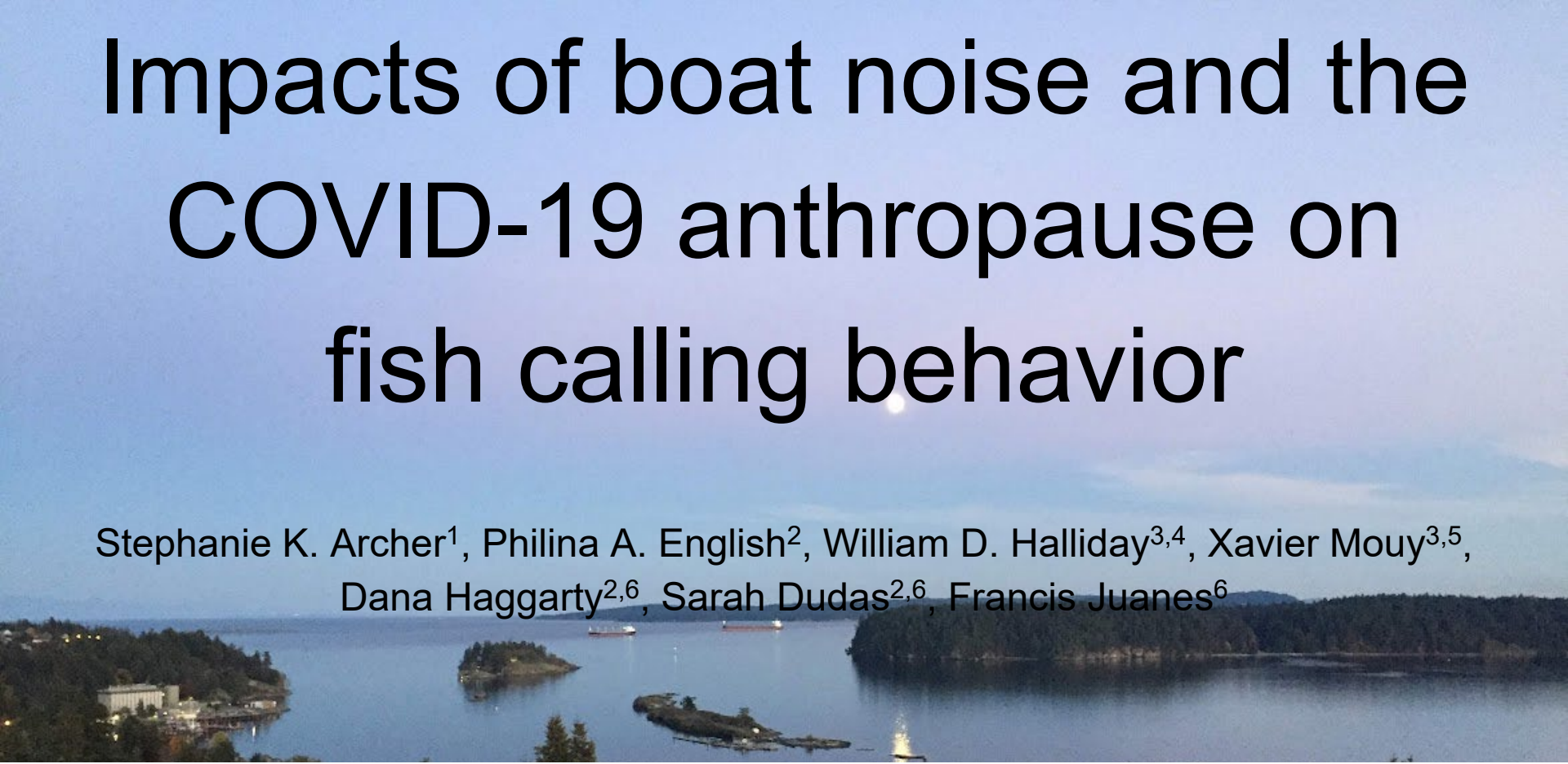
Impacts of boat noise and the COVID-19 anthropause on fish calling behavior



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1. Louisiana Universities Marine Consortium; 2. Pacific Biological Station, Fisheries and Oceans Canada; 3. School of Earth and Ocean Sciences, University of Victoria 4. Wildlife Conservation Society Canada; 5. Integrated Statistics, Inc., under contract to NOAA, NMFS; 6. Department of Biology, University of Victoria

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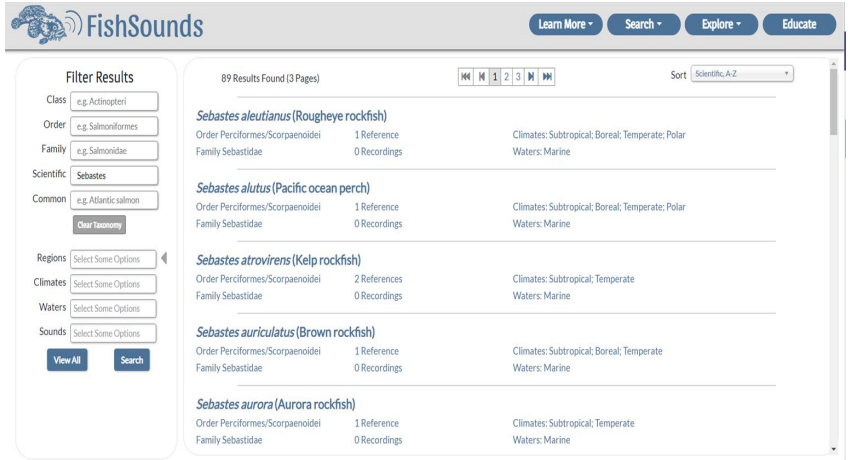
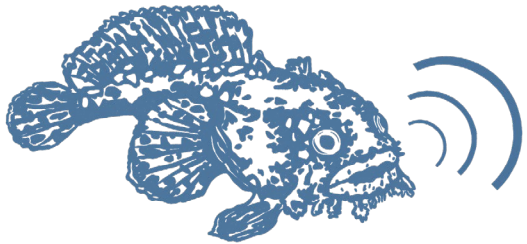
Fishes Use Sound

