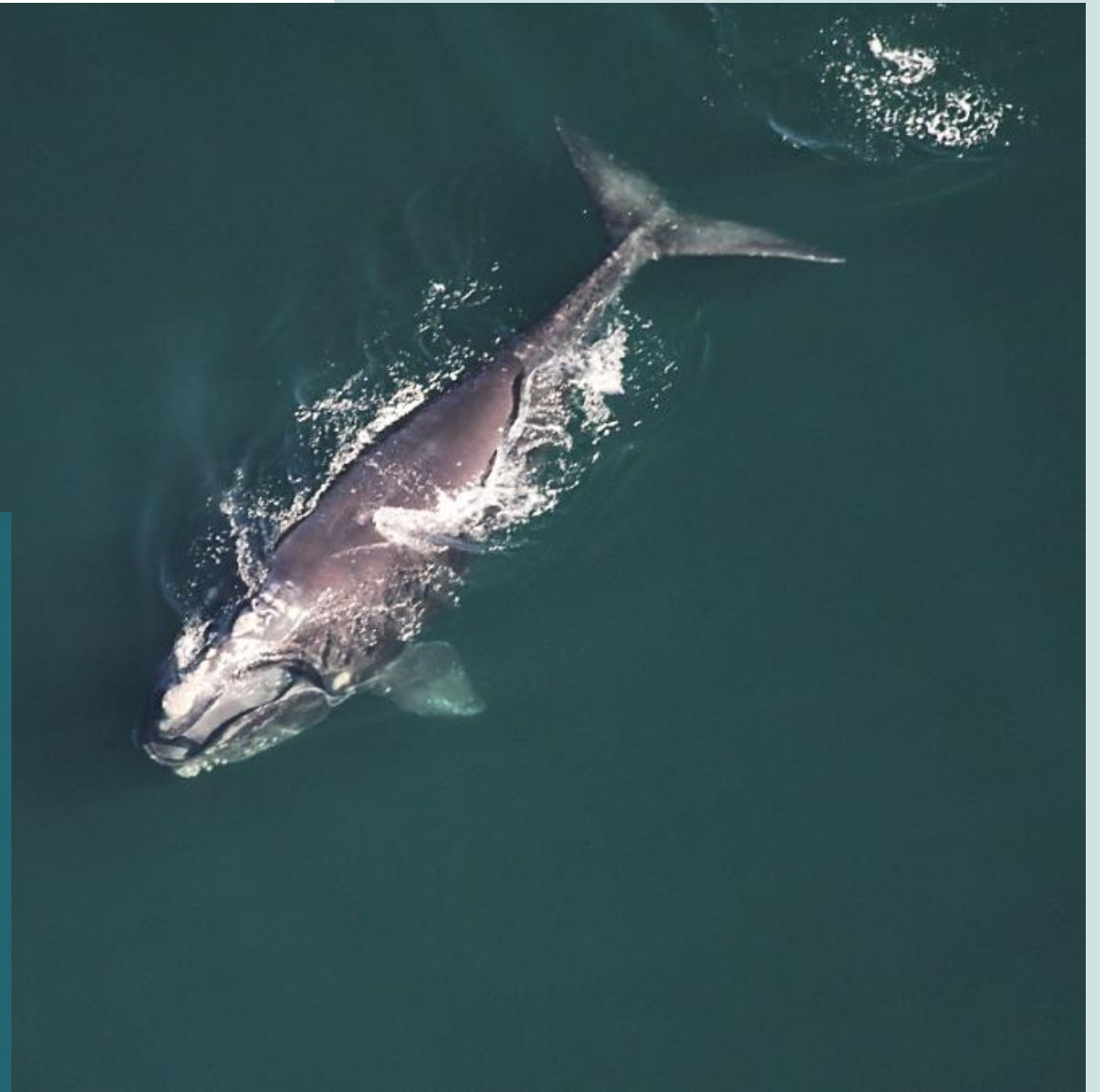


# smartWhales

SPACE-BASED DETECTION SYSTEM

**Towards near-real time automatic detection  
of whales from space in Canadian waters**

Beyond the Horizon Webinar  
October 29, 2024



Aerial photo of North Atlantic Right Whale, Catalog #4714, NARWC, 2019.

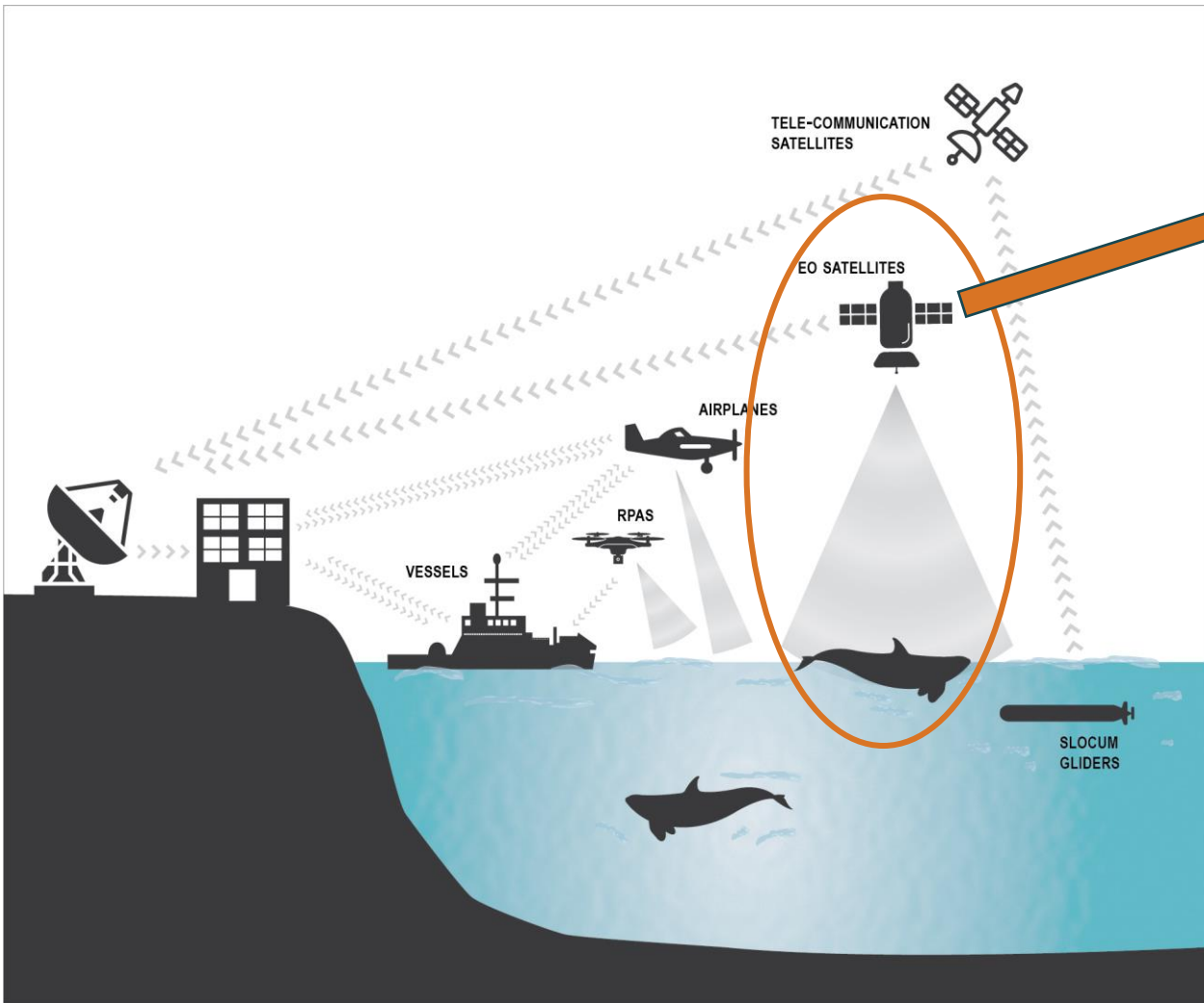
# North Atlantic right whales

About 336 left in the world

Recently changed migration patterns

Suffer entanglements and vessel strikes





Original graphic by Ocean Tracking Network

Satellite detections helps detect and monitor whales and compliments acoustic, aerial and ship-based detections

