

# HALLO

## Humans and ALgorithms Listening for Orcas

A decorative graphic on the left side of the slide. It features several circles in orange, teal, and light blue. A central teal circle contains the word 'MERIDIAN' in white capital letters and is filled with a pattern of small white and orange numbers. To the right of this circle is a vertical orange waveform with varying bar heights. Other circles are scattered around: a large orange circle with a white border at the top left, a medium teal circle to the right, a small orange circle below it, a light blue circle below the teal one, and a small orange circle at the bottom left.

MERIDIAN

**Oliver Kirsebom**  
(on behalf of the HALLO team)

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

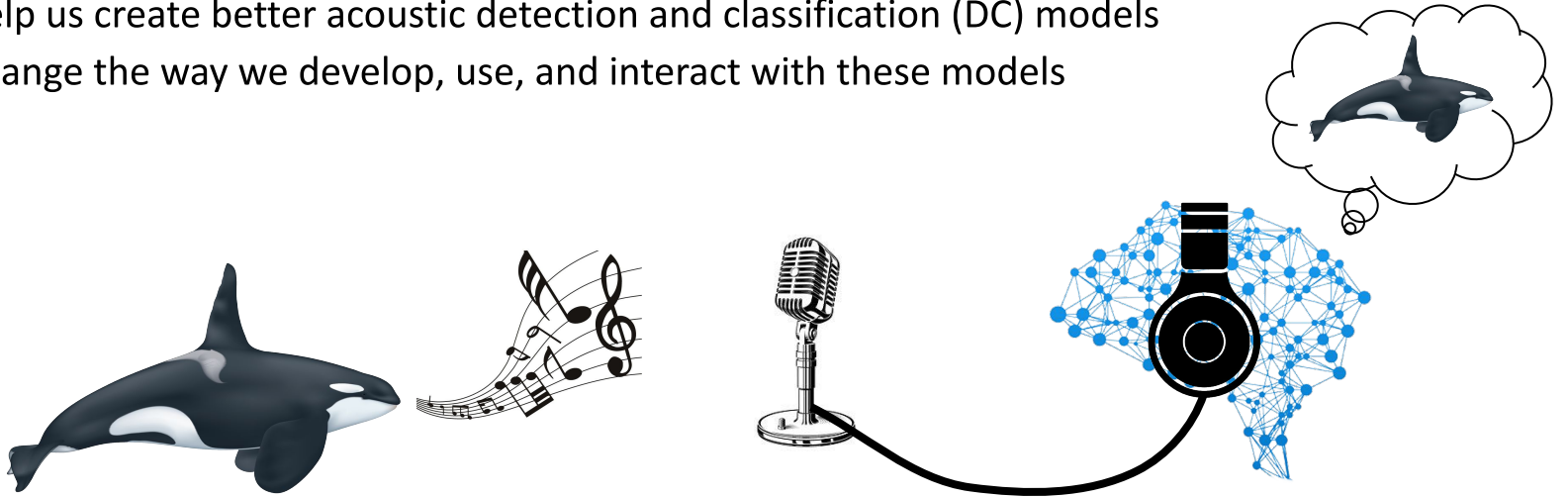


- HALLO = Humans and ALgorithms Listening for Orcas
- Two-year R&D project
- \$550k in support from DFO
- Multi-institutional & multi-disciplinary team
- Goal: Develop **deep learning** software for detecting and classifying the vocalisations of killer whales (esp. Southern Residents) to support researchers and conservationists in BC.



## Deep learning can ...

- help us create better acoustic detection and classification (DC) models
- change the way we develop, use, and interact with these models



# Deep Learning

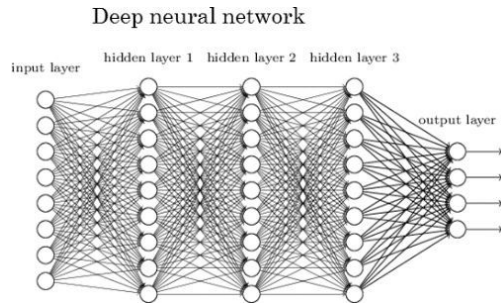


# What is deep learning ?



## Everyday applications:

Deep learning is an approach to **machine learning** that utilizes **deep neural networks**



