Acoustic detection and classification of killer whales with deep neural networks

Sadman Sakib

Deep Learning Developer

MERIDIAN, Institute for Big Data Analytics, Dalhousie University, Halifax, Canada

Brief outline

Introduction to Machine Learning and Deep Neural Networks

Deep learning in marine bioacoustics

The HALLO project

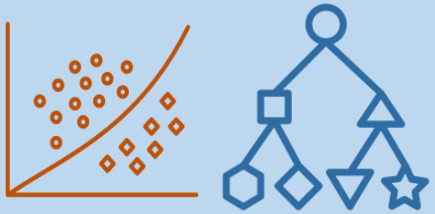
Machine Learning (ML) and Deep Learning (DL)

Artificial Intelligence (AI)

Any technique that enables machine to mimic human intelligence through programs, logic, statistical methods, neural networks, etc.

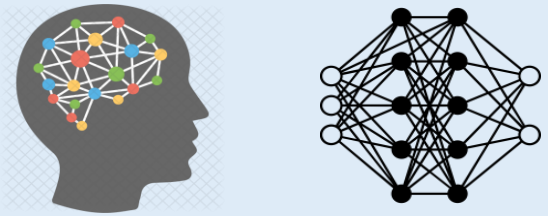
Machine Learning (ML)

A subset of AI that includes statistical techniques that enables machine to learn without being explicitly programmed.



Deep Learning (DL)

A subset of ML leverages artificial deep neural networks to learn from vast amounts of data by simulating the structure of human cells.

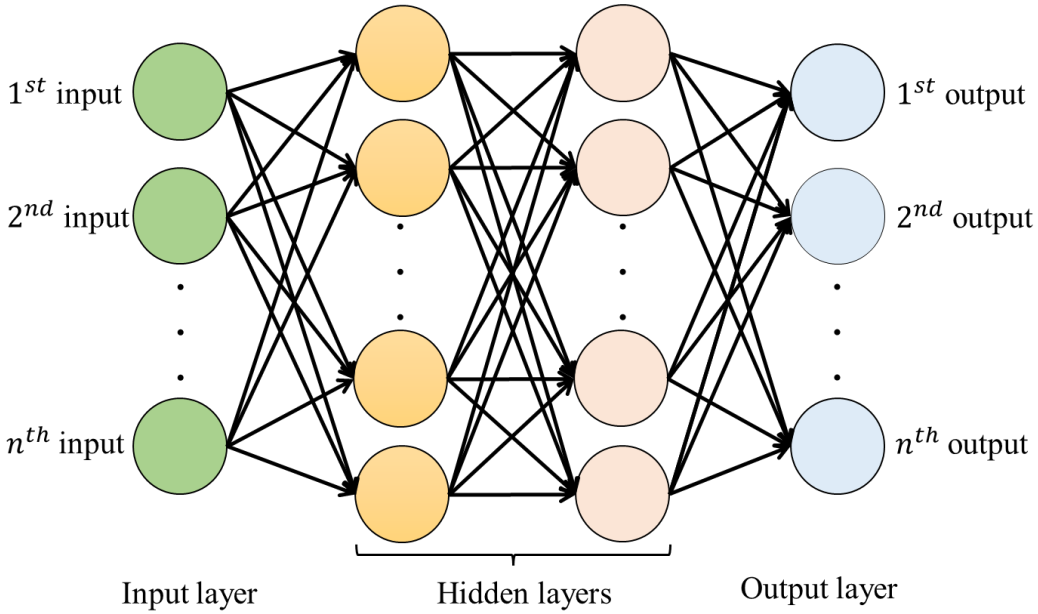


Supervised Learning	Labeled data Direct feedback Predict outcome/future
Unsupervised Learning	No labels No feedback Find hidden structure in data
Reinforcement Learning	Decision process Reward system Learn series of actions

SUPERVISED LEARNING | UNSUPERVISED LEARNING | REINFORCEMENT LEARNING

Introduction to Deep Neural Network

- A **deep neural network (DNN)** is an artificial neural network (ANN) with **various layers** between the input and output layers. There are different types of neural networks, but they always consist of the same components: **neurons, synapses, weights, biases, and functions**.
- Deep learning is an approach to **machine learning** that utilizes **deep neural networks**



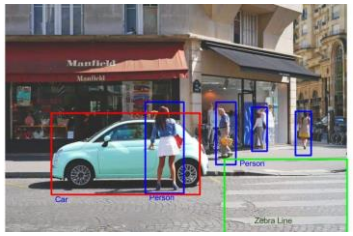
Everyday applications:

Speech recognition & audio processing

Natural Language Processing

Self driving car

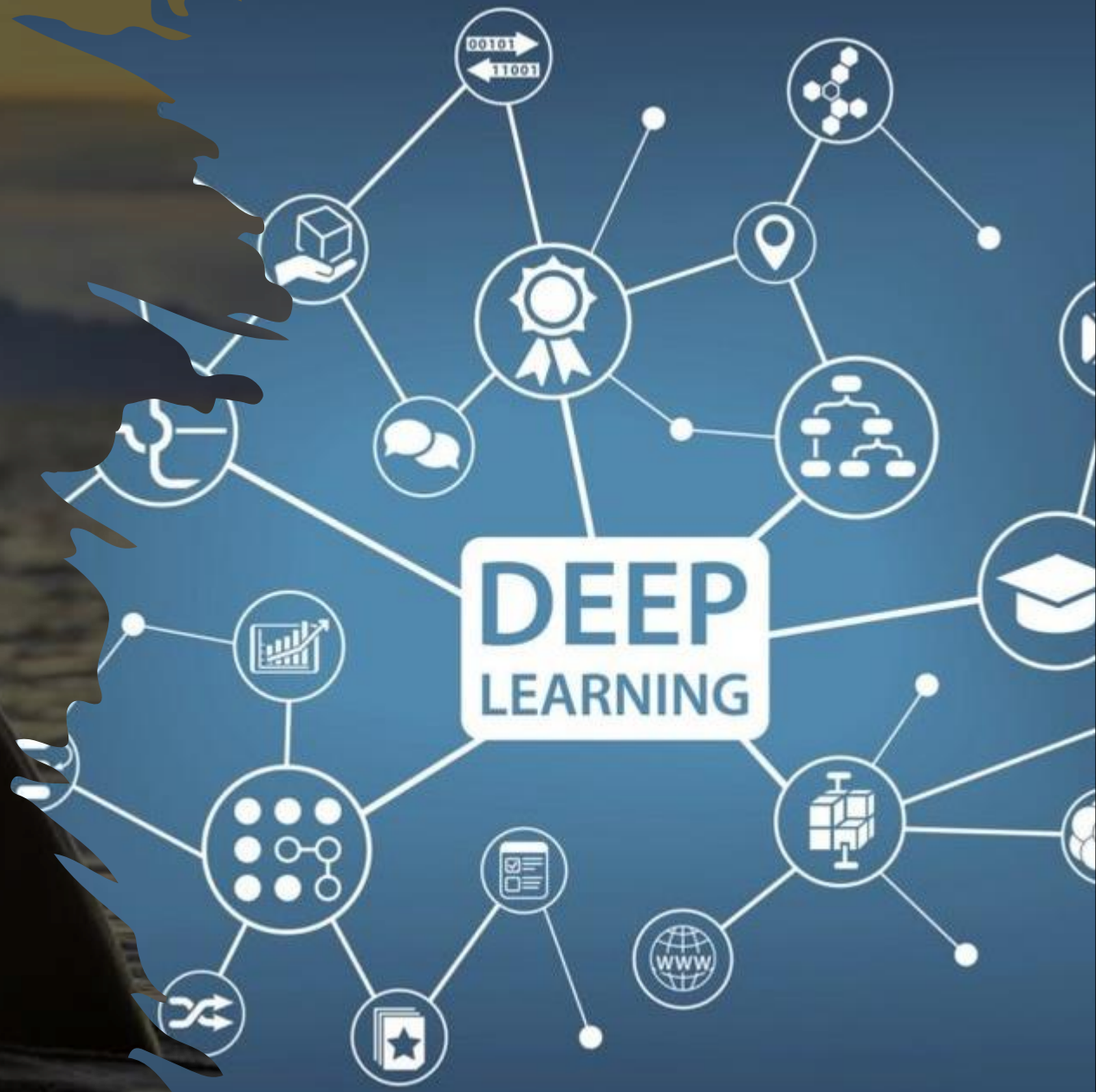
Object detection



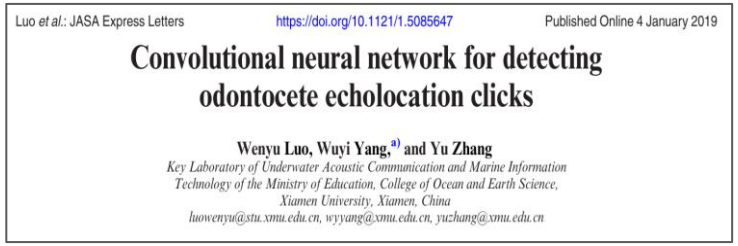
Healthcare

Bioinformatics

Deep learning in marine bioacoustics



Some existing works

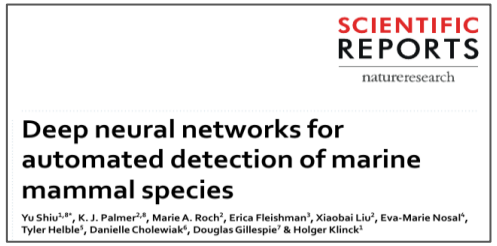

Luo *et al.*: JASA Express Letters https://doi.org/10.1121/1.5085647 Published Online 4 January 2019

Convolutional neural network for detecting odontocete echolocation clicks

Wenyu Luo, Wuyi Yang,[a] and Yu Zhang

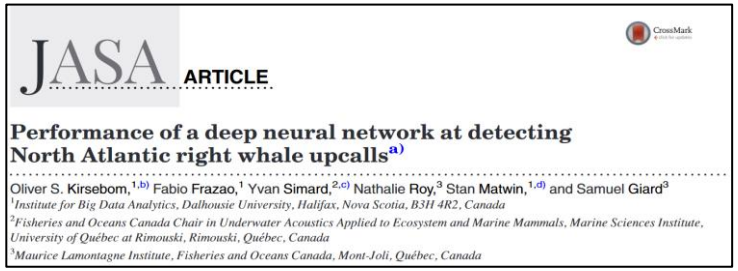
Key Laboratory of Underwater Acoustic Communication and Marine Information Technology of the Ministry of Education, College of Ocean and Earth Science, Xiamen University, Xiamen, China

luowenyu@stu.xmu.edu.cn, wyyang@xmu.edu.cn, yuzhang@xmu.edu.cn


SCIENTIFIC REPORTS
nature research

Deep neural networks for automated detection of marine mammal species

Yu Shiu[1,8*], K. J. Palmer[2,8], Marie A. Roch[2], Erica Fleishman[3], Xiaobai Liu[2], Eva-Marie Nosal[4], Tyler Helble[5], Danielle Cholewiak[6], Douglas Gillespie[7] & Holger Klinck[1]