Whale Insight interface showing filters and summary statistics:

- Filter by date:** Past 14 days (selected), Current Month, Current Week, Today, Pick a date range
- Filter by species:** Show Right whales only, All whales
- Filter by calves sighted:** All (selected), Display calves only
- Filter by platform type:** Buoy, Plane, Vessel
- Filter detections by platform name:** [Dropdown menu]
- Filter by score/type:** Definite acoustic (selected), Definite visual
- Filter by number of whales:** 1, 2, 3+

**Summary Statistics:**

- Number of definite sighting events: 45
- Number of whales sighted: 59 (includes duplicates)
- Number of definite acoustic detections: 5
- Number of possible acoustic detections: 0
- Earliest observation: 5/18/2022, 8:37 AM (local time)

**Map:** Shows the Atlantic region with various sighting locations marked. Legend includes: Acoustic detections, Sighting events, Acoustic Survey Effort, Visual Survey Effort.

Version: 1.0.110 (published 2022-05-11)



# smartWhales Initiative

## CSA Funded

- Stream 1: Detection and Monitoring 2021-2024
- Stream 2: Prediction and Modelling



### TECHNICAL REPRESENTATIVES



Transport Canada

Transports Canada



Fisheries and Oceans Canada

Pêches et Océans Canada

Aerial photo of North Atlantic Right Whale, Catalog #4714, NARWC, 2019.