Speech recognition  
& synthesis



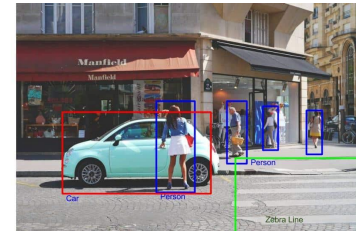
Face Recognition



Translation



Object detection



# Deep learning in marine bioacoustics



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<sup>✉</sup> and Yu Zhang  
Key Laboratory of Underwater Acoustic Communication and Marine Information  
Technology of the Ministry of Education, College of Ocean and Earth Science,  
University, Xiamen, China  
wuyang@xmu.edu.cn, yuzhang@xmu.edu.cn

## Marine Mammal Species Classification using Convolutional Neural Networks and a Novel Acoustic Representation

Mark Thomas<sup>✉</sup>, Bruce Martin<sup>2</sup>, Katie Kowarski<sup>2</sup>, Briand Gaudet<sup>2</sup>, and Stan Matwin<sup>1,3\*</sup>

SCIENTIFIC REPORTS  
nature research

SCIENTIFIC REPORTS  
nature research

## Deep neural networks for automated detection of marine mammal species

Yu Shiu<sup>1,✉</sup>, K. J. Palmer<sup>2,✉</sup>, Marie A. Roch<sup>2</sup>, Erica Fleischman<sup>2</sup>, Xiaobai Liu<sup>2</sup>, Eva-Marie Nosal<sup>2</sup>, Tyler Helble<sup>2</sup>, Danielle Cholewiak<sup>2</sup>, Douglas Gillespie<sup>2</sup> & Holger Klinck<sup>2</sup>

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

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

JASA ARTICLE

## Beluga whale acoustic signal classification using deep learning neural network models

Ming Zhong<sup>1</sup>, Manuel Castellote<sup>2,✉</sup>, Rahul Dodhia<sup>2</sup>, Juan Lavista Ferres<sup>1</sup>, Mandy Keogh<sup>2</sup> and Ariel Brewer<sup>2</sup>

<sup>1</sup>AI for Good Research Lab, Microsoft, Redmond, Washington 98052, USA  
<sup>2</sup>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  
<sup>3</sup>Alaska Department of Fish and Game, Juneau, Alaska 99802, USA

## Performance of a Deep Neural Network at Detecting North Atlantic Right Whale Upcalls

Oliver S. Kirsebom<sup>1,✉</sup>, Fabio Frazao<sup>1</sup>, Yvan Simard<sup>2,3</sup>, Nathalie Roy<sup>3</sup>, Stan Matwin<sup>1,4</sup> & Samuel Giard<sup>3</sup>

<sup>1</sup>Institute for Big Data Analytics, Dalhousie University, Halifax, Nova Scotia B3H 4R2, Canada  
<sup>2</sup>Fisheries and Oceans Canada Chair in underwater acoustics applied to ecosystem and marine mammals, Marine Sciences Institute, University of Quebec at Rimouski, Rimouski, Quebec, Canada  
<sup>3</sup>Mauricie Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, Quebec, Canada  
<sup>4</sup>Institute of Computer Sciences, Polish Academy of Sciences, Warsaw, Poland

SCIENTIFIC REPORTS  
nature research

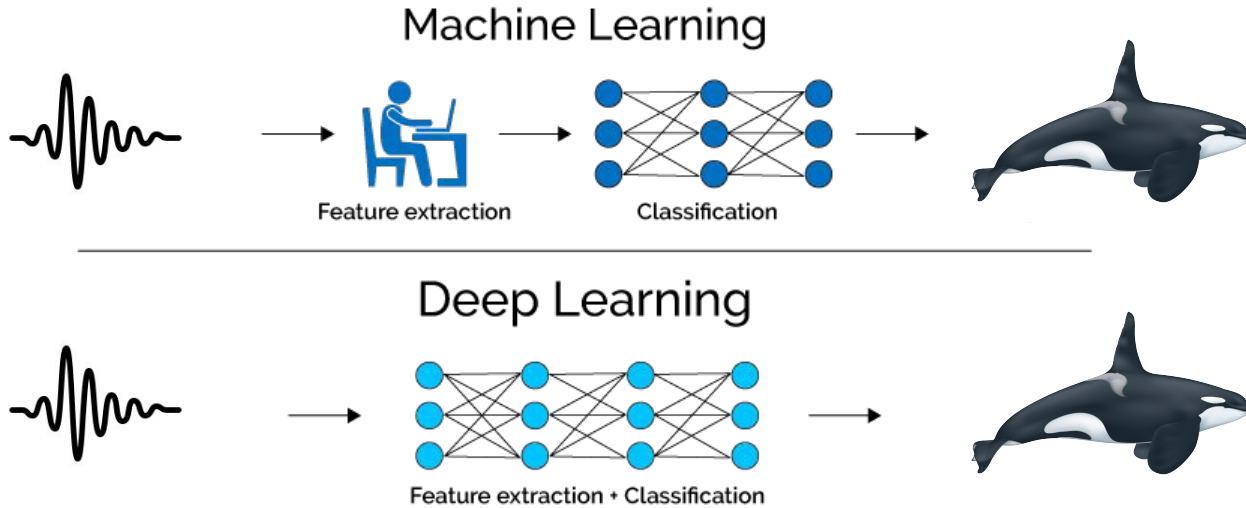
## Deep Machine Learning Techniques for the Detection and Classification of Sperm Whale Bioacoustics

