186th Meeting of the Acoustical Society of America

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

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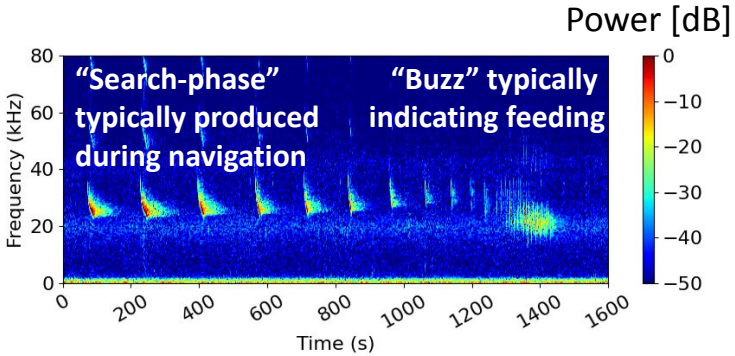
UNIVERSITY of WASHINGTON

PAM needs strategic subsampling

Passive acoustic monitoring (PAM)

- Useful method for environmental surveys

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



PAM needs strategic subsampling

Passive acoustic monitoring (PAM)

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

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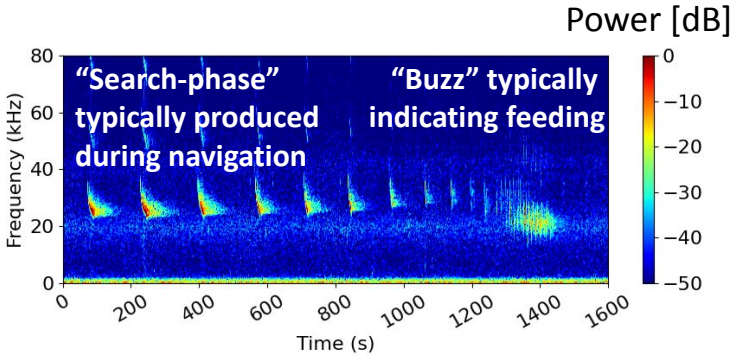

Subsampling strategies

- 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)

Recorded 24/7 data from July to October 2022

The Union Bay Natural Area, Seattle, WA

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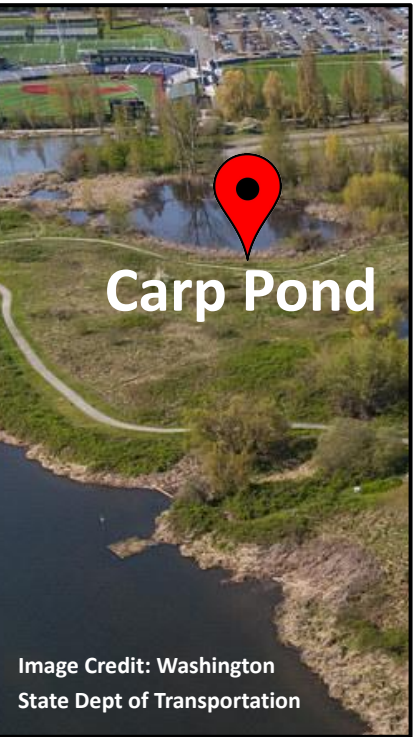
The Union Bay Natural Area, Seattle, WA

- Focusing on Carp Pond for this talk



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Audiomoths

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

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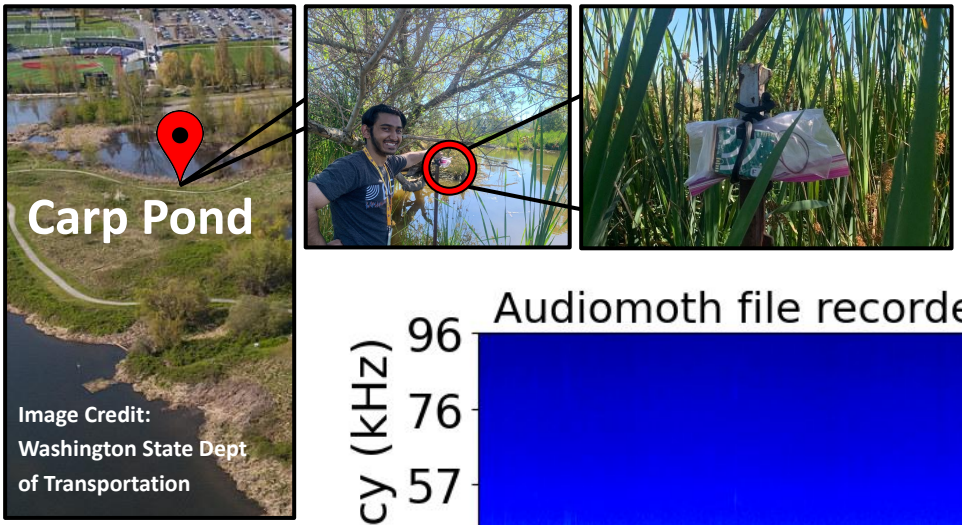

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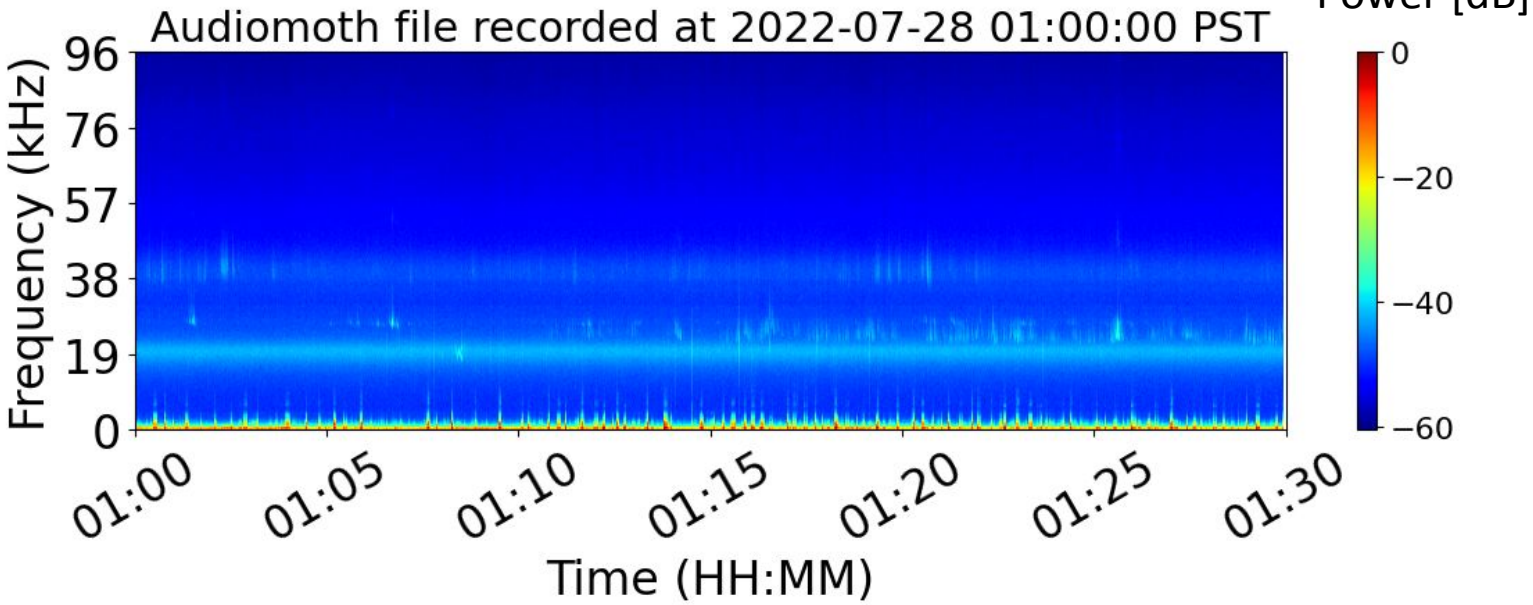

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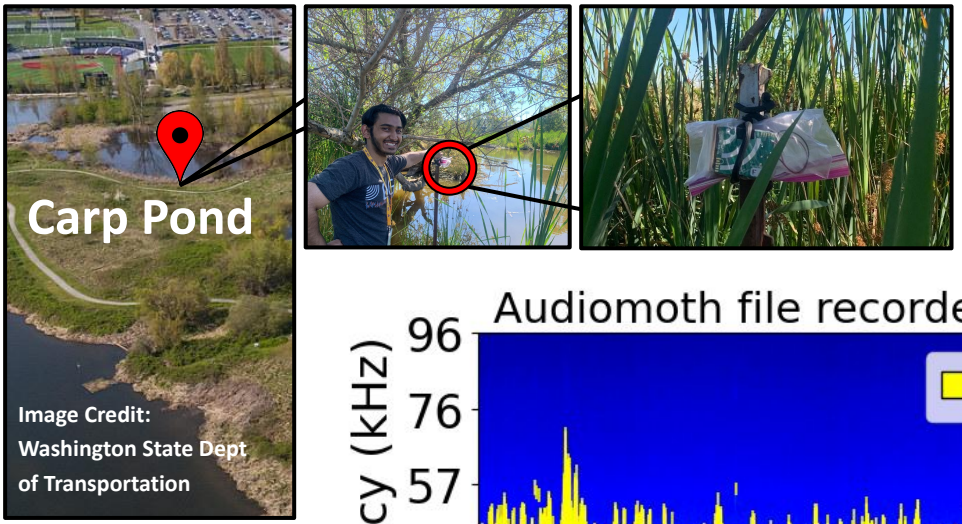

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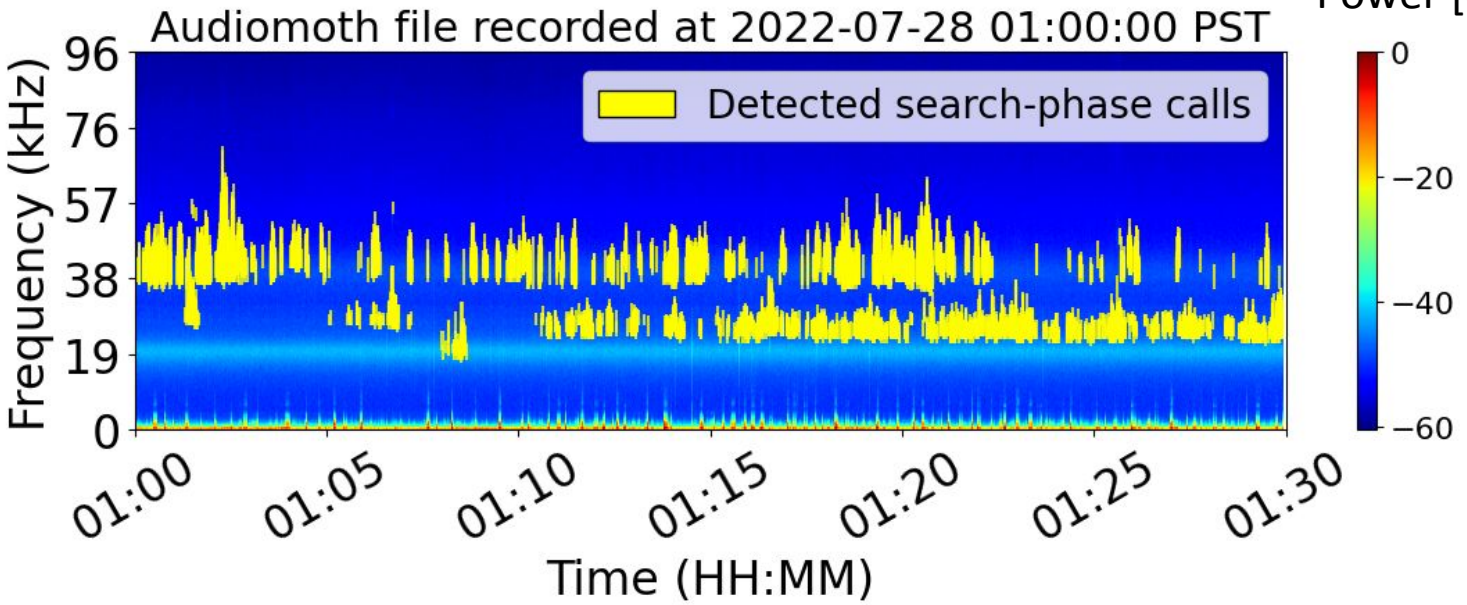

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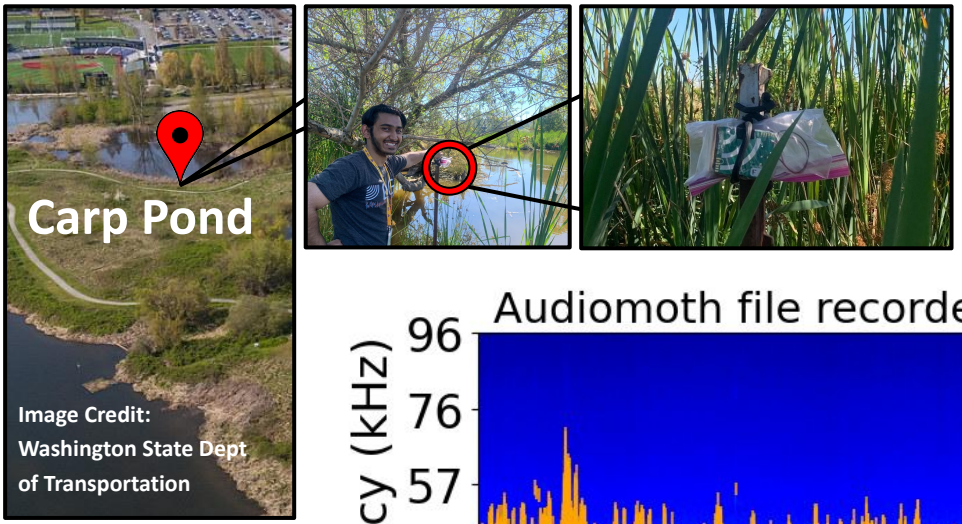

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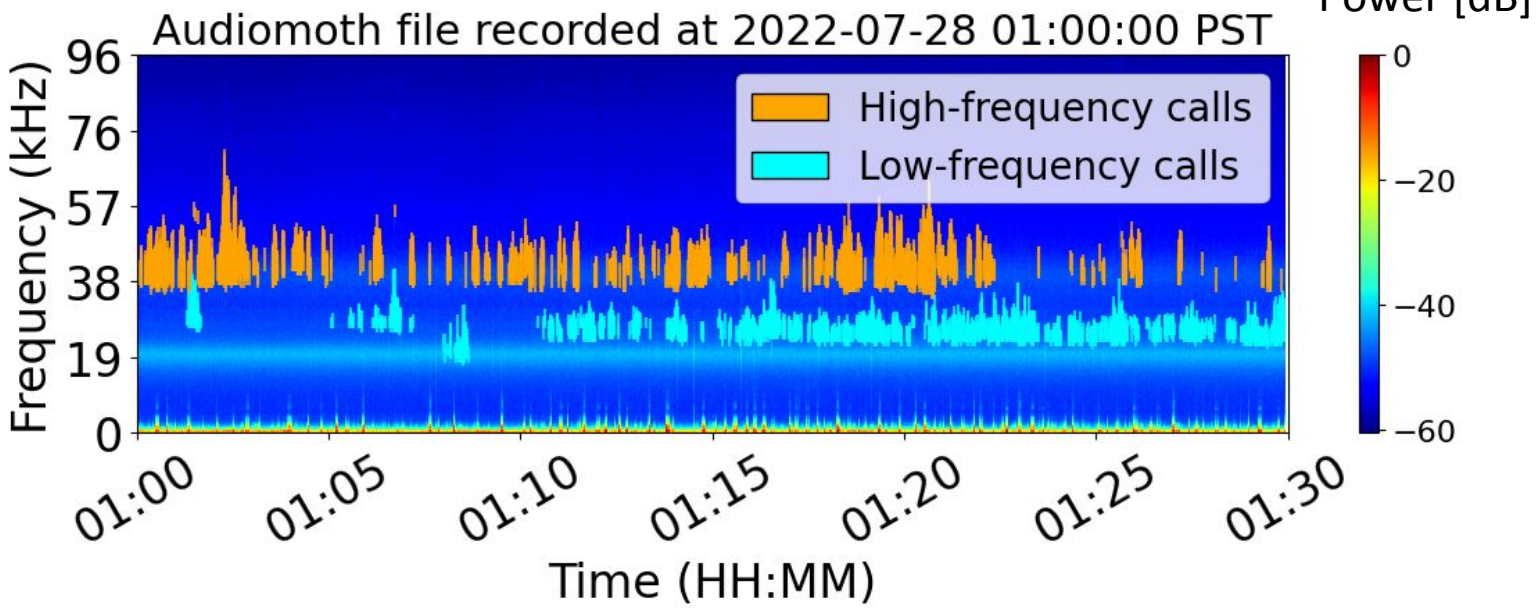

