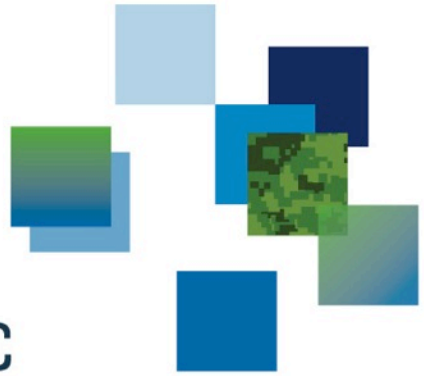
Defence Research and Development Canada | Recherche et développement pour la défense Canada

DALHOUSIE UNIVERSITY
Inspiring Minds

Automated passive acoustic detection and aural classification of blue and fin whale calls

Carolyn Binder, Paul Hines

DCLDE Workshop 2015
La Jolla, CA
13–16 July 2015



DRDC | RDDC

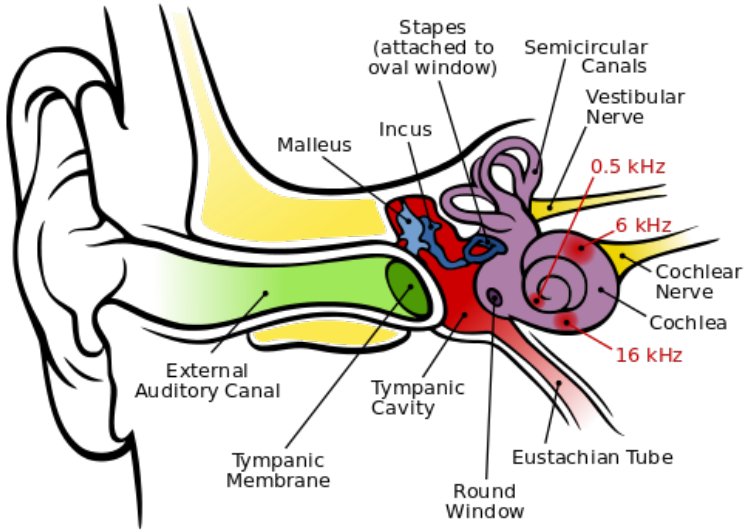
Canada

Introduction

- Want to develop robust classifier capable of identifying different species and removing false detections
- Implement a general automatic detector with a high detection rate
  - Accept a high false positive rate
- Detections passed to automatic classifier to reduce number of false detections and classify marine mammal species

Introduction – Aural Classifier

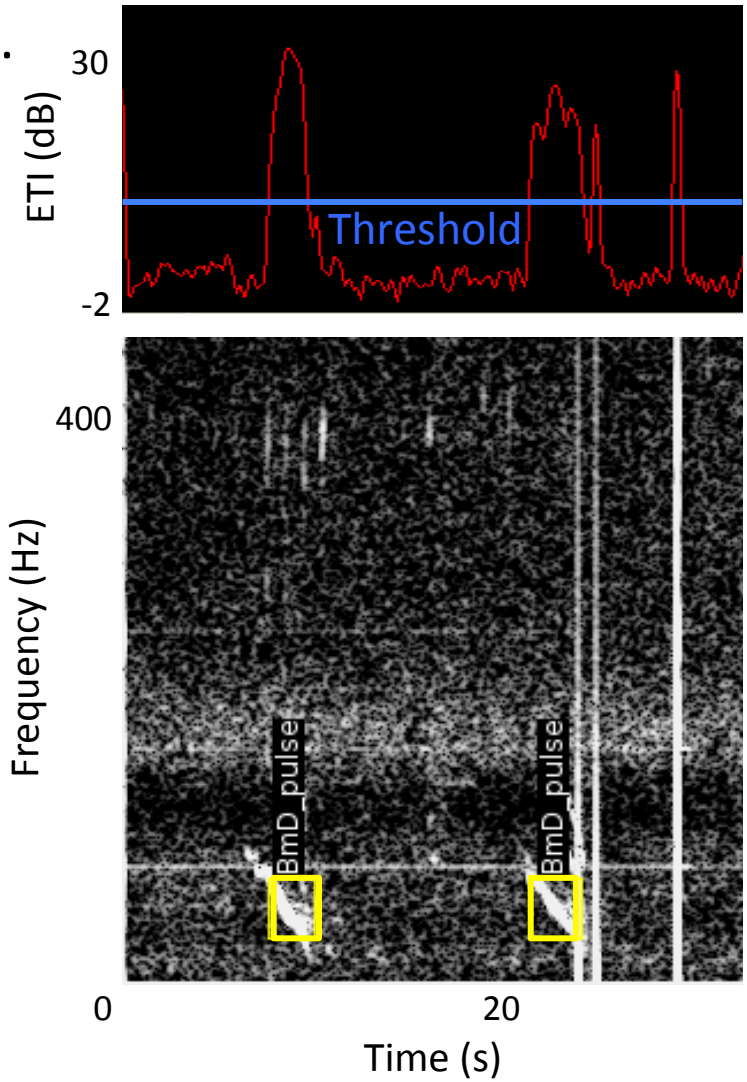
- Aural classifier previously developed at Defence R&D Canada (DRDC)
  - Uses perceptual signal features that model how humans perceive sound
  - Designed for broadband signals that may be more complicated than calls considered here
  - Use simple Bayesian classifier (Gaussian statistics)
  - Previously been successfully used for inter-species discrimination of cetacean vocalizations



[1]V.W. Young and P.C. Hines, *JASA*, **122**, 1502 – 1517 (2007).
[2]S.M. Murphy and P.C. Hines, *JASA*, **135**, 626 – 636 (2014).
[3]C.M. Binder and P.C. Hines, *JASA*, **135**, 2113 – 2125 (2014).

