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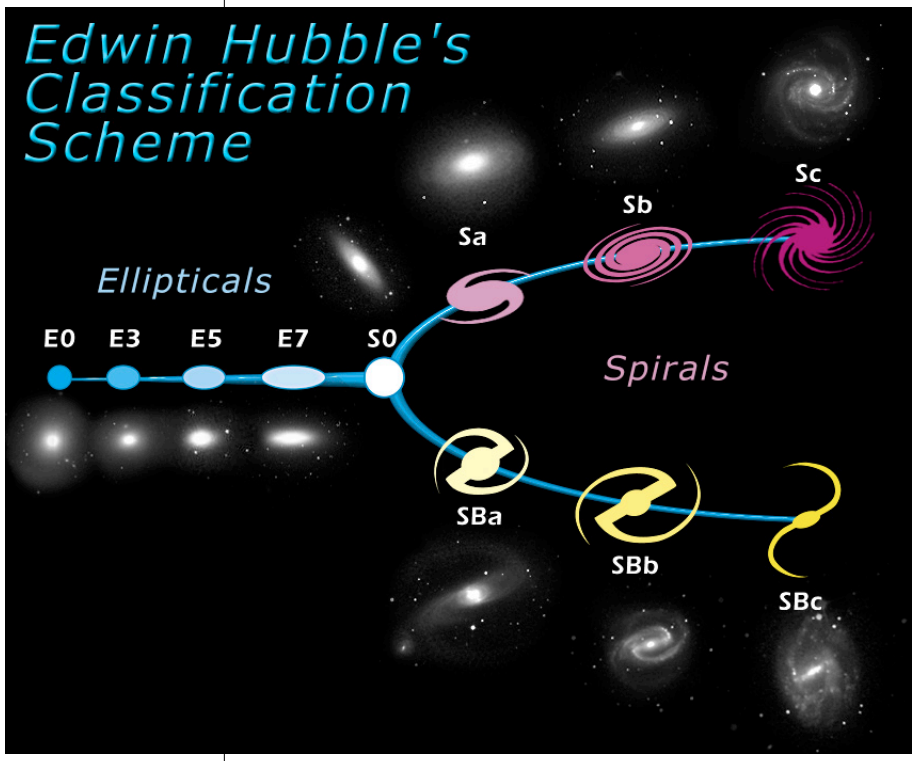
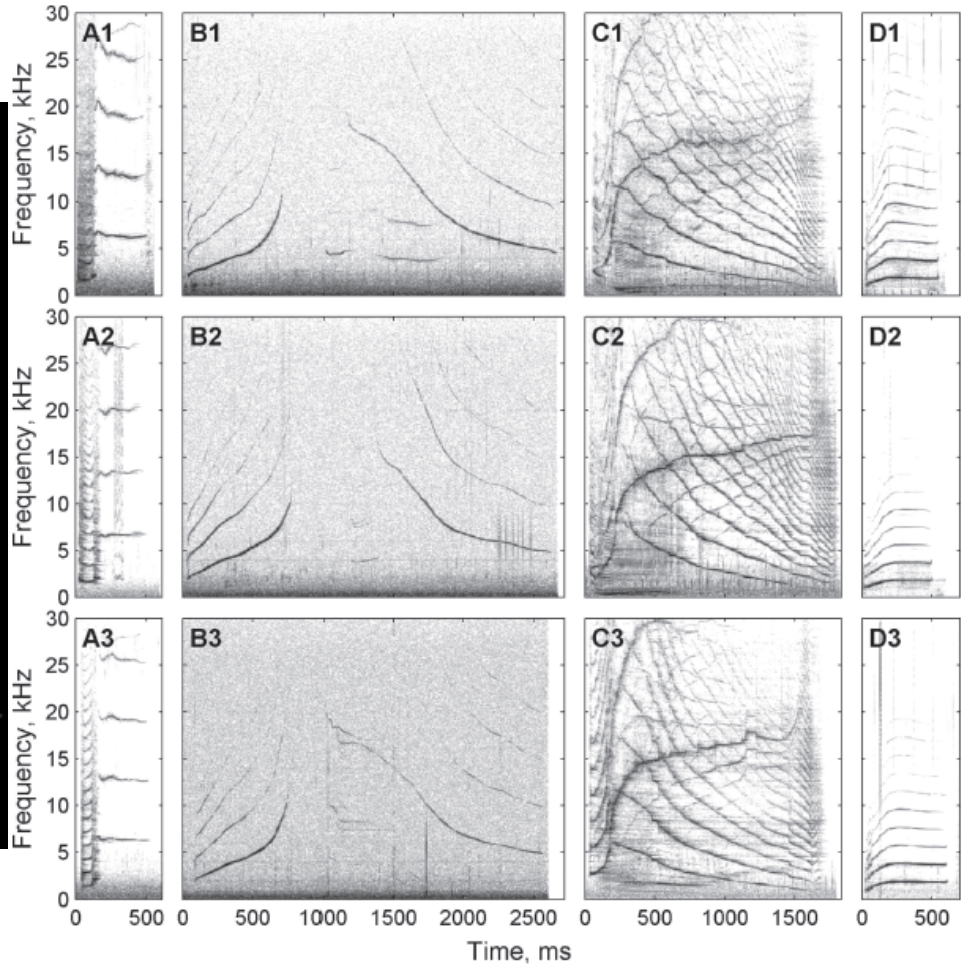
Bioacoustics meets Astronomy…





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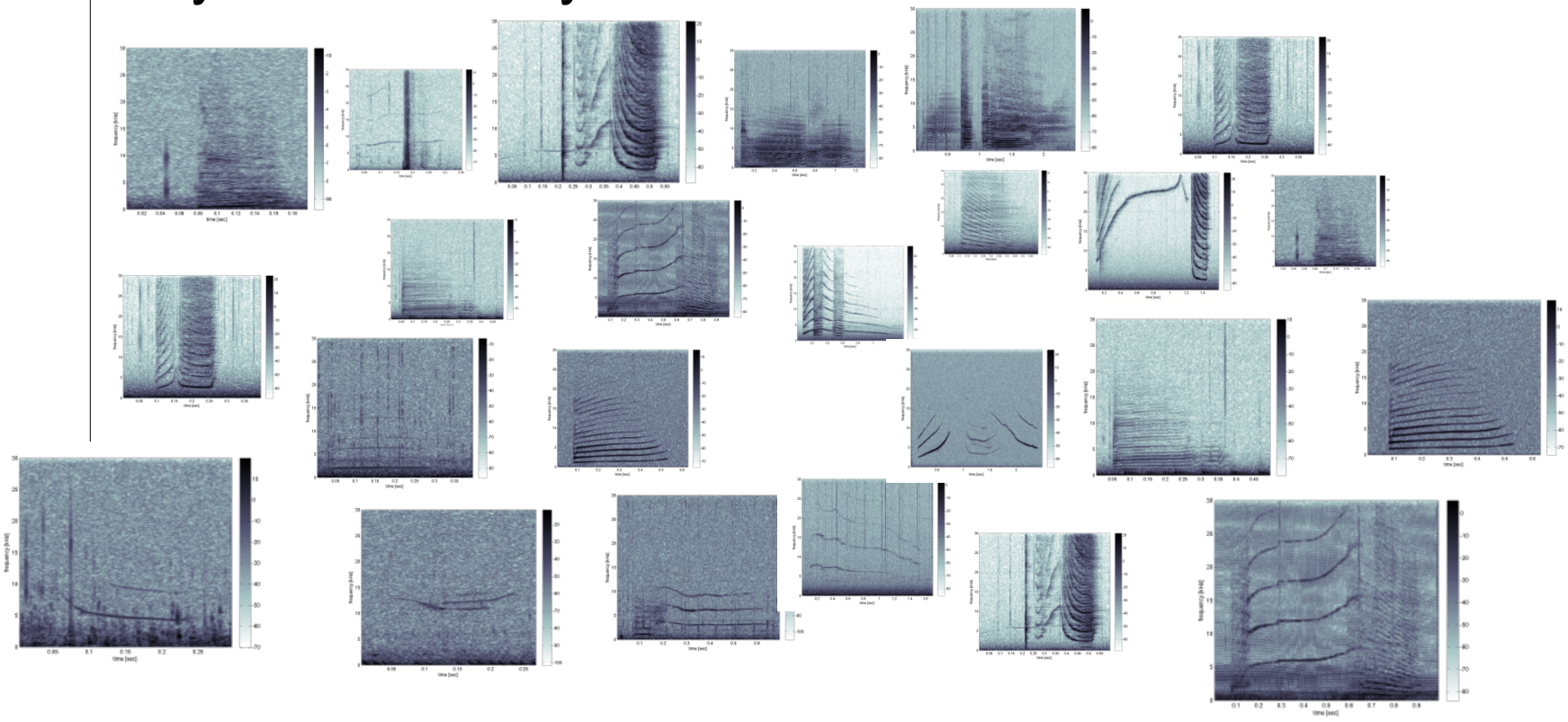
Classification of marine mammals sounds

- Problem: Large acoustic datasets require auditing by human ear/eye.



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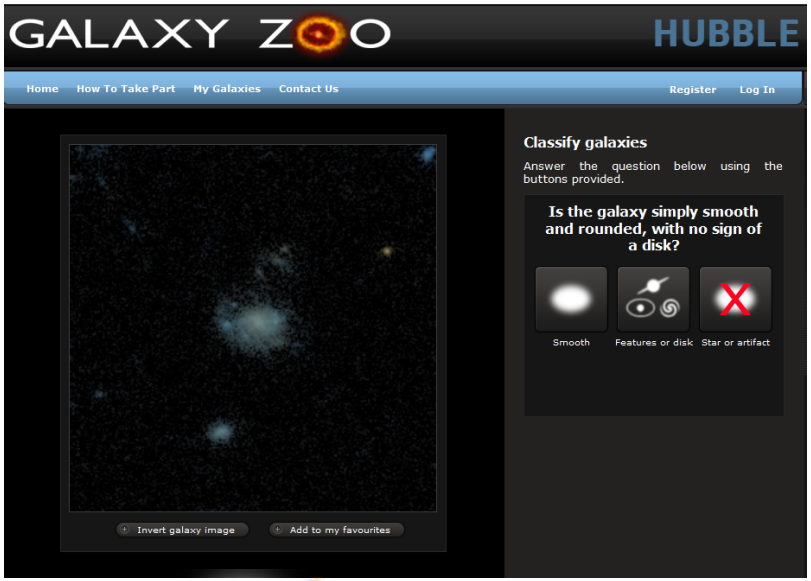
Crowdsourcing/ Citizen Science

- Involve large number of (non-expert) volunteers in classification/categorization process

Galaxy Zoo

- 500,000 volunteers classified > 300,000 galaxies (Lintott et al. 2008, Lintott et al. 2011).
- Resulting dataset superior in size and quality to previous datasets.
- Leads to unexpected discoveries
  - `Hanny's Voorwerp', a quasar light echo (Lintott et al. 2009)



