1st International Conference on Drones and Unmanned Systems (DAUS 2025)

19-21 February 2025
Granada, Spain

Special Session:
Drone Applications for Wildlife Research, Management, and Conservation

(Part 3)

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DAUS 2025

Special Session:
Drone Applications for Wildlife Research, Management, and Conservation

LIST OF PRESENTATIONS*

PART 1
Keynote Presentation: The Use of Drones in Wildlife Ecology: Future Challenges and Opportunities – **Rick Spaulding**
Considerations When Using Drones to Study Wildlife: Lessons Learned So Far – **Fred Tremblay** and Kyle Elliott

PART 2
A Short History of the Use of Drones to Study and Conserve Wildlife – **David Bird**

PART 3
Uncrewed Aerial Vehicles: Taking Cetacean Research to New Heights – **Gina Lonati**, John Durban, Don LeRoi, Michael Moore, and Kim Davies
Spectral-Based Classification of Invasive Wildlife Using Uncrewed Aerial Systems and Hyperspectral Imagery – **Daniel McCraine**, Sathishkumar Samiappan, Leon Kohler, Timo Sullivan, and David Will
Drone Data Management, Processing, and Analysis: Best Practices with Examples from California and Costa Rica – **Sean Hogan**
Monitoring Large Non-breeding Aggregations: Using Drones to Enhance Avian Research in Dense and Urban Environments – **Craig Gibson**
Designing Drones for Wildlife Radio Telemetry – **Michael Shafer**

*Presenters in bold

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Special Session:
Drone Applications for Wildlife Research, Management, and Conservation

Session Co-Chairs:

Rick Spaulding, Sr. Wildlife Biologist
ManTech Advanced Systems International
Chair, TWS Drone Working Group
(https://wildlife.org/drone/)
Bainbridge Island, WA, USA
Rick.spaulding@mantech.com

David M. Bird, Ph.D.
Emeritus Professor of Wildlife Biology
McGill University, Montreal, Quebec, Canada
(currently residing in North Saanich, BC, Canada)
david.bird@mcgill.ca

Summary: Wildlife biologists are relying on an ever-increasing suite of tools to answer questions and solve problems related to wildlife ecology, management, and conservation. The use of unoccupied aircraft/aerial systems (UASs), remotely piloted aircraft/aerial systems (RPASs), or more commonly known as drones, has exploded in popularity in ecological studies in general, and in wildlife biology in particular. Drones have many advantages over traditional research techniques. They eliminate safety risks associated with fixed-wing and helicopter surveys, reduce cost and disturbance, increase accuracy, and allow the collection of high-resolution data over large or otherwise inaccessible areas. Some of the major areas of application of drones that have emerged in wildlife ecology include, but are not limited to: (1) population surveys, Including breeding colonies and non-breeding aggregations; (2) nest monitoring; (3) radio-tracking surveys; (4) acoustic surveys; (5) wildlife habitat research and monitoring; (6) the use of different drone sensors (e.g., visible/RGB, thermal IR, multi- and hyperspectral); and (7) wildlife dispersal, either for nuisance or invasive species or to deter from hazards. This special session provides highlights of the use of drones in wildlife ecology and a forum for discussion among both experts and potential users of drones that may result in future research collaborations between wildlife biologists in academic, government, and private sectors.

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Uncrewed Aerial Vehicles: Taking Cetacean Research to New Heights

Gina Lonati[1], John Durban[2], Don LeRoi[3], Michael Moore[4], and Kim Davies[1]

[1]Department of Marine Biology and Coastal Science, University of New Brunswick Saint John, Saint John, New Brunswick, Canada; gina.lonati@unb.ca
[2]Southall Environmental Associates, Inc., Aptos, CA, USA
[3]Aerial Imaging Solutions, Old Lyme, CT, USA
[4]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Summary: Uncrewed aerial vehicles (UAVs) or drones have revolutionized the study of cetaceans (i.e., whales, dolphins, and porpoises), inspiring new lines of scientific inquiry that were previously impractical to pursue with traditional field methods. In particular, the non-invasive, overhead perspective, the variety of available payloads, the high-resolution data, and the increasing affordability of the technology are just a few reasons for cetacean researchers to add UAVs to their field toolkits. In 2023 alone, over 50 scientific publications cited the use of UAVs for cetacean research – from observing behaviors and measuring body condition with small, consumer-level quadcopters to surveying large expanses of critical marine habitats with industrial fixed-wing drones. However, challenges still exist with studying these highly mobile, aquatic animals with UAVs, including short battery lives, weather restrictions, low surface availabilities of cetaceans, and other limitations associated with at-sea operations. For this presentation, I will review how UAVs have advanced the fields of cetacean biology, behavior, reproduction, physiology, and health, including insights from my PhD dissertation research on the use of UAV-based infrared thermography to measure the heat signatures of whales. I will also touch on other uncrewed technologies (e.g., underwater ocean gliders) that is contributing to a broader understanding of the distributions and habitats of these animals. I will conclude with a vision for where UAVs can take cetacean research next, especially if we can overcome some of the obstacles listed above, as well as the application of UAV imagery for educating and inspiring non-scientific audiences to care about imperiled marine species.

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North Atlantic right whales observed by drone
G. Lonati, UNB

Uncrewed Aerial Vehicles: Taking Cetacean Research to New Heights

Gina Lonati, PhD (she/her) – University of New Brunswick Saint John, Canada

Co-authors: John Durban, Don LeRoi, Michael Moore, Kim Davies

Cetaceans

- **Whales, dolphins & porpoises**
- Fully aquatic mammals
- Fat stored as blubber
    - Energy for metabolism
    - Thermoregulation

- **~26% of species are threatened due to:** climate change, entanglement, ship strike, contaminants, plastic & noise pollution

Challenges with studying cetaceans

- Spend most of their lives completely submerged

- Hold their breath & dive deeply

  Some dive >2 km deep for >1 hour!

- Vast ranges

  Some migrate >1000 km each year!

G. Lonati, UNB

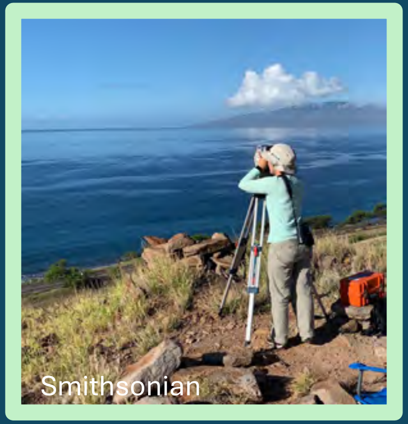
Existing methods for studying cetaceans

Live captures
(smaller species)

Stranded/dead animal sampling

Boats

Occupied aircraft



Land

Health & physiology | Behaviors, distributions & movements

Invasive ⟷ Non-invasive

$$$ | $$ | $$$ | $$$$ | $

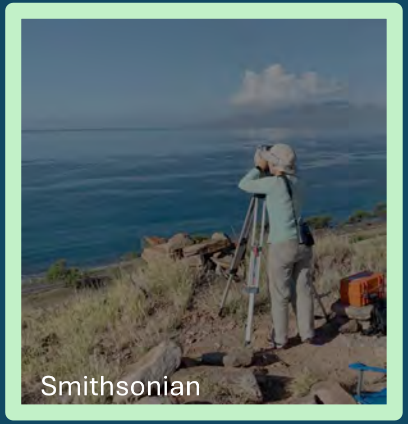
Existing methods for studying cetaceans

Live captures
(smaller species)

Stranded/dead animal sampling

Boats

Occupied aircraft



Land

Higher resolution data than occupied aircraft

Less invasive than close boat approaches

Safer than putting people in the sky

Increasingly affordable

Allowing more research groups to access cetaceans & conduct new, insightful studies!

UAV makes & models

- Large, fixed-wing or helicopter
  - For surveillance, human impact mitigation
- Small, rotary wing
  - Manually piloted, follow whales in real-time

Examples:

- DJI: Inspire, Phantom, Matrice, Mavic, Mini
- Swellpro: SplashDrone
- Aerial Imaging Solutions: APH-22
- Freefly: Astro*

**Blue UAS Cleared List*

Scheibel S100 helicopter drone

A. Warren, NEAq

* *For rotary-wing drones*

UAV flight logistics*

- Launch from land or vessel
- Locate and follow cetaceans using UAV live-stream
- Altitude limitations based on country regulations & marine mammal permits

Durban et al. (2016) – APH-22


G. Lonati – M210 V2


Domínguez-Sánchez et al. (2018) – Phantom 2 over blue whale


G. Lonati, UNB – humpback whales

* For rotary-wing drones

UAV flight logistics*

- Hand-launching/catching
  - Ensures proper IMU calibration
  - Avoids landing on unstable deck

__Limitations:__

- Max drone weight: ~7 kg
- Conservative flight times: <20 min
- Max winds: ~15 knots

__Safety gear:__

gloves, sleeves, helmet, goggles

** For rotary-wing drones*

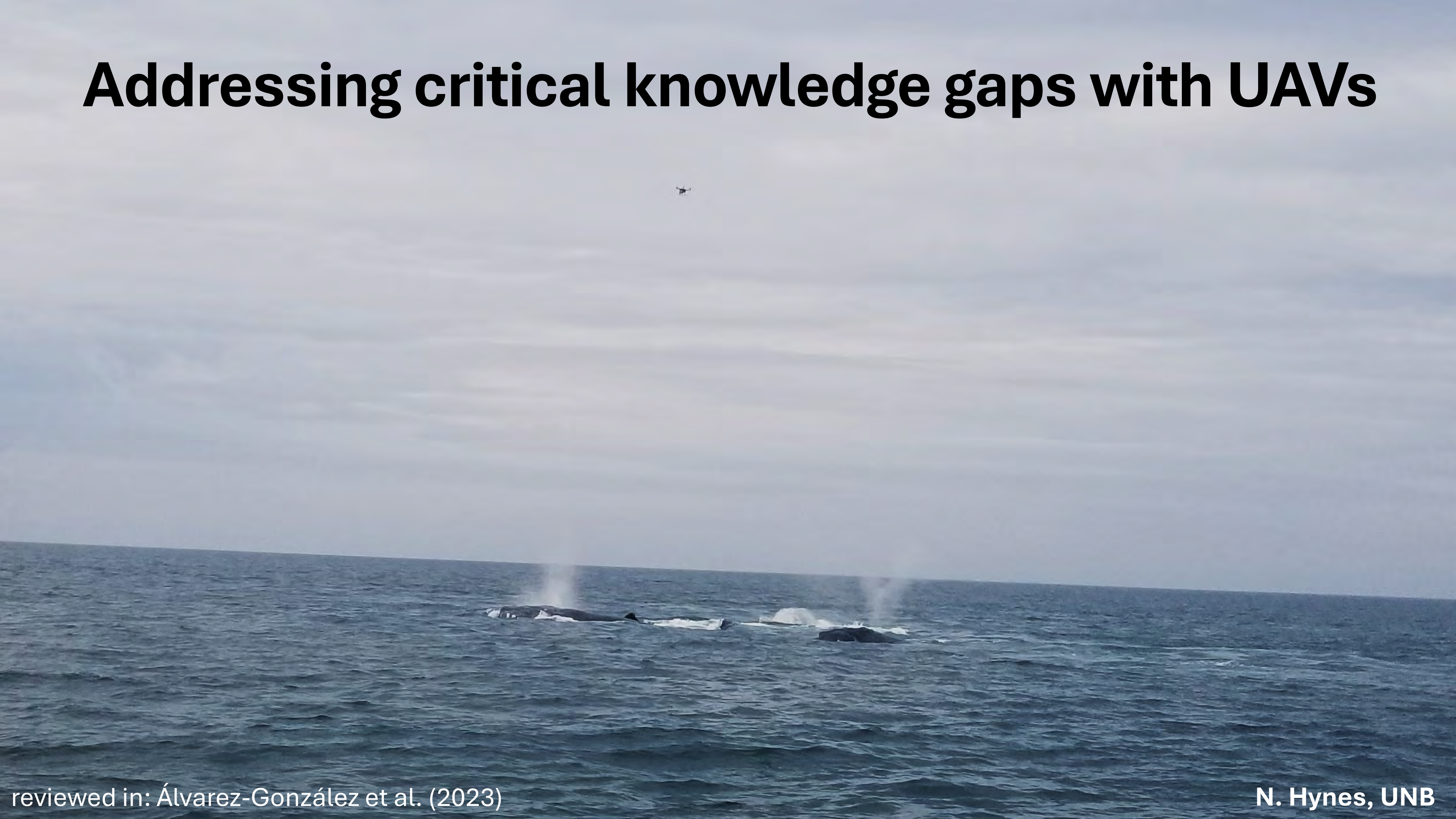
UAV flight logistics*

- Mitigating risk of drone loss
  - Some insurance companies will not cover lost drones
  - Foam or emergency flotation devices
    - But add weight & affect flight dynamics

Costa et al. (2023) – foam flotation on a DJI Mavic Pro 2

Drone Retriever DR14 on a Matrice 210 V2 RTK

Addressing critical knowledge gaps with UAVs



reviewed in: Álvarez-González et al. (2023)

N. Hynes, UNB

1. Photo-identification

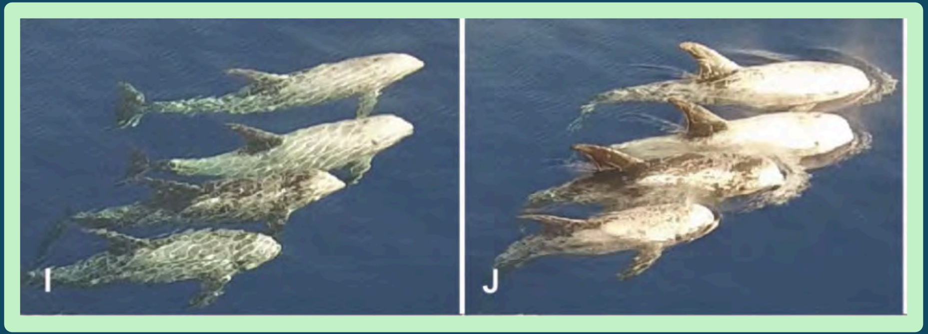
- Visible-spectrum (RGB) imagery from UAVs
- Identify individuals based on distinct features/markings
- Helps estimate population sizes & better manage species

Degollada et al. (2023) – Phantom/Mavic – fin whales

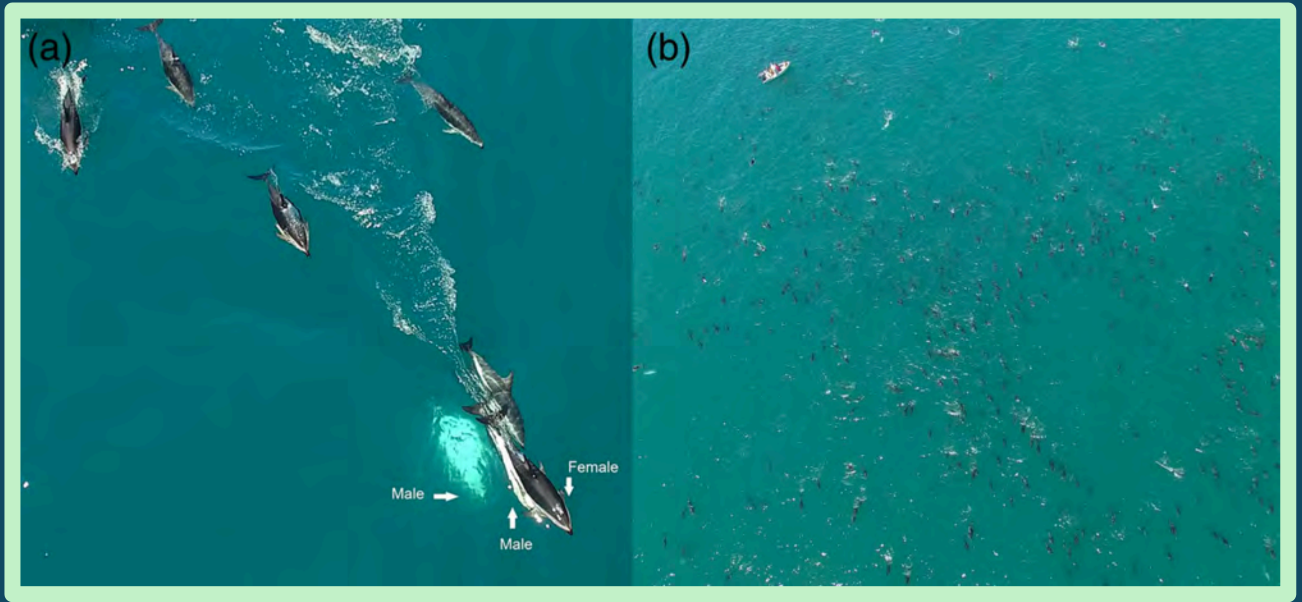
2a. Behavioral observations

- Visible-spectrum (RGB) imagery from UAVs
- When at surface: insight into social structures and mating systems

G. Lonati – Matrice 210 V2 – humpback whale



Hartman et al. (2020) – Phantom 4 –Risso's dolphins

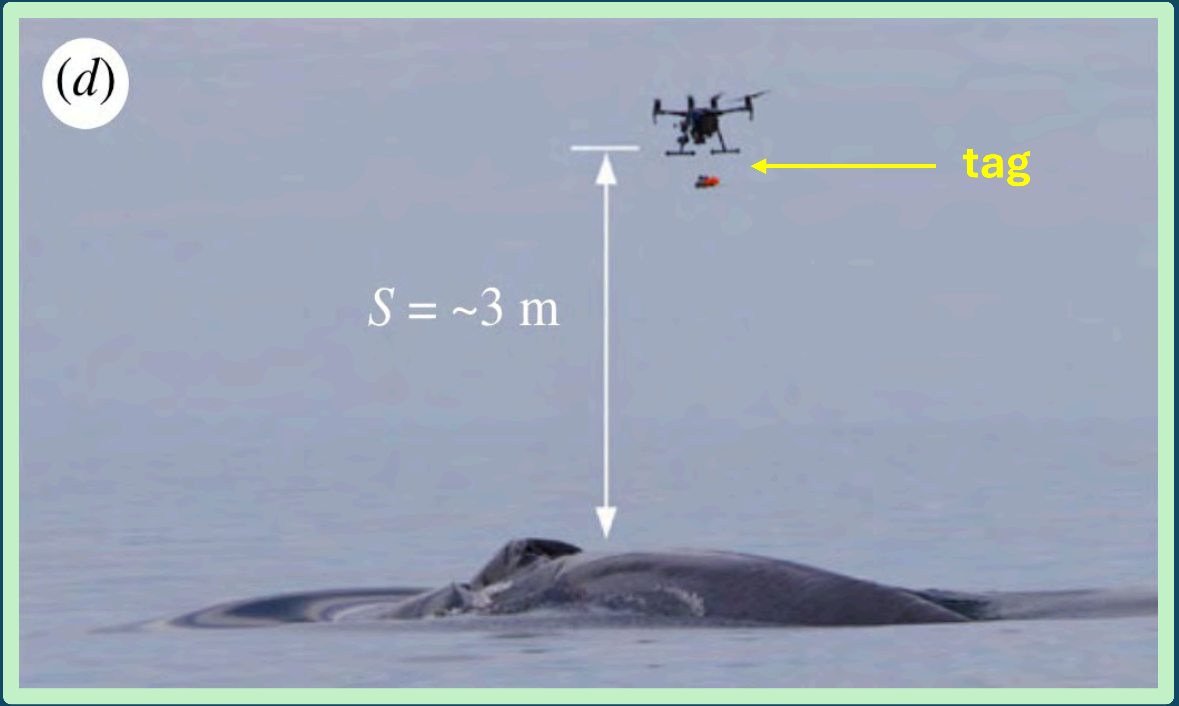


Orbach et al. (2019) – Phantom 4 – dusky dolphins

2b. Behavioral observations

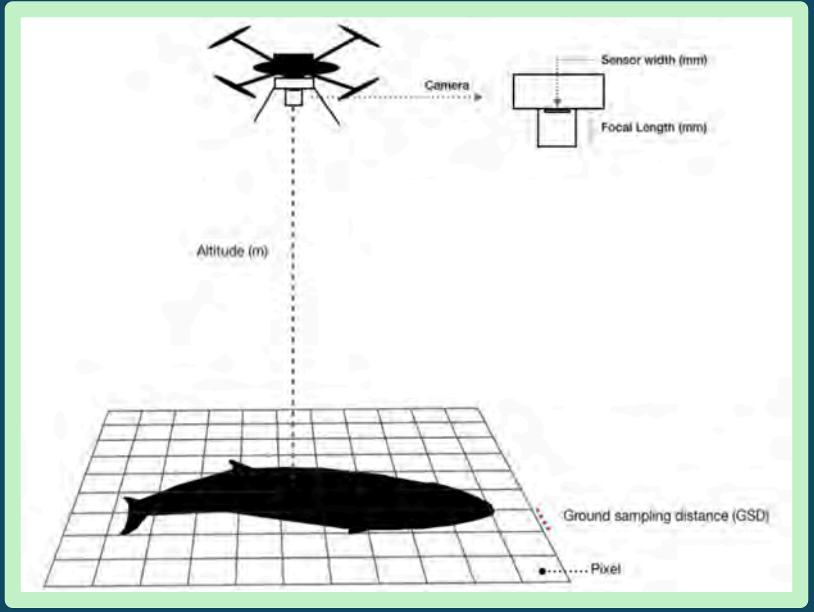
- Custom payloads to deploy biologging tags
- Equipped with sensors, cameras & satellite trackers
- Can collect data when animal dives
- Attach by suction cup

Wiley et al. (2023) – DJI Matrice 210 dropping tag on a blue whale

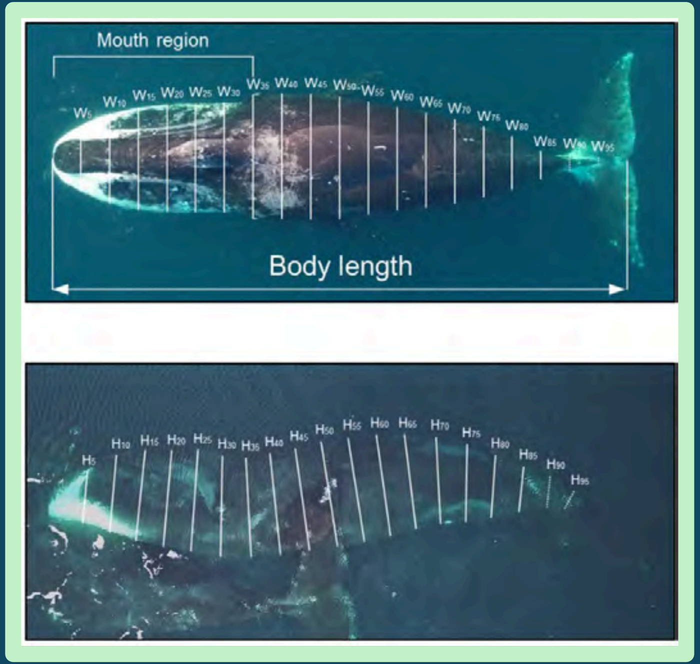


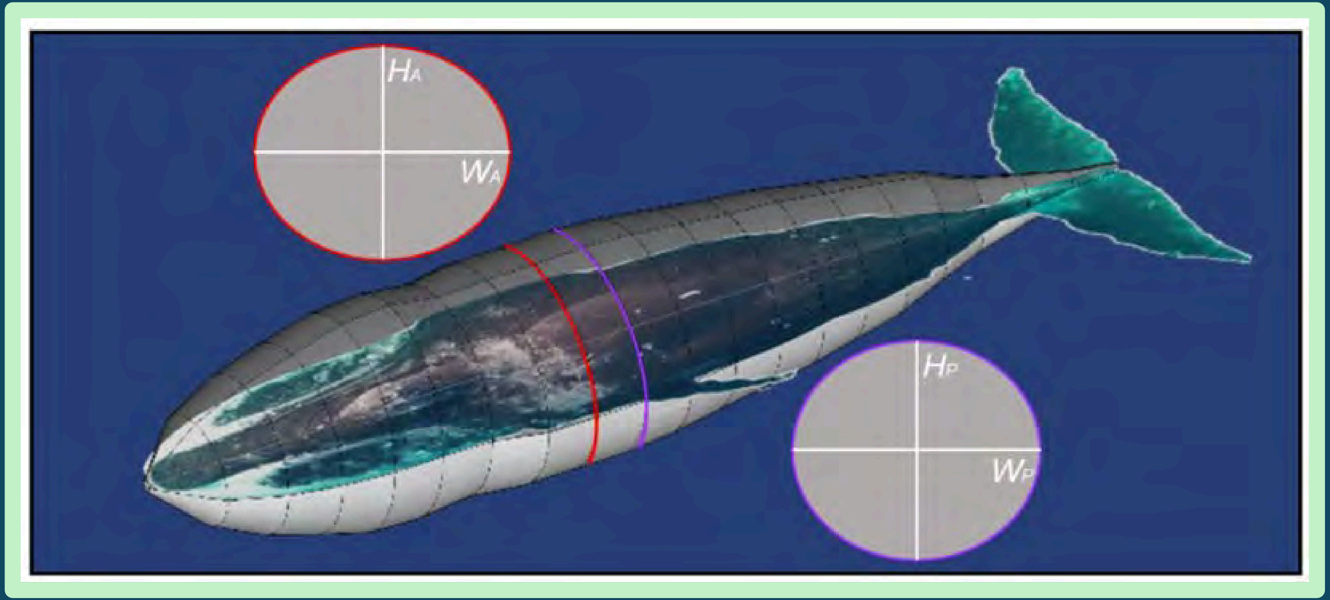
3. Photogrammetry

- Visible-spectrum (RGB) imagery + altimeter
- Quantify biometrics such as: body volumes, weights, growth rates, energetics