JASA ARTICLE

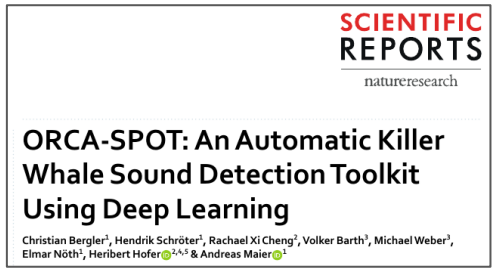
Performance of a deep neural network at detecting North Atlantic right whale upcalls[a)]

Oliver S. Kirsebom,[1,b)] Fabio Frazao,[1] Yvan Simard,[2,c)] Nathalie Roy,[3] Stan Matwin,[1,d)] and Samuel Giard[3]

[1]*Institute for Big Data Analytics, Dalhousie University, Halifax, Nova Scotia, B3H 4R2, Canada*

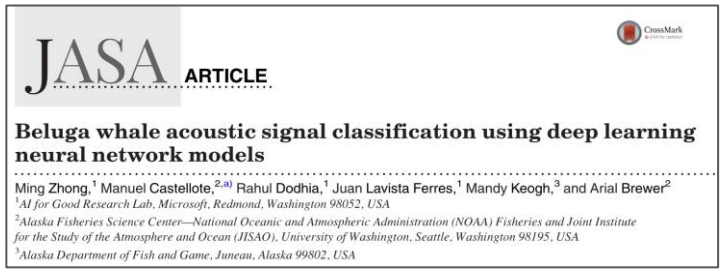
[2]*Fisheries and Oceans Canada Chair in Underwater Acoustics Applied to Ecosystem and Marine Mammals, Marine Sciences Institute, University of Québec at Rimouski, Rimouski, Québec, Canada*

[3]*Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, Québec, Canada*


SCIENTIFIC REPORTS
nature research

ORCA-SPOT: An Automatic Killer Whale Sound Detection Toolkit Using Deep Learning

Christian Bergler[1], Hendrik Schröter[1], Rachael Xi Cheng[2], Volker Barth[3], Michael Weber[3], Elmar Nöth[1], Heribert Hofer[2,4,5] & Andreas Maier[1]


JASA ARTICLE

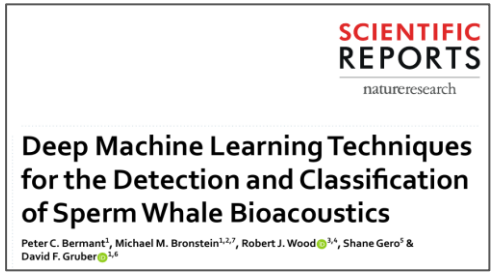
Beluga whale acoustic signal classification using deep learning neural network models

Ming Zhong,[1] Manuel Castellote,[2,a)] Rahul Dodhia,[1] Juan Lavista Ferres,[1] Mandy Keogh,[3] and Arial Brewer[2]

[1]*AI for Good Research Lab, Microsoft, Redmond, Washington 98052, USA*

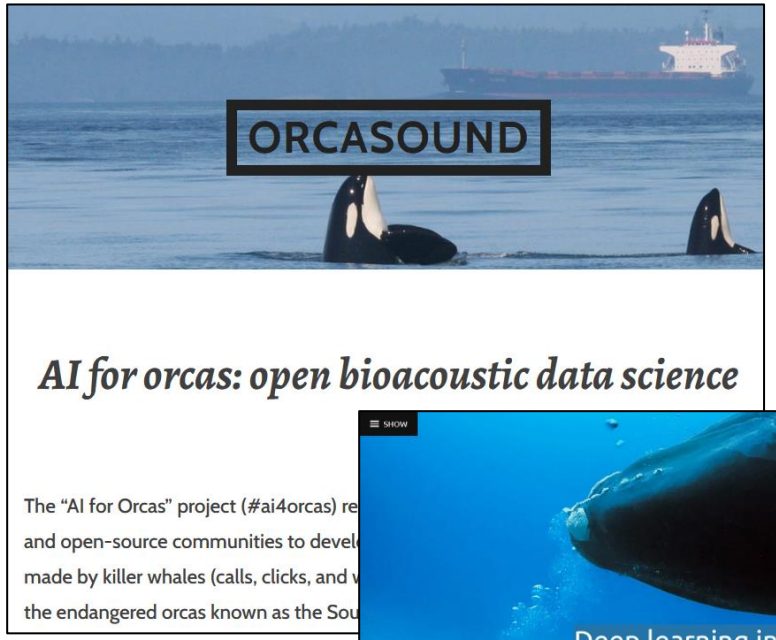
[2]*Alaska Fisheries Science Center—National Oceanic and Atmospheric Administration (NOAA) Fisheries and Joint Institute for the Study of the Atmosphere and Ocean (JISAO), University of Washington, Seattle, Washington 98195, USA*

[3]*Alaska Department of Fish and Game, Juneau, Alaska 99802, USA*


SCIENTIFIC REPORTS
nature research

Deep Machine Learning Techniques for the Detection and Classification of Sperm Whale Bioacoustics

Peter C. Bermant[1], Michael M. Bronstein[1,2,7], Robert J. Wood[3,4], Shane Gero[5] & David F. Gruber[1,6]