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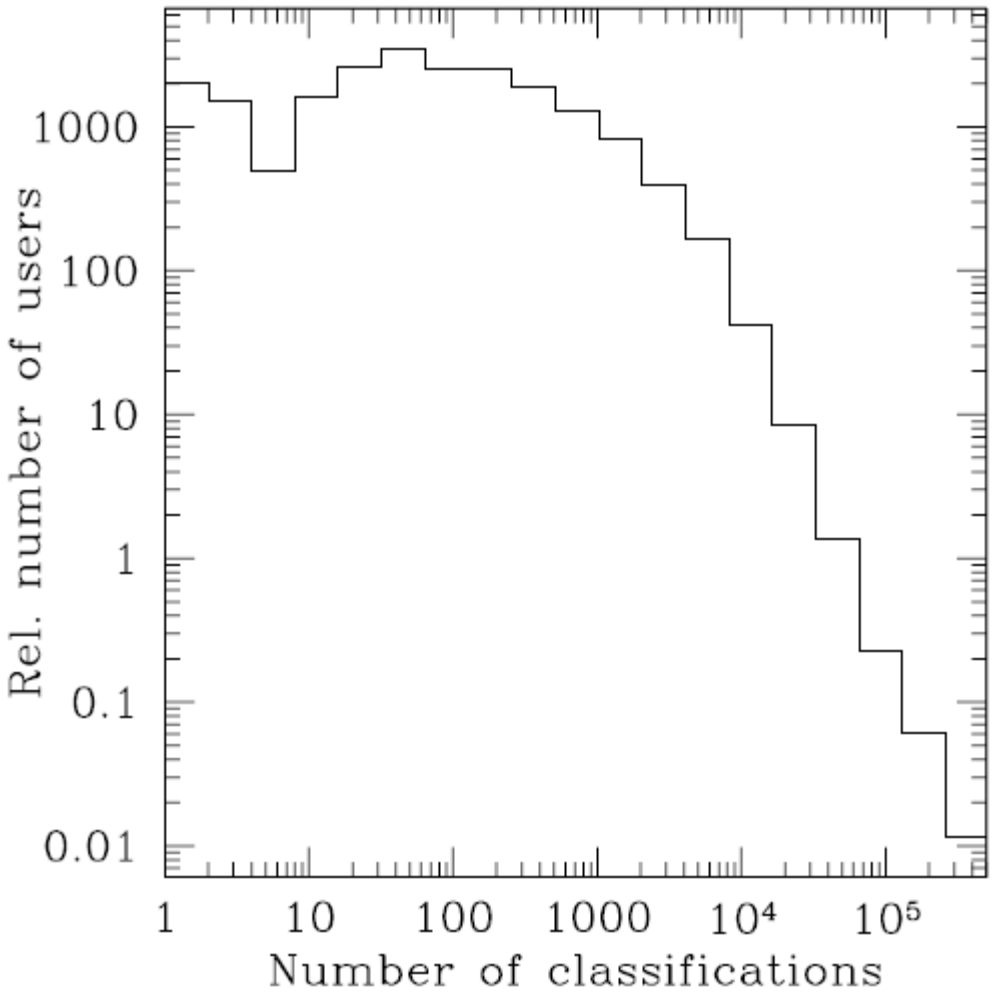
Galaxy Zoo citizen science classifications



Whale FM Citizen Science Project

- Aim: establish call repertoire of two species:
  - Killer whales
    - vocal species, and repertoire relatively well established
    - test reliability of crowdsourcing

  - Pilot whales
    - very vocal species but repertoire not well established
    - establish new repertoire

Behavioral Response Studies

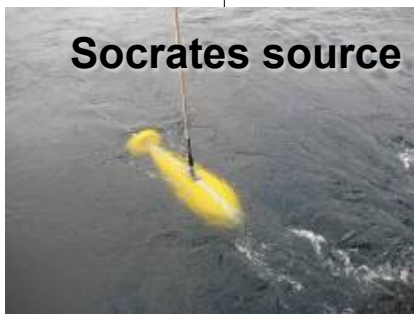
MS
Strønstad R/V HU Sverdrup II

-LFAS 1-2 kHz @ 214 dB

-MFAS 6-7 kHz 199 dB

-1 s hyperbolic up/down-sweeps

-20s pulse interval



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Recorded data

WHALEFM

15,000 calls recorded in different locations

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WHALE FM

Welcome to the Whale Song Project

You can help marine researchers understand what whales are saying. Listen to the large sound and find the small one that matches it best. Click 'Help' below for an interactive guide.

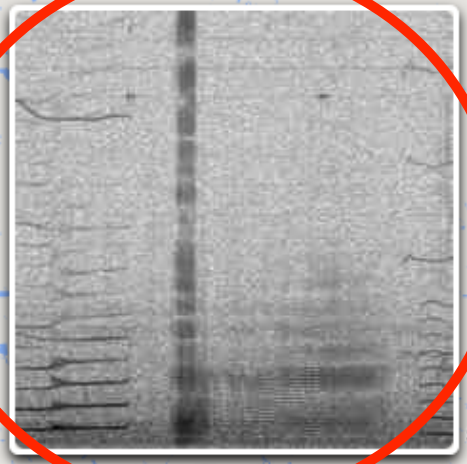
Home | About | How to Take Part | Account | Help

www.whale.fm

12 NOVEMBER 2013 12:04
NAME: ANDREN
LOG IN TO ENABLE TRACKING

Picture of whale

Whale call to be classified



Location of recording

Tromsø
Harstad
Bodø
Kiruna
Sodankylä
Murmansk (Мурманск)
Monchegorsk (Мончегорск)
Apatity (Апатиты)

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Suggested whale calls

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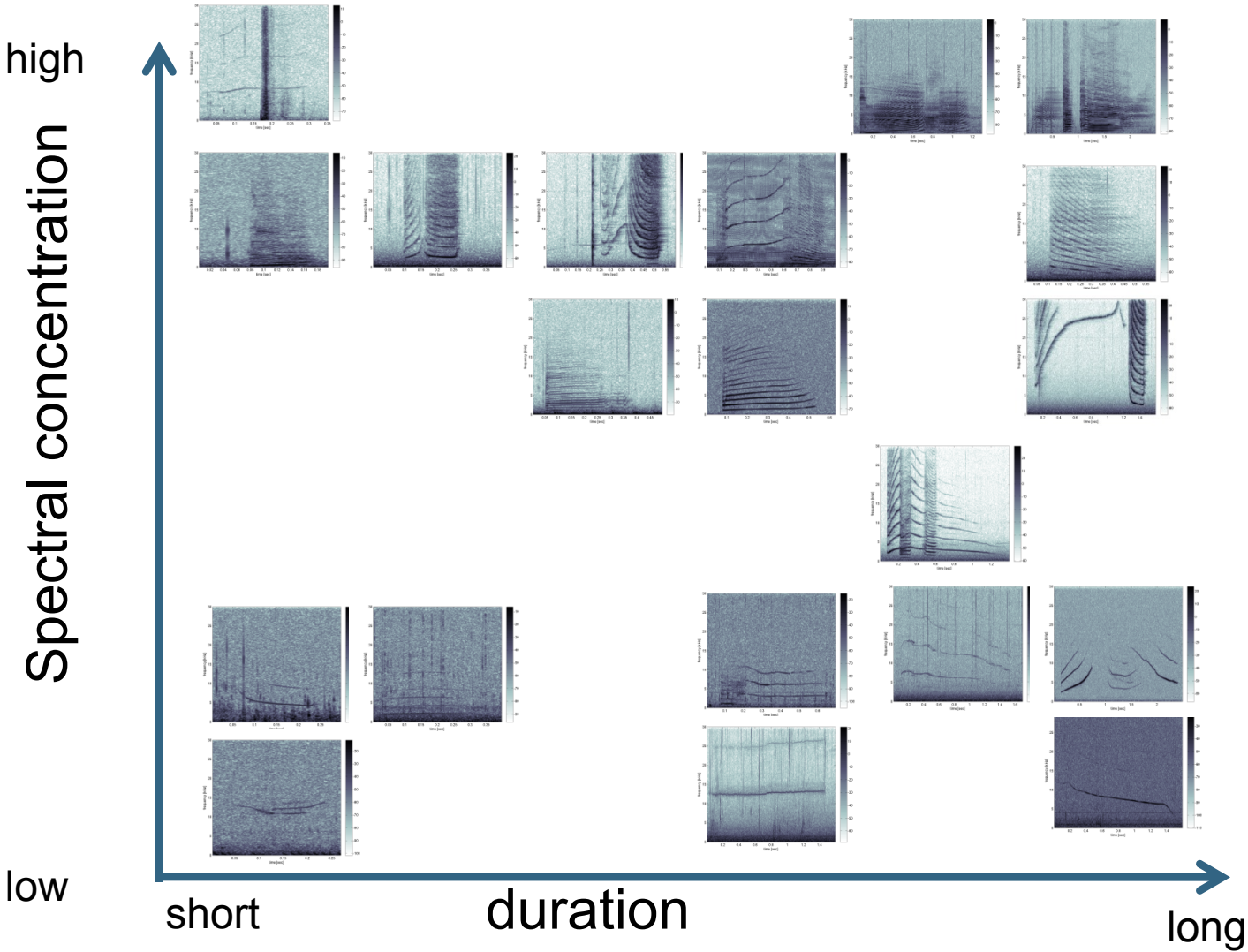
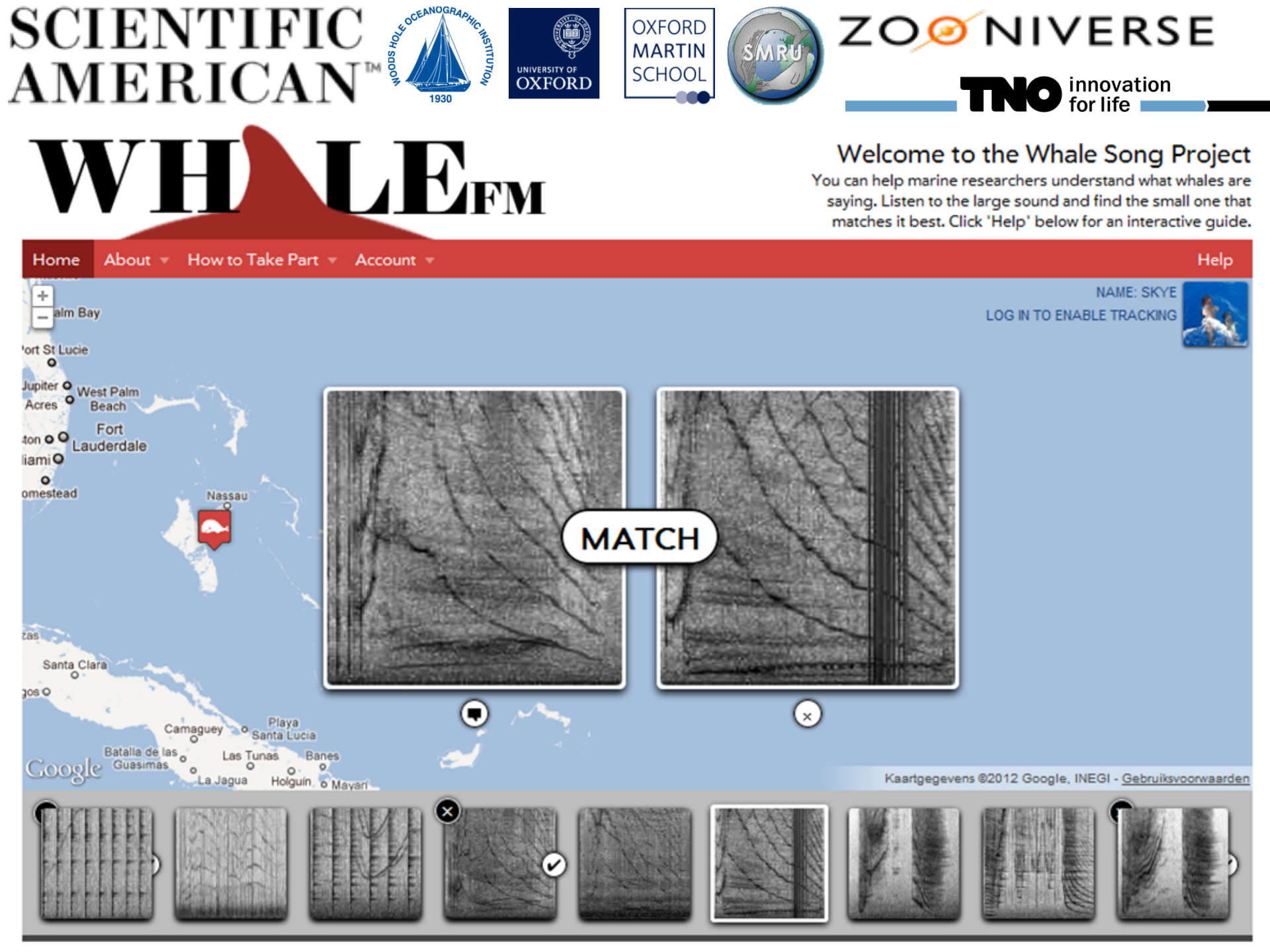
Pre-selection before presenting to volunteers