### LEAD



### PARTNERS



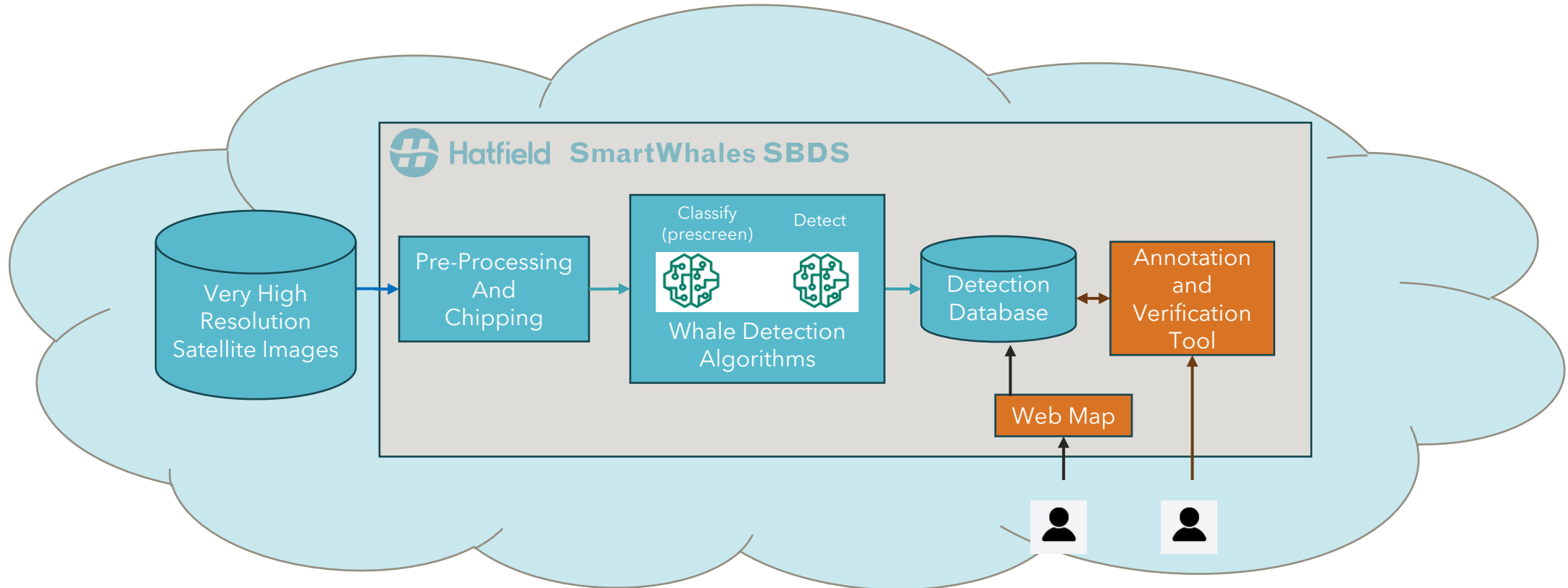
AltaML



CANADIAN WILDLIFE FEDERATION

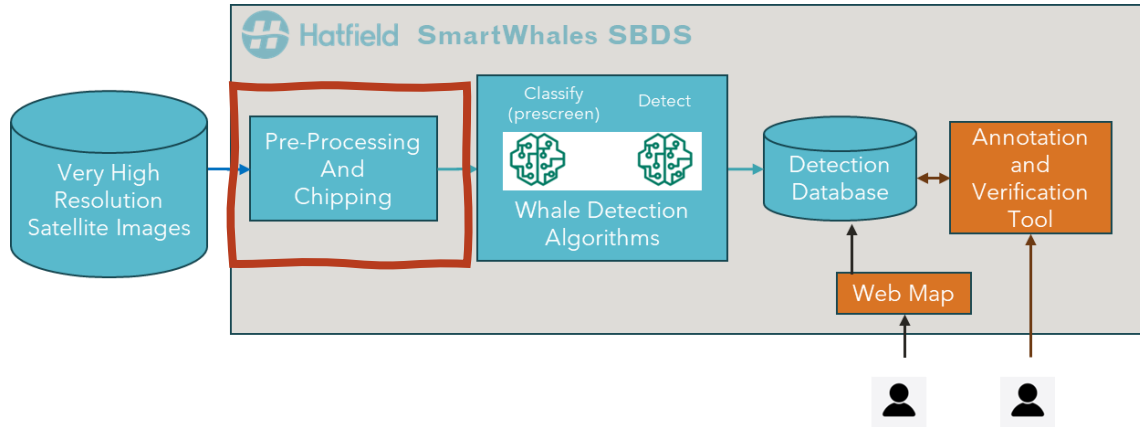


# SPACE-BASED DETECTION SYSTEM (SBDS)

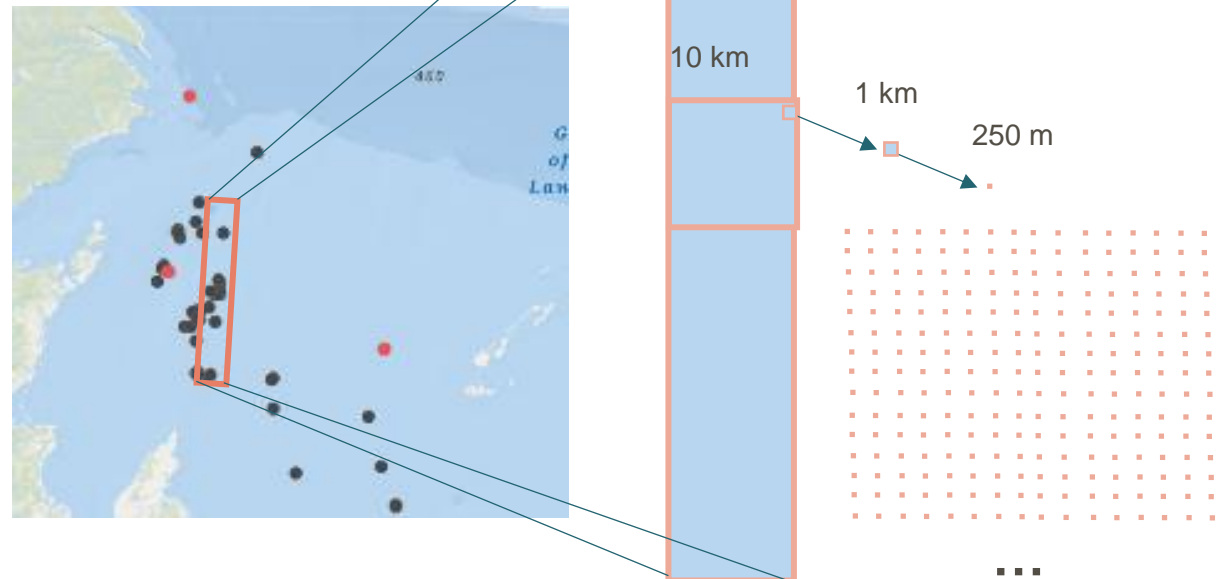
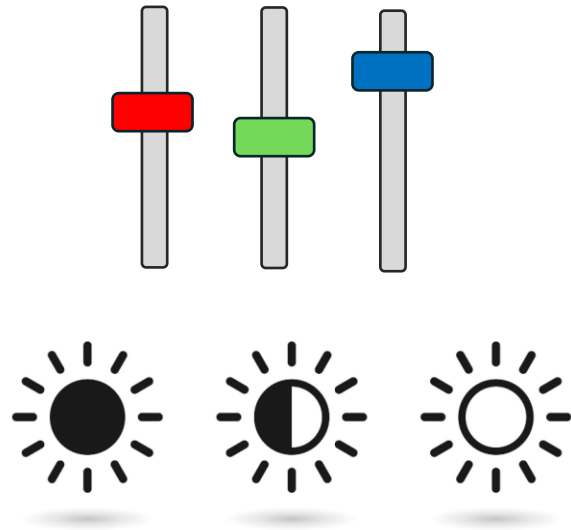


- **Develop a prototype cloud-based automated processing system for detection of whales in very-high-resolution (<0.5m) satellite data (with focus on NARW)**
- Develop AI approach for finding individual whales over vast areas under different conditions
- Perform a representative validation in application concept from end-to-end (unseen data)

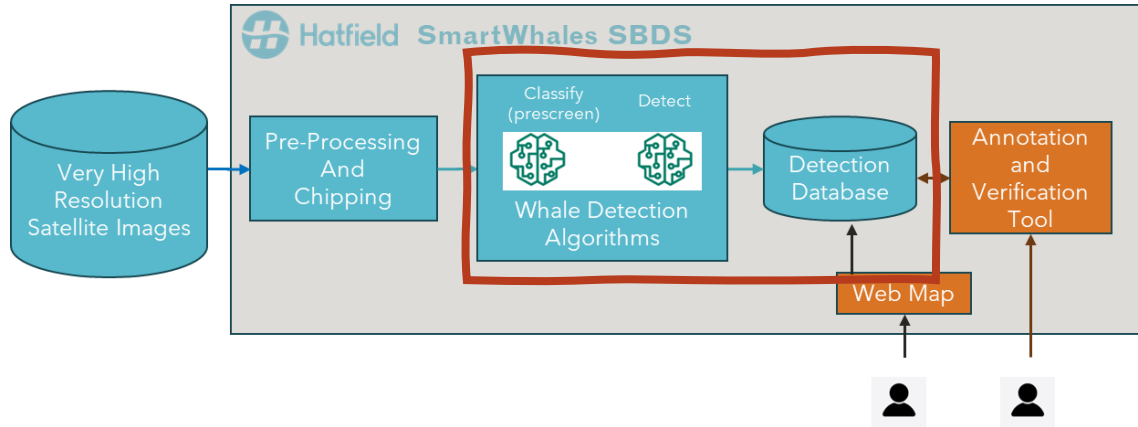
# SPACE-BASED DETECTION SYSTEM (SBDS)



## Pre-processing and chipping



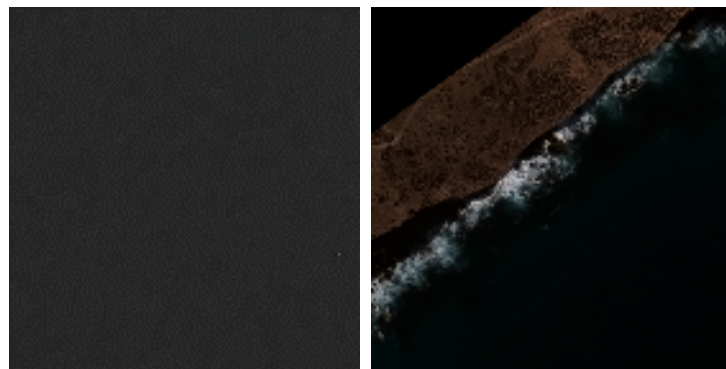
# SPACE-BASED DETECTION SYSTEM (SBDS)