- At least 989 fish species from 133 families produce intentional sounds
- 61 species of Rockfishes listed on the Fish Sounds Educate website
  - https://fishsounds.net/index.js
- Fish use sound to
  - Attract/assess mates
  - Establish dominance/territorial boundaries
  - Convey distress/alarm
  - Assess habitats

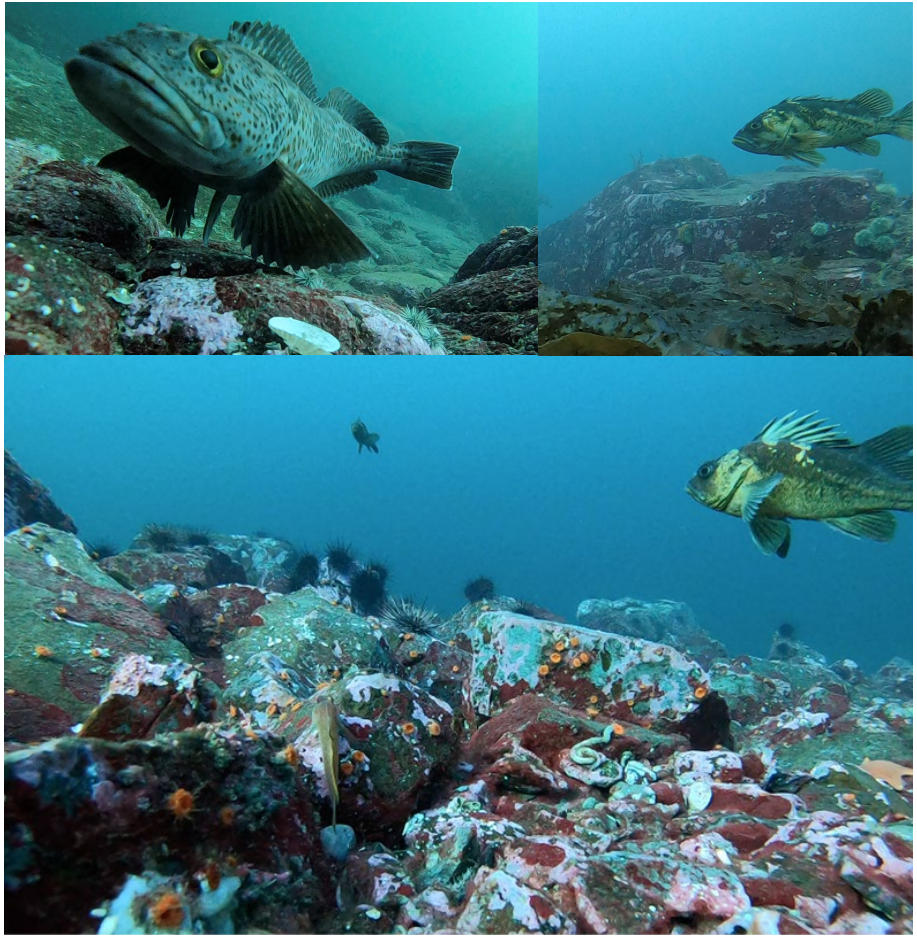




Looby, et al. 2022. *Reviews in Fish Biology and Fisheries* 32: 581–595. https://doi.org/10.1007/s11160-022-09702-1.

Fishes use sound

- Fish calls are species-specific
- Recent and ongoing work is building a library of species-specific fish calls in the Northeast Pacific
- Recorded and Identified Calls of
  - Quillback and Copper Rockfishes
  - Lingcod
  - Black-eye Gobies
- Collecting data on more species of rockfishes



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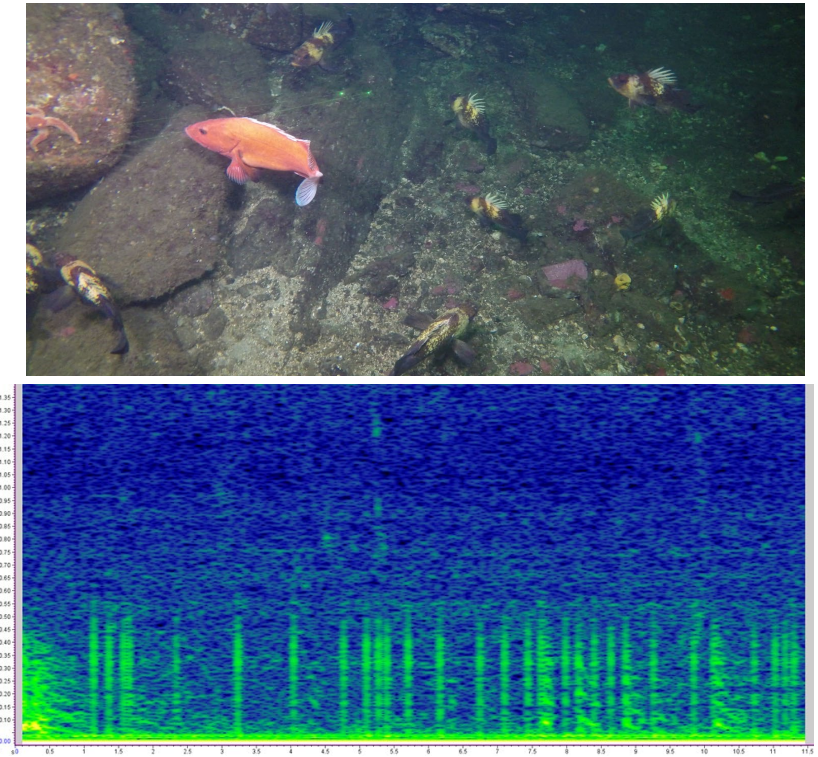
Passive Acoustic Monitoring of Fishes in BC