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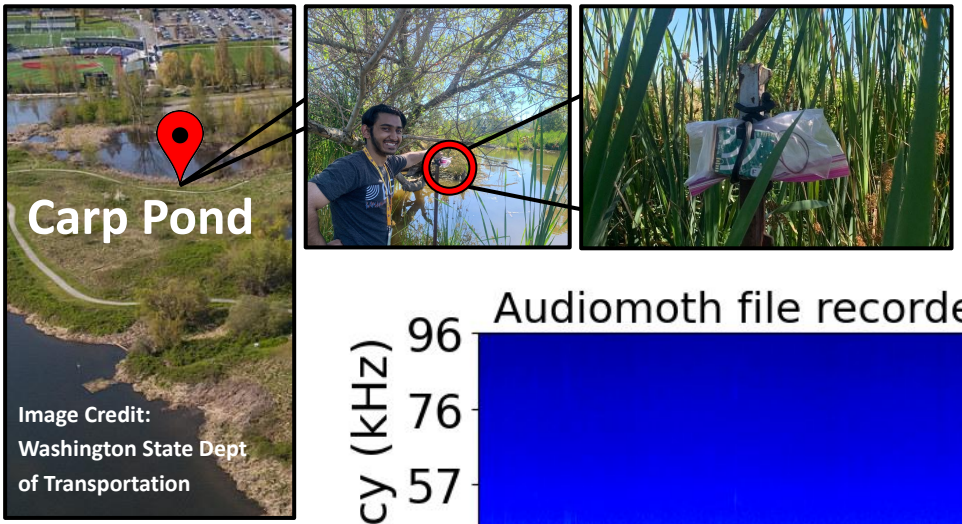

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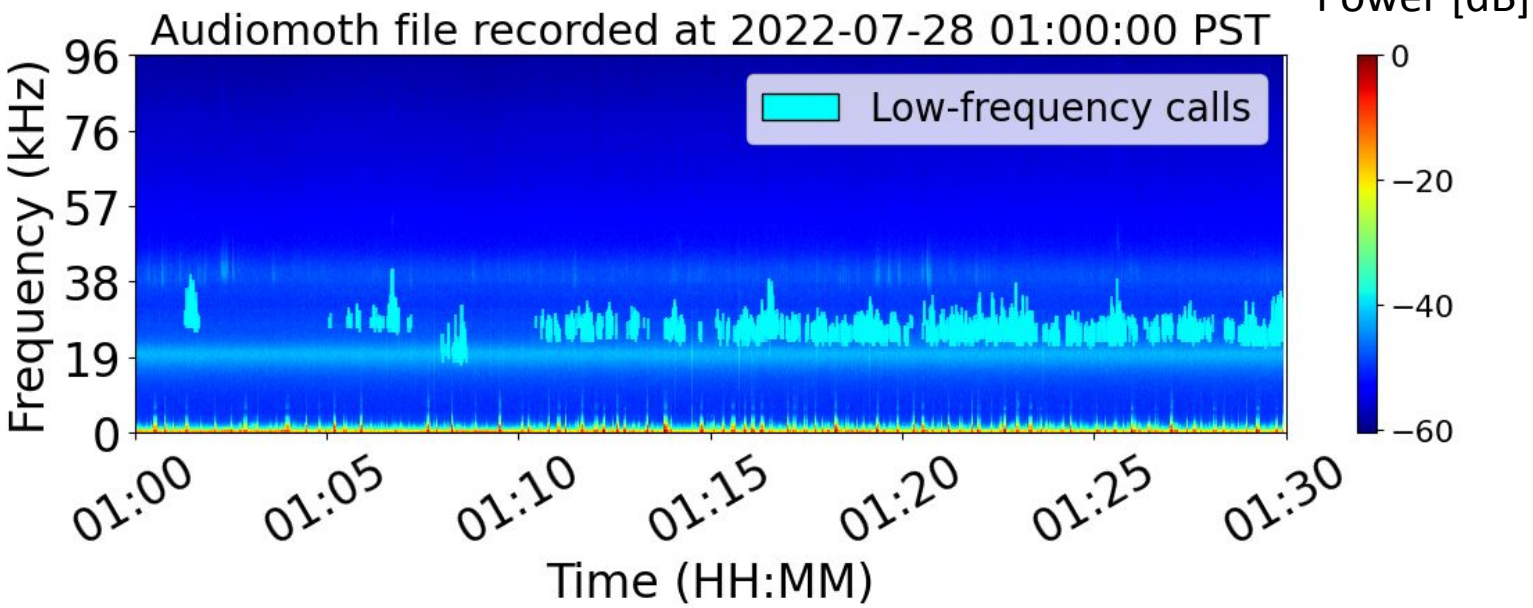
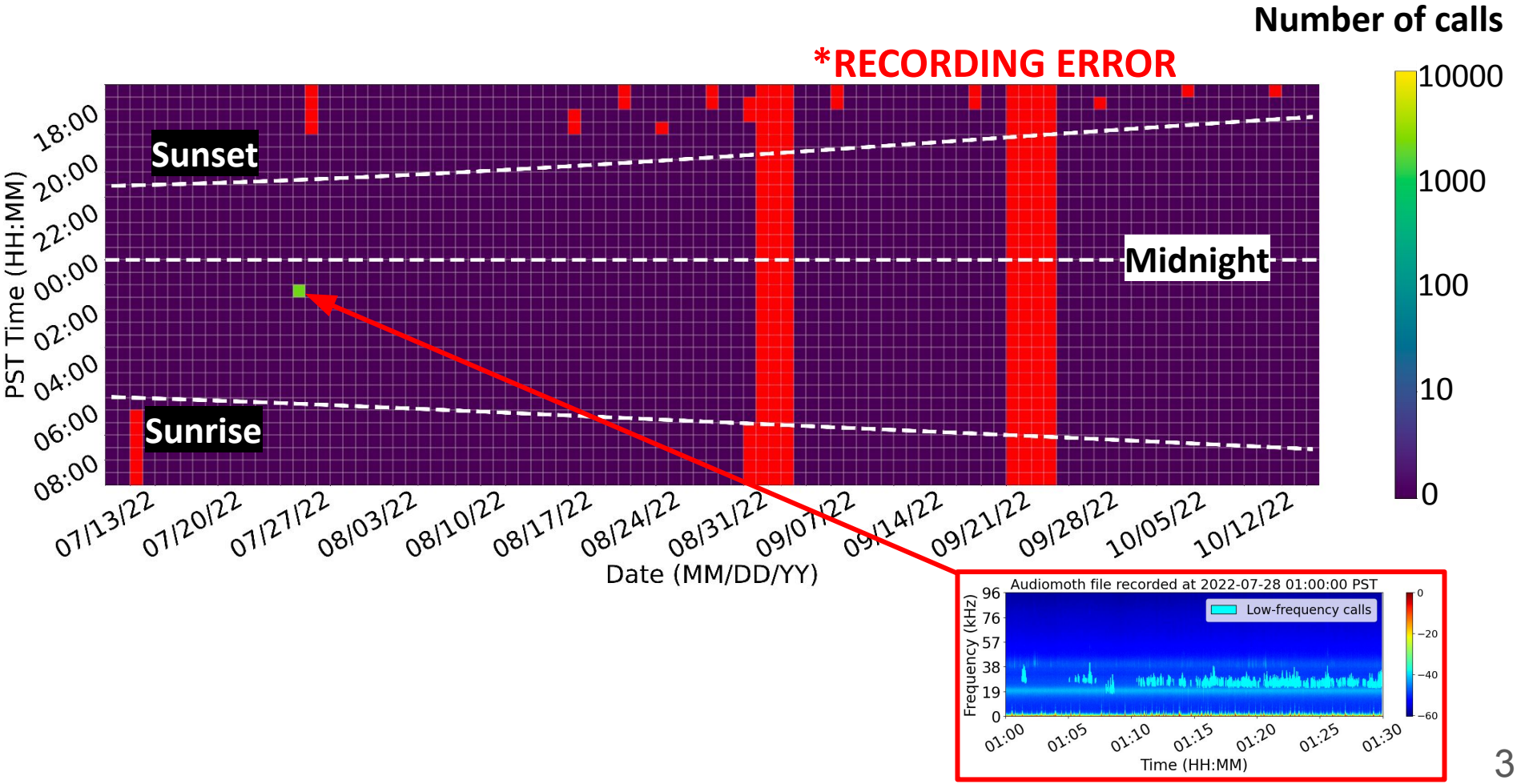


Research Questions

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



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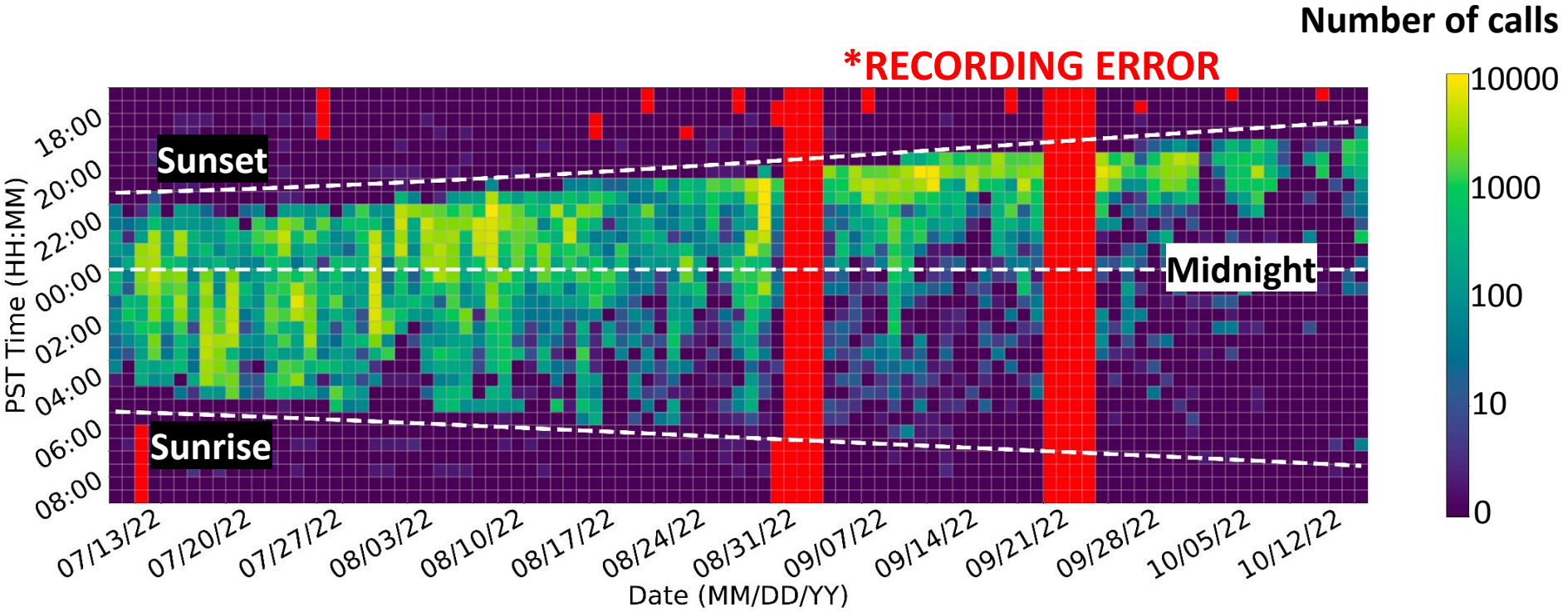


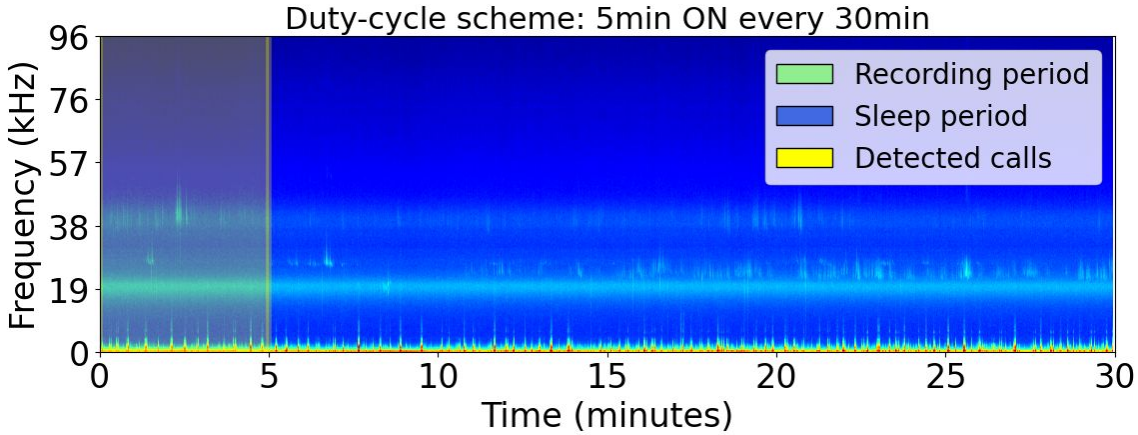
- Number of calls per 30-min file

How to subsample using duty cycles?

Parameters:

(1) Listening ratio

(2) Cycle length



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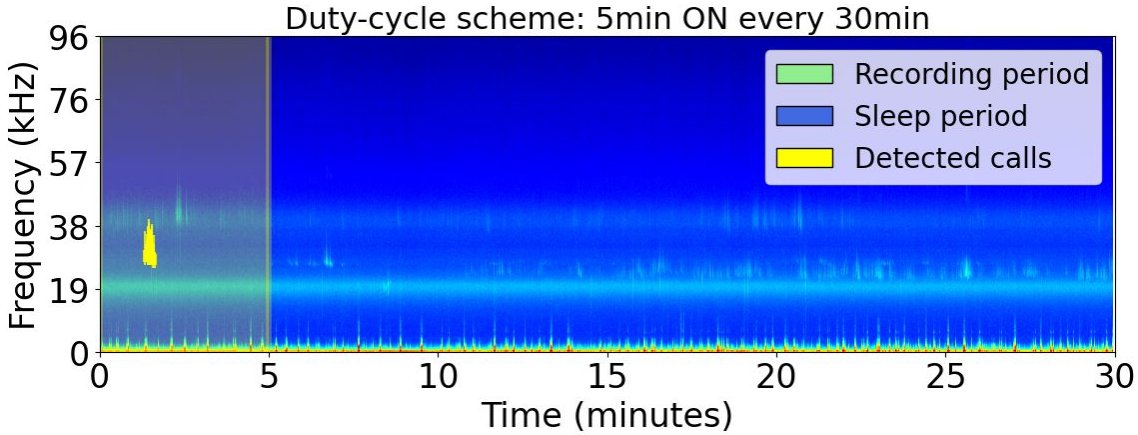
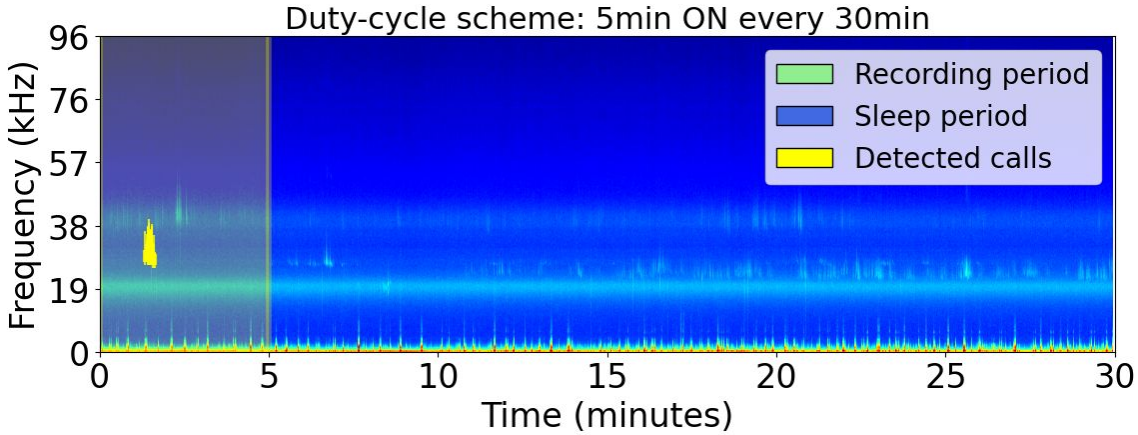


How to subsample using duty cycles?