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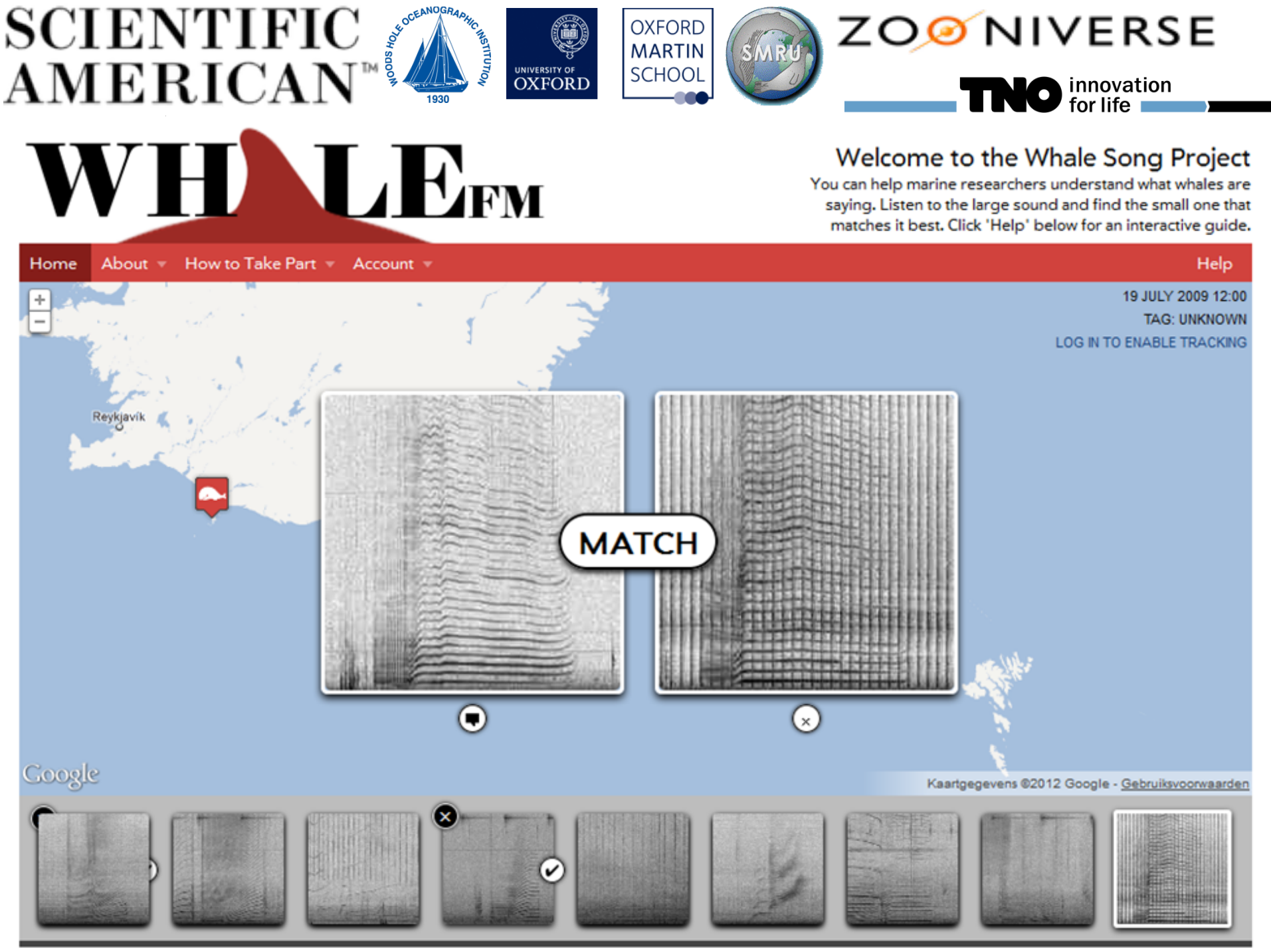
NAME: SKYE
LOG IN TO ENABLE TRACKING
MATCH
Nassau
Fort Lauderdale
West Palm Beach
Santa Clara
Camaguey
Playa Santa Lucia
Las Tunas
Banes
Holguin
Mayari
La Jagua
Batalla de las Guasimas
Google
Kaartgegevens ©2012 Google, INEGI - Gebruiksvoorwaarden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Help
19 JULY 2009 12:00
TAG: UNKNOWN
LOG IN TO ENABLE TRACKING
Reykjavik
MATCH
Google
Kaartgegevens ©2012 Google - Gebruiksvoorwaarden

Forum for volunteers to exchange ideas

RECENT DISCUSSIONS

Updated since 2013-09-01

Object: new to this	started by TomYah	
1 user 1 comment 1 new comment	last post 1 day ago by TomYah	
Object: AWH10008ca		
1 user 1 comment 1 new comment	last post 1 day ago by TomYah	
Chat: La Comunicación y el contexto	started by mariasilviarino	
1 user 1 comment 1 new comment	last post 22 days ago by mariasilviarino	
Science: not able to access answers to questions	started by shocko61	
1 user 1 comment 1 new comment	last post 22 days ago by shocko61	
Help: something went wrong	started by shocko61	
1 user 1 comment 1 new comment	last post 26 days ago by shocko61	
Science: RE: soundtrack problems	started by shocko61	
1 user 1 comment 1 new comment	last post 29 days ago by shocko61	
Science: soundtrack problems	started by shocko61	
1 user 1 comment 1 new comment	last post 29 days ago by shocko61	
Object: AWH10004tl		
1 user 5 comments 5 new comments	last post 29 days ago by shocko61	

Are the loud clicks on this recording man made or part of the song?

science

Marking examples with superimposed calls

Volunteers can add “tags”, Which can be monitored

Data Collected

- Since launch end of November 2011
  - > 220,000 matched calls by > 14,000 volunteers
- Scientific output so far:
  - Support expert judged call categories for pilot whales in Bahama's (Sayigh et al. 2012)
  - Comparison to unsupervised machine learning (Shamir et al., submitted)

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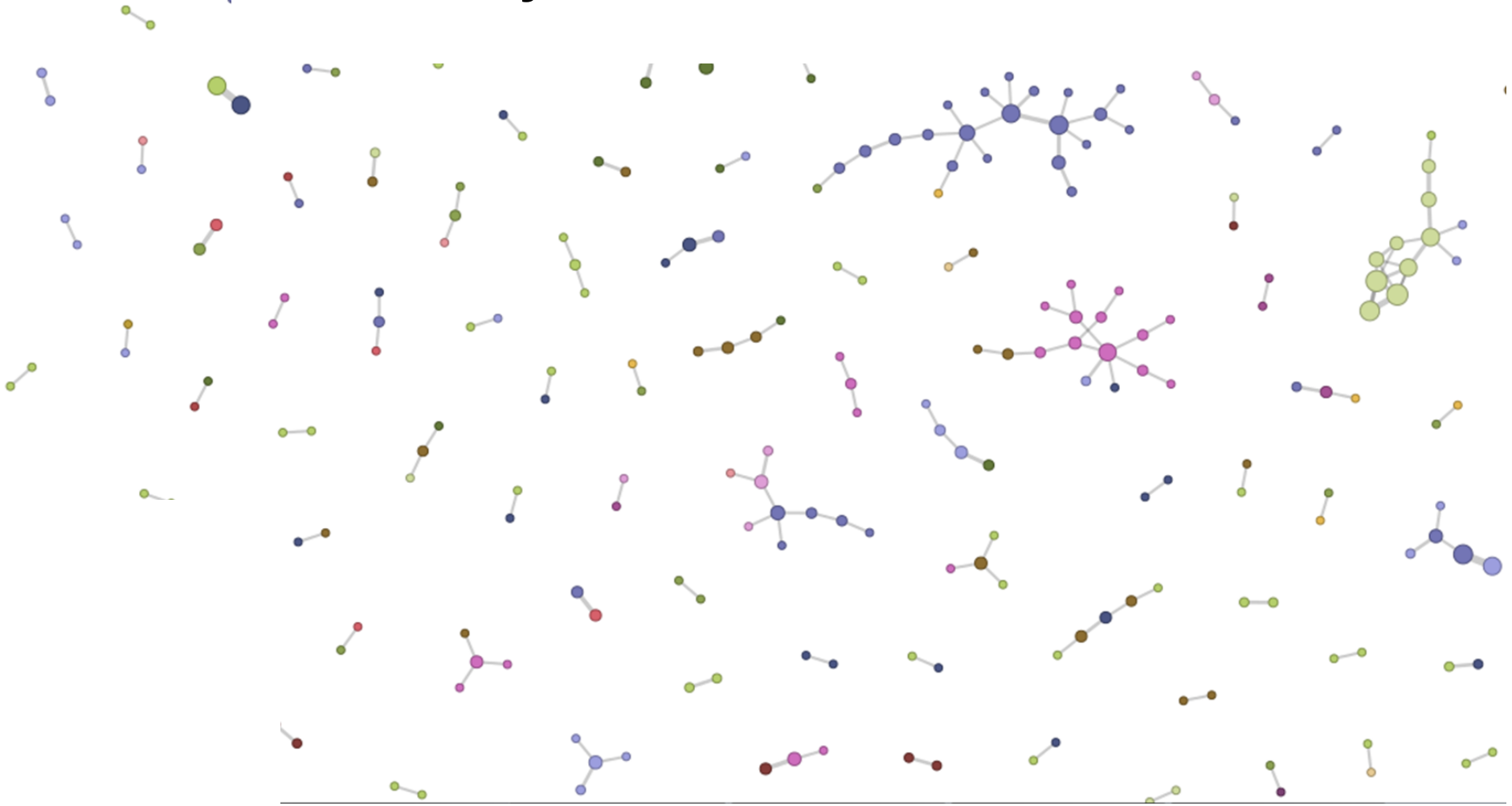
All matches occurring a

How to analyze Citizen Science data?