AI for orcas: open bioacoustic data science

The "AI for Orcas" project (#ai4orcas) re
and open-source communities to devel
made by killer whales (calls, clicks, and
the endangered orcas known as the Sou

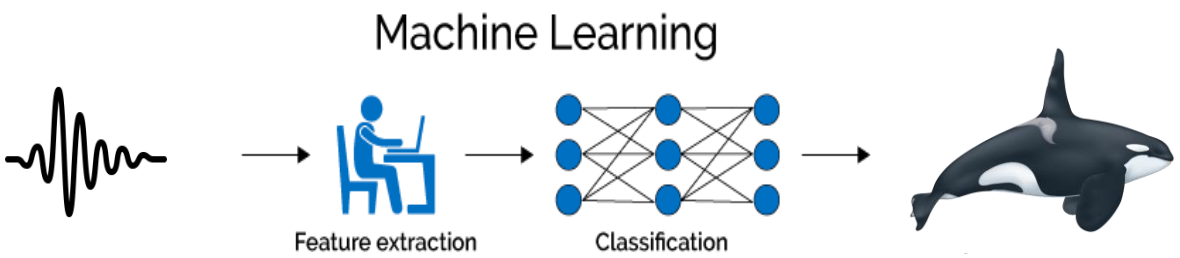
Deep learning works!

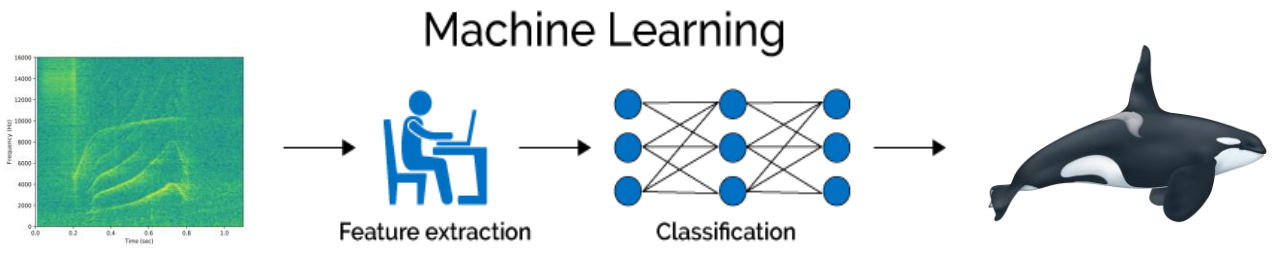
It's time to design more robust DL model and build software tools that makes deep learning accessible to researchers and conservationists.

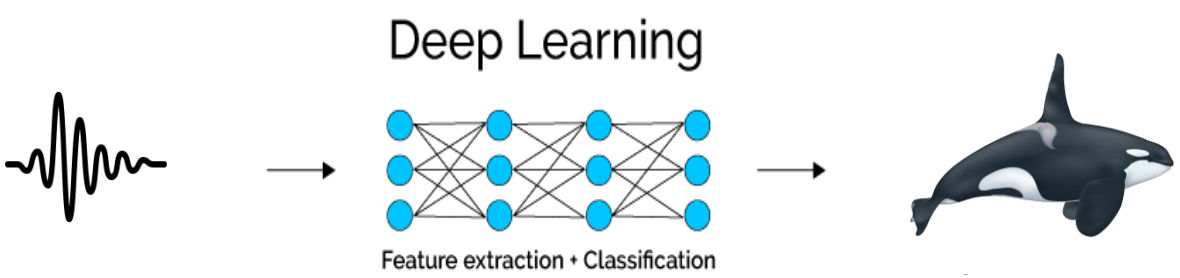
Why Deep Learning for Passive Acoustic Monitoring?

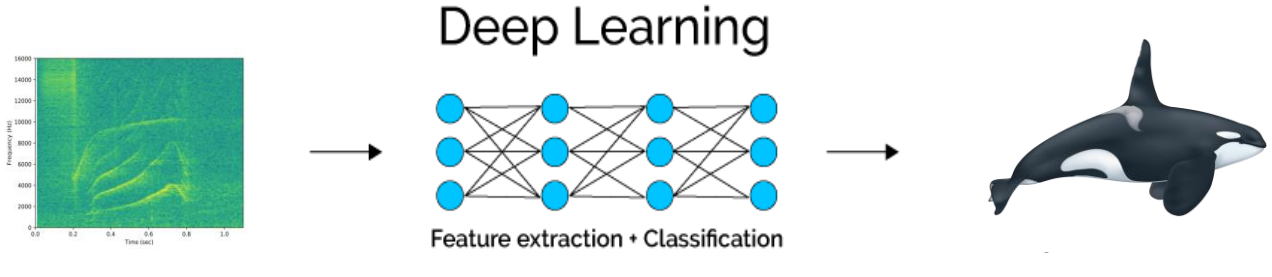
- **Real-time or near real-time detection** of killer whales are needed to **protect endangered species**.
- **Manual or semi-manual validation** of data might have been an option but with such vast amount of data, this is **no longer feasible**.
- **Robust automated DL-based monitoring system** is needed to **improve the performance of the software**.
- **Trained deep learning models are easily scalable.** It also **increases in performance with the more training data**, making it viable for Big Data from numerous hydrophones.

How to utilize Deep Learning for Passive Acoustic Monitoring?









Deep learning techniques **do not require additional feature extraction** from data.
Both feature extraction and classification is done within the neural networks of the DL model.