Parameters:

(1) Listening ratio = 1/6

(2) Cycle length = 30



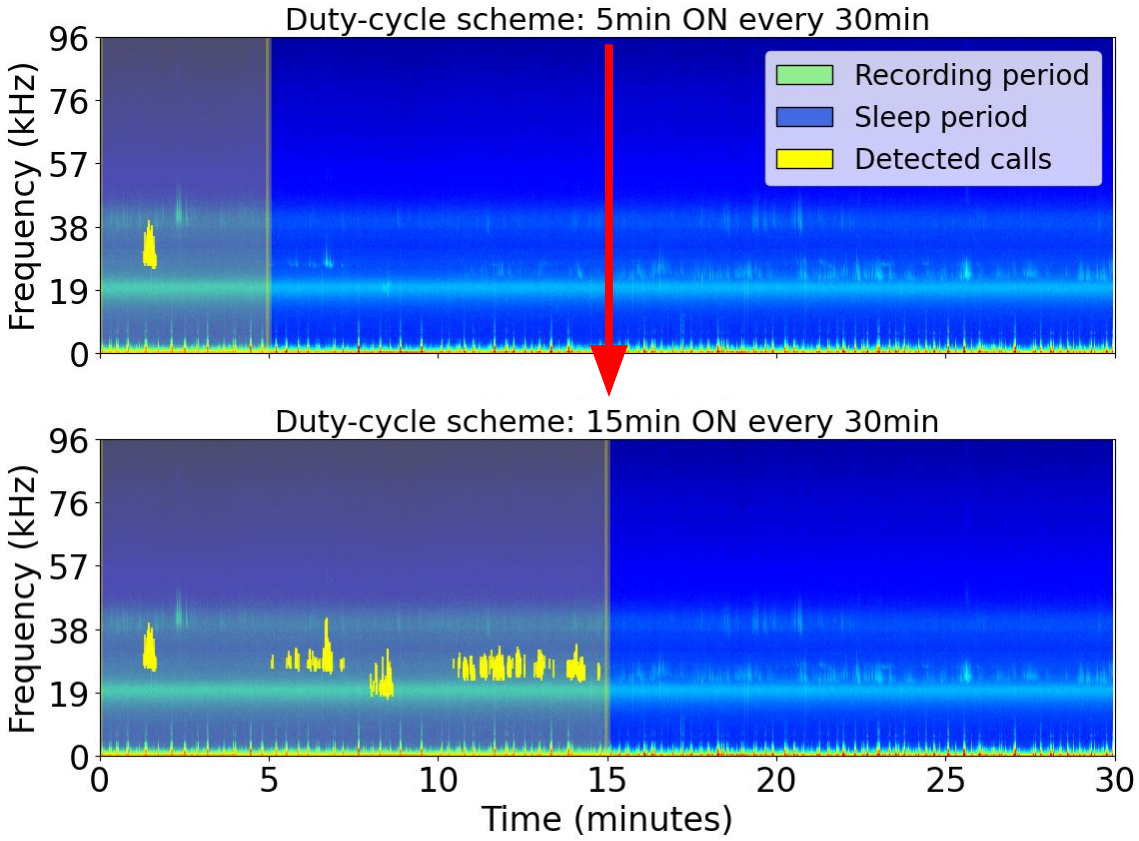
How to subsample using duty cycles?

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?

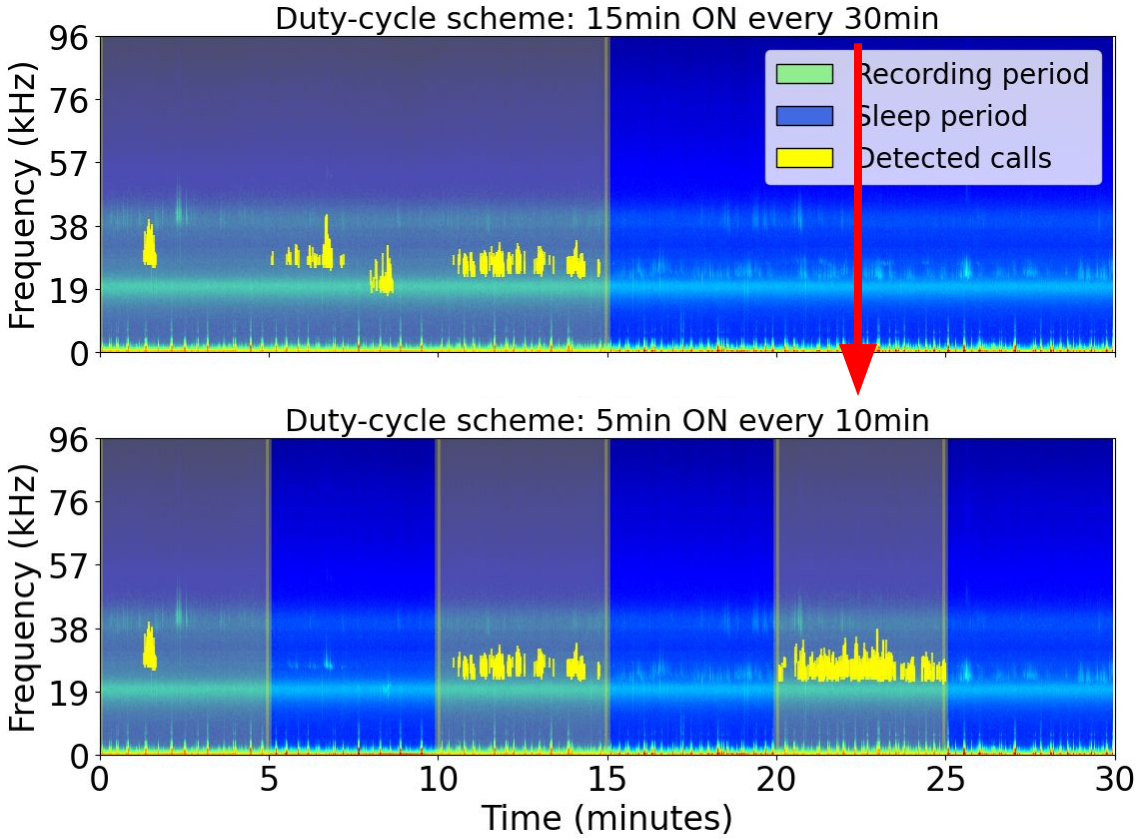
Parameters:

(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**



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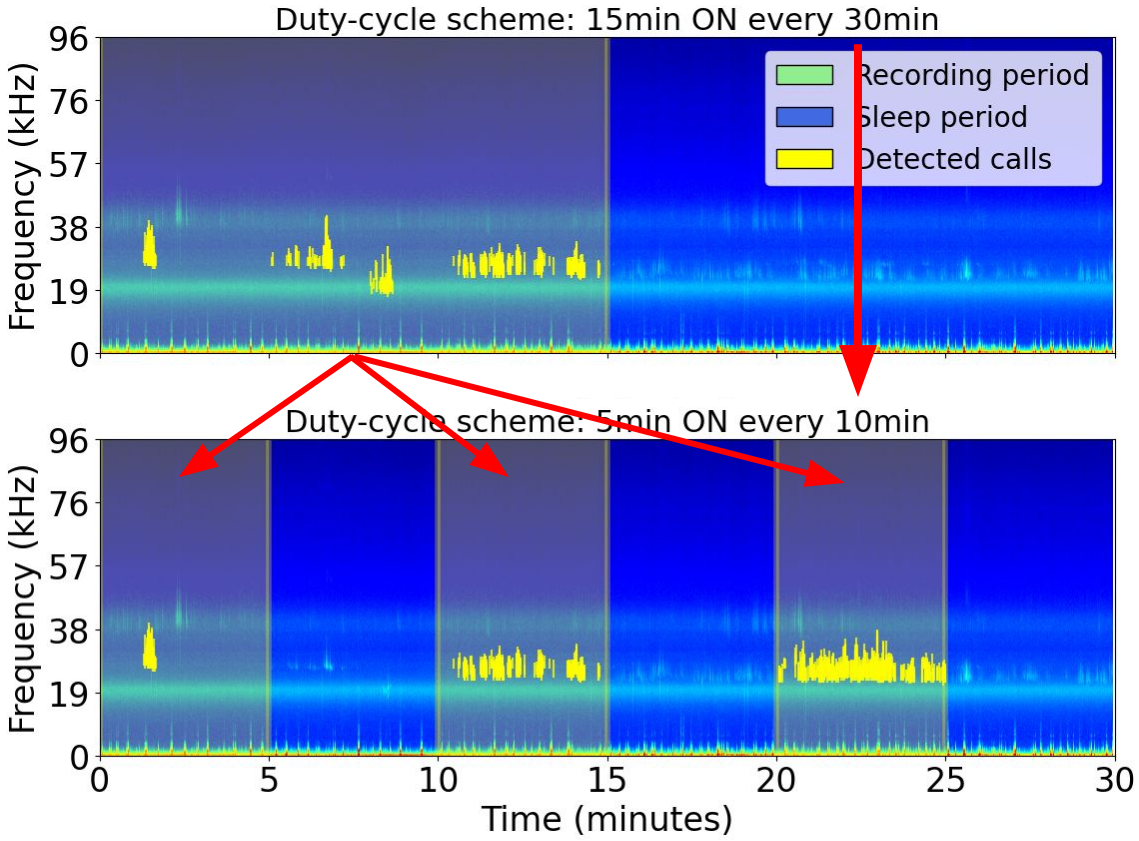
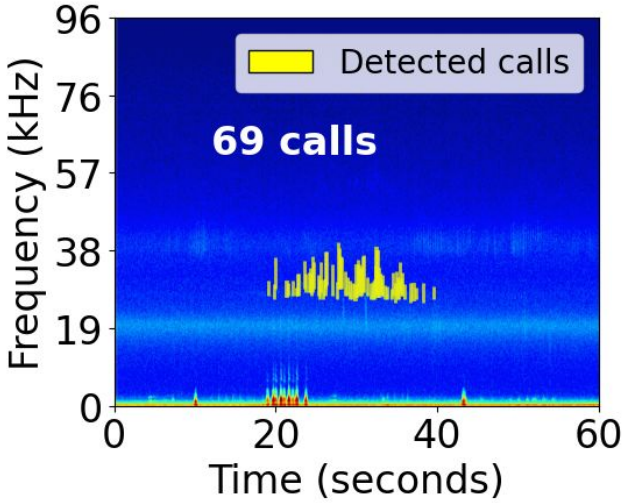


How to measure activity using bat search calls?

(1) Call rate
(calls/min)



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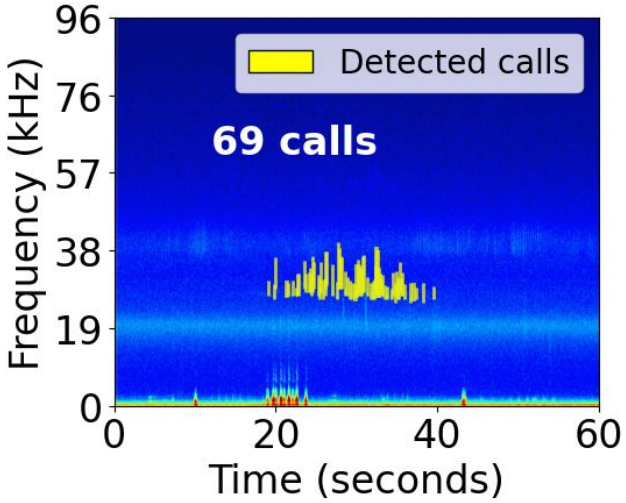

69 calls/min

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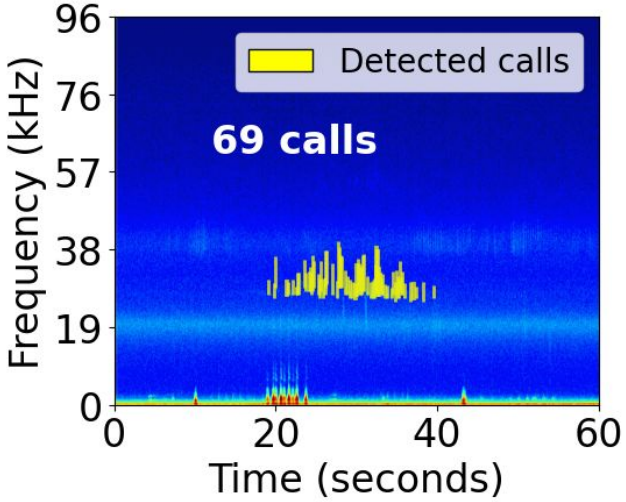
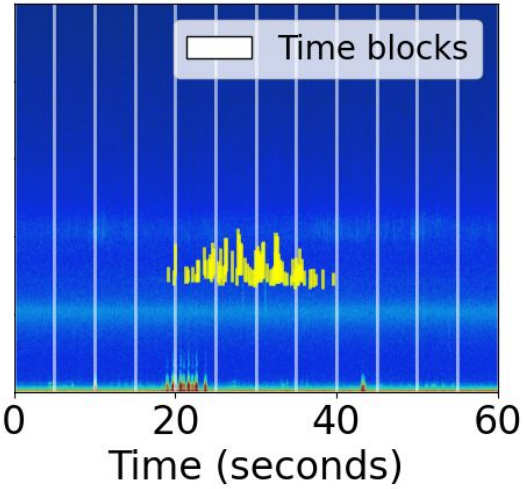


69 calls/min

(2) Activity Index
(Miller, 2001)



5 blocks out of 12 blocks

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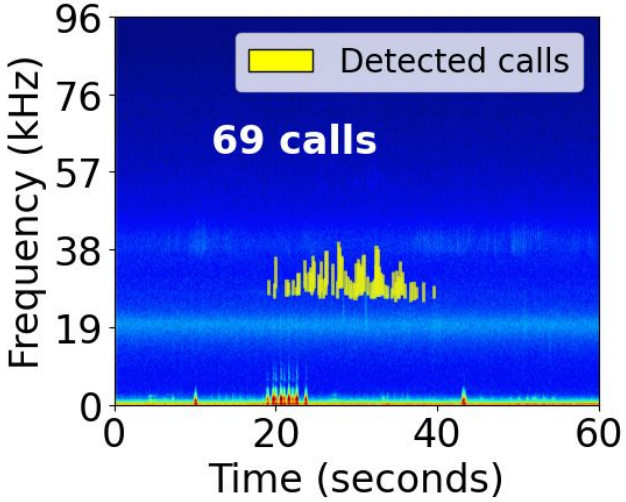

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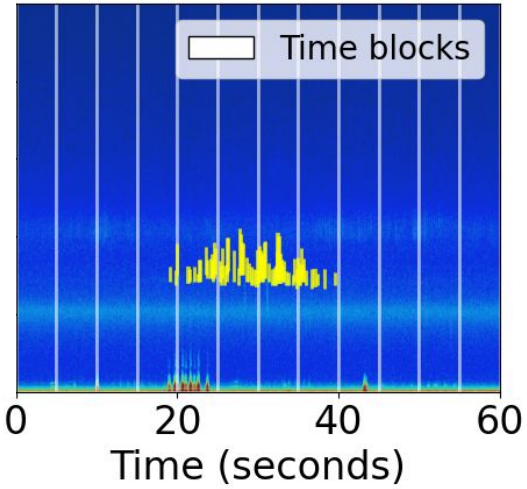

41.67% AI

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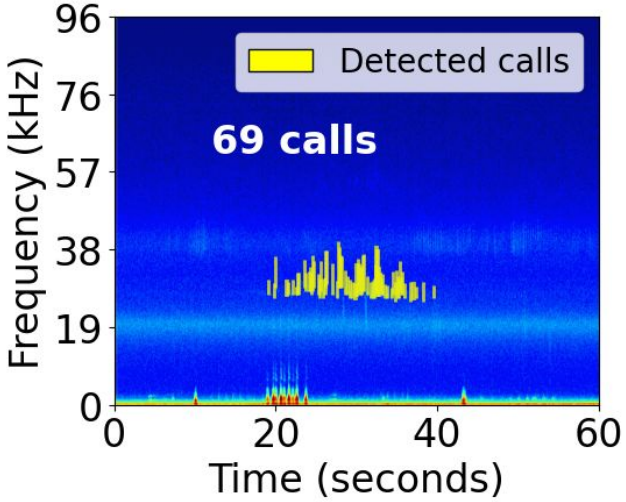

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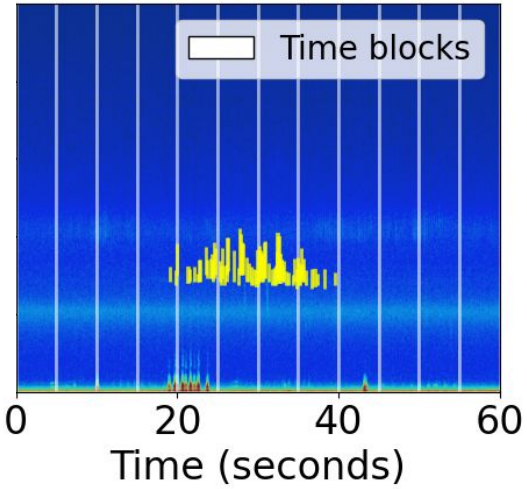

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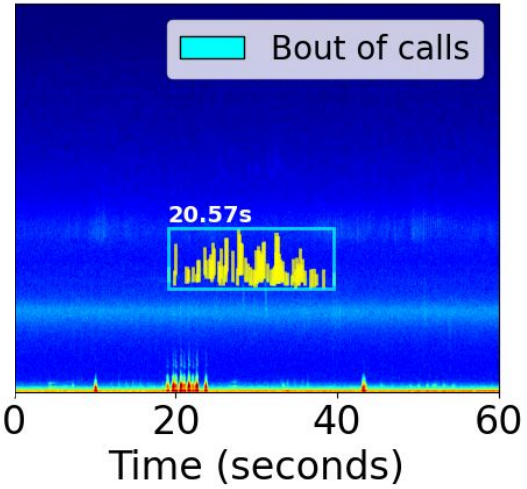
(3) Bout-Time Percentage (Slater and Lester, 1982)



20.57s of bout in 60s

How to measure activity using bat search calls?