## Whale Detection

AI Model 1: Pre-screen

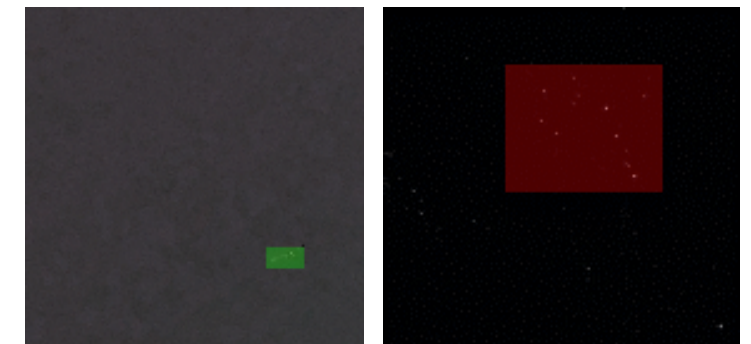
AI Model 2: Object Detection



NO OBJECTS OF INTEREST



POSSIBLE OBJECTS OF INTEREST

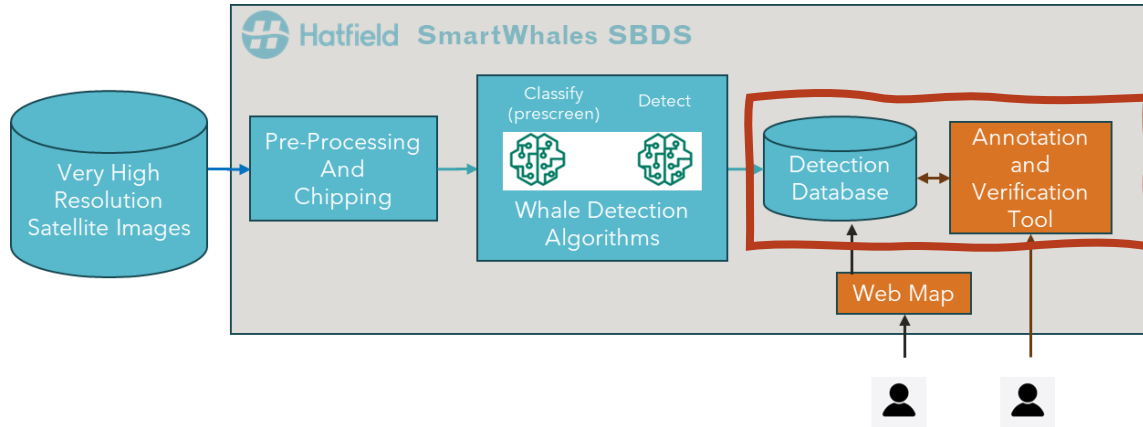


whale

ice



# SPACE-BASED DETECTION SYSTEM (SBDS)



## Human (MMO) Verification



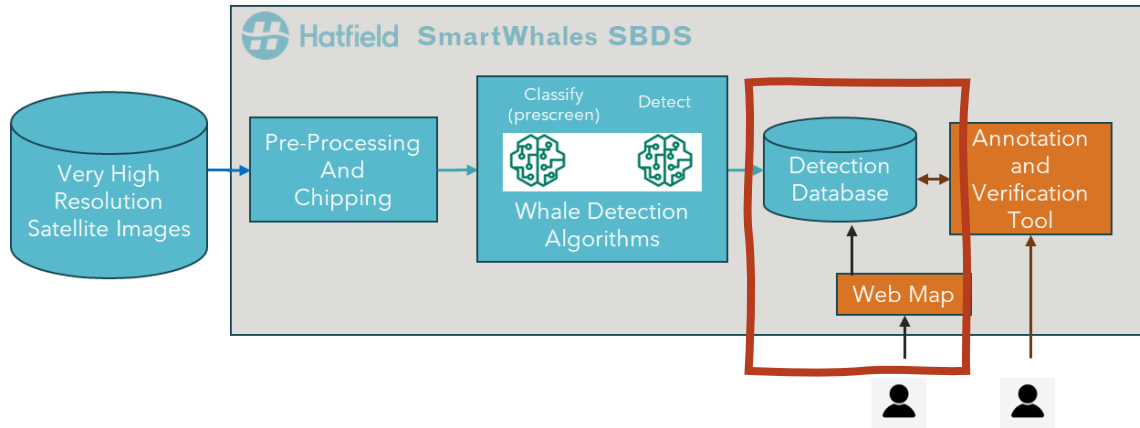
ID	Completed	Time	Lat	Long	Image
49985	Jan 15 2024, 20:15:35	1	0	1	
49986	Jan 15 2024, 20:15:47	1	0	1	
49987	Jan 15 2024, 20:15:56	1	0	1	
49988	Jan 15 2024, 20:15:58	1	0	1	
49989	Jan 15 2024, 20:16:00	1	0	1	
49990	Jan 15 2024, 20:16:02	1	0	1	
49991	Jan 15 2024, 20:16:04	1	0	1	
49992	Jan 15 2024, 20:16:05	1	0	1	
49993	Jan 15 2024, 20:16:07	1	0	1	
49994	Jan 15 2024, 20:16:09	1	0	1	
49995	Jan 15 2024, 20:16:11	1	0	1	
49996	Jan 15 2024, 20:16:29	1	0	1	
49997	Jan 15 2024, 20:16:32	1	0	1	



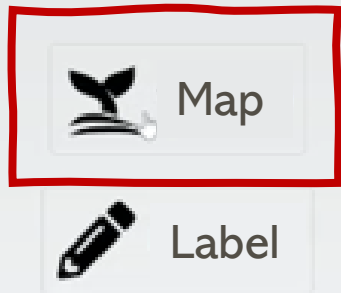
The screenshot shows the Label Studio web interface. The main view is a satellite image with a bounding box around a whale. The right sidebar shows 'Selection Details' for a 'whale' object, with 'Definite whale' selected. Below this, there are 'Regions' and 'Relations' tabs. At the bottom, there is a 'Submit' button and a 'Skip' button.