- Goal to estimate relative abundance from call frequency, i.e., use PAM in monitoring.
- Lots of questions to answer first:
  - Detection?
  - What species are making sounds?
  - How often do they call? Is this modified by conspecific density?
  - When are they calling? Seasonal, diurnal patterns?
- How how does anthropogenic noise (including boat noise) impact calling rates?



Fish calls from Northumberland Channel RCA

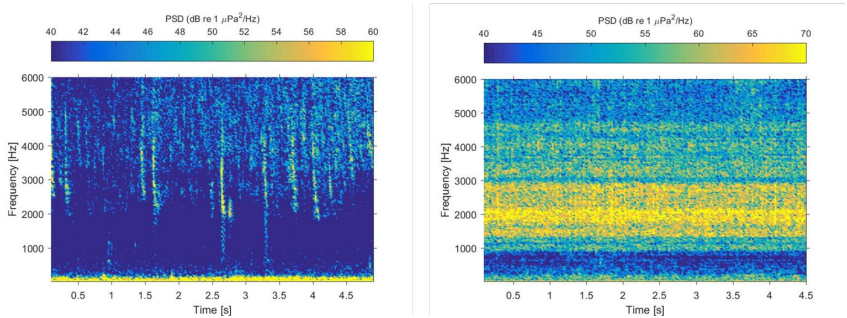
Anthropogenic Noise and Fishes

- Meta analysis: Negative effects of noise were consistently observed on some aspects of fish behavior and physiology
  - Increased movements (predator response), greater nest care, increased stress levels,
  - Decreased foraging behavior
  - Reduced ability to detect sound (increased hearing threshold)
  - 36 of 42 studies included occurred in the lab
- In the presence of noise Plainfin Midshipman reduce calling rate, increase call intensity and lowered the frequency of their calls

Cox et al. 2018. *Global Change Biology* 24: 3105–3116. https://doi.org/10.1111/gcb.14106.; Brown et al. 2021. Animal Behaviour 181: 29–39. https://doi.org/10.1016/j.anbehav.2021.08.025.

We know boat noise is bad

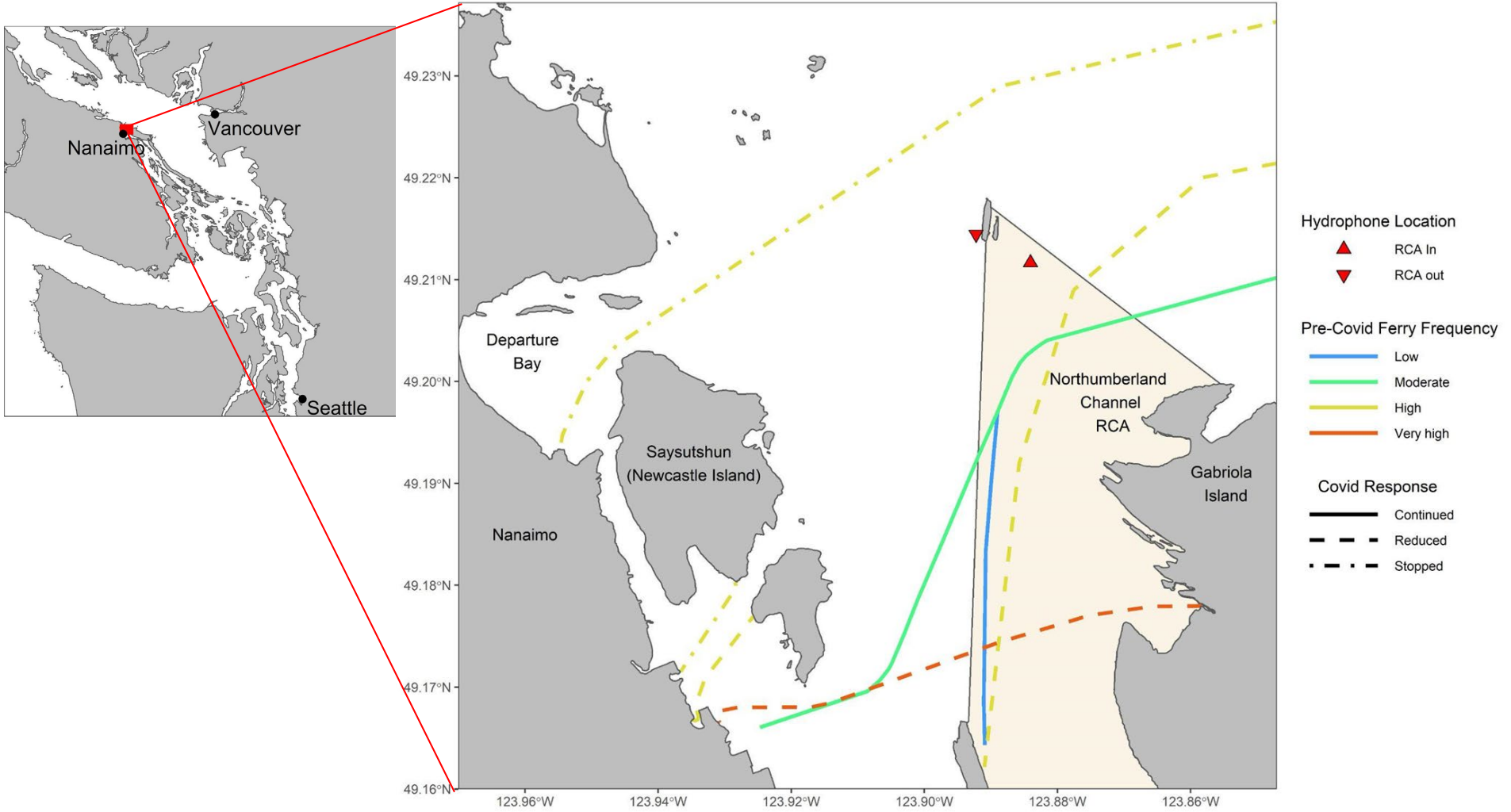
- Many ways boat noise may impact fish calling
  - Call less (change behavior)
  - Masking - when the perception of one sound is impaired by the presence of another
  - Lombardi effect- change calls when noise is present
    - Get louder
    - Change frequency
  - Call rate compensation after noise ceases
- Evidence for all - but mostly from lab play-back experiments
- Key to understand if we hope to estimate relative abundance