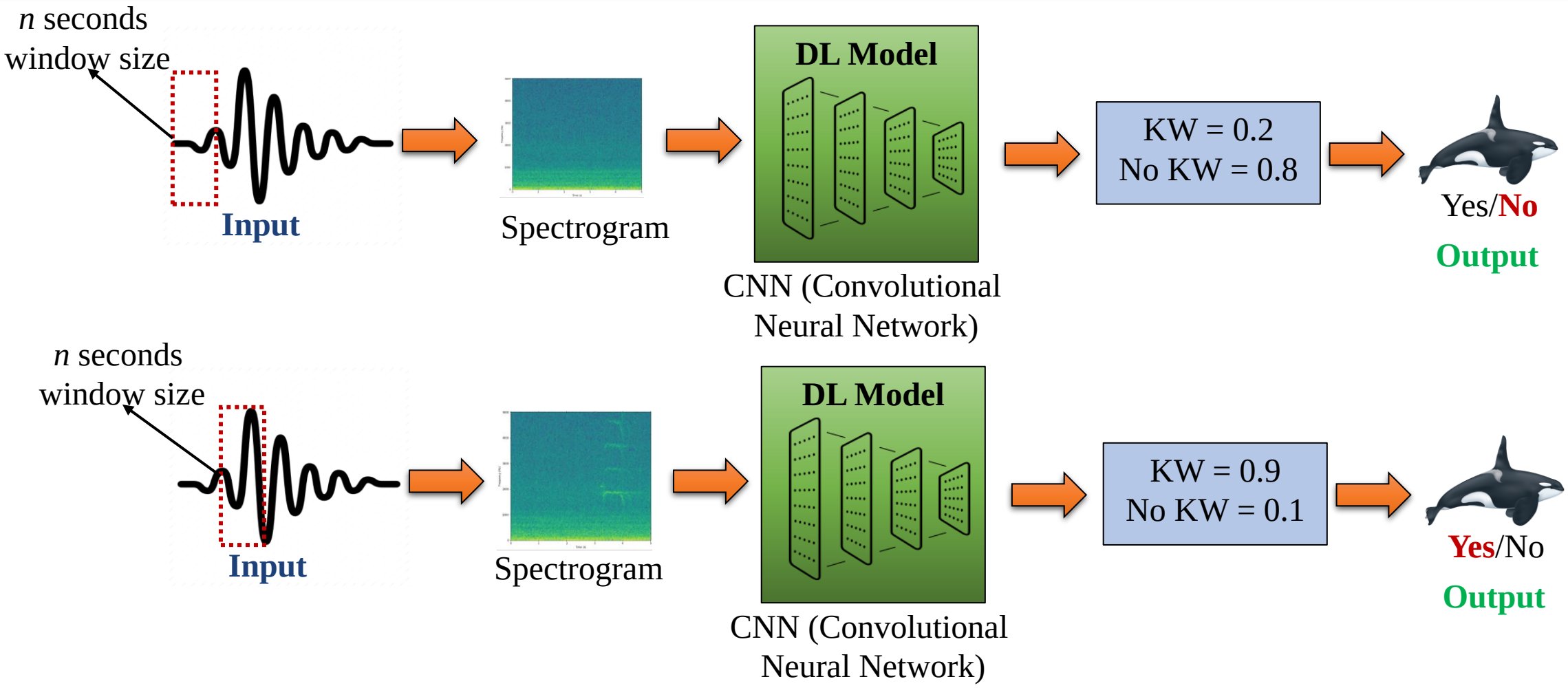
The HALLO project

HALLO goals

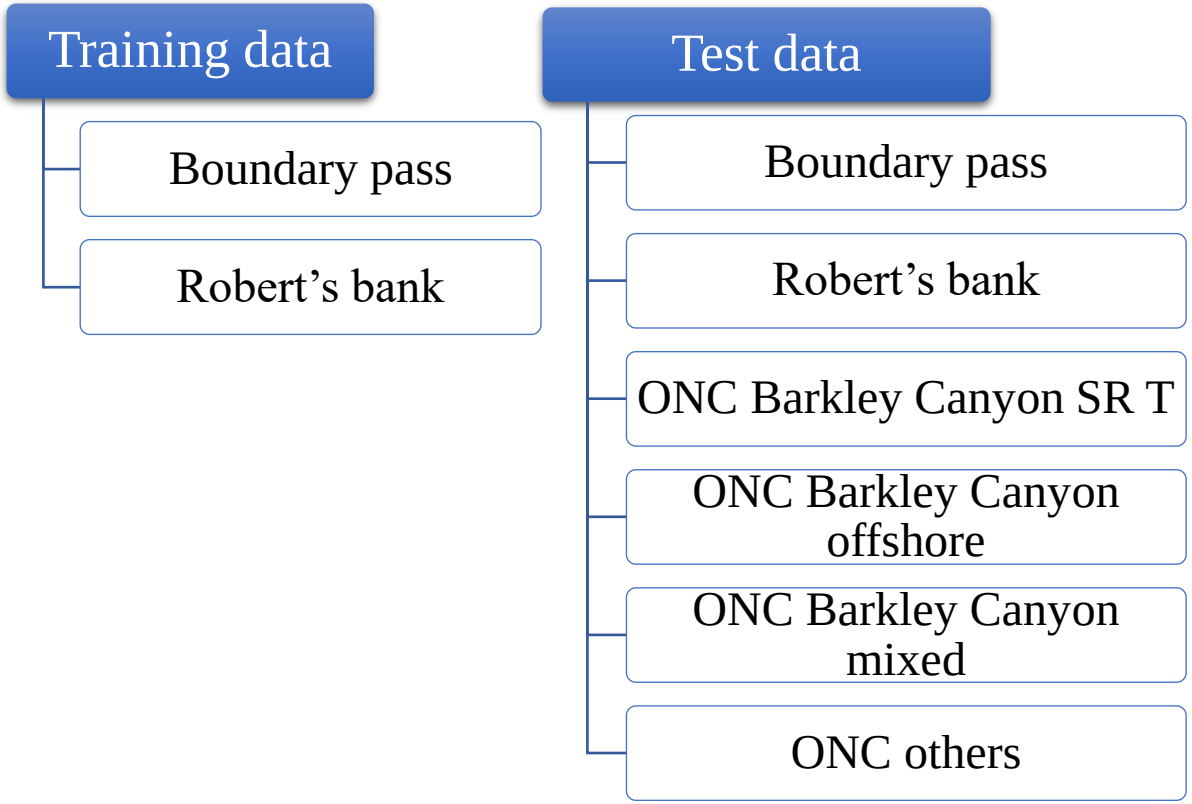
- **HALLO = Humans and ALgorithms Listening for Orcas**
- Multi-institutional & multi-disciplinary team
- Goal is to develop **deep learning software for detecting and classifying the vocalizations of Killer Whales** (especially Southern Residents Killer Whales) to support researchers and conservationists.
- Employ standard CNN architectures (i.e., DenseNet) to **achieve high accuracy in classification of KW sounds**, surpassing existing algorithms.
- DL models developed using the **Ketos** framework developed by MERIDIAN team