# SPACE-BASED DETECTION SYSTEM (SBDS)



## Interactive Web Map

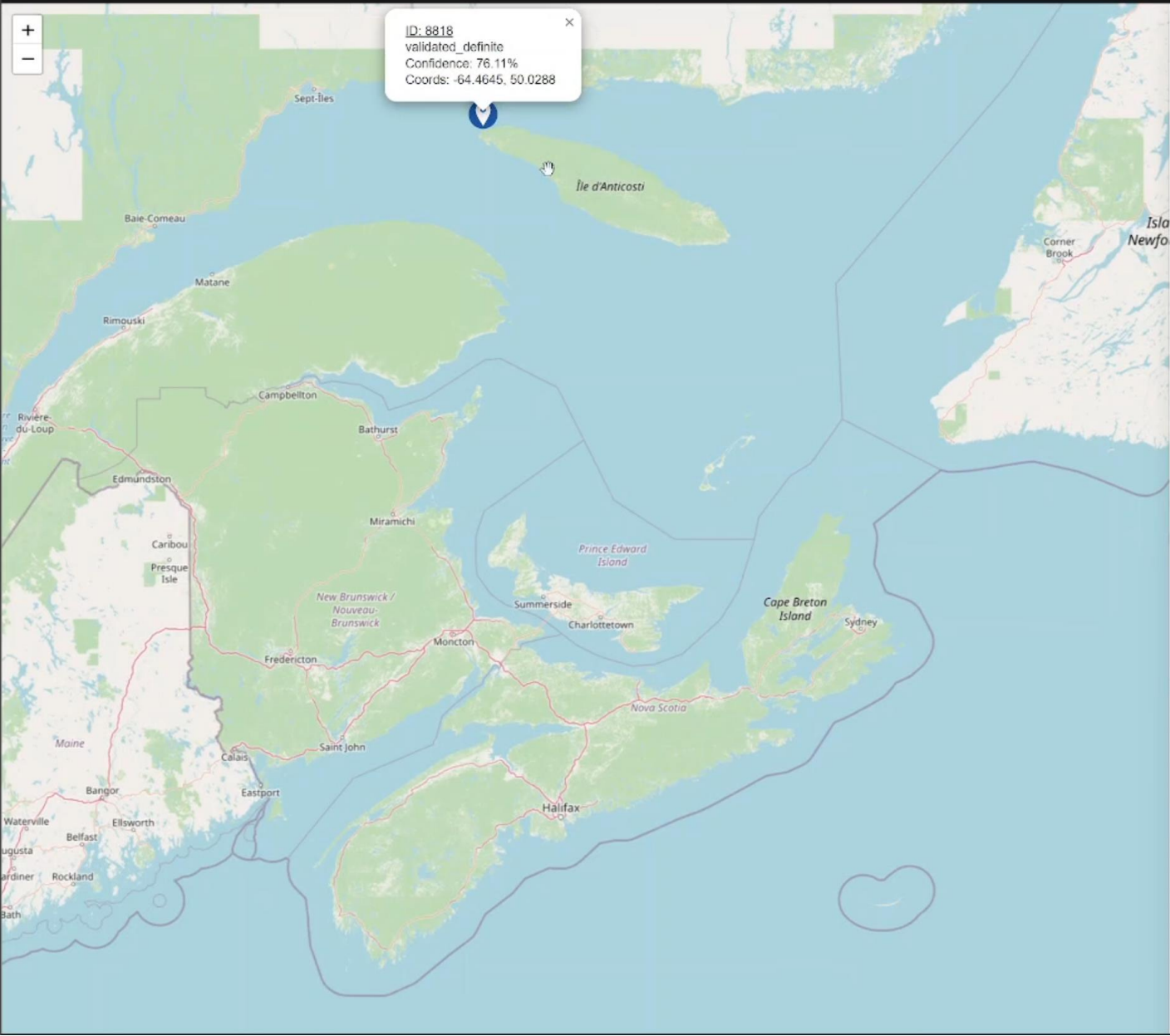


The screenshot shows the 'DataMap' interface. On the left is a map of the ocean with several blue location pins. A tooltip for ID 3338 is visible, showing 'validated\_definite' and 'Confidence: 94.07%'. On the right, there is a control panel with 'Start Date' (04/04/2023) and 'End Date' (04/05/2023) fields, a 'Fetch Data' button, and a table of whale detections.

ID	Confidence	Loc.
44921	0.4070	47.6646, -63.9396
3226	0.5105	41.8602, -70.3376
3322	0.8744	41.8609, -70.3467
3338	0.9407	41.8602, -70.3458
5729	0.6919	41.9532, -70.3909
5779	0.8940	41.9569, -70.3902
5838	0.8778	41.9811, -70.3863
5873	0.8382	41.9871, -70.3845
6136	0.8574	41.9176, -70.4089



Data Map



Start Date: 04/01/2023 📅 End Date: 09/30/2023 📅

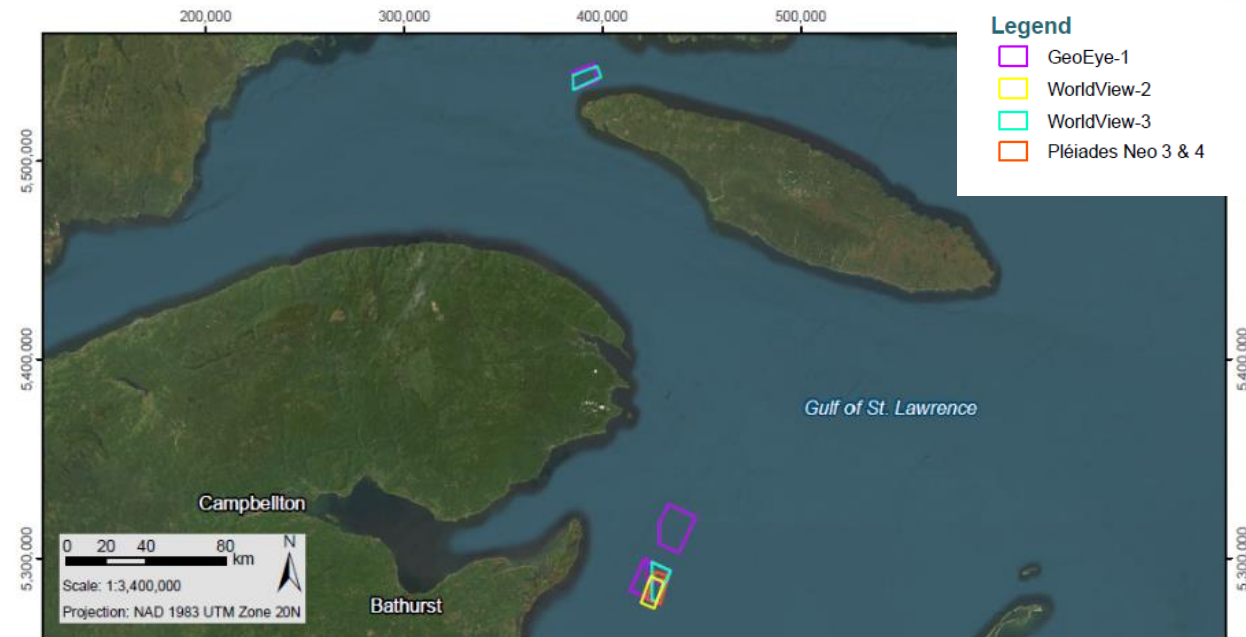
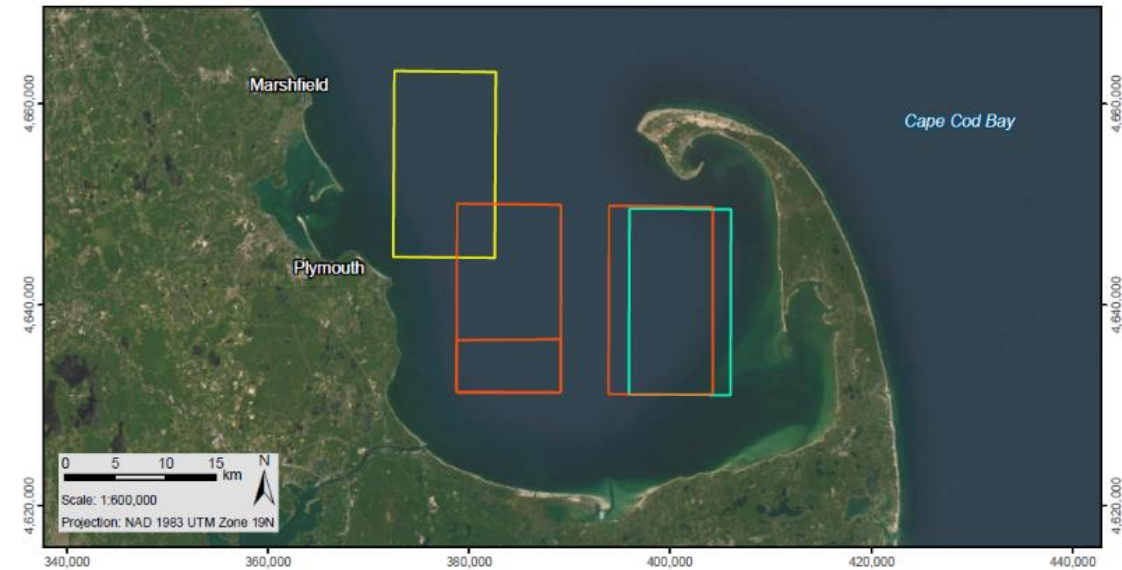
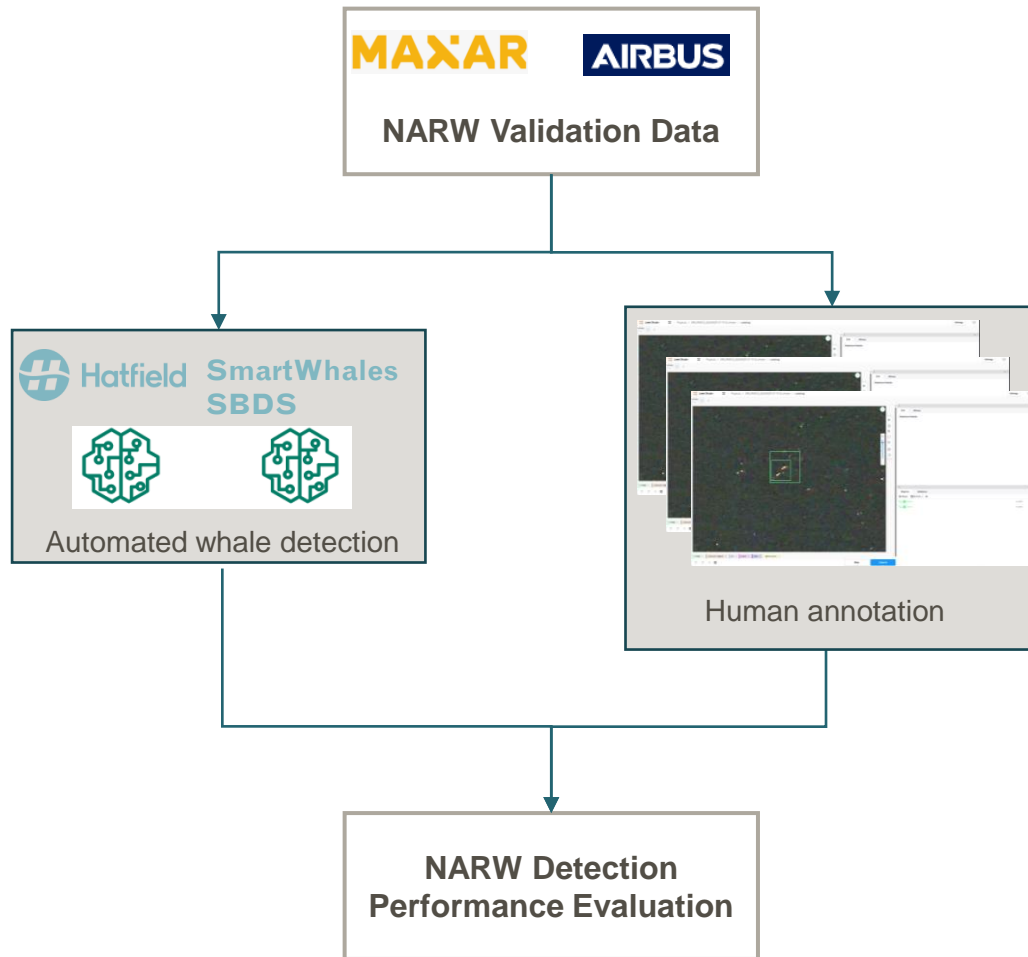
Detection Type: validated\_definite ▼