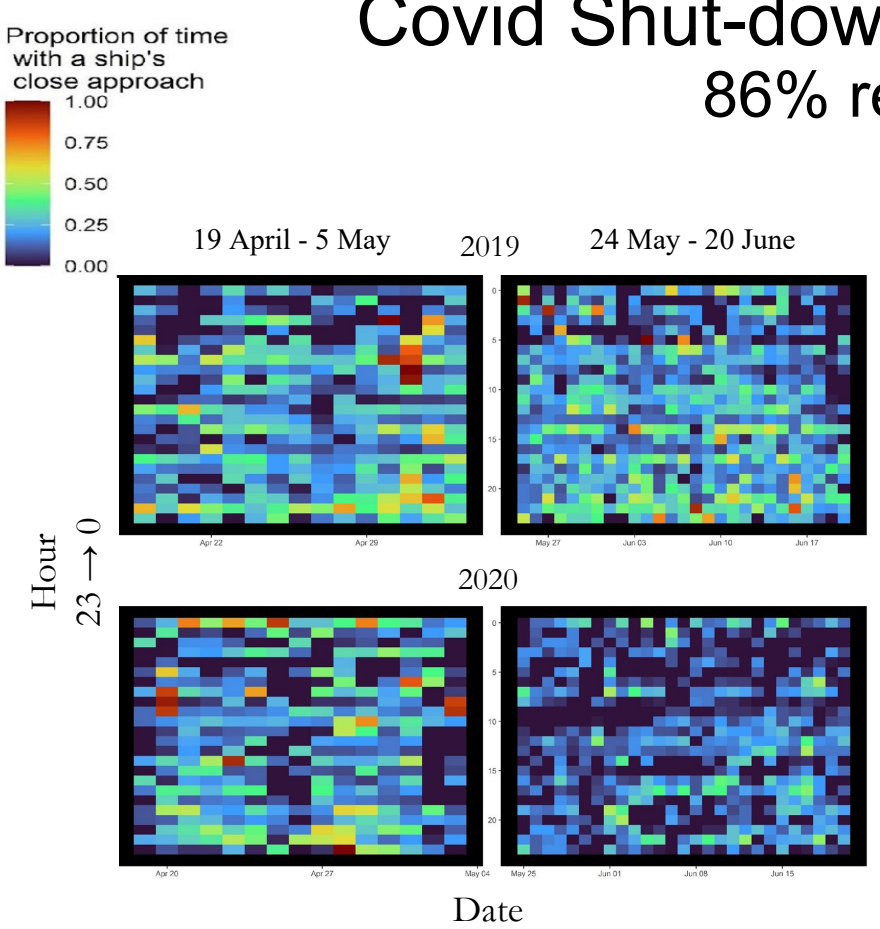
Covid lockdown

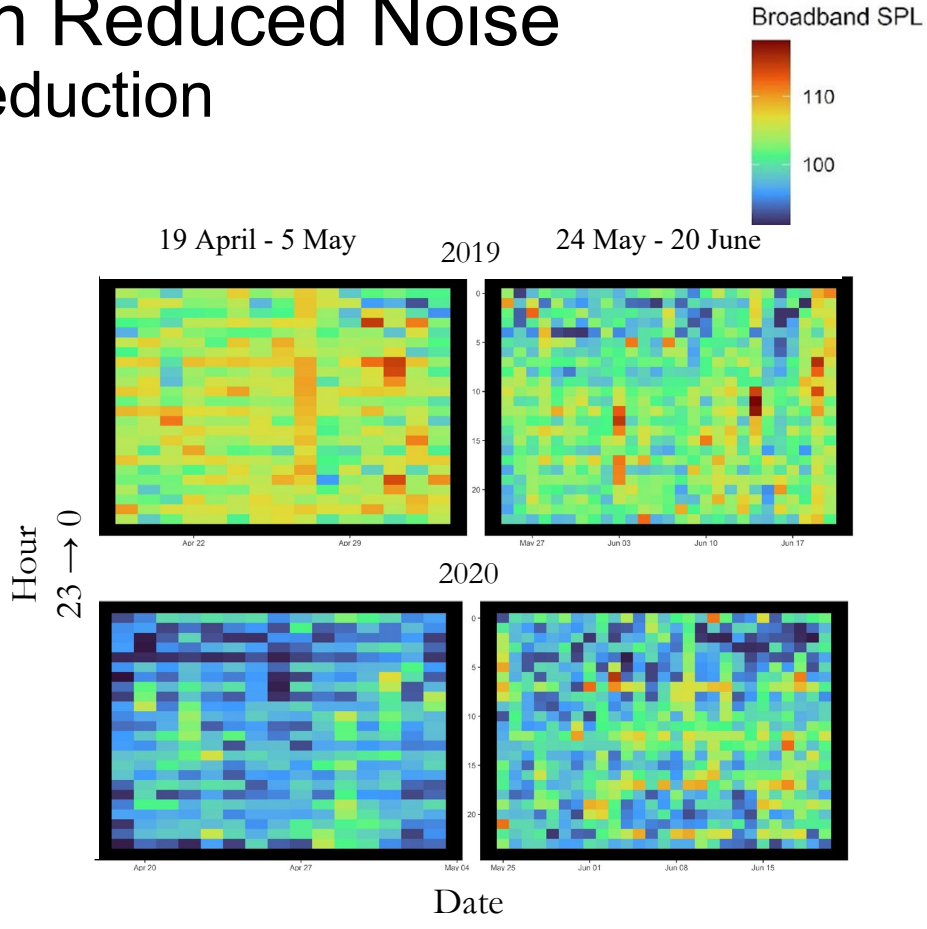
- Covid19 lock-down resulted in reduced boat traffic including shut-down of the Departure Bay Ferry
- We measured an 86% reduction in sound energy in 2020 vs 2019
- related to reduced ferry traffic, recreational boats, float planes.
- Contributed to paper on the “Anthropause” (Bates et al. 2021).

Bates, et al. 2021. *Biological Conservation* 263 .https://doi.org/10.1016/j.biocon.2021.109175