- Marine bioacousticians
- Data scientists
- Deep learning experts
- Data managers
- Software developers
- System administrators

Use of Deep Learning in the HALLO project



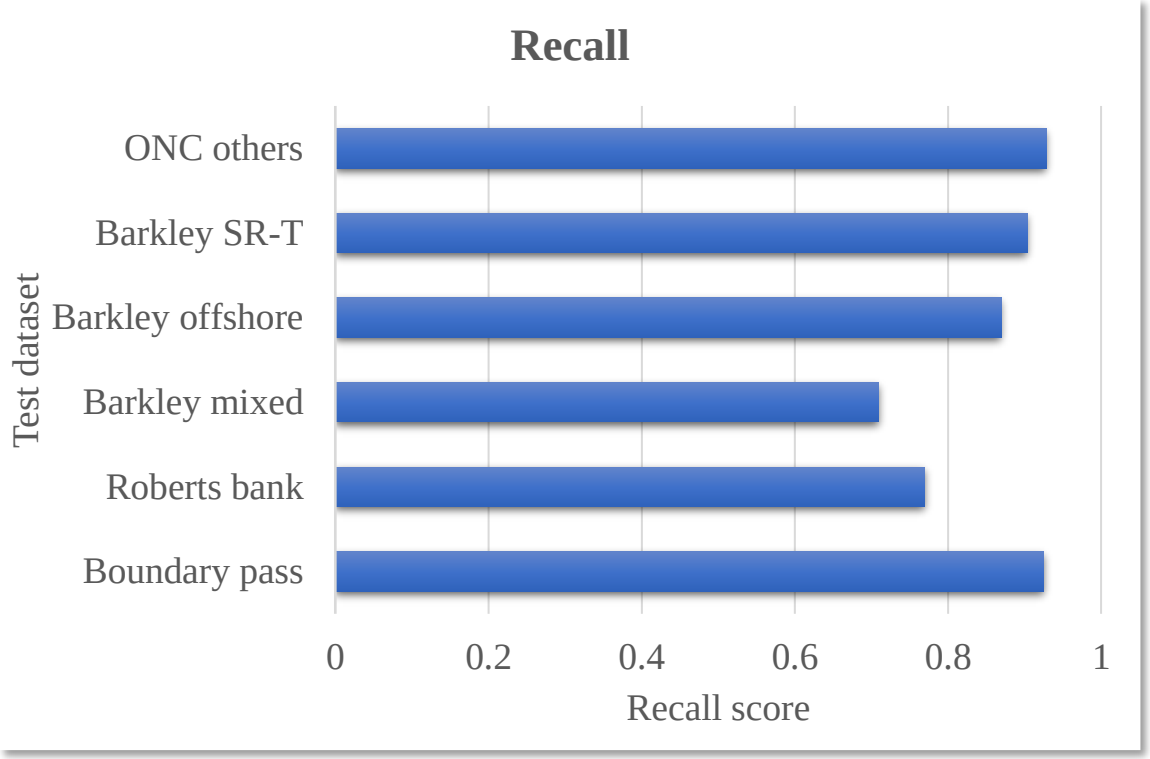
Data sources

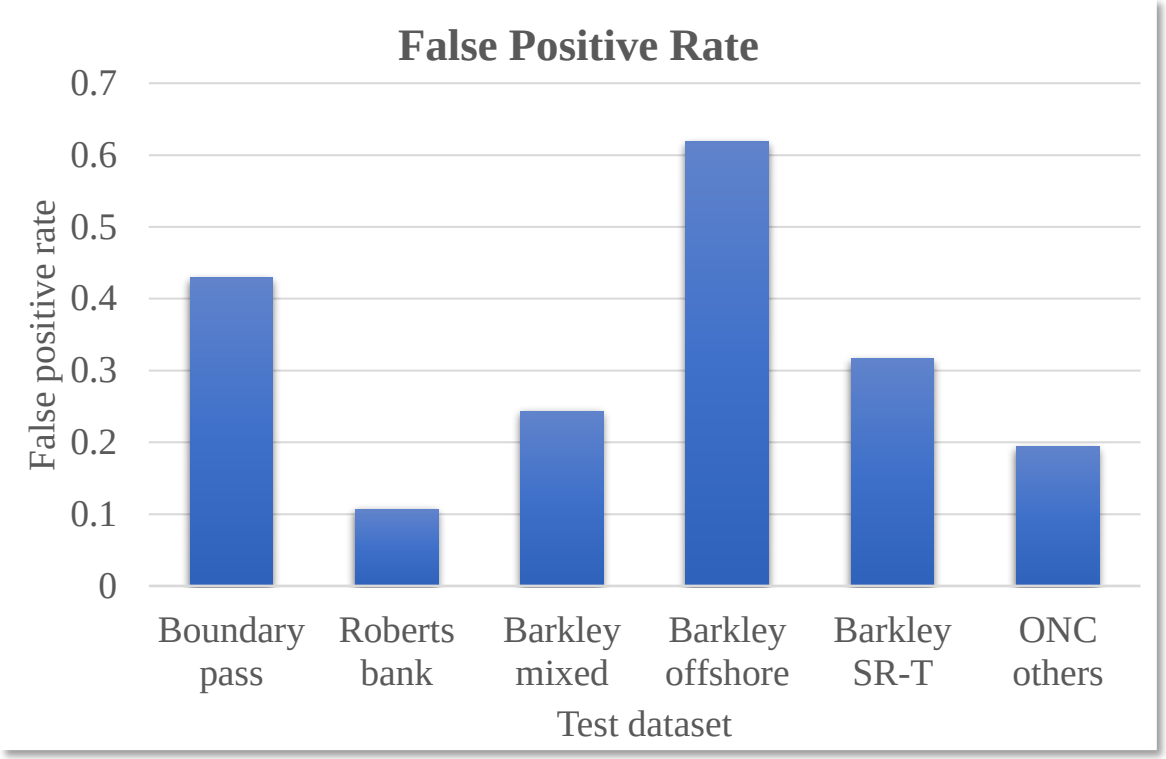


	Dataset	Number of files