Torres & Bierlich (2020)

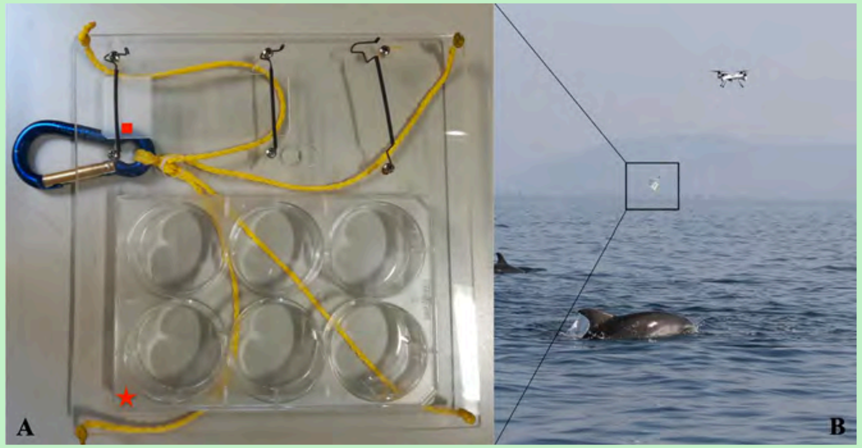




Christiansen et al. (2023) – DJI Inspire 2 – bowhead whales

4. Blow sampling

- Custom petri dish payloads
- Study respiratory health (microbiome, viruses, hormones)



Centelleghe et al. (2020) – SplashDrone with petri plate – bottlenose dolphins

Apprill et al. (2017) – APH-22 with petri plate – humpback whale


My drone research
North Atlantic right whales (*Eubalaena glacialis*)
Status: critically endangered
G. Lonati, UNB

My drone research
North Atlantic right whales
(*Eubalaena glacialis*)

- ~15 m (50 ft) long, ~65 tonnes
- Inhabit the eastern coast of US & Canada
- Loss of ~23% of population since 2010 (current size = **372 whales**)
- Leading threats to species: vessel collisions & fishing gear entanglements


G. Lonati, UNB

North Atlantic right whale #5120 in 2021

#5120 dead in 2024 from fishing rope

New York Times

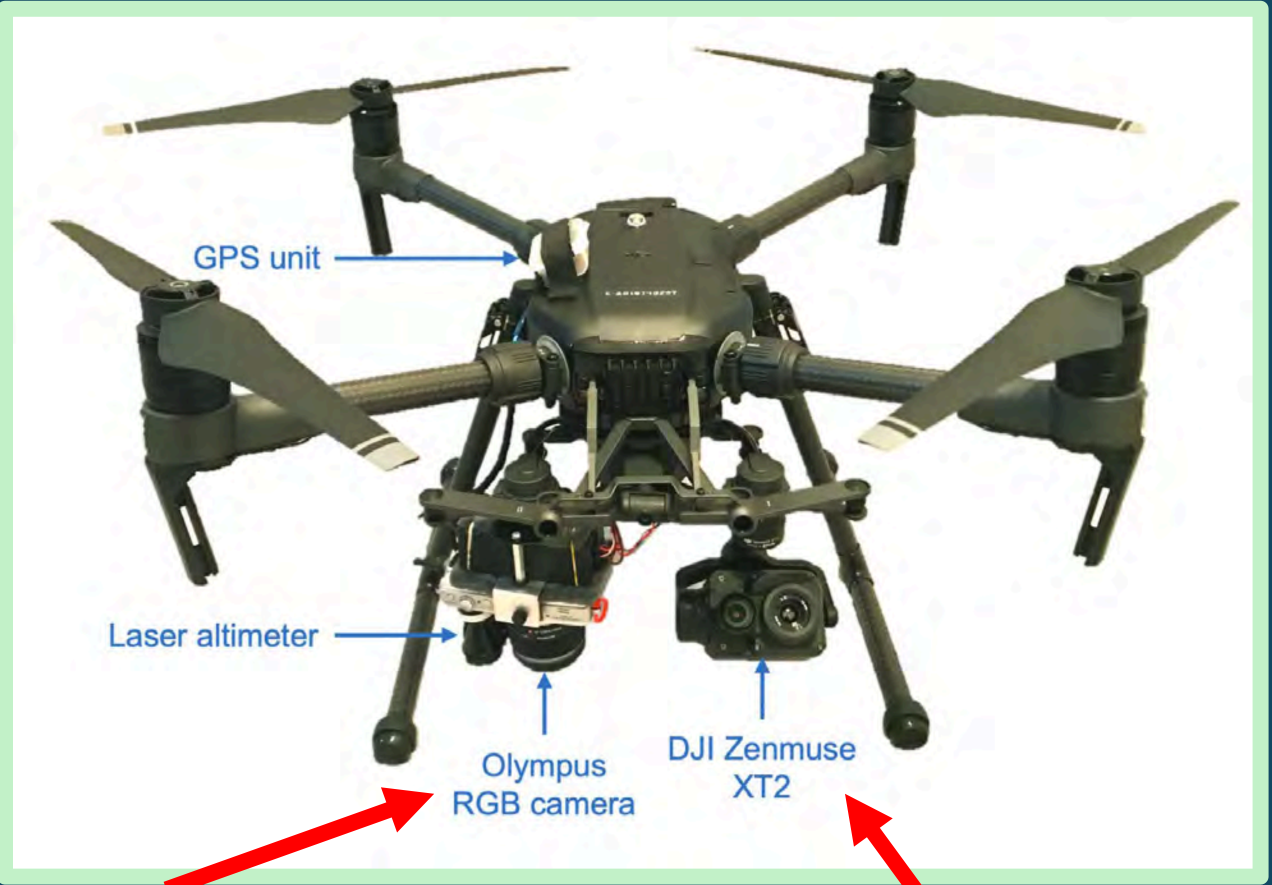
My drone research
North Atlantic right whales
(*Eubalaena glacialis*)

DJI Matrice 210 V2

<u>**Research objectives:**</u>

A. Photogrammetry to evaluate blubber fat stores (***body condition***)

B. Infrared thermography to quantify body temperatures



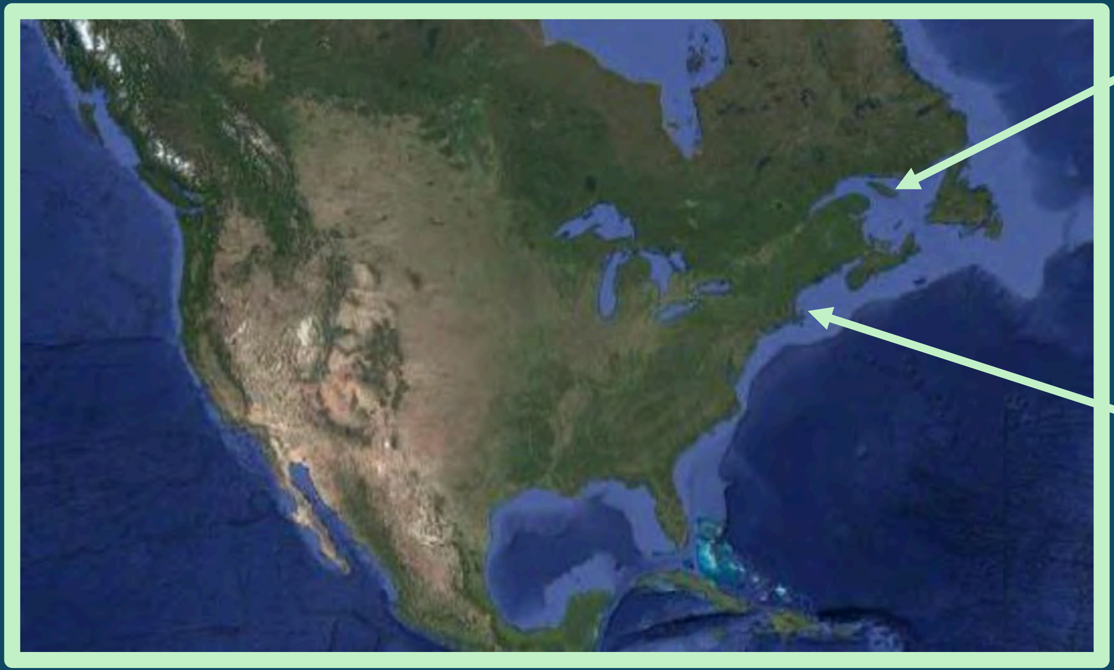
Conduct photogrammetry and infrared thermography simultaneously

Records raw sensor intensity metadata in TIFF sequence video

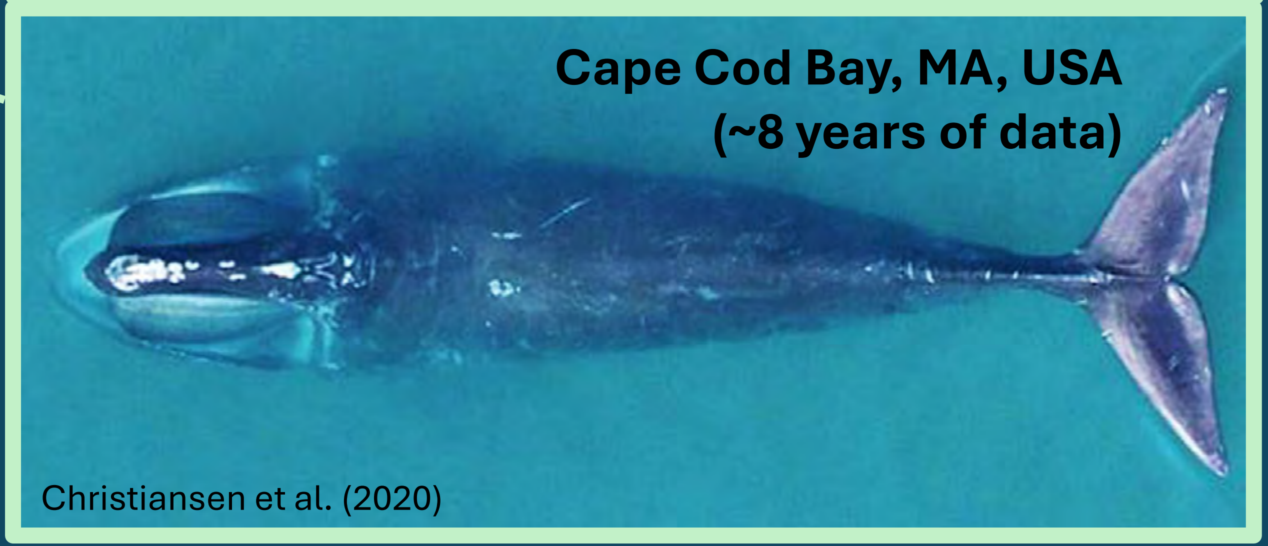
A. Body condition of North Atlantic right whales

Monitor body condition by measuring width:length ratios

Via UAV-based photogrammetry



G. Lonati, UNB



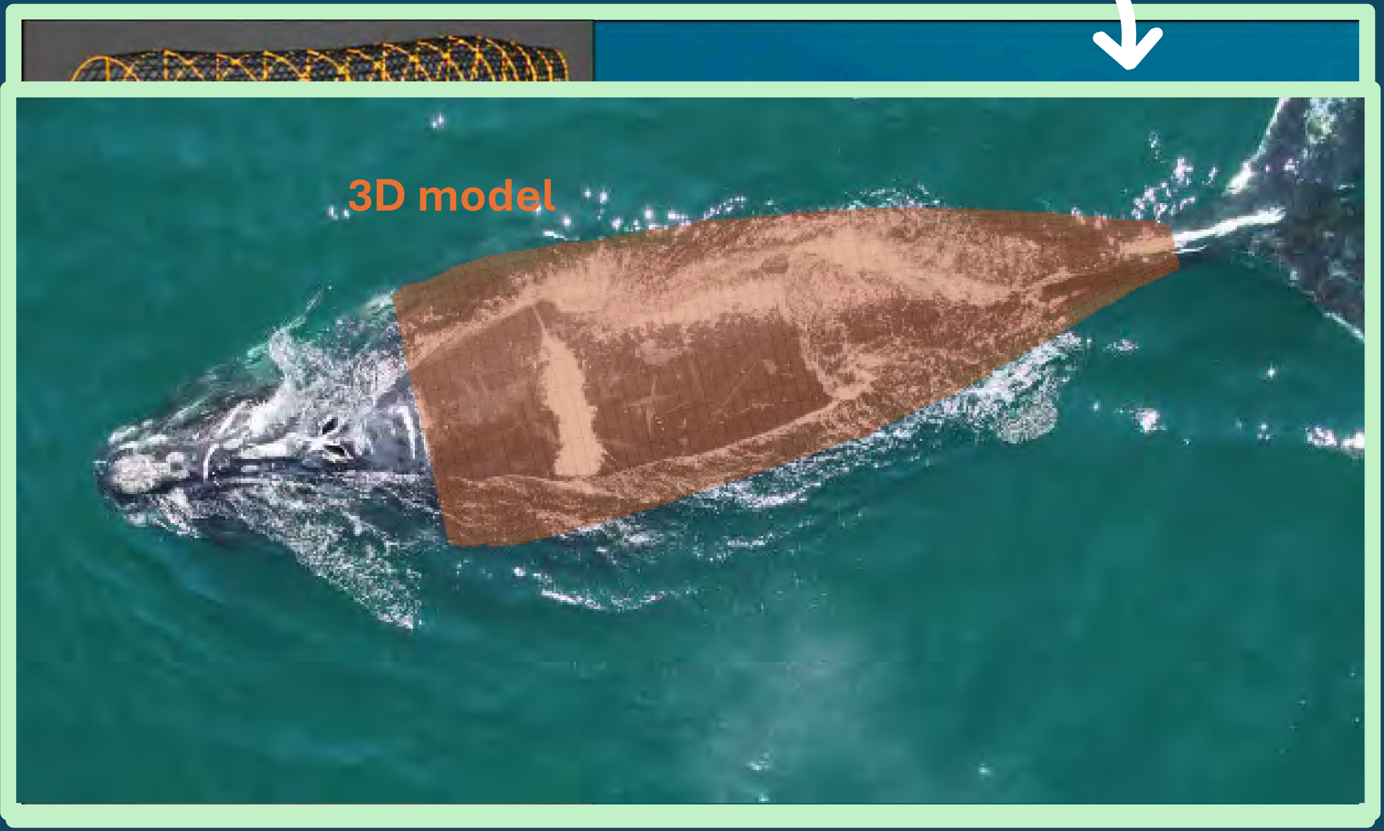
Christiansen et al. (2020)

A. Body condition of North Atlantic right whales

- 3D model of right whale in Blender software
- Scale model to "suboptimal" photographs of whales
- Goal: measure body condition of right whales in different habitats

suboptimal photos

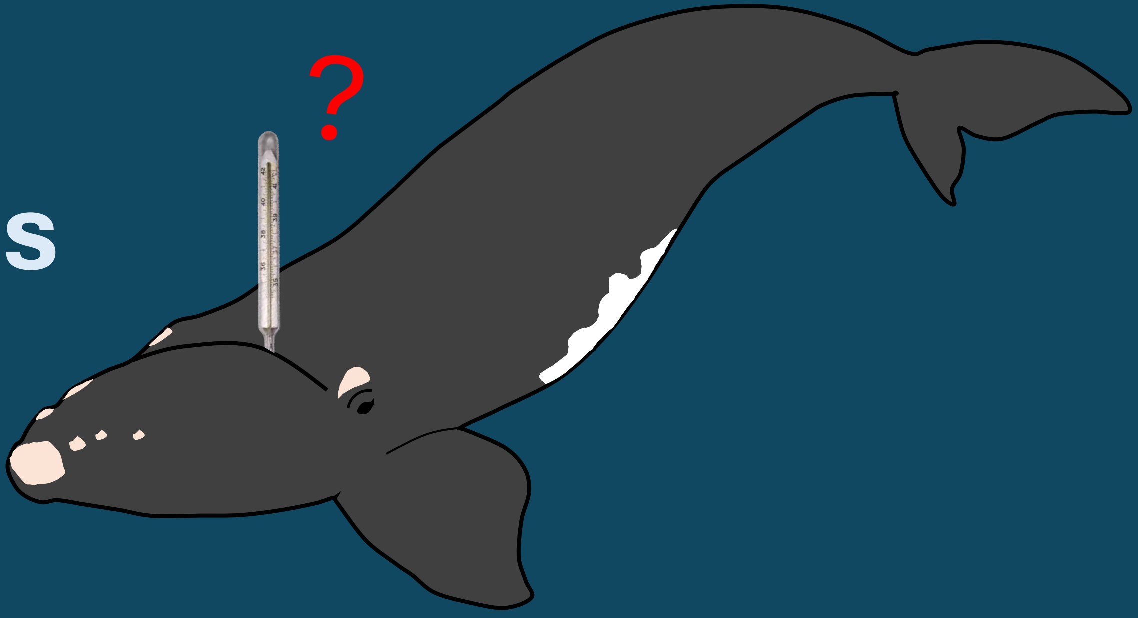
ideal photos



3D model

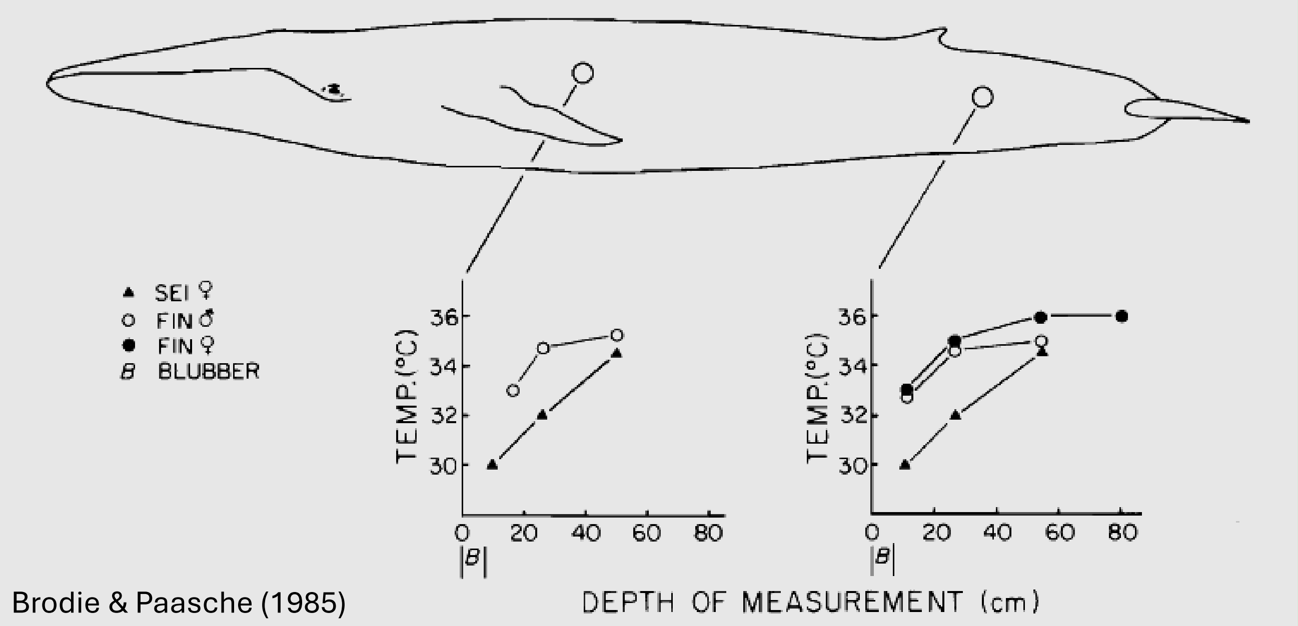
Lonati et al. *in prep*

B. Thermal physiology of North Atlantic right whales



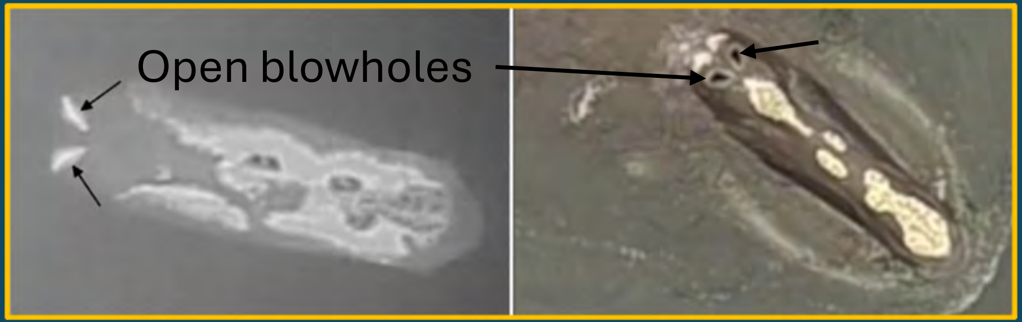
- Internal body temperature measurements of large whales are scarce
  - Post-mortem: **30-36°C**

- Goal: develop a repeatable, non-invasive method to measure body temperatures
  - Would provide insight into health & thermoregulation

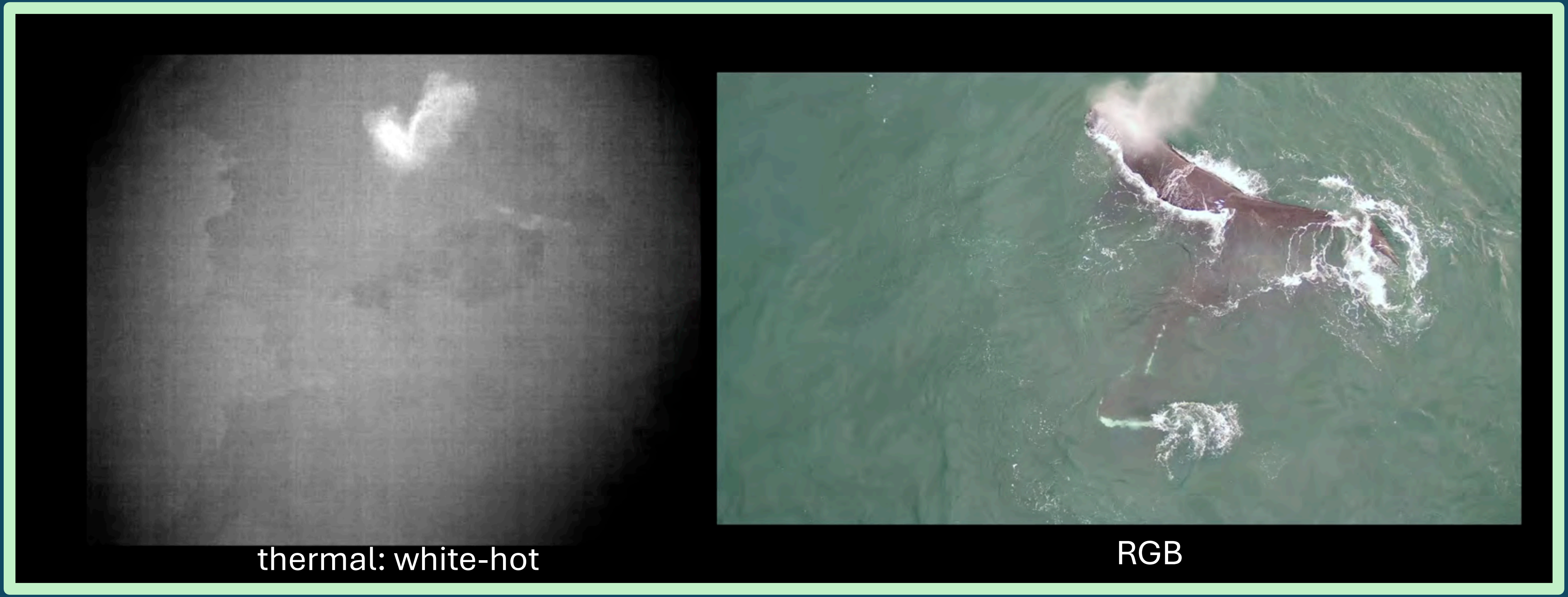


Brodie & Paasche (1985)

