ORCASOUND

open source software for catalyzing conservation of Southern Resident killer whales (in real-time)

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orcasound.net/talks

Our orcas: the southern salmon seekers

Southern Resident Killer Whales (SRKWs) are:

- **Southern** = ranging from northern California to SE Alaska
- **Resident** = historically re-occurring within the Salish Sea (inland waters of WA and BC)
- **Killer** = apex predators, salmon specialists
- **Whales** = cultural icons, both historically & as modern “charismatic megafauna”

How can we collaborate across State and International boundaries to conserve these orcas?

Our orcas: recovery by a 1000 actions

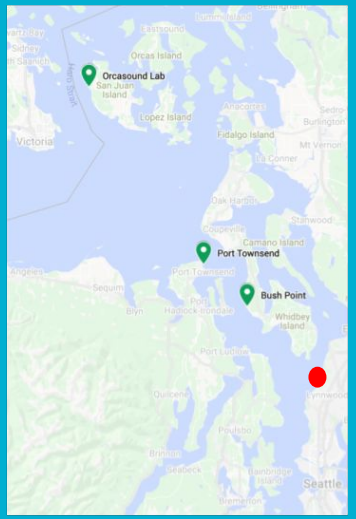
Cumulative human impacts
NOAA recovery plan

- 3 key risks:
  - Scarce salmon
  - Persistent pollutants in blubber
  - Vessel effects
- Vessel noise impacts:
  - Ship noise masks communication & echolocation
  - Boat interference lowers foraging efficiency

How can AI & human listeners work synergistically to conserve SRKWs (in real-time)?

How? cooperate as a hydrophone network

2002: Orcasound Lab (Val's "back yard")
2008-12 NOAA funding (expansion to 5 nodes)
2013-15 Philanthropy only (decline to 2 nodes)
2016-now Cooperative network (17 NGOs in 2021)



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2017 crowd-funding ($20k Kickstarter)
2018 open-sourcing, crowd-sourcing, open data...
2020+ hackathons, philanthropy, Amazon+Microsoft cloud credits

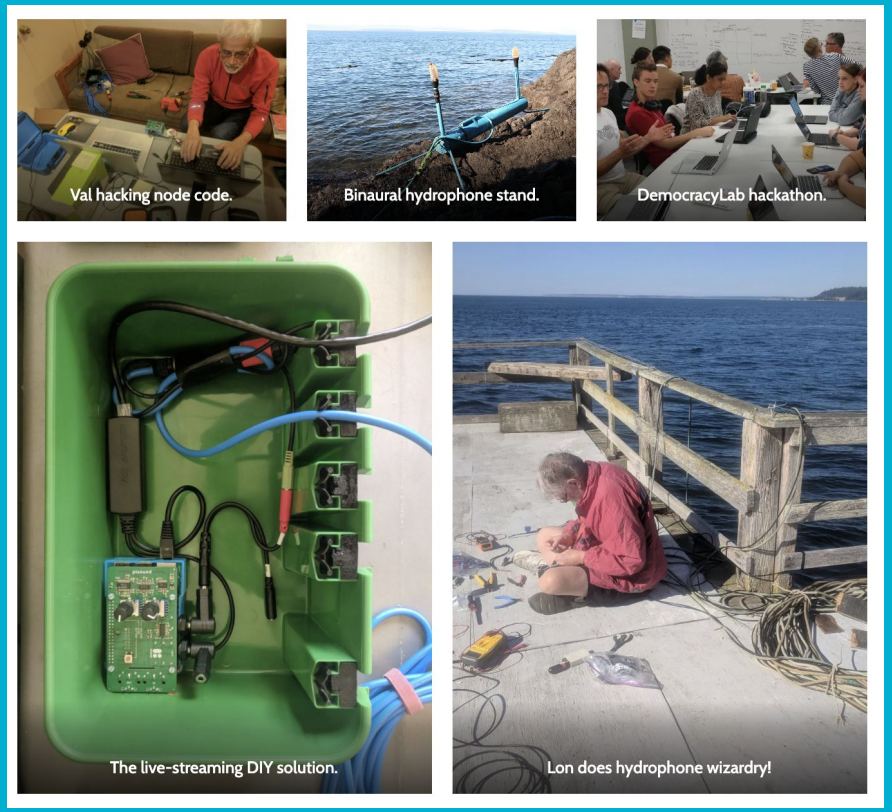
How? collaborate openly in soft/hard-ware

<2002-17
-- humans listening via Shoutcast mp3 streams
-- Val building custom software, alone
-- Scott building web static web sites, Google sheets, manual Twitter/email notifications...