Train	Boundary pass	586
	Robert's bank	704
Test	Boundary pass	34
	Robert's bank	4
	ONC Barkley Canyon SR T	40
	ONC Barkley Canyon offshore	26
	ONC Barkley Canyon mixed	57
	ONC others	7

Multiple data sources ⇨ large variance in data

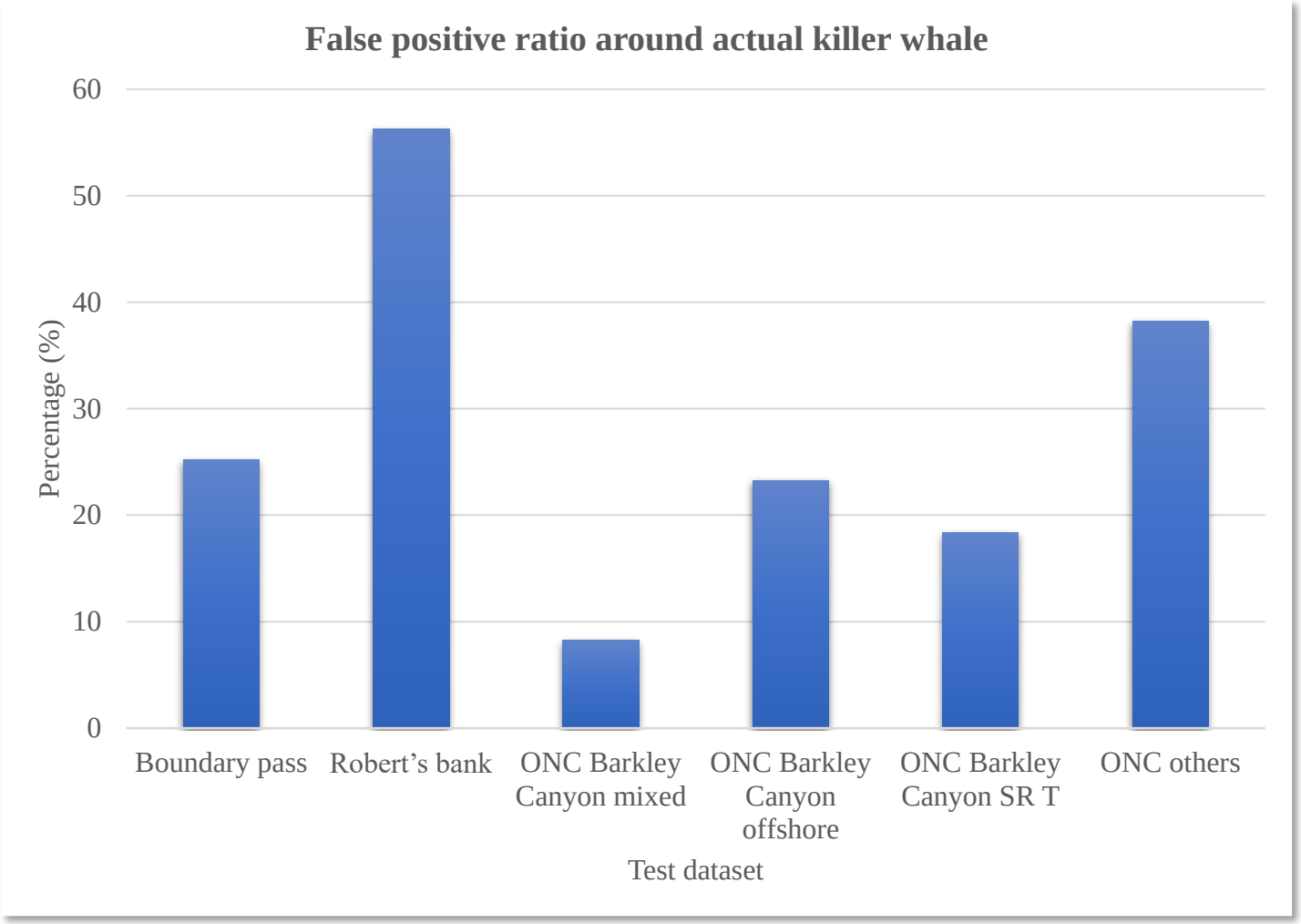
Preliminary results so far (1/2)