B. Thermal physiology of North Atlantic right whales

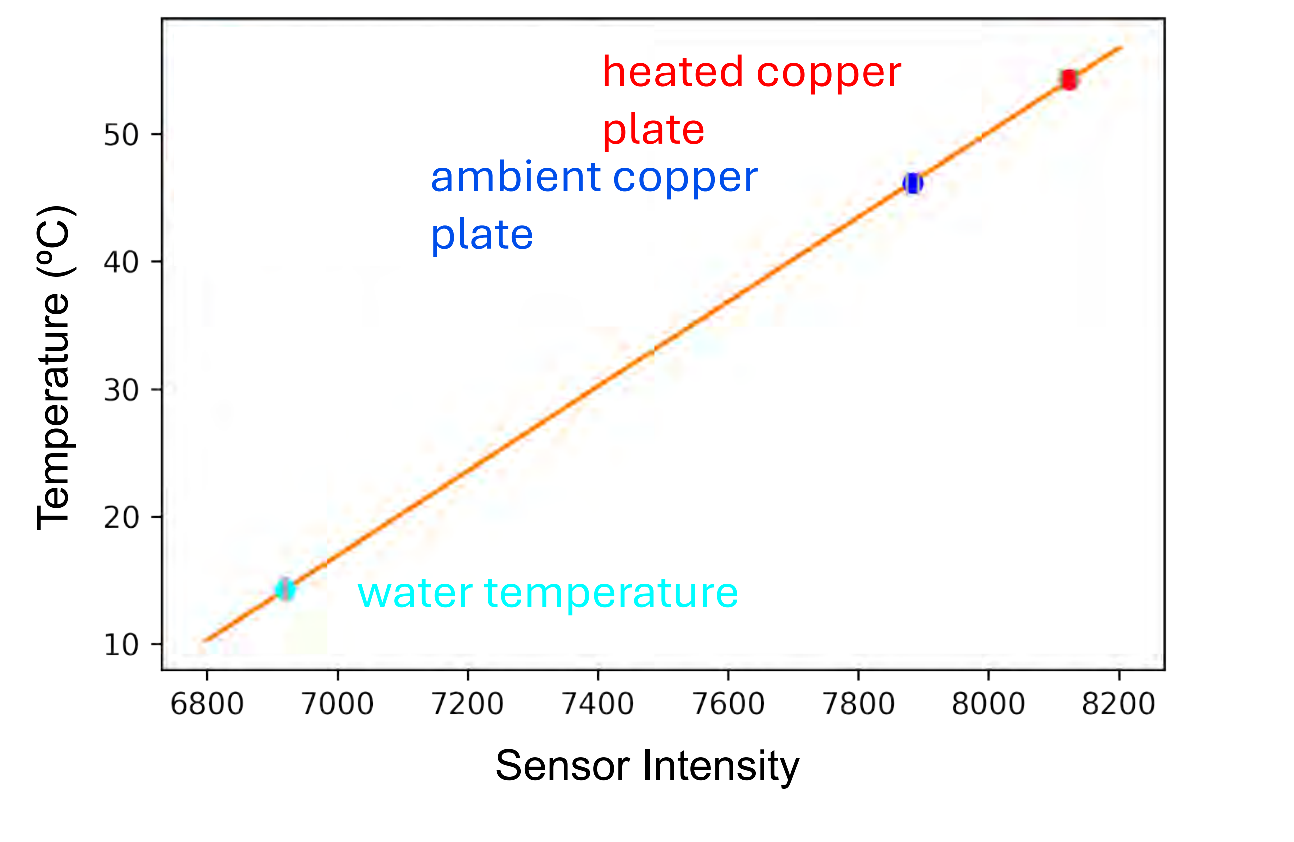


Investigating drone-based infrared thermography to study heat signatures of whales when they surface (Lonati et al. 2022, 2024)

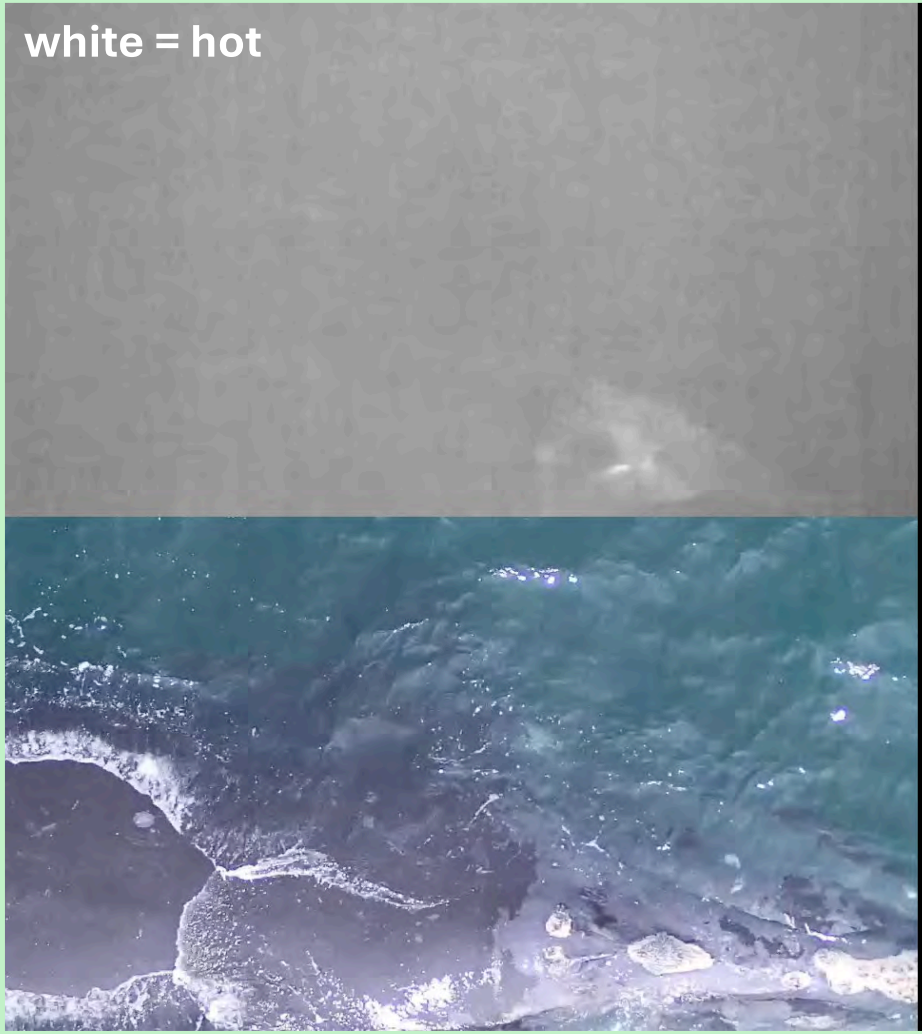


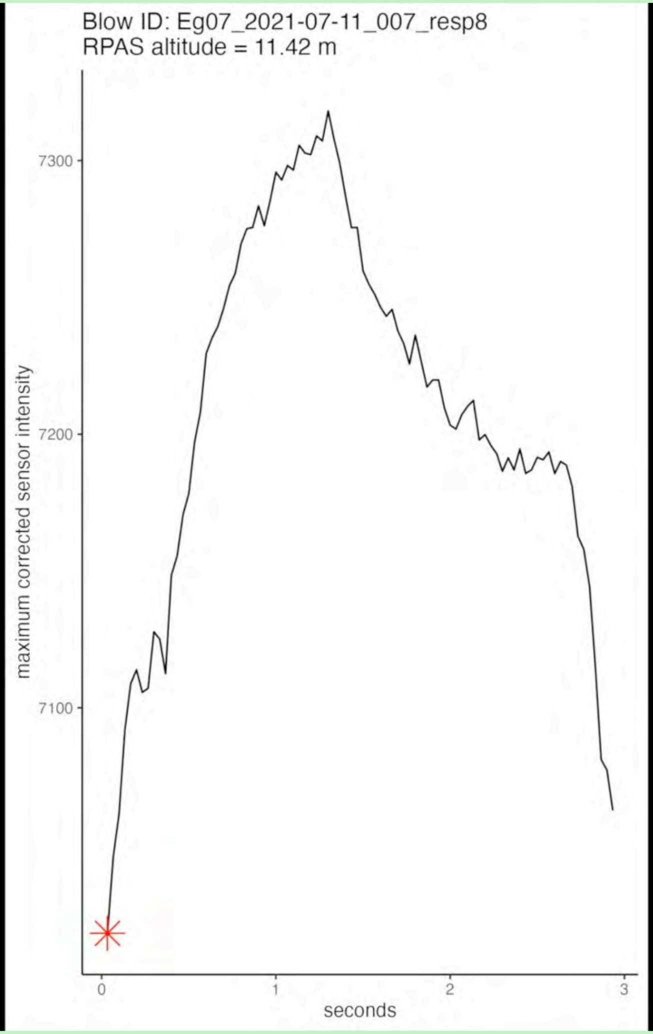
Generate flight-specific sensor intensity-to-known temperature linear calibration regression

Example:



B. Thermal physiology of North Atlantic right whales





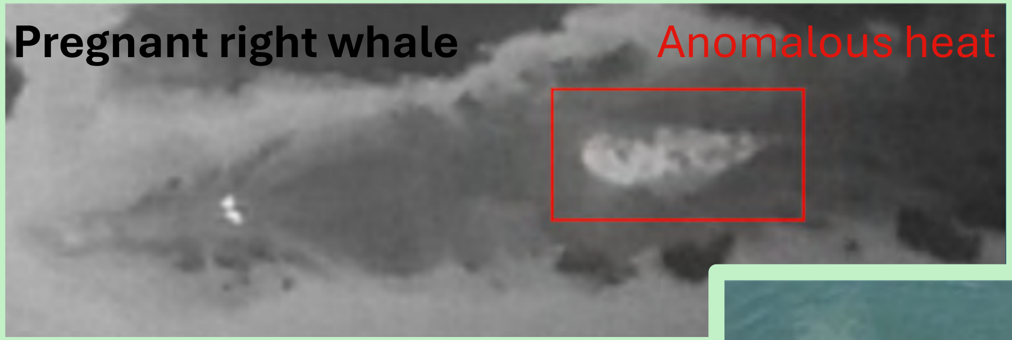
DJI Matrice 210 V2 with Zenmuse XT2

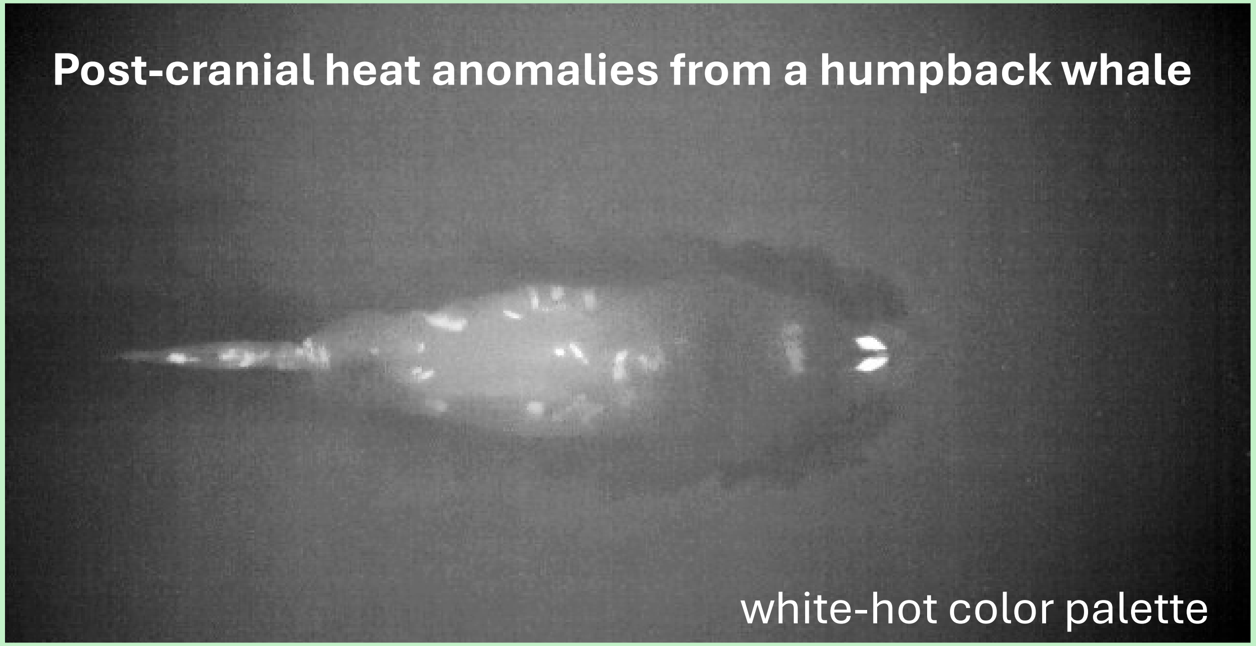
Average blowhole temperature = **26.9 ± 1.7°C** (n = 21 whales)

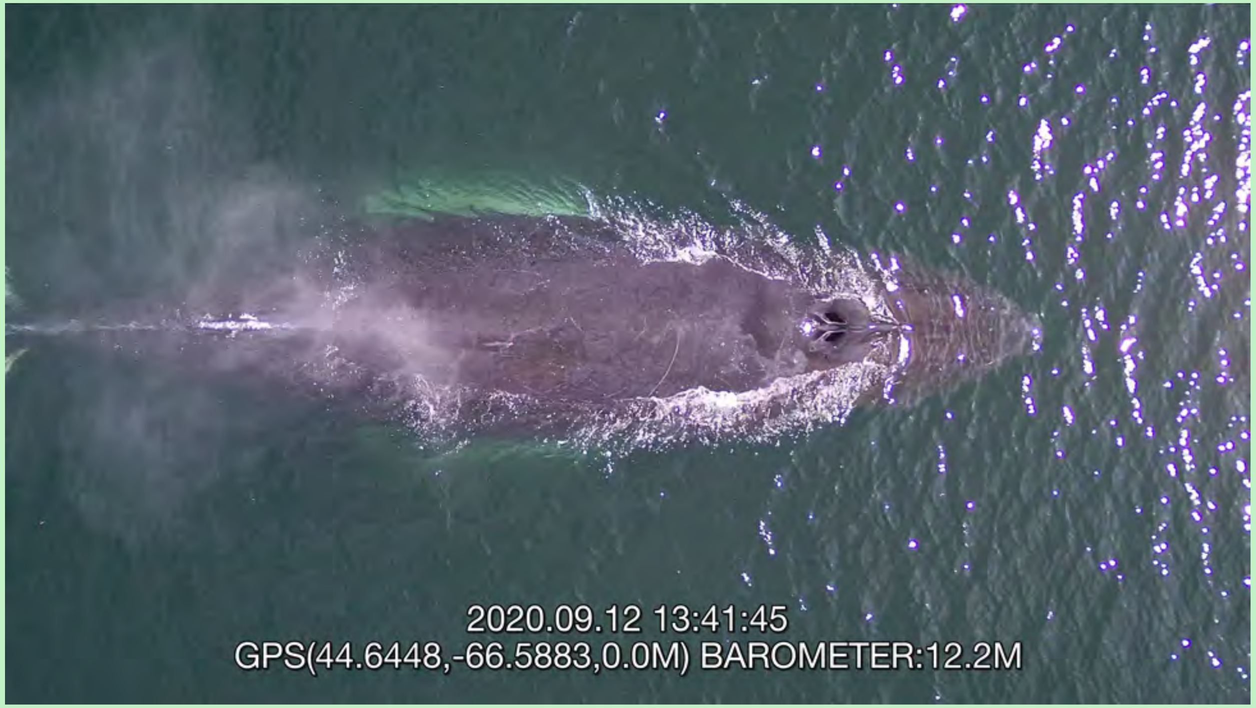
For more details, see Lonati et al. (2024) – *International Journal of Remote Sensing*

My future research objectives

- Investigate post-cranial heat signatures of whales
  - Heart rates (Horton et al. 2019)
  - Pregnancy (Lonati et al. 2022)
  - Injuries (inflammation)







The power of UAV imagery for conservation

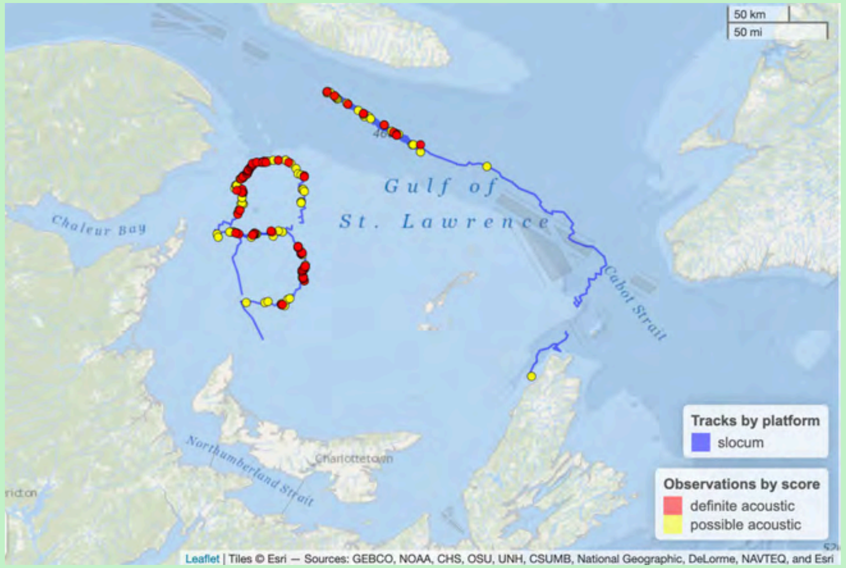
- Work with filmmakers & media outlets to share plight of right whales

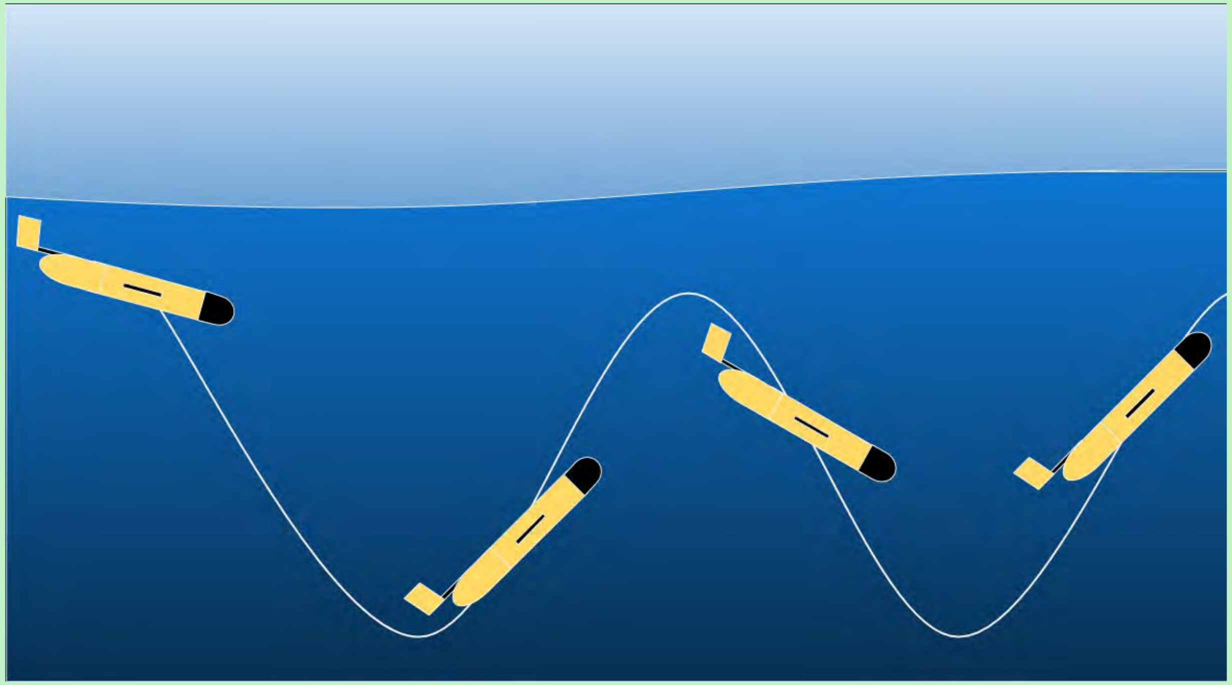
Available on Amazon Prime & Apple TV+

North Atlantic right whale entangled in fishing gear (G. Lonati, UNB)

Other marine drones for studying cetaceans

- Autonomous ocean gliders
  - Equipped with various sensors to sample oceanographic features and listen for whale calls





Ruckdeschel et al. (2020);
Durette-Morin (2021); Mossman (2022); Hynes (2024)

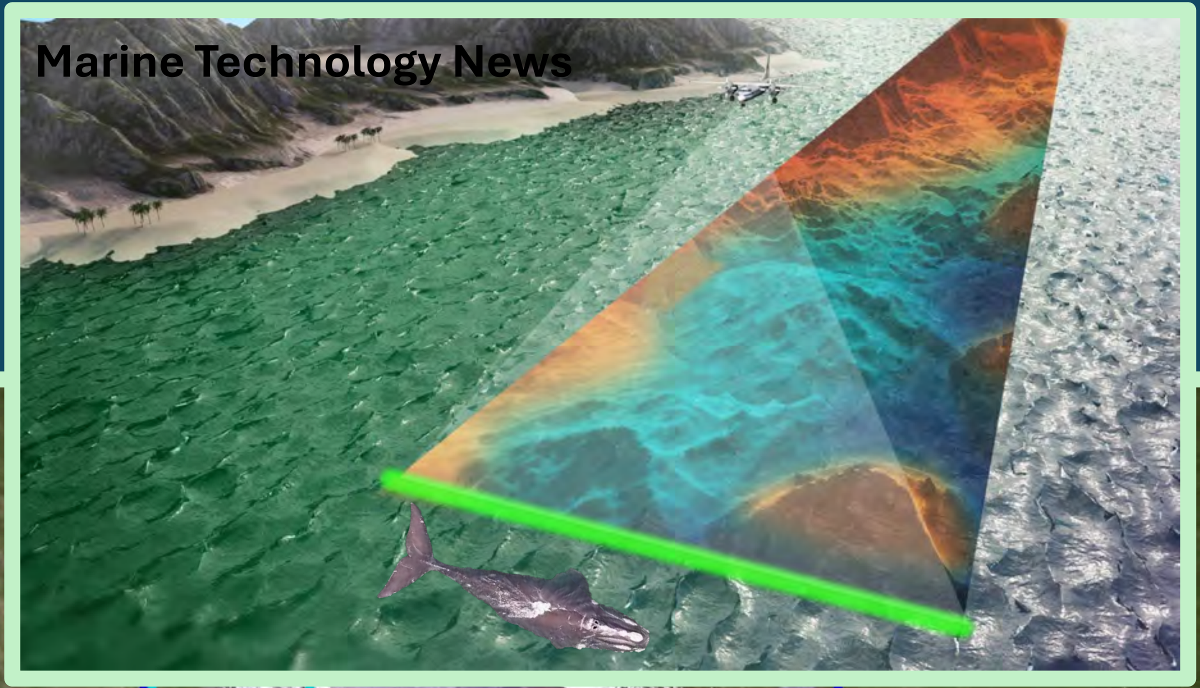

Humpback whale and research vessel –
G. Lonati, UNB

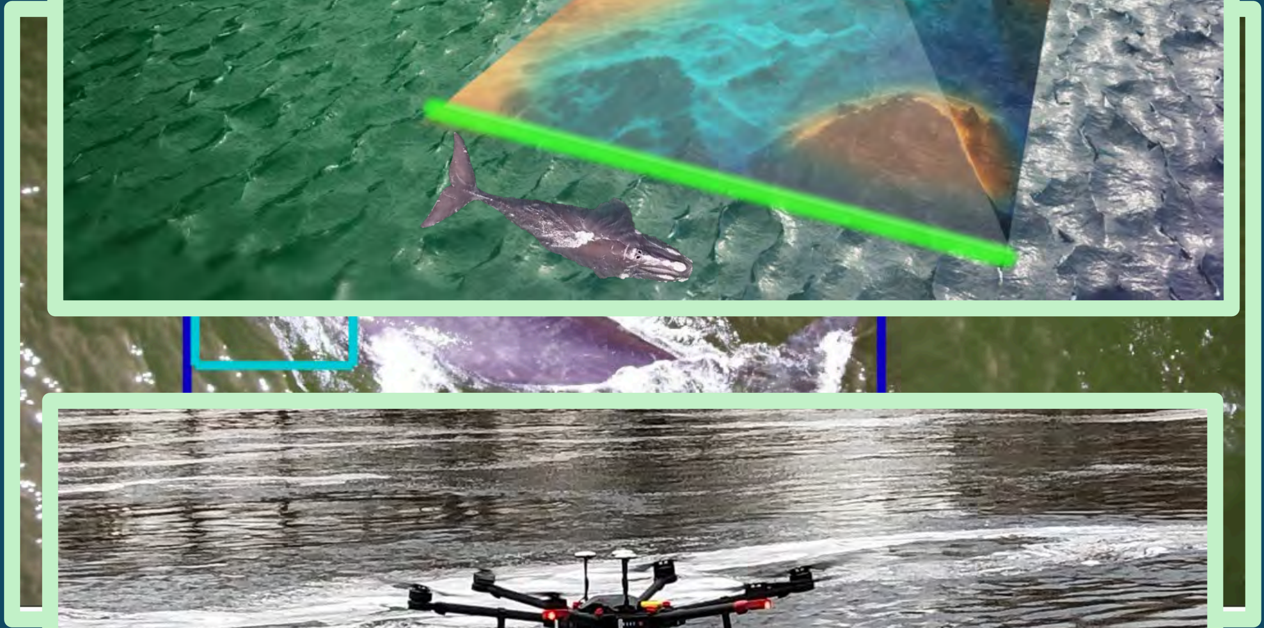
Where can drones take cetacean research next?