Vancouver
Nanaimo
Seattle
49.23°N
49.22°N
49.21°N
49.20°N
49.19°N
49.18°N
49.17°N
49.16°N
123.96°W
123.94°W
123.92°W
123.90°W
123.88°W
123.86°W
Departure Bay
Saysutshun (Newcastle Island)
Nanaimo
Northumberland Channel RCA
Gabriola Island
Hydrophone Location
RCA In
RCA out
Pre-Covid Ferry Frequency
Low
Moderate
High
Very high
Covid Response
Continued
Reduced
Stopped

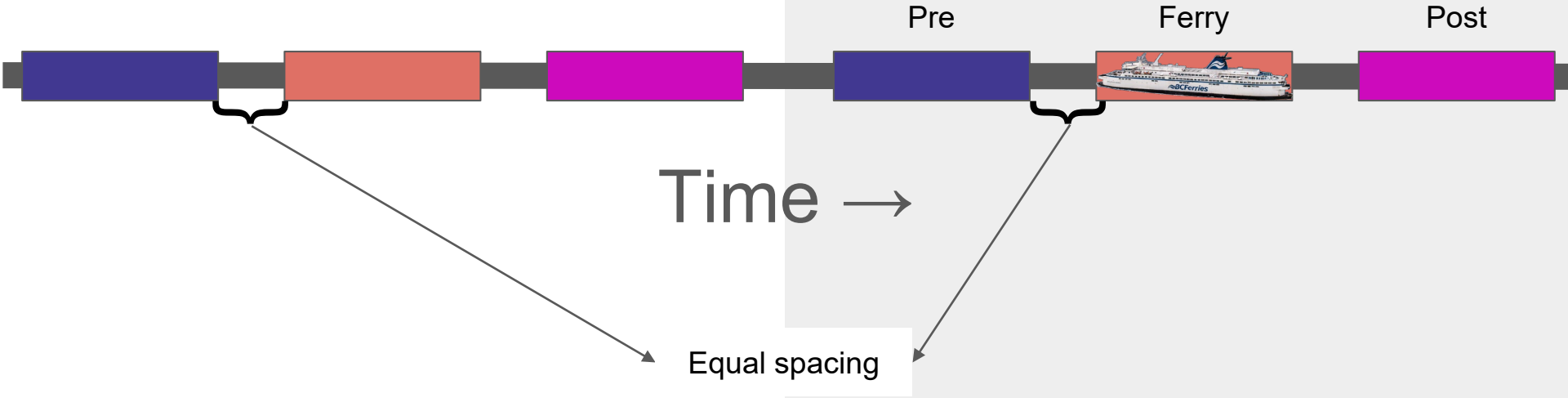
Covid Shut-down Reduced Noise
86% reduction

