Investigation of Duty Cycles for Measuring Activity in Passive Acoustic Bat Monitoring

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UNIVERSITY *of* WASHINGTON
Applied Physics Laboratory

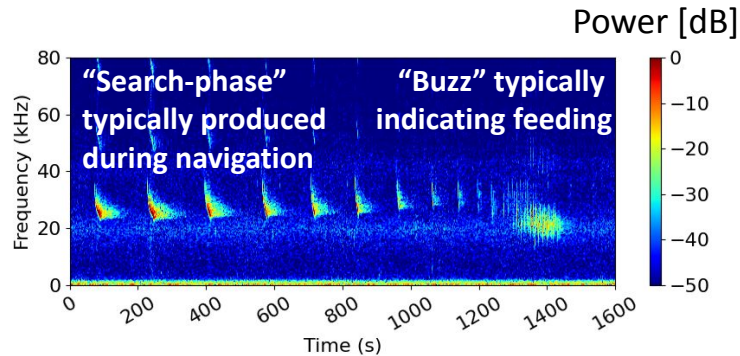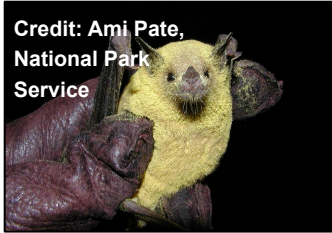**W** ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY *of* WASHINGTON

PAM needs strategic subsampling

Passive acoustic monitoring (PAM)

- Useful method for environmental surveys

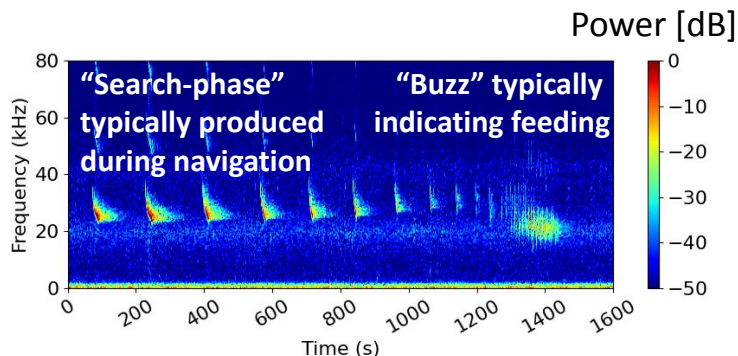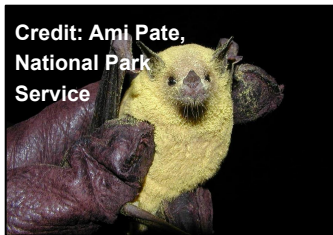*Slowed down by 1.2x to be **audible**.

Power [dB]

PAM needs strategic subsampling

Passive acoustic monitoring (PAM)

- Useful method for environmental surveys
- Labor-intensive and data-demanding

*Slowed down by 1.2x to be **audible**.

Credit: Ami Pate, National Park Service

Power [dB]

"Search-phase" typically produced during navigation

"Buzz" typically indicating feeding

Subsampling strategies

- Mitigate costs of PAM
- Commonly implemented with ON/OFF **duty-cycling**
- Thoroughly investigated for multiple animal groups

Echolocators may require **specific considerations** for subsampling (Rand et al. 2022)

The Union Bay Natural Area, Seattle, WA

Open Ponds

Dense Forests

Image Credit: Washington State Dept of Transportation
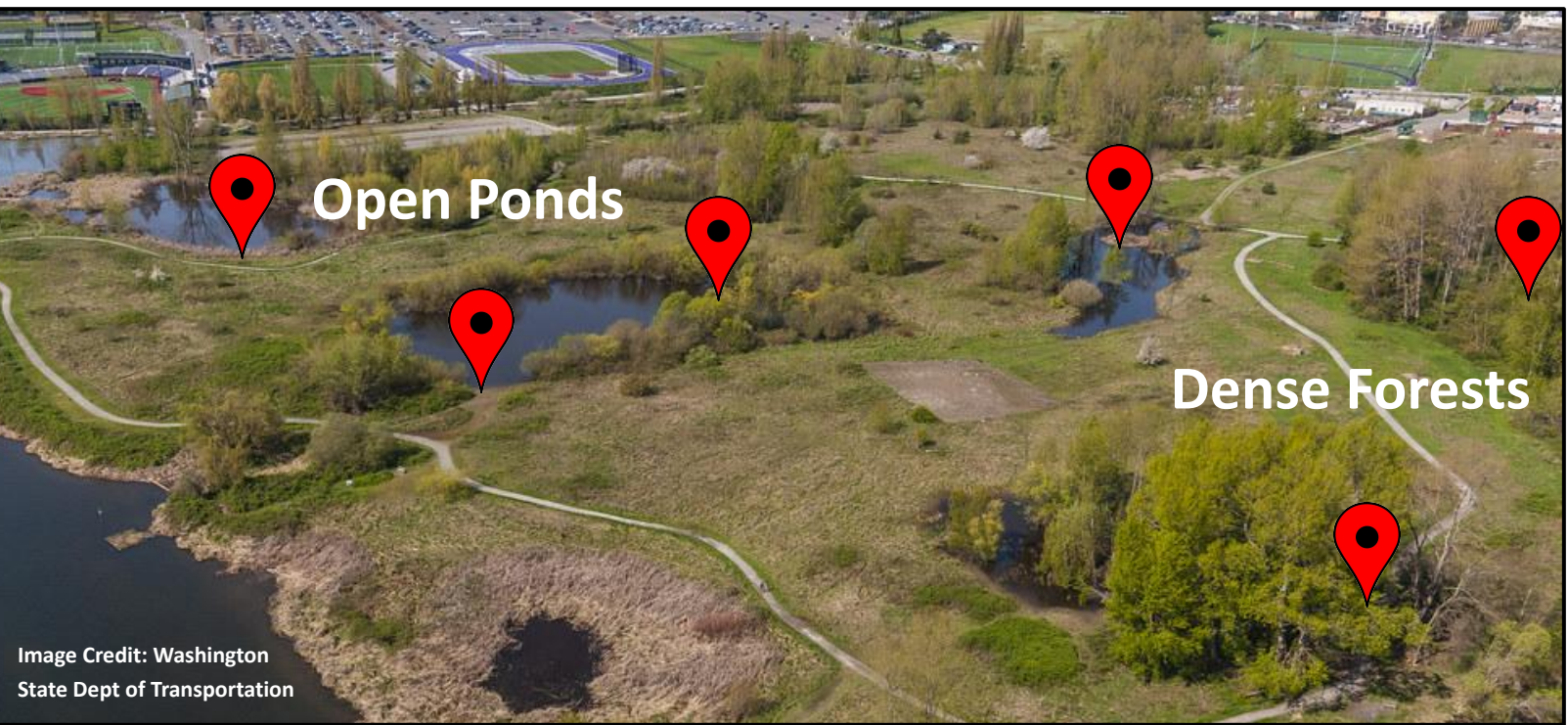
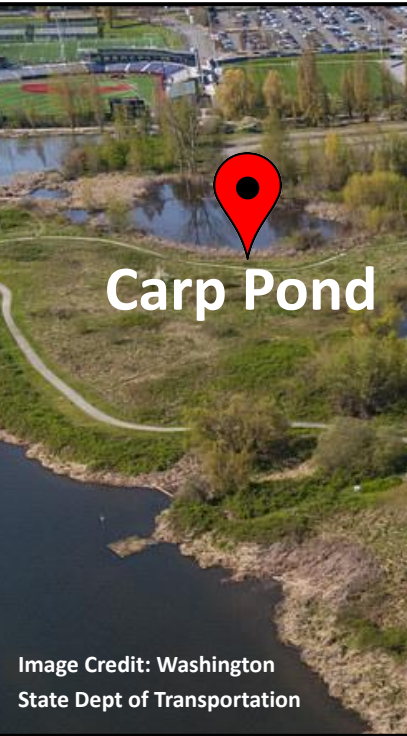# Recorded 24/7 data from July to October 2022

The Union Bay Natural Area, Seattle, WA
- Focusing on Carp Pond for this talk
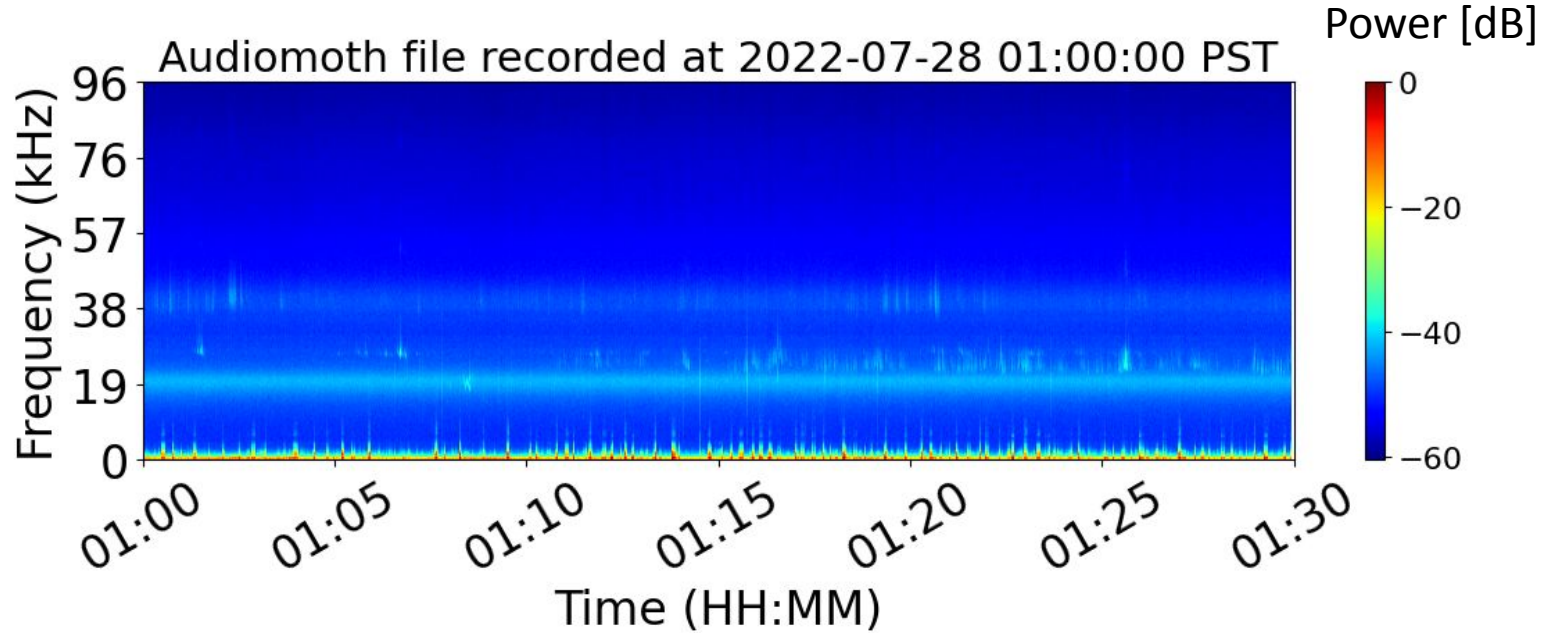

Carp Pond

Image Credit: Washington State Dept of Transportation

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The Union Bay Natural Area, Seattle, WA

Carp Pond

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Audiomoths

- Rechargeables + 128GB SD
- 192kHz sampling for bats
- Roughly 30GB / day
- Replacements every 3 days

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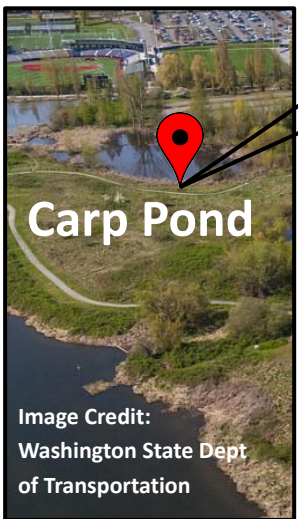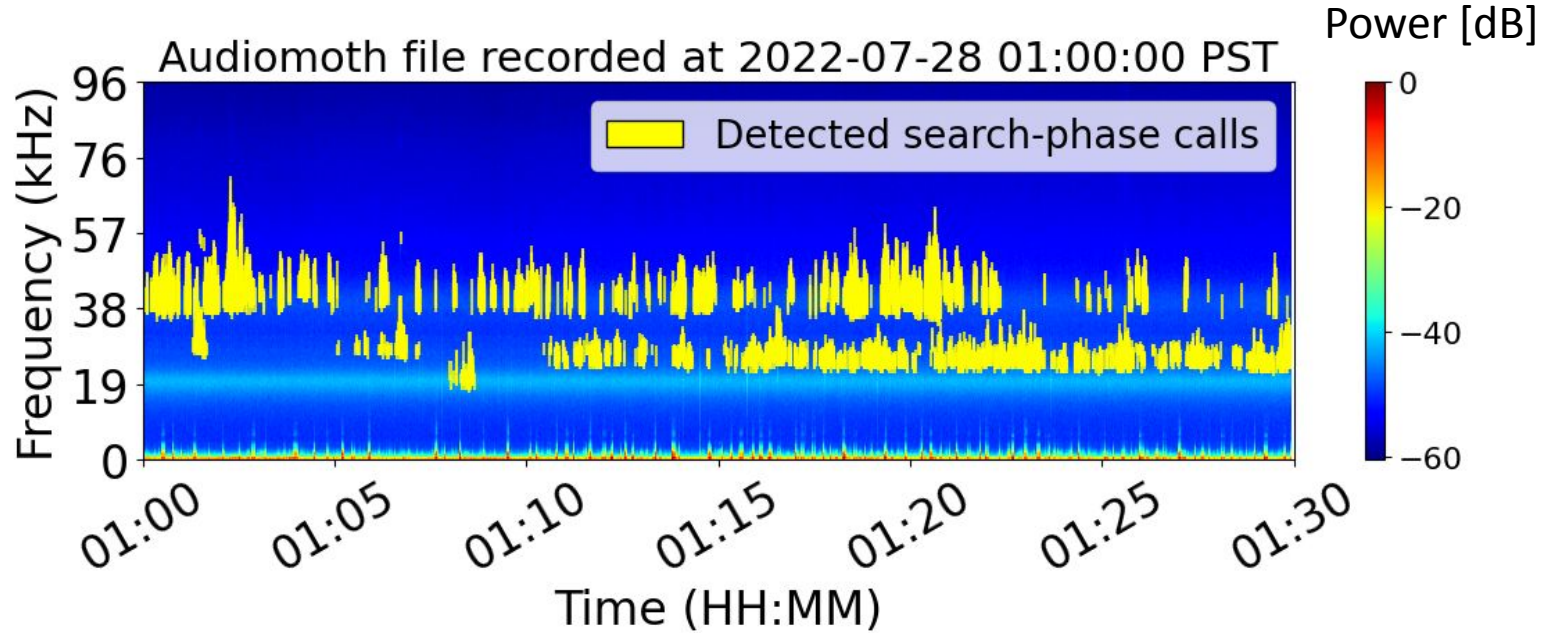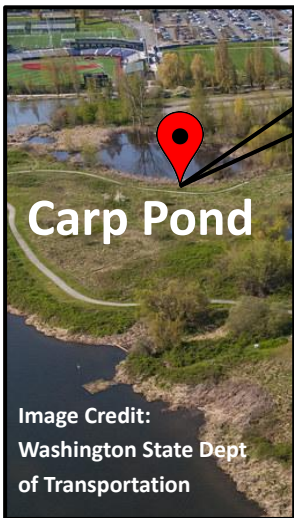

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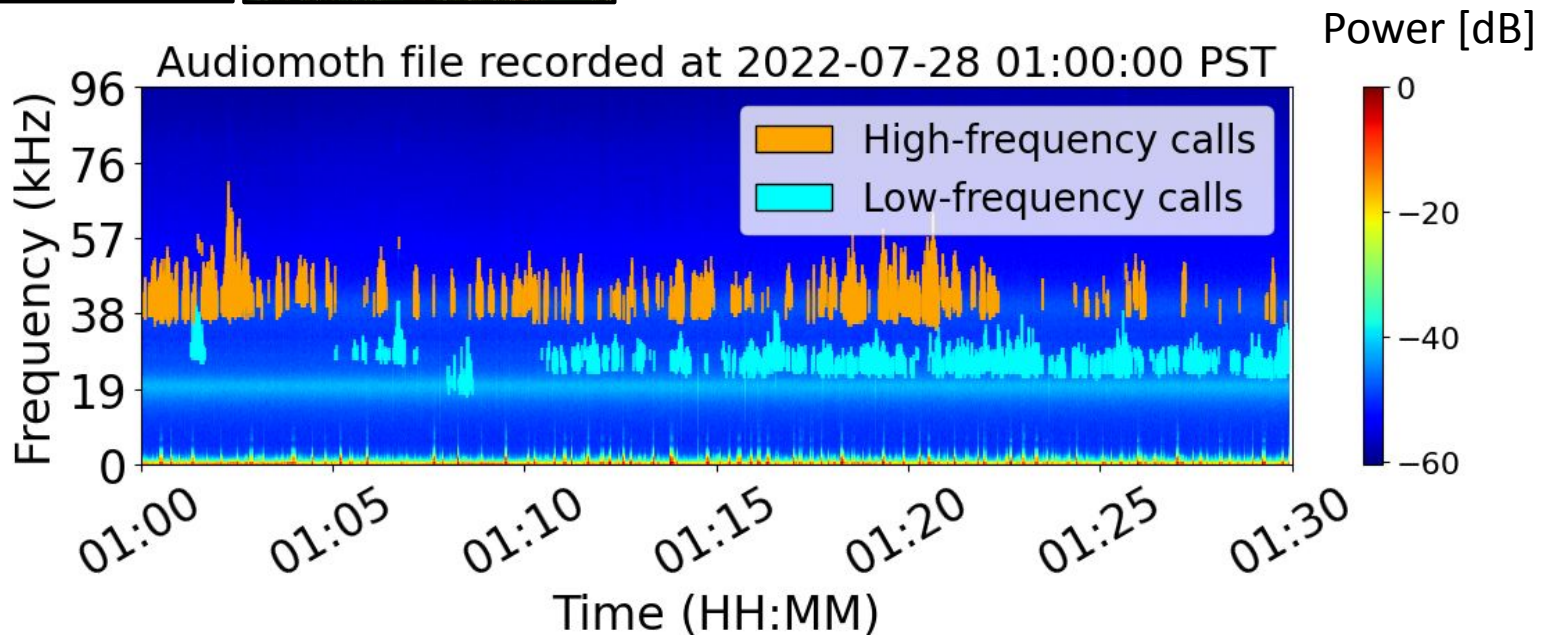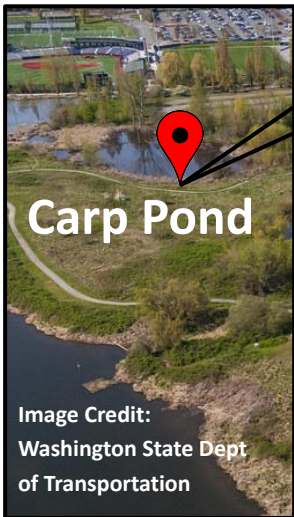Audiomoth file recorded at 2022-07-28 01:00:00 PST