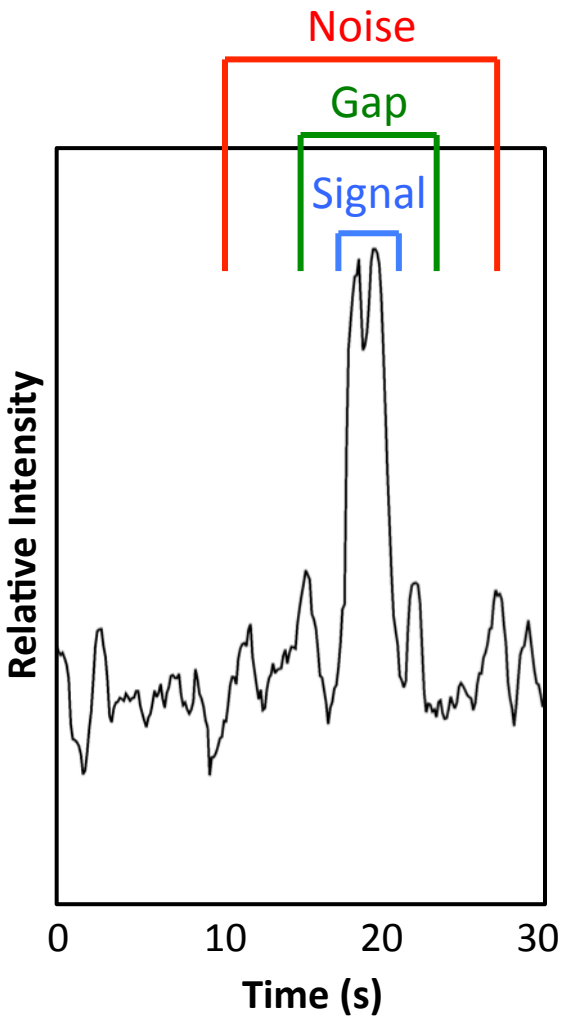
Detections

- Detections performed by Geospectrum Inc. using band-limited energy detector developed for DRDC under previous contracts
  - Detection function calculated by estimating short-term energy average in signal band and dividing by longer average of noise energy
- True detections are considered to be detections that overlap with analysts' annotated calls
  - Only D and 40 Hz calls
- Detections are placed in center of .WAV file to be input to aural classifier algorithm



Detection Results

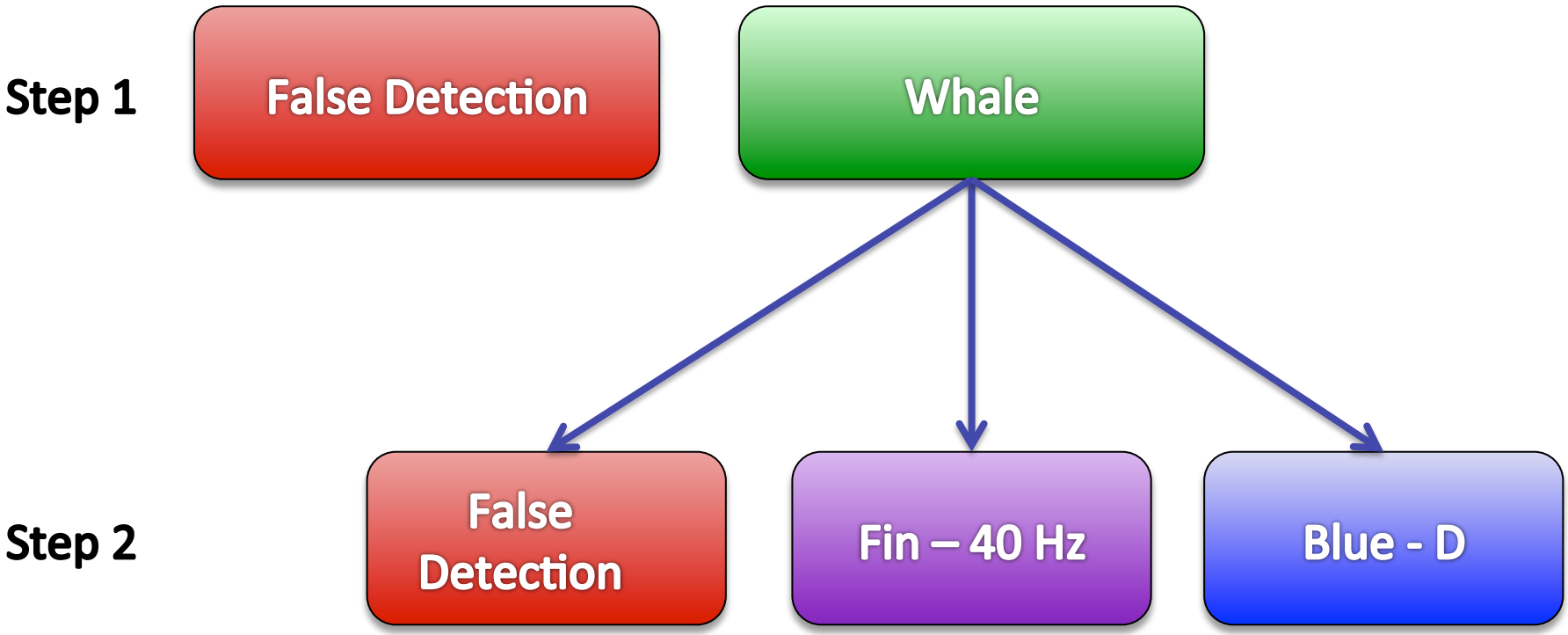
Detector	Blue whale D	Fin whale 40 Hz
Frequency Band (Hz)	30 – 70	50 – 65
SNR threshold (dB)	4.0	6.0
Signal window length (s)	1.0	0.2
Number of true detections [Detection rate]	4 268 [89.4 %]	1 450 [88.1 %]
Number of false detections [False positive rate *]	210 975 [27.3 s/(FP)]	311 875 [18.5 s/(FP)]