Peter C. Bermant<sup>1</sup>, Michael M. Bronstein<sup>1,2</sup>, Robert J. Wood<sup>3,4</sup>, Shane Gero<sup>5</sup> & David F. Gruber<sup>2,6</sup>

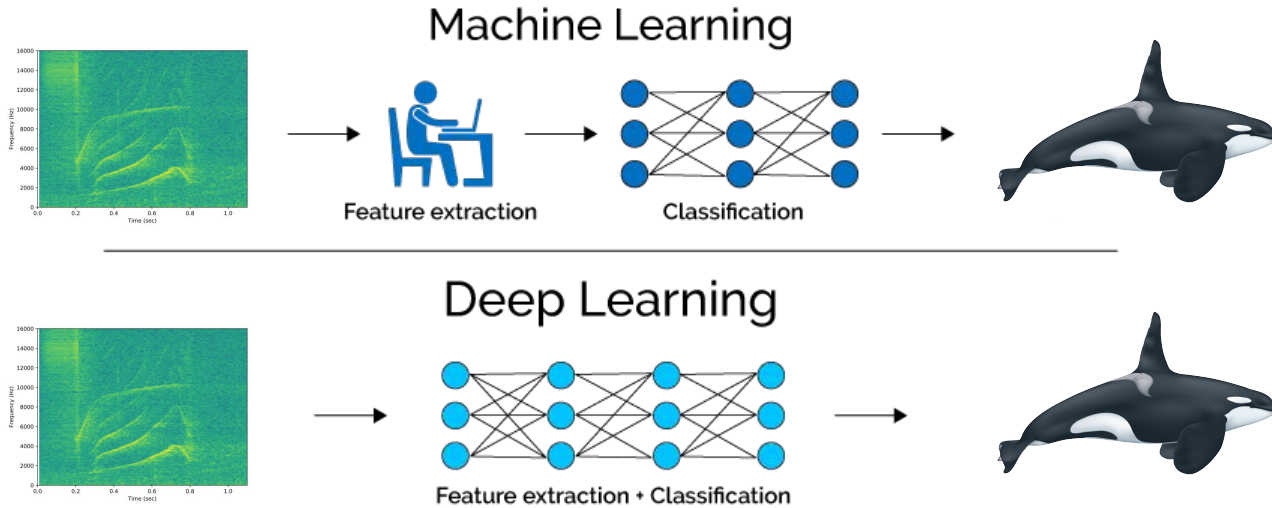
Deep learning works!

It's time to build software tools that makes deep learning accessible to researchers and conservationists.

# Deep learning aims to be end-to-end



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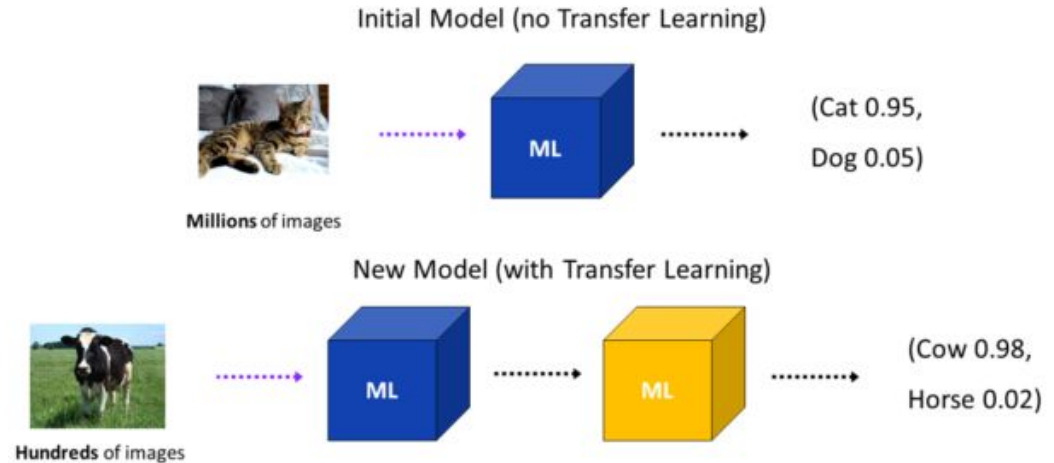