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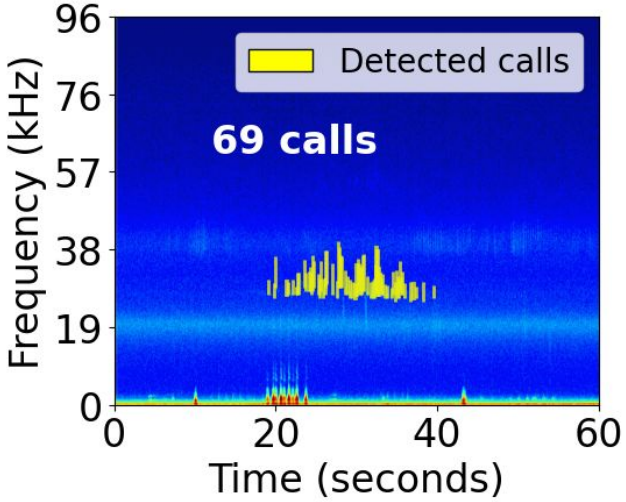

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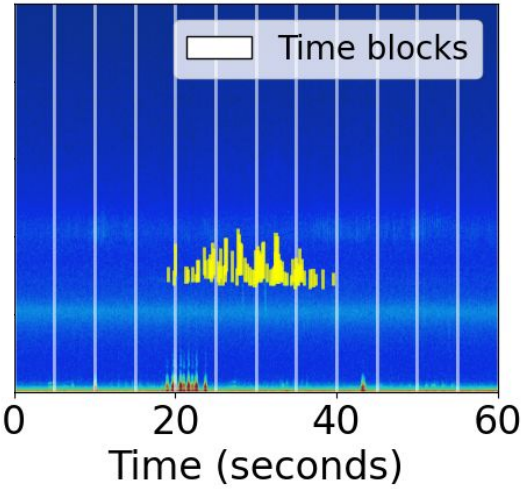

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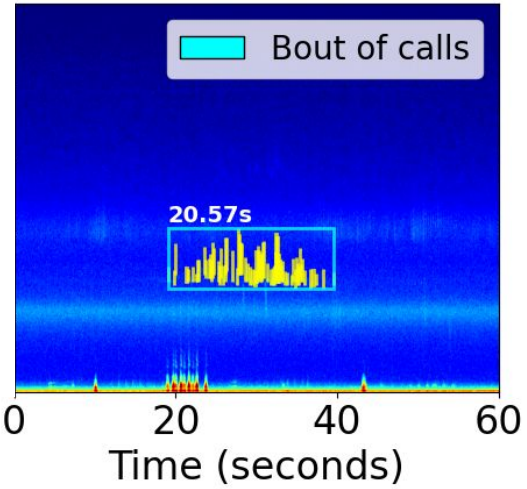

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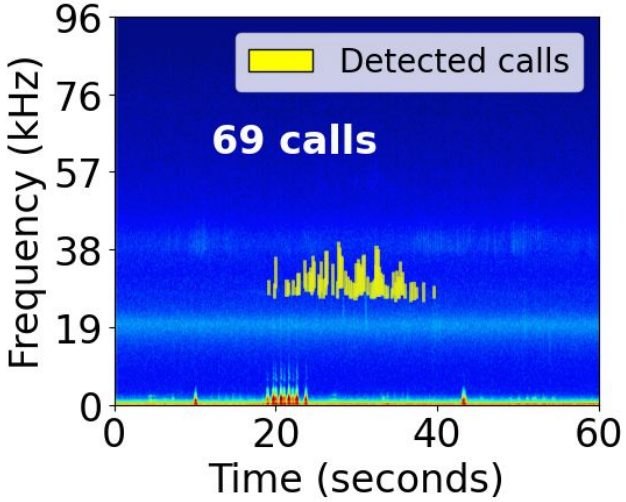

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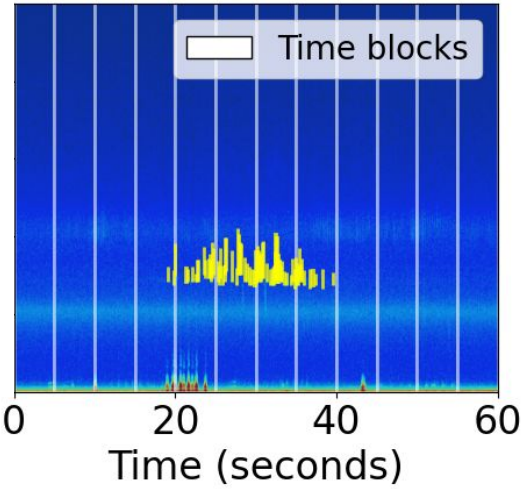

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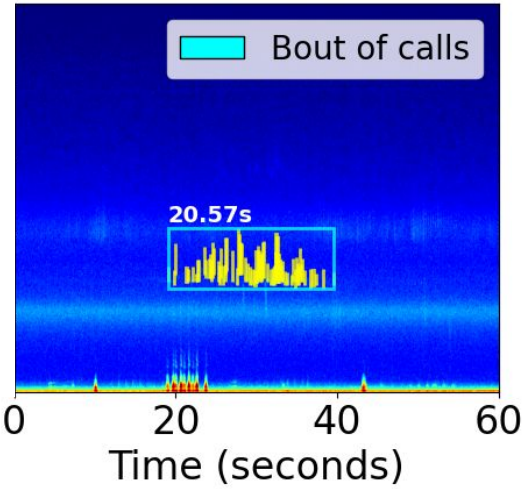

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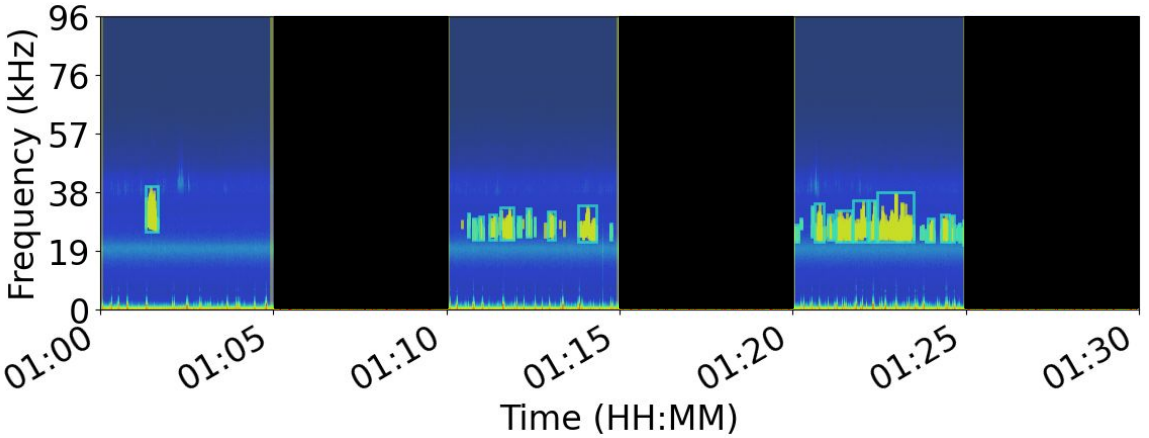
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling



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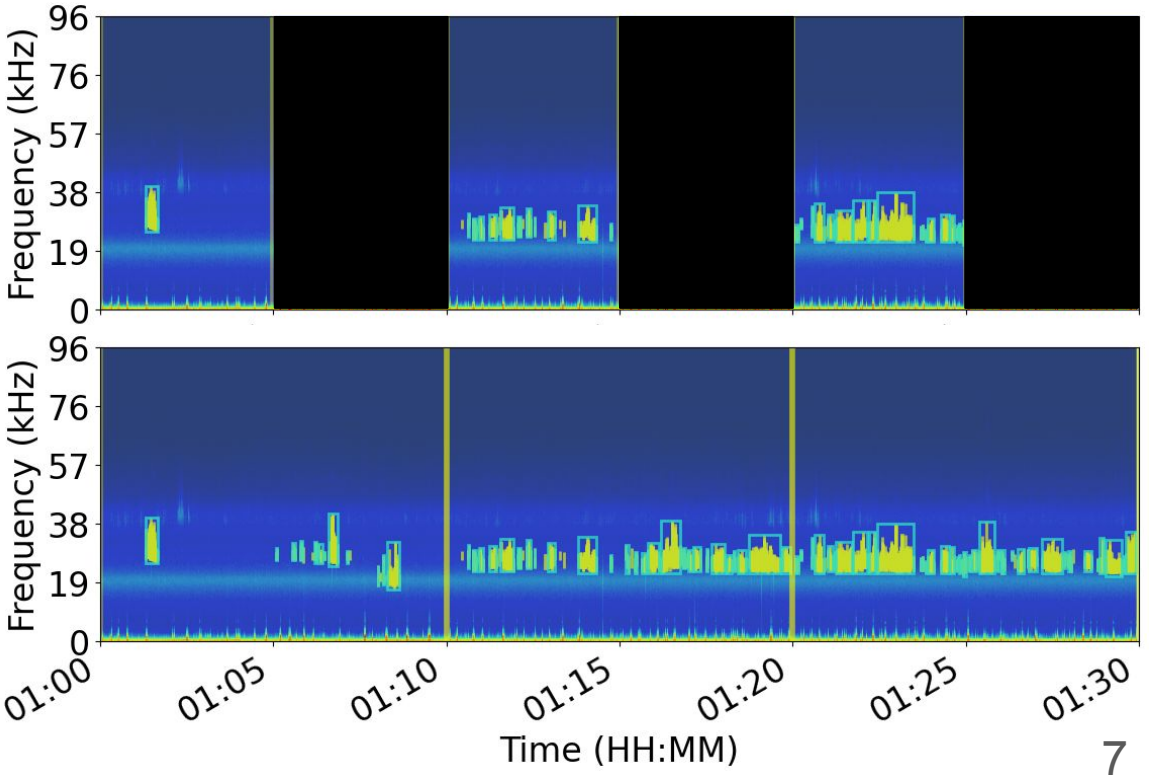

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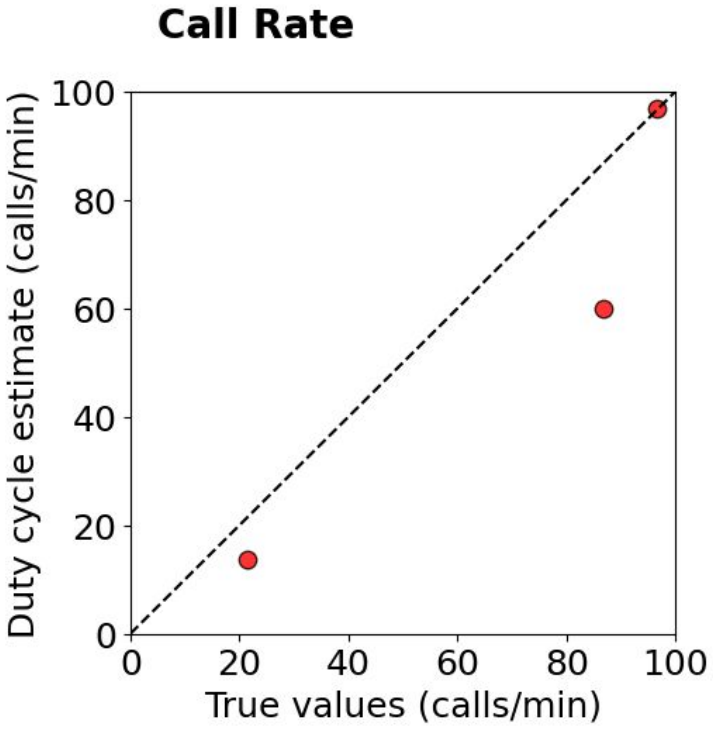

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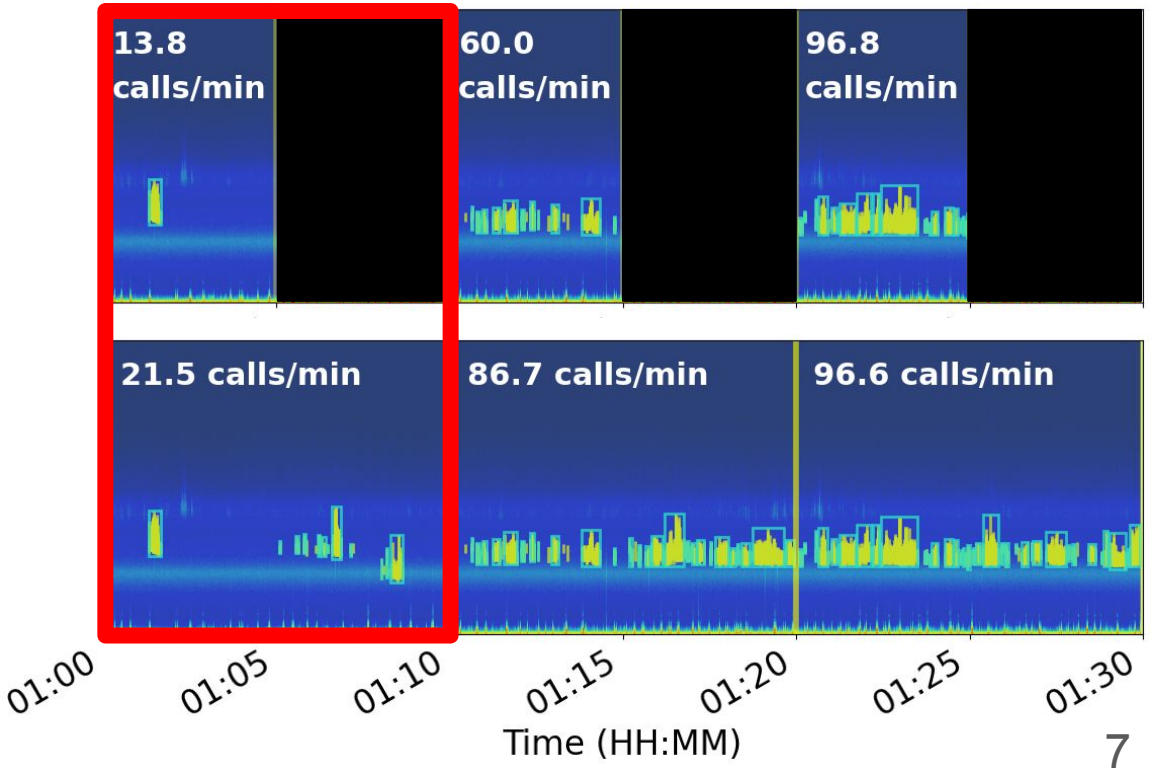

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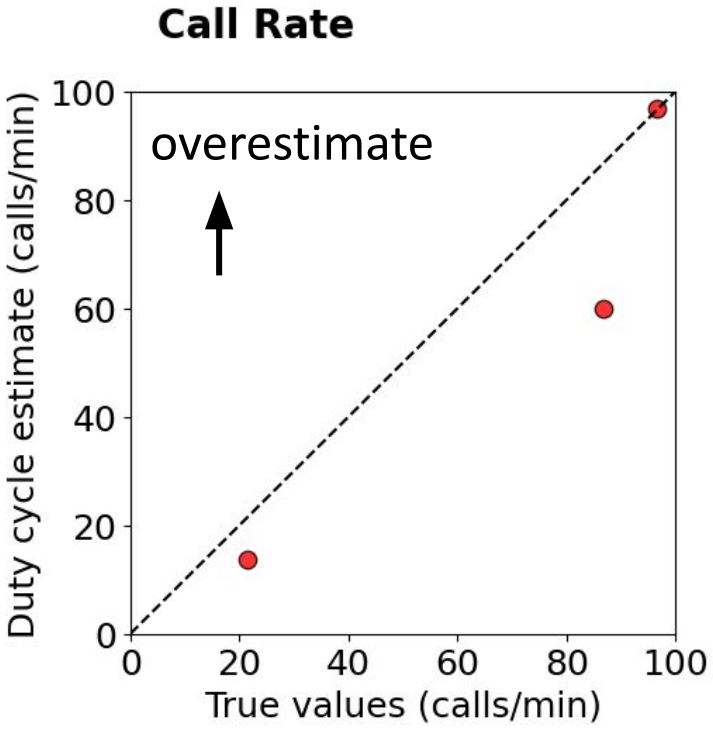

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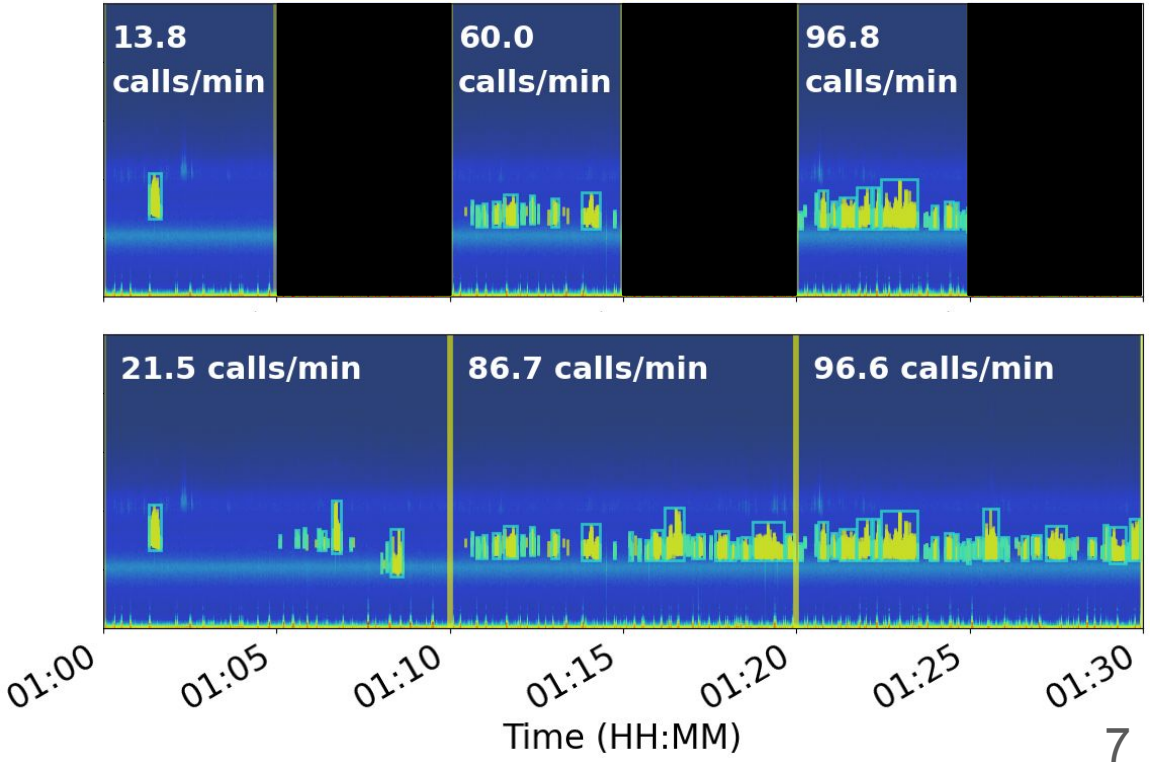