~15,000 calls, >220,000 matches

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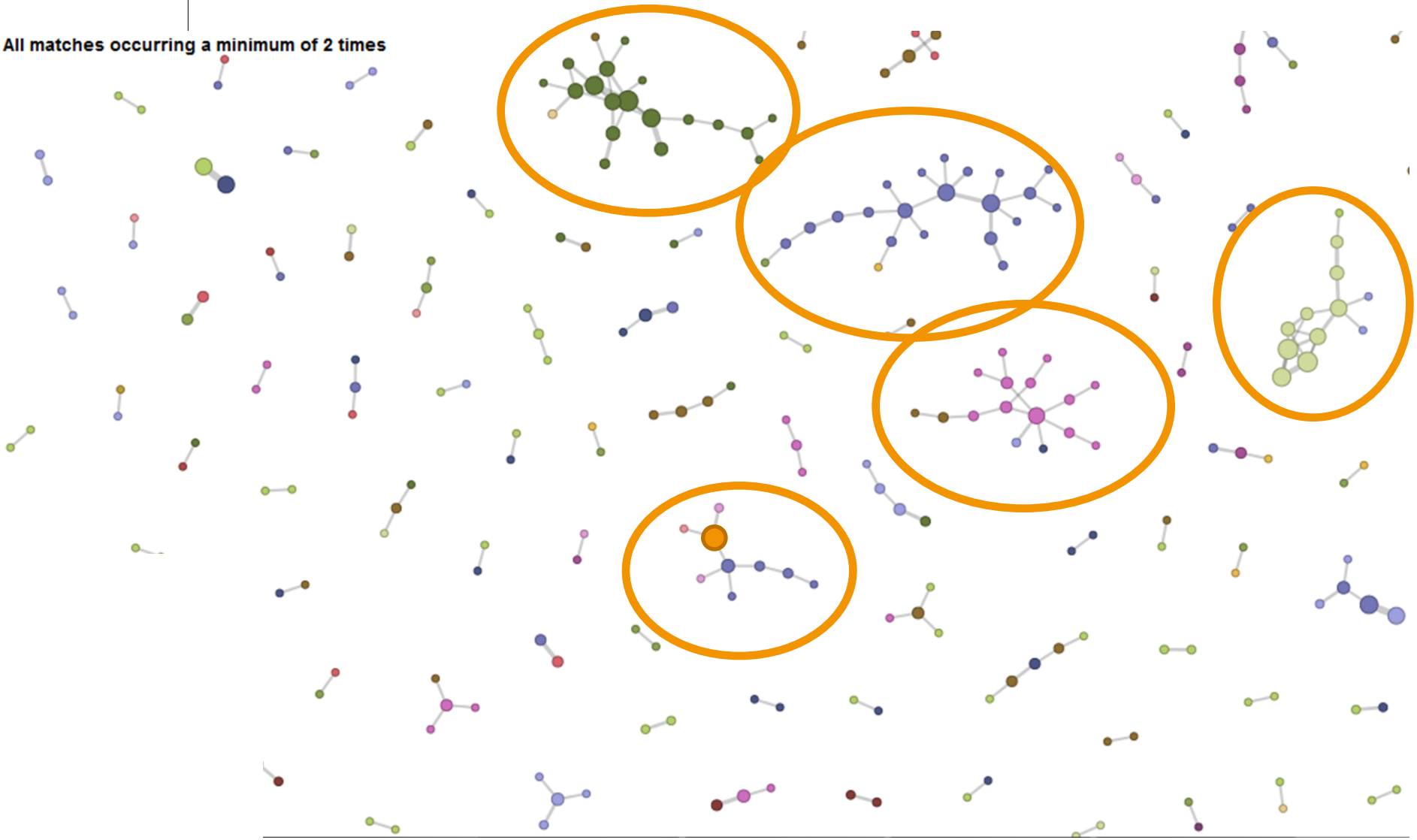
All matches occurring a minimum of 2 times



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All matches occurring a minimum of 2 times

How to analyze Citizen Science data?

11331

~15,000 calls, >220,000 matches

Killer whales: grouped by 3+ matches

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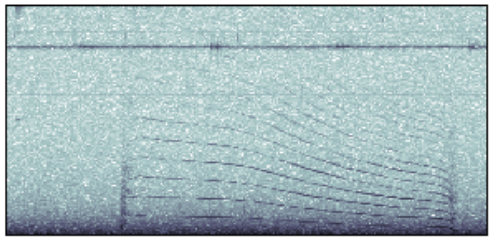

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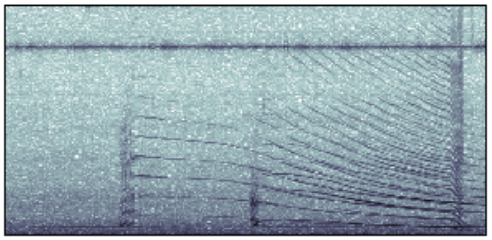

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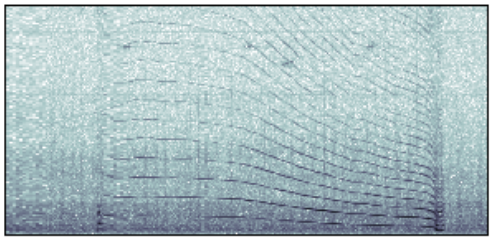

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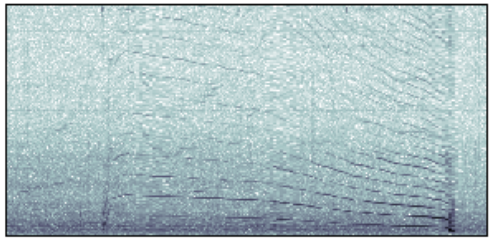

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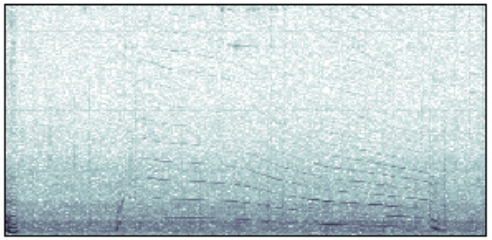

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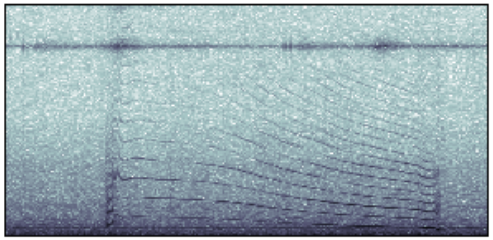

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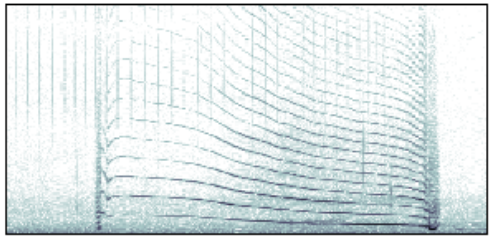

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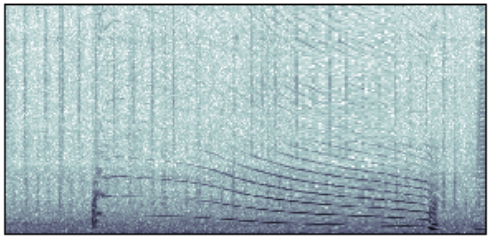

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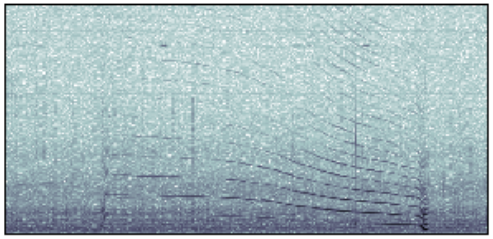

Pilot whales: grouped by 2+ matches

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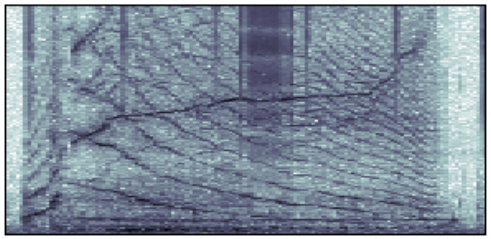

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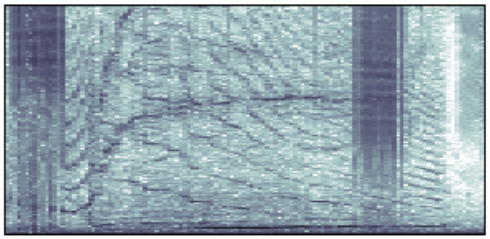

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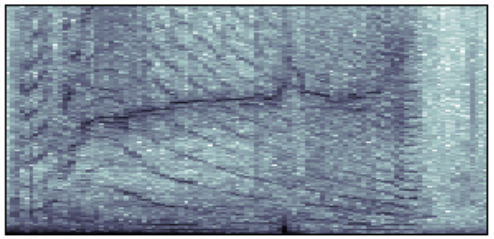

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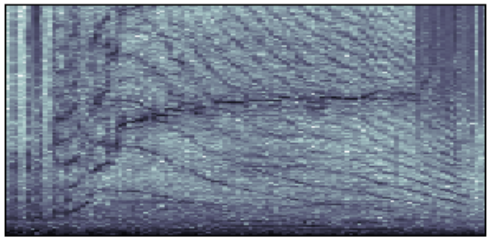

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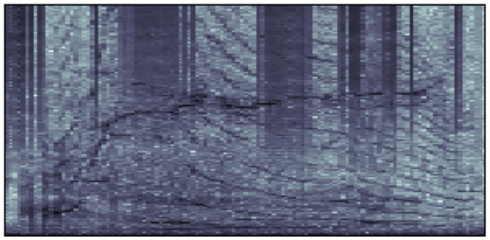

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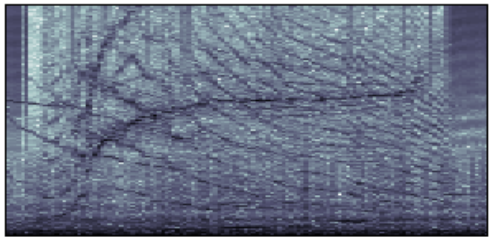

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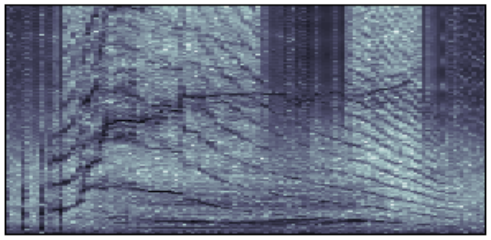

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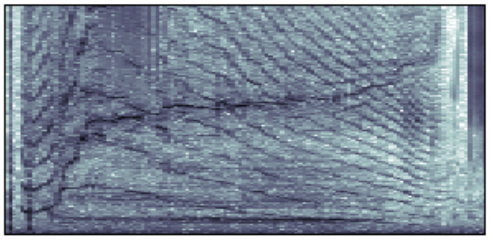

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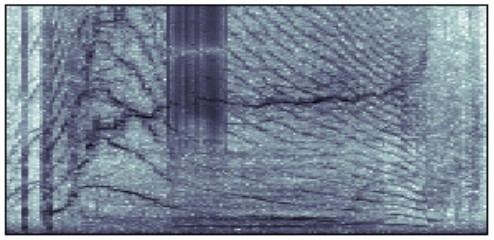

Pilot whales: grouped by 2+ matches

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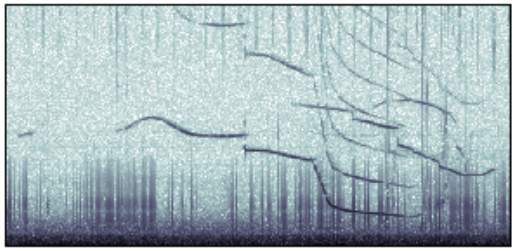

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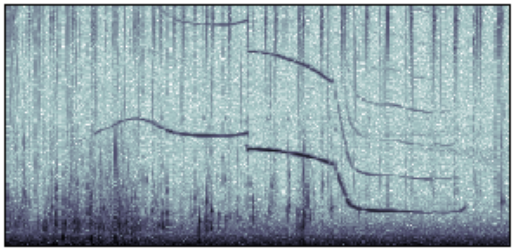