Power [dB]

Recorded 24/7 data from July to October 2022

Carp Pond

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Washington State Dept
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Audiomoths
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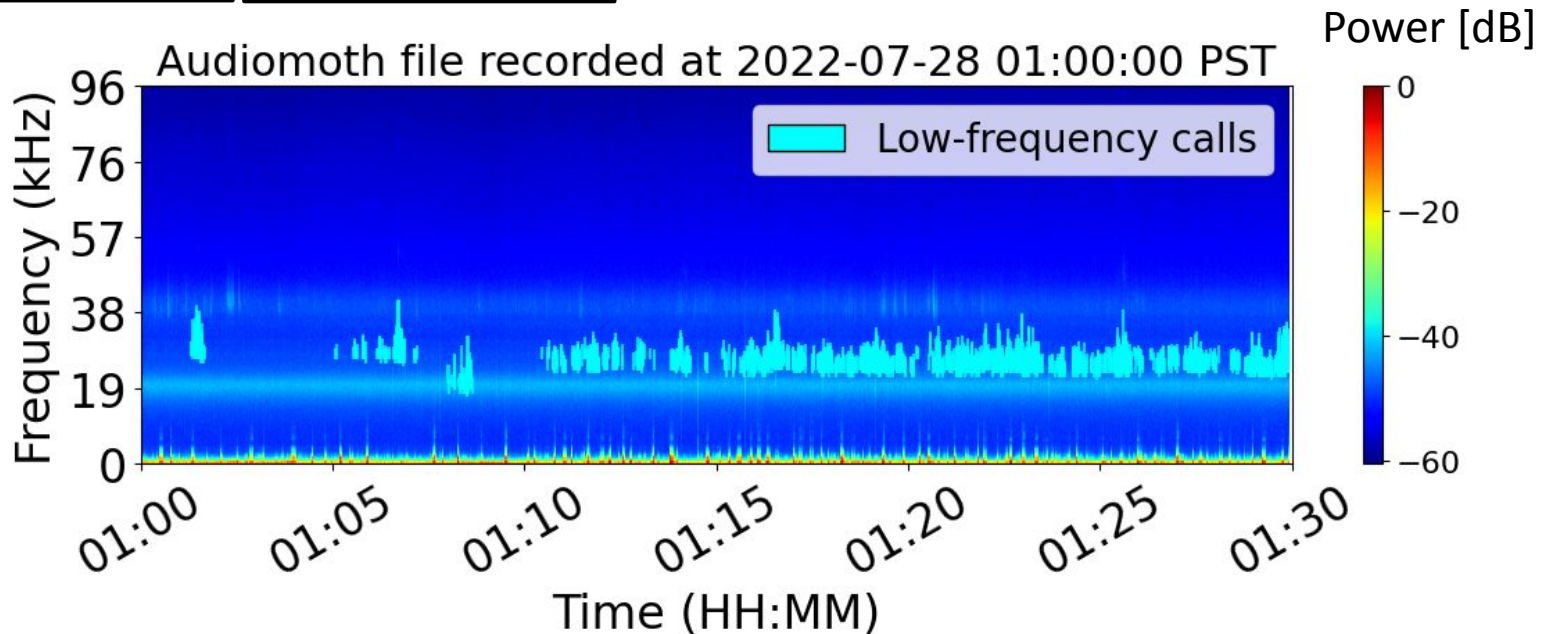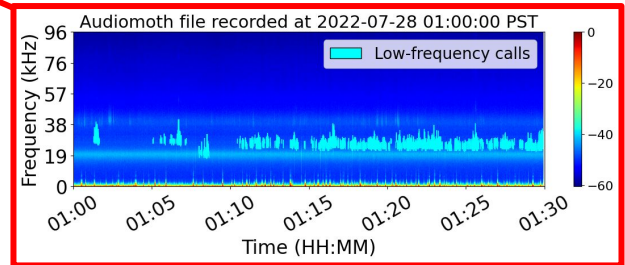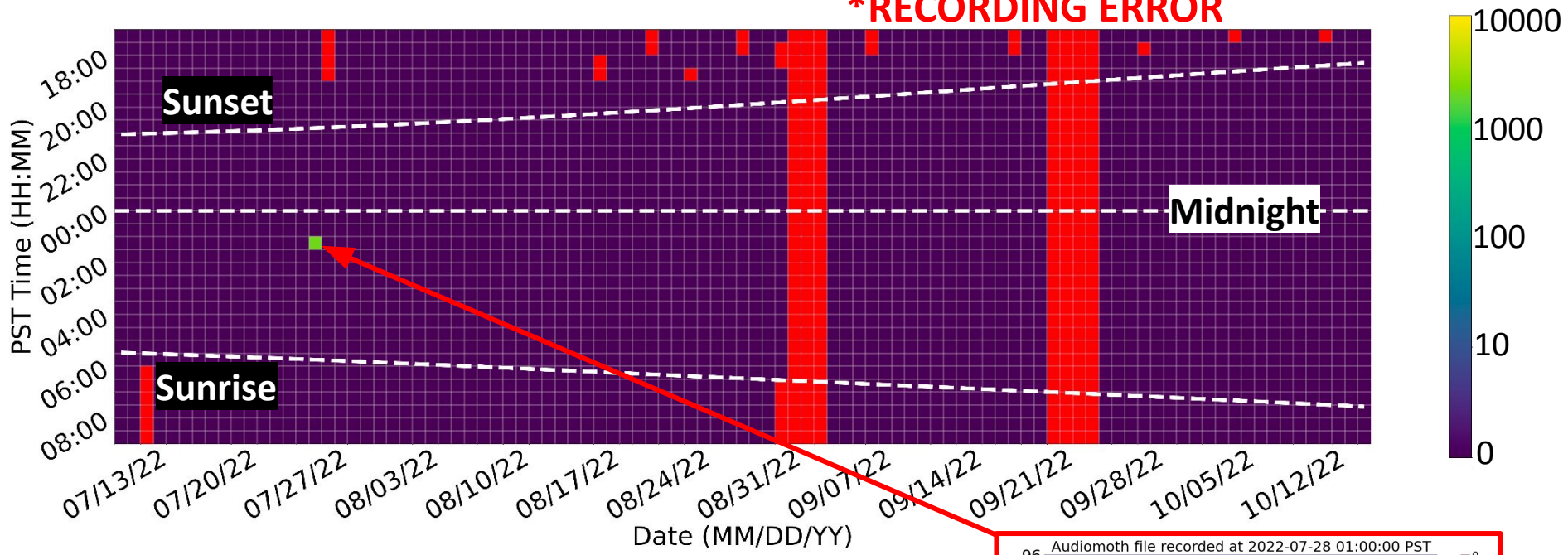Audiomoth file recorded at 2022-07-28 01:00:00 PST

Detected search-phase calls

Power [dB]

Recorded 24/7 data from July to October 2022

Carp Pond

Image Credit:
Washington State Dept
of Transportation

Audiomoths

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- Roughly 30GB / day
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Audiomoth file recorded at 2022-07-28 01:00:00 PST

Power [dB]

High-frequency calls
Low-frequency calls

Frequency (kHz): 96, 76, 57, 38, 19, 0

Time (HH:MM): 01:00, 01:05, 01:10, 01:15, 01:20, 01:25, 01:30

Recorded 24/7 data from July to October 2022

Image Credit:
Washington State Dept
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Carp Pond

Audiomoths

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Audiomoth file recorded at 2022-07-28 01:00:00 PST

Low-frequency calls

Research Questions

1) How do our activity measurements change when we use duty-cycle based subsampling?

2) Is the number of calls a good measure for activity? Are there other better metrics?

Dataset consisted of natural fluctuations in activity

Number of calls

*RECORDING ERROR

Dataset consisted of natural fluctuations in activity
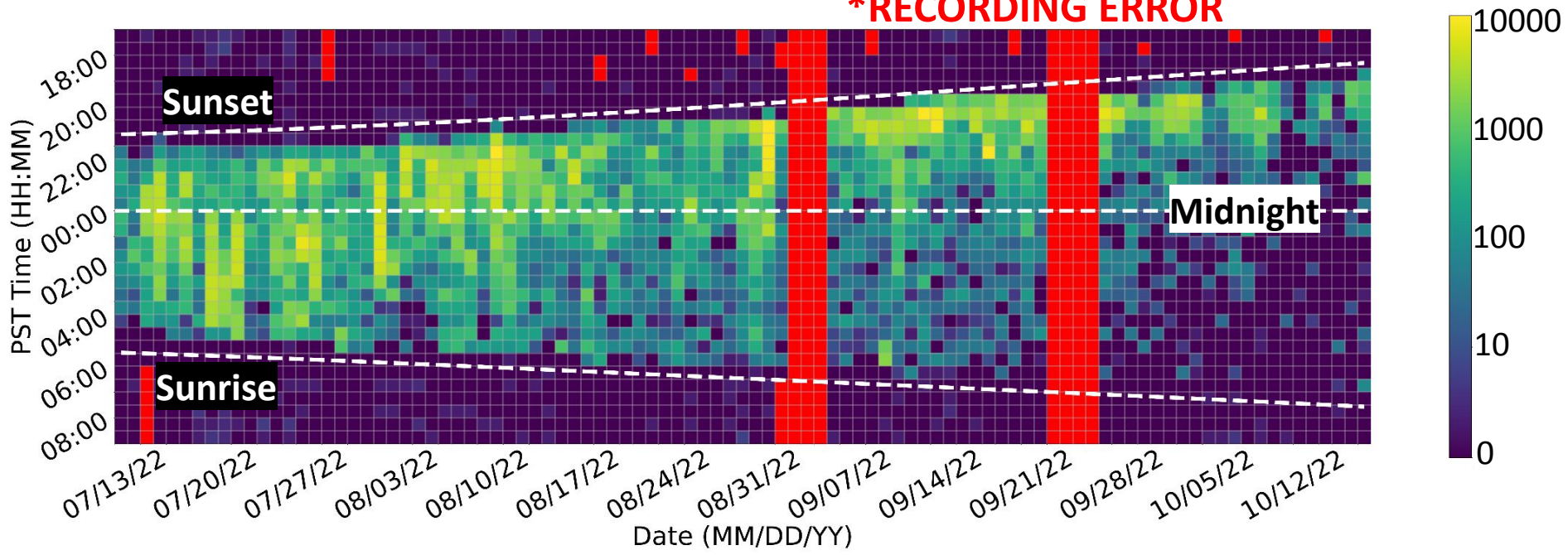
- Number of calls per 30-min file

Dataset consisted of natural fluctuations in activity
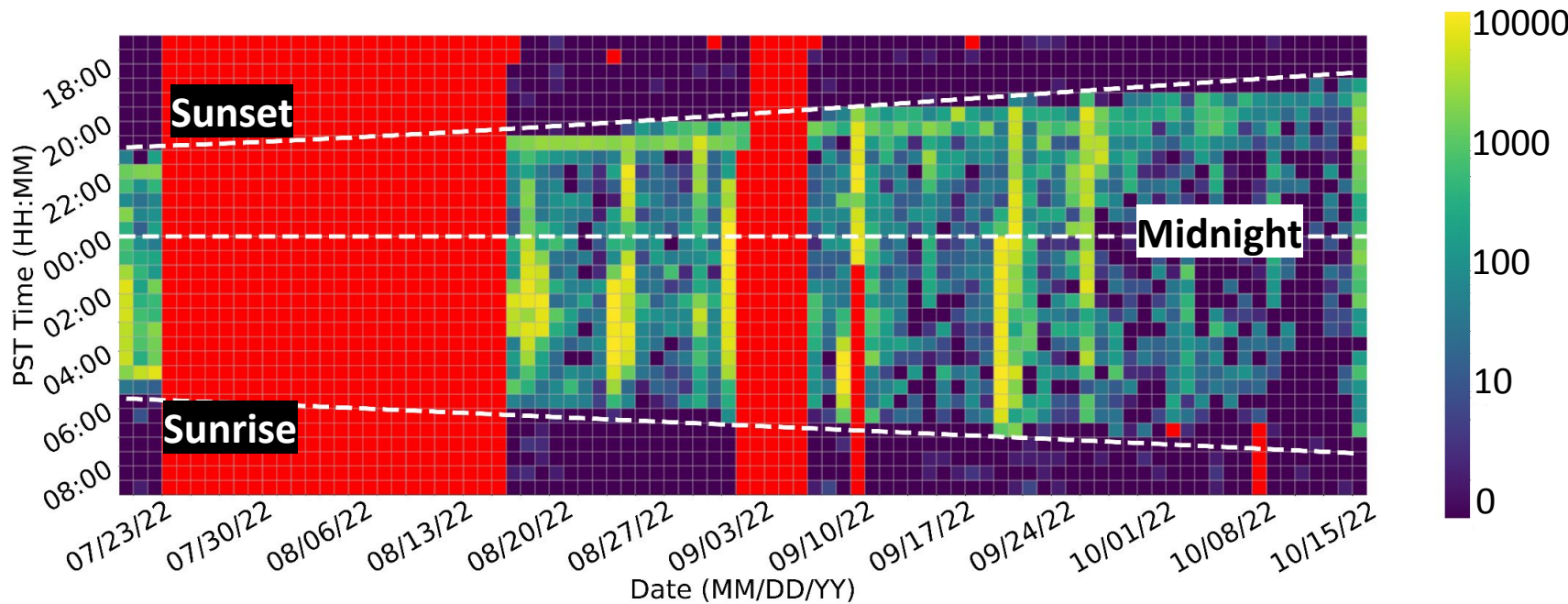
- Number of calls per 30-min file

3

How to subsample using duty cycles?

Parameters:

(1) Listening ratio
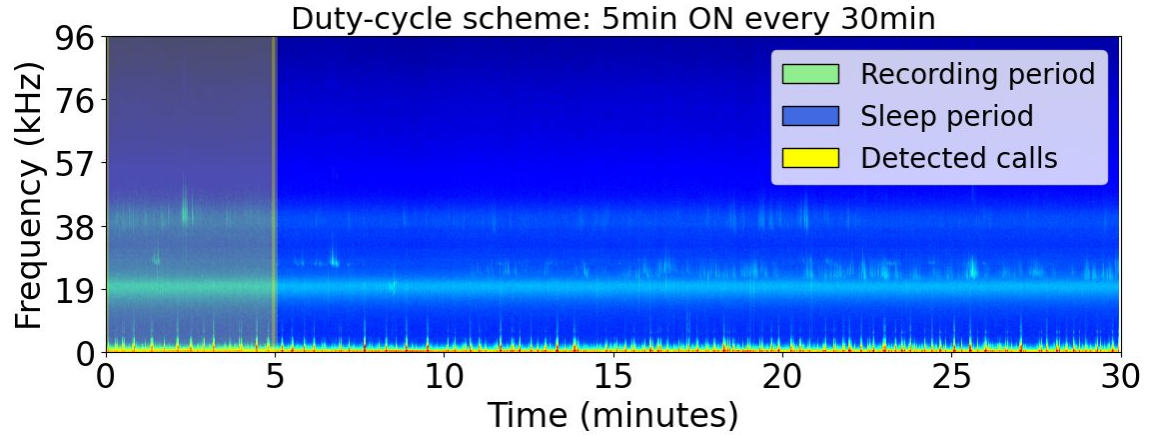
(2) Cycle length

How to subsample using duty cycles?

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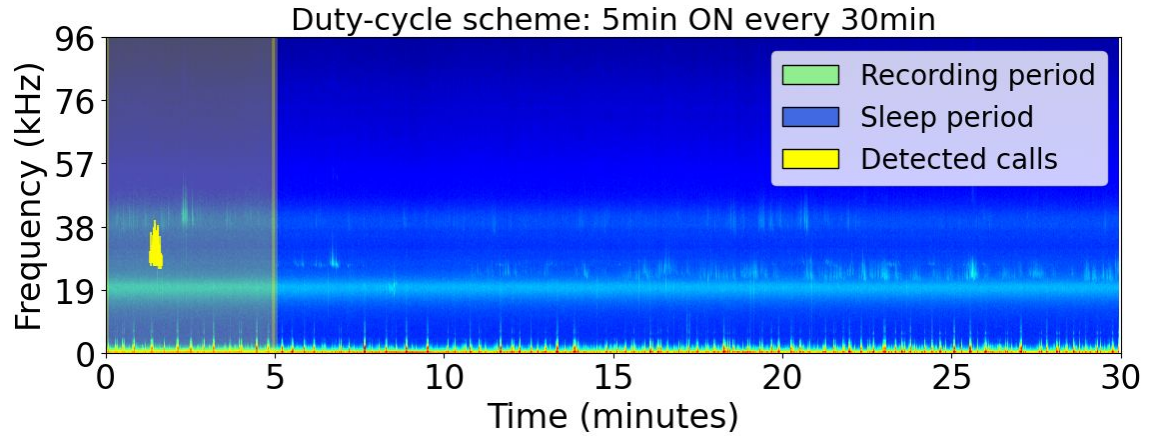
(2) Cycle length

How to subsample using duty cycles?