* The time between false detections; considers anything other than blue or fin calls a false detection

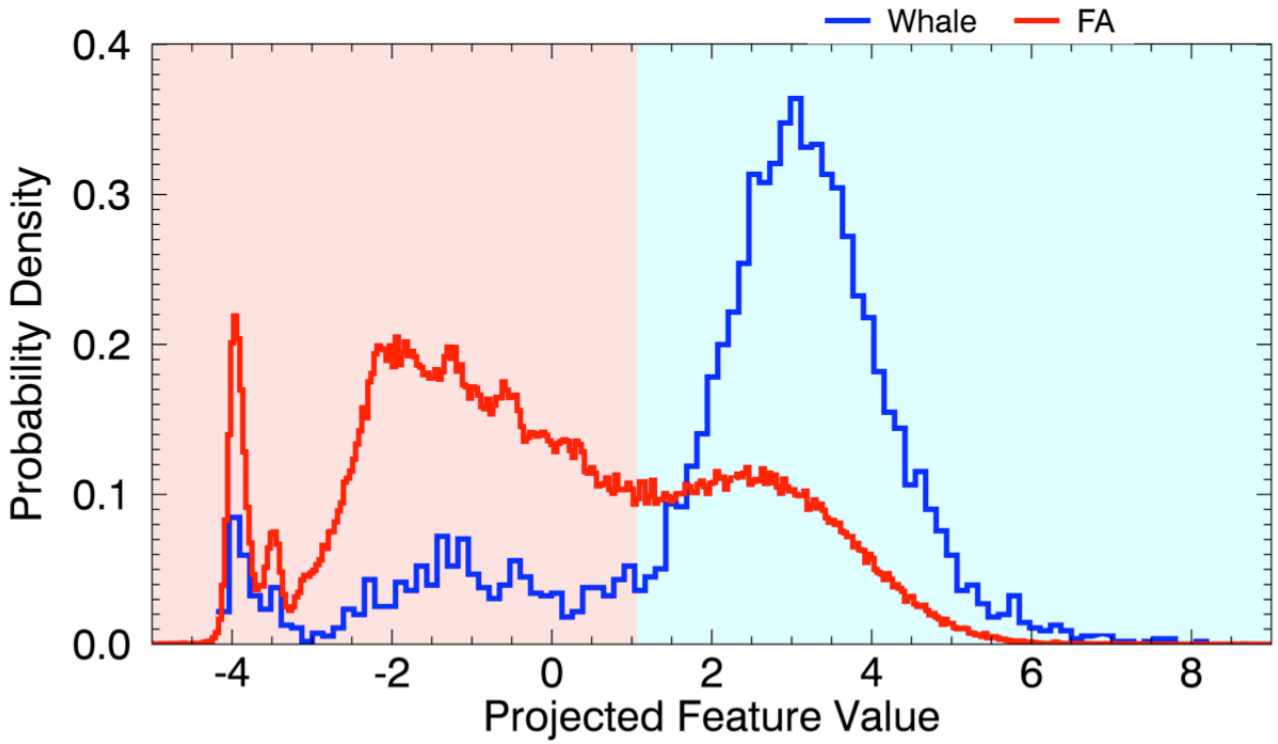
Classification method

- Performed a two step classification with data from each of the detectors



Blue Whale D Call Detector Results

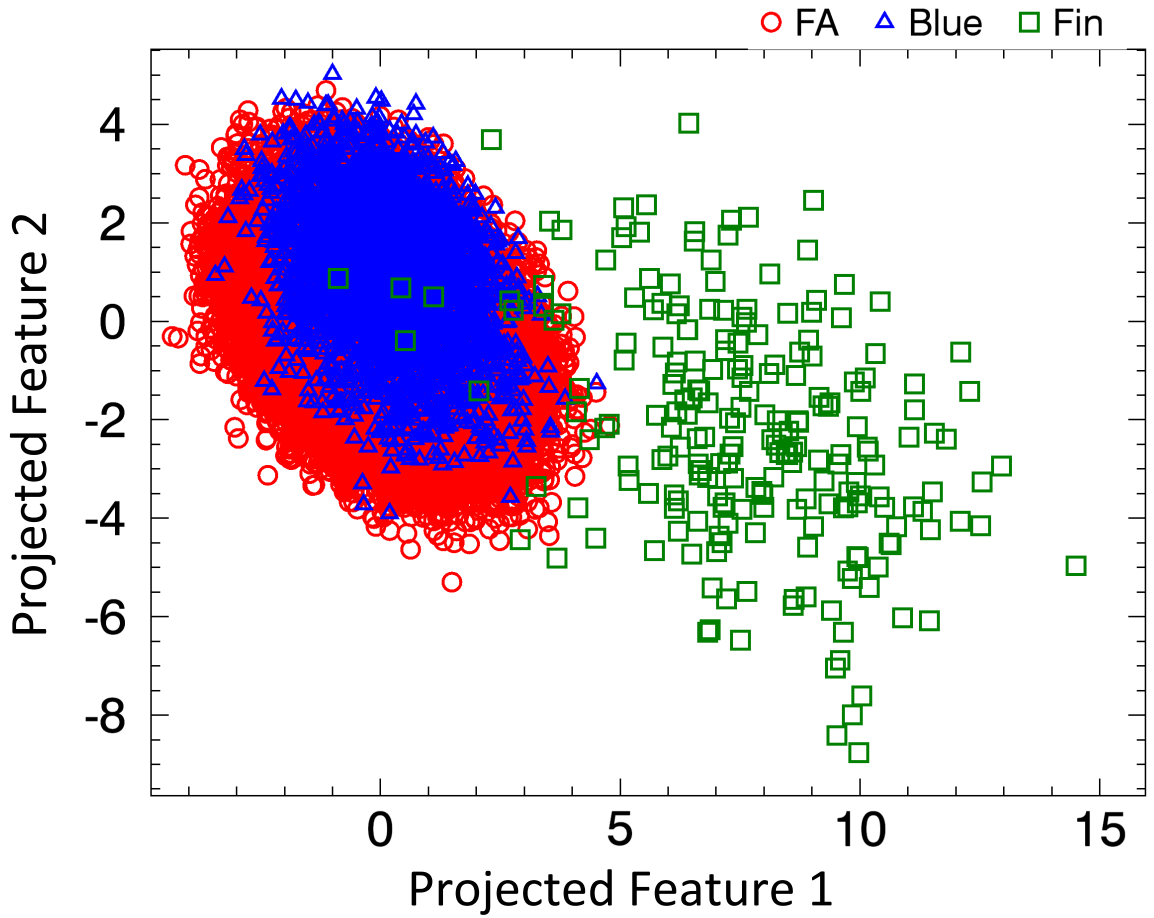
- Stage 1
  - Use all calls that were classified as whale as inputs to the next processing stage



Overall accuracy	67.8%
AUC	0.785
Number of correctly classified whale calls	3 464 (81.2%)
Number of incorrectly classified false detections	68 397 (32.4%)

Blue Whale D Call Detector Results

- Stage 2
  - This is the final classification decision for data from blue whale detector.



Overall accuracy	65.4%
Blue accuracy	63.2%
Fin accuracy	91.8%
False detection accuracy	65.4%
AUC	0.785
Precision	0.169