2017-18: software + hardware (Kickstarter for v1 web app), live.orcasound.net launched Nov '18

2019-20: v2 UI beta-tested in Nov '19, launched in May, 2020

2021: v3 UI + a proliferation of related projects (24 *public* Orcasound Github repositories)

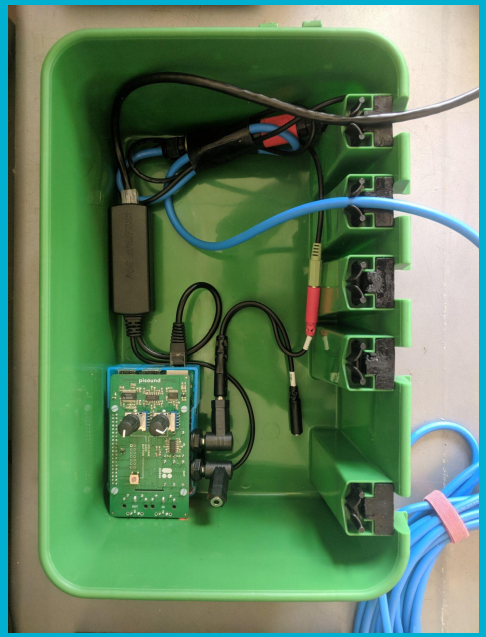


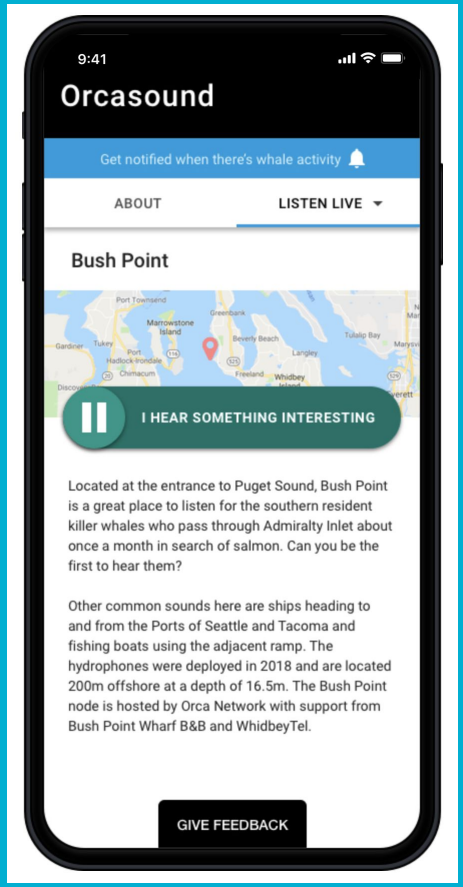
ORCASOUND

Easy to listen live. Scales inexpensively. Lets user tag data.

- 3 cabled nearshore sites streaming 24/7 (2018-21)
- Streaming hardware cost: ~U$300 per node
- Hydrophone $300-1500
- PiSound HAT = 2 channel, 24 bit, 48/96/192 kHz
- Free open source code!

Community scientists detect orca & novel sounds in real-time via a web app -- live.orcasound.net





Orca sounds

orcanode code

orcasite code

How? open access raw data

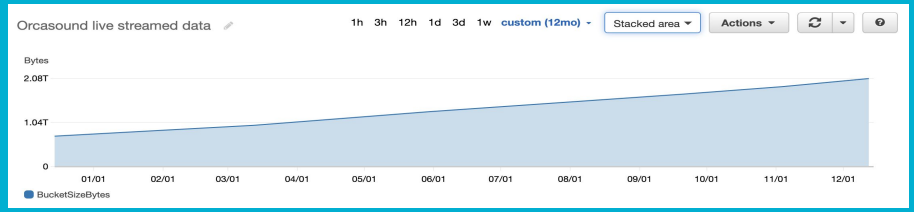
```
aws --no-sign-request s3 sync streaming-orcasound-net
```