Parameters:

(1) Listening ratio = 1/6

(2) Cycle length = 30

Duty-cycle scheme: 5min ON every 30min
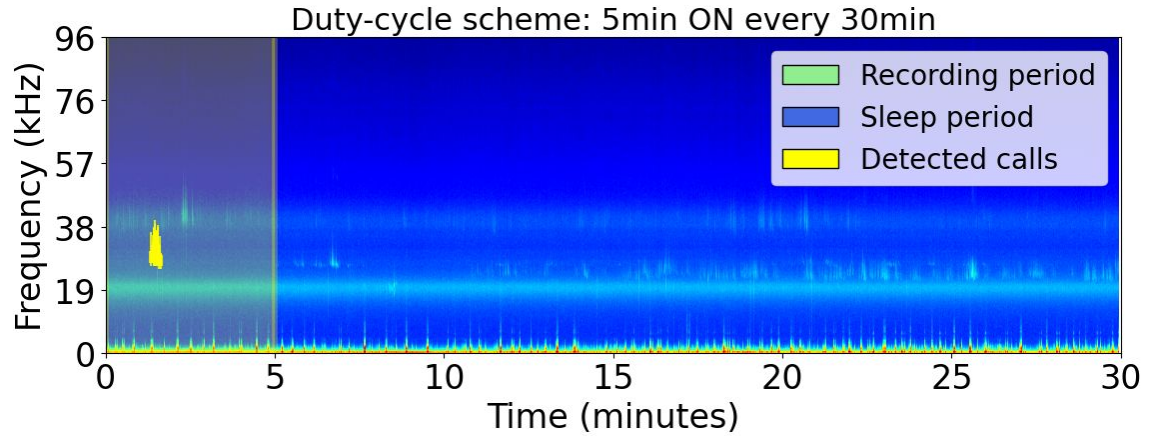
How to subsample using duty cycles?

Parameters:
(1) Listening ratio = 1/2
(2) Cycle length = 30

Increasing (1) while keeping (2) fixed: **listening more for each cycle of data**
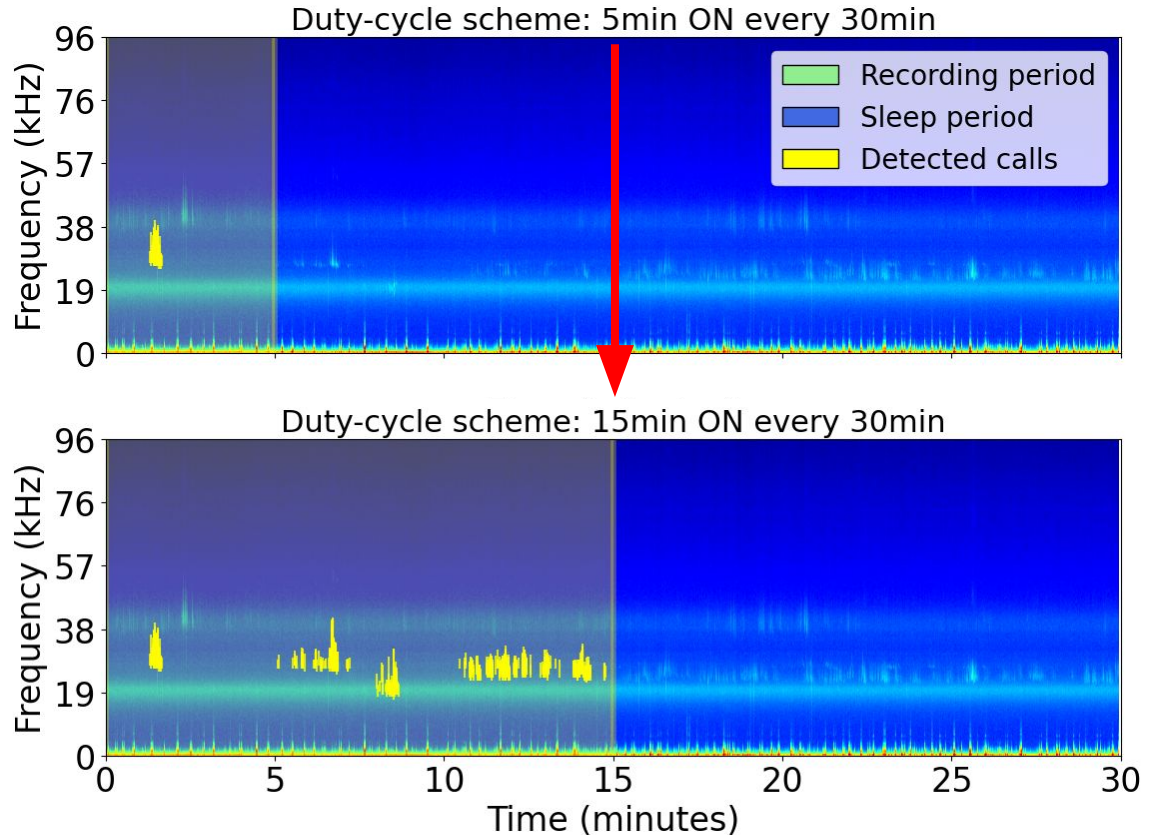
How to subsample using duty cycles?

Parameters:
(1) Listening ratio = 1/2
(2) Cycle length = 10

Increasing (1) while keeping (2) fixed: **listening more for each cycle of data**

Decreasing (2) while keeping (1) fixed: **reallocating listening time across the full data**

How to subsample using duty cycles?

Parameters:
(1) Listening ratio = 1/2
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Increasing (1) while keeping (2) fixed: **listening more for each cycle of data**

Decreasing (2) while keeping (1) fixed: **reallocating listening time across the full data**

5
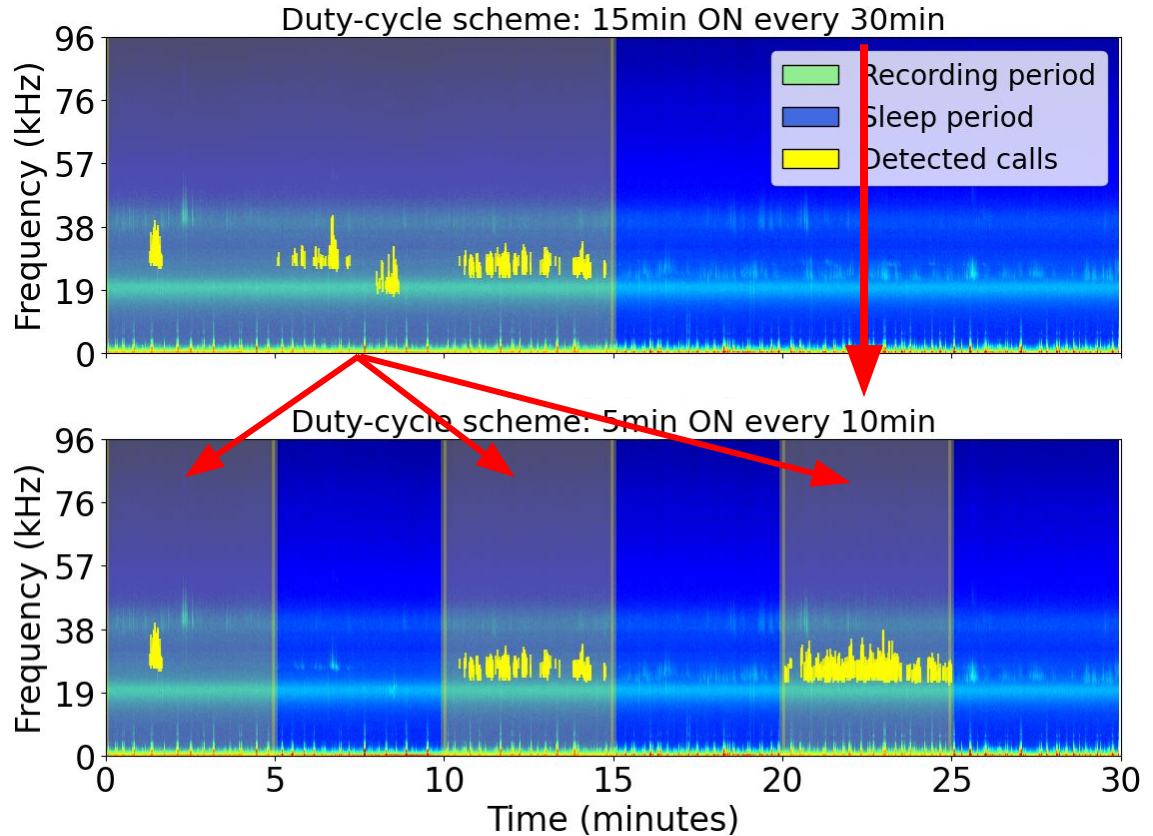
How to measure activity using bat search calls?

(1) Call rate
(calls/min)
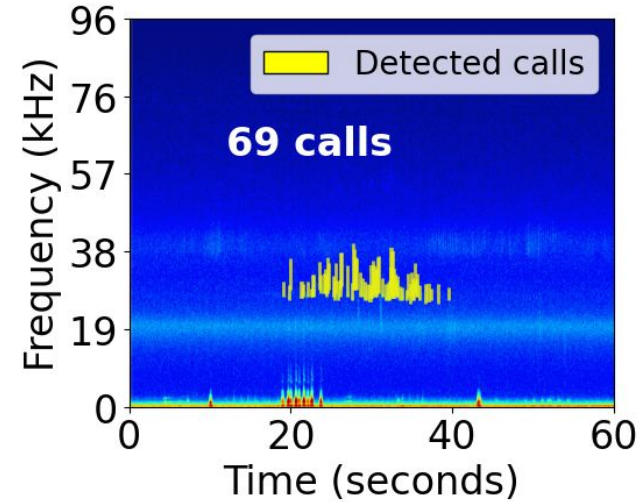
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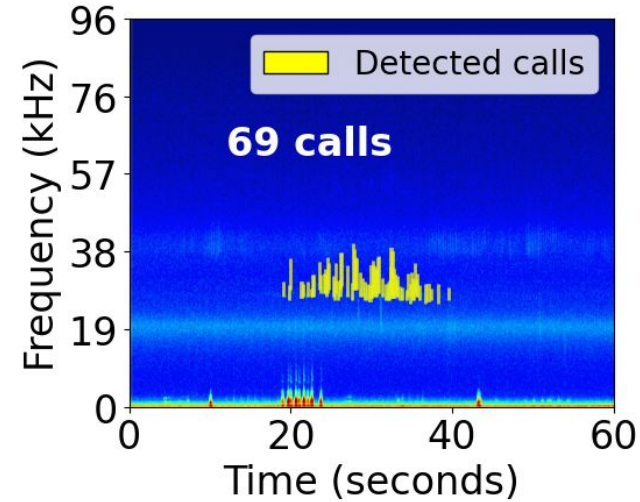
69 calls/min

How to measure activity using bat search calls?

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(2) Activity Index
(Miller, 2001)
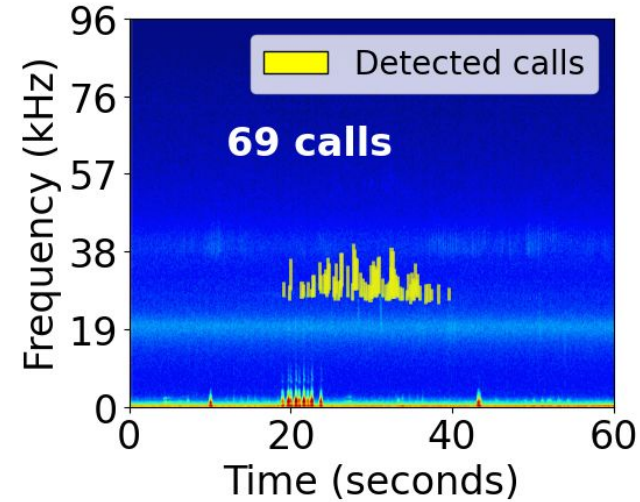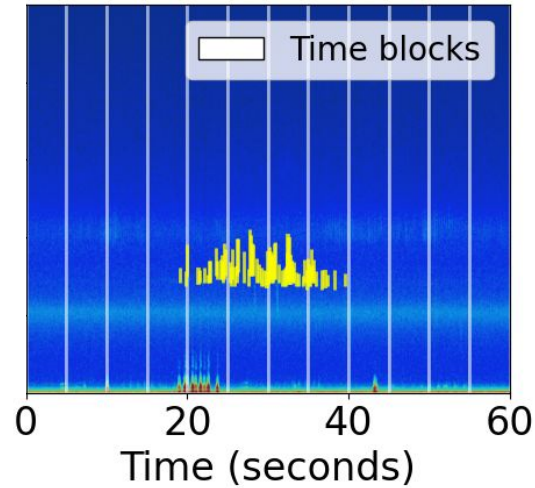
69 calls/min

5 blocks out of 12 blocks

How to measure activity using bat search calls?

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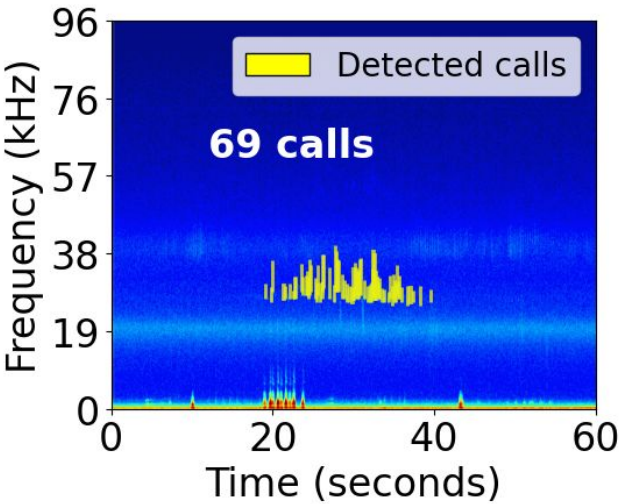
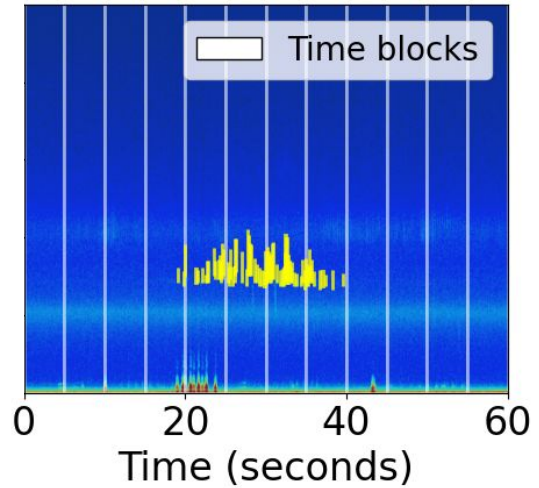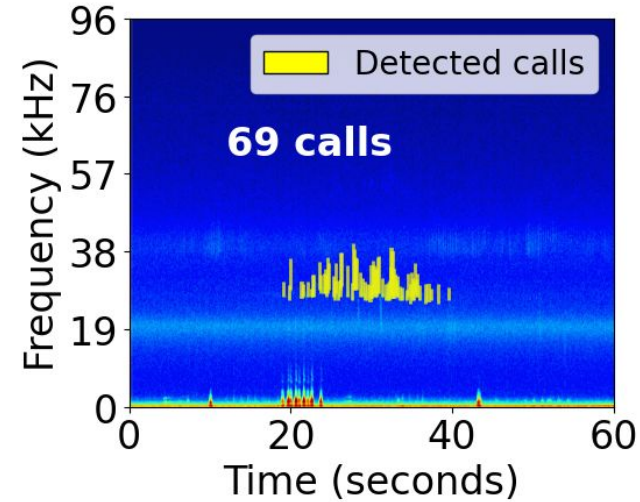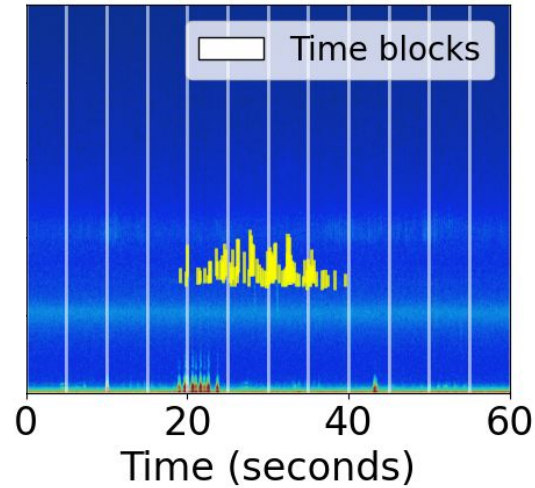(2) Activity Index
(Miller, 2001)
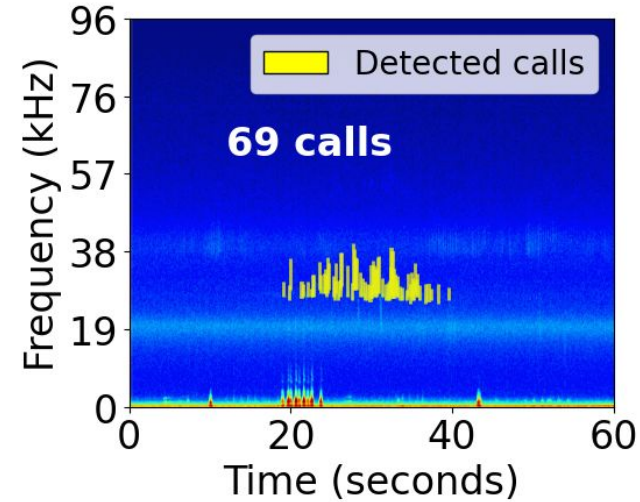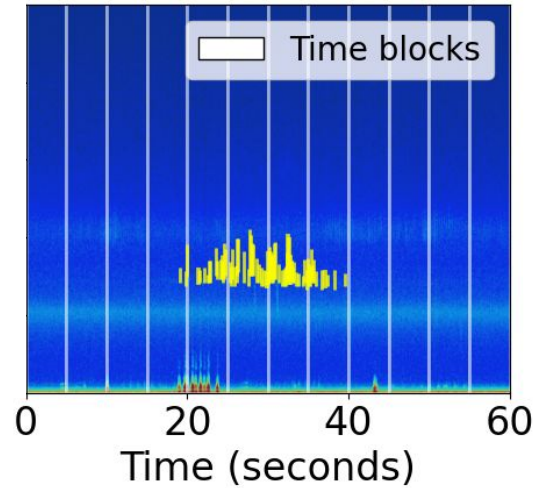
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41.67% AI

How to measure activity using bat search calls?