Fetch Detections

ID	Confidence	Loc.
3338	0.9407	41.8602, -70.3458
5729	0.6919	41.9532, -70.3909
5779	0.8949	41.9569, -70.3902
5838	0.8778	41.9811, -70.3863
4926	0.8646	41.8953, -70.4469
5483	0.9952	41.8991, -70.3606
4192	0.6635	41.8441, -70.3381
4423	0.9737	41.9430, -70.3918
5228	0.9643	41.8924, -70.4103

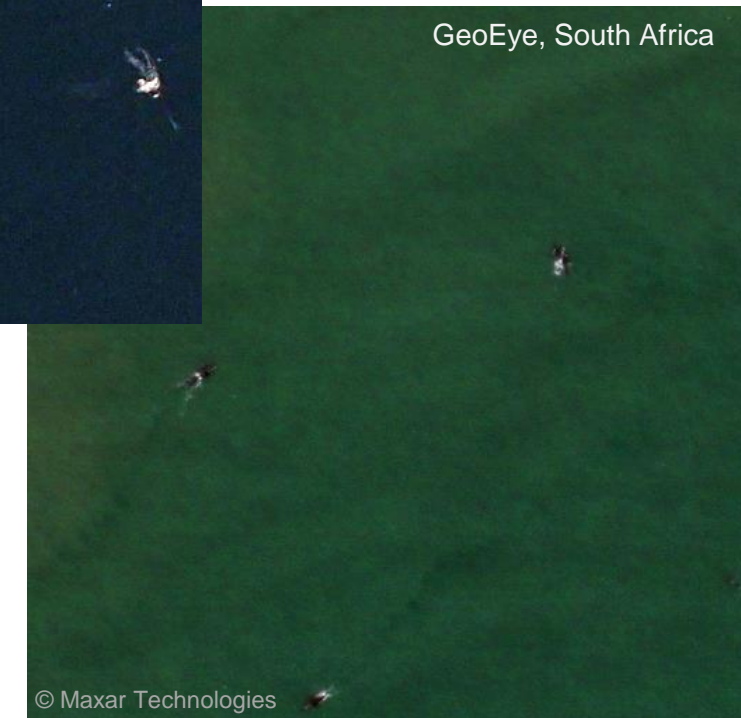


# PERFORMANCE VALIDATION

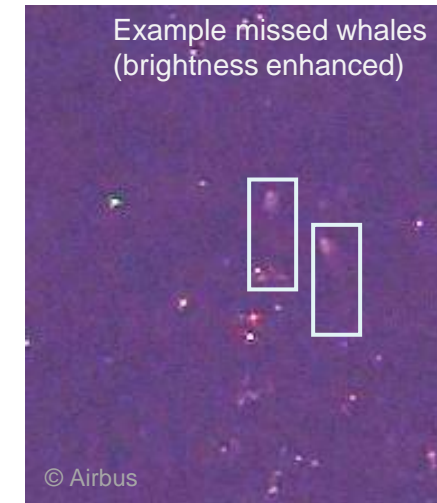
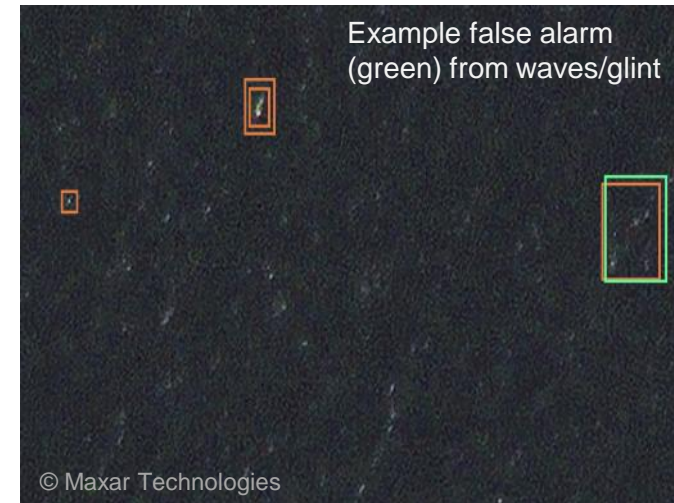
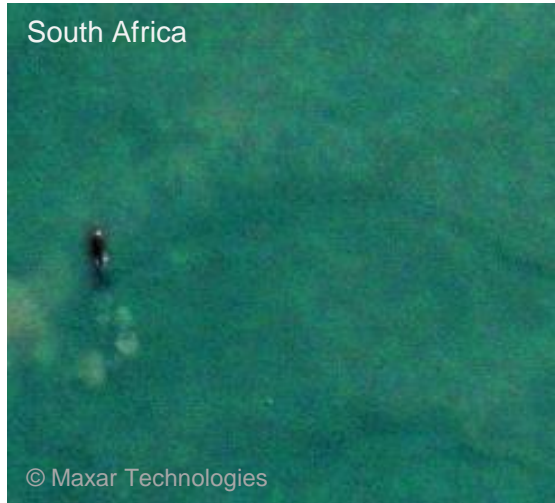