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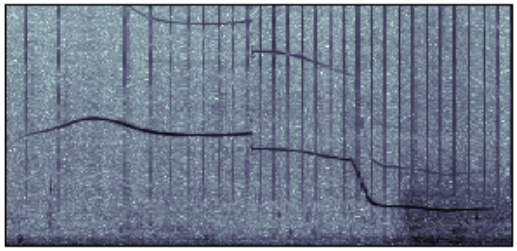

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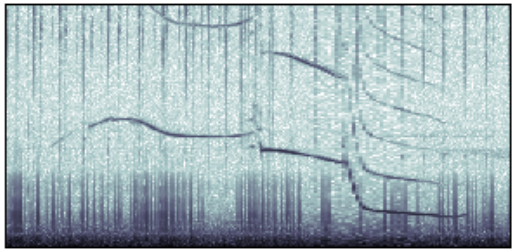

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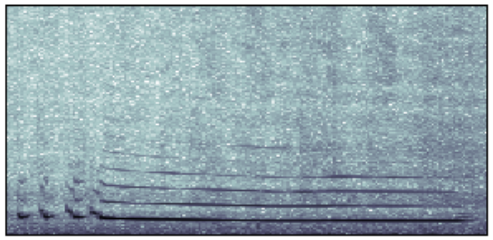

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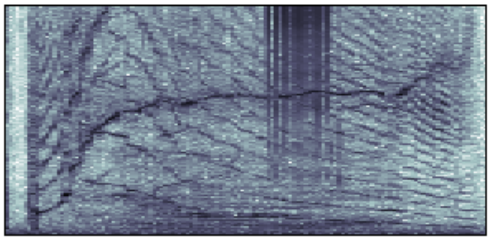

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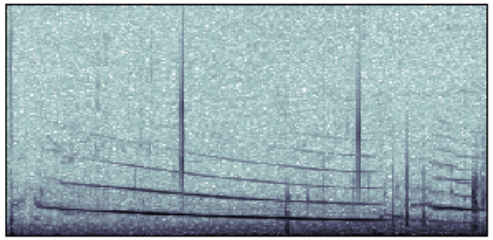

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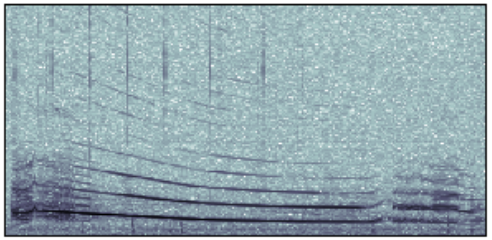

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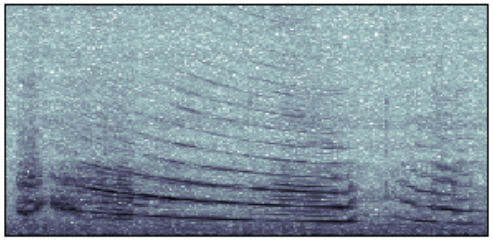

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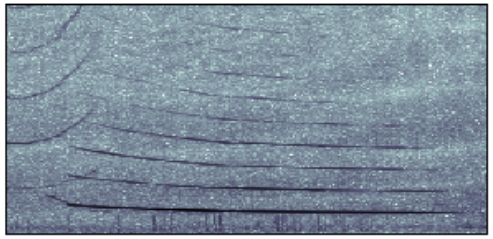

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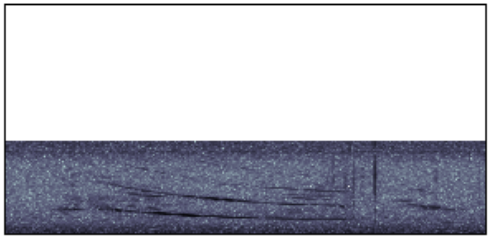

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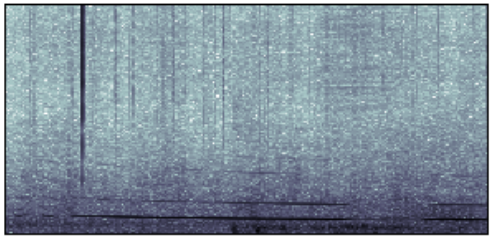

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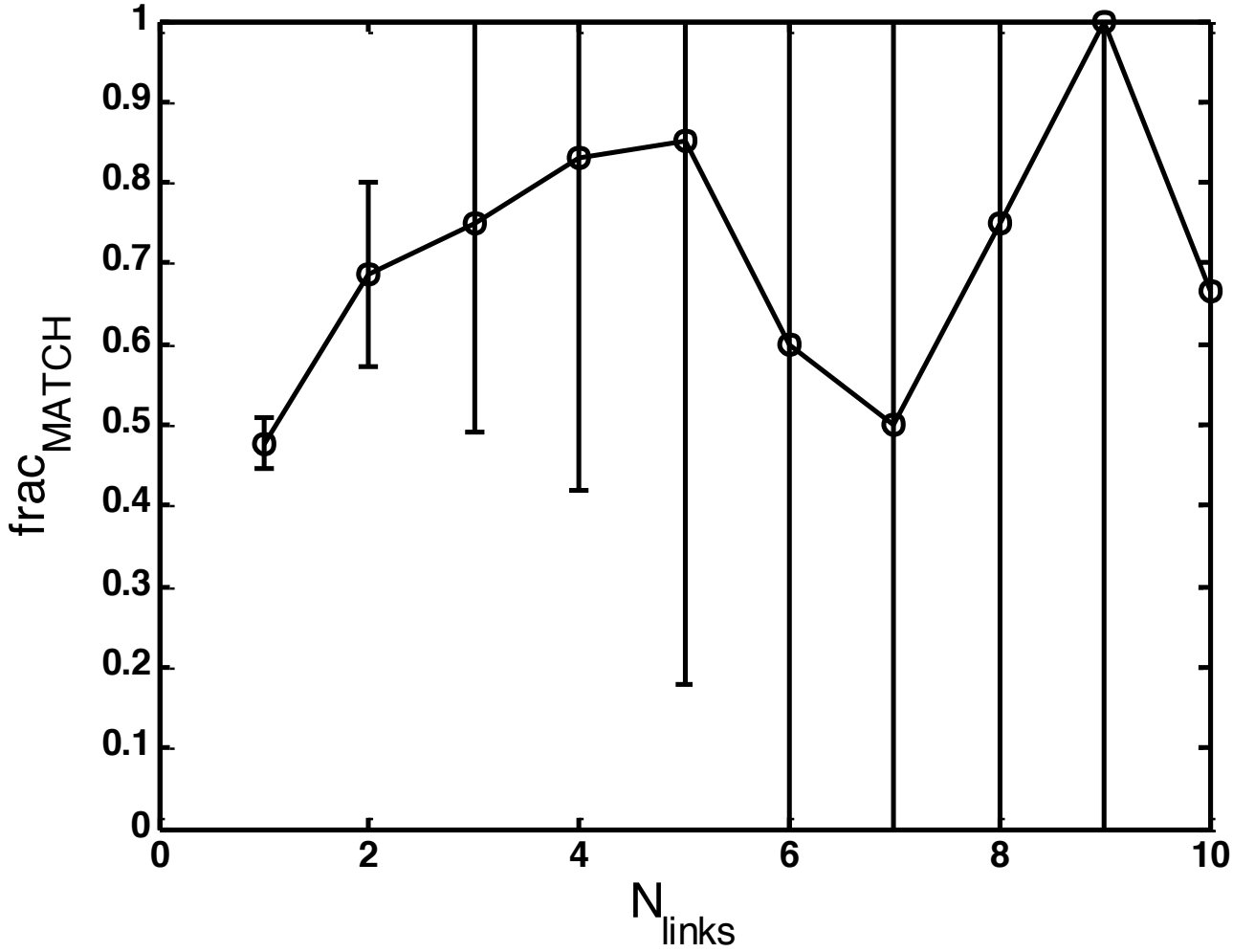
Comparison of volunteer matches to expert judgment of killer whale call categories



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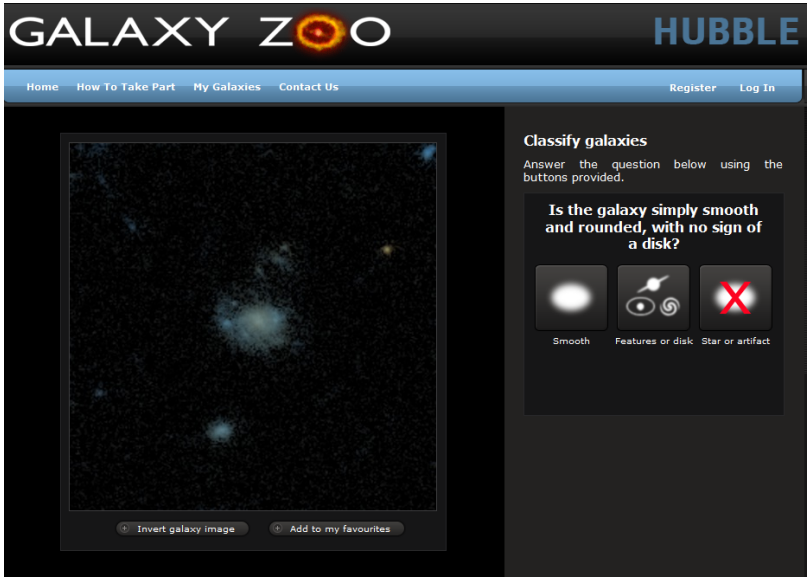
Galaxy Zoo 2



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- Classification biases (Willet et al. 2012)

$$\kappa = \frac{1}{N_\mathrm{r}} \sum_{i=1}^{N_\mathrm{r}} \kappa_i ,$$

$$\kappa_i = \begin{cases} f_\mathrm{r} & \text{if vote corresponds to this response,} \\ (1 - f_\mathrm{r}) & \text{if vote does not correspond.} \end{cases}$$

- Votes which agree with the majority thus have high values of consistency,
- votes which disagree have low values.

