PASSIVE ACOUSTIC MONITORING OF BLUE & FIN WHALES THROUGH MACHINE LEARNING

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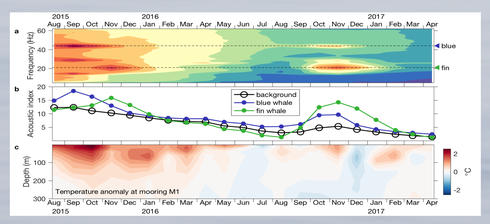
Background

- The Monterey Bay Aquarium Research Institute (MBARI) is studying the presence of marine mammals by passive acoustic detection of their vocalizations via a hydrophone located 32 km off the shore of Moss Landing, California.
- This study focused on blue and fin whales; both of which are endangered species that inhabit the region seasonally, with their greatest presence during the Fall.
- Variation in presence of these species can be related to variation in environmental conditions, such as the recent NE Pacific oceanic warm anomaly.



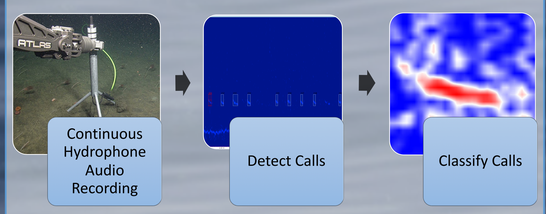
- Machine Learning: computer programming that enables a system to automatically learn and enhance itself from experience without explicit code. i.e.:
  - Snapchat filters
  - Spam filtering
  - Siri
- As of the past few years, there has been much success on the development of accurate pattern recognition in image-based machine learning algorithms.

Research Question

How effective is a machine learning algorithm in classifying blue and fin whale calls?

Objective

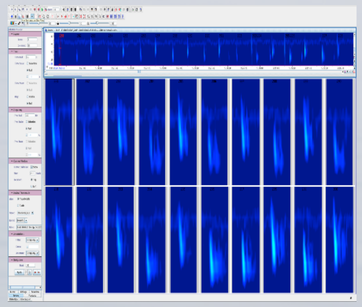
Establish a detection-classification system capable of recognizing blue whale b and fin whale pulse calls.



Method

Part I: Data Collection

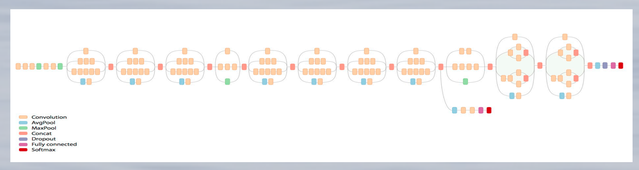
A. Audio was decimated from hydrophone recordings in the months of November 2015 and 2016 and a couple weeks in September 2015.
B. Raven's Band Limited Energy Detector was run across all decimated recordings.
C. Every detection was manually annotated as either a true-positive or false-positive.
D. Each detection was saved as a WAV with the date and time of the recording along with its corresponding annotation in the filename.

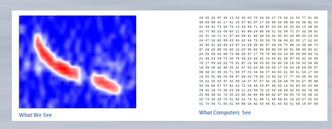


Part II: Preprocessing

A. A set of scripts were developed and fine-tuned using normalization and bi-linear interpolation functions along with a convolving filter array to generate smoother spectrograms images from the aforementioned WAV files.
B. Each generated spectrogram image file was then saved in either the true-positive or false-positive directory that the detection was initially labeled as.

Part III: The Machine Learning Algorithm



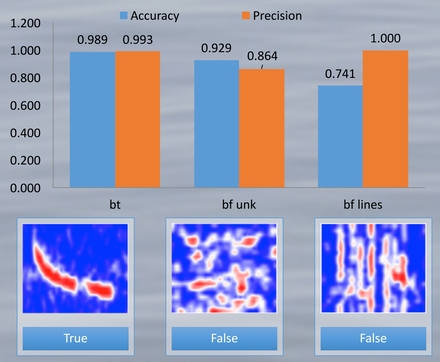


A. A transfer learning approach was implemented using Google's Inception V3 deep convolutional neural network classifier.
B. After fitting the network into a pipeline with the TensorFlow toolkit, only the final layer of the network was trained and tested with all of the collected spectrogram images.
C. The network was trained to classify different types of reoccurring false-positive patterns along with the prototypical true-positive pattern to increase accuracy and precision and decrease confusion.
D. The network's overall performance was qualitatively measured by comparing the acoustic index registered by the hydrophone and the quantity of blue and fin whale calls counted by the classifier.

Results

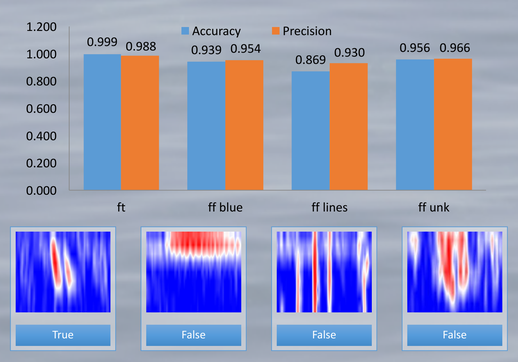
Blue Whale B Call

(16,886 total calls collected)



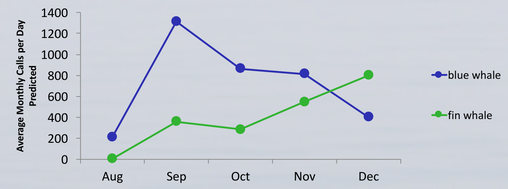
Fin Whale Pulse Call

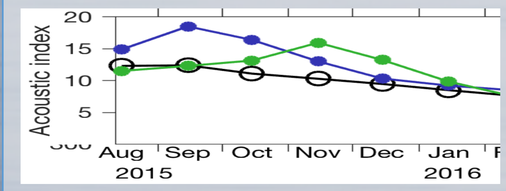
(5,927 total calls collected)



Results

Qualitative Comparison





Conclusion

- These results indicate that using a deep convolutional neural network classifier in conjunction with Raven's Band Limited Energy Detector is a viable option in quantitatively monitoring blue and fin whale acoustic activity.
- The proportional behavior between the acoustic index curves and predicted calls curves during the months of August through December 2015 shows consistency between two methods of quantifying temporal variation in the presence of these species.
- Differences in blue and fin whale call presence during the fall periods of 2015 and 2016 indicate inter-annual variation in habitation, which may relate to variation in the environment and whale food sources.
- After further development of a more fine-tuned detection-classification system, continuous live streaming audio can be autonomously analyzed to monitor whale calls synchronously with the hydrophone to give scientists valuable data regarding whale migratory behavior over a greater period of time.

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