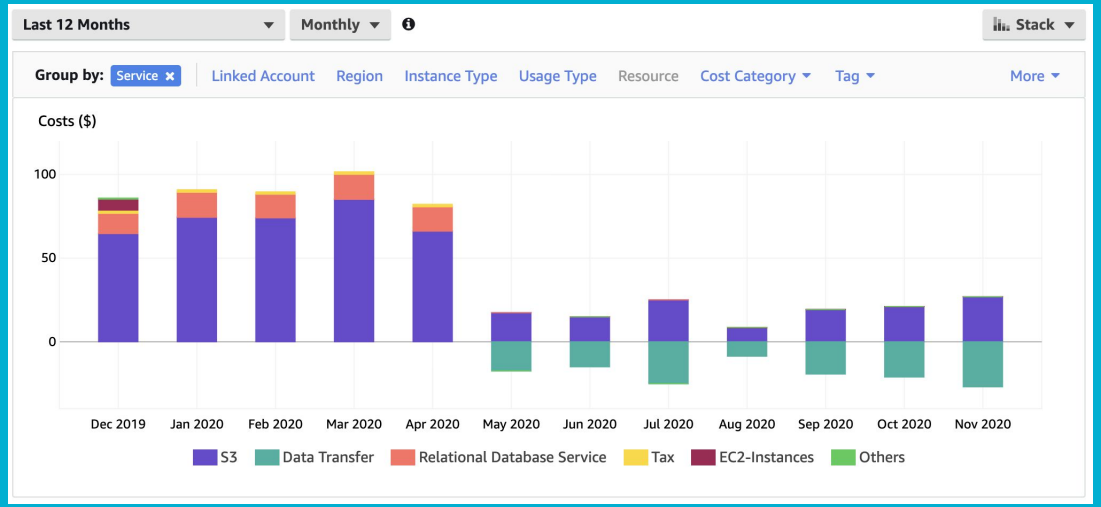
Data volume

- 3.2 TB (HLS audio only)
- 0.4 TB/yr/node
- Increasing soon...
  ...FLAC, 48/96 kHz

Data costs

- <$100/mo w/3 nodes
- ~30$/mo/node, but scalable
- Free thus far with cloud credits!
- AWS open data registry + Quilt





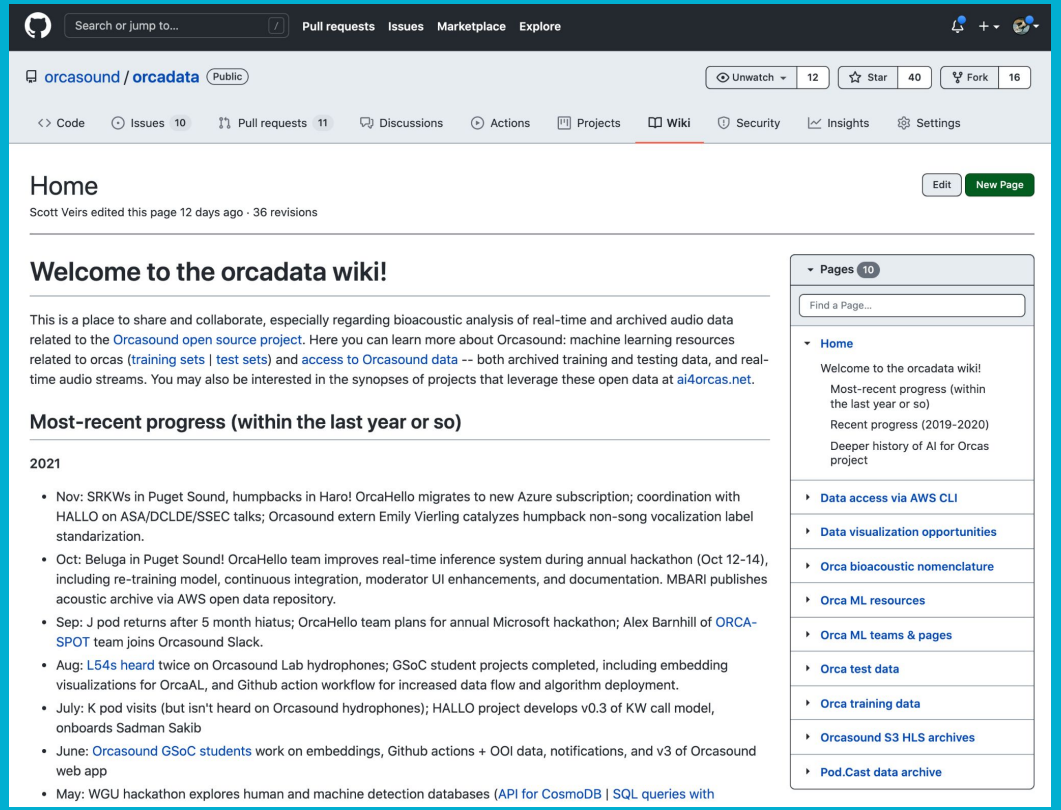
How? open labeled data & labeling tools

Labeled data (orcadata wiki)