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(Slater and Lester, 1982)
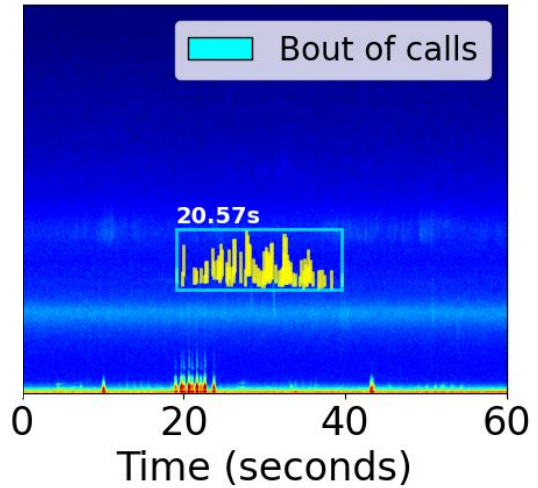
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20.57s of bout in 60s

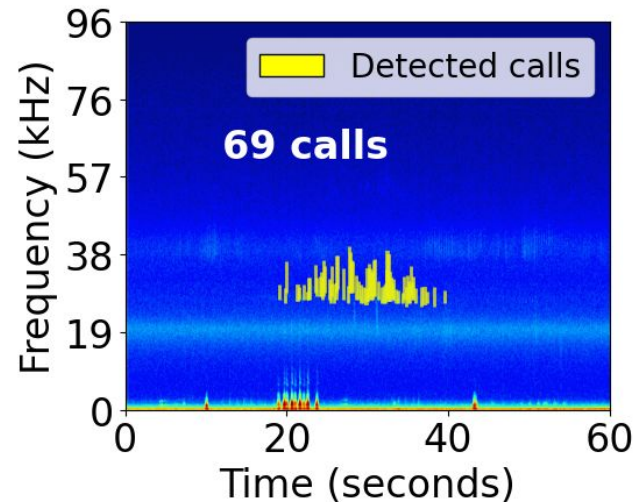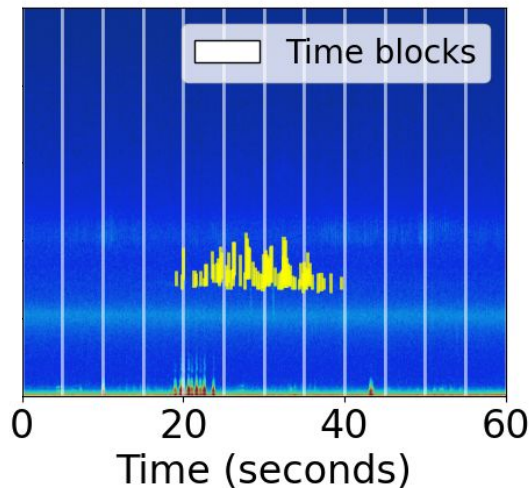# How to measure activity using bat search calls?

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34.29% BTP

How to measure activity using bat search calls?

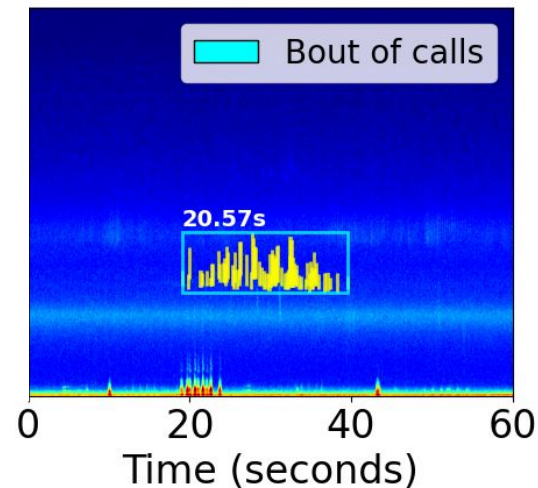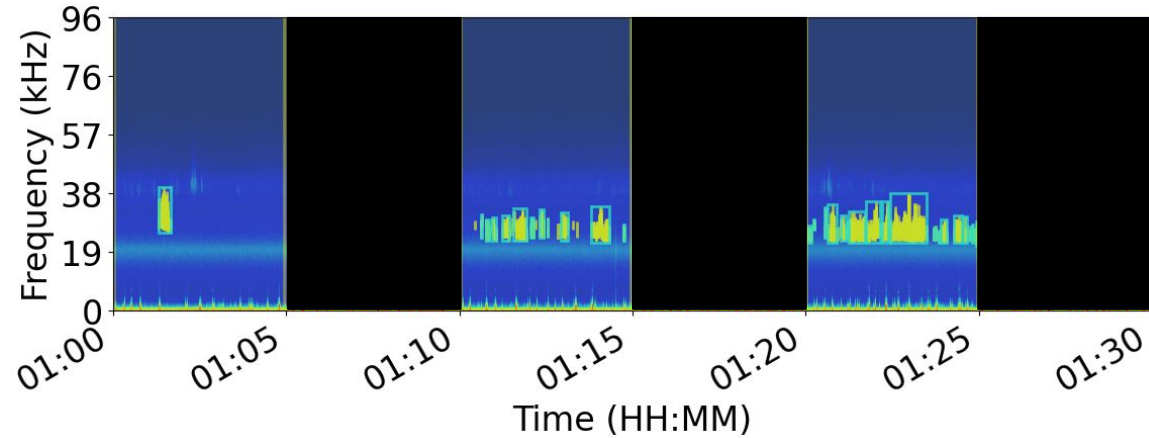(1) Call rate
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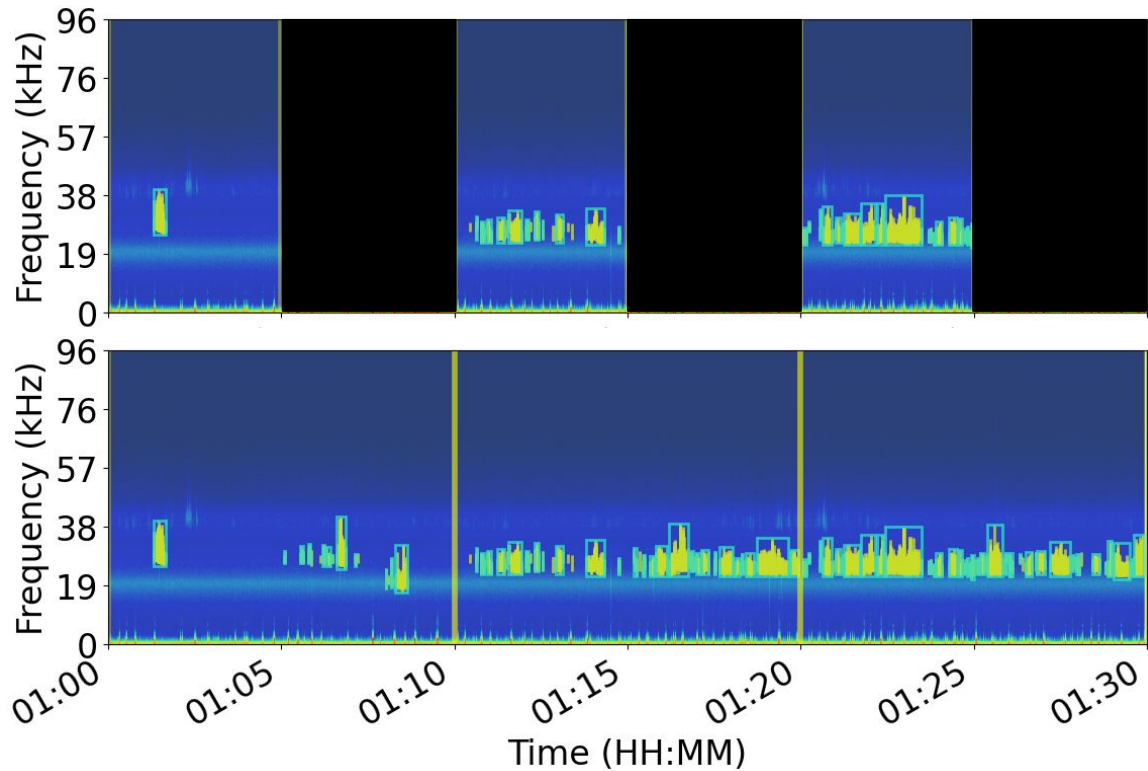
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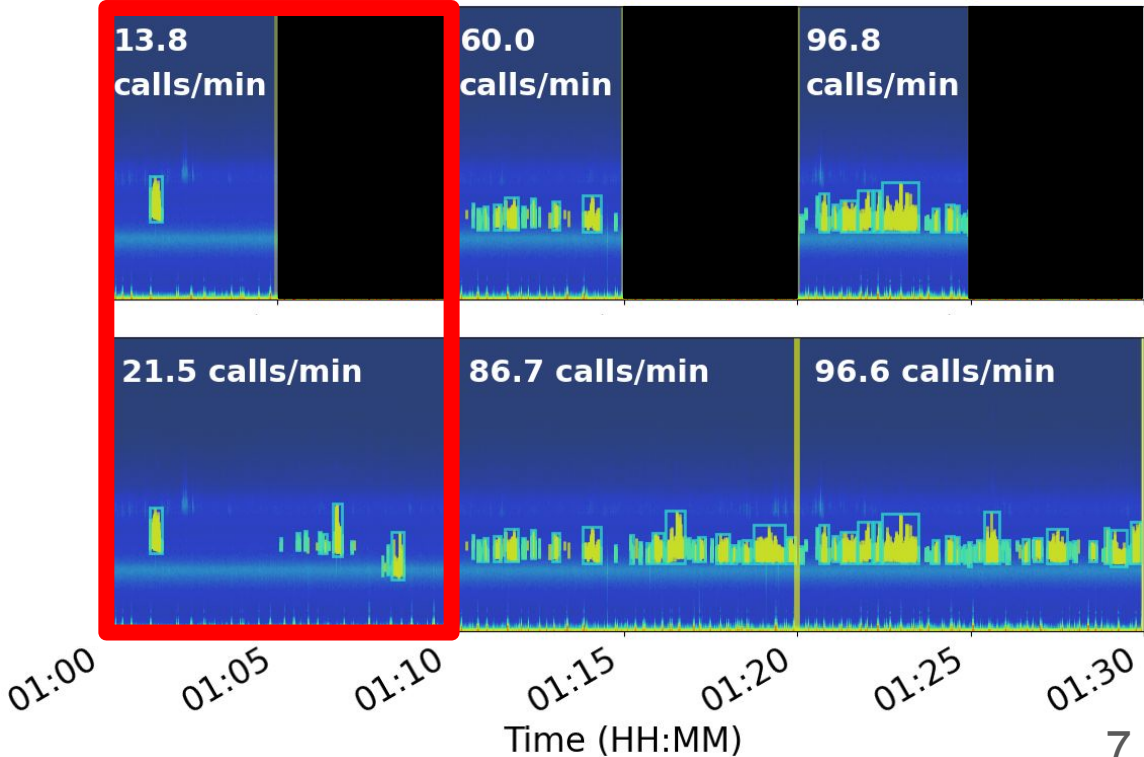
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling
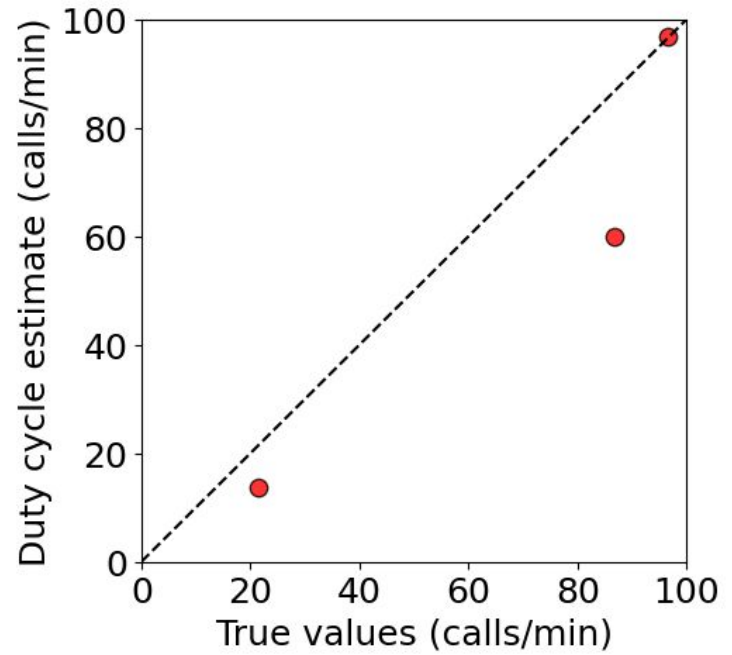
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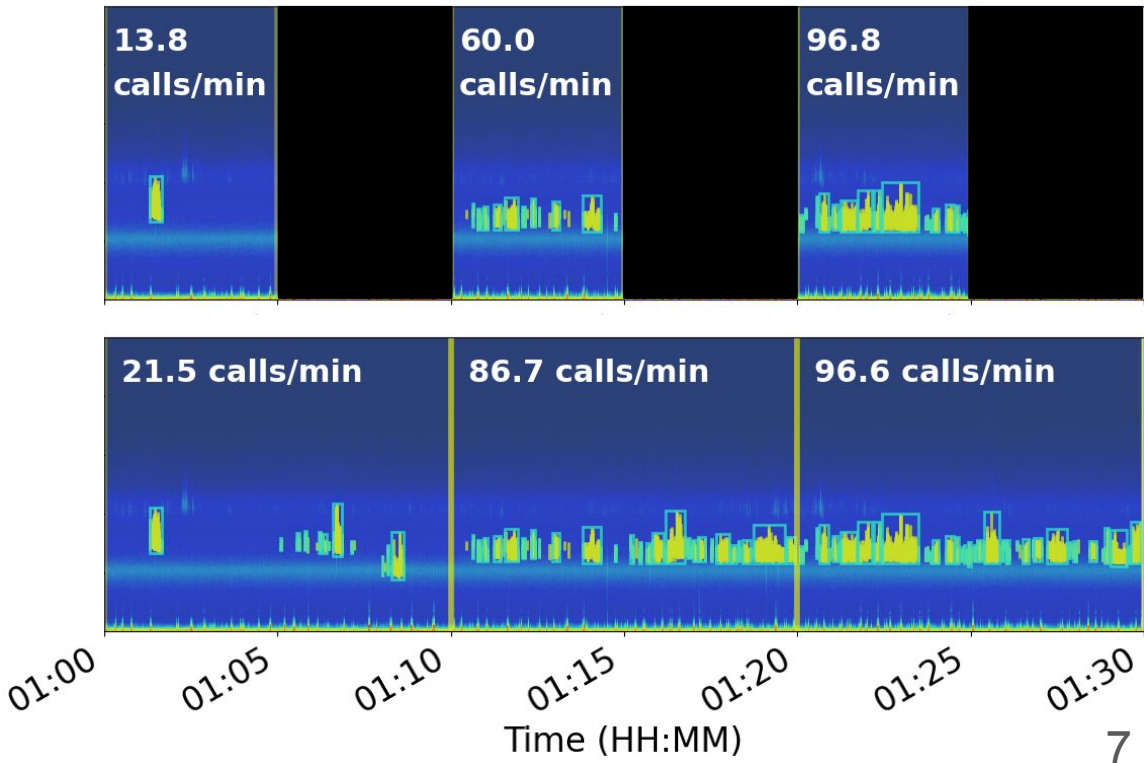Evaluating 5 min ON every 10 min duty-cycling