# Transfer learning (model adaptation)



- Transfer learning can ...
  - drastically reduce amount of training data and training time
  - make models more adaptable and reusable



# The deep learning workflow



## Neural network adaptation to new data



### Pre-trained network

The Deep Neural Network detects sounds and proposes classifications.



### Validation

A human analyst validates the network's detections and classifications.



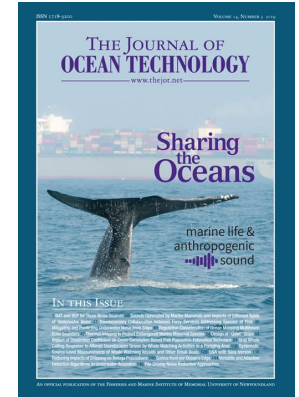
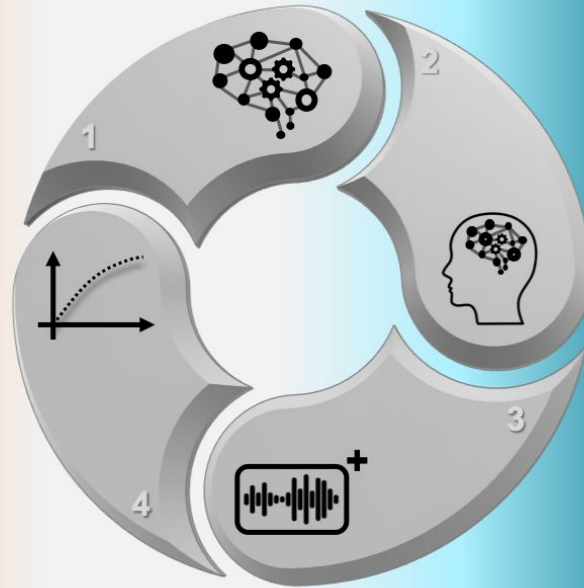
### Improved training data

The new validated examples are added to the network's pool of training data.



### Enhanced performance

The human analyst can now retrain the neural network to improve its performance.



p. 144-145:  
"Towards Versatile and Adaptive  
Detection Algorithms in  
Underwater Acoustics"

# The HALLO Project



# HALLO - at a glance



- HALLO = Humans and ALgorithms Listening for Orcas
- Two-year R&D project
- \$550k in support from DFO
- Multi-institutional & multi-disciplinary team
- **Goal:** Develop deep learning software for detecting and classifying the vocalisations of killer whales (esp. Southern Residents) to support researchers and conservationists in BC.

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

Say hello to the HALLO team!



**Ruth Joy**  
**Steven Bergner**  
**Alex Harris**  
**Emma Cummings**  
**Kaitlin Palmer**  
**Jennifer Wladichuk**



**Amalis Riera**  
**Fabio Frazao**  
**Bruno Padovese**  
**Oliver Kirsebom**



**Dave Campbell**  
**Paul Nguyen Hong Duc**



**Scott Veirs**  
**Val Veirs**



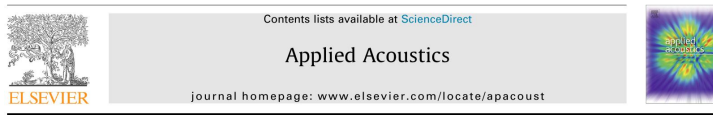
## 1. Academic studies

**SCIENTIFIC  
REPORTS**  
nature research

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

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

Applied Acoustics 150 (2019) 169–178



Whistle detection and classification for whales based on convolutional neural networks

Jia-jia Jiang<sup>a,\*</sup>, Ling-ran Bu<sup>a,1</sup>, Fa-jie Duan<sup>a</sup>, Xian-quan Wang<sup>a</sup>, Wei Liu<sup>b</sup>, Zhong-bo Sun<sup>a</sup>, Chun-yue Li<sup>a</sup>

<sup>a</sup>The State Key Lab of Precision Measuring Technology and Instruments, Tianjin University, 92 Weijin Road, Nankai District, Tianjin, China  
<sup>b</sup>The Department of Electronic and Electrical Engineering, University of Sheffield, United Kingdom