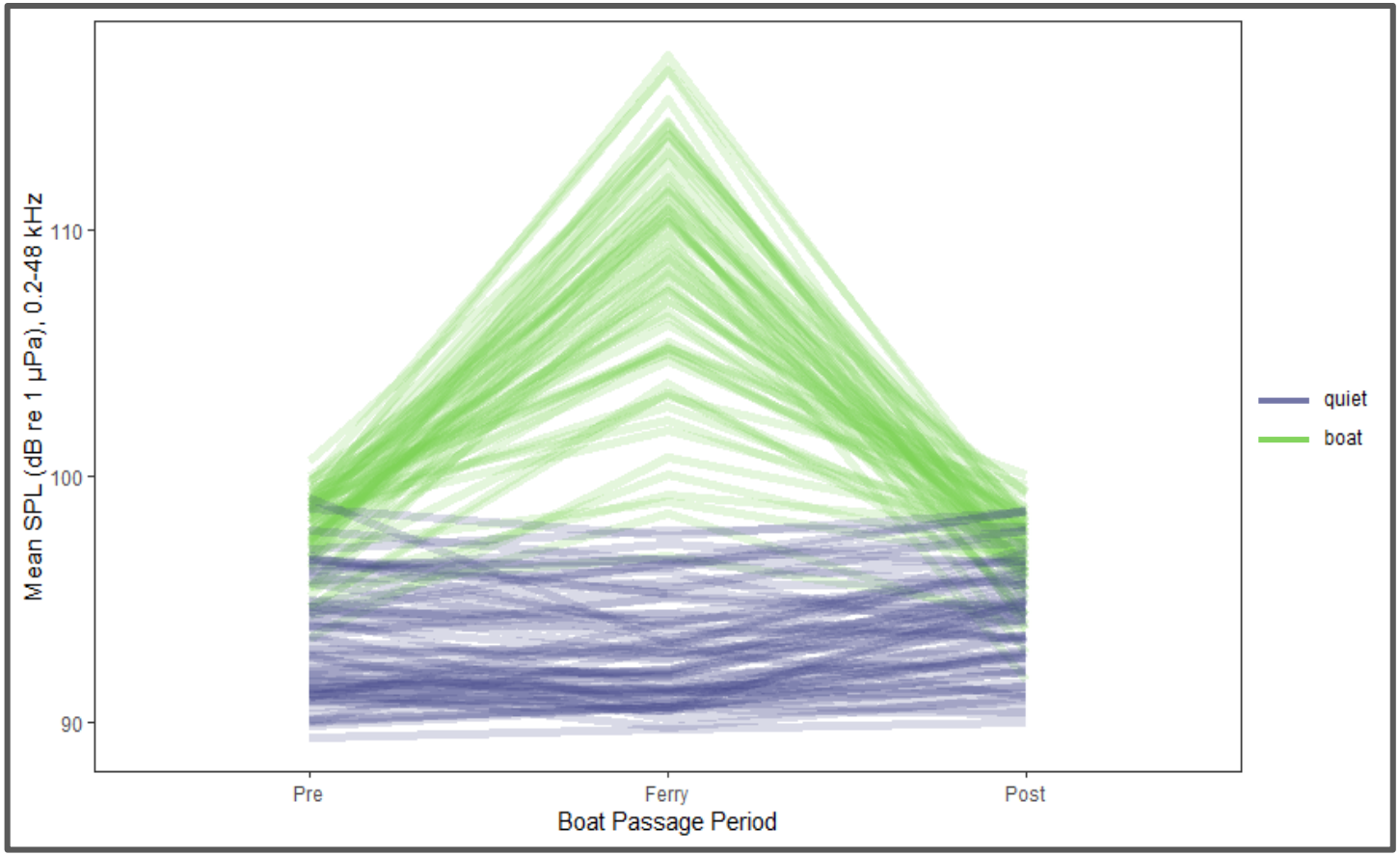




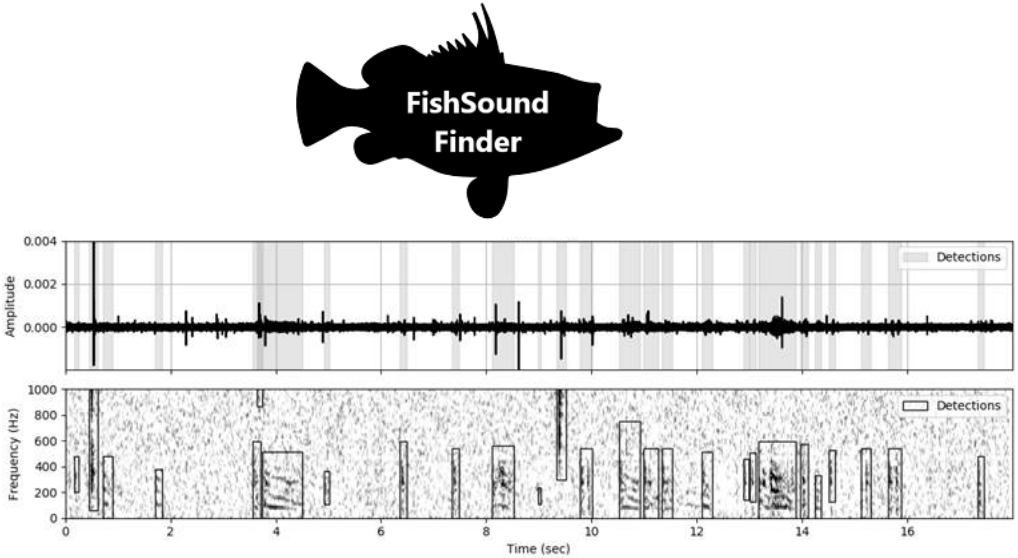
Quiet /Control

Boat Passage



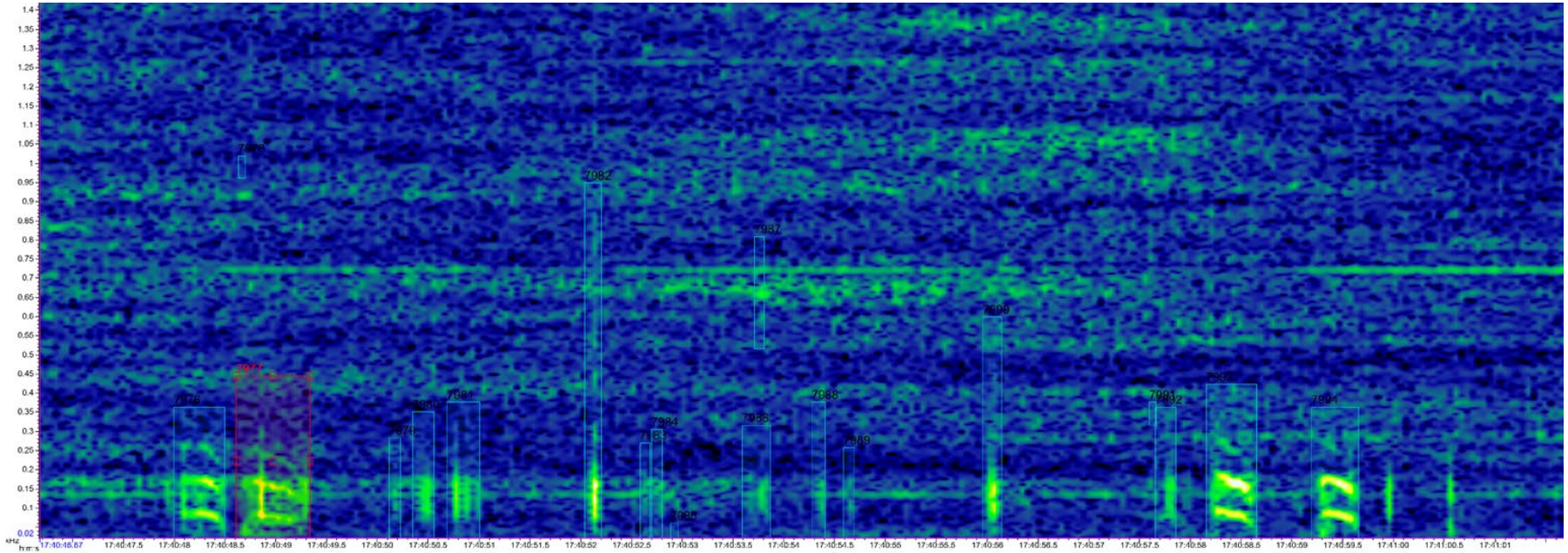

Mean SPL (dB re 1 µPa), 0.2-48 kHz
110
100
90
Pre
Ferry
Post
Boat Passage Period
quiet
boat