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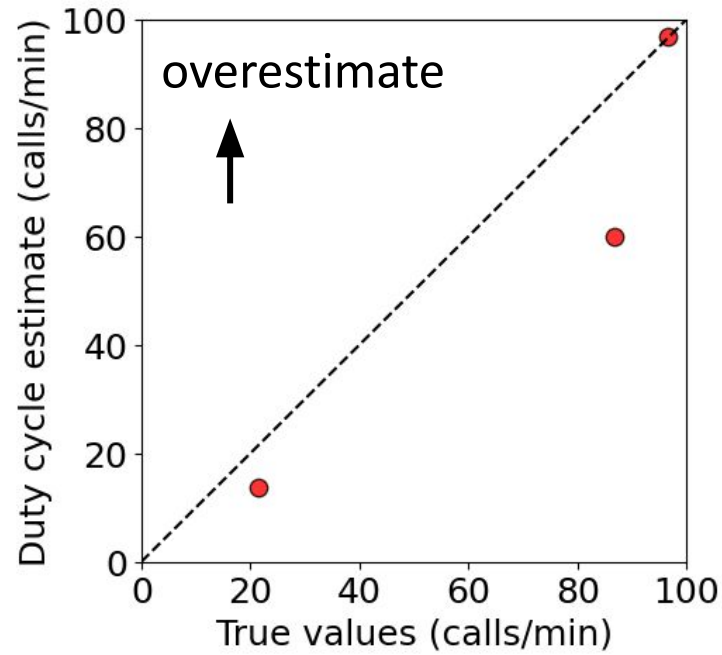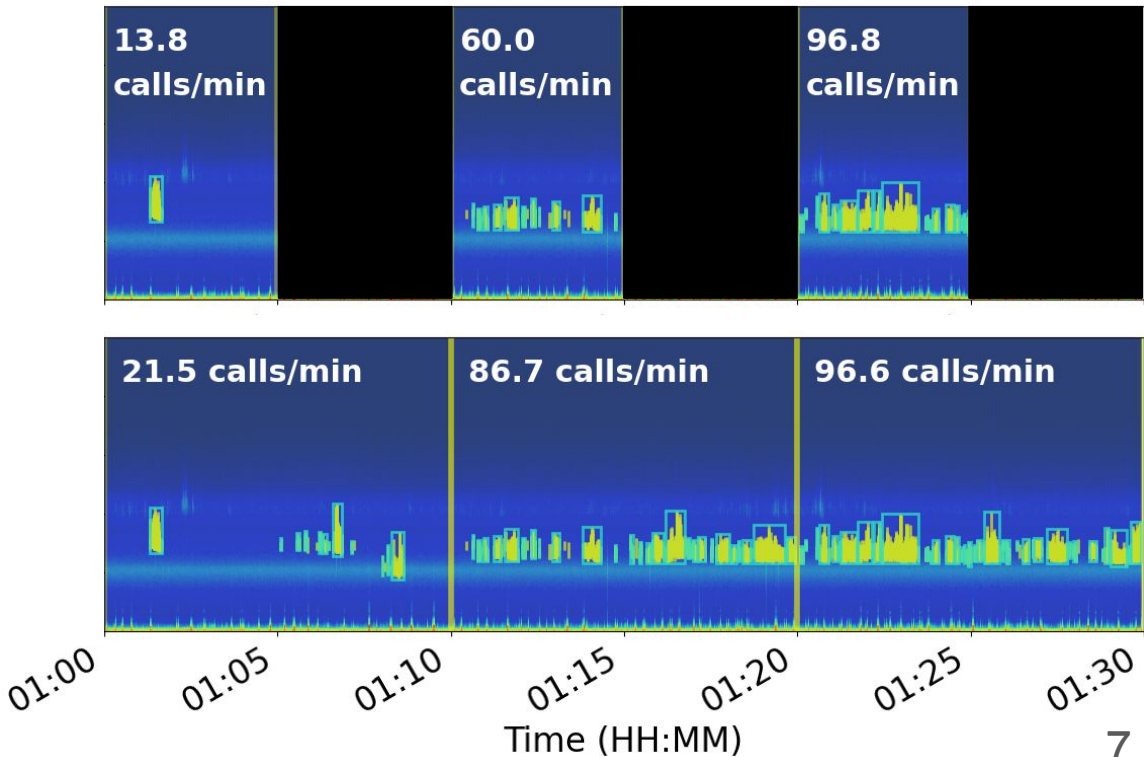# How we evaluated the effects of duty-cycling
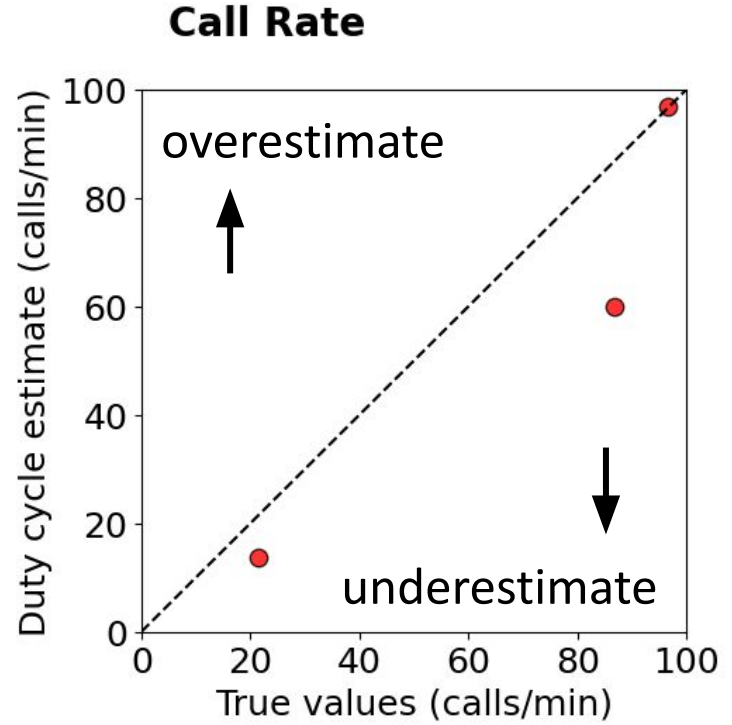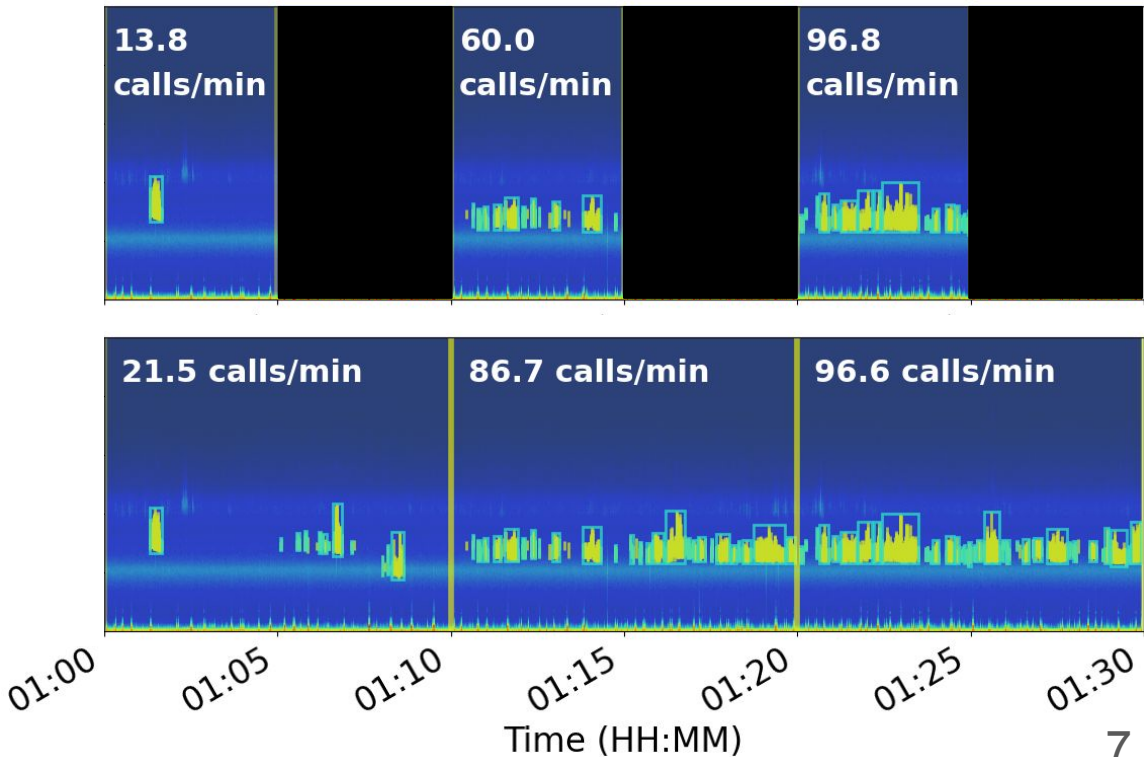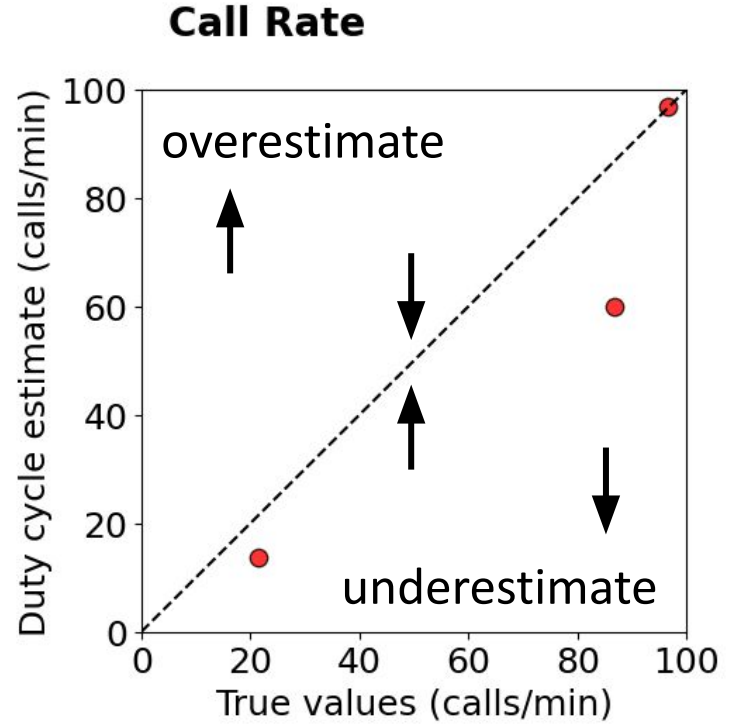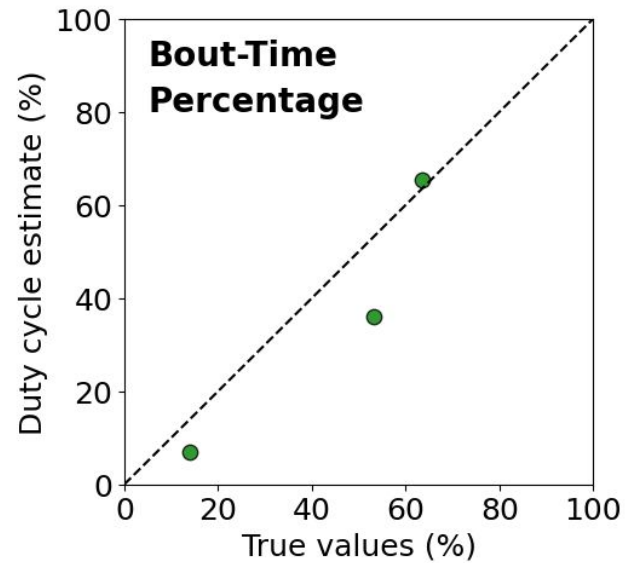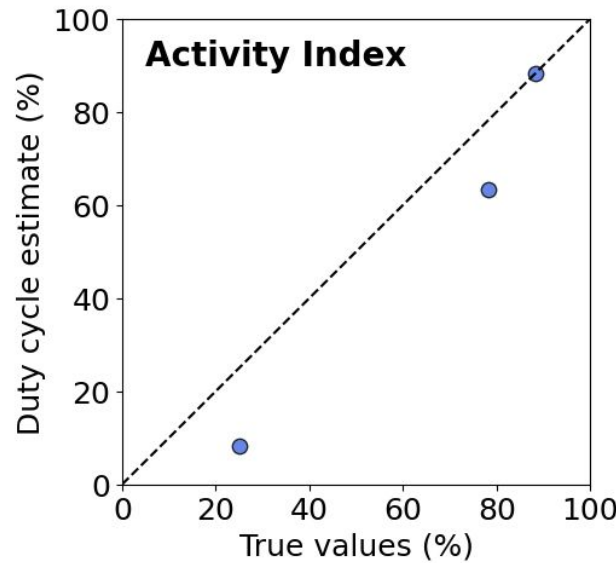
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 file

How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 week

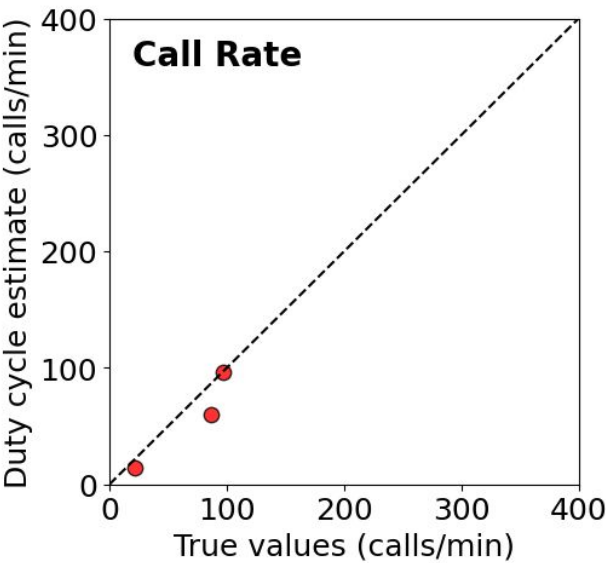# How we evaluated the effects of duty-cycling