Potential areas for R&D

- Other payloads:
  - LiDAR to 3D map a whale?
  - Ground penetrating radar to conduct whale ultrasounds?
  - Disentanglement tools (safer for humans)

- Tracking whales with UAVs in real-time using on-board AI detection algorithms
  - Easier tagging and blow sampling





Contributors

- **University of New Brunswick & the Davies Lab**
- **Transport Canada**
- **Carleton University**
- **Woods Hole Oceanographic Institution**
- **Dalhousie University**
- **New England Aquarium**
- **Canadian Whale Institute**
- **Aerial Imaging Solutions**
- **F/V *J.D. Martin* & F/V *Barker Boys***

Other drone research collaborators

- **Oregon State University**
- **Stony Brook University**
- **National Oceanic & Atmospheric Administration**
- **University of Hawaii at Manoa**
- **Center for Coastal Studies**
- **Duke University**
- **Fisheries & Oceans Canada**
- **Aarhus University**

All drone- and boat-based research conducted under permits from the US and Canadian governments

Looking for ideas/feedback:

THANK YOU!!

- Alternatives to hand-launching/catching (gimballed table that can also account for swell?)
- Other infrared sensors that can capture videos and preserve raw sensor intensity metadata
- Drone platforms that can conduct simultaneous infrared thermography & photogrammetry
- Efficient ways to time-align separate data streams (laser altimeter, RGB, IRT data)
- Ways to extend drone battery lives to increase time observing animals
- Ways to safely operate drones in worse weather conditions (wind, swell)
- Blue UAS Cleared List solutions

Feel free to photograph this slide!

Keep in mind:* ***cetacean biologists have limited budgets!**

Gina Lonati, PhD
University of New Brunswick
Saint John
gina.lonati@unb.ca

@EubalaenaGina

Cetacean responses to UAVs

- Individualized
- Depends on species, altitude, UAV model
  - Smaller species (dolphins) more sensitive
- Hard to attribute to drone, versus conspecifics, versus boat
- Personal observations of right whales (typically during fast descents/ascents <20 m):
  - Aborting respirations
  - Accelerated swimming
  - Sudden turns
  - Tail slashes
  - Rolling

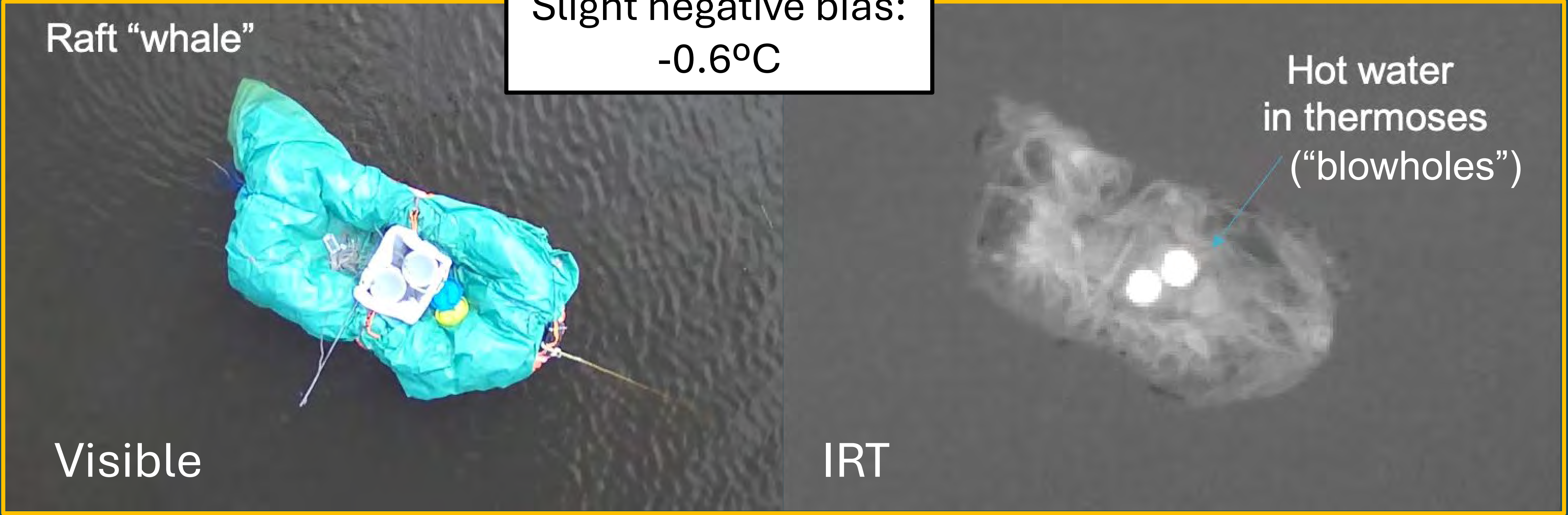
Lonati et al. (2024) – *International Journal of Remote Sensing*

Thermal physiology

CALIBRATION

"Whale simulation" experiment

Slight negative bias: -0.6ºC



Lonati et al. (2024) – *International Journal of Remote Sensing*

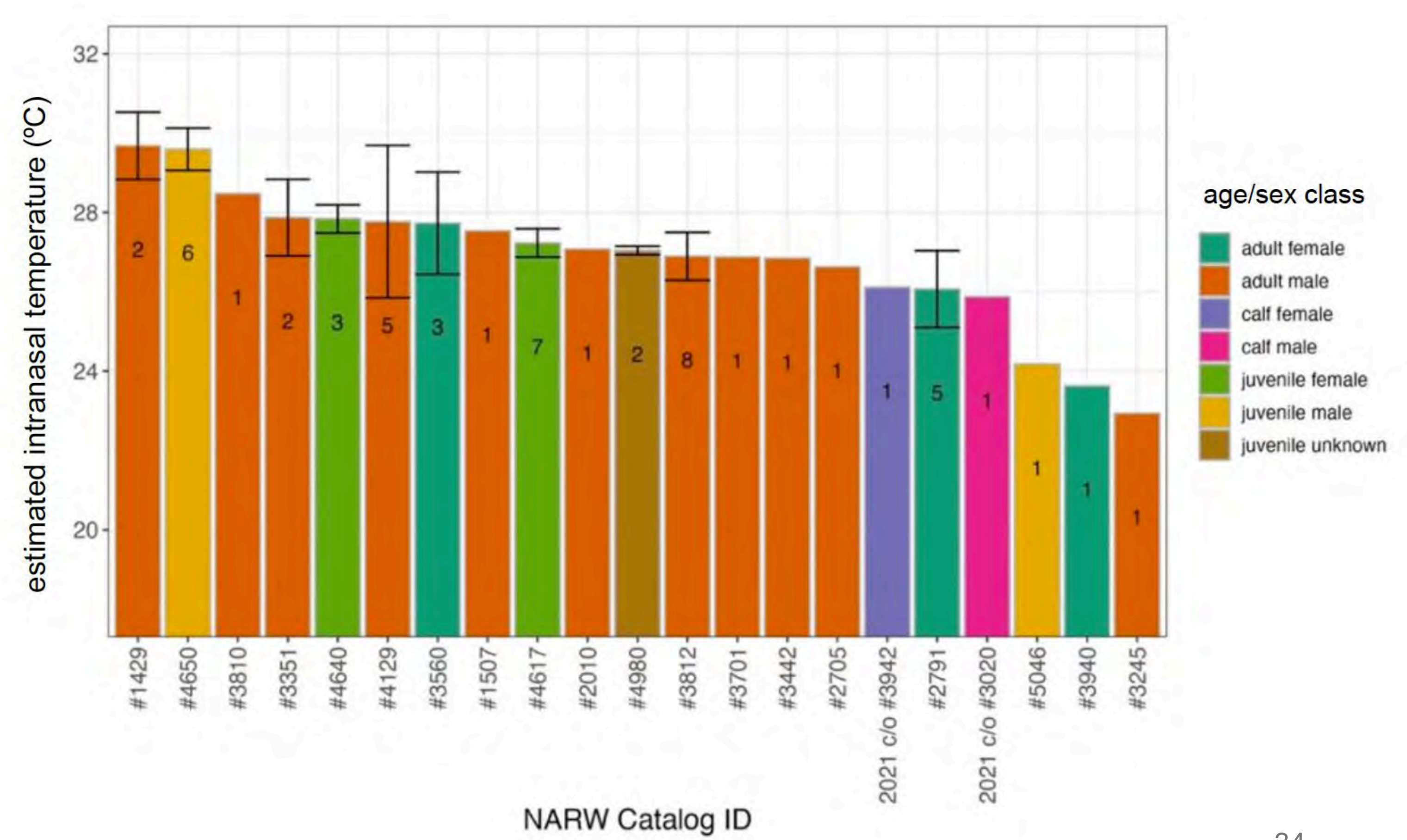
Thermal physiology

- Selected results:
  - Average intranasal temperature =

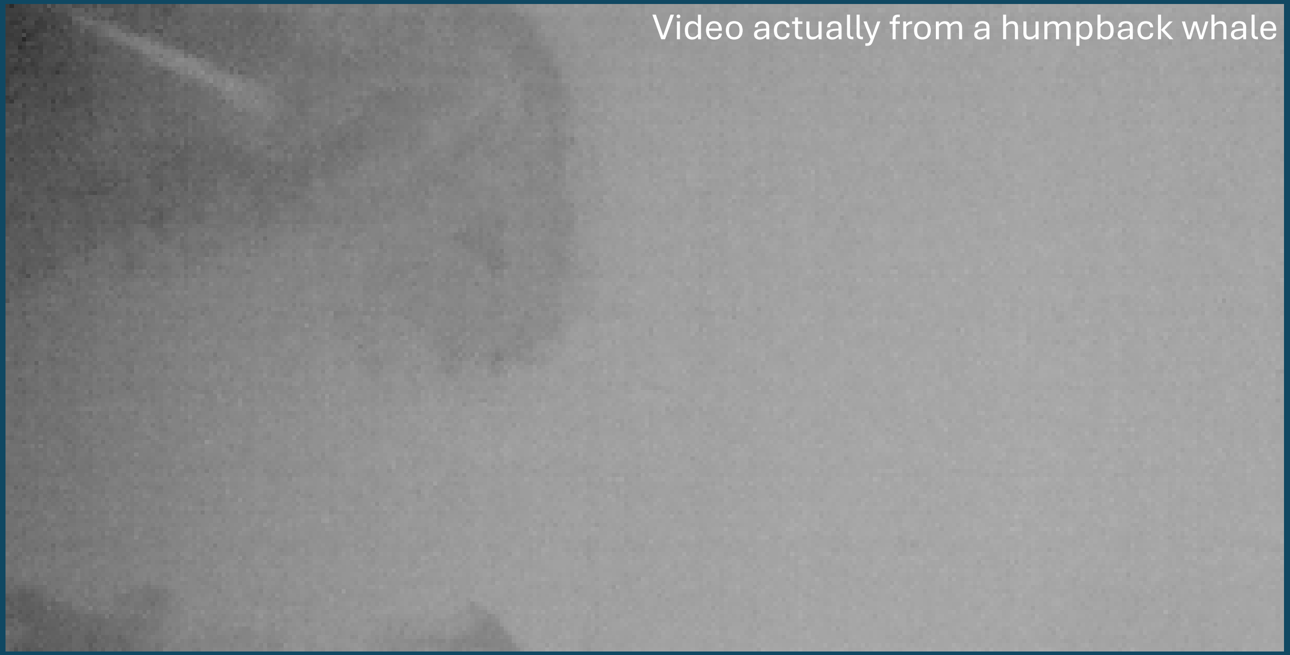
    26.9 ± 1.7ºC

    (n = 54 respirations from 21 whales)

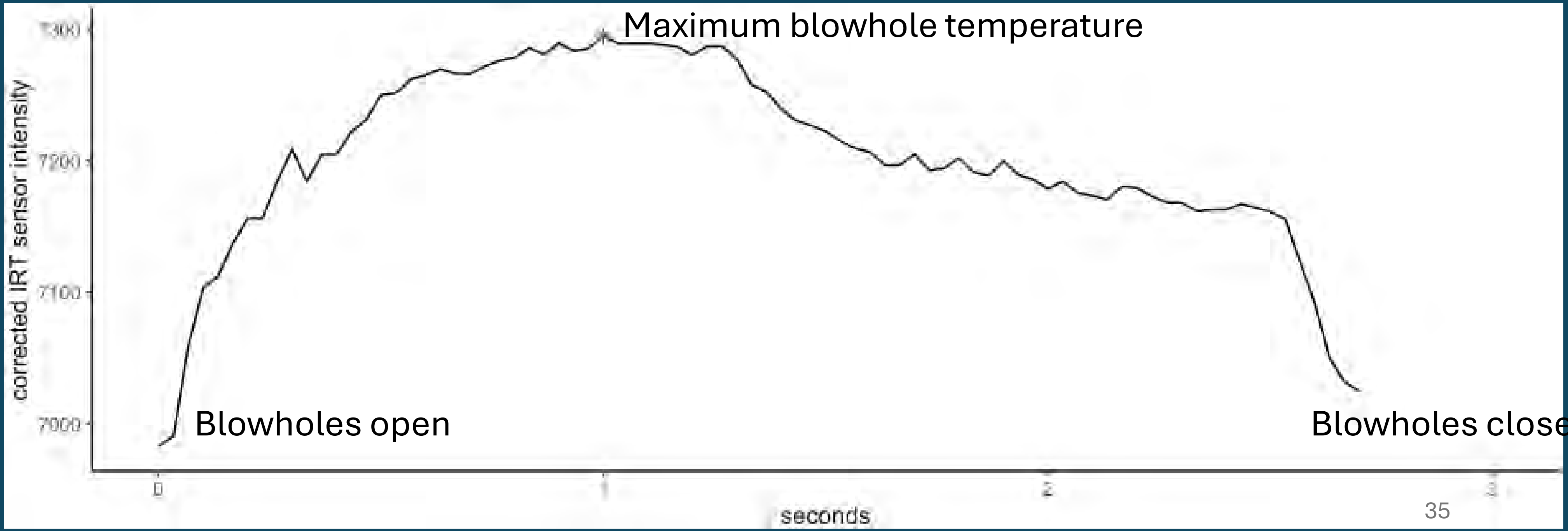
- First intranasal temperatures of free-swimming whales
- Colder than expected
- Low intra-whale, but high inter-whale variability (up to 7ºC)



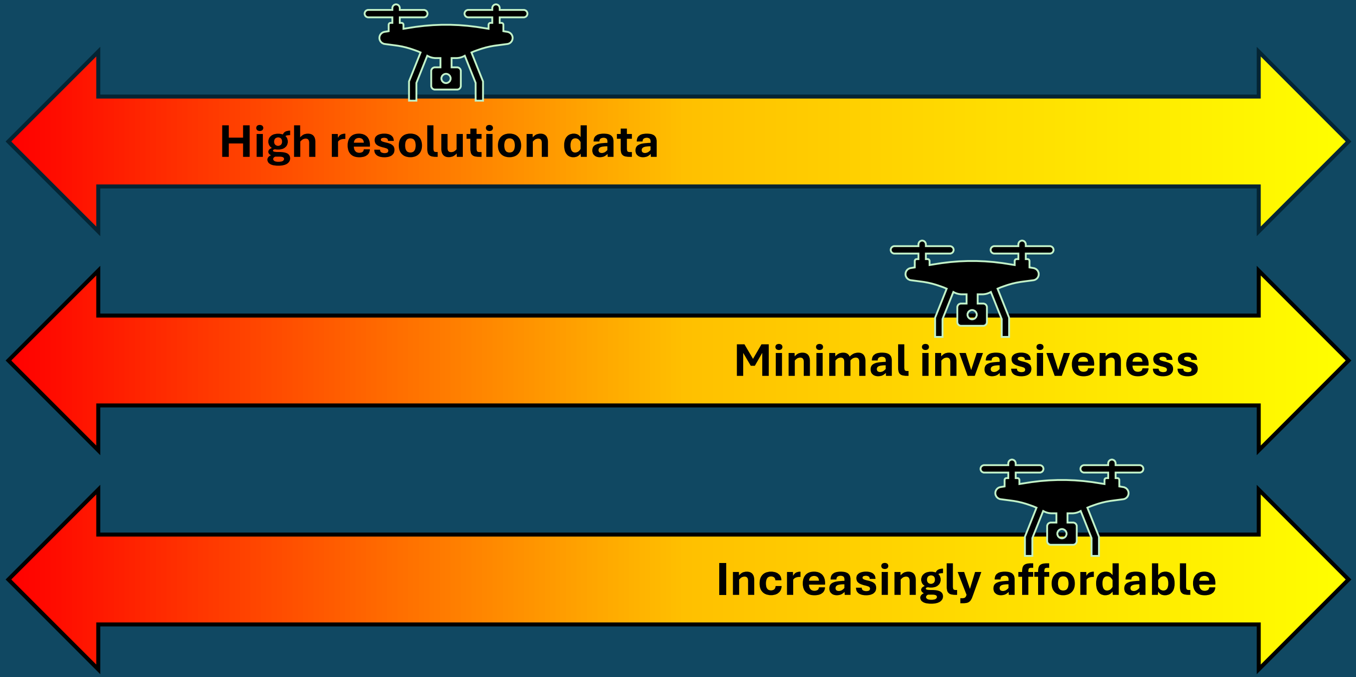
Thermal physiology



Characteristic blowhole temperature over time:

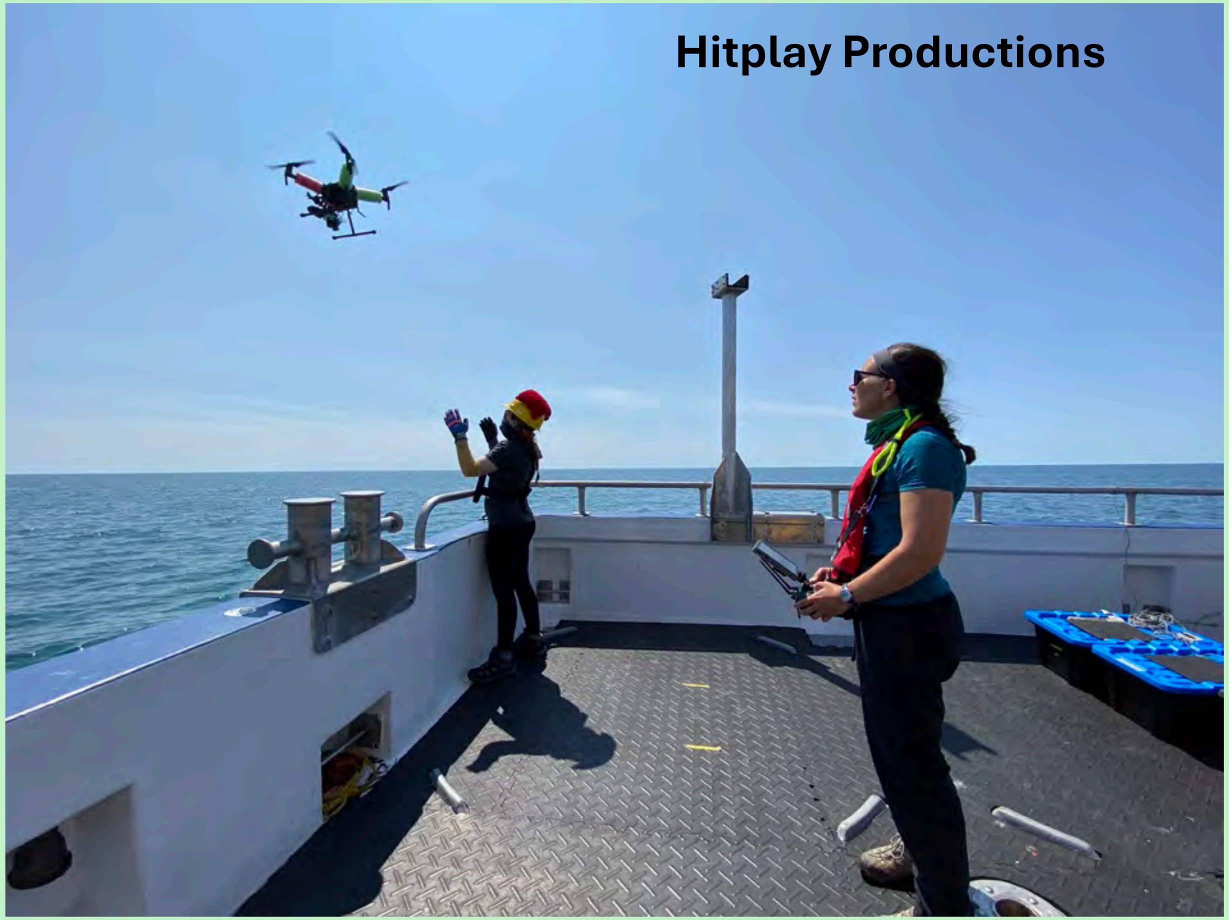


UAV research on cetaceans is "taking off"



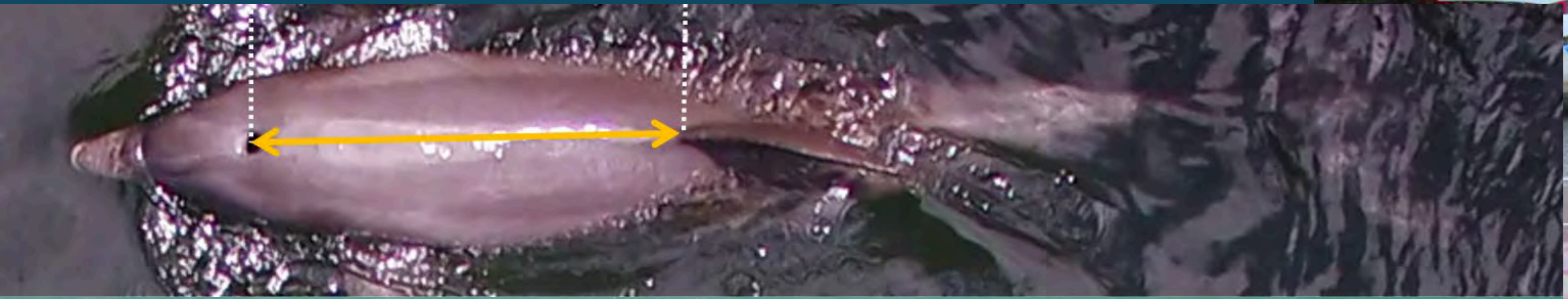
Allowing more research groups to access cetaceans and conduct new, insightful studies!