Fish call detections



https://github.com/xaviermouy/FishSound_Finder

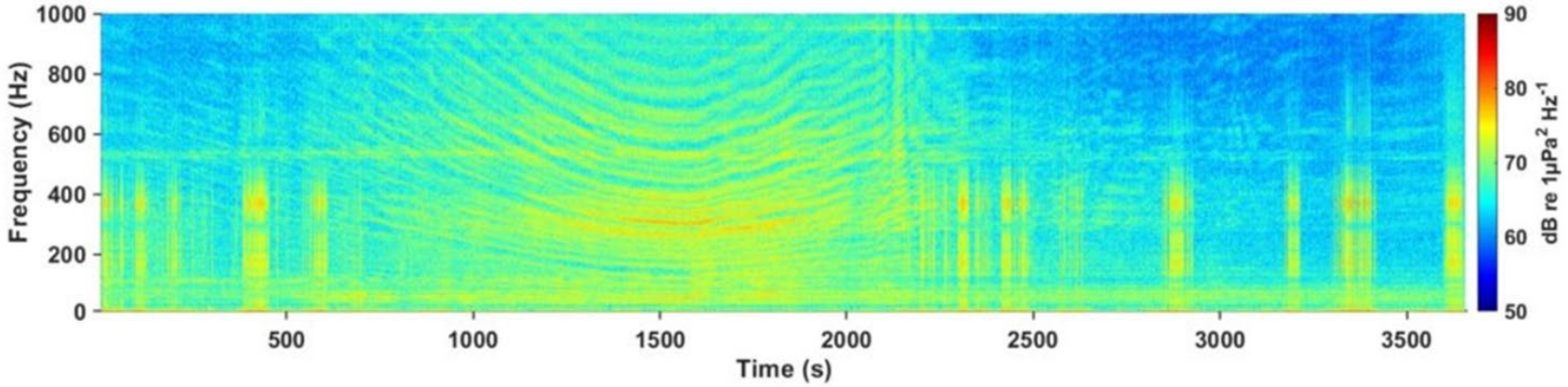
Fish call detections



Accounting for masking

Inband Power - Integral of the average power spectral density over the call selection.