# HUMAN ANALYSIS

- **30,892** image chips validated
- **78** definite whales and **45** possible
- Definite whales:
  - 20 in Cape Cod Bay
  - 1 in the GoSL
  - 57 in South Africa
  - 3 of 5 Cape Cod Bay scenes
  - 1 of 12 GoSL scenes



# VALIDATION RESULTS



	NARW habitats (Canada/USA)		SRW habitat (South Africa)	
	Definite and Possible	Definite only	Definite and Possible	Definite only
Whales missed by SBDS	26%	24%	25%	14%
Whales from SBDS that human dismissed (false alarm)	80%	90% <sup>1</sup>	5%	16% <sup>1</sup>

Whales missed by SBDS

Whales from SBDS that human dismissed (false alarm)

Note: Publication in progress

1. Precision will be lower because the correctly detected possible whales are now considered false alarms

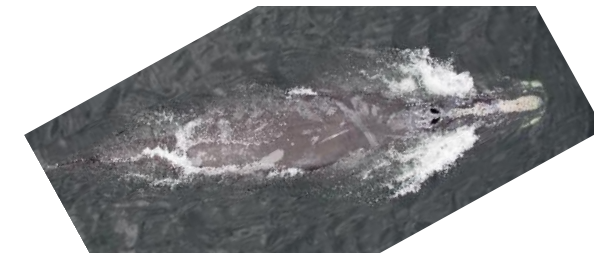


# VALIDATION RESULTS

- SBDS use results in **98% fewer chips for human verification**

- 479 out of 30,892 chips in this validation
- E.g. 258 hours vs. 4 hours if avg 30 sec/chip

- SBDS found **75% of the whales** found by human validators



NARW Drone data (UNB)

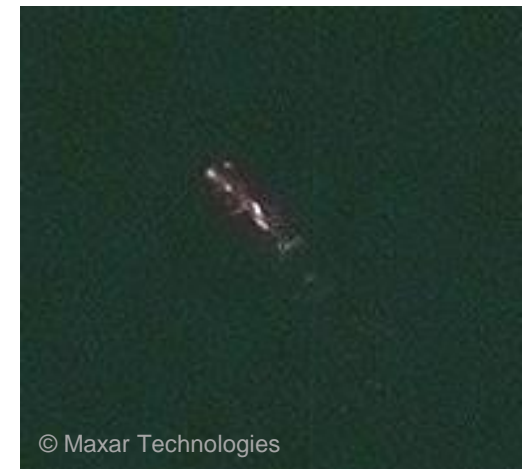


NARW Drone data (UNB)  
NMFS Permit No. 21371



# SUMMARY

- Current state: prototype whale detection system with fast scalable processing in the cloud
  - 10-20 min for 100km<sup>2</sup> (not optimized)
- Can support current monitoring methods to gain more insights
  - Continued analysis of known aggregation areas
  - Rarely or irregularly surveyed areas





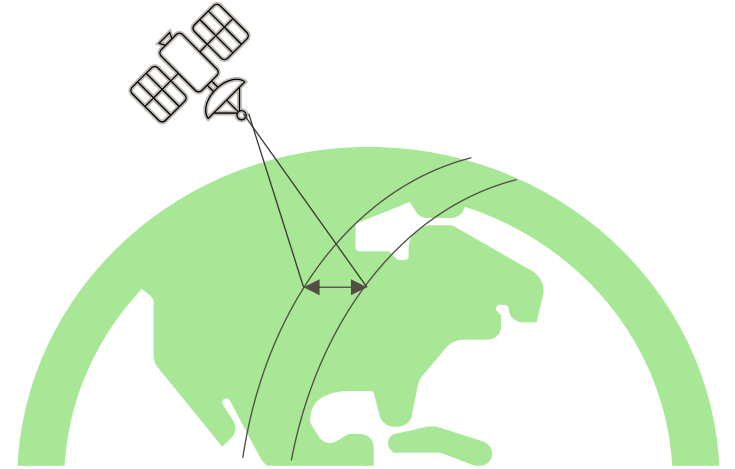
# TOWARDS NEAR-REAL TIME AUTOMATIC DETECTION

- Challenges in data collection and latency
- Challenges in system accuracy



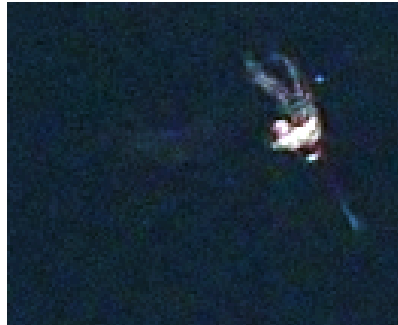
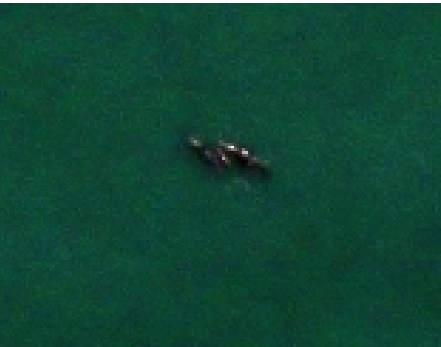
# CHALLENGE: DATA COLLECTION

- Satellite availability:
  - Time of day
  - Desired day
- Data delivery latency
  - Currently with Pleiades NEO - “Just a few hours” after image acquisition
- Coverage (swath)
- Cost



Sensor	Resolution (GSD)	Swath	Approx. Time of day (local)
WorldView-2	50 cm	16.4 km	10:30 am
WorldView-3	30 cm	13 km	10:30 am
Legion <i>(4 new + 2 anticipated)</i>	29 cm	9 km	Various
Pleiades	50 cm	20 km	10:30 am
<b>Pleiades Neo</b>	30 cm	14 km	10:30 am
Kompsat-3A	55 cm	13 km	1:30 pm
<i>Clarity-1 (anticipated 2025)</i>	10 cm	TBA	TBA (fixed)
<i>SpaceEye-T (anticipated 2025)</i>	30 cm	14 km	TBA