Hitplay Productions


Hitplay Productions


G. Lonati, UNB

G. Lonati, UNB



Viver et al. (2023) – bottlenose dolphins

Domínguez-Sánchez et al. (2018) – blue whales

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Spectral-Based Classification of Invasive Wildlife Using Uncrewed Aerial Systems and Hyperspectral Imagery

Daniel McCraine[1], Sathishkumar Samiappan[1], Leon Kohler[2], Timo Sullivan[3], & David Will[3]

[1]Geosystems Research Institute, Mississippi State University, MS, USA; cdm366@msstate.edu
[2]Department of Mechanical Engineering, Mississippi State University, MS, USA
[3]Island Conservation, Santa Cruz, CA, USA

Summary: Invasive mammals are a serious threat to island ecosystems and managing them is vital for indigenous flora and fauna to flourish. Current detection methods and population counts using true color (i.e., red-green-blue [RGB]) and thermal infrared (IR) imagery have limitations and typically require spatial-based features for classification. This study explores using hyperspectral imaging (HSI) from a small uncrewed aerial system for mammal classification via maximum likelihood and machine learning classification models. HSI captures reflectance across many spectral bands, providing richer data than traditional imagery. These spectral signatures can potentially identify animals independent of shape, overcoming limitations of traditional methods. This presentation will show how HSI can distinguish between mammals using spectral data only, even with single-pixel detections. HSI inherently has a high degree of correlation between the bands which leads to redundant information. Dimensionality reduction techniques are used to make the data more manageable and resolve the redundant information while preserving important features. The reduction techniques identified key spectral bands for potential sensor development, and simulated multispectral data showed promise for using commercially available sensors. Some of the challenges include high intra- and inter-species spectral signature variability, seasonal changes in pelages, and issues classifying shaded or shadowed animals. Future research should focus on building a comprehensive spectral library, exploring multispectral sensors for classification, and cost-benefit analyses with traditional methods. Overall, spectral-based detection methods hold promise for improving invasive species management and conservation efforts on islands.

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Spectral-Based Classification of Invasive Wildlife Using Uncrewed Aerial Systems and Hyperspectral Imagery

Daniel McCraine
GRI Research Engineer

Sathishkumar Samiappan, Leon Kohler, Timo Sullivan, and David Will

Acknowledgements

This research was funded by the Seaver Institute

Outline

- Motivation
- Hyperspectral Imagery Background
- Methodology
  - Data Collections
  - Processing
  - Dimensionality Reduction
  - Classification Models
- Results
- Discussion

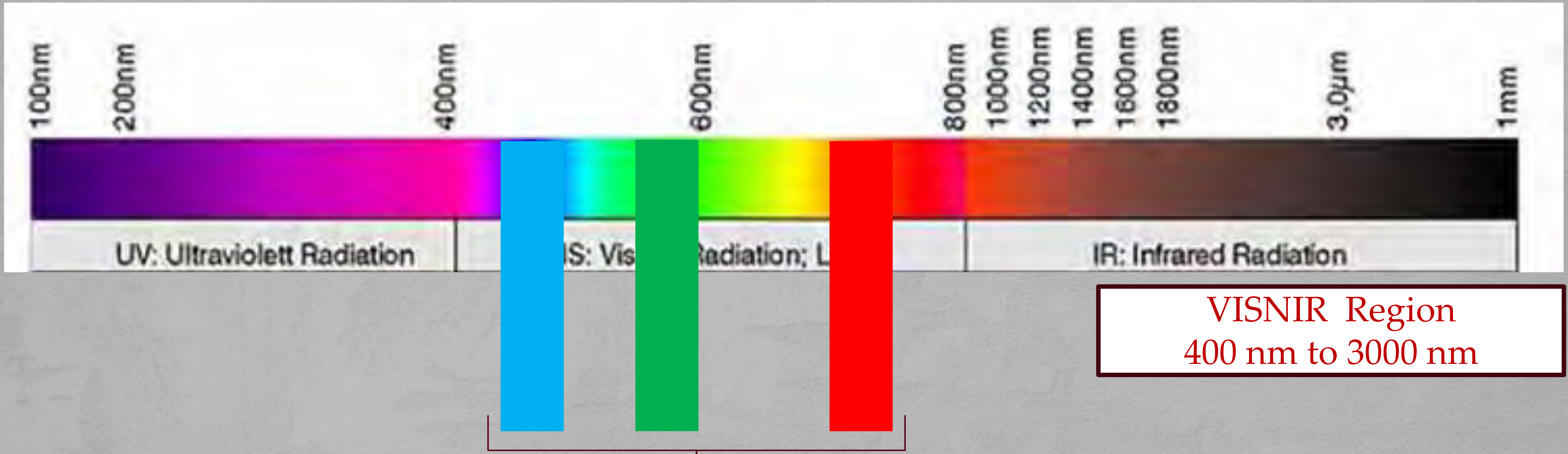
Motivation

- Invasive species have negative effects on island ecosystems
- Current detection and counting methods are challenging and typically involve significant manual intervention
- Canopy cover restricts the efficacy of most passive sensors

Motivation

Possible to detect and classify target animals based on low sample size hyperspectral imagery?

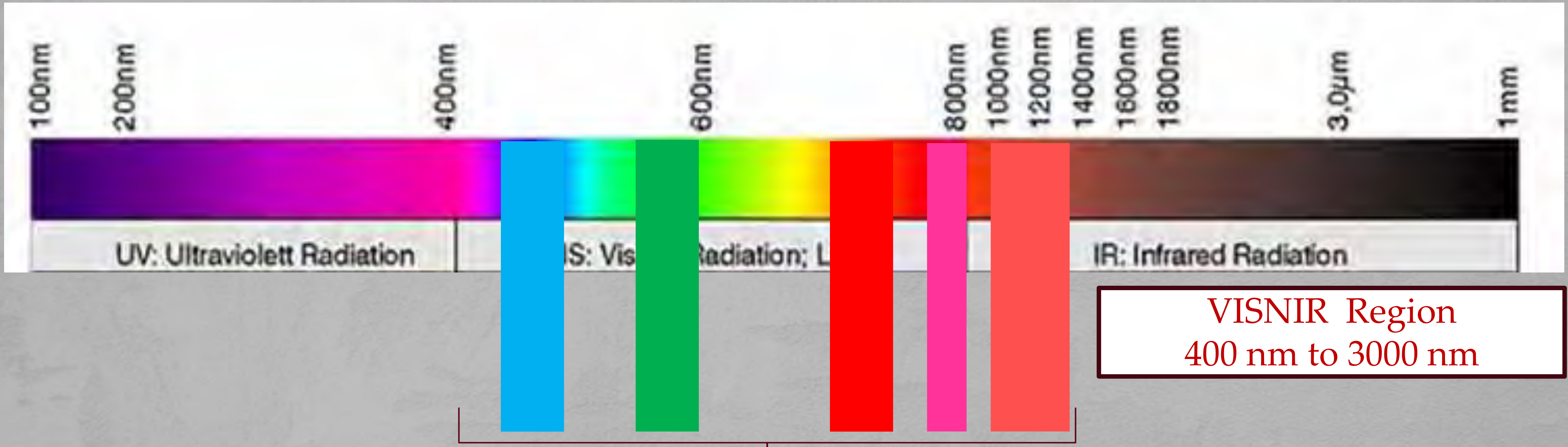
Background



VISNIR Region
400 nm to 3000 nm

Visible Imagery – Blue, Green and Red

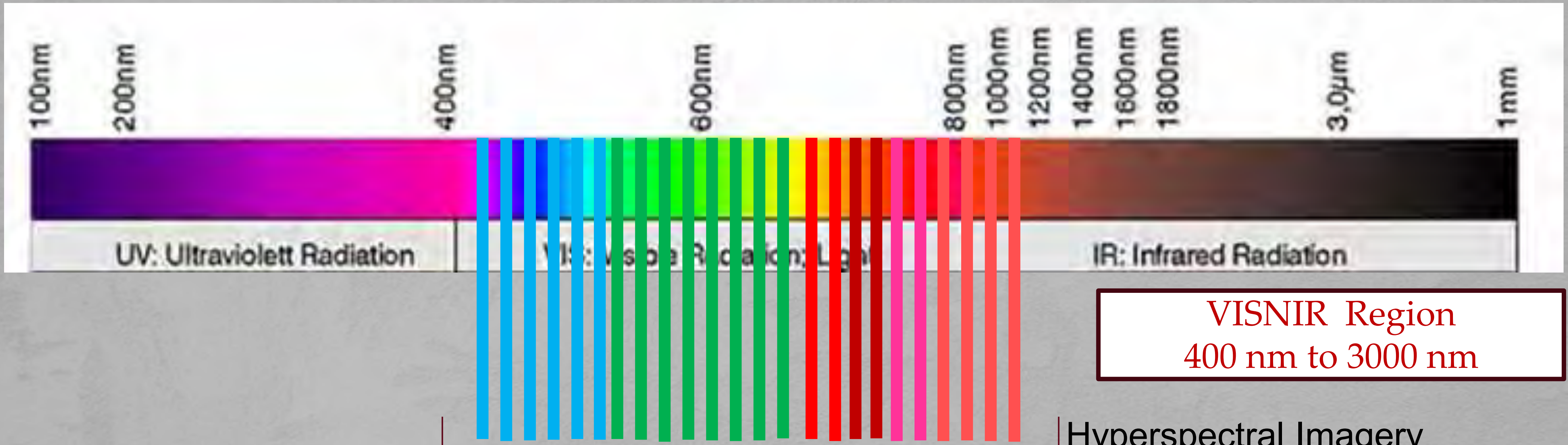
Background



VISNIR Region
400 nm to 3000 nm

Multispectral Imagery 5 – 10 broad bands

Background



VISNIR Region
400 nm to 3000 nm

Hyperspectral Imagery
10s to 100s of narrow bands

Methodology
Data Collections – What & How

- DJI Matrice 600 Pro
- Headwall Photonics Nano Hyperspec VNIR (4.8mm Lens)
  - 270 bands (400nm – 1000nm)
- 100′ Altitude resulting in ~5cm GSD
- 5m/s flight speed
- Group 8 calibrated reflectance tarp

Methodology

Data Collections – Who & Where

- Starkville Mississippi
  - H. H. Leveck Research Park
    - Cows (*Bos taurus*)
    - Horses (*Equus caballus*)
  - M.S.U. Deer Lab
    - White-tailed Deer (*Odocoileus virginianus*)
  - Magowah Ranch
    - Goats (*Capra hircus*)

Methodology

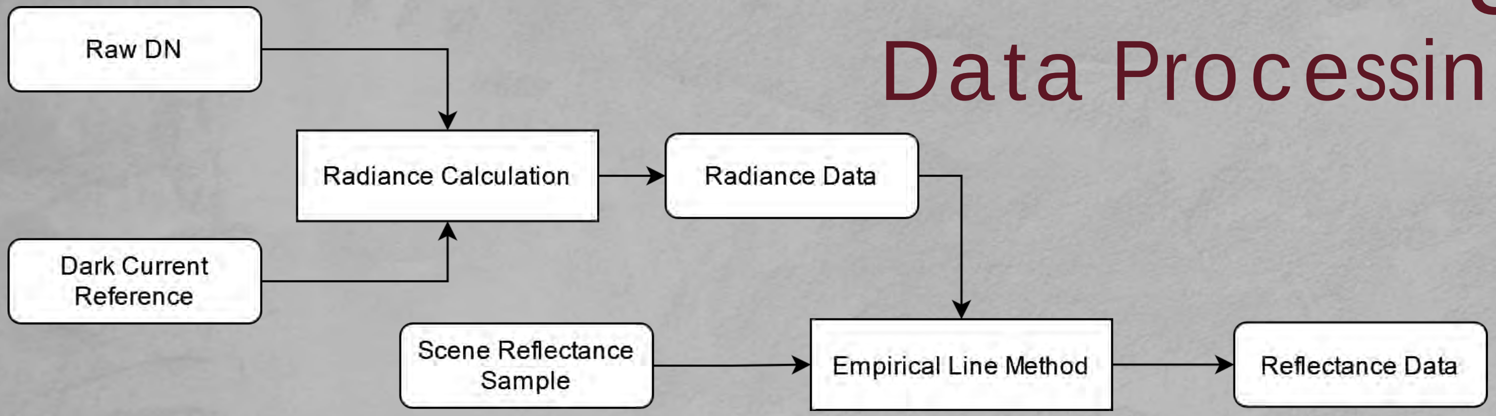
Sample Data

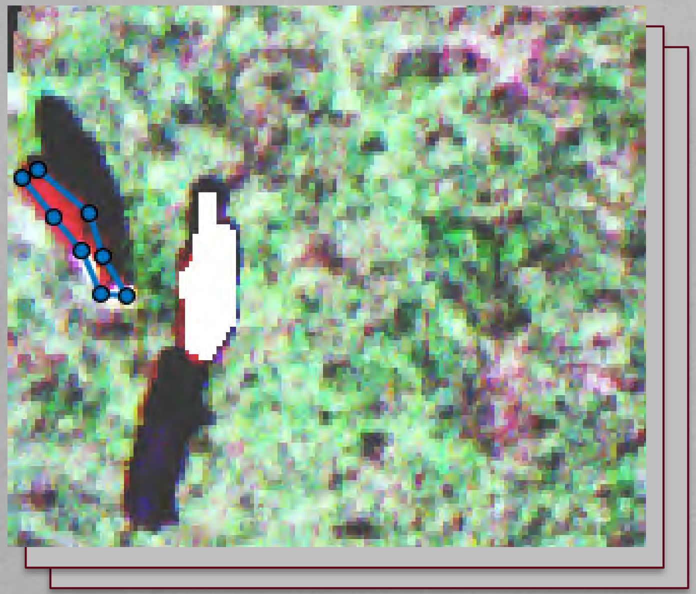
(# Samples)

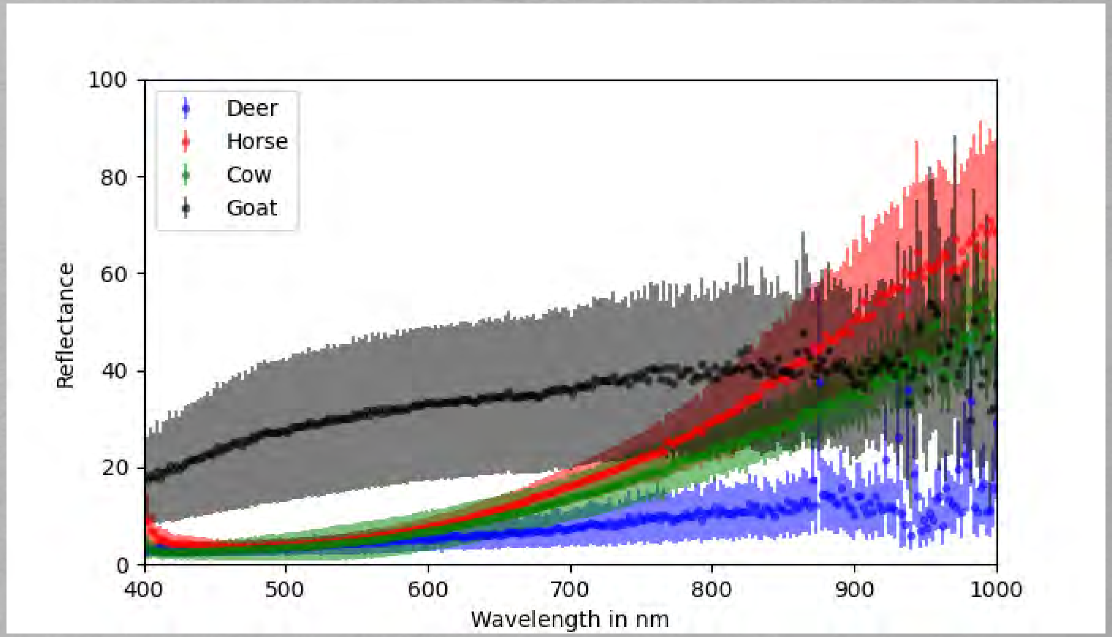
A. White-tailed Deer (219)
B. Goat (2811)
C. Horse (2351)
D. Cow (703)

Methodology

Data Processing







Methodology

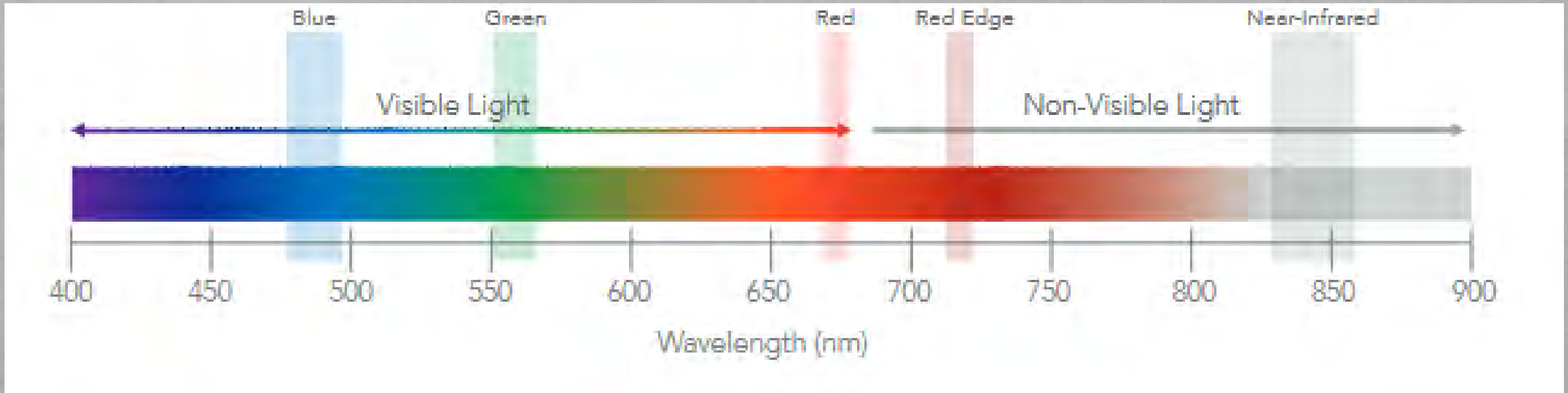
Dimensionality Reduction

Transformed Feature Space

- Principal Component Analysis (PCA)
- Linear Discriminant Analysis (LDA)

Same Feature Space

- Forward Selection
- Backwards Rejection
- 5-Band Composite Data (Micasense Rededge)



Methodology

Supervised Classification Models

- Maximum Likelihood Classification
- 1D Convolutional Neural Network
- 1D Artificial Neural Network

Results

Best Dimensionality Reduction for Each Model

Classifier (Dim. Red.)	Overall Accuracy	Cohen's Kappa	Deer F1	Horse F1	Cow F1	Goat F1	Background F1
Max. L. (PCA)	79%	**0.98**	**0.88**	**0.99**	**0.98**	**1**	**0.98**
CNN (LDA)	**98%**	**0.98**	0.69	**0.99**	**0.98**	**1**	**0.98**
ANN (LDA)	98%	0.97	0.67	**0.99**	0.96	0.99	**0.98**

Results
Simulated Multispectral Data

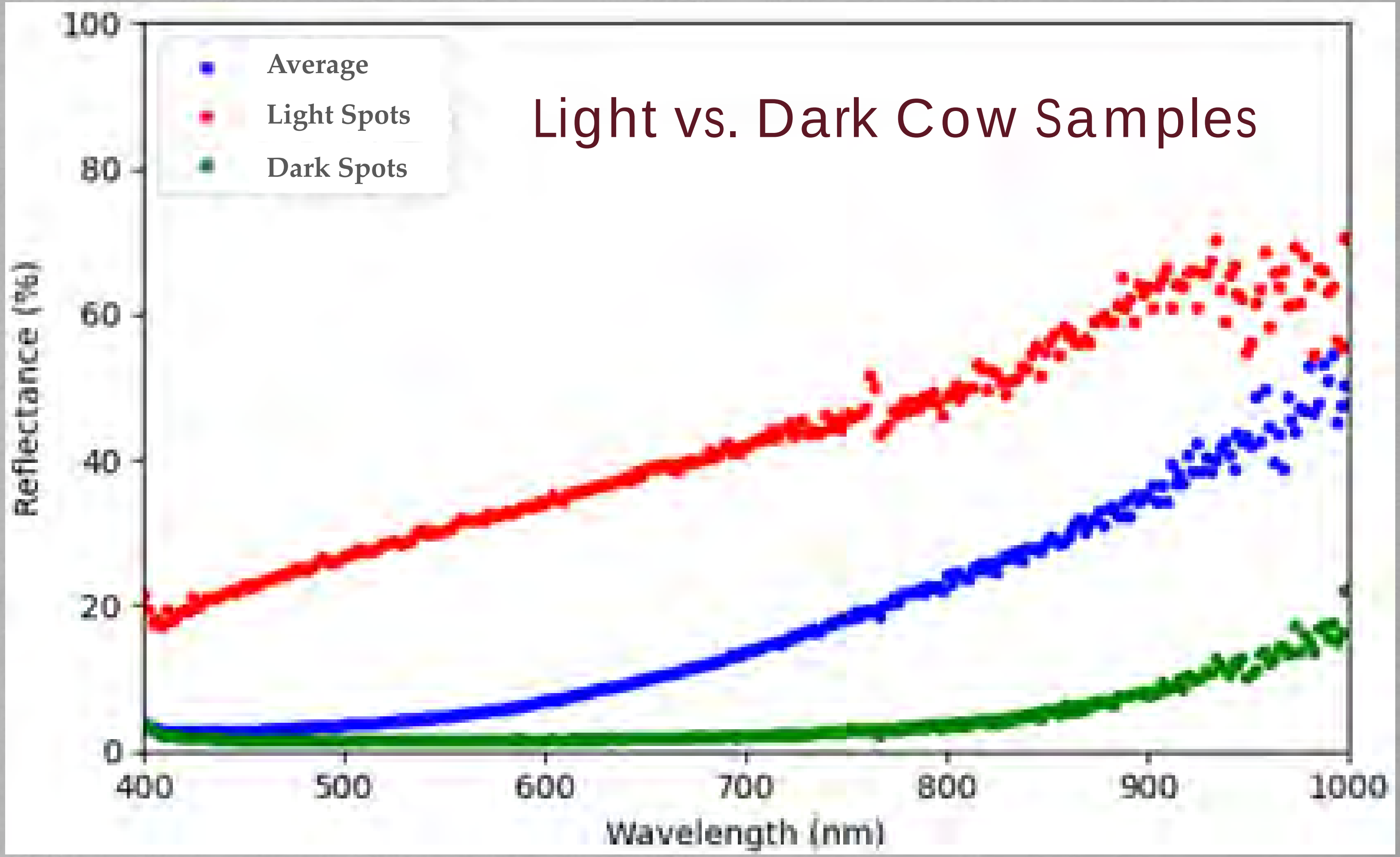
Classifier	Overall Accuracy	Cohen's Kappa	Deer F1	Horse F1	Cow F1	Goat F1	Background F1
Max. L.	**87%**	**0.82**	**0.75**	**0.87**	0.12	**0.93**	**0.86**
ANN	67%	0.59	0.35	0.51	0.45	0.88	0.68
CNN	75%	0.68	0.48	0.69	**0.48**	0.90	0.72

Discussion

- Implications
  - Definitely possible to differentiate between animals and background.
  - Allows for classification from single pixel
  - Potential sub canopy classification
- Simulated multispectral data
  - Reasonable results from classification
  - Can potentially reduce costs in sensor, easier data collections, more areal coverage per flight at increased spatial resolution

Limitations

- Small sample sizes
- High intraspecies variability
  - Light and Dark spots on same species differ significantly