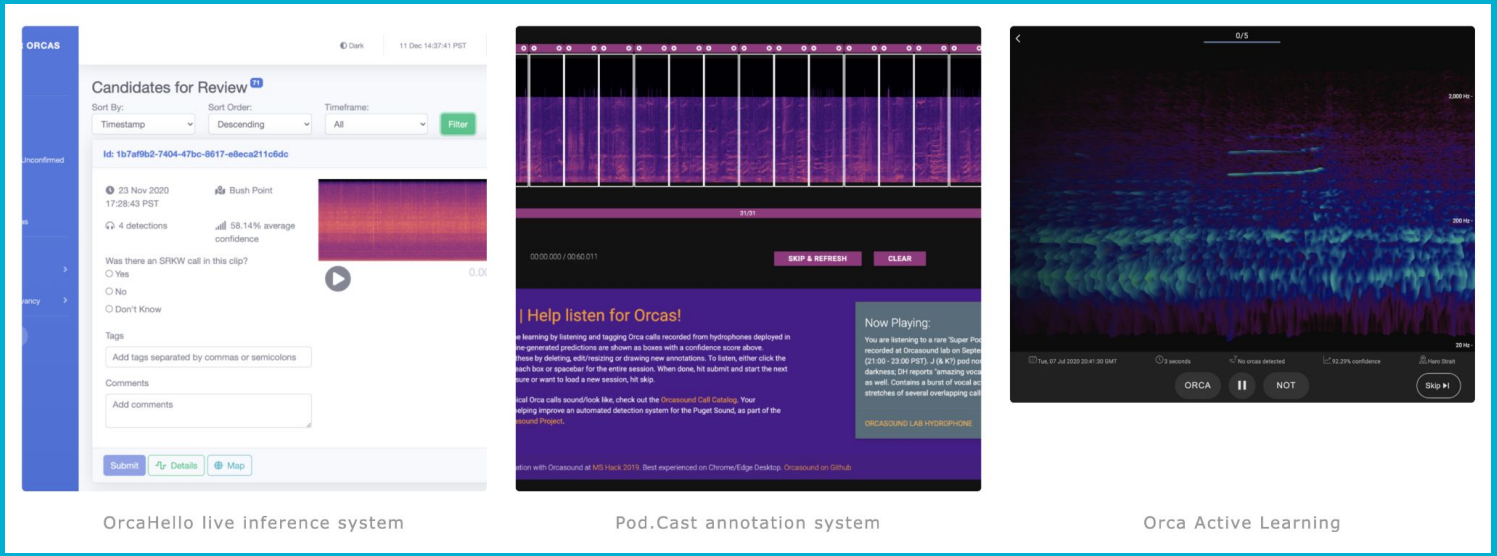
- SRKW calls
- 2022: signals of other SRKW sounds, Bigg's KW, and humpback

Labeling tools

- 2000 Orcasound human labels (~100/month, free text)
- Pod.Cast (2019)
- OrcaHello tags (2020+) w/D. Bain
- Orca Active Learning (2020+)
- Audacity (expert labeled test sets)
- *2022: HALLO annotation tool*



Artificial Intelligence for orcas



OrcaHello live inference system | Pod.Cast annotation system | Orca Active Learning

AI for orcas (#ai4orcas) -- ai4orcas.net -- OrcaHello | Pod.Cast | OrcaAL

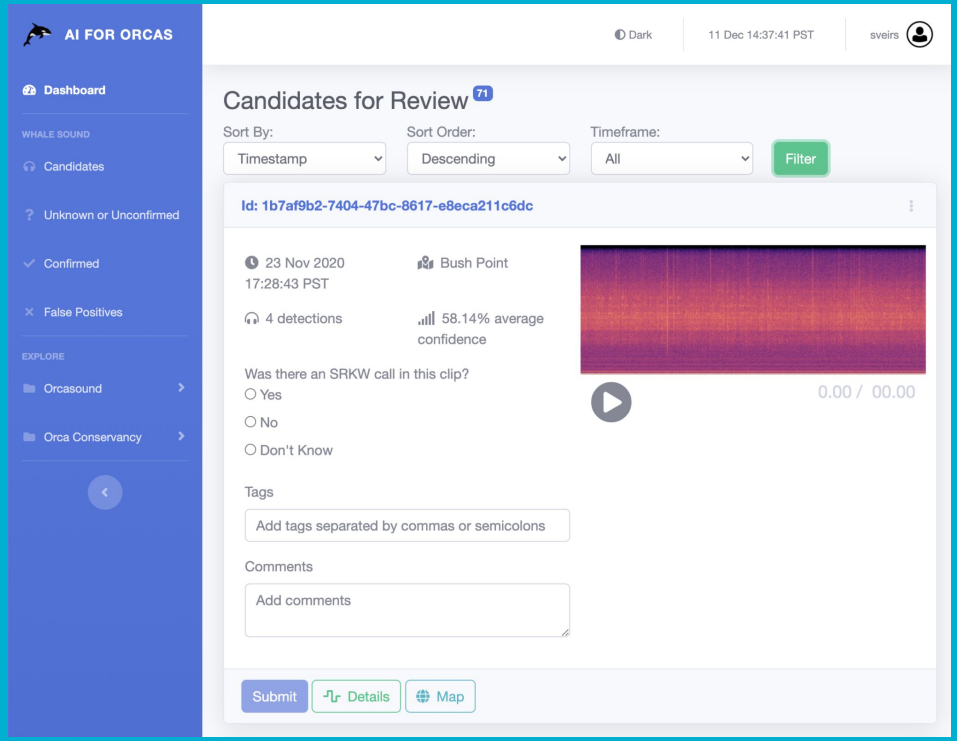
towards (more) open (marine) bioacoustic data science...