# CHALLENGE: APPEARANCE AND NO. OF SAMPLES



Possible



# CHALLENGE: VARYING WATER CONDITIONS

Good

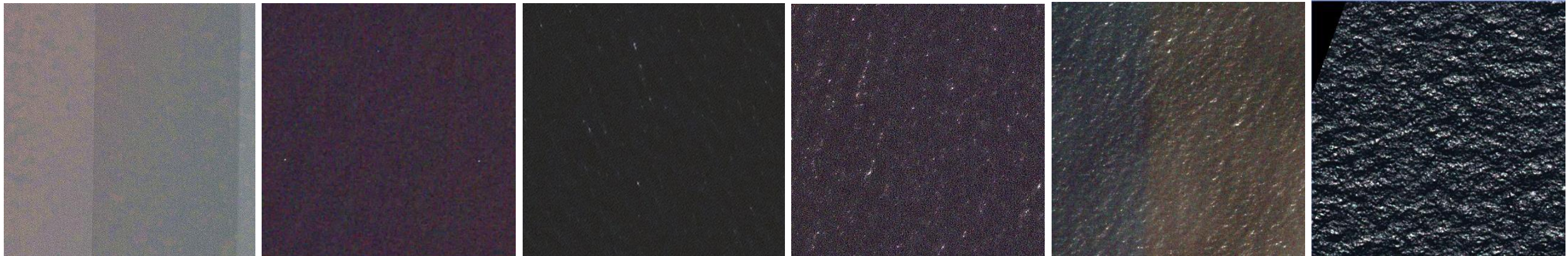
Moderate

Average

Sub-Average

Poor

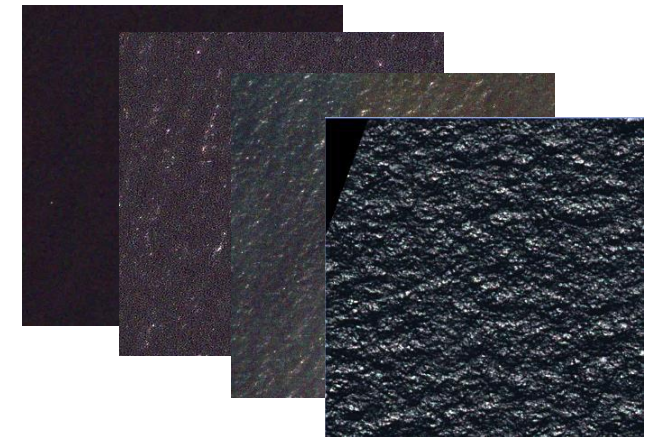
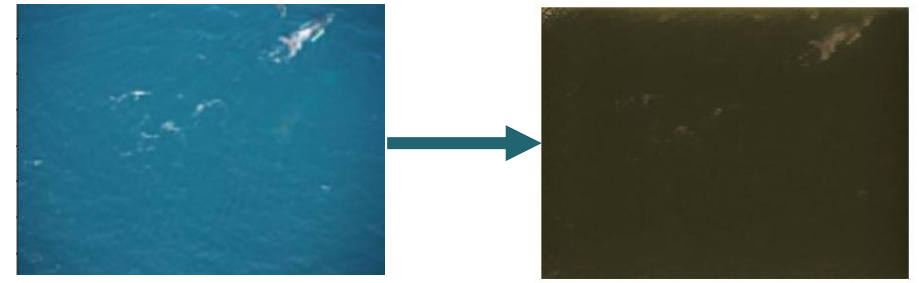
Very Poor



- Unsure what whales look like in sub-average to very poor (no examples yet)
- From tasked data, most scenes in Gulf of St. Lawrence were average to poor

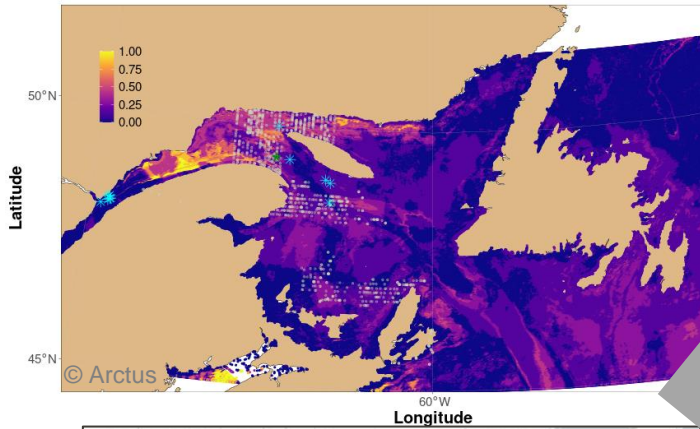
# LOOKING FORWARD

- Appearance and no. of samples
  - Leverage aerial imagery + generative AI
  - Species-level detections
  - New locations: Pacific (Canada)
- Water variations
  - Further R&D into detection limits
- Data Collection
  - New technologies and advances within satellite industry

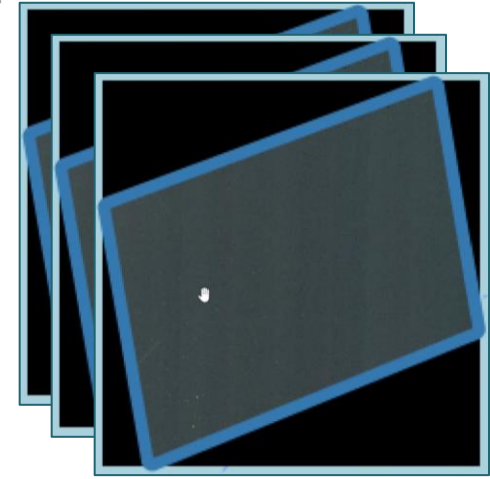
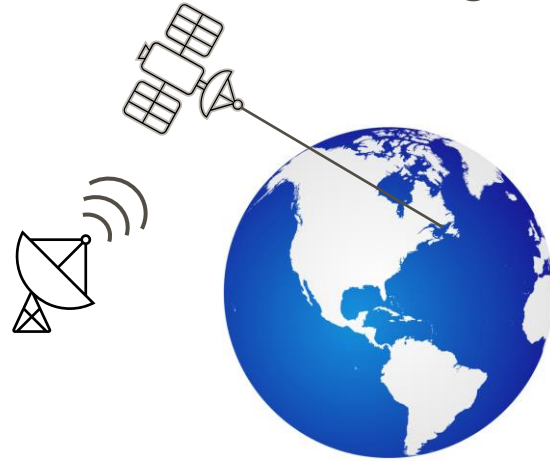


# LOOKING FORWARD

## Predictive modeling



## Tasking



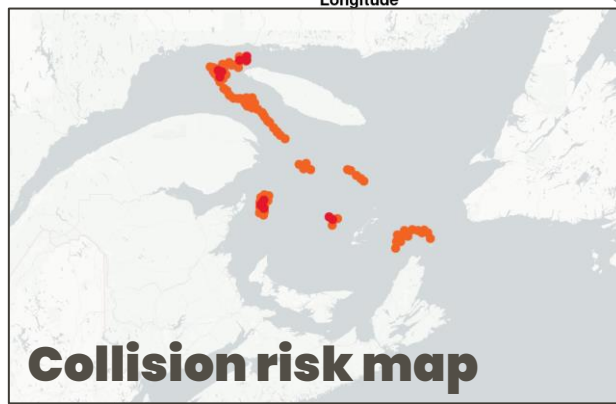
## Automated detections

Hatfield SmartWhales SBDS

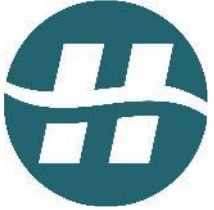
ID	Confidence	Loc.
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3226	0.5105	41.8602, -70.1376
3322	0.8744	41.8608, -70.3467
3338	0.5407	41.8602, -70.3458
5723	0.6915	41.0512, -70.3908
5779	0.8949	41.9568, -70.3902

**Updated risk**

**Other detections**



# ACKNOWLEDGEMENTS



## Hatfield Consultants

**Olivier Tsui:** Project Director

**Anne Webster:** Project Manager and Remote Sensing Specialist

**Benjamin Smith:** Platform Developer



## AltaML

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**Harsh Sharma:** AI Development Lead

**Colby Armstrong:** Infrastructure and Platform Developer

**Bruce Nie:** Junior AI Developer



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**Gina Lonati:** PhD Candidate & RPAS Pilot

**Cody Carlyle:** PhD Candidate



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**Dr. David Johnston:** RPAS and Remote Sensing Science Lead

**Cristiana Falvo:** Research Technician

**Rebecca Edgell:** Research Technician



## Can. Wildlife Federation

**Dr. Sean Brilliant:** Senior Conservation Biologist



Fisheries and Oceans Canada / Pêches et Océans Canada



Transport Canada / Transports Canada



# smartWhales

SPACE-BASED DETECTION SYSTEM

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