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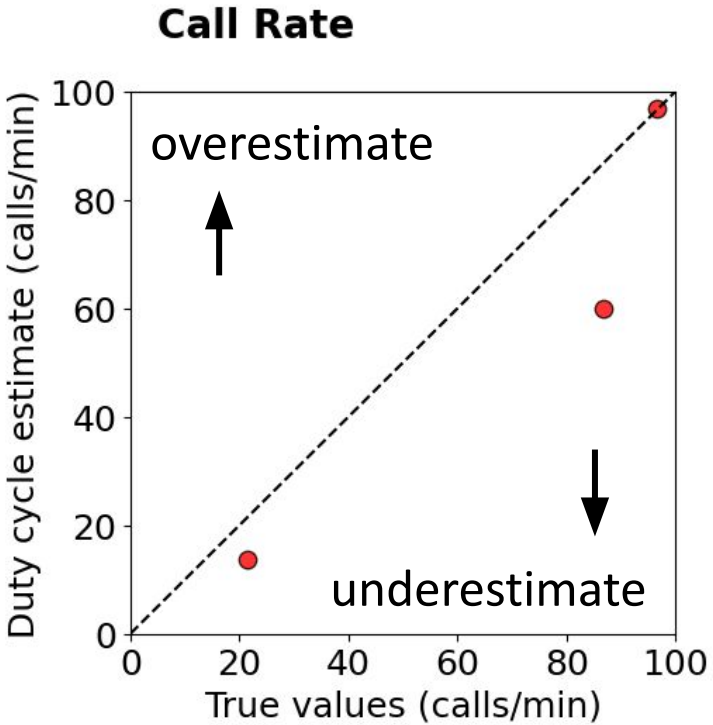

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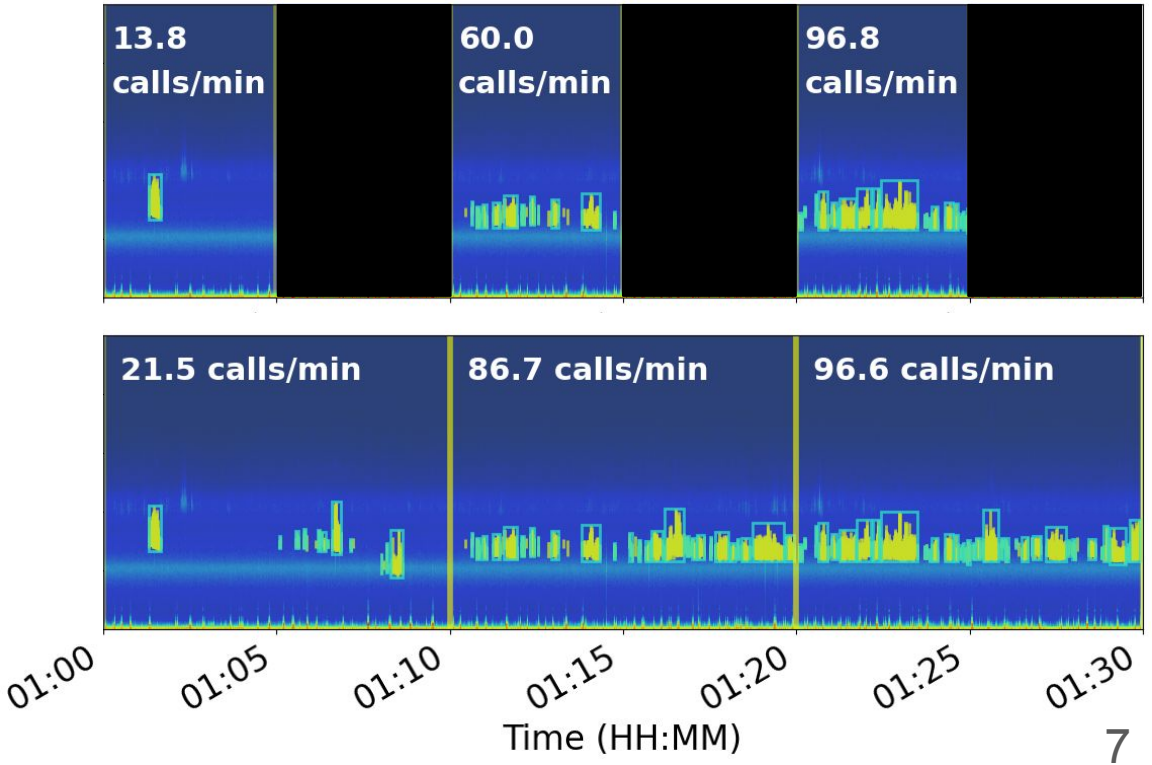

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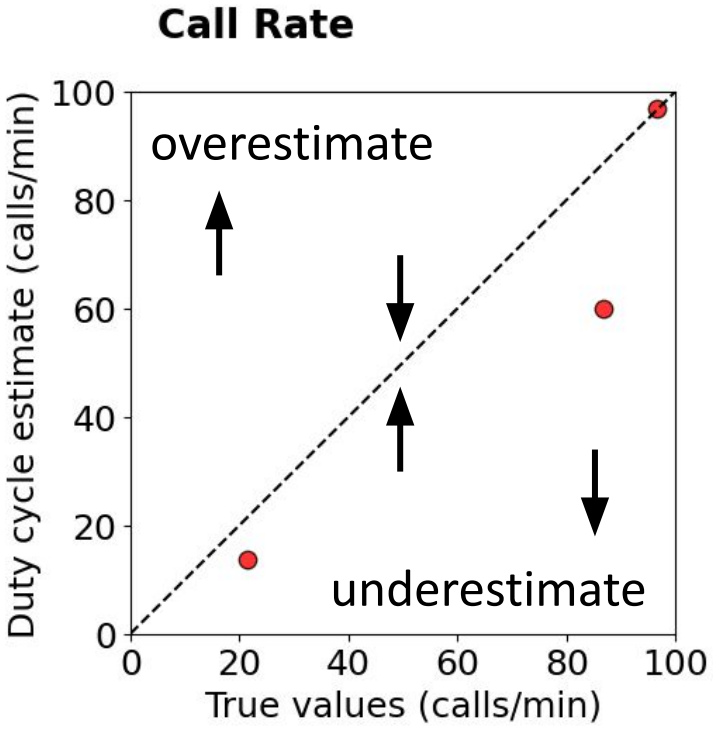

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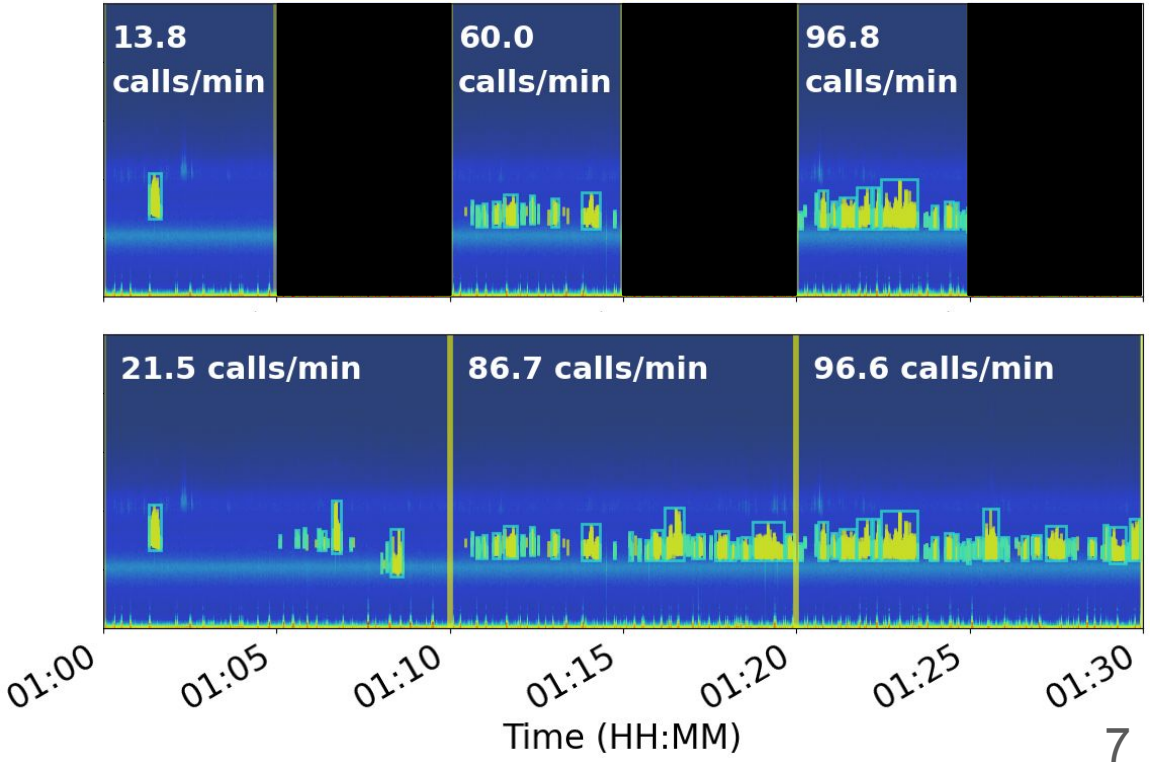
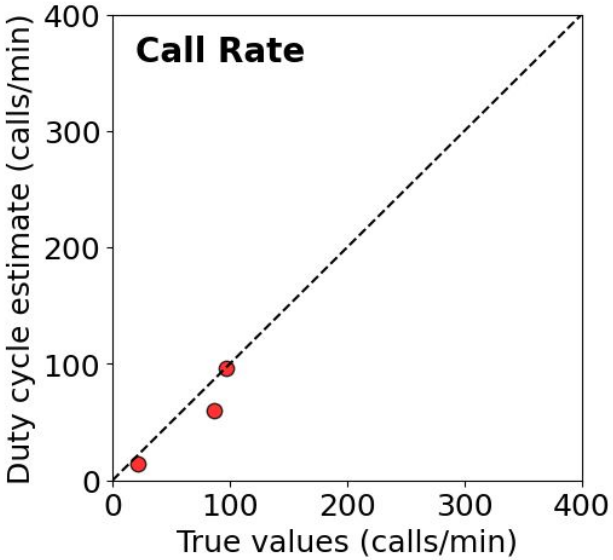
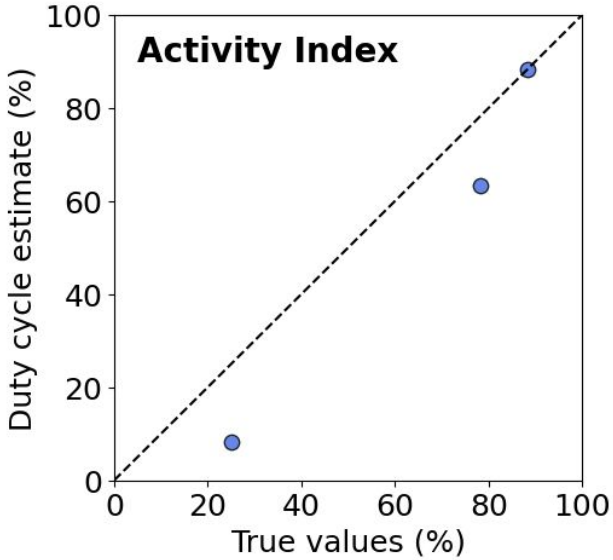


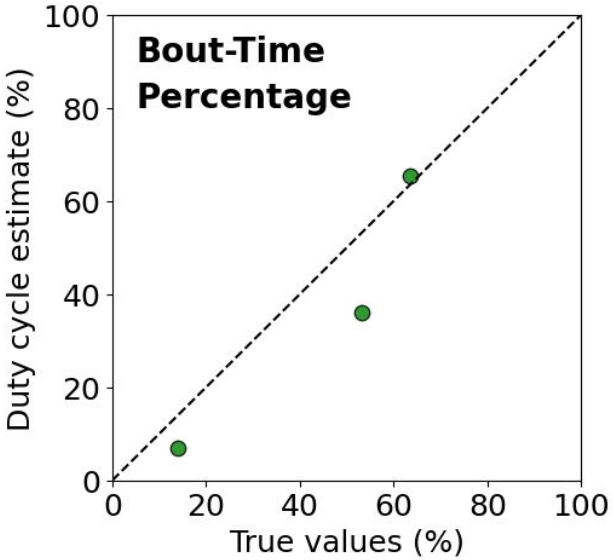
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 file







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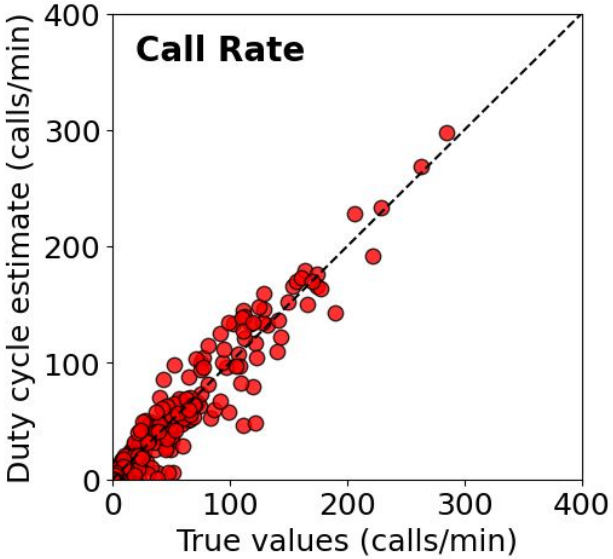
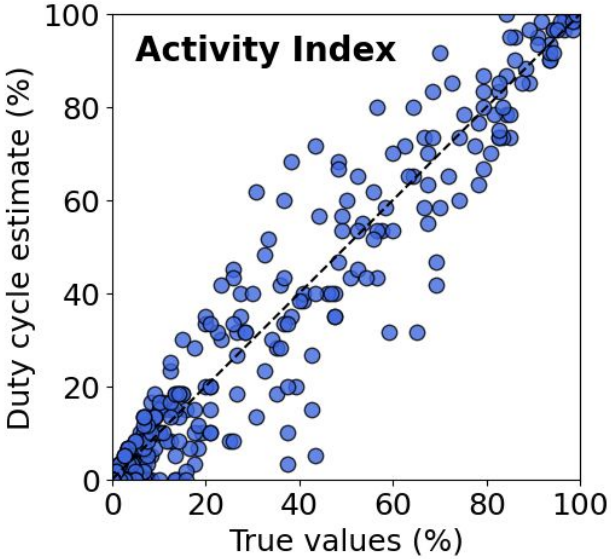
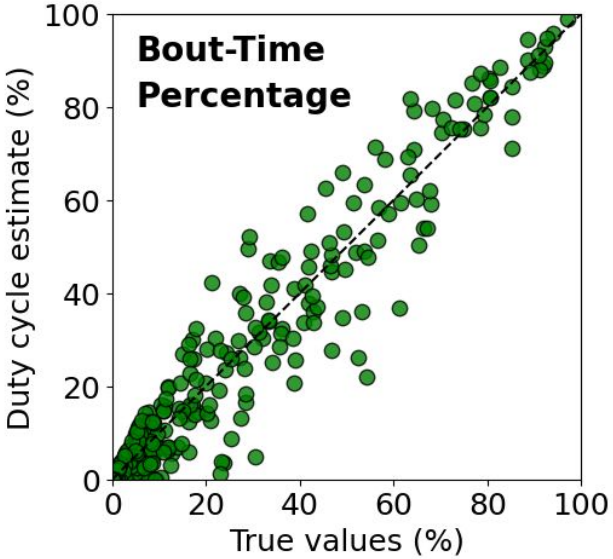
Evaluating 5 min ON every 10 min duty-cycling