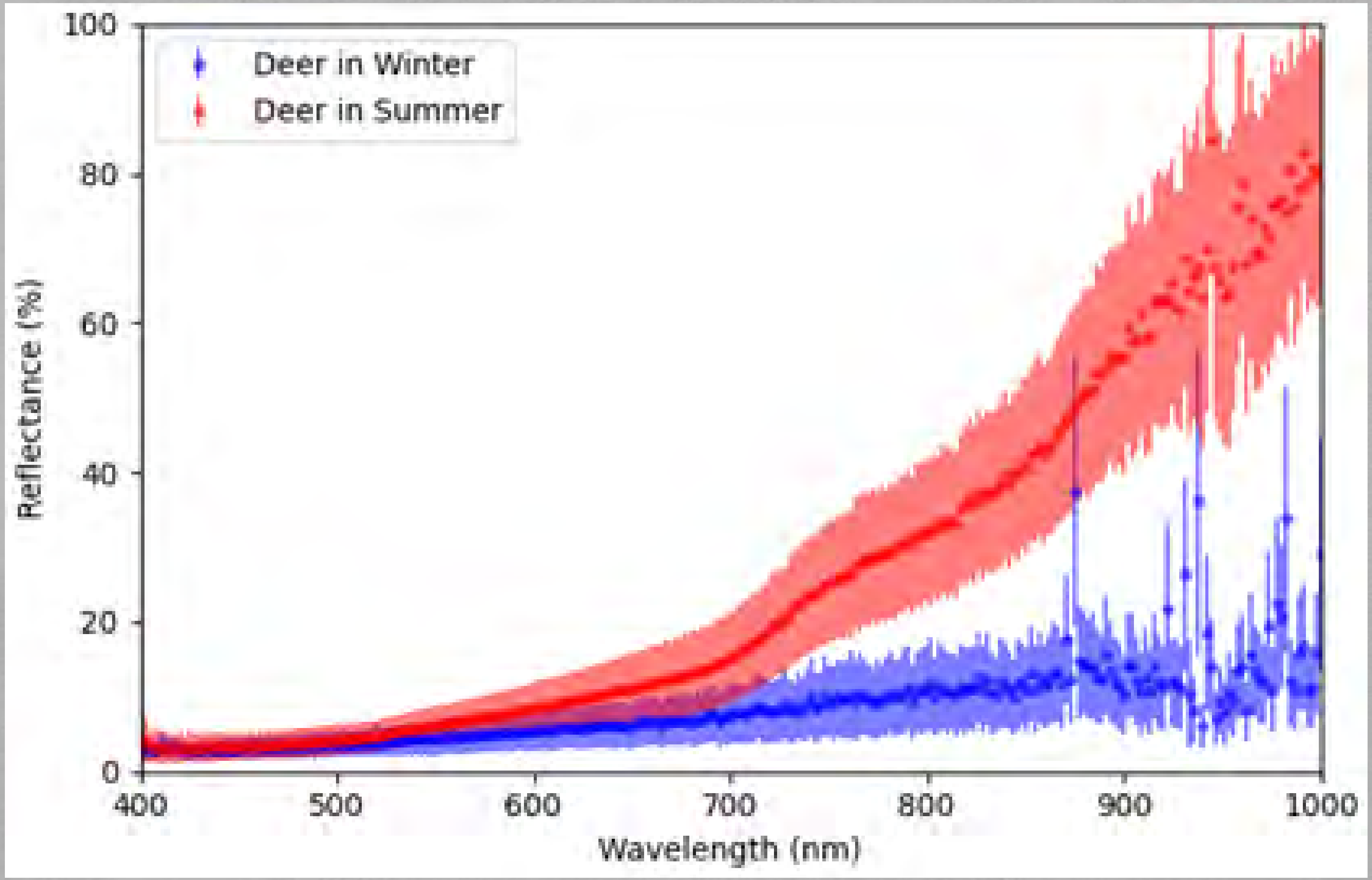


Questions

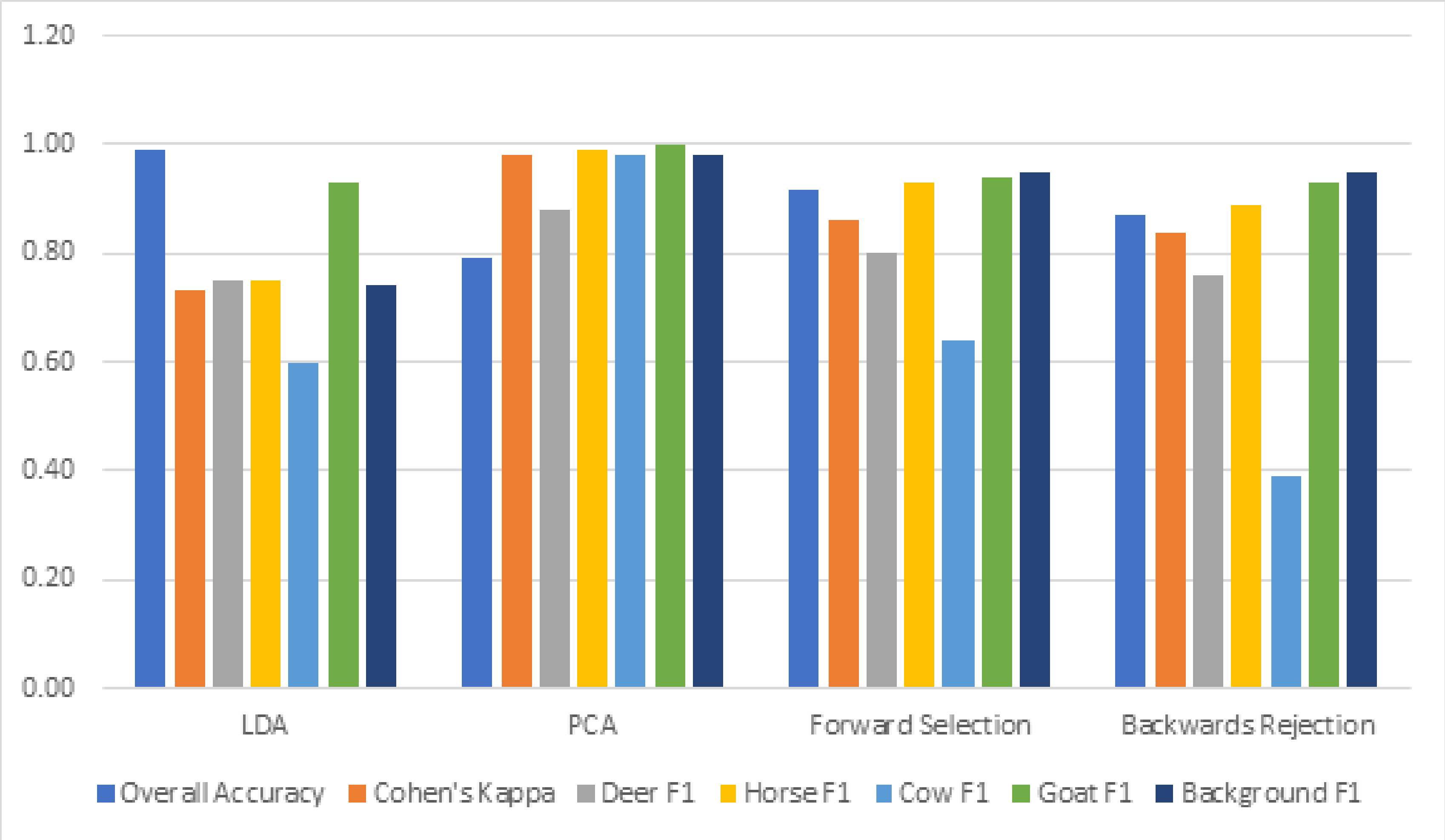
McCraine, D.; Samiappan, S.; Kohler, L.; Sullivan, T.; Will, D.J. Automated Hyperspectral Feature Selection and Classification of Wildlife Using Uncrewed Aerial Vehicles. *Remote Sens.* **2024**, *16*, 406. https://doi.org/10.3390/rs16020406

Daniel McCraine | *Research Engineer*
Geosystems Research Institute | Mississippi State University
carymc@gri.msstate.edu | (662) 325-8885

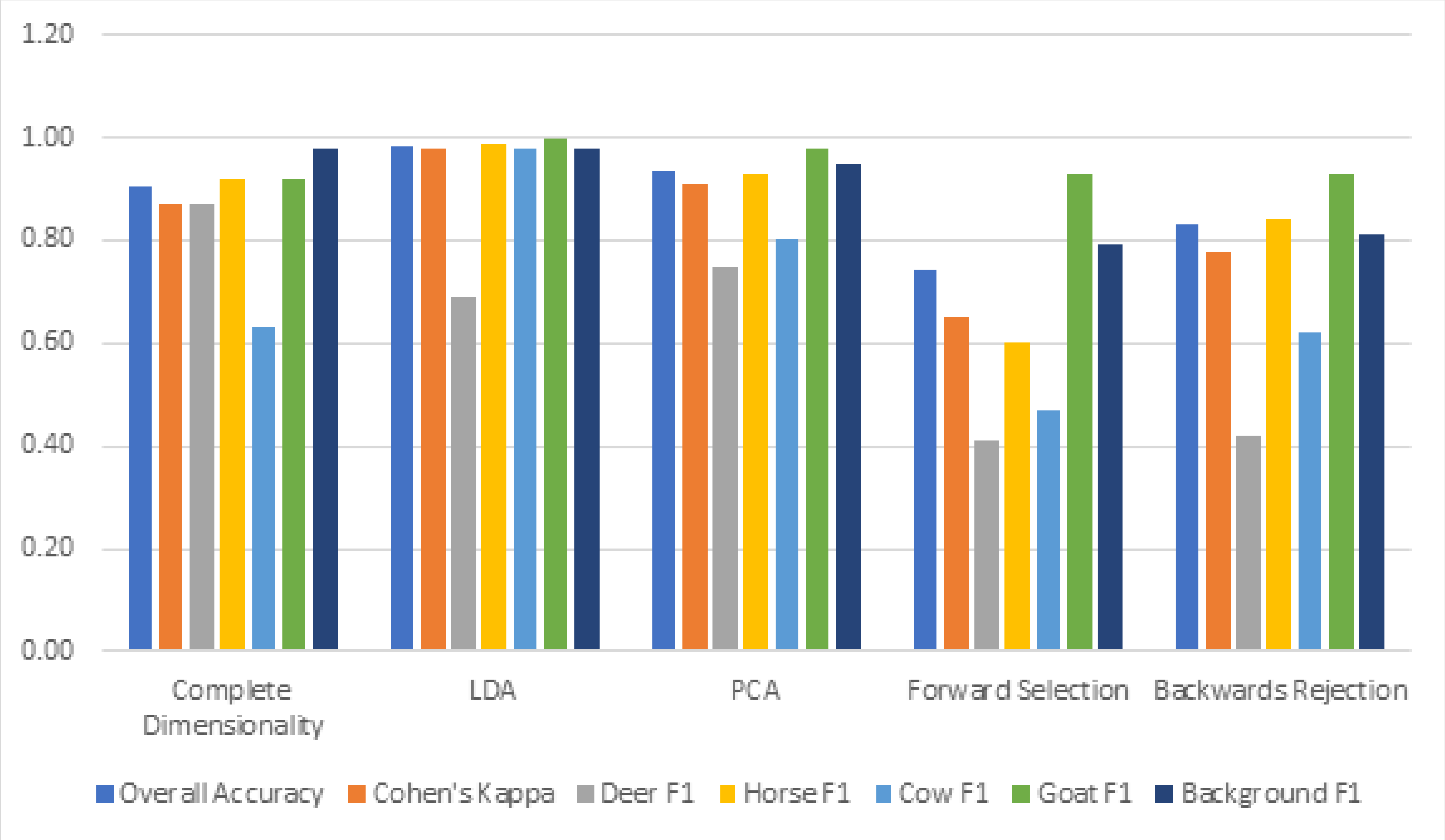
Winter vs. Summer Deer Signature



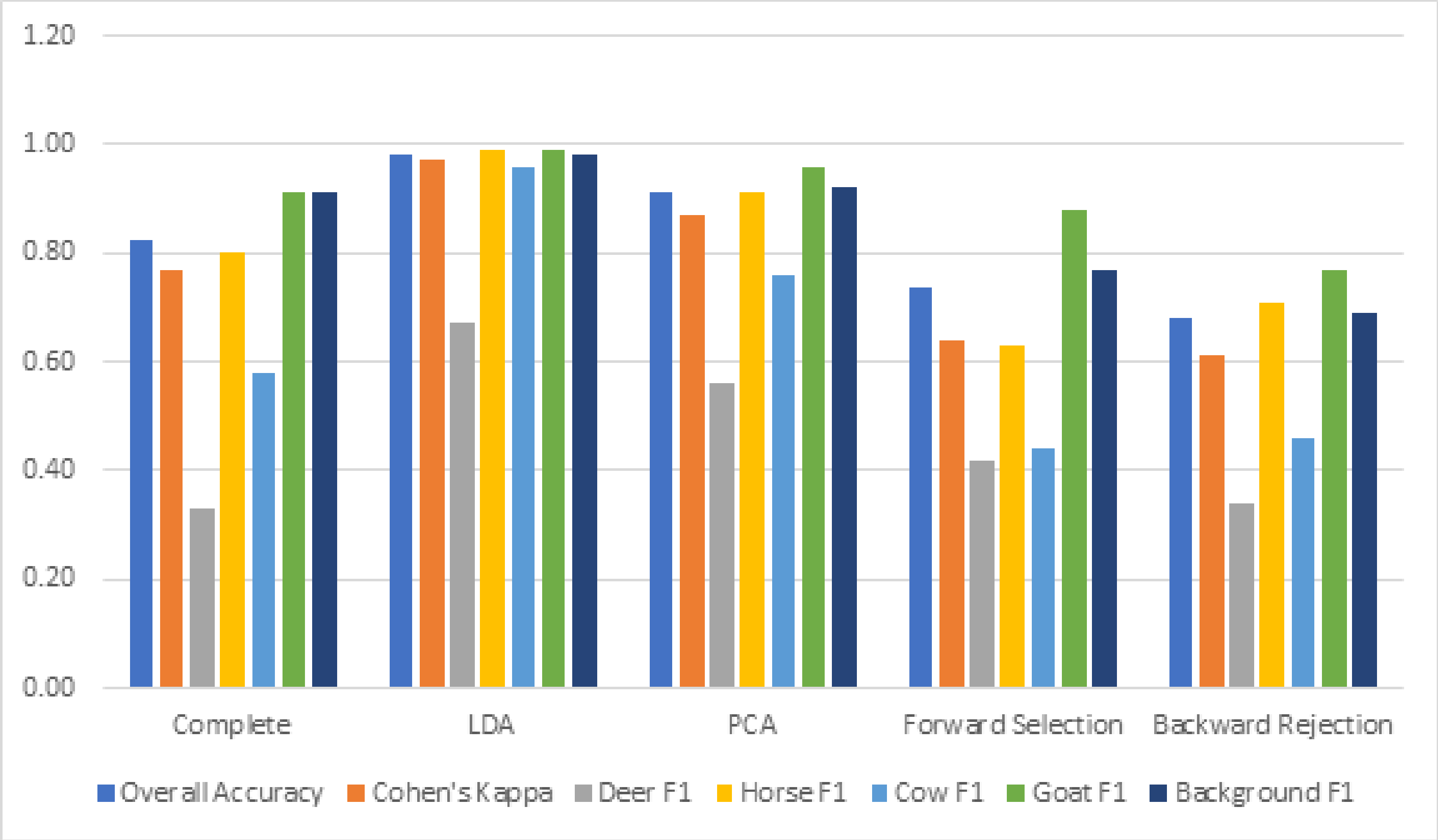
Maximum Likelihood Classification Results



CNN Classification Results



ANN Classification Results



CNN Architecture

Layer Name	Output Size	Layer Info	Processing
Input	1 × 270 *	-	-
Conv1D	268 × 32	kernel size = 3	ReLU
MaxPooling1D	89 × 32	pool_size = 3	-
Flatten	1 × 2848	-	
Dense	1 × 128	-	ReLu
Dense	1 × 4 **	-	SoftMax

* Depending on the input of the data. Dimensionality reduction methods lead to smaller output sizes. ** Depending on the number of classes present.

ANN Architecture

Layer	Layer Name	Output Size	Layer Info	Processing
1	Input	1 × 270 *	-	-
2	Dense	1 × 20	-	ReLU
3	Dense	1 × 8	-	ReLU
4	Dense	1 × 8	-	ReLu
5	Dense	1 × 4 **	-	SoftMax

* Depending on the input of the data. Dimensionality reduction methods lead to smaller output sizes. ** Depending on the number of classes present.

Drone Data Management, Processing, and Analysis: Best Practices with Examples from California and Costa Rica

Sean Hogan, Drone Program Coordinator, Division of Agriculture and Natural Resources, University of California; sdhogan@ucanr.edu

Summary: When people think of drone applications, they tend to initially focus on equipment specifications and the operation of the drone platforms. However, the true scientific value of this emergent technology doesn't necessarily lie in its mechanical properties, but rather in the cutting-edge ways that the data collected by these platforms can be used to efficiently gain new and exciting actionable insights. This presentation will refer to ecological research conducted in the valleys and mountains of California and cloud forests of Costa Rica, to describe typical drone project workflows, while highlighting potential challenges for data management, analysis, and visualization, as well as considerations for data storage and sharing. The goal of this data-centric presentation will be to convey things that the presenter wishes that he knew when he first began conducting drone research for the University of California in 2016, starting with habitat research for desert tortoises and voles, followed by a number of projects related to ecological recovery to wildfires, invasive pest impacts on oak woodlands, and water stress related to tropical climate change. These collaborative research projects have resulted in the accumulation of several dozen terabytes of shared drone data and processed geographic information system (GIS) files, and through this presentation, the importance of proper file naming conventions, folder organization, processing setting, standardized analysis workflows, quality control and assurance, and data backup/storage strategies will become evident.

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Monitoring Large Non-breeding Aggregations: Using Drones to Enhance Avian Research in Dense and Urban Environments

Craig Gibson, Director, Wildlife Conservation Multimedia, Winchester, MA, USA;
cbgibson@comcast.net

Summary: This presentation will explore the use of drone technology in monitoring large non-breeding aggregations of birds in urban settings. Drones provide valuable insights into roost size, composition, and behavioral patterns of birds, and this presentation highlights best practices for using RGB, IR, and thermal cameras to capture critical data both during daylight and after dark. Case studies, including a winter crow roost of over 15,000 individuals in Lawrence, MA, USA and an overnight winter turkey vulture roost in Florida, USA will showcase effective strategies to observe roost behaviors and dynamics with minimal disturbance. Key operational considerations include optimal sensor choice, mission-specific flight planning, and drone type selection (multirotor vs. fixed-wing) based on research goals. To address challenges like bird disturbance, battery limits, and data management, solutions are discussed such as buffer zones, real-time observation with dedicated visual observers, and noise minimization techniques. For nighttime operations, flight planning, safety and compliance issues, as well as special strategies for image capture in low-light situations are discussed. This presentation will equip attendees with practical methods and solutions to conduct responsible and higher impact drone surveys of large non-breeding aggregations of birds, contributing valuable data to conservation and urban wildlife management efforts.

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Monitoring Large Avian Non-Breeding Aggregations

Using Drones to Enhance Avian Research in Dense and Urban Environments

Welcome!

- Craig Gibson: Boston, MA
- Bird & wildlife photographer
- Fascinated by bird flocks and roosts
- Drones for conservation research
- Working with conservation groups to enhance communications for mission

Introduction

- Explore drones for avian research
- Monitoring large flocks and roosts
- How drones can provide unique insights for bird populations
- Explore key questions, methods, and case studies

Fish Crows Streaming Towards Roost After Sunset

Crows Back to Roost Before Dark!

Chaotic Flight Bursts at Roost!

Why Study Groups & Roosts?

- Rare Insights – A unique glimpse into wintering bird behavior.
- Understudied Phase – Wintering bird habits remain largely unknown: under 100 species
- Migration Research – Enhances the understanding of seasonal patterns.
- Better Bird Counts – Helps refine population estimate methods.

Range of Habitats for Groups and Roosts!

Key Questions for Research & Monitoring

- Core Questions: Drone Bird Surveys
  - What is the size and composition of the group or roost?
  - How does group/roost composition change over time?
  - Where are key roosting locations, and what behaviors are observed?
  - Factors influencing large group movements and behaviors?

Winter Roost: Slow Motion Flight Pattern Dynamics

Drone Type Selection: Quadcopter vs. Fixed Wing

- Quadcopter Drones:
  - Ideal for close monitoring and hovering over specific points
- Fixed Wing Drones:
  - Suitable for large area coverage with efficient flight times
- Choosing Based on Survey Goals and Environmental Context

DJI Mini 3 Pro

Phantom 4 Pro+ V2 NIR

Mavic 3 Pro

Mavic 3 Thermal

Fixed Wing

Selecting Drone Sensors

- RGB, Infrared, & Thermal Cameras:
  - RGB (color) for visual data, species ID, and counting
  - Night Mode for low light
  - NIR Infrared for dusk & dark
  - Thermal for low light & night
- Sensor Combinations Times of Day
  - Daylight, twilight, and nighttime monitoring considerations

Mini 3 Pro

Mavic 3 Pro

3rd party ad content
12 MP 1/2" Telezoom
4k@60fps max. Fixed f/3.4 aperture.
166mm equivalent. ProRes 422 (Cine only)
48 MP 1/1.3" Medium Zoom
4k@60fps max. Fixed f/2.8 aperture. 10 bit D-LOG M.
70mm equivalent. ProRes 422 (Cine only)
MAVIC 3 PRO
HASSELBLAD
20MP Hasselblad 4/3 Sensor
5.1k@50fps max. 4k@120fps slow motion. 10 bit D-LOG M.
24mm equivalent. f/2.8 - f/11 aperture. ProRes 422 (Cine only)

Mavic 3 Pro: Night Mode

Phantom 4Pro+ V2.0 NIR

Mavic 3 Thermal

Mavic 3 Thermal

RGB & Thermal

Mavic 3 Pro: Night Mode

Mavic 3T: Night Mode (LE)

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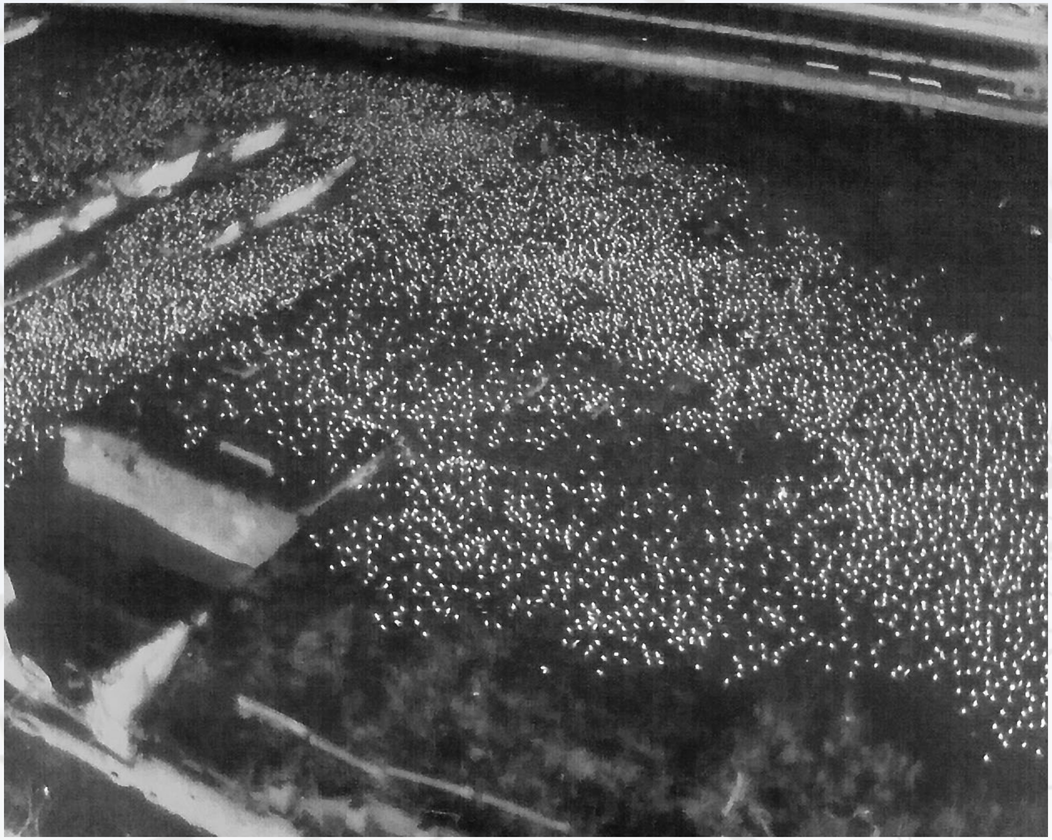
Infrared with IR Lighting

Thermal: White Hot



Thermal: Roost Video

Case Study:
Winter Crow Roost

- Location: Lawrence, MA
  - Description of a winter crow roost with up to 15,000 American Crows and Fish Crows
  - Survey objectives: understanding behavior and flight movements from dusk to dawn in an urban setting

Urban Setting:
New Balance Sneaker Factory

Flight bursts from roost trees!