Recall/True positive rate: Percentage of total relevant/positive results correctly classified by the model
False positive rate: The proportion of negative examples predicted incorrectly as positive
Still room for improvements in unseen environment!

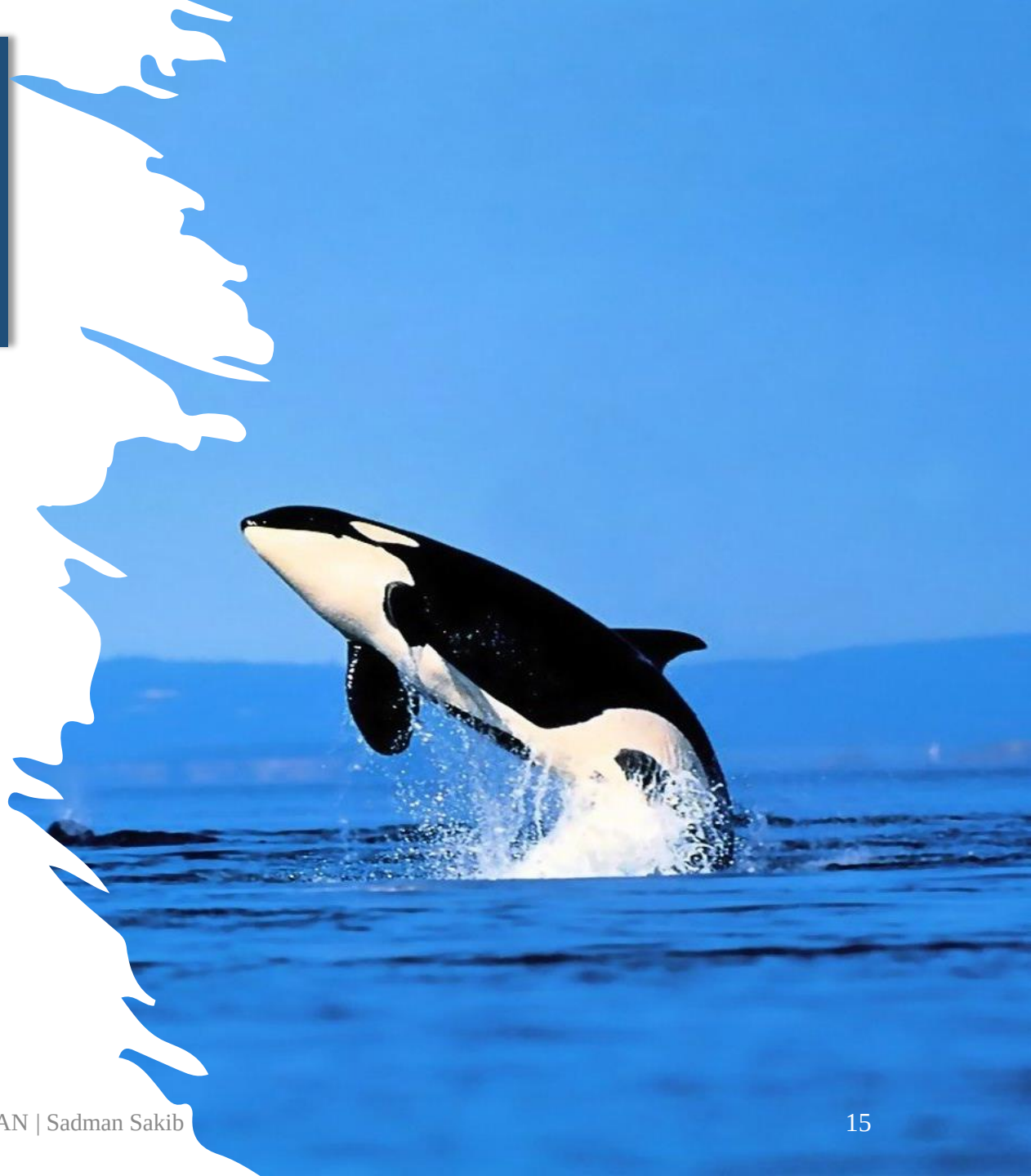
Preliminary results so far (2/2)



Current challenge with False positives: Many of the false positives are occurring around the actual killer whale calls

Conclusion and Future directions

- **Deep learning can** aid the orca detection if we can find the right sufficient data and tweak the model accordingly
- **Improve** deep learning model **performance**
- **Ecotype and pod-level** classification
- **Adapt the model** for data collected from **different sources and hydrophones**.
- **Ready-to-use software** deployed in a **network of hydrophones** for near real-time detection
- **Open-source software** for the community



Thank You!
Questions?