AI+human detection is optimal

For many end-users, expert validation of acoustic &/or visual detections is still important.

2021 results:

- 71 hr SRKW bouts
- 30 hr Bigg's bouts
- 18 hr humpback bouts
- Of 41 known SRKW transits: AI detected 54%; humans 81%; and 100% combined
- AI outage in Oct missed 12 (31%)



Technical and scientific challenges

Where are they now?

Applied conservation problems

Can we automate reliable real-time notification of SRKW presence, or will humans remain in the loop?

1. Notify as soon as possible, or only when “sure” of SRKW?
2. What is end-user’s false positive tolerance?
3. The conservation challenge: how to inspire users to act for SRKWs when empathy is maximized during a live acoustic event?

What are they saying?

Basic biology problems

Bioacoustics topics our data can inform:

- marine mammal communication systems
- biosonar
- marine acoustic ecology
- soundscape analysis

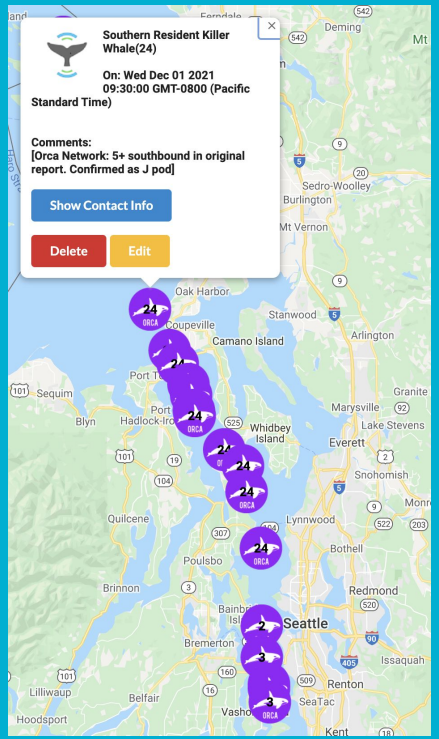
Lots of visualization opportunities!

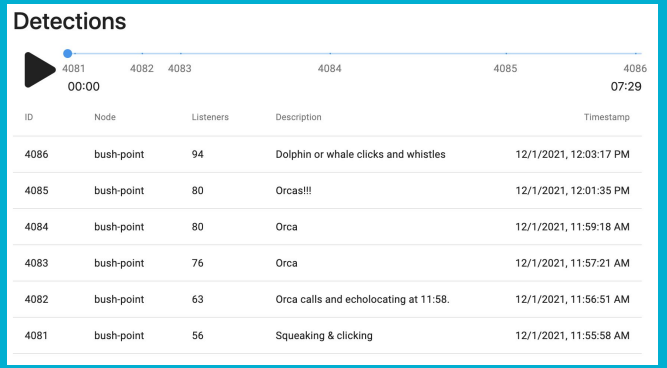
Sighting & listening together

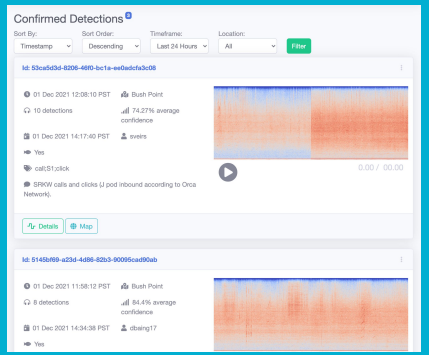
Great synergies lie in integrating acoustic and visual real-time observations!

2022 goals:

- Data cooperative for sharing:
  - vetted sightings
  - verified human detections
  - moderated OrcaHello detections
- Public API & Creative Commons license
- Notifications API
- Orca Network Facebook group