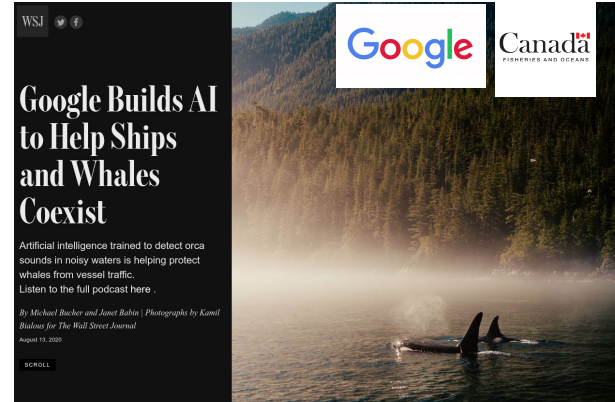
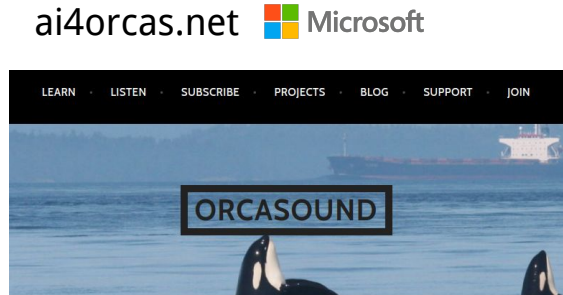
### Deep Learning and Domain Transfer for Orca Vocalization Detection

Paul Best<sup>\*</sup>, Maxence Ferrari<sup>\*1</sup>, Marion Poupard<sup>\*2</sup>, Sébastien Paris<sup>\*</sup>, Ricard Marxer<sup>\*</sup>,  
Helena Symonds<sup>§</sup> and Paul Spong<sup>§</sup>, Hervé Glotin<sup>\*</sup>

<sup>\*</sup>Univ. Toulon, Aix Marseille Univ.  
CNRS, LIS, DYNI Marseille, France  
<sup>1</sup>LAMFA, CNRS Amiens France  
<sup>2</sup>BIOSONG SARL France  
<sup>§</sup>OrcaLab Alert Bay  
Email: paul.best@univ-tln.fr



## 2. Collaborations between big tech and NGO/government





### Results:

- The "CNN binary classifier" approach has produced impressive results (on restricted data sets)
- But models generalize poorly to new acoustic environments

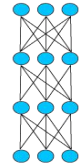
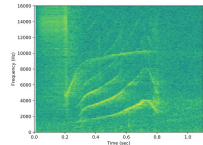
### Open questions:

- Can we make models generalize better? (e.g. by enlarging the training dataset)
- And/or can we develop methods (e.g. transfer learning) that allow us to readily adapt models to new environments?
- Can we teach models to distinguish between KW ecotypes, and pods?

### Still missing:

- Ready-to-use tools

### CNN binary classifier



**CNN**

(Convolutional  
Neural Network)