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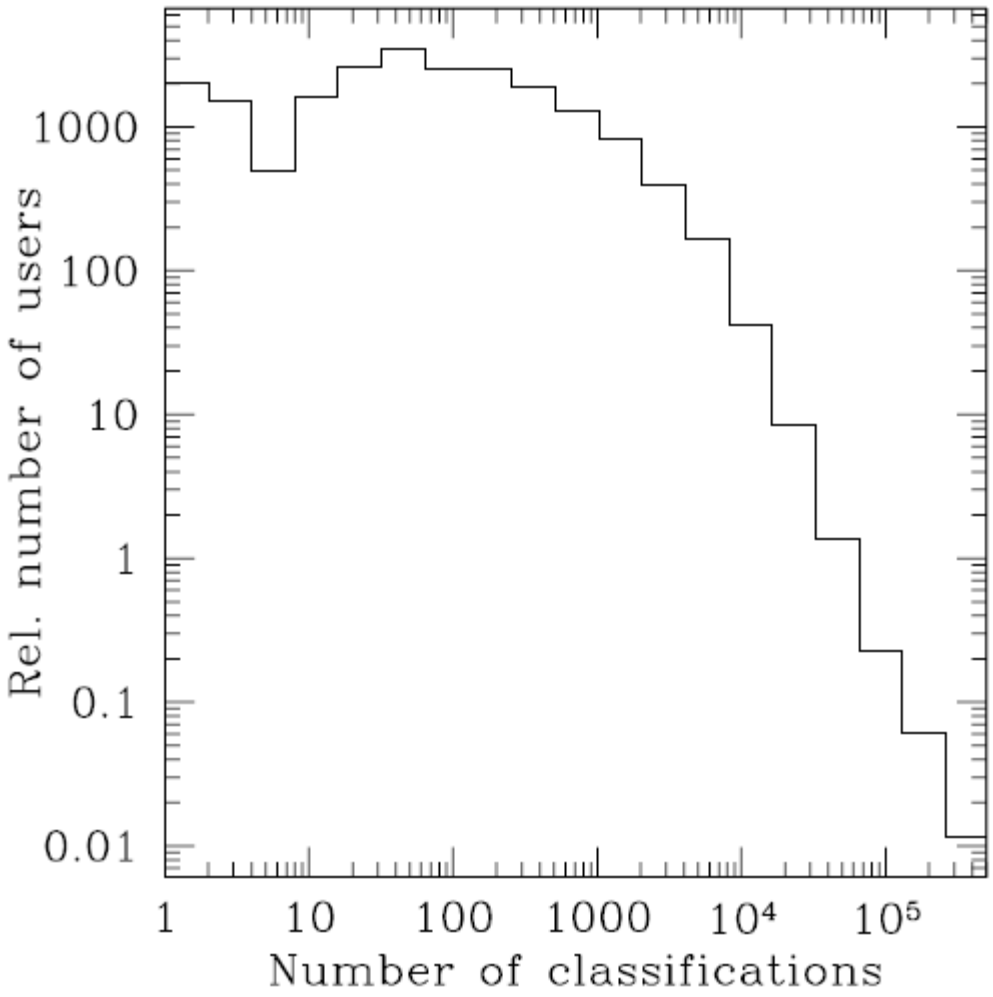
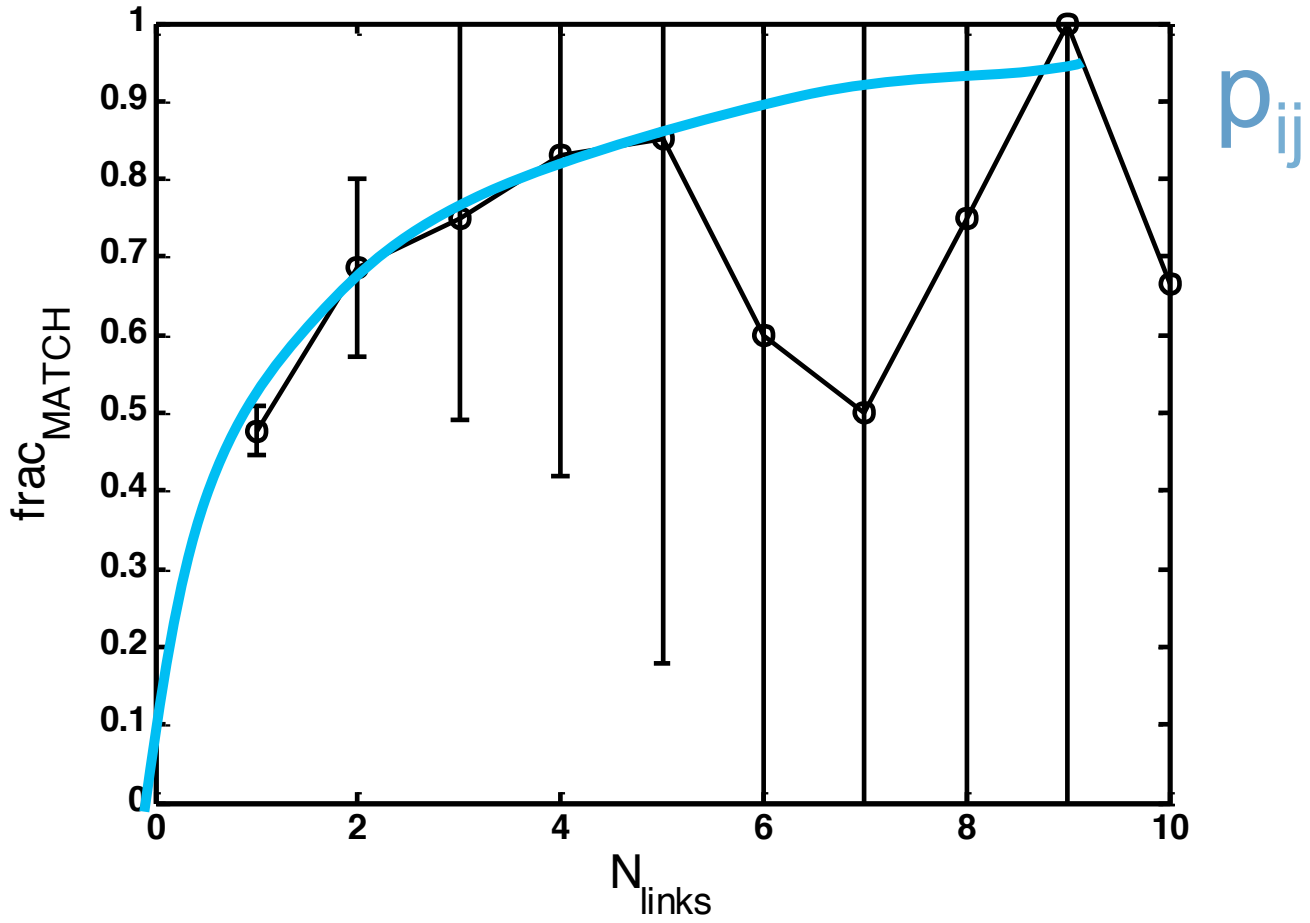
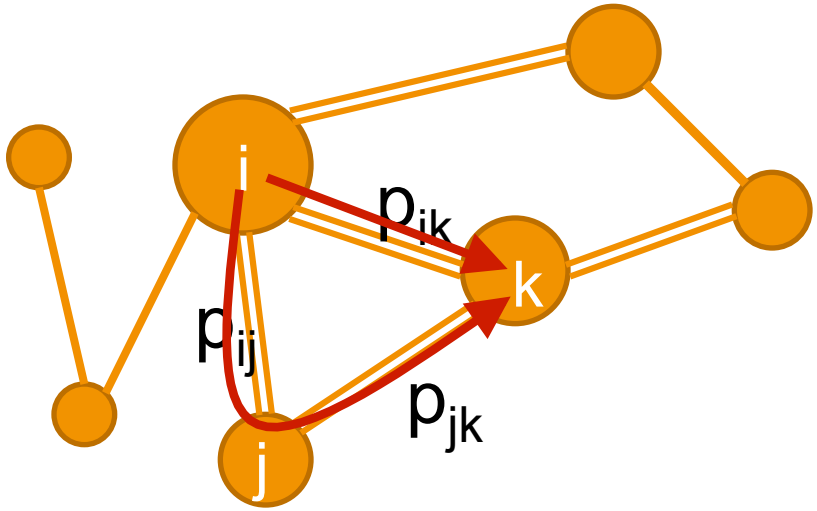
Galaxy Zoo citizen science classifications



Calibrate p_{ij} as function of number of matches using killer whale expert judgment



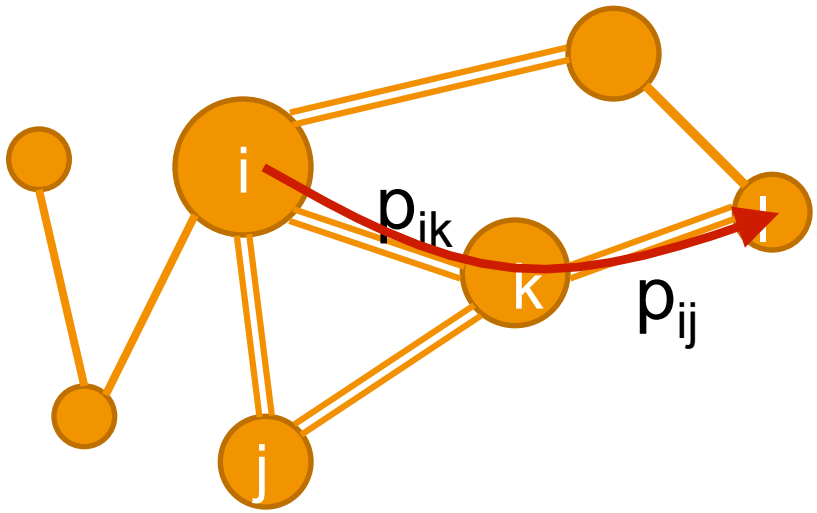
Probilistic linking of matched calls



$$P_{ij} = 1 - (1 - p_{ij})x(1 - p_{ik}x\ p_{kj})\ldots$$

- Use indirect paths as well using AND and OR logical rules

Probilistic linking of matched calls



Also compare calls indirectly that have not been matched directly.