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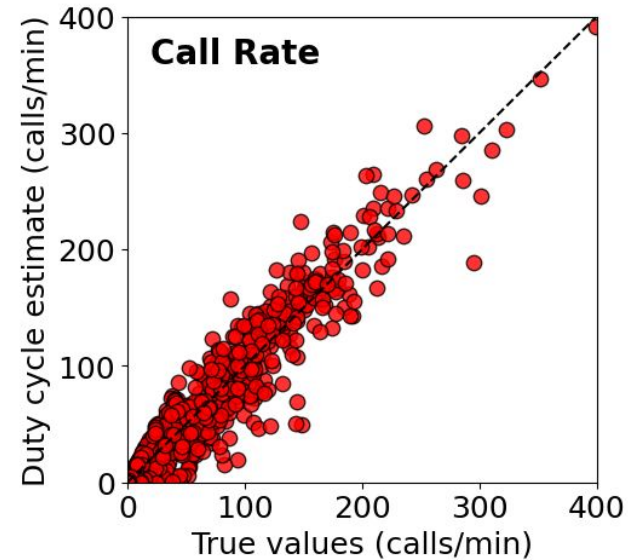
1 month
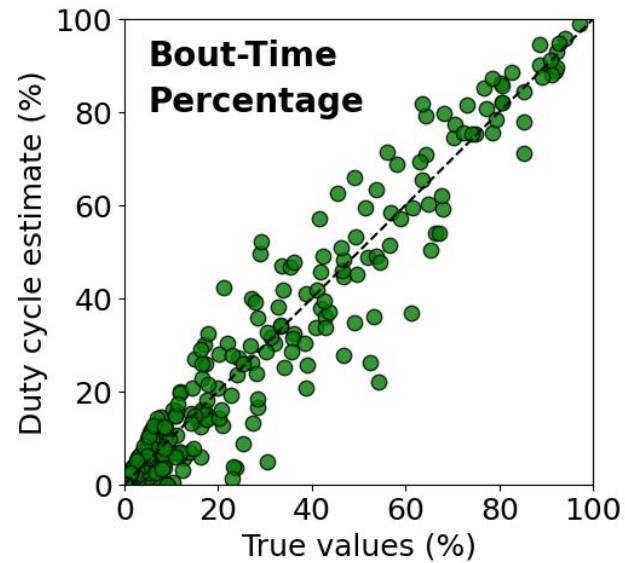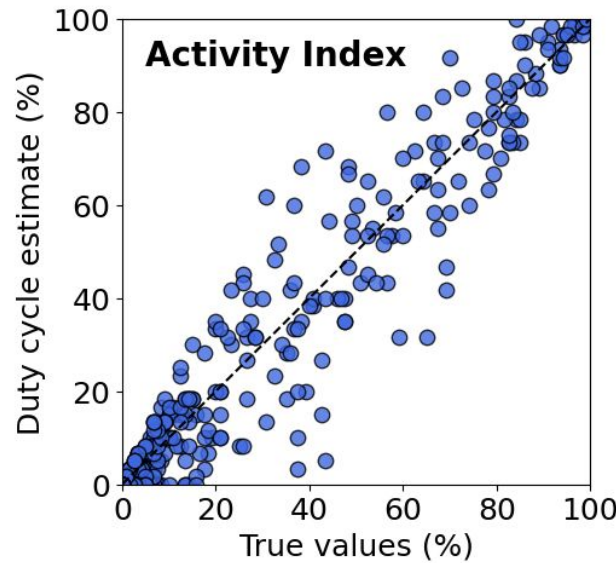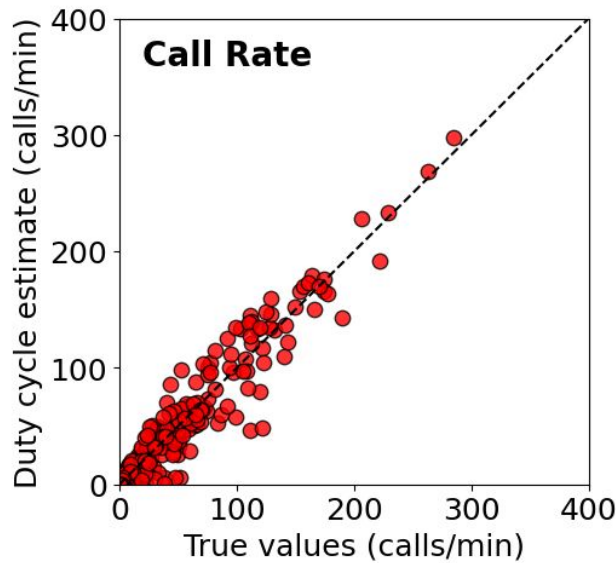
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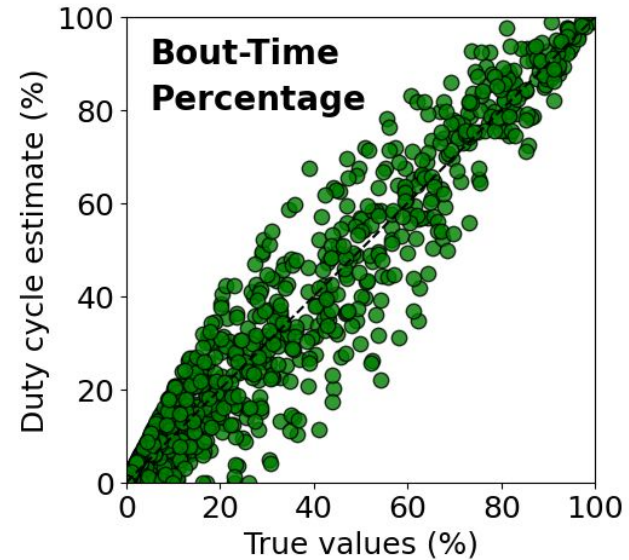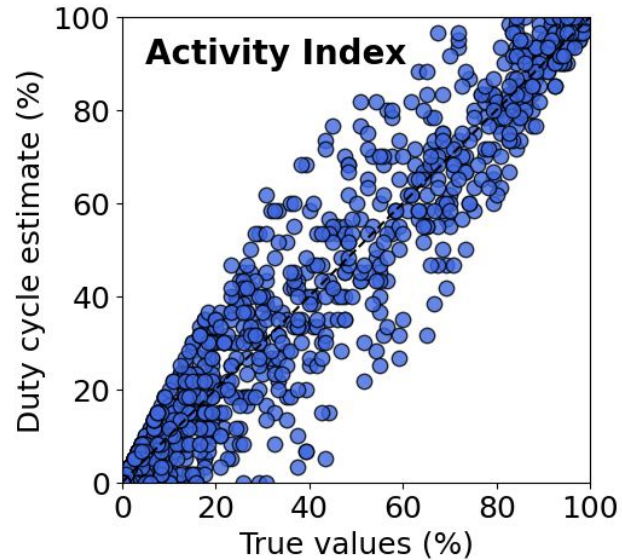Evaluating 5 min ON every 10 min duty-cycling
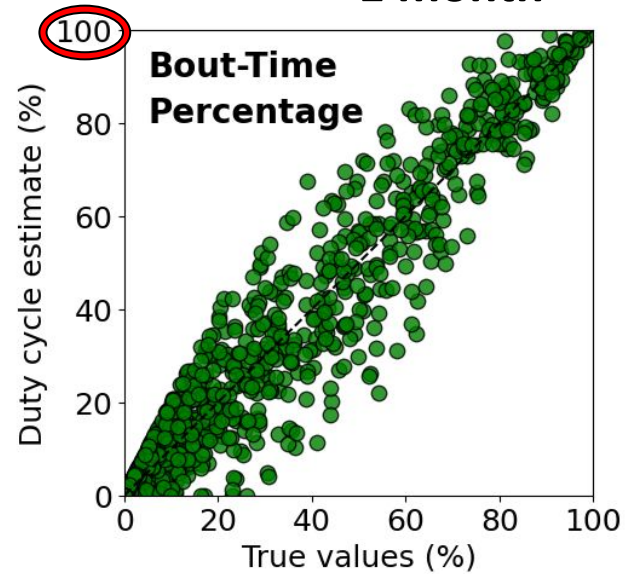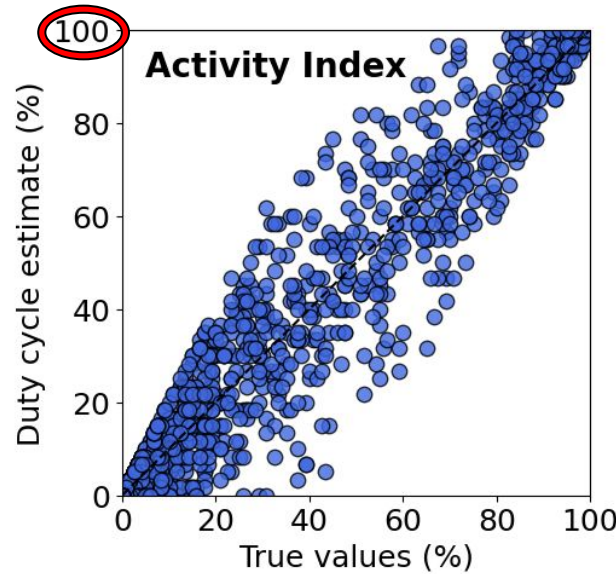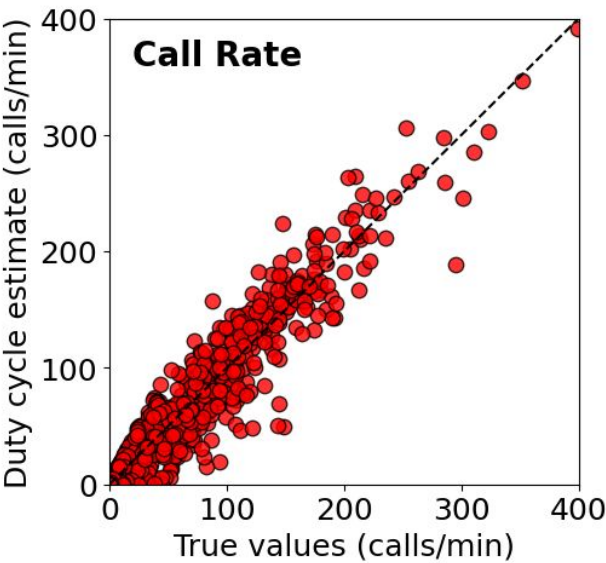
1 month

- Relative metrics

How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 month
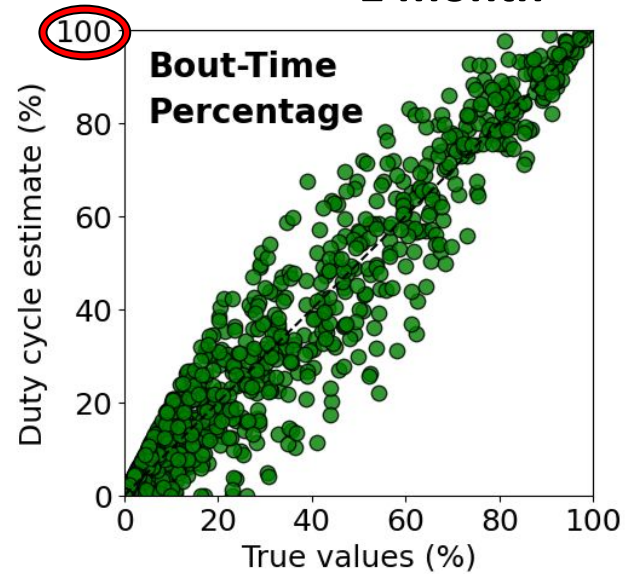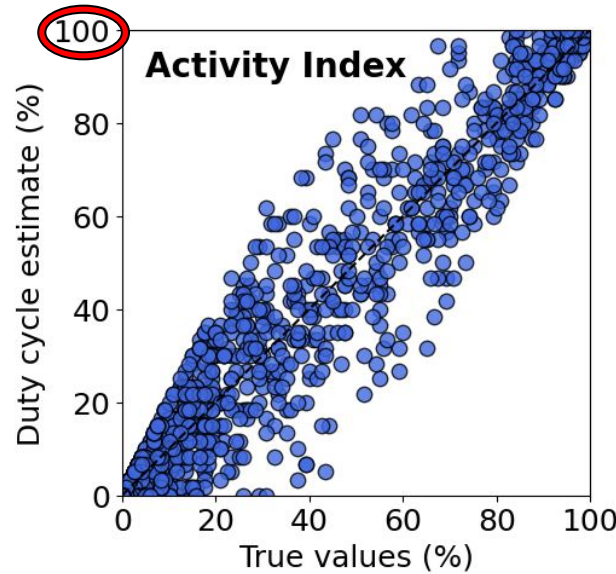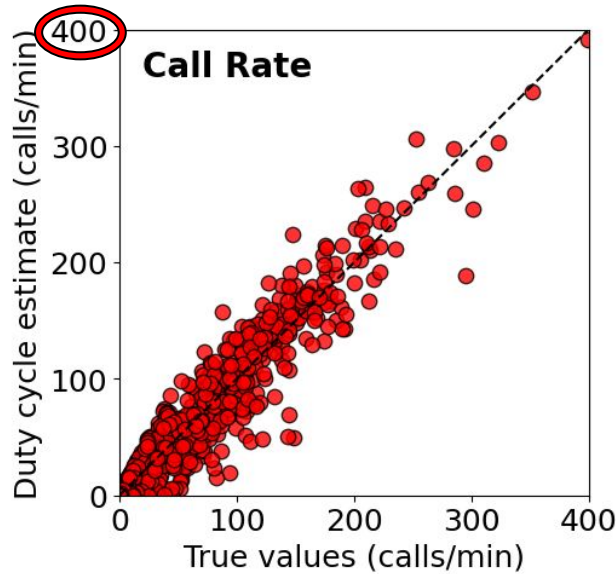
- Absolute metric
- Relative metrics