Peak Power Density - The maximum acoustic intensity, or power, within the selection

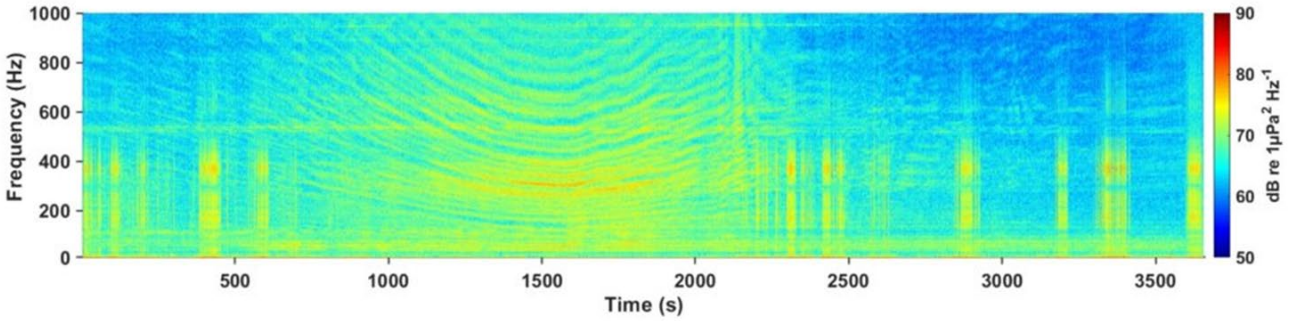


Accounting for masking

Find first quartile of call power (inband or peak) during the ferry passage period.

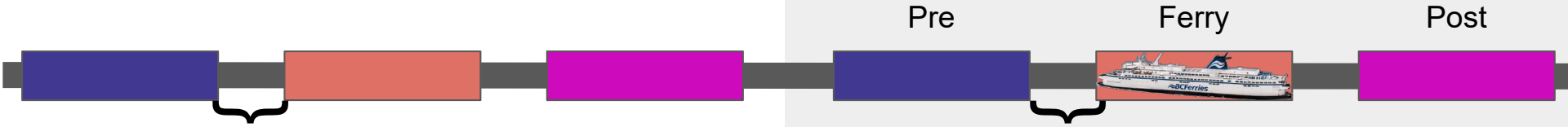
Filter out all calls detected that night with lower power.

Final dataset only includes calls that would have been loud enough to be heard du



Quiet /Control

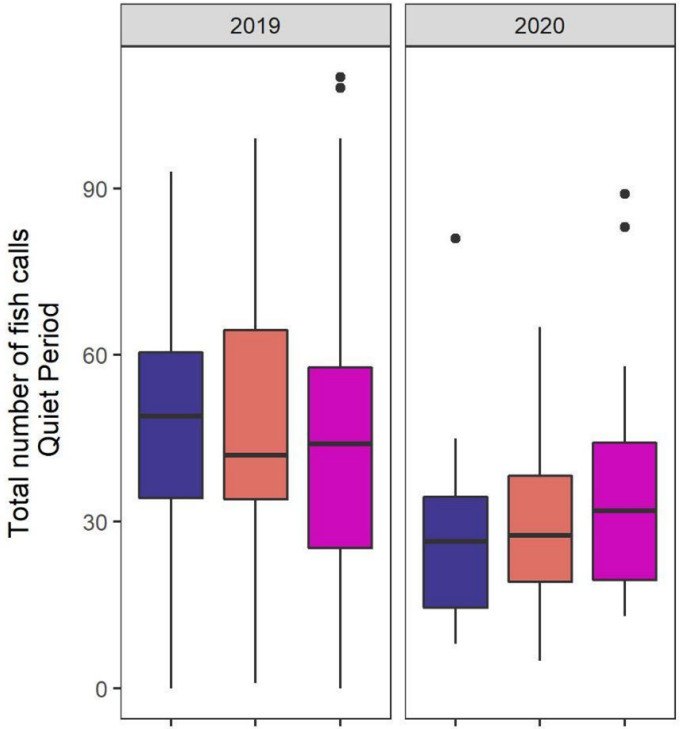
Boat Passage



Time →

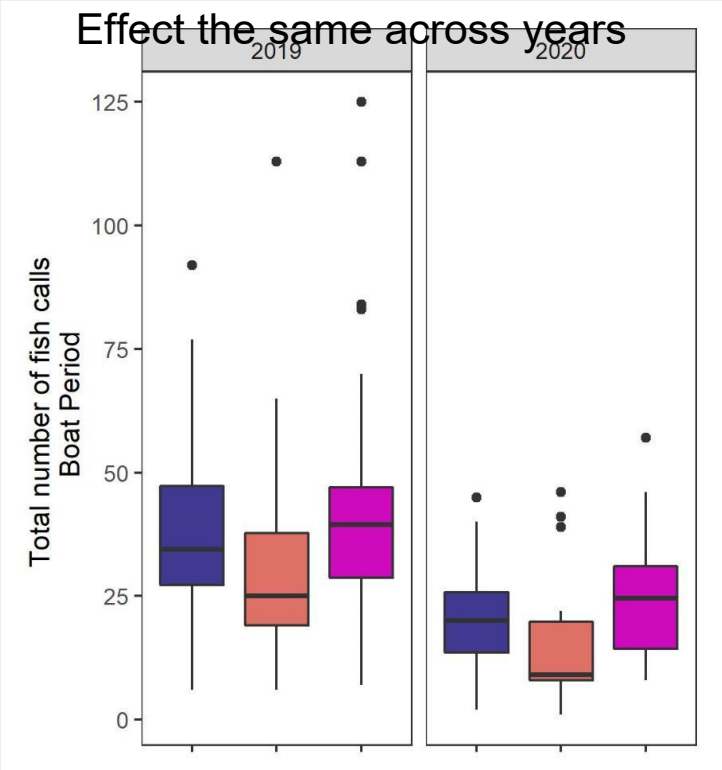
Total Number of Fish Calls ~ Period Type * Boat? + (1|Date)

No effect of period