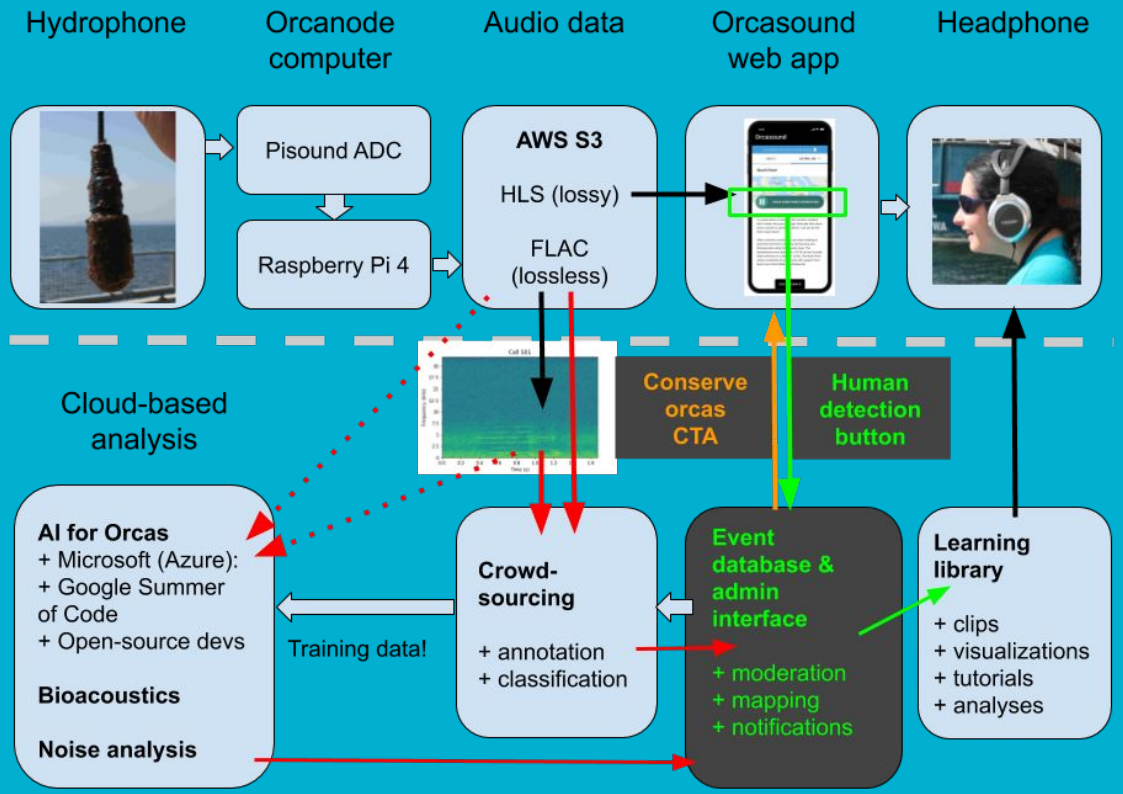
2022 challenge: Saving SRKWs & salmon

Will users label, heed a Conservation Call To Action, or both?

- 1800 subscribers
- Baseline survey via subscription form
- Conservation effect survey

Guiding principles:

- User-centered design
- Open roadmap (Trello)

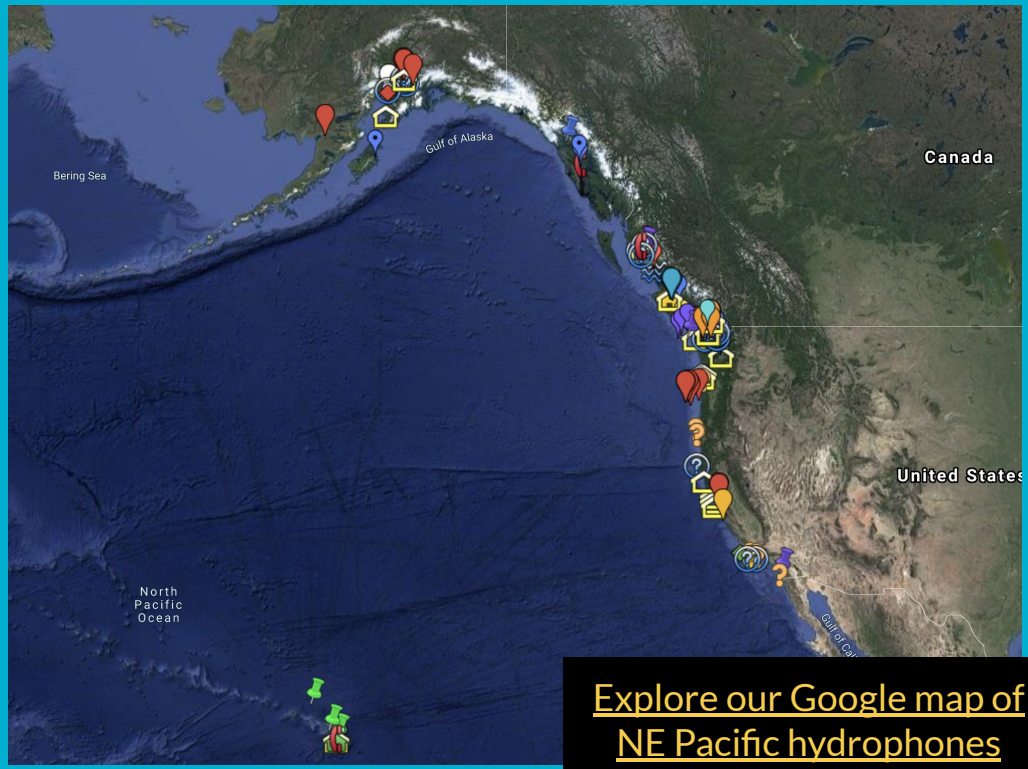


Grand challenge: sharing solutions globally

There are lots of soniferous species that need a voice!