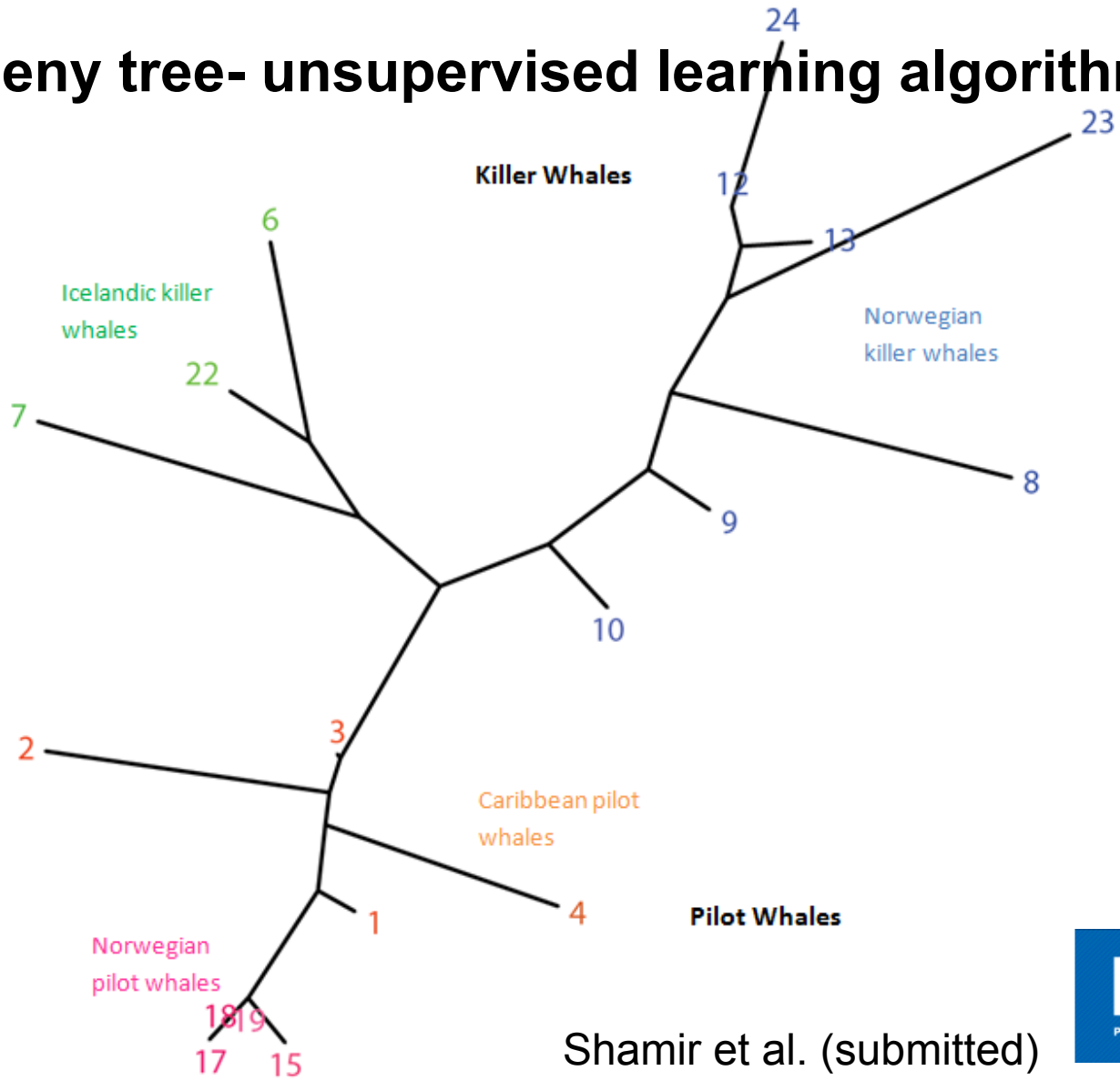
Similarity matrix

1	-	-	-
p_{12}	1	-	-
-	-	1	-
p_{14}	-	p_{34}	1

1	-	-	-
P_{12}	1	-	-
P_{23}	P_{23}	1	-
P_{23}	-	P_{23}	1

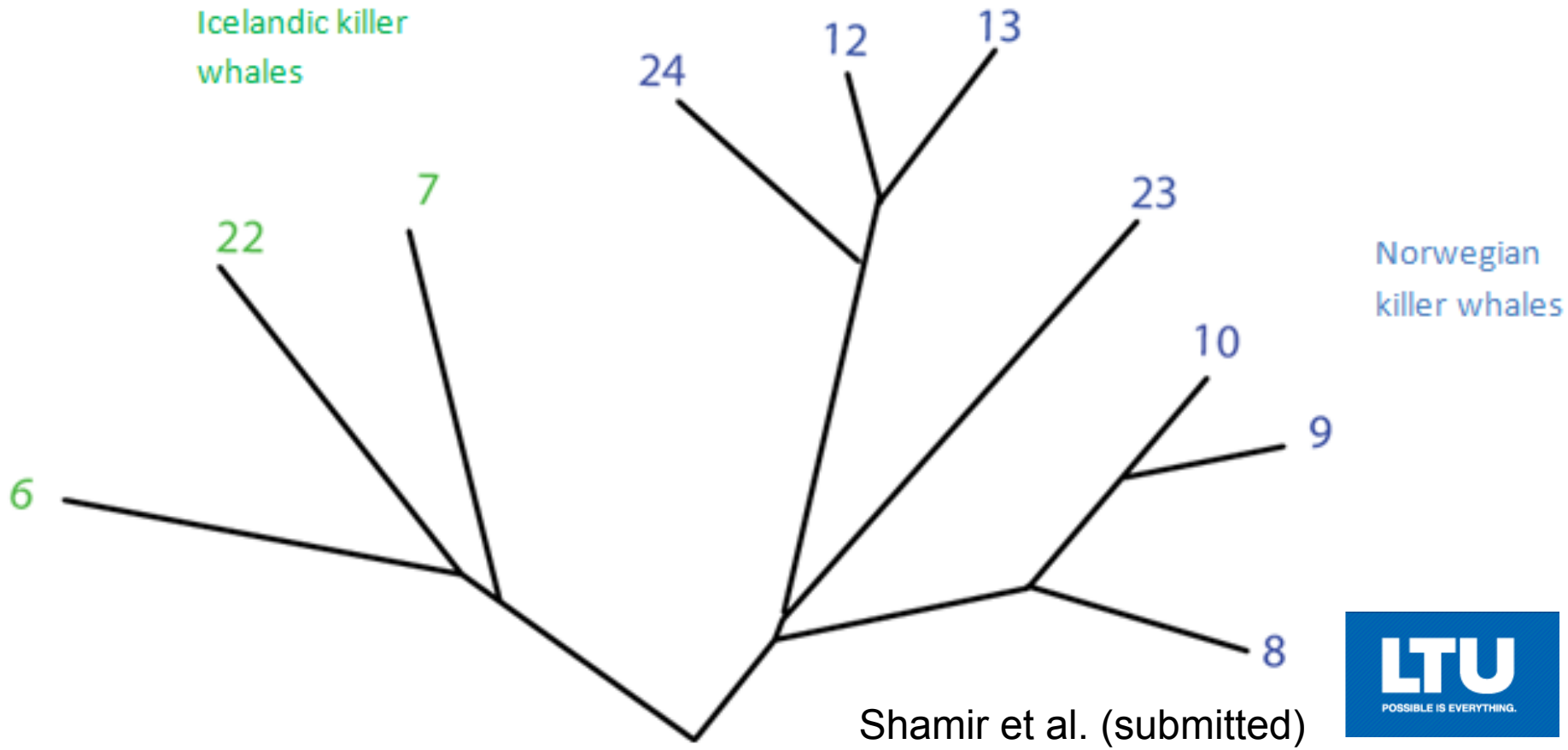
More densely populated similarity matrix?

Pylogeny tree- unsupervised learning algorithm



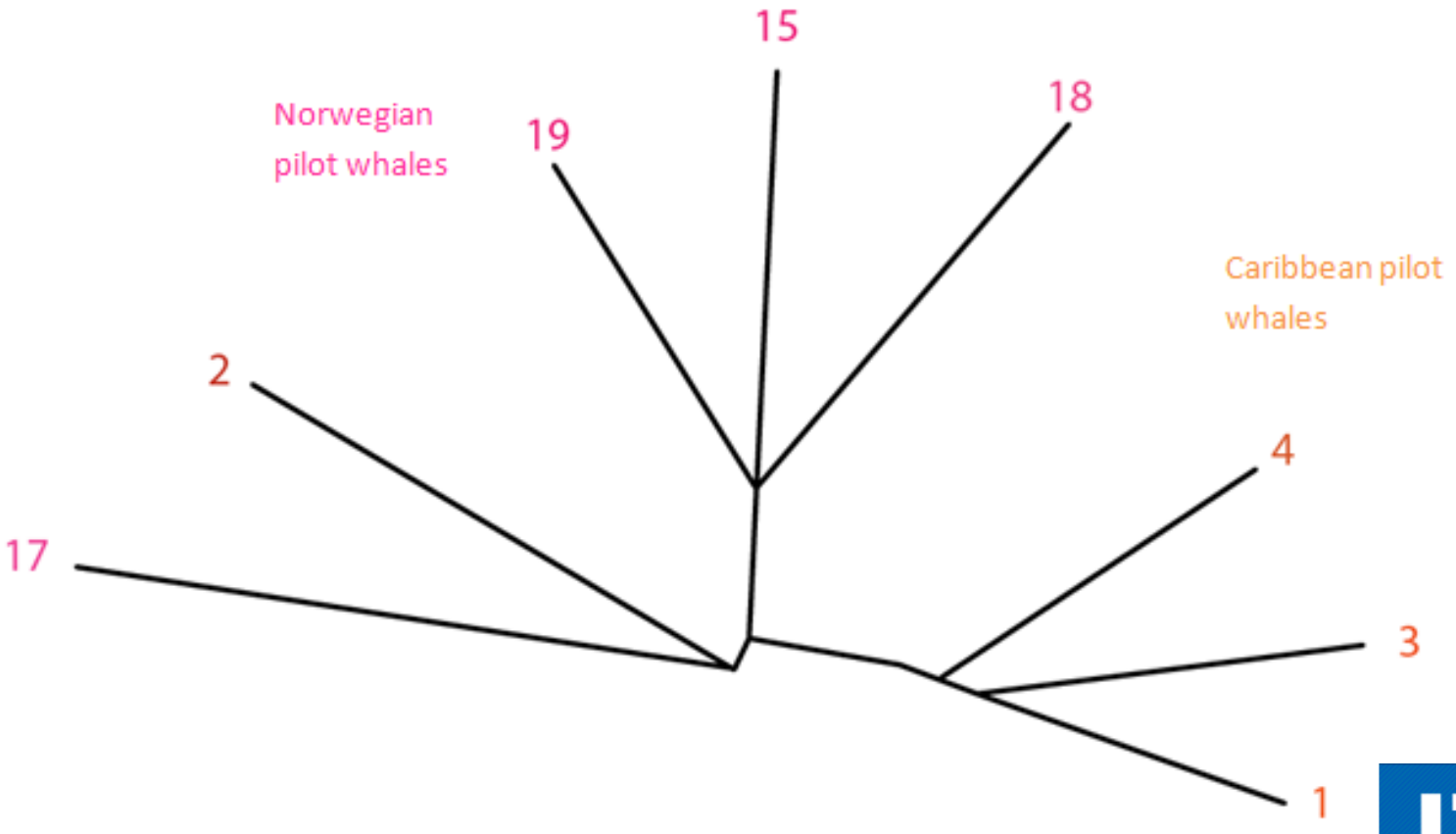
Shamir et al. (submitted)

Pylogeny tree- Citizen Science



Shamir et al. (submitted)

Pylogeny tree- Citizen Science



Shamir et al. (submitted)

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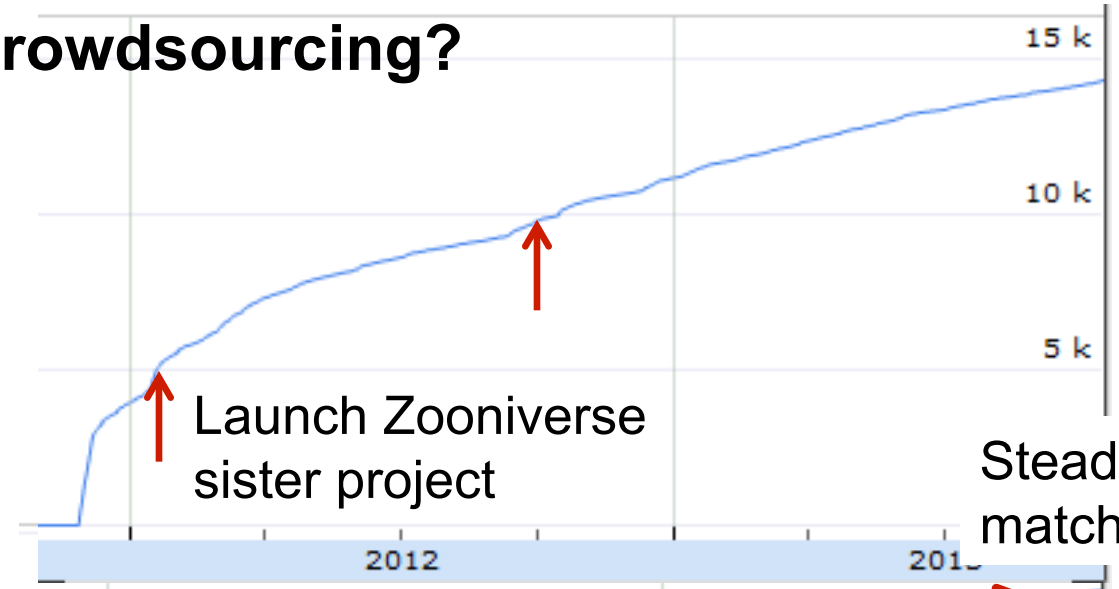
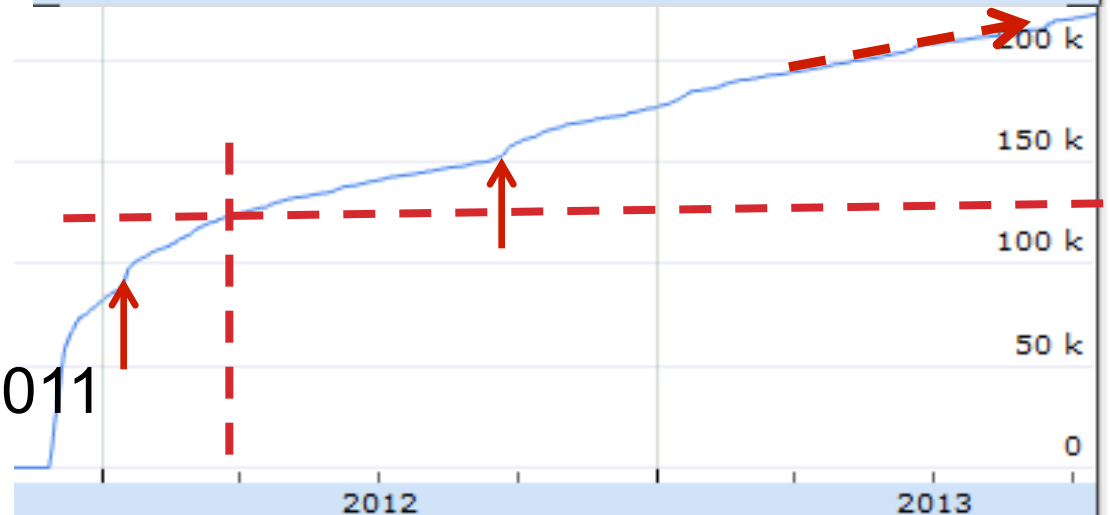
Motivation: How did Whale FM volunteer respond to crowdsourcing?



users

Steady increase of matches



matches

Launch Nov 2011

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Space

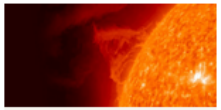
Sort by Category

How do galaxies form?
NASA's Hubble Space Telescope archive provides hundreds of thousands of galaxy images.