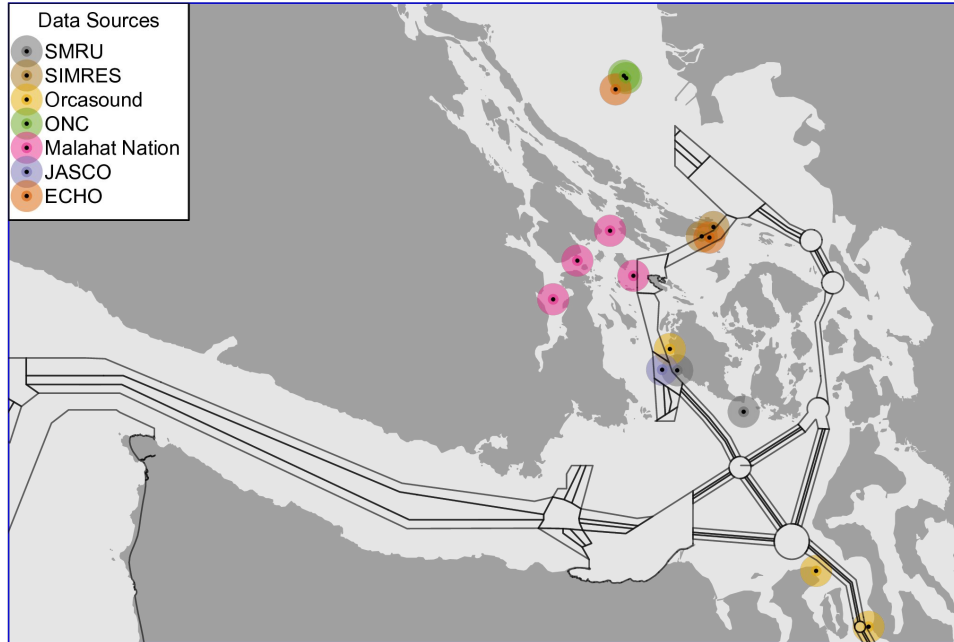
Yes/No





1. High-quality annotated KW acoustic data
2. Improved deep learning models; ecotype- and pod-level classification
3. Ready-to-use tools
4. Open-source software, developed with reusability and extensibility in mind
5. Collaborative approach; data and code publicly available

# Data sources



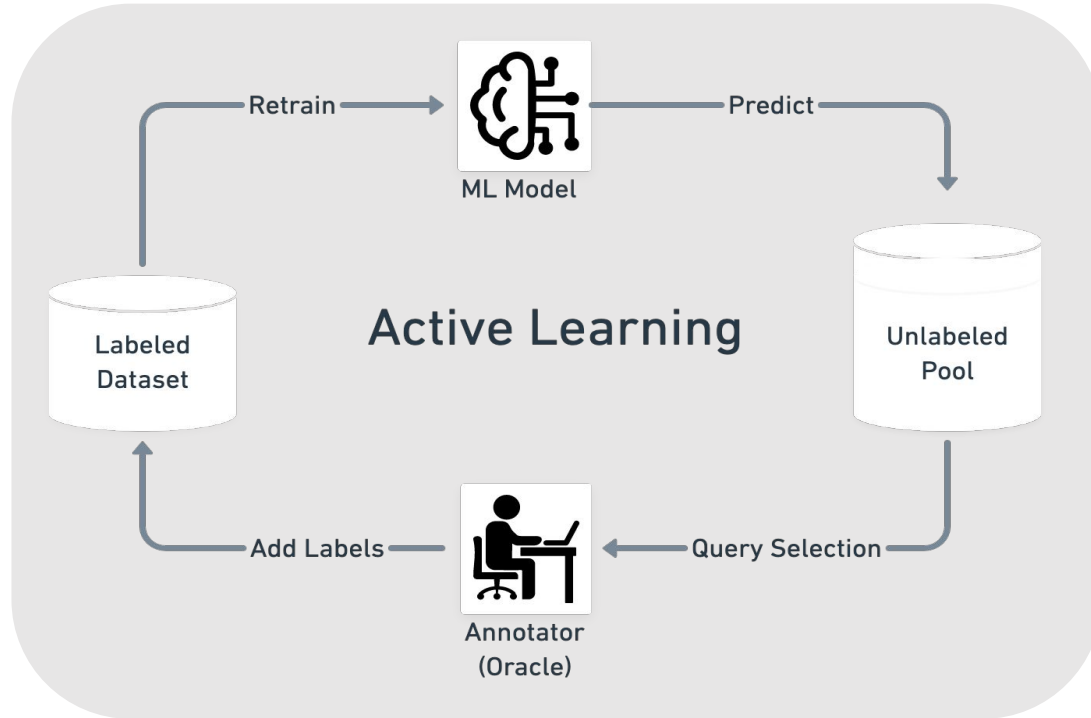
Also, ongoing conversations about data sharing with

- Cetacean Research Program, DFO Science (T. Doniol-Valcroze)
- Harald Yurk

among others ...

**Multiple data sources** ⇨ **large variance**

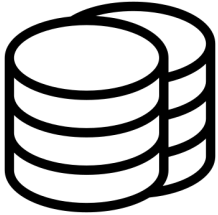
# Active learning approach



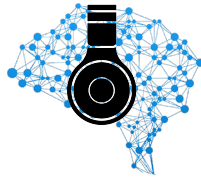
Credits:  
Kunal Mehta



1. Training and test datasets  
(accessible via web portal)

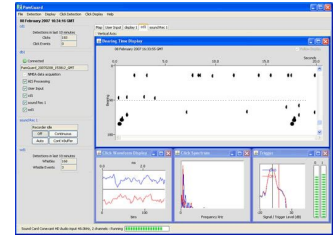


2. Trained deep  
learning models



3. Ready-to-use tools

- Plug-in for PAMGuard
- Active learning & transfer learning application



4. Workshops

5. Scientific papers

# Thank you!