Expansion possibilities for our open source solutions:

- More SRKW nodes (U.S.)
- SRKW nodes in Canada
- Separate networks in other regions of the world (map) for other species? (belugas?!)



Explore our Google map of NE Pacific hydrophones

Acknowledgements & links

Give orcas a voice!
live.orcasound.net

Thanks to all our collaborators!

- The Orcasound open source community's volunteer hackers
- The many NGOs & volunteers who maintain the hydrophones at each node
- Google Summer of Code
- Microsoft AI for Earth

More info:

- orcasound.net
- ai4orcas.net
- github.com/orcasound

Extra slides...

—

From other Orcasound talks...

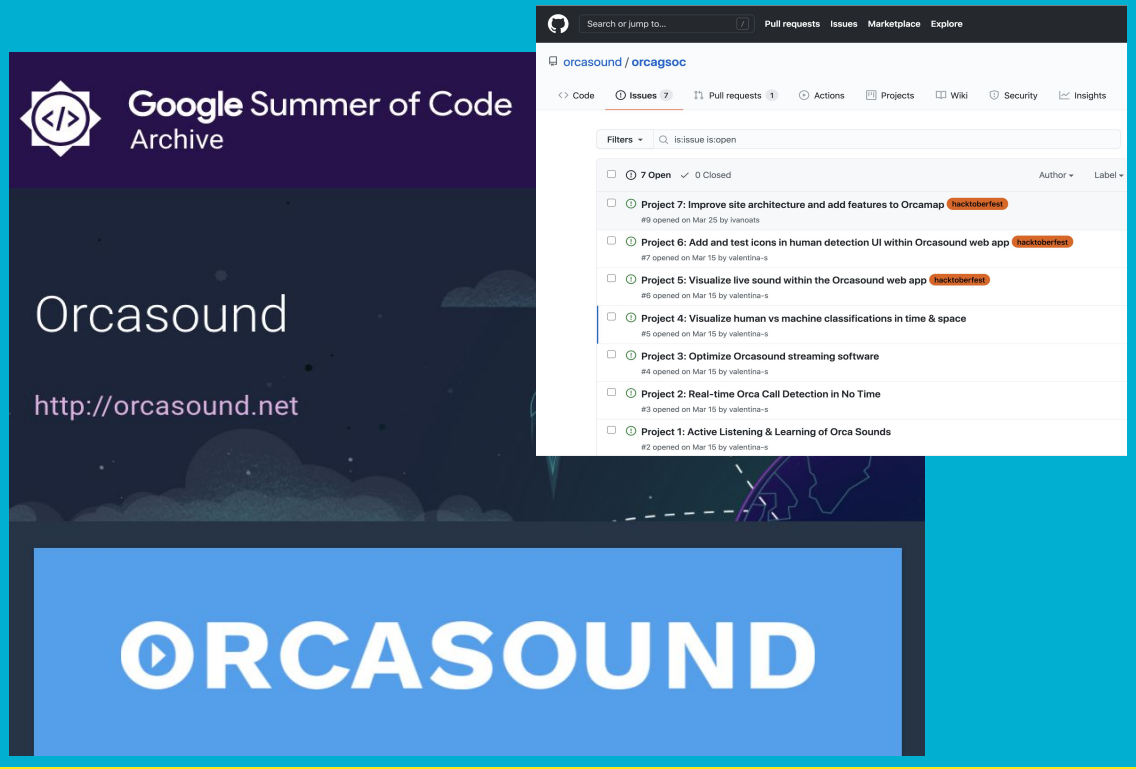
Extra discussion topics:

Practical detection vs miss rates
    From candidate table
    “False alarm”
Talk about false positive rate (10 per day)
- About right winter 2021
- Uncomfortable in spring (pigeon guillemot)
- Too low in summer (ACI bugs)
- Still too low/slow in fall?
- Just right this winter?

User info
    Adrian plots (e.g. subscriber growth?)
    Geographic partitioning

Orcasound & Google Summer of Code

- **GSoC:** supports students & open-source software projects, like Orcasound
- **2019:** OrcaCNN for Alaskan killer whale calls
- **2020:** Build a tool to speed up the labeling of SRKW calls

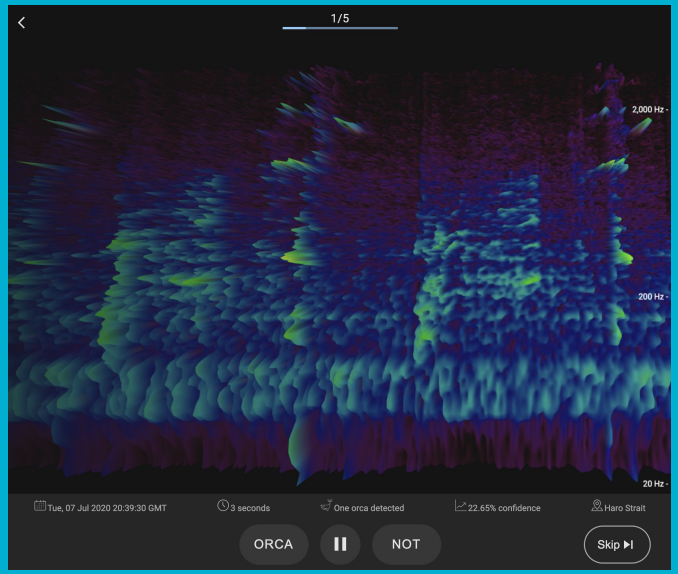


Orca active learning (OrcaAL)