Recall	0.635

Fin Whale 40 Hz Detector Results

- Performed same two stage method for fin whale 40 Hz detector

Stage 1

Overall accuracy	82.7%
AUC	0.694
Number of correctly classified whale calls	1 762 (42%)
Number of incorrectly classified false detections	36 284 (11.6%)

Stage 2

Overall accuracy	75.8%
Blue accuracy	88.1%
Fin accuracy	79.0%
False detection accuracy	75.2%
AUC	0.950
Precision	0.022
Recall	0.681

Combined Results

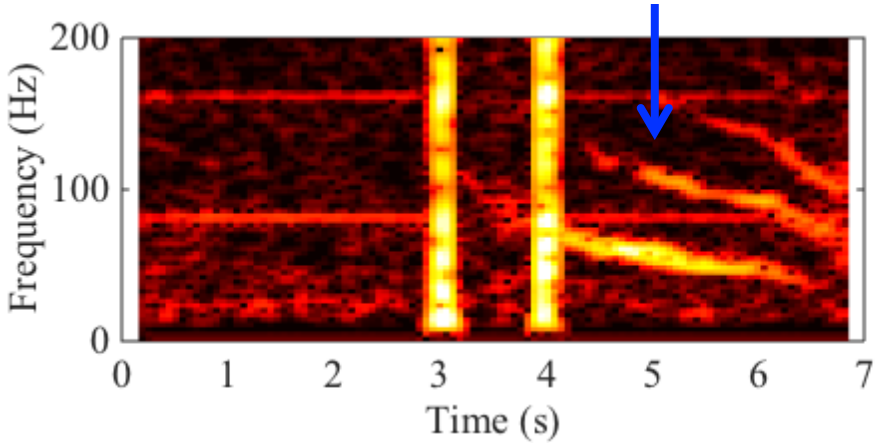
- Combined results from both the blue whale D and fin whale 40 Hz call detectors

Precision	0.120
Recall	0.638

- Possible explanations for poor results
  - Detector generated too many false detections
  - A lot of variability in false detections, particularly between the sites
  - Other whale calls not annotated, so they were classified as false detections