Winter Crow Roost

- Crows are very social and smart
- More social during roost season
- Loud vocalizations in roost, both at dusk and at dawn
- Known for intelligence and wariness to humans
- Also very family-centered
- Cooperative breeders

Winter Crow Roost

- May change locations during winter months
- Changes made often for added weather/wind protection
- Shifts may be gradual or sudden
- Locations tend to be within 1-2 mile radius

Winter Crow Roost

- at first light, after quiet, awaken with growing vocalizations
- start to depart nautical twilight
- by sunrise, almost all have departed roost in small groups
- fly out in all directions
- fly out directly to feeding grounds

Woodstock, Ontario
Flight Patterns: 90,000+

Time of Day Considerations

- Daylight, Twilight, and After Dark Challenges:
  - Different bird behaviors across range of light conditions
  - Use of night vision and thermal cameras for dusk/dark data capture
  - Still photos and long exposure versus video imaging after sunset

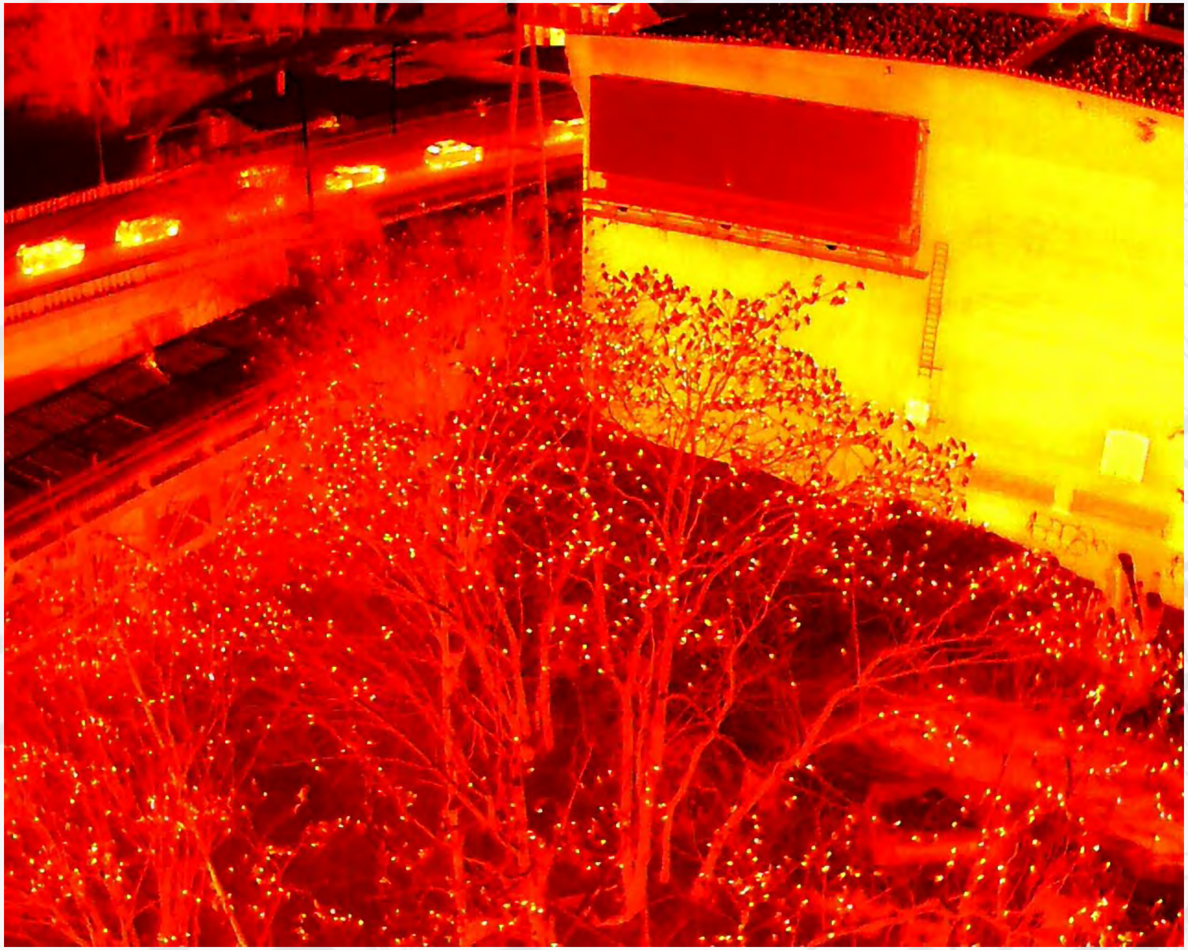
Mini 3 Pro: Low Light Video

Mavic 3 Pro
Night Mode Still Image

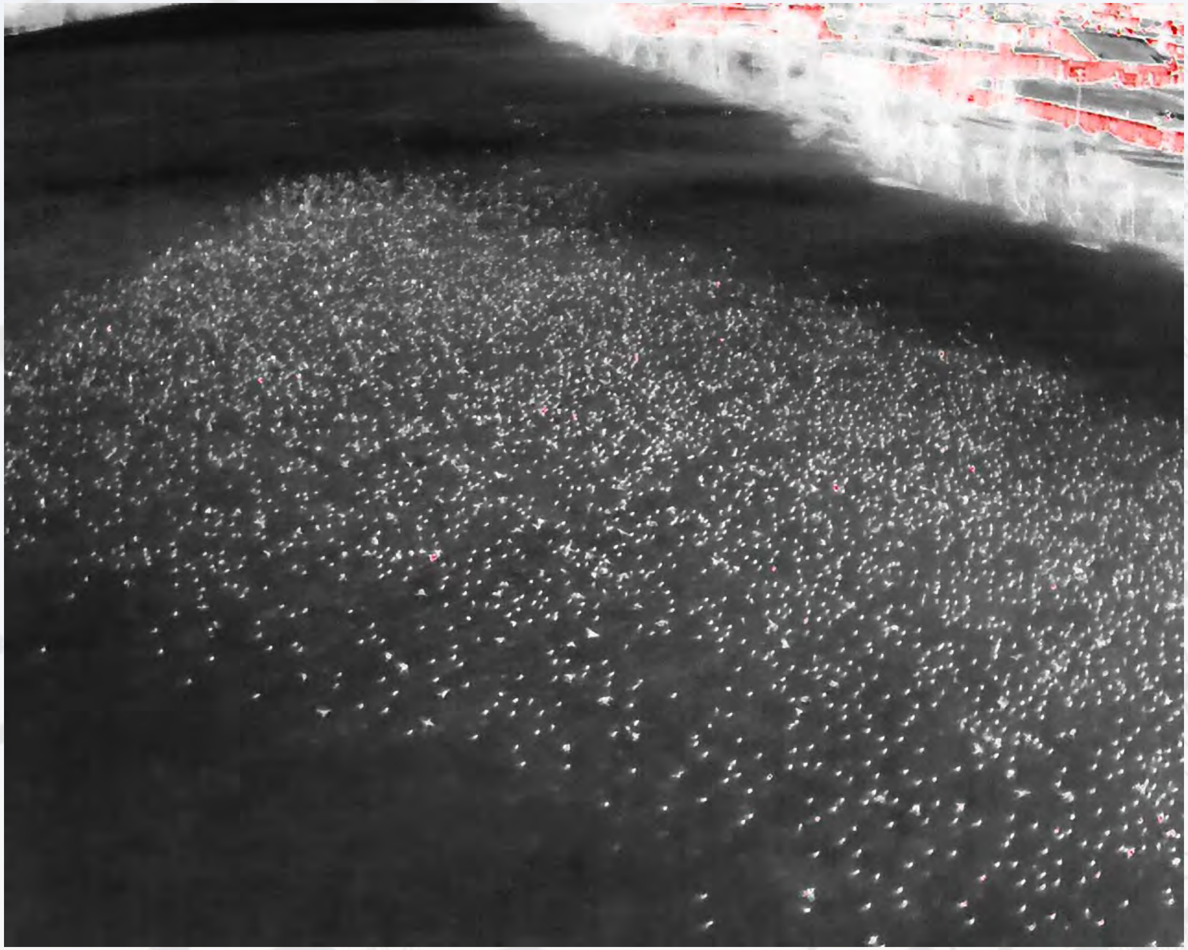
Mavic 3T: Staging at Dusk

Roost: Long Exposure

Mavic 3 Thermal: Trees



Mavic 3 Thermal: On Ice



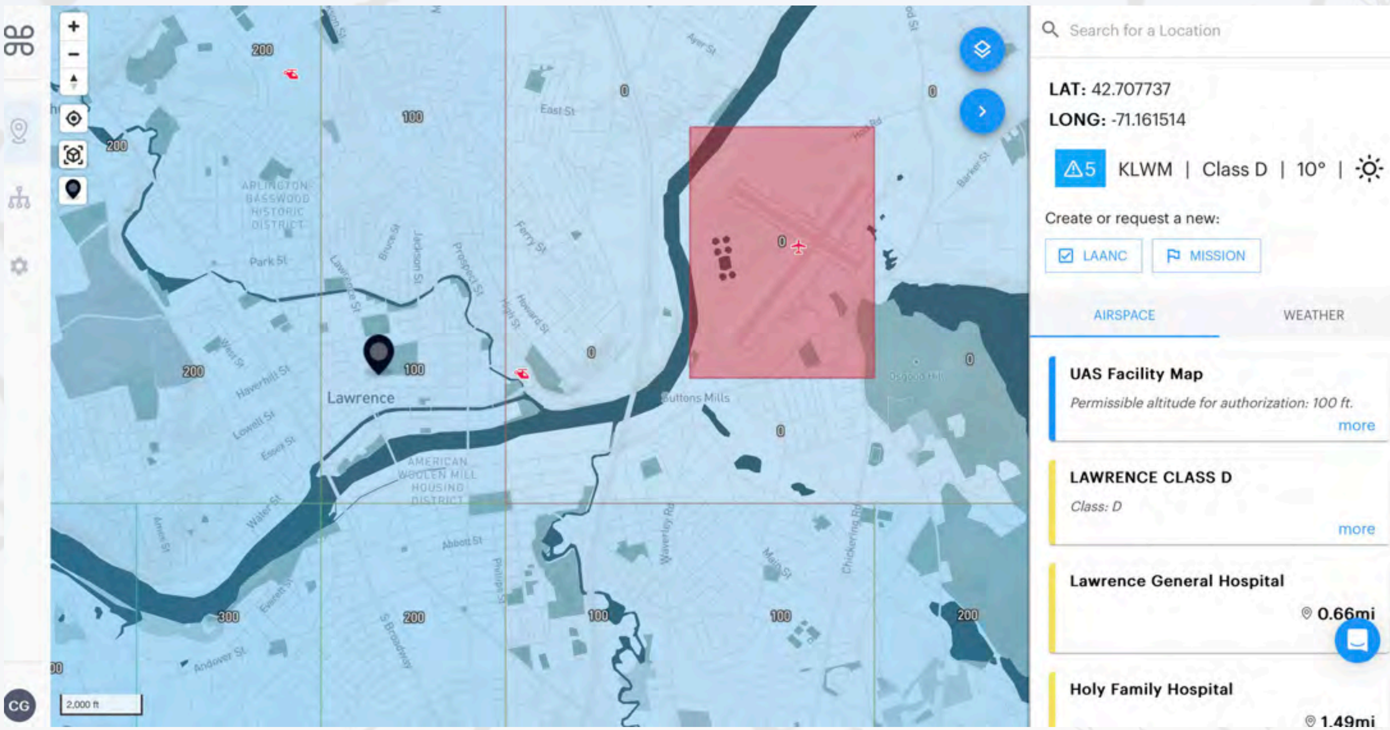
Mission Planning & Protocols

- Factors to Plan For:
  - Size and location of the survey area
  - Permits, regulations, and compliance with aviation and relevant wildlife regulations
- Flight Patterns & Disturbance Issues
  - Developing flight protocols that maintain safe distances
  - Drone and propeller selection to minimize noise

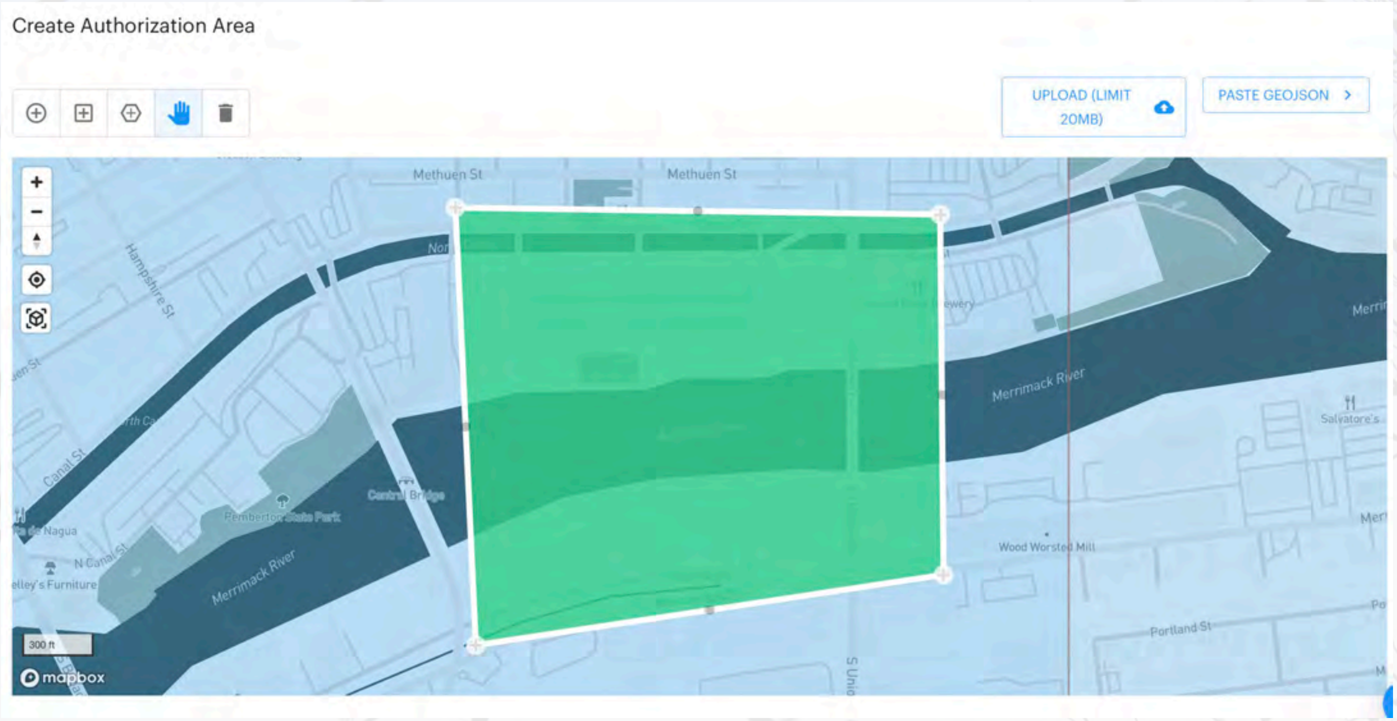
FAA:Remote Pilot

Aloft Air Control App

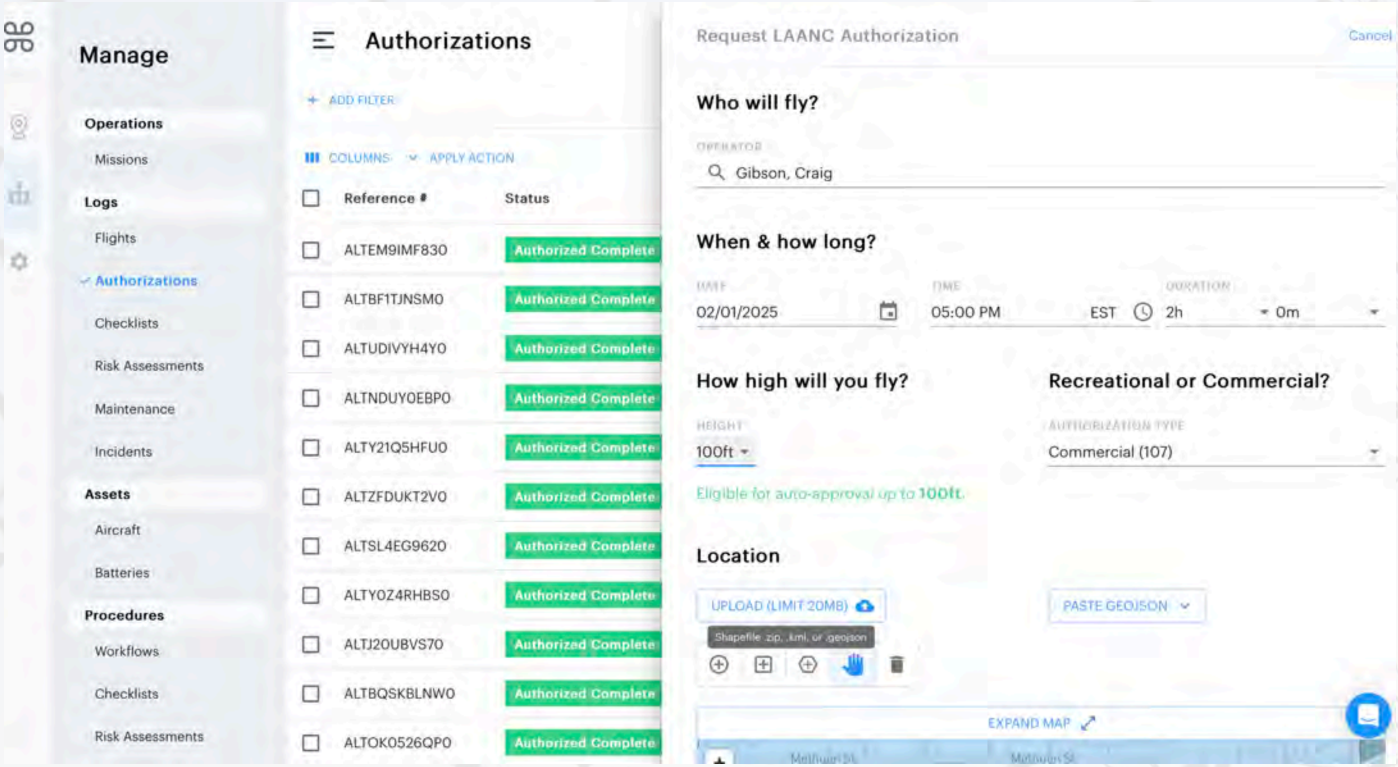
Controlled Space: Survey Area



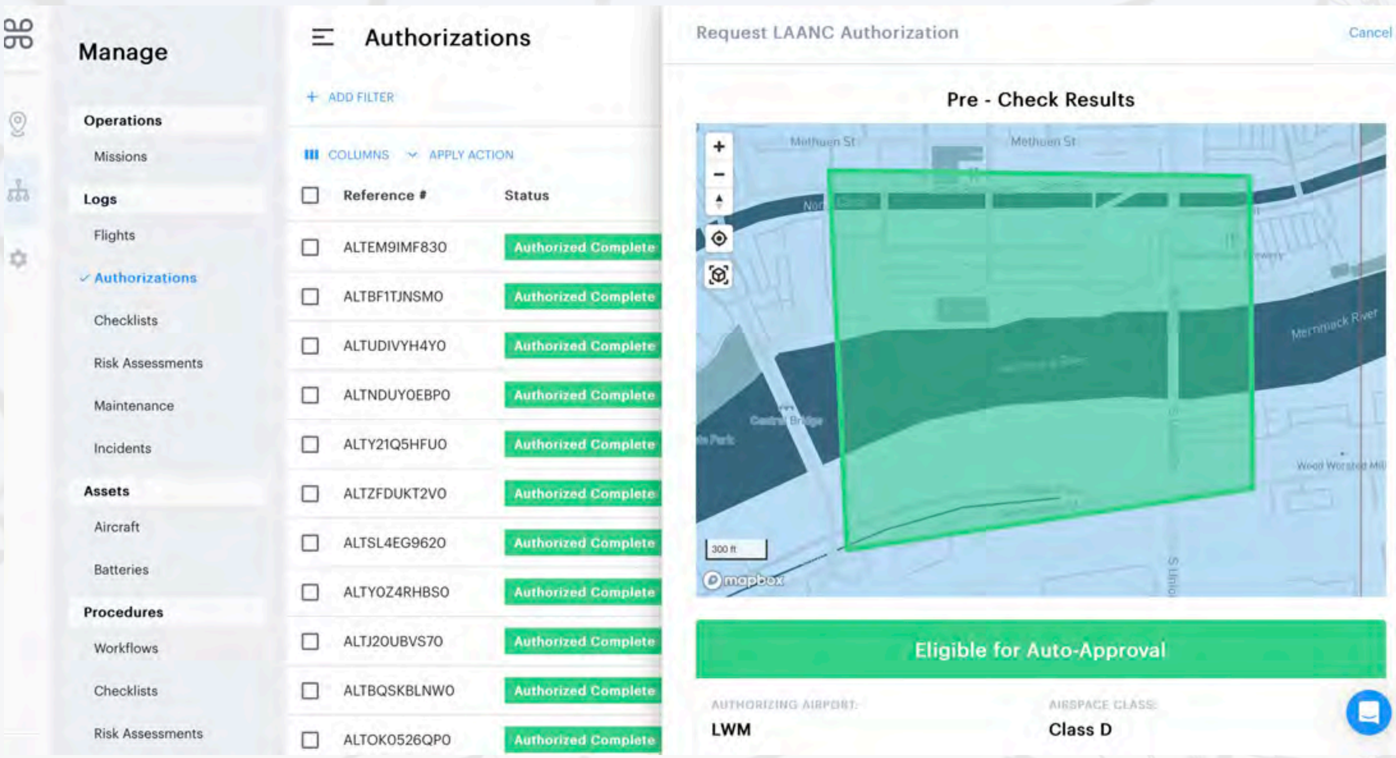
Location & Size of Survey Area



Air Control: Request



Air Control Pre-check



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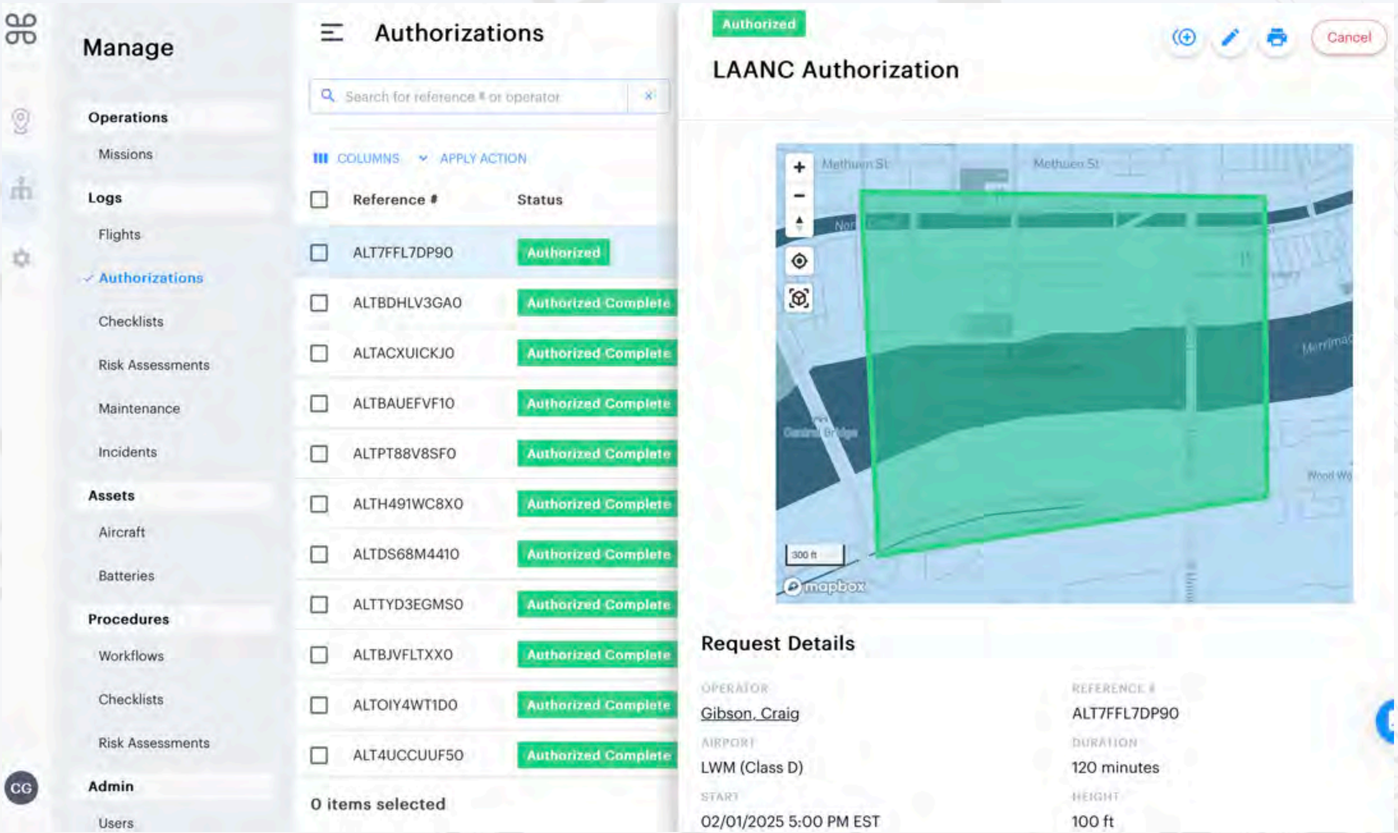
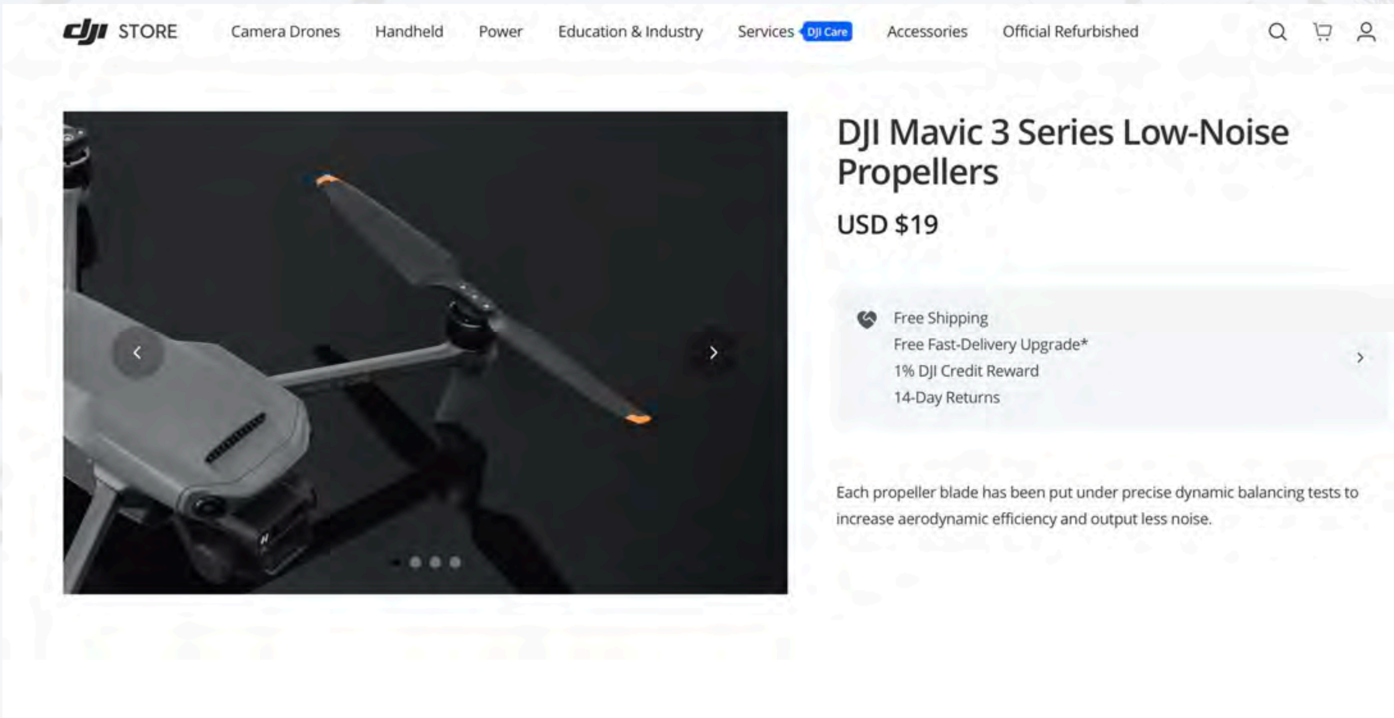
Air Control: Authorization



Lower Noise Signature Levels



Pre-flight Checklist

Preflight Checklist

PARTS CHECK
Ensure that all parts are in good working condition.