GALAXY ZOO

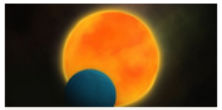
Explore the surface of the Moon
We hope to study the lunar surface in unprecedented detail.

MOON ZOO



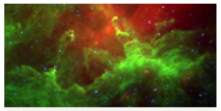
Study explosions on the Sun
Explore interactive diagrams to learn about the Sun and the spacecraft monitoring it.

SOLAR STORMWATCH



Find planets around stars
Lightcurve changes from the Kepler spacecraft can indicate transiting planets.

planethunters.org

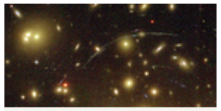


How do stars form?
We're asking you to help us find and draw circles on infrared image data from the Spitzer Space Telescope.

THE MILKY WAY PROJECT

Explore the Red Planet
Planetary scientists need your help to discover what the weather is like on Mars.

PLANET FOUR



Help us find gravitational lenses
Imagine a galaxy, behind another galaxy. Think you won't see it? Think again.

SPACEWARPS

Climate

Model Earth's climate using historic ship logs
Help scientists recover Arctic and worldwide weather observations made by US Navy and Coast Guard ships.

Classify over 30 years of tropical cyclone data.
Scientists at NOAA's National Climatic Data Center need your help.

Humanities

Study the lives of ancient Greeks
The data gathered by Ancient Lives helps scholars study the Oxyrhynchus collection.

Nature

Hear Whales communicate
You can help marine researchers understand what whales are saying

WHALEFM

Help explore the ocean floor
The HabCam team and the Woods Hole Oceanographic Institution need your help!

SEAFLOOR EXPLORER

You're hot on the trail of bats!
Help scientists characterise bat calls recorded by citizen scientists.

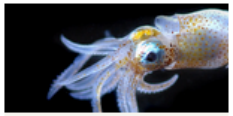
BAT DETECTIVE

Go wild in the Serengeti!
We need your help to classify all the different animals caught in millions of camera trap images.

SNAPSHOT SERENGETI

Take Notes from Nature
Transcribe museum records to take notes from nature, contribute to science.

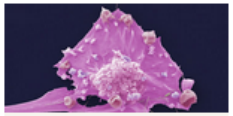
Notes from Nature



No plankton means no life in the ocean
Plankton are a critically important food source for our oceans.

PLANKTON PORTAL

Biology



Analyse real life cancer data.
You can help scientists from the world's largest cancer research institution find cures for cancer.

Track genetic mysteries
We can better understand how our genes work by spotting the worms laying eggs.

www.zooniverse.org

Motivation: What motivates volunteers?

- Poll amongst 11,000 Galaxy Zoo volunteers (Raddick et al. 2012).

Motivation Category	Frequency	Percentage
Contribute	4,192	39.8%
Astronomy	1,301	12.4%
Discovery	1,091	10.4%
Beauty	939	8.9%
Vastness	870	8.3%
Science	718	6.8%
Zoo	429	4.1%
Helping	300	2.8%
Fun	294	2.8%
Learning	172	1.6%
Other	135	1.3%
Teaching	75	0.7%
Community	16	0.2%

Motivation: What motivates volunteers?

- Poll amongst 11,000 Galaxy Zoo volunteers (Raddick et al. 2012)
  - "the general trend in responses suggests that a greater number of volunteers are motivated by identification with project goals and interest in scientific content, and are less motivated by learning science and participating in a social community."
  - "Men are more likely to be motivated by interest in science, while women are more likely to be motivated by desire to see beautiful galaxy images and the fun of classifying galaxies.

Summary (1)

- Citizen Science or Crowdsourcing has the potential to help scientists classify large acoustic datasets that are still difficult to tackle using automated pattern recognition software.

- Outlook:
  - Construct high fidelity call categories using citizen scientist data
  - Evaluate reliability of non-expert judgment
  - Check for biases (e.g. background noise, signal quality, sensor type, etc.)
  - Comparison to automated classification algorithms

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Summary (2)

- Ingredients for a good citizen science project:
  - Clear science objective
    - what does the volunteer contribute to?
  - Simple and short task
  - Must be fun!
    - e.g. following individual whale, background of recorded whales, allowing volunteers to choose names
  - Aim for multiple views of same data
    - > 4 comparisons to obtain reliable results

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Summary (3)

- Ingredients for a good citizen science project:
  - Create active user-group community
    - requires a lot of effort!
  - Different tasks with different effort (easy first time, more advances when volunteer is interested)
  - Users can attach “tags” for features you haven’t thought of before.
  - Good publicity!

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Future

- Platform for scientists to put in their acoustic data and have community of volunteers to audit the data?

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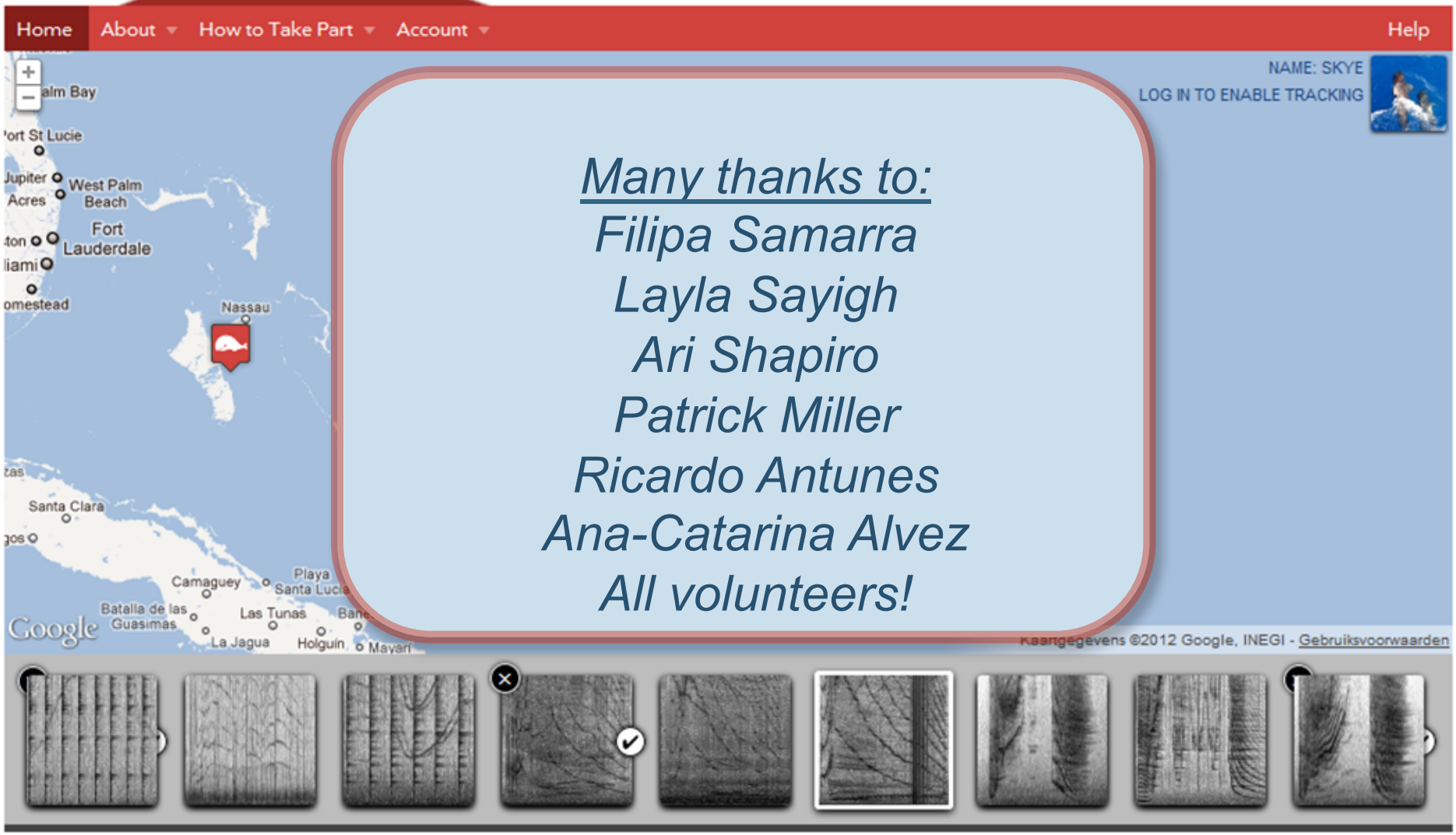
WHALE FM

Welcome to the Whale Song Project

You can help marine researchers understand what whales are saying. Listen to the large sound and find the small one that matches it best. Click 'Help' below for an interactive guide.



Many thanks to:

Filipa Samarra

Layla Sayigh

Ari Shapiro

Patrick Miller

Ricardo Antunes

Ana-Catarina Alvez

All volunteers!

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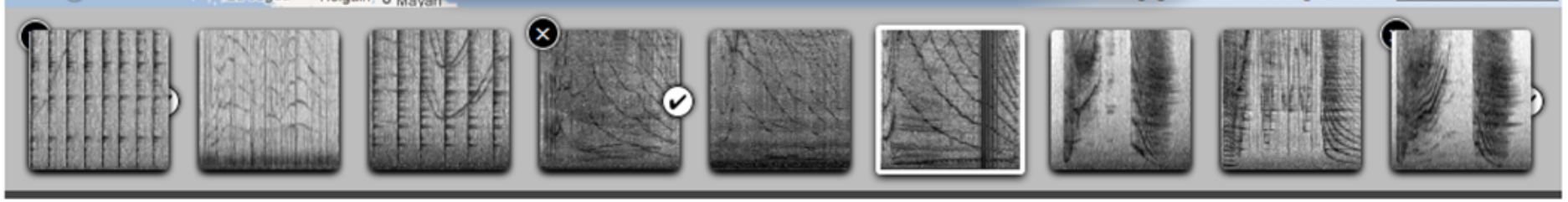
Home | About | How to Take Part | Account | Help

NAME: SKYE

LOG IN TO ENABLE TRACKING

Stay tuned to Whale FM!

www.whale.fm