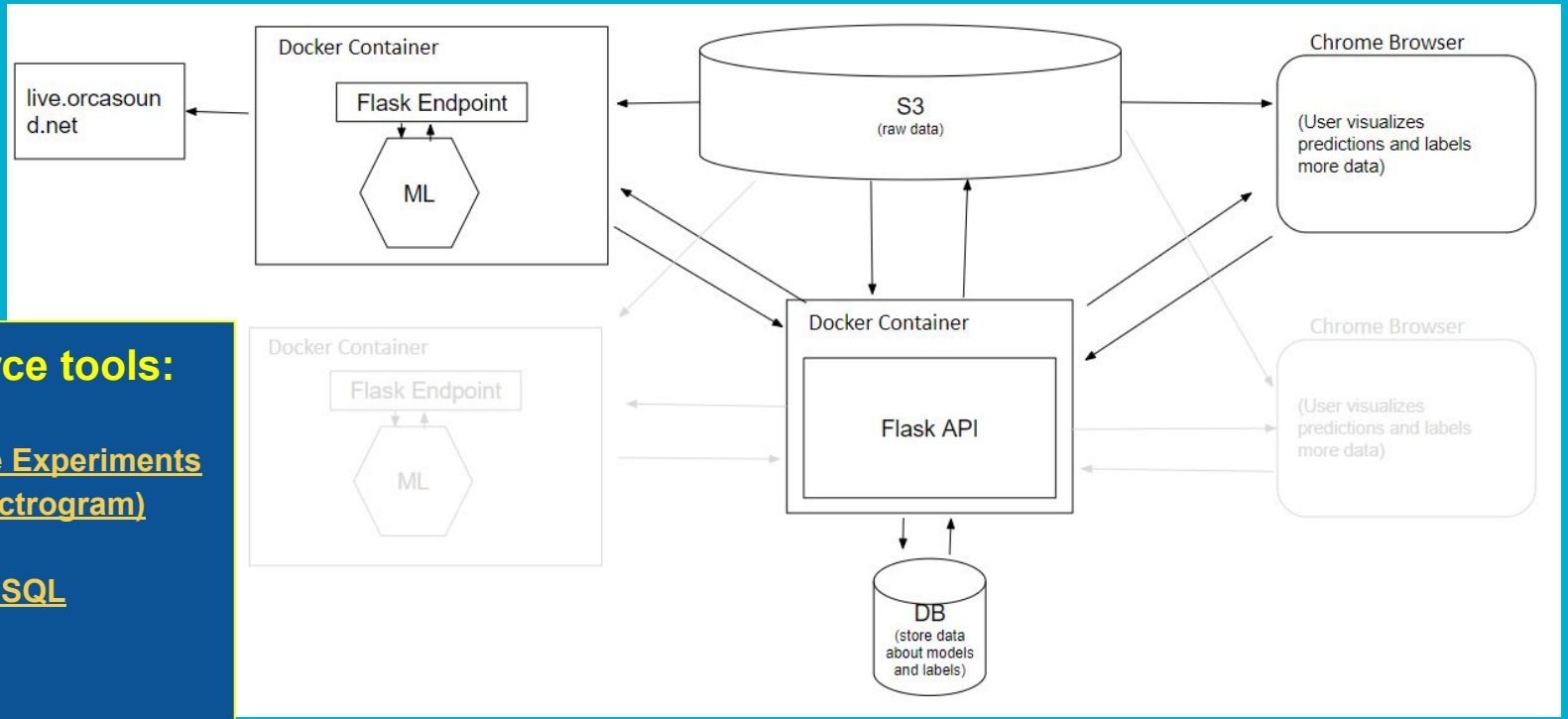
- Train a **deep learning** algorithm on an initial small labeled dataset
- Use "**uncertainty sampling**" strategy to label only those samples for which the model is most uncertain (i.e. samples with confidence near 0.5)
- Integrate model training, sample selection, and annotation in an AL tool.

Motivating question: How much does labelling a subset of the samples increase accuracy?

Demo of the new citizen-science labeling tool!



OrcaAL's architecture



Open-source tools:

- Chrome Experiments (3D spectrogram)
- Docker
- PostgreSQL
- Flask