CHARGE STATUS
Ensure the remote controller, flight battery, and tablet are charged to an acceptable level.

CAMERA CHECK
Ensure that there is no foreign object stuck to the camera, and that gimbal can rotate freely before powering it on

PROPELLERS CHECK
Ensure the propellers are securely mounted onto the motors, and the motors can start and function normally.

SD CARD CHECK
Ensure SD Card has been inserted.

SOFTWARE & FIRMWARE CHECK
Ensure the app is functioning correctly and aircraft's firmware has no system errors. Notify UAS core team of ALL system errors.

COMPASS & SATELLITE CHECK
Ensure compass is functioning as expected and amount of satellites lock is at/above minimum.

FLIGHT MODE CHECK
Be familiar with the selected flight mode and understand all safety functions and warnings.

IMSAFE CHECK
Ensure Pilot is fit to fly. Illness, Medication, Stress, Alcohol, Fatigue, Emotion

Post-flight Checklist

Post-Flight Checklist

TURN OFF DRONE
Also power down remote controller and other equipment.
BATTERY
Unplug and remove. Check for overheating.
DRONE
Inspect equipment for damage. Check landing gear, wiring, batteries, propellors, etc.
DATA
Download flight data or SD card.
PROPS
Check for damage.
BATTERIES
Organize and mark discharged batteries.
DATA
Don't forget to download or transfer data as needed. The drone will need to be left on for data transfer.

Specific Issues & Solutions: Drone Based Bird Surveys

- Disturbance to Birds
  - Safe distance and altitude to avoid disrupting behavior
- Flight Duration Battery Limits
  - Solution: longer endurance drones or plan staggered flights
- Weather Conditions and Adaptability
  - Solution: Monitor forecasts closely
- Data Management
  - Storage & data processing protocols

Safe Distance & Altitude

Longer Battery Limits

Weather: UAV Forecast

Data Storage & Protocols

- Multiple Micro SD cards
- Always transfer to hard drive
- Always delete data SD card
- Always format after mission

Micro SD Card: 512GB

Portable Hard Drive: 5TB

Safety Considerations: Urban Roost Monitoring

- Urban Roost Case Study Challenges:
  - Proximity to buildings, people, and other urban features
- Strategies for Safety and Compliance
  - Buffer zones and regulated flight paths
  - Clear communication with local authorities and residents

Safety/Obstacles

Buffer Zones

Journal of Applied Ecology

BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE | Open Access

Drone-induced flight initiation distances for shorebirds in mixed-species flocks

Joshua P. Wilson, Tatsuya Amano, Richard A. Fuller

First published: 13 July 2023 | https://doi.org/10.1111/1365-2664.14467 | Citations: 6

Handling Editor: Vitor Paiva

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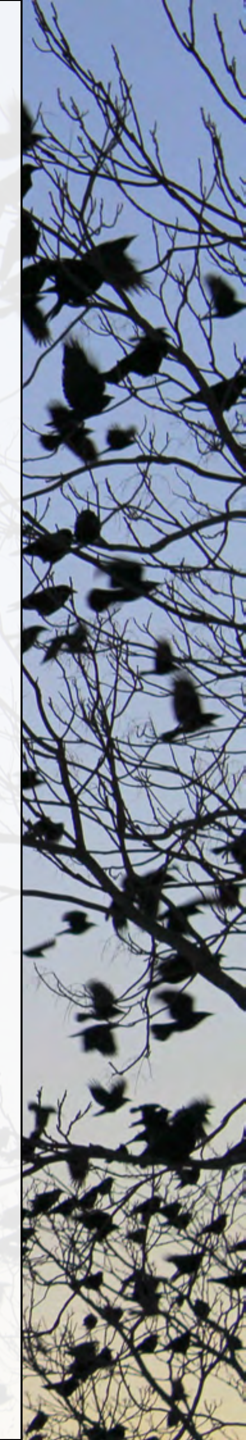
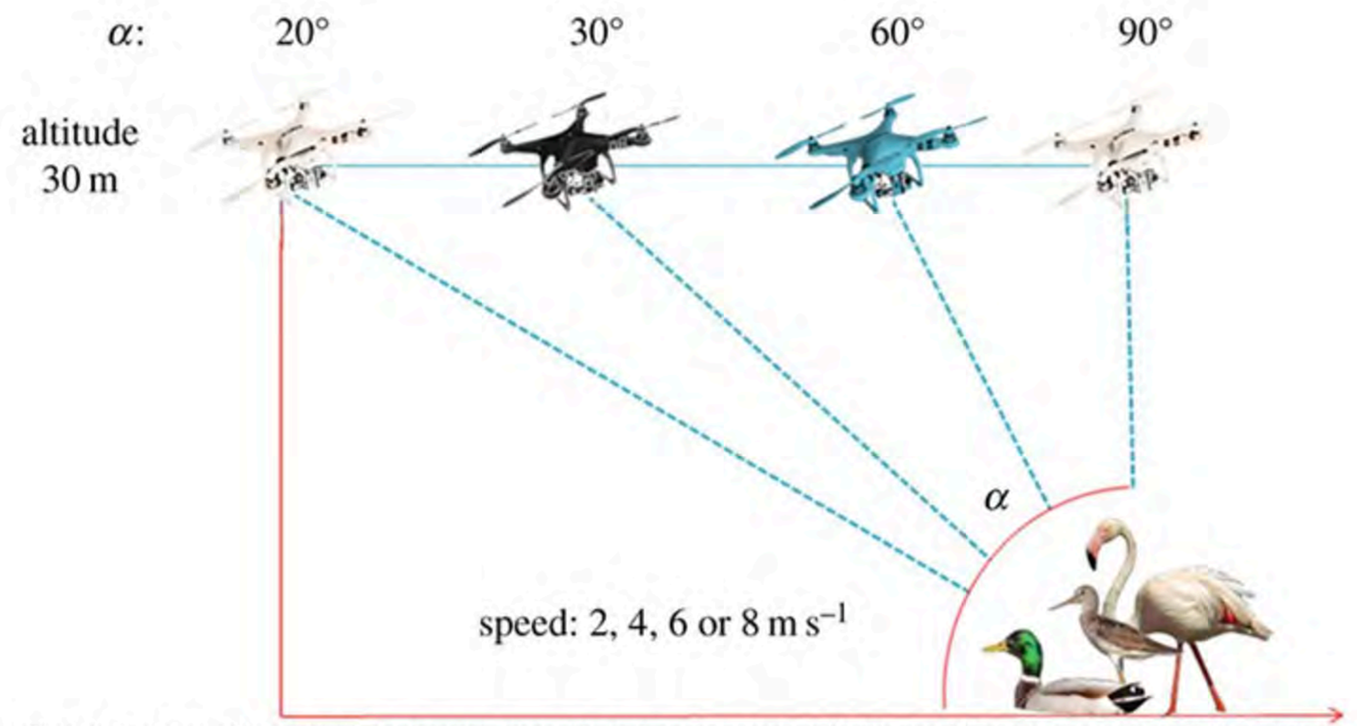


Buffer Zone

- Drones above 30m, but species show varied sensitivity.
- Disturbing sensitive species may trigger flock-wide responses.
- Plan mission to account for species-specific and flock dynamics.

Buffer Zones



Flight plan for approaching birds with the Phantom drone. The drone was first ascended to 30 m, and then moved at speeds of 2,4,6 or 8 m s-1 towards the birds at angles a of 20°, 30°, 60° or 90°. Drones of three colours were used (white, black and blue).

Buffer Zones

- Drones within 4m in 80% of cases not altering bird behavior.
- Vertical approaches were most disruptive, predator threats.
- Launch from 100m away, avoid vertical approaches, and study predatory species.

Night Flight Courtesy Call: Local Police Dept.

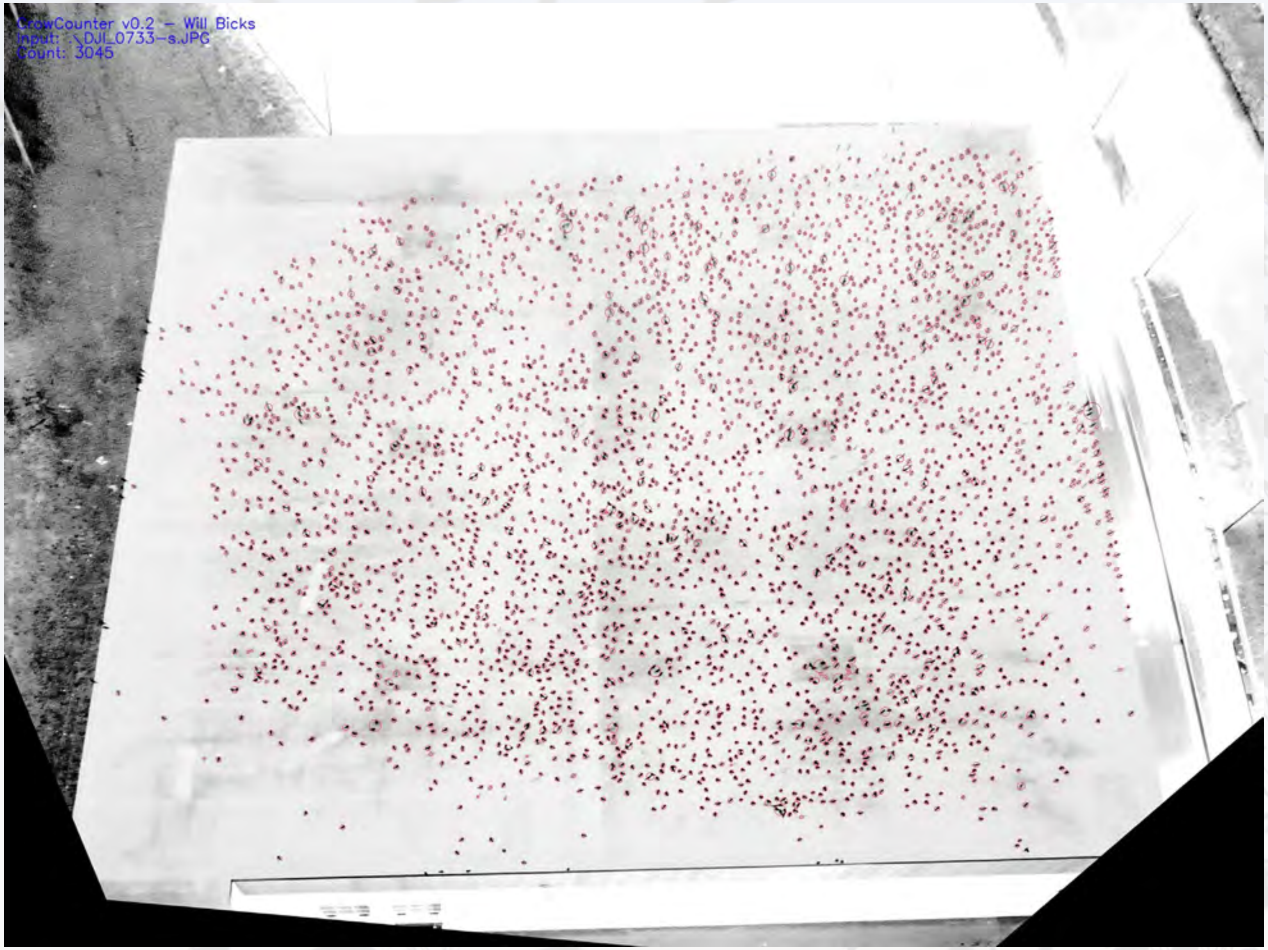
Bird Interactions & Minimizing Disturbance

- Plan for Bird Drone Interactions
- Plan for Minimizing Disturbance
- Close Approaches & Bird Reactions:
  - How to avoid provoking stress or aggression in birds
- Visual Observer Role (VO)
  - Use of VOs to monitor birds' responses in real time and adjust flight paths as needed

Data Collection & Processing

- Challenges in Data Management:
  - Processing large datasets, and tracking bird groupings
- Automated Analysis Tools
- Software and machine learning applications for bird counting and species ID

Automated Counting

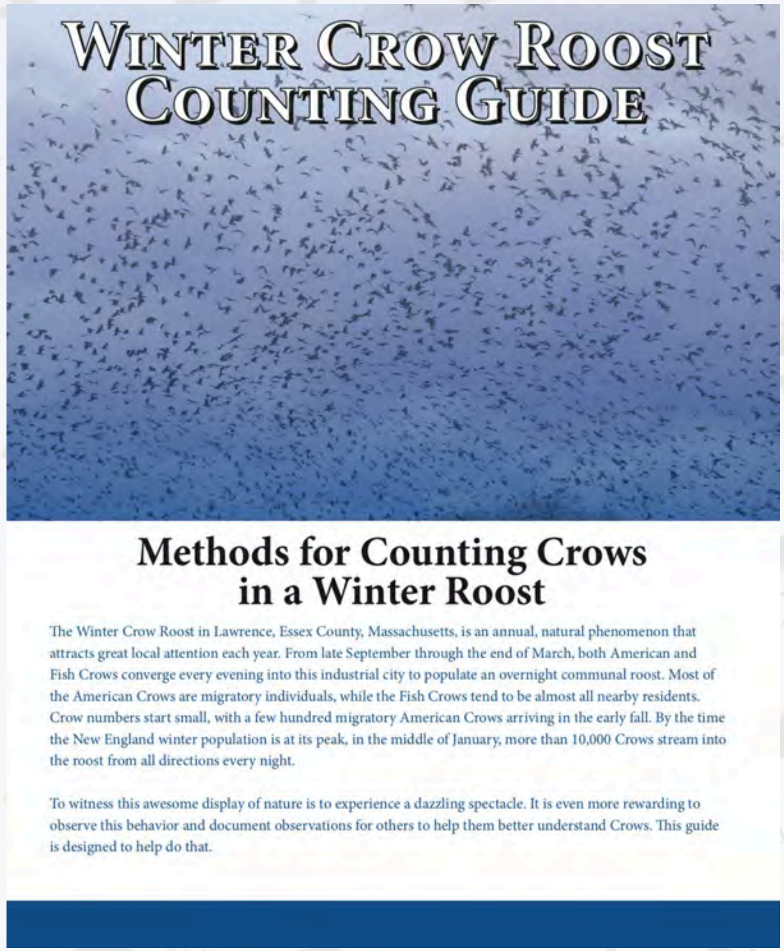


Automated Counting

Automated Counting

Automated Counting

New Counting Guide



WINTER CROW ROOST
COUNTING GUIDE

Methods for Counting Crows in a Winter Roost

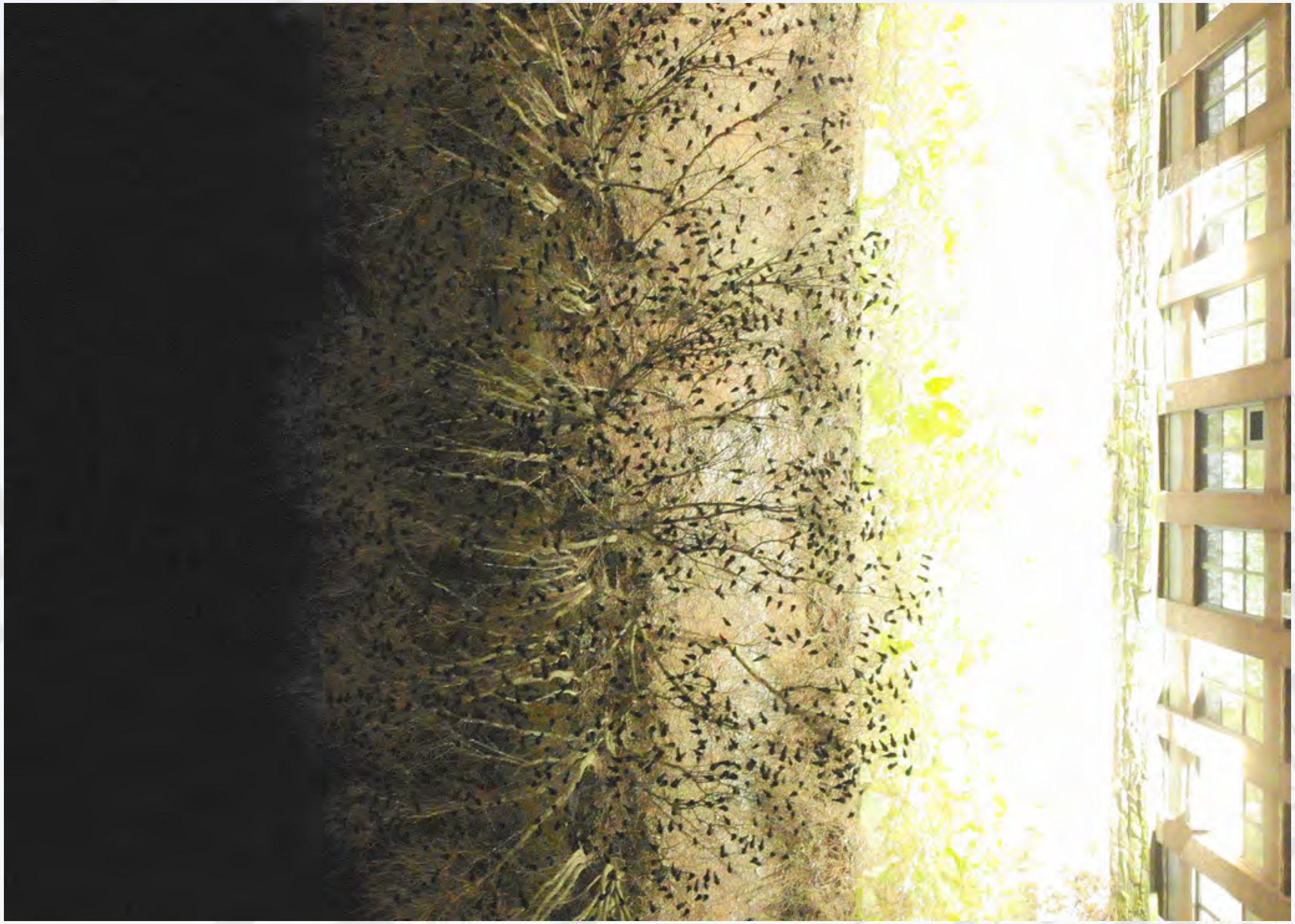
The Winter Crow Roost in Lawrence, Essex County, Massachusetts, is an annual, natural phenomenon that attracts great local attention each year. From late September through the end of March, both American and Fish Crows converge every evening into this industrial city to populate an overnight communal roost. Most of the American Crows are migratory individuals, while the Fish Crows tend to be almost all nearby residents. Crow numbers start small, with a few hundred migratory American Crows arriving in the early fall. By the time the New England winter population is at its peak, in the middle of January, more than 10,000 Crows stream into the roost from all directions every night.

To witness this awesome display of nature is to experience a dazzling spectacle. It is even more rewarding to observe this behavior and document observations for others to help them better understand Crows. This guide is designed to help do that.

Case Study Recap: Lawrence Roost Insights

- Key Findings from Roost Surveys
  - Behavioral insights, size and movement trends, and nighttime roost locations
- Impact on Conservation and Management Efforts
  - Practical applications of data for local wildlife authorities

Aerial: Roost Overhead



Aerial: Truck Depot

Aerial: Warehouse Rooftop

Conclusions

- Main Takeaways:
  - Create effective drone strategies for large flock monitoring
  - Balance research needs with minimizing disturbance to wildlife
- Recommendations for Future Surveys:
  - Improved sensor technology and expanded use of AI in data analysis

Blog: wintercrowroost.com

THANK YOU!

- Thanks to IFSA/Dr. Sergey Yurish
- Thanks Rick/David & TWS
- Thanks TWS Drone Working Group
- Thanks to all of you at conference
- Please share questions & feedback!

Questions/Feedback

- Please send any/all thoughts!
- Email: cbgibson@comcast.net

Questions?

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Designing Drones for Wildlife Radio Telemetry

Michael W. Shafer, Northern Arizona University, Department of Mechanical Engineering, Flagstaff, AZ, USA; michael.shafer@nau.edu

Summary: Globally there is a sustained need for wildlife telemetry systems by governmental agencies and academic institutions to conduct population monitoring and habitat use studies of wildlife species. Although significant advances in microelectronics have ushered in a new era of tagging for large species, with GPS and satellite connectivity, the mass constraints for smaller wildlife species continue to limit the devices they can carry. Very high frequency (VHF) radio tags continue to be a primary method of tracking small wildlife species and are also used on larger species as a fail-safe if more advanced devices fail. The limited transmission power for these tags (often in the range of microwatts), non-ideal antenna size and orientation, topography, and foliage all conspire against the human trackers on the ground confounding their efforts to localize their subjects. This presentation will cover the purpose-built uncrewed aerial vehicle for radio telemetry (UAV-RT) system. This system has been developed to integrate a software defined radio and receiving antenna with the flight control system that enables received data to be presented to the user on a tablet-based ground control station. The system has been extensively redesigned from an original incarnation to improve system sensitivity and reception range through both algorithmic and physical design features. This presentation will highlight the RF design considerations needed when developing a high-sensitivity airborne receiver, solutions to emitted RF noise from the drone, and testing results that demonstrate system performance. Testing results will show the amount of emitted broadband RF noise and how antenna placement can be optimized to reduce this interferer. We also will present comparisons of antenna configurations developed to minimize drone-induced interference to maximize system reception range.

Presentation unavailable – please contact Michael Shafer @ michael.shafer@nau.edu if you would like further details on this research.