1 week



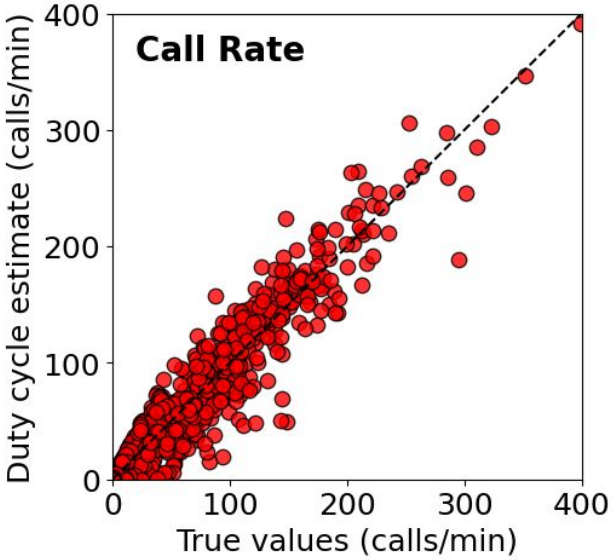


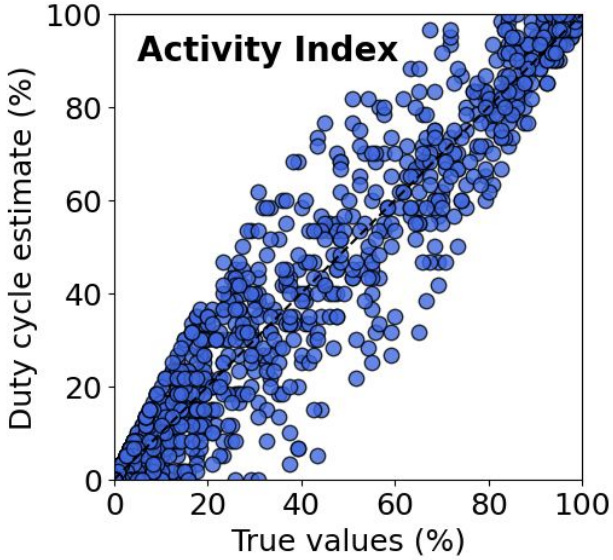


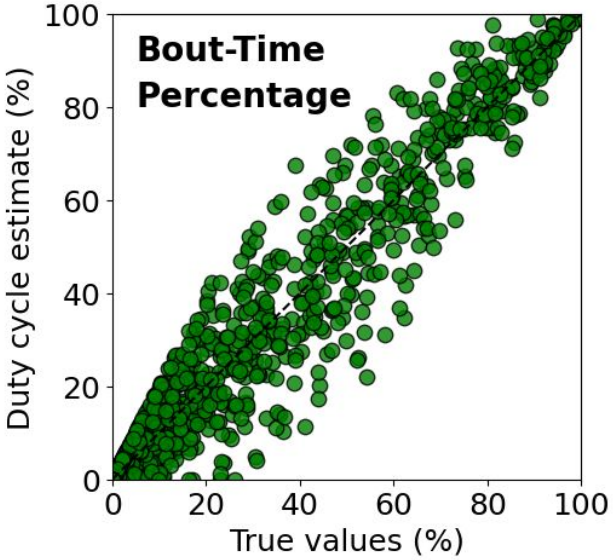
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 month



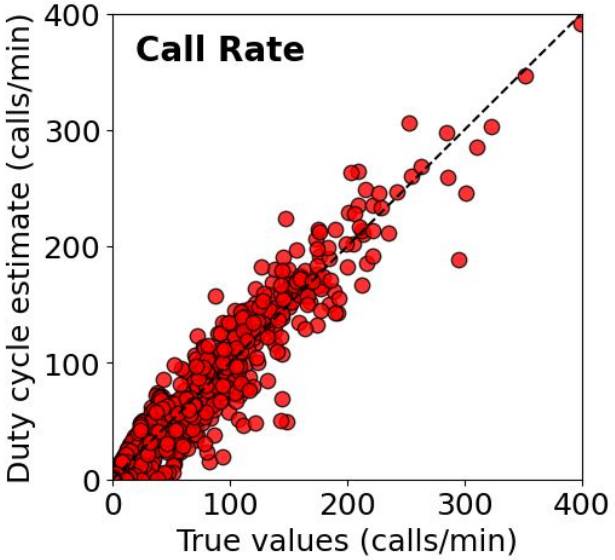


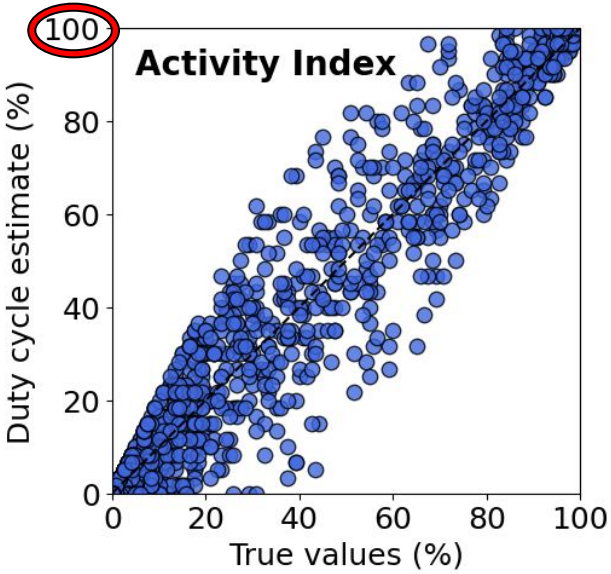


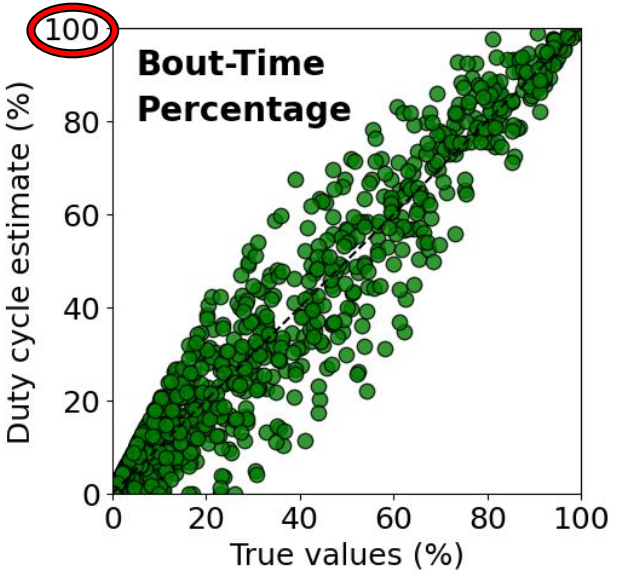
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 month





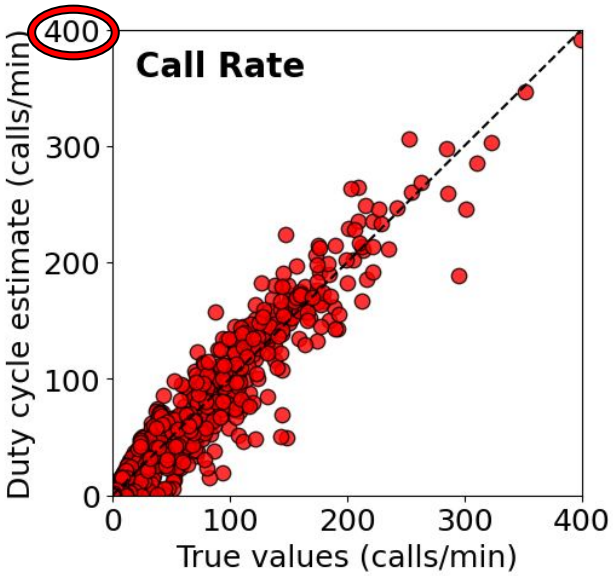


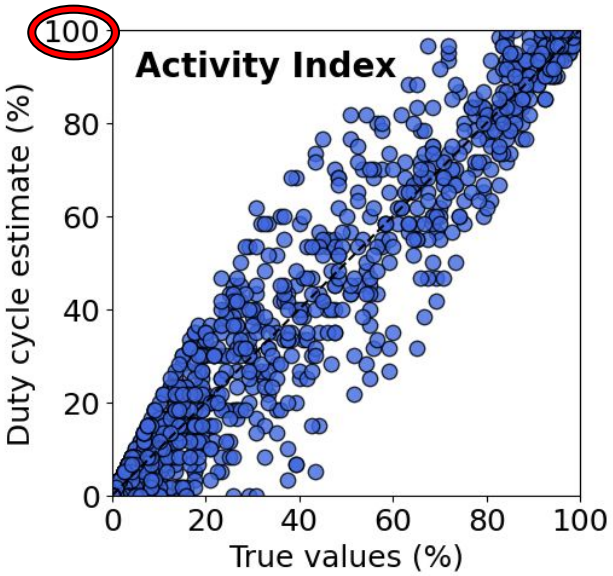
- Relative metrics

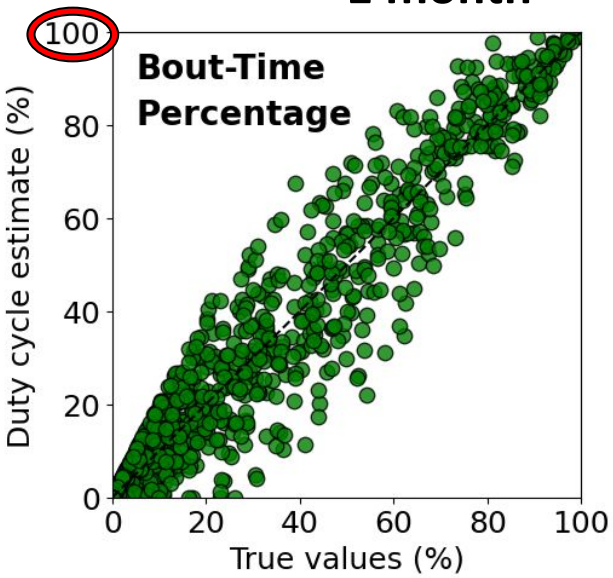
How we evaluated the effects of duty-cycling

Evaluating 5 min ON every 10 min duty-cycling

1 month



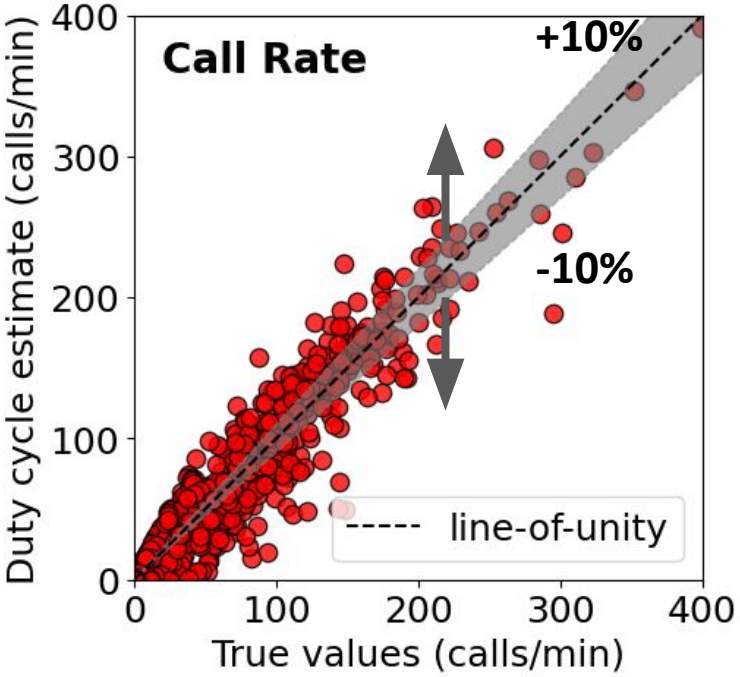


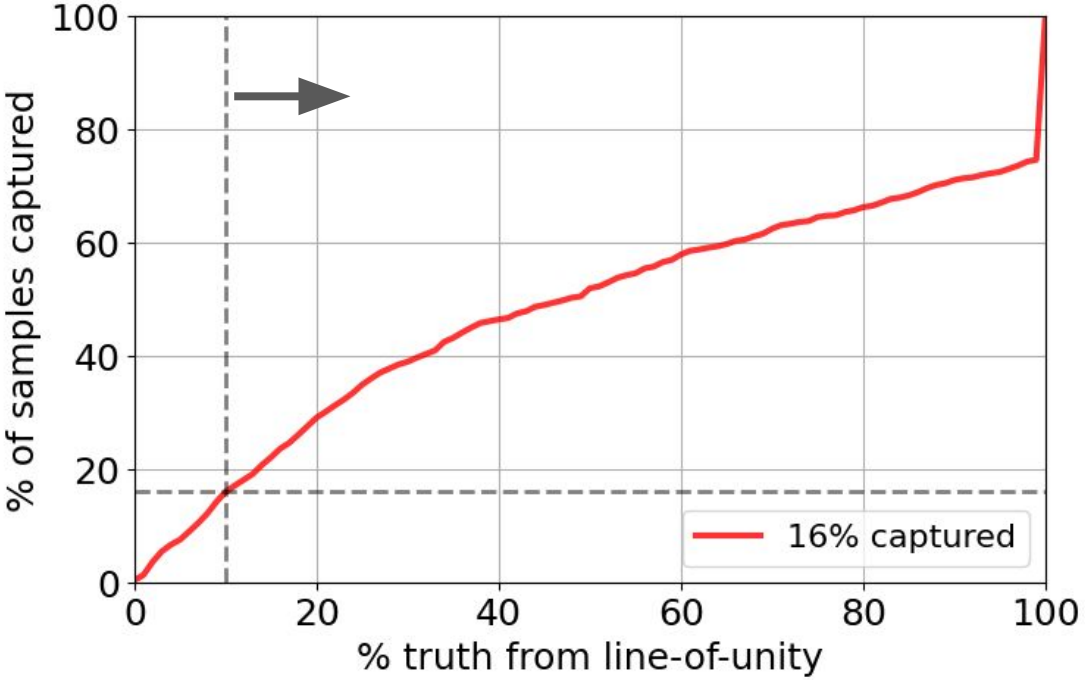


- Absolute metric
- Relative metrics

Summarizing the estimation from duty-cycling

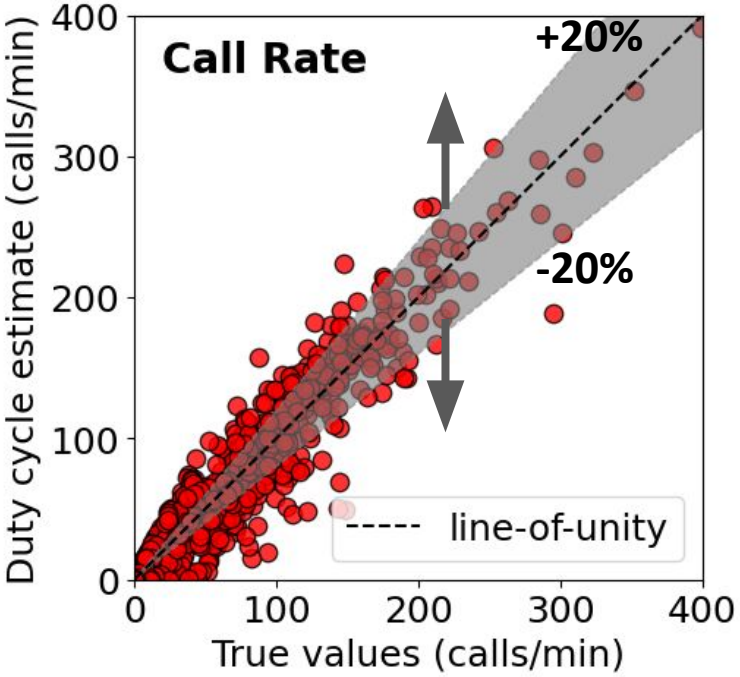
Evaluating 5 min ON every 10 min duty-cycling