Summarizing the estimation from duty-cycling

Evaluating 5 min ON every 10 min duty-cycling
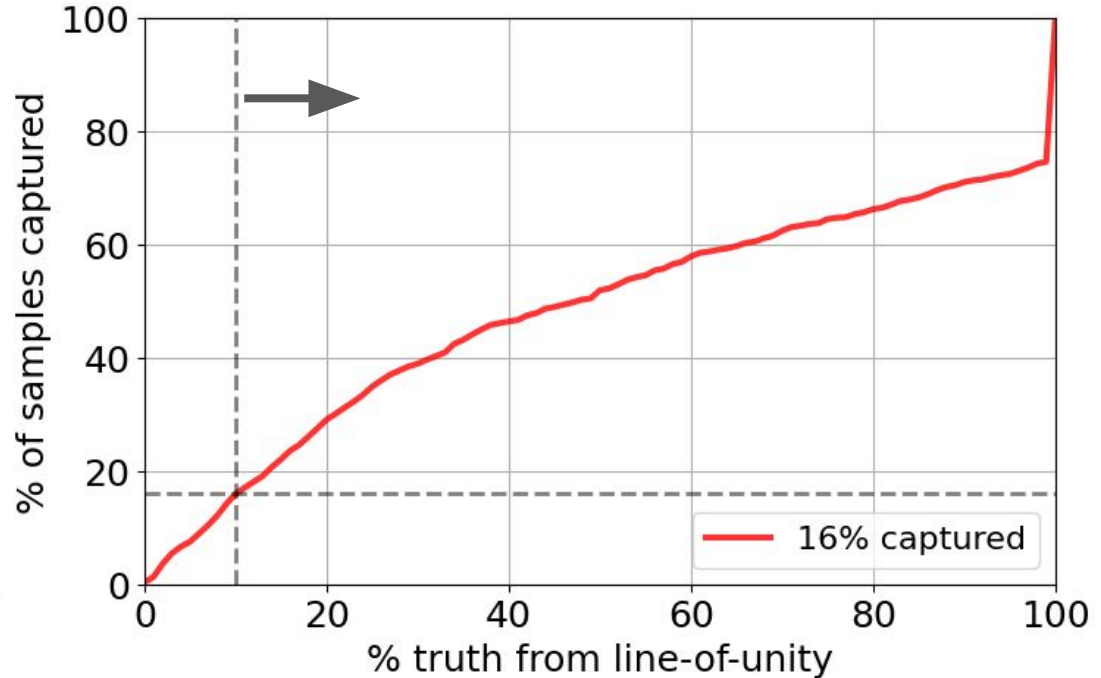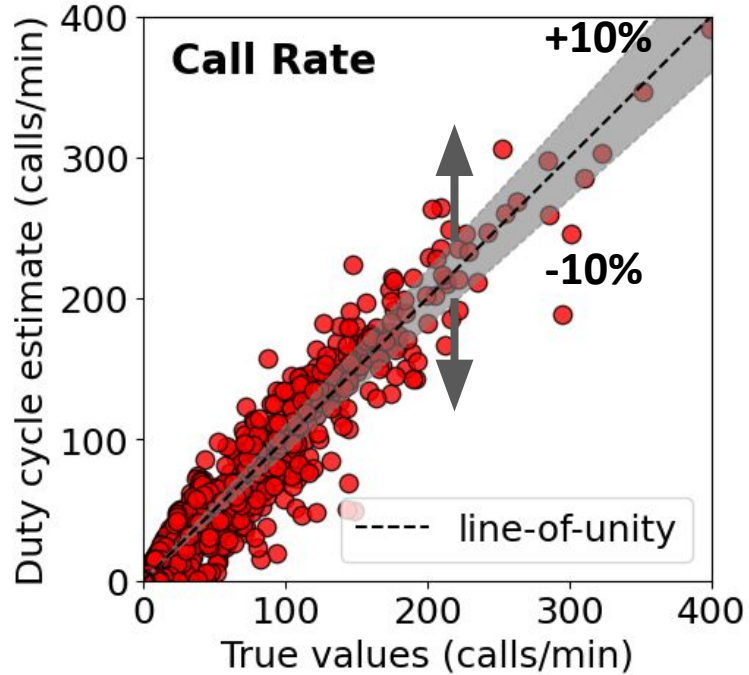
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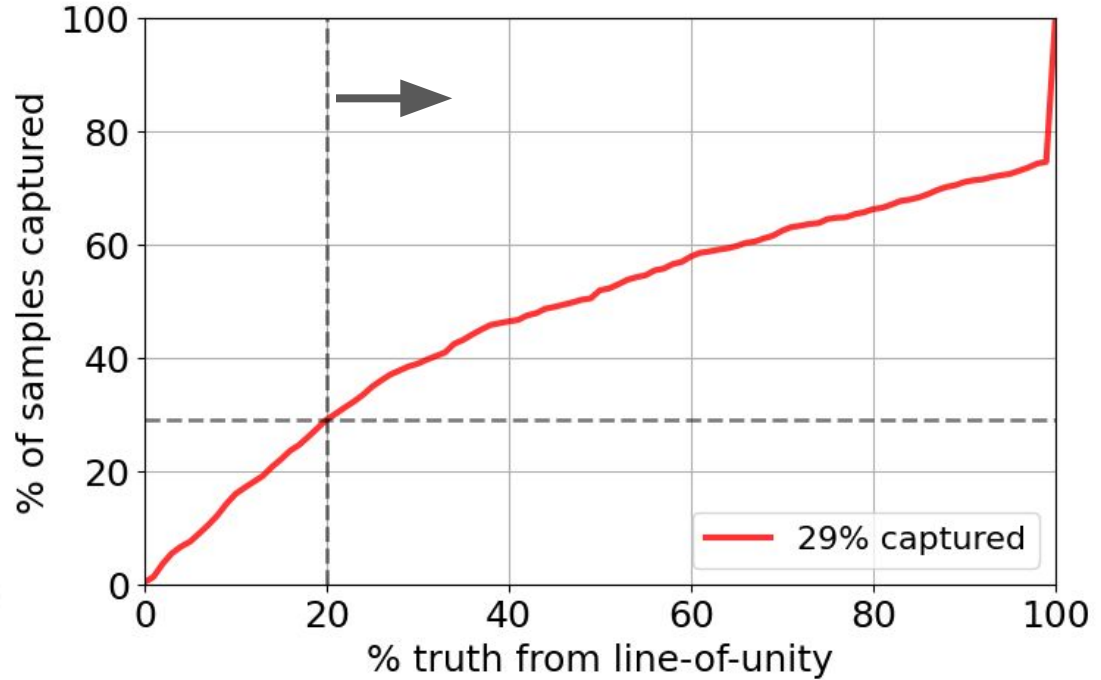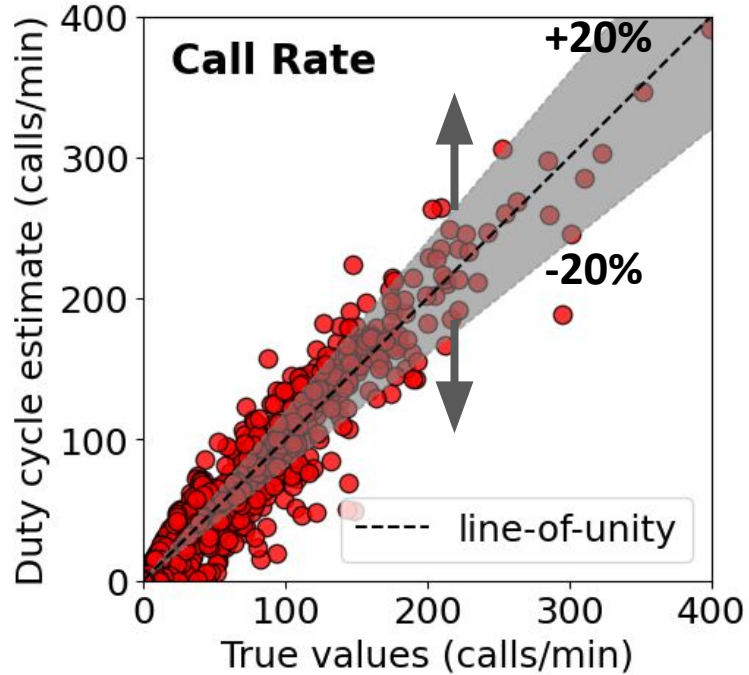
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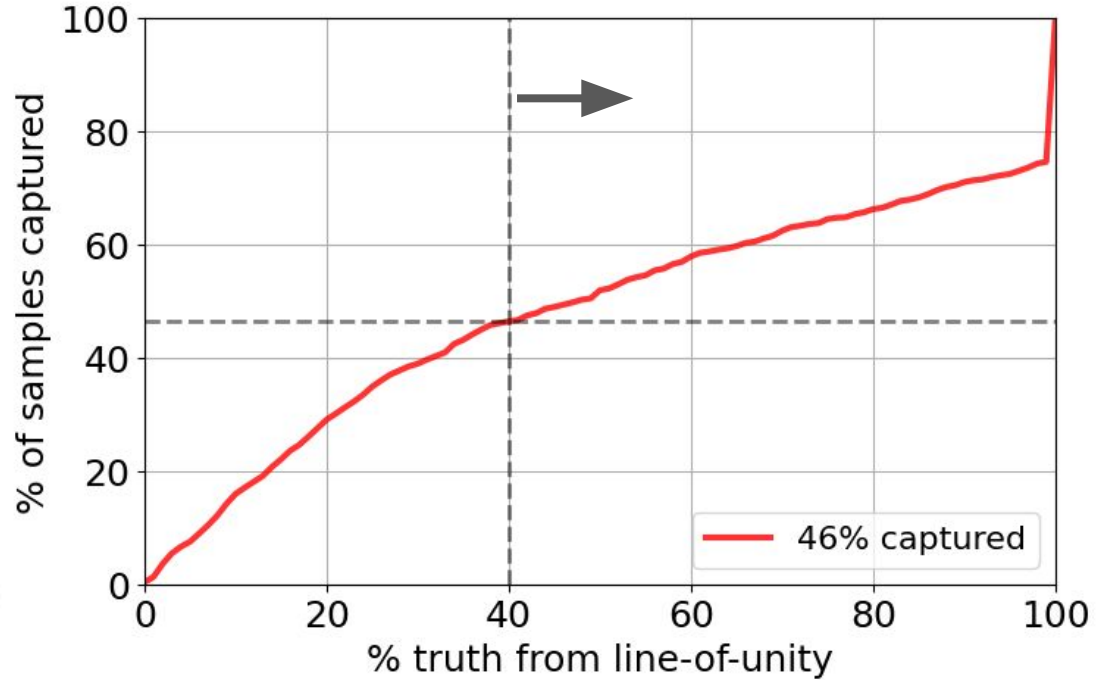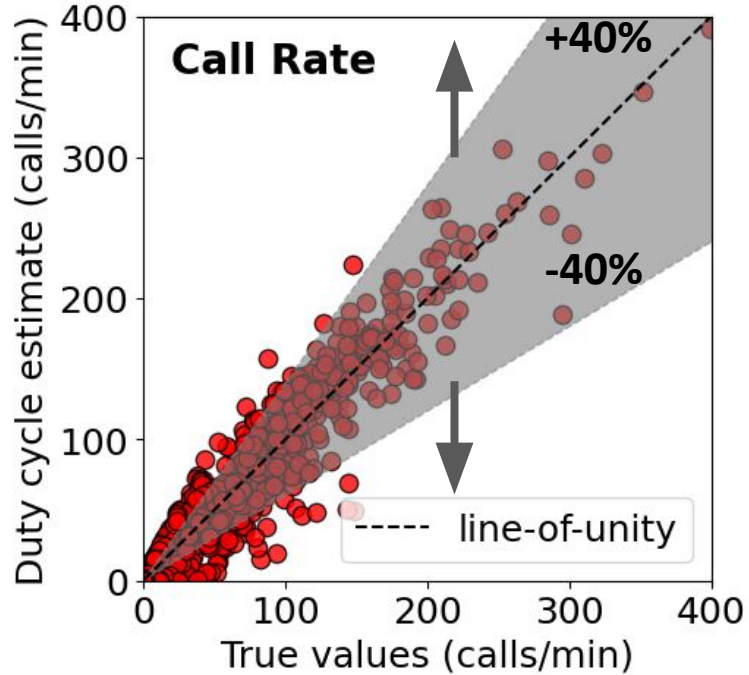
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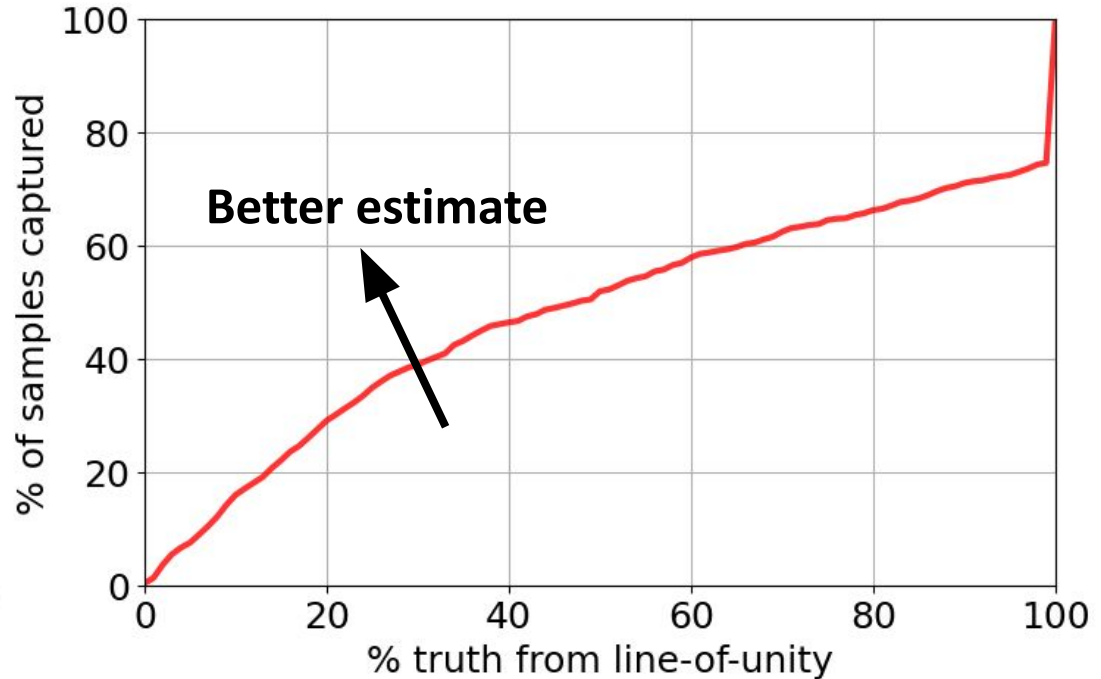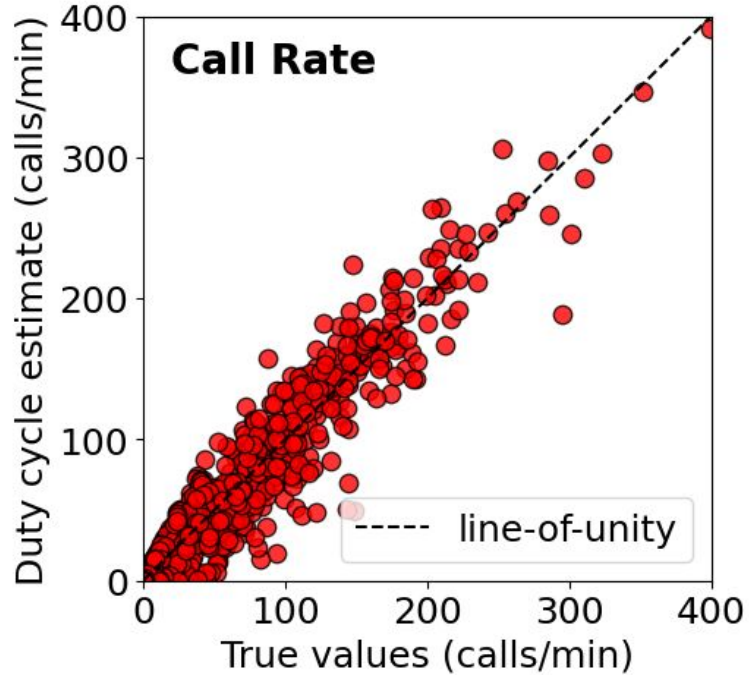
How each metric responds to duty-cycling

Call Rate
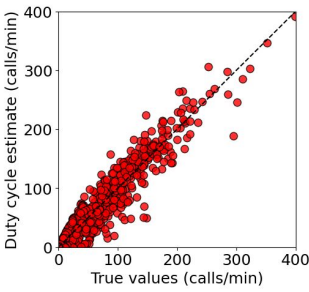
Activity Index
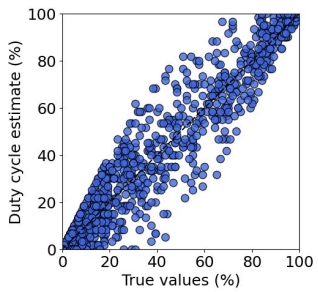
Bout-Time Percentage

Evaluating 5 min ON every 10 min duty-cycling

Better estimate
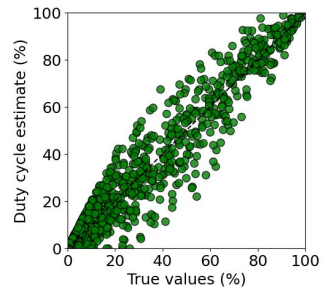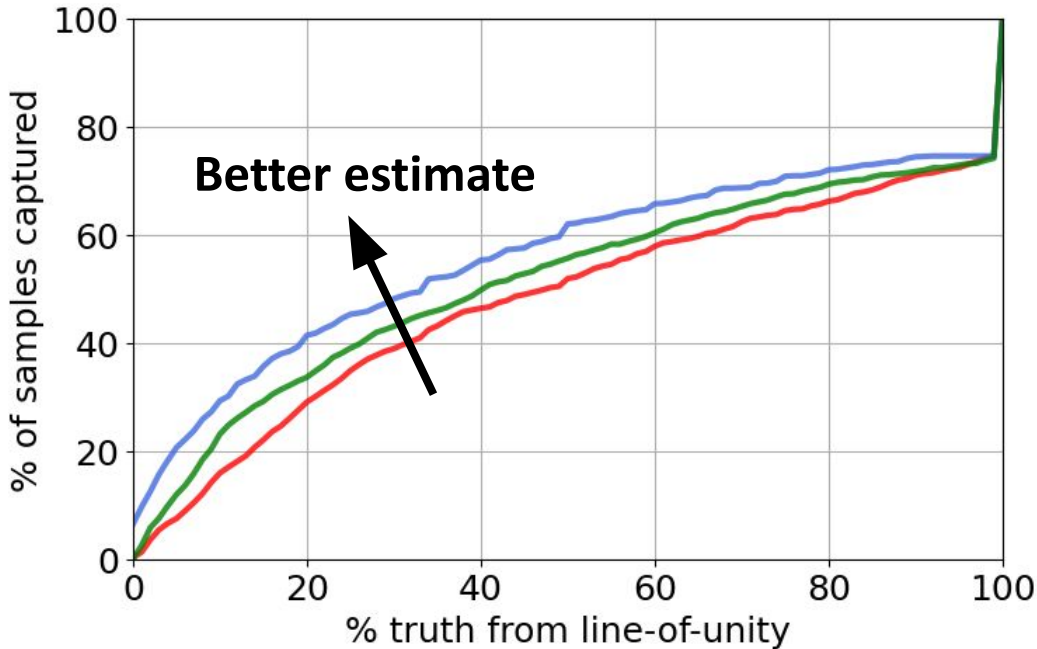
Activity Index and Bout-Time Percentage are more robust to duty-cycling

10

Estimates are closer to truth when activity is high

Activity threshold:
50% AI/BTP or 100 calls/min

Evaluating 5 min ON every 10 min duty-cycling

Activity

High   Low

Call Rate

Activity Index

Bout-Time Percentage

Better estimate
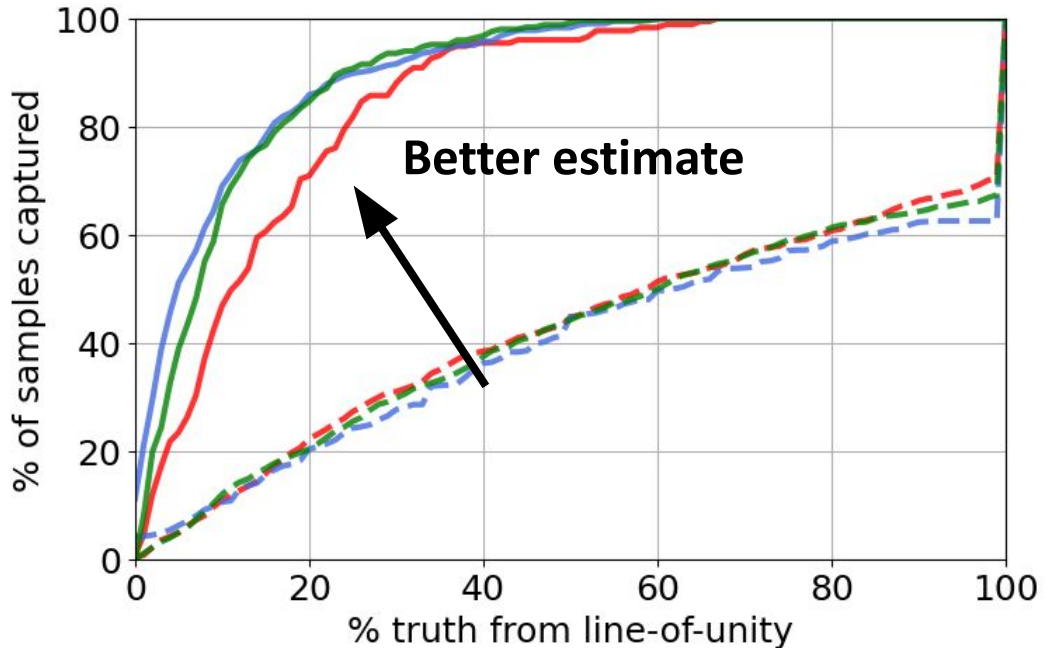
Increasing listening ratio with fixed cycle length improves activity estimates

Fixed cycle length of 30 min

Listening

	15min	5min
Call Rate	——	- - -
Activity Index	——	- - -
Bout-Time Percentage	——	- - -
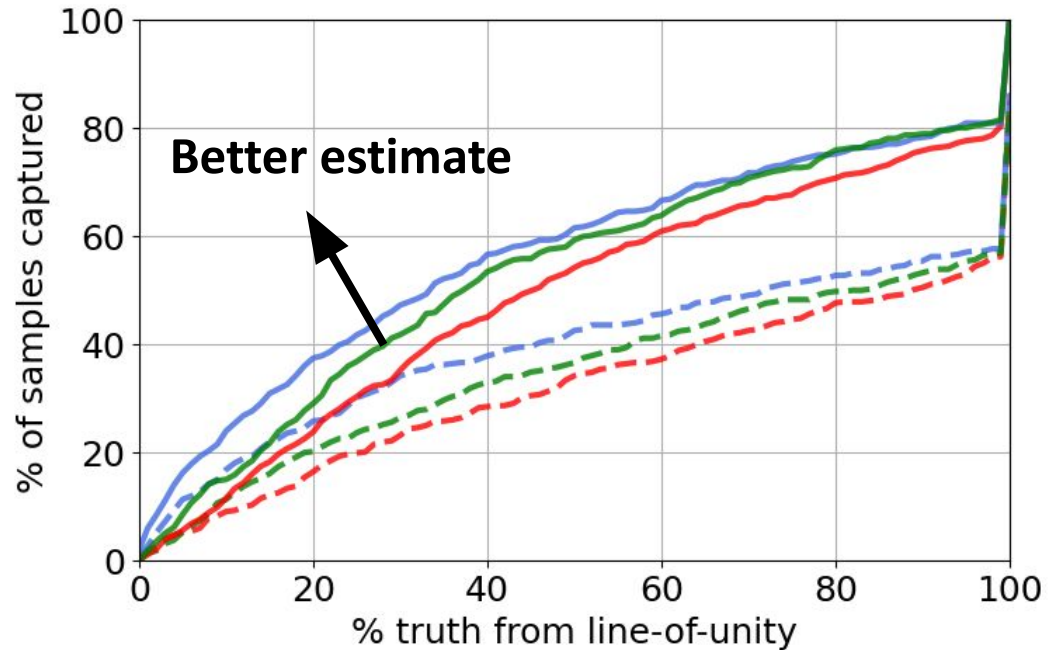
Decreasing cycle length with fixed listening ratio improves activity estimates