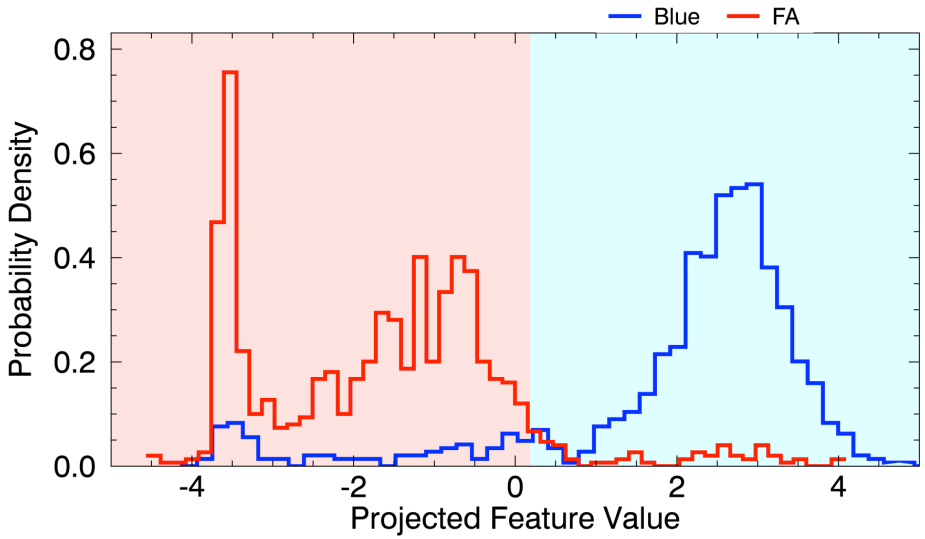
DCPP A site

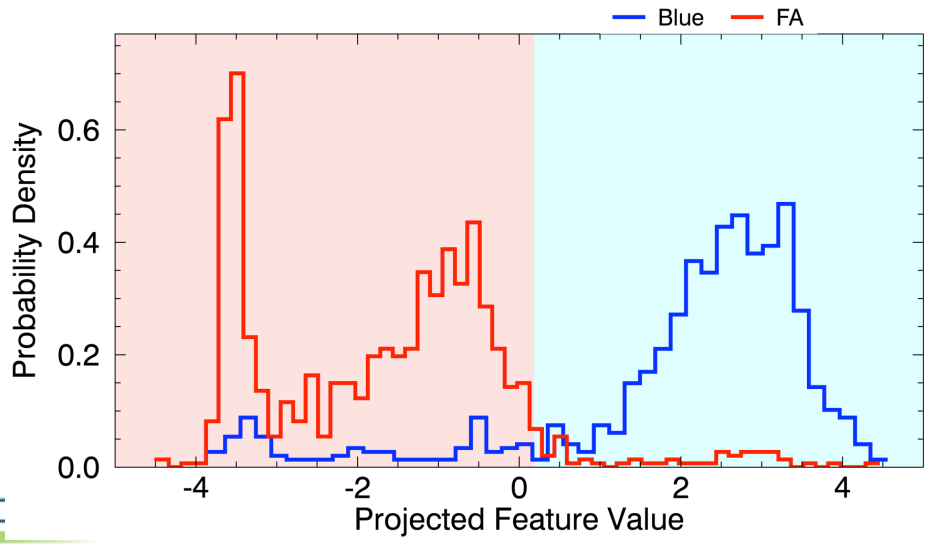
- Look at reduced set to get a better idea of strengths/challenges
  - Calls from July 2013; 955 signals for each of blue whale calls and false detections in training set; same number of calls in testing set
  - Classification results ok, ~70% of blue whale calls and ~90% of false detections correctly classified
- Further reduced set by removing detections that had been labelled as true detections but were contaminated with other loud signals
  - For example,



DCPP A site

- Further reduced set with “bad” detections removed
  - Training set: 764 blue, 955 false detections
  - Testing set: 775 blue, 955 false detections