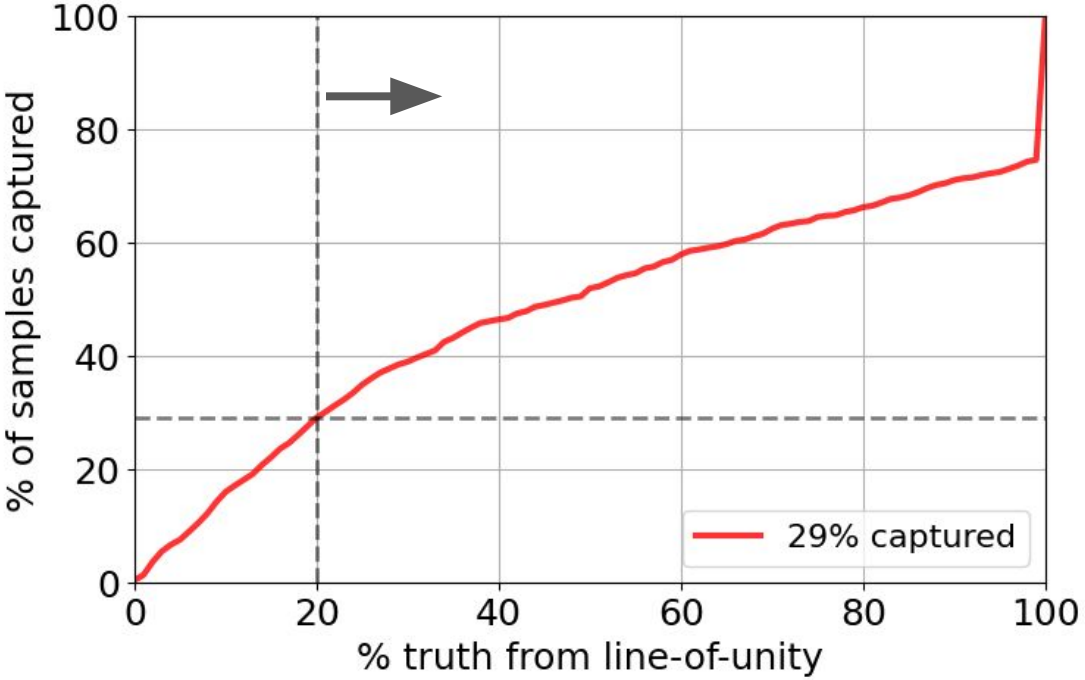




Summarizing the estimation from duty-cycling

Evaluating 5 min ON every 10 min duty-cycling





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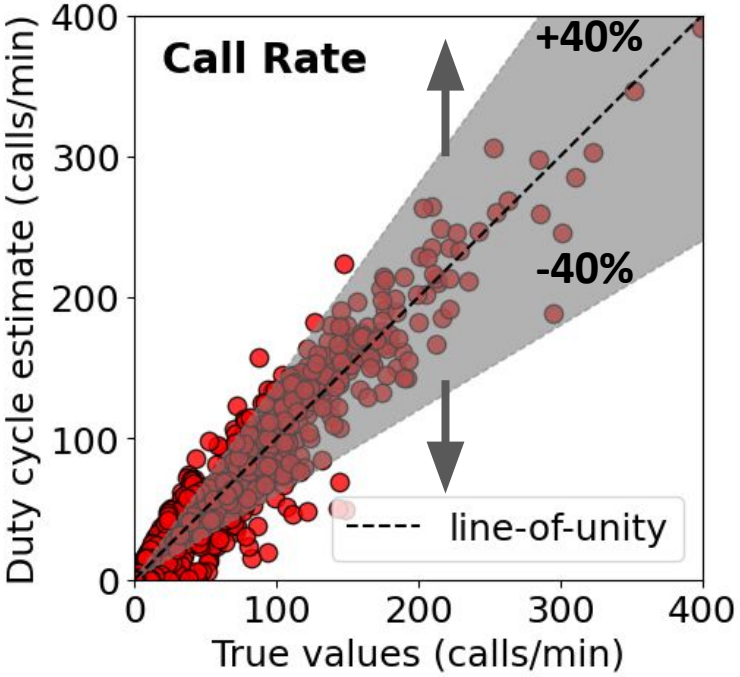
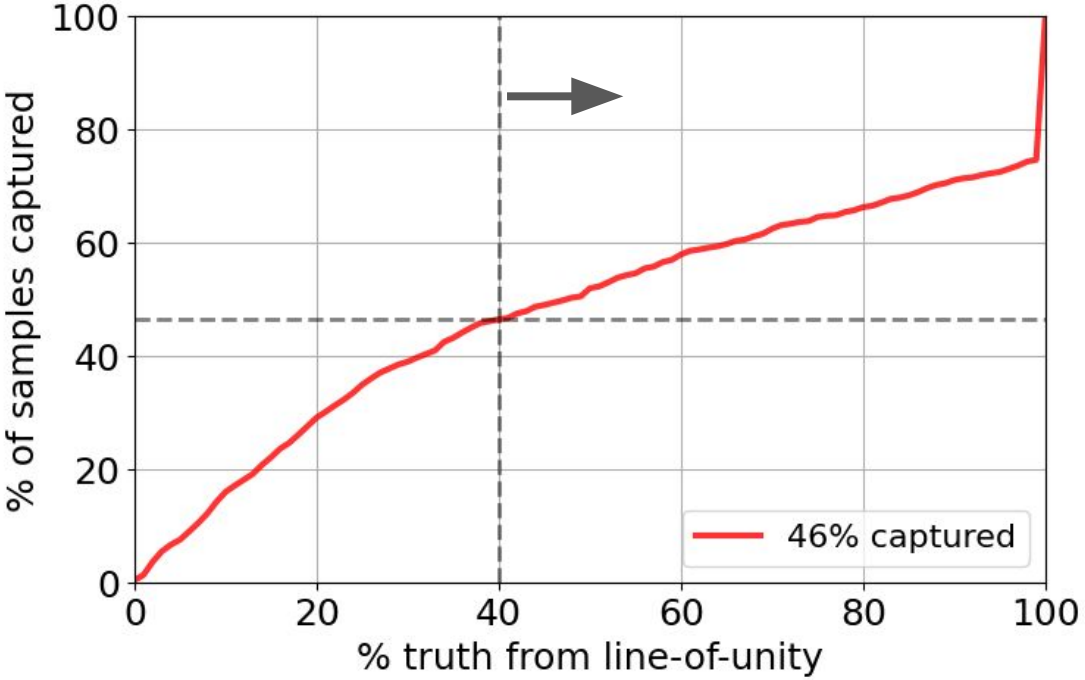
Evaluating 5 min ON every 10 min duty-cycling





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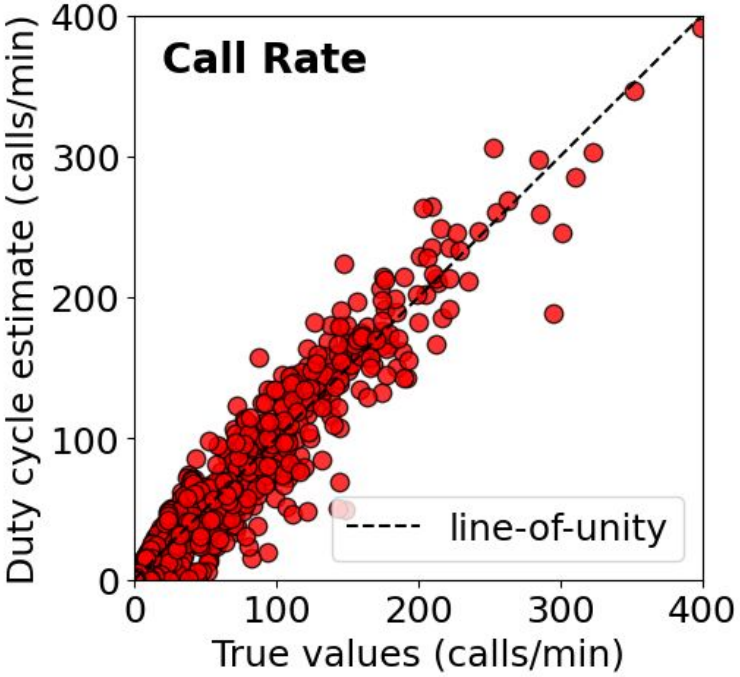
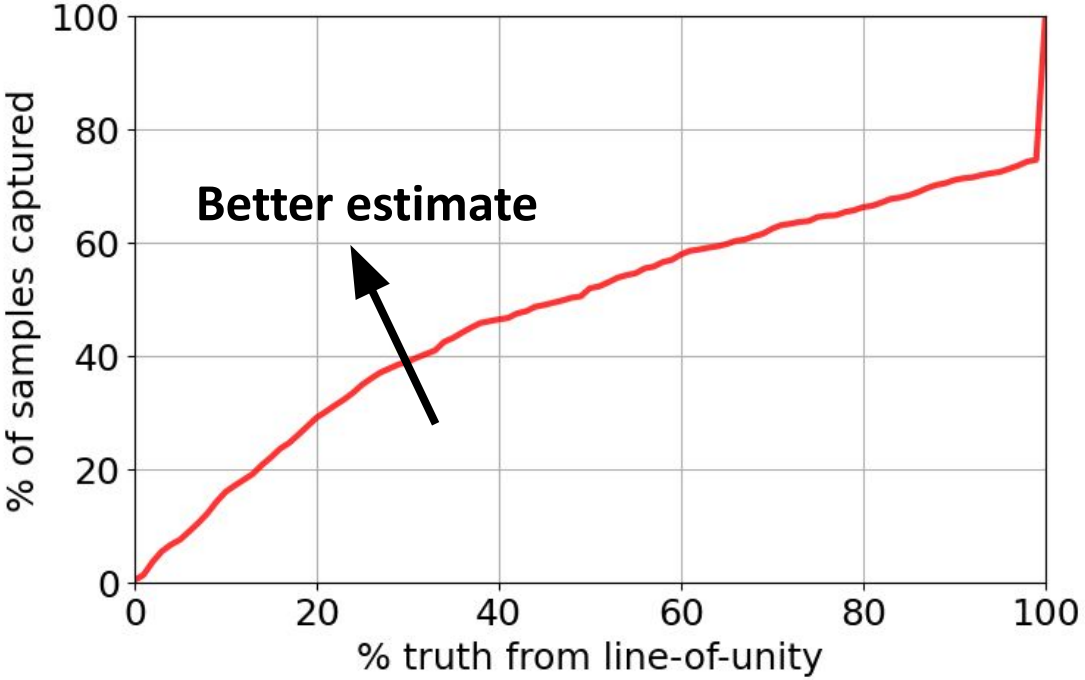
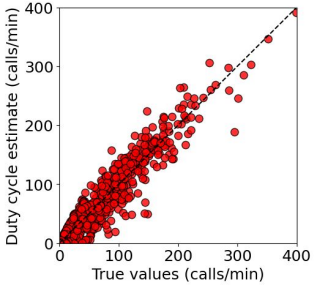


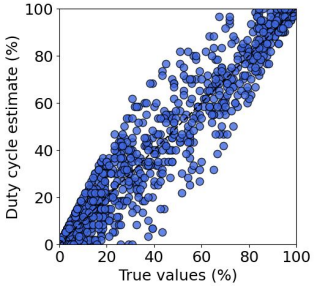


How each metric responds to duty-cycling

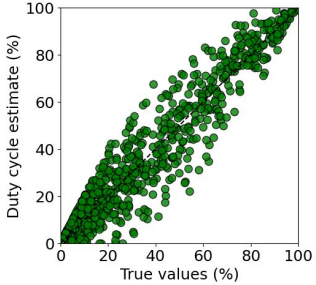
Call Rate



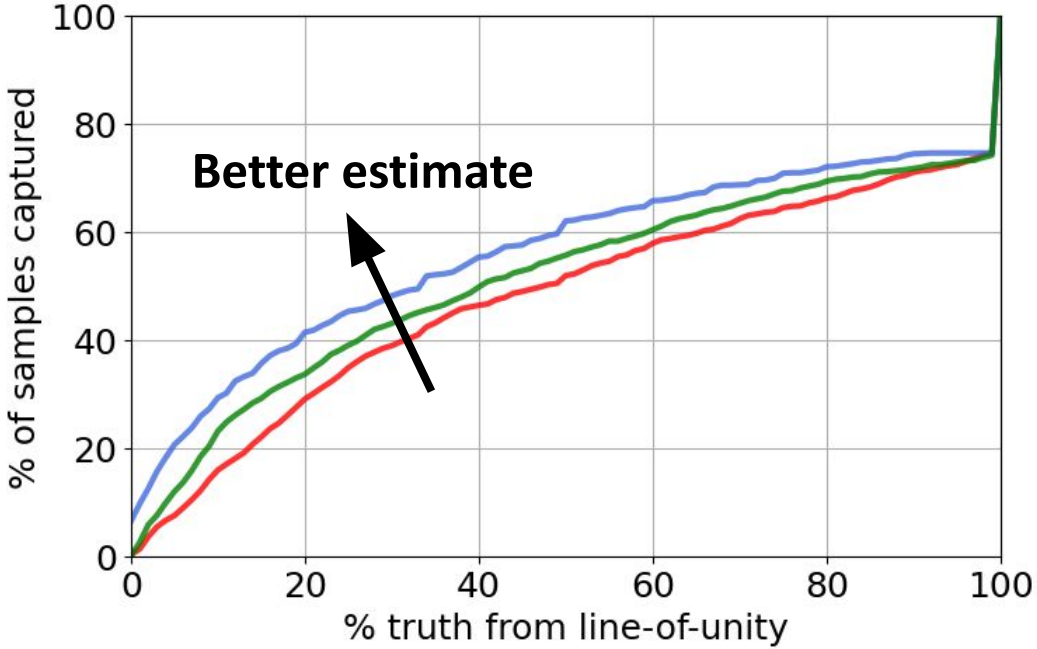
Activity Index



Bout-Time Percentage



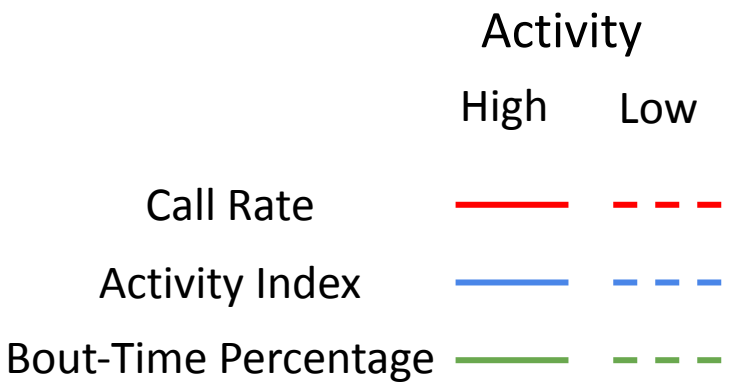
Evaluating 5 min ON every 10 min duty-cycling



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

Estimates are closer to truth when activity is high

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



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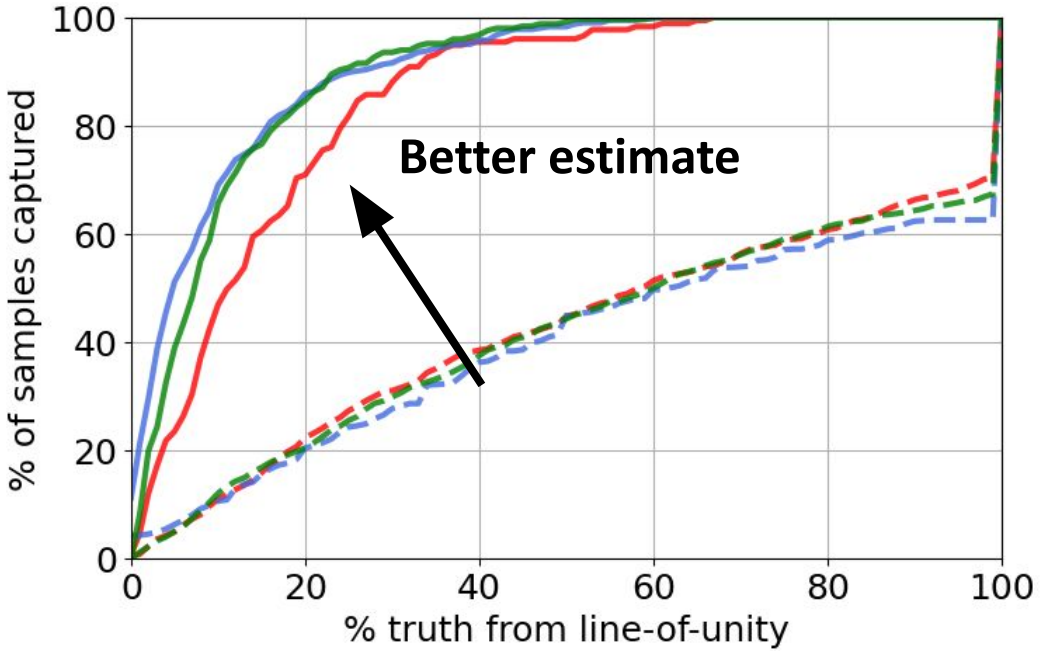
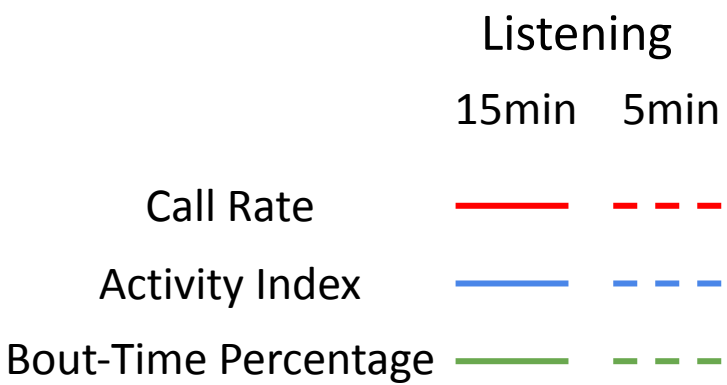
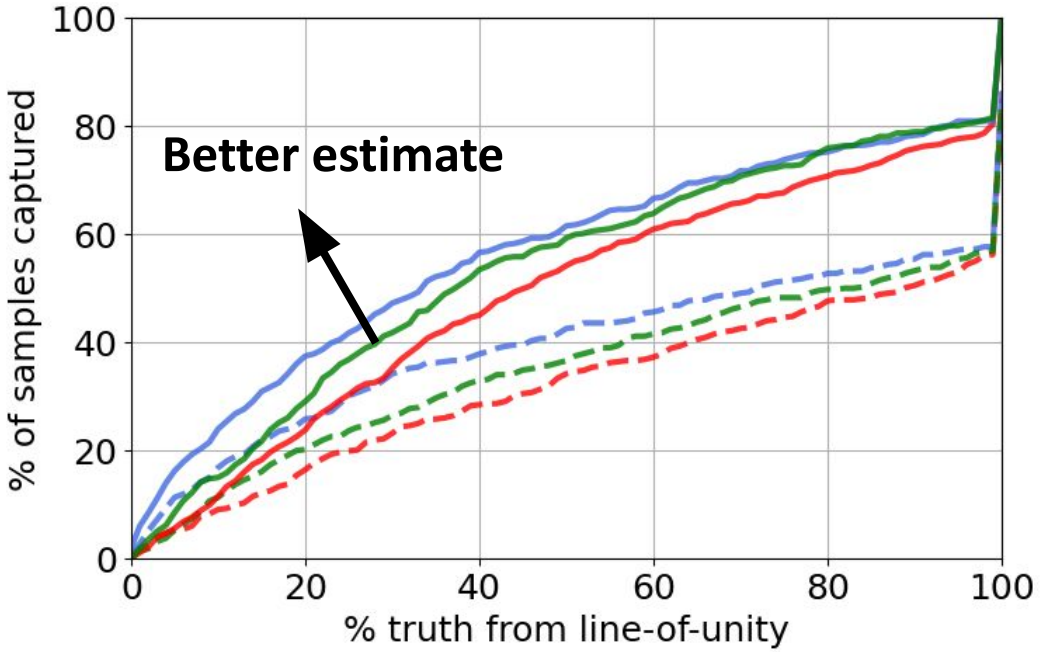