Fixed listening ratio of ½
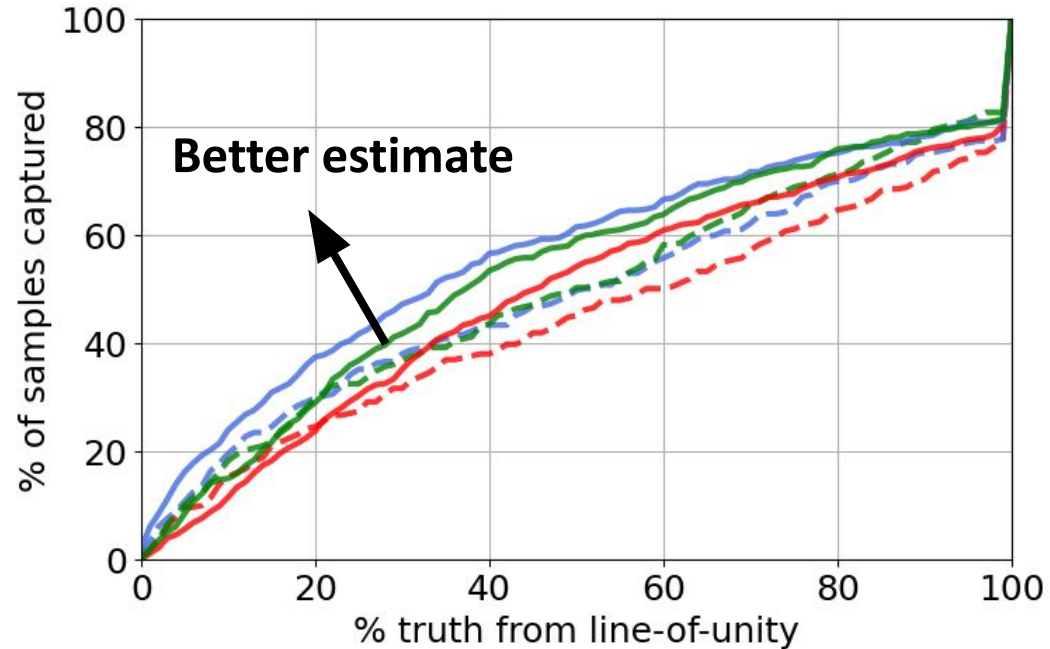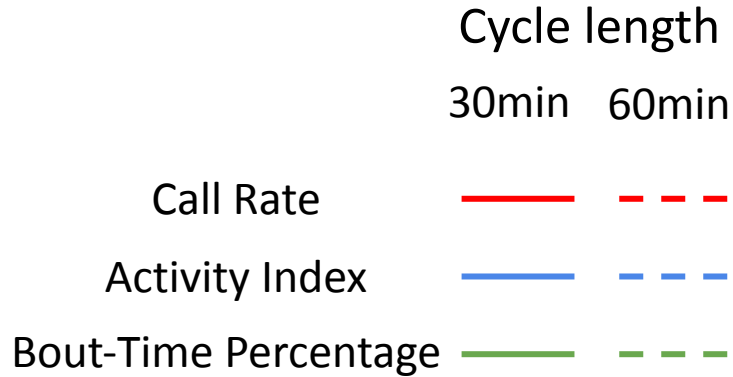
Cycle length

	30min	60min
Call Rate	——	- - -
Activity Index	——	- - -
Bout-Time Percentage	——	- - -

General guidelines

1. **Activity Index** and **Bout-Time Percentage** are robust and informative
2. Duty-cycling when activity is **high** is safer than when activity is low
3. **Keeping listening ratio high** when duty-cycling
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5 minutes ON every 10 minutes

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5 minutes ON every 10 minutes

- Any lower than 10 and we increase power consumption due to ON/OFF

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5 minutes ON every 10 minutes

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- Any higher than ½ and we lose benefits of duty-cycling

General guidelines

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This expanded Audiomoth deployment length from 3 days to 1 week!

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This expanded Audiomoth deployment length from 3 days to 1 week!

and reduced detector processing time by factor of 2!

Summary and Ongoing Work

Summary

- Continuous 24/7 recording enabled systematic investigation of duty cycle-based subsampling

Ongoing Work

Summary and Ongoing Work

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d

-based subsampling
- Identified 2 informative metrics for measuring activity

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- Looking into species-specific duty-cycling

Summary and Ongoing Work

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Ongoing Work

- Looking into species-specific duty-cycling
- Studying how detector performance influences activity measurements

Acknowledgements

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UNIVERSITY *of* WASHINGTON

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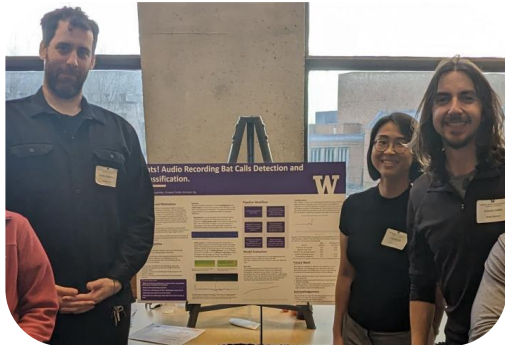**YeonJoon Cheong**

Caesar Tuguinay

Mollie Ball

Liuyixin Shao

Varun Krishnakumar

Automated call detection
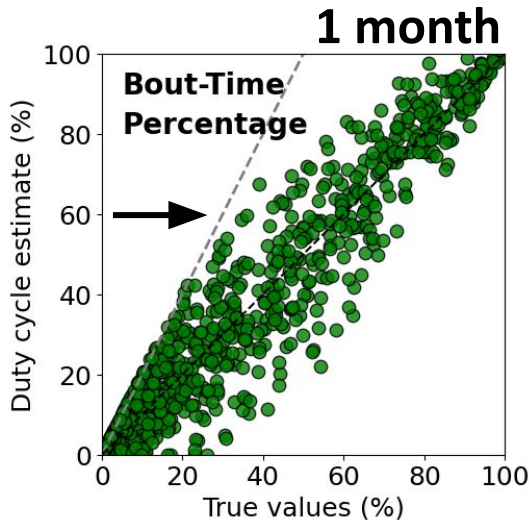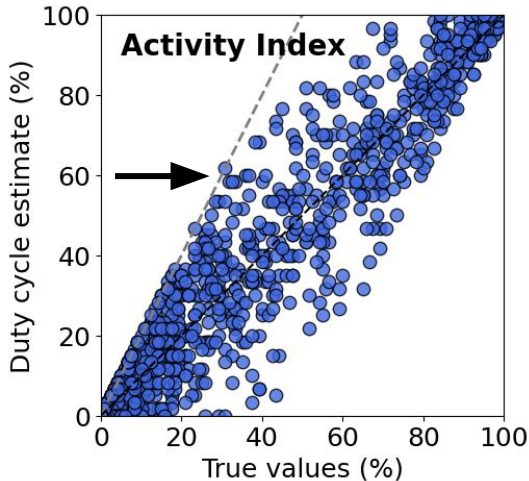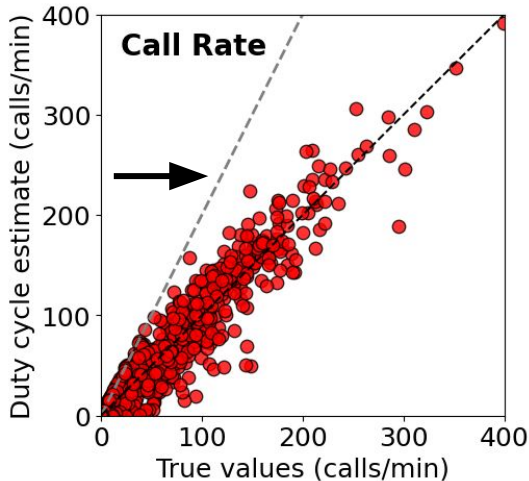- **Corbin Charpentier**
- **Kirsteen Ng**
- **Ernesto Cediel**
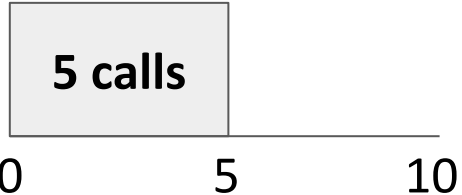
MARY GATES ENDOWMENT FOR STUDENTS

Defining traits for each metric using duty-cycles
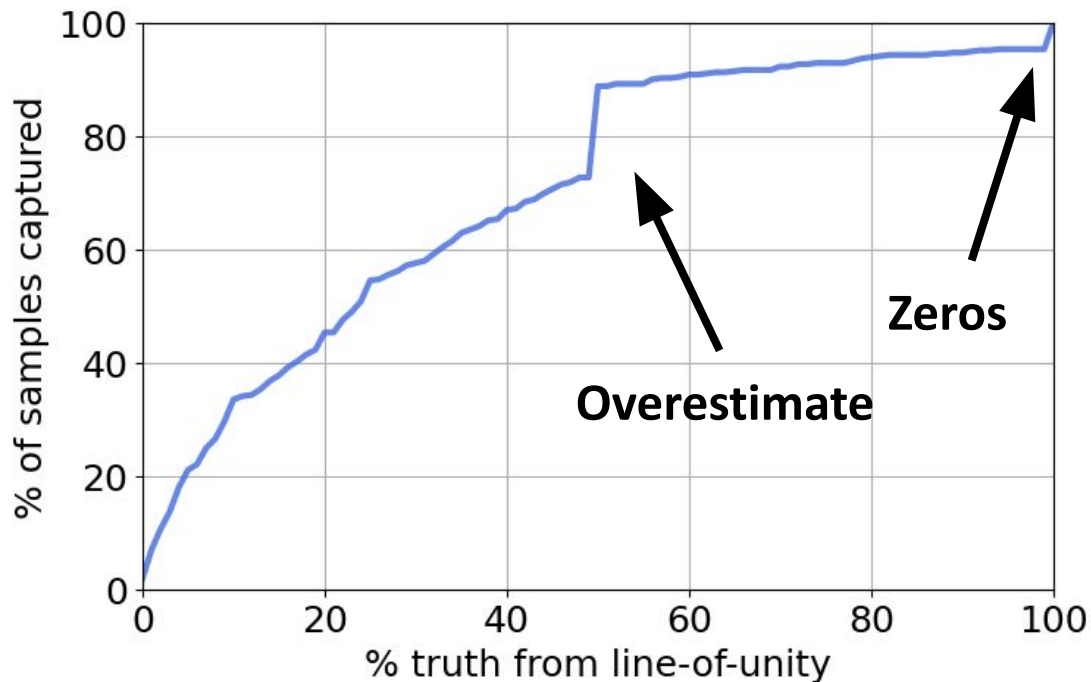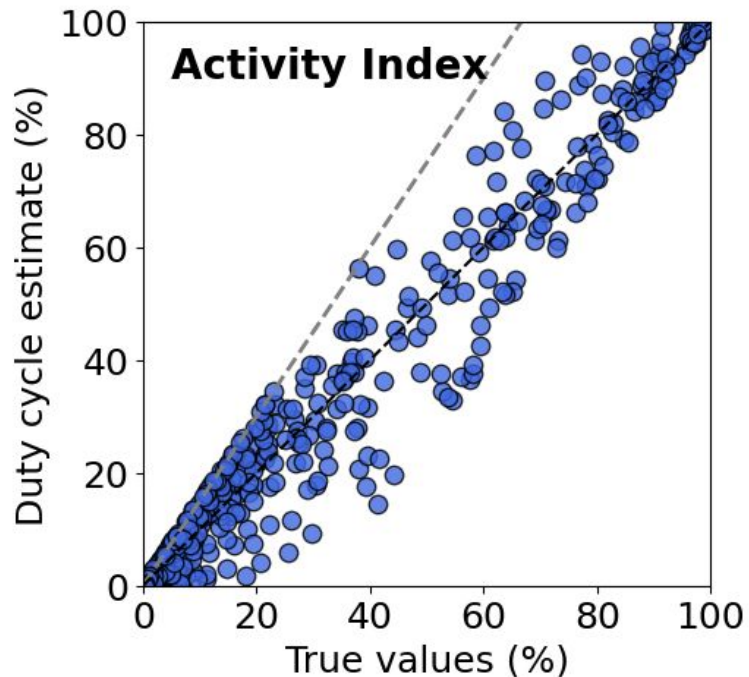
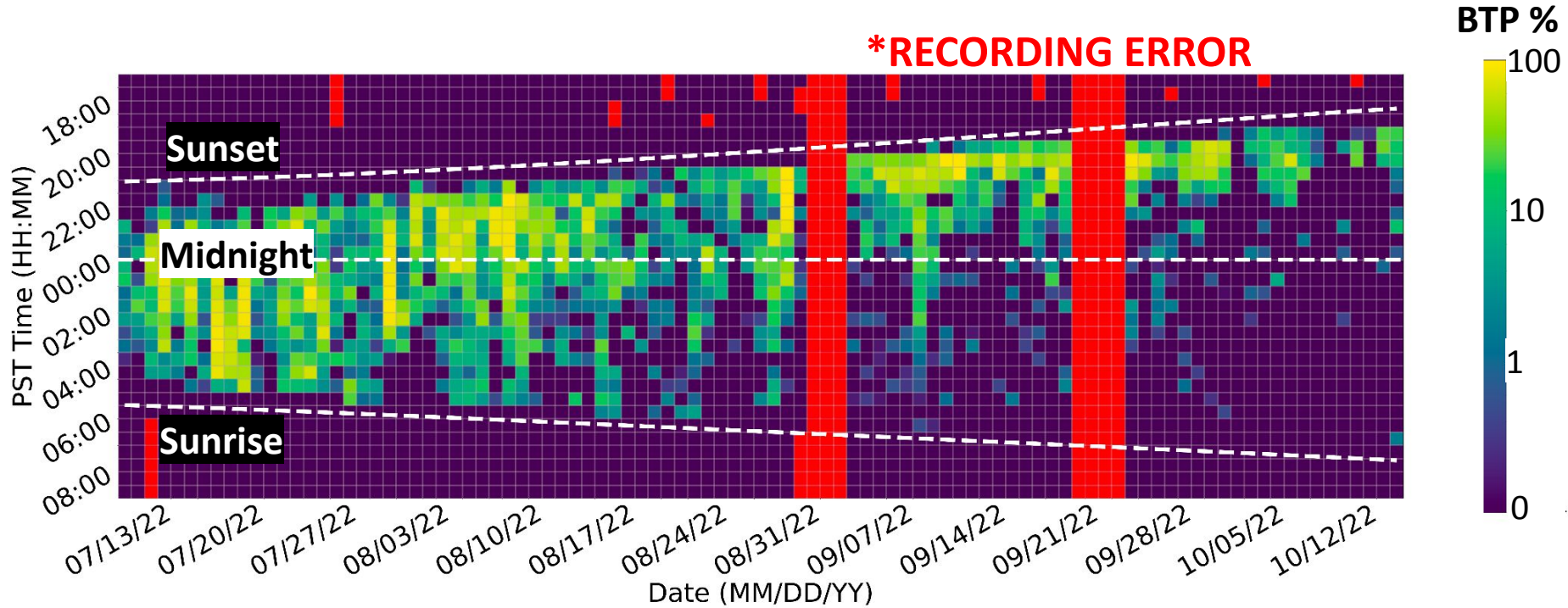Evaluating 5 min ON every 10 min duty-cycling

- Overestimate bound

- Listening for 10 min vs. 5 min
- 2x increase in call rate
- Same can be applied for other metrics

Summarizing the estimation from duty-cycling

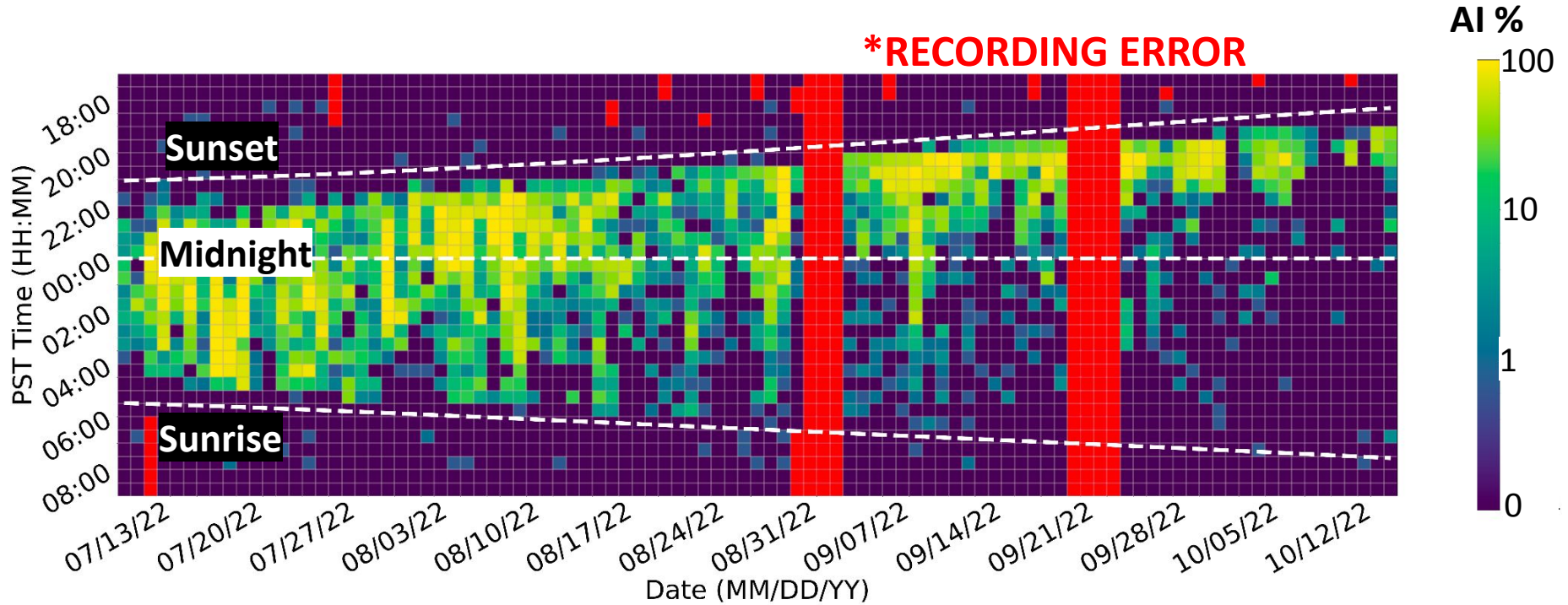## Evaluating 20 min ON every 30 min duty-cycling

Activity using the BTP metric with 5/10 scheme

*RECORDING ERROR

BACKUP

- Conserved the activity observed previously

Activity using the AI metric with 5/10 scheme

*RECORDING ERROR

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BACKUP