpback Whale from UAV deployed from Sampling Site 2 at Cumberland Bay.

Image 8. The vessel used by the team for a week-long expedition to extend the study from the sea.

Image 9. Our team bids farewell as they return from the final day of fieldwork.