Increasing listening ratio with fixed cycle length improves activity estimates

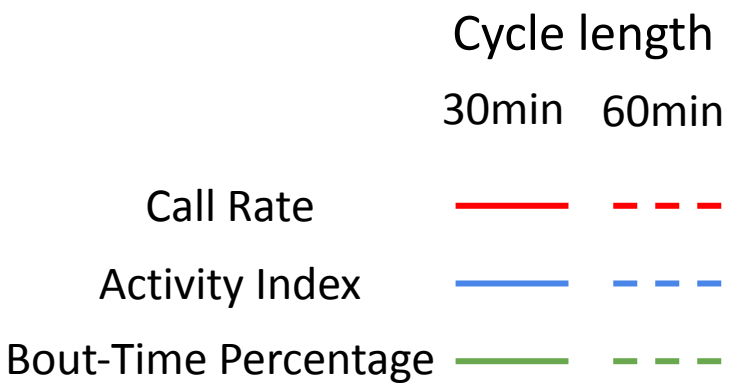
Fixed cycle length of 30 min

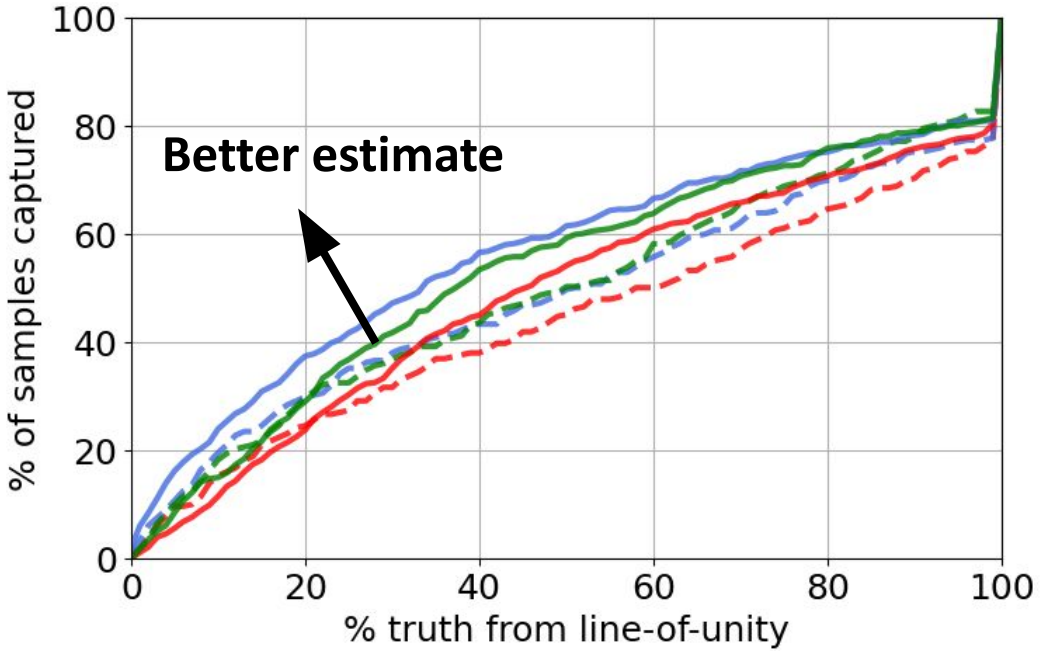




Decreasing cycle length with fixed listening ratio improves activity estimates

Fixed listening ratio of ½





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
4. **Keeping cycle length low** when duty-cycling

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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

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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

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- Looking into species-specific duty-cycling

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

Acknowledgements

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Varun Krishnakumar

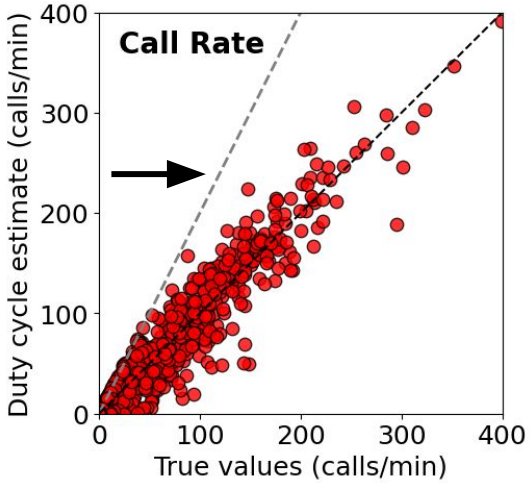
Automated call detection

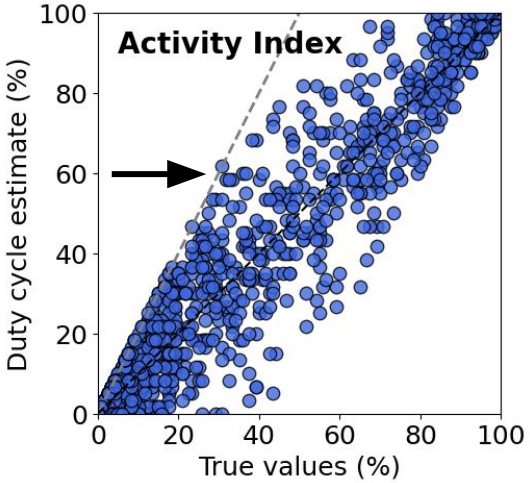
- **Corbin Charpentier**
- **Kirsteen Ng**
- **Ernesto Cediel**

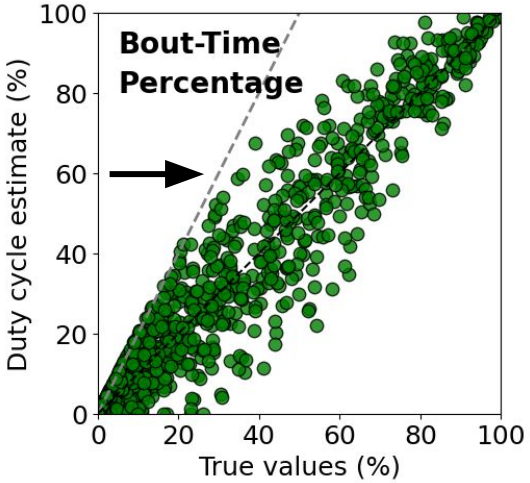
MARY GATES ENDOWMENT FOR STUDENTS

Defining traits for each metric using duty-cycles

Evaluating 5 min ON every 10 min duty-cycling







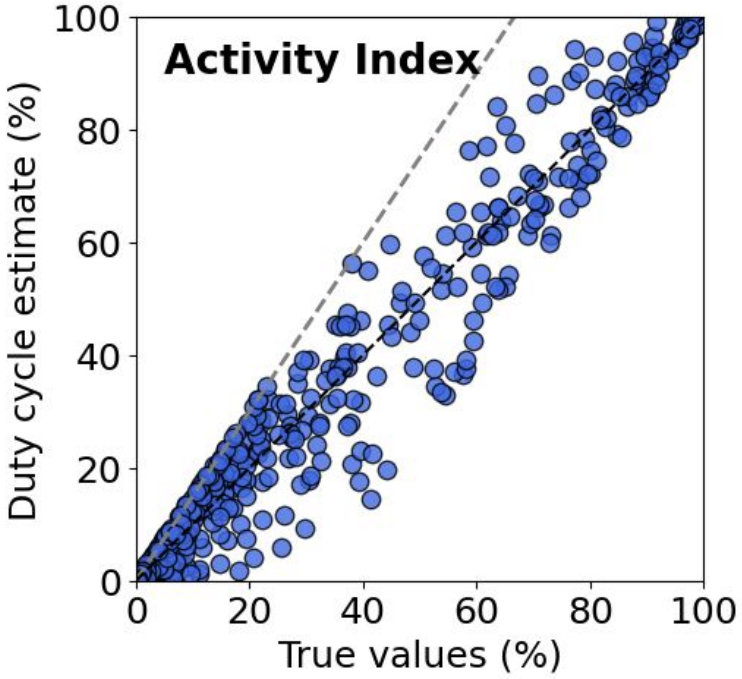
- Overestimate bound

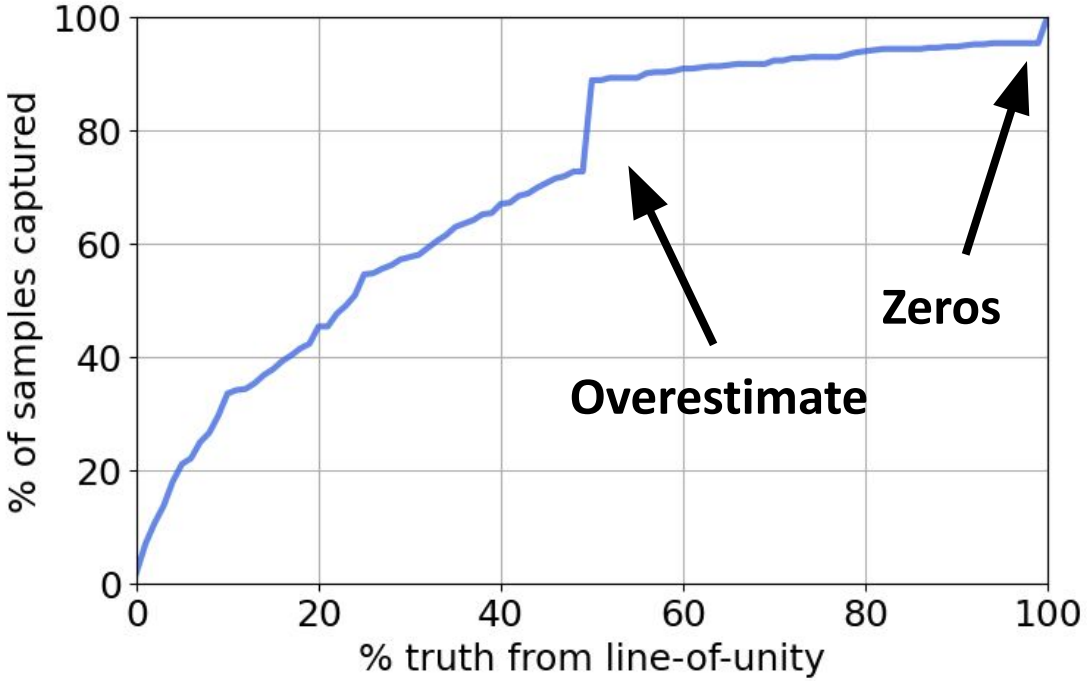
- Listening for 10 min vs. 5 min
- 2x increase in call rate
- Same can be applied for other metrics

BACKUP

Summarizing the estimation from duty-cycling

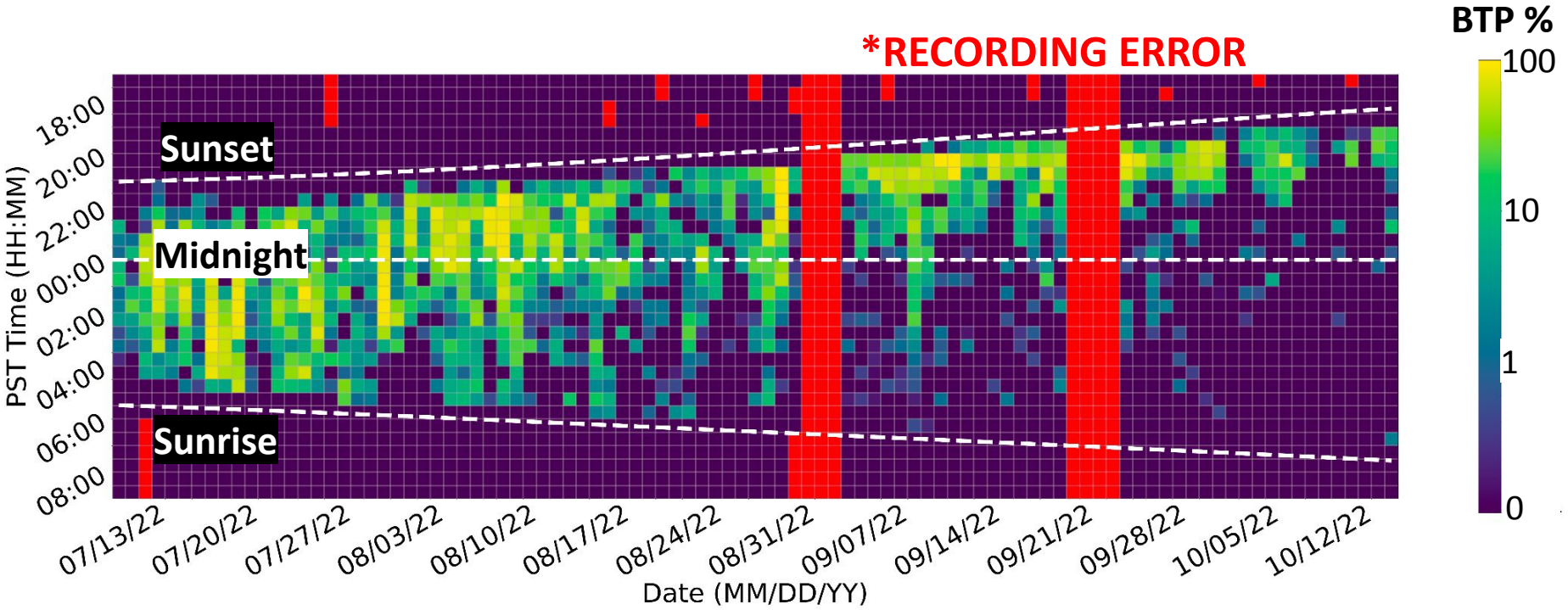
Evaluating 20 min ON every 30 min duty-cycling





BACKUP

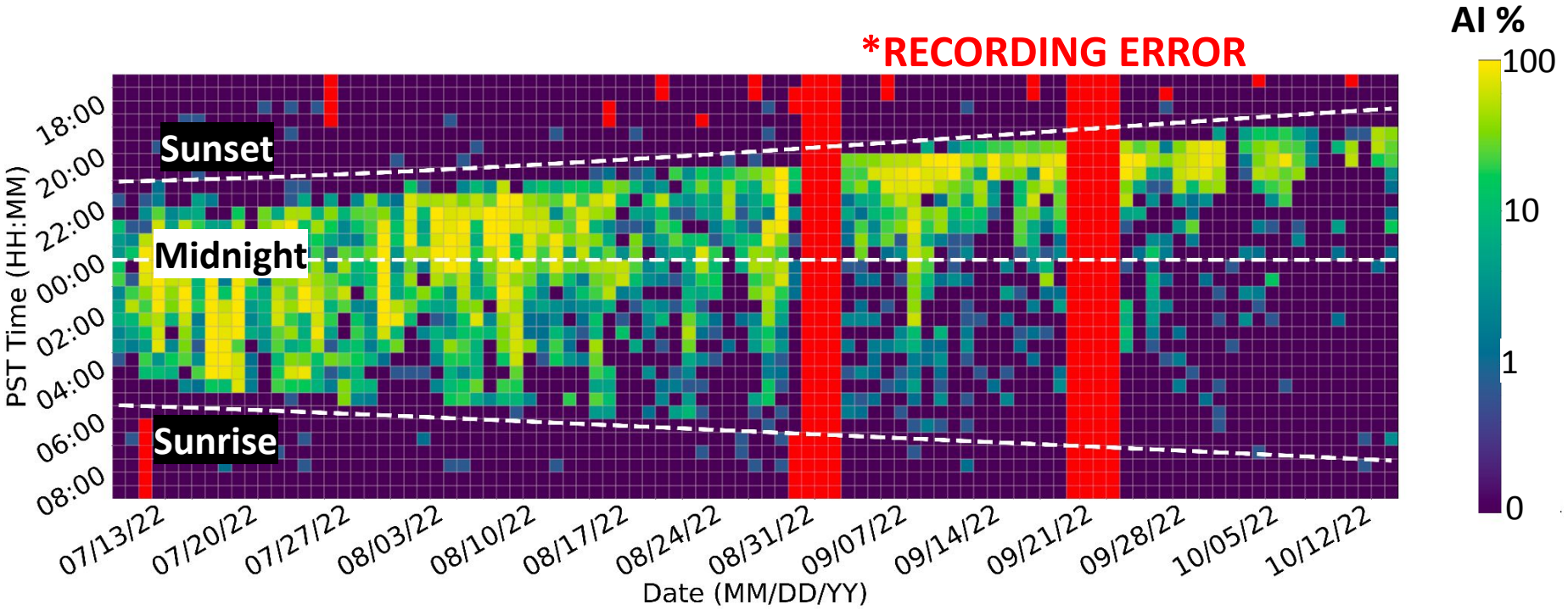
Activity using the BTP metric with 5/10 scheme



- Conserved the activity observed previously

BACKUP

Activity using the AI metric with 5/10 scheme



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