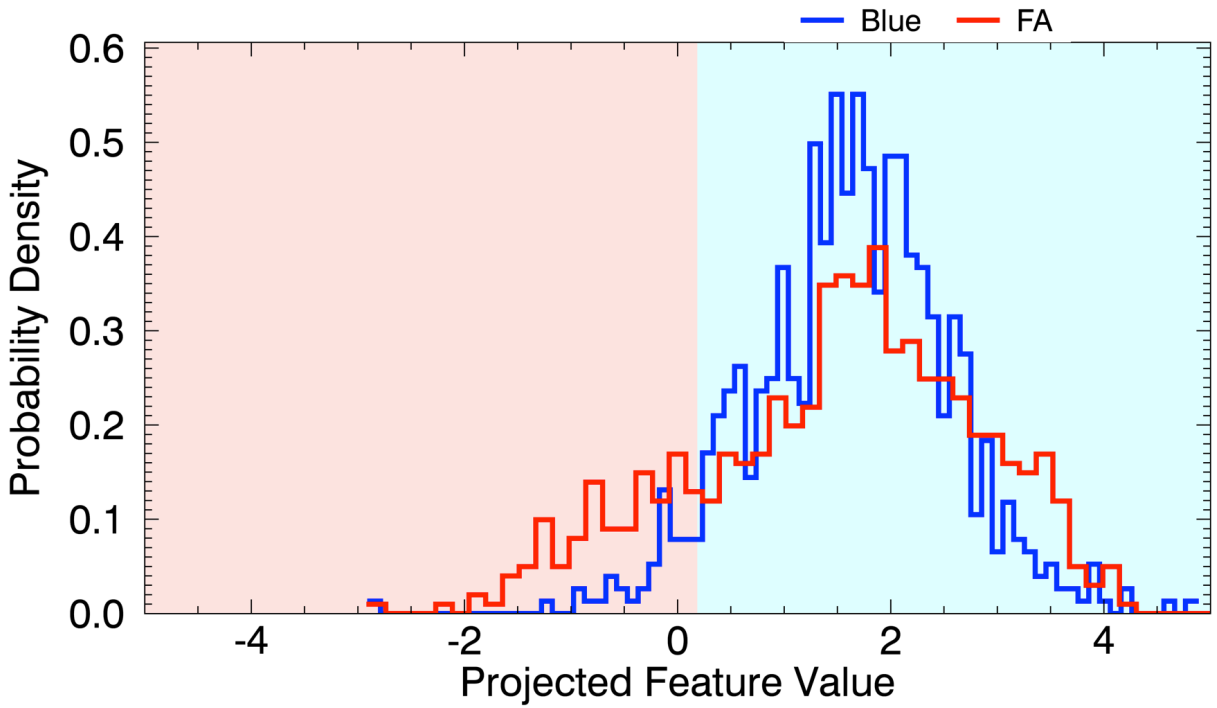


Training	
Overall accuracy	91%
Blue accuracy	88%
False detection accuracy	93%
AUC	0.92

Testing	
Overall accuracy	91%
Blue accuracy	87%
False detection accuracy	94%
AUC	0.92

Between-site Variability

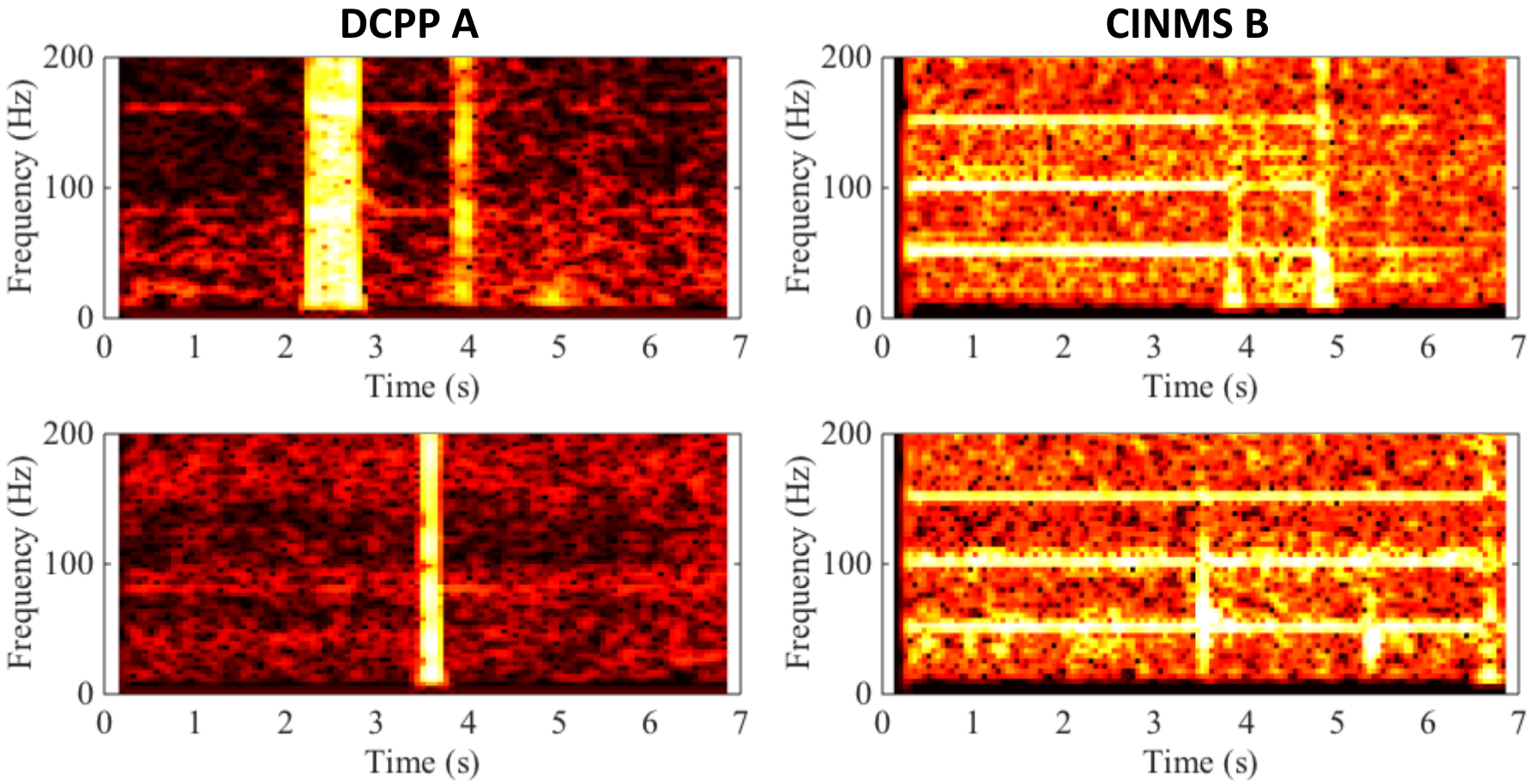
- Apply classifier trained with data from DCPP A site to calls recorded at CINMS B during June 2012
  - 757 blue whale calls and 642 false detections

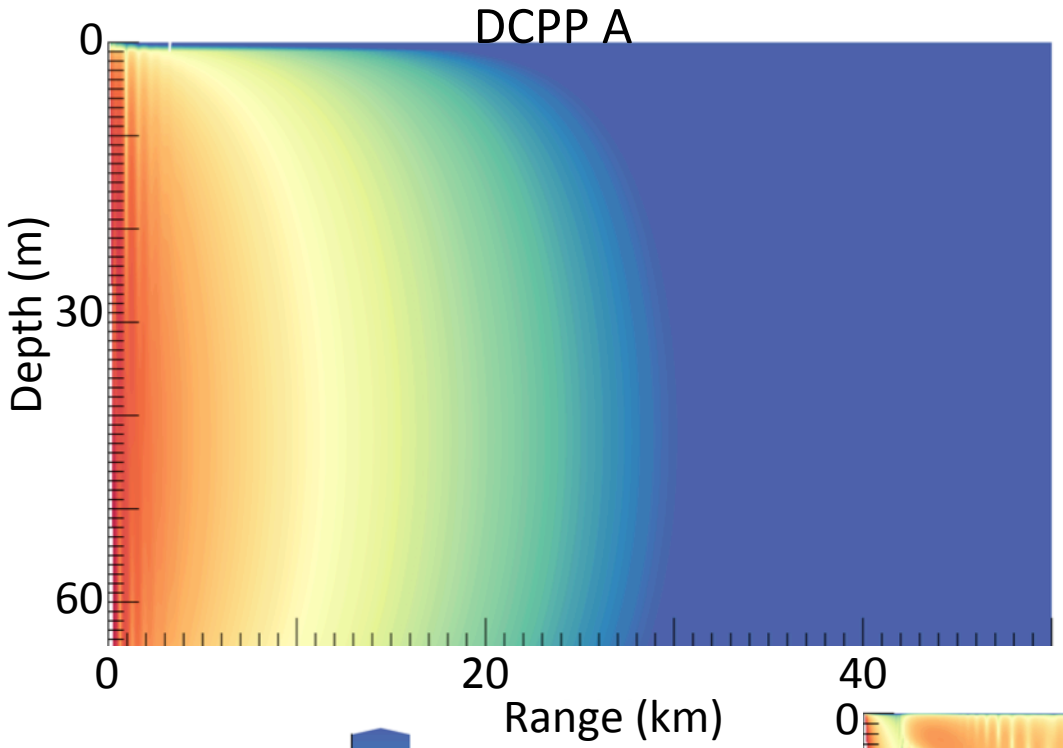


Testing	
Overall accuracy	60%
Blue accuracy	94%
False detection accuracy	19%
AUC	0.52

Between-site Variability

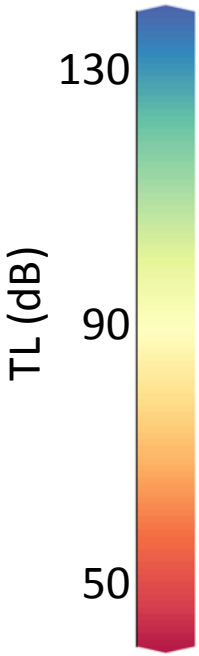
- Majority of false detections from CINMS B site different from those at DCCP site A

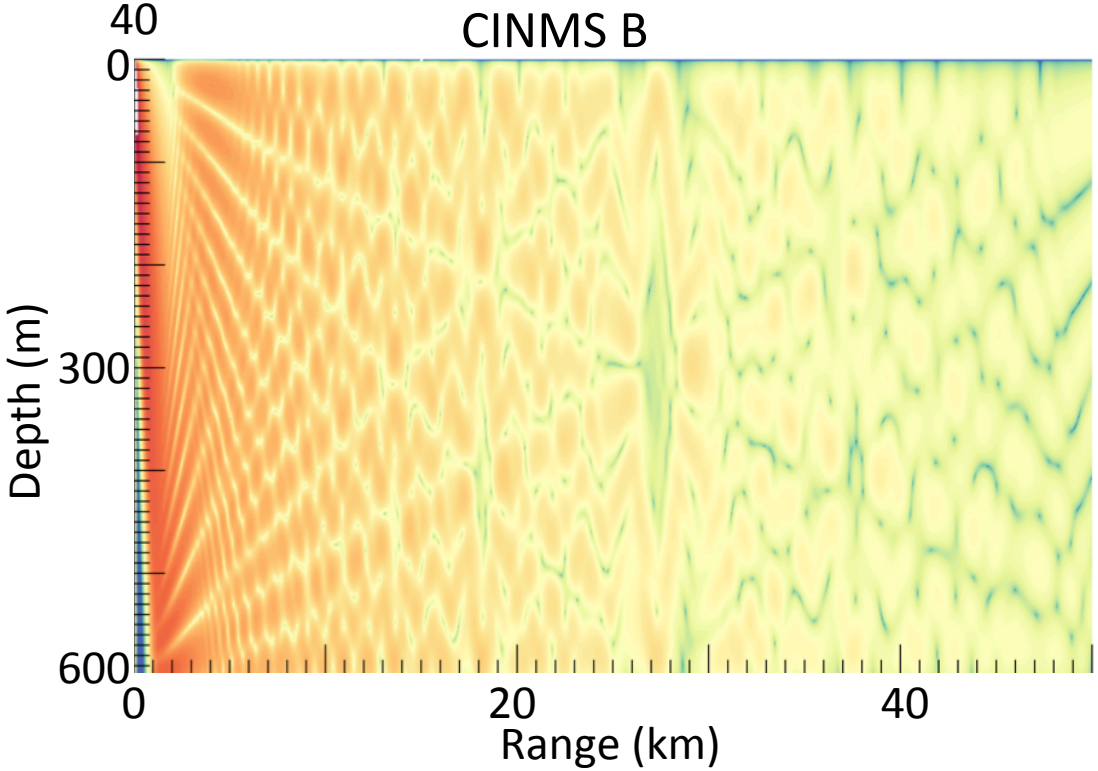




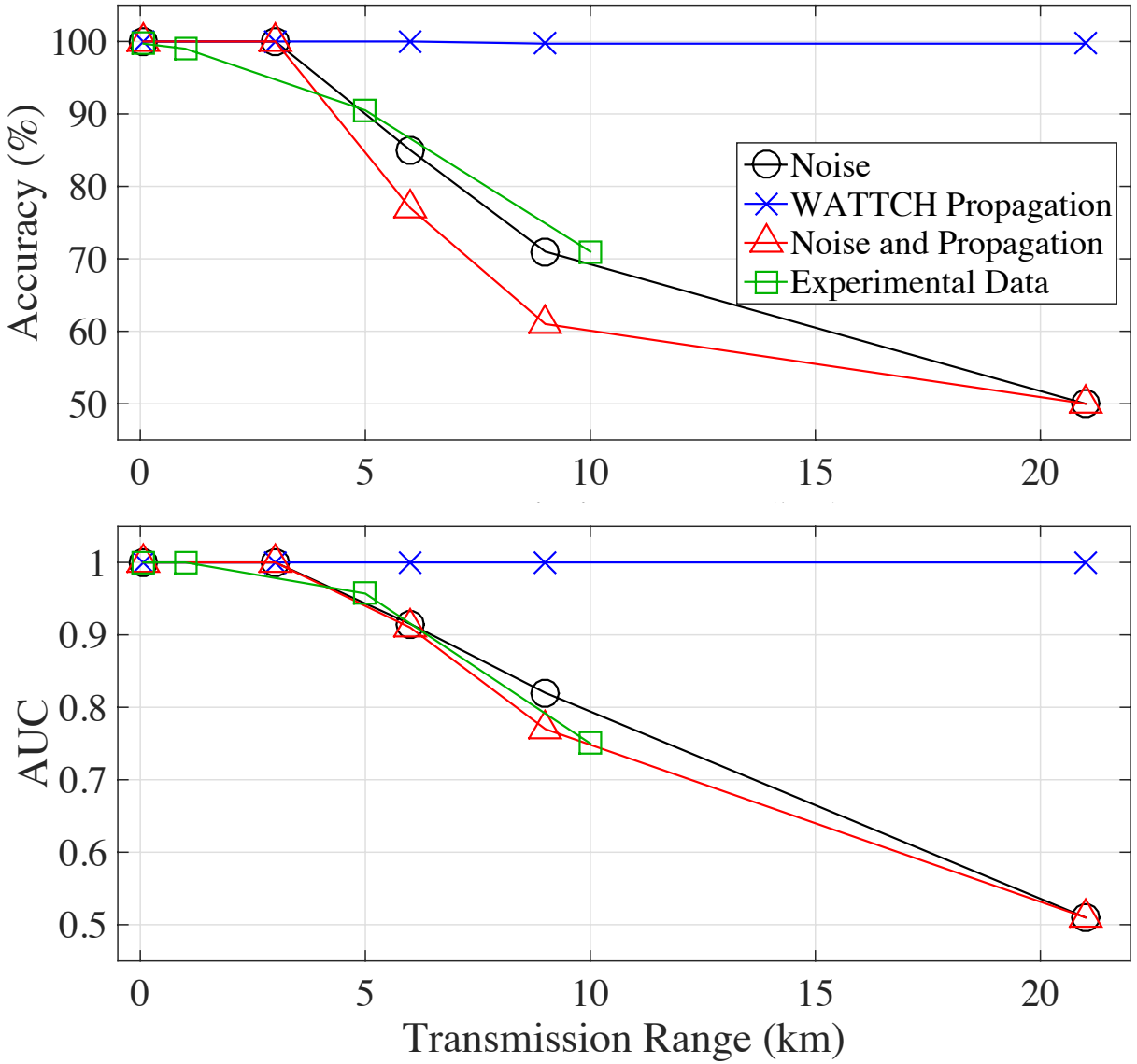
Propagation Modelling

- PECan model results
  - Range-independent environment
  - Frequency 55 Hz, source depth 20 m
  - Monthly-averaged sound speed profile from June
  - Silt over sedimentary rock





Performance Dependence on SNR and Propagation



Concluding Remarks

- Aural classifier did not perform particularly well
  - Detector settings need to be refined to limit the number of false detections
  - Large variability in types of noise in false detection class
  - Features were originally designed for transients with more complicated time-frequency features

- When developing training set all whale calls in band of interest should be annotated not just a few call types

- *Need to keep in mind impact of propagation and SNR on classifier performance*

Acknowledgements

- Kevin Dunphy, Joe Hood, and Matthew Coffin (GeoSpectrum Technologies Inc.)

- DCLDE 2015 workshop organizers

- Sean Pecknold (DRDC)

Defence Research and Development Canada

- Tetjana Ross (Dalhousie University)

- Supported in part by US Office of Naval Research, Award Number N00014-14-1-0237

Defence Research and Development Canada

Recherche et développement pour la défense Canada

DRDC | RDDC

SCIENCE, TECHNOLOGY AND KNOWLEDGE FOR CANADA'S DEFENCE AND SECURITY

SCIENCE, TECHNOLOGIE ET SAVOIR POUR LA DÉFENSE ET LA SÉCURITÉ DU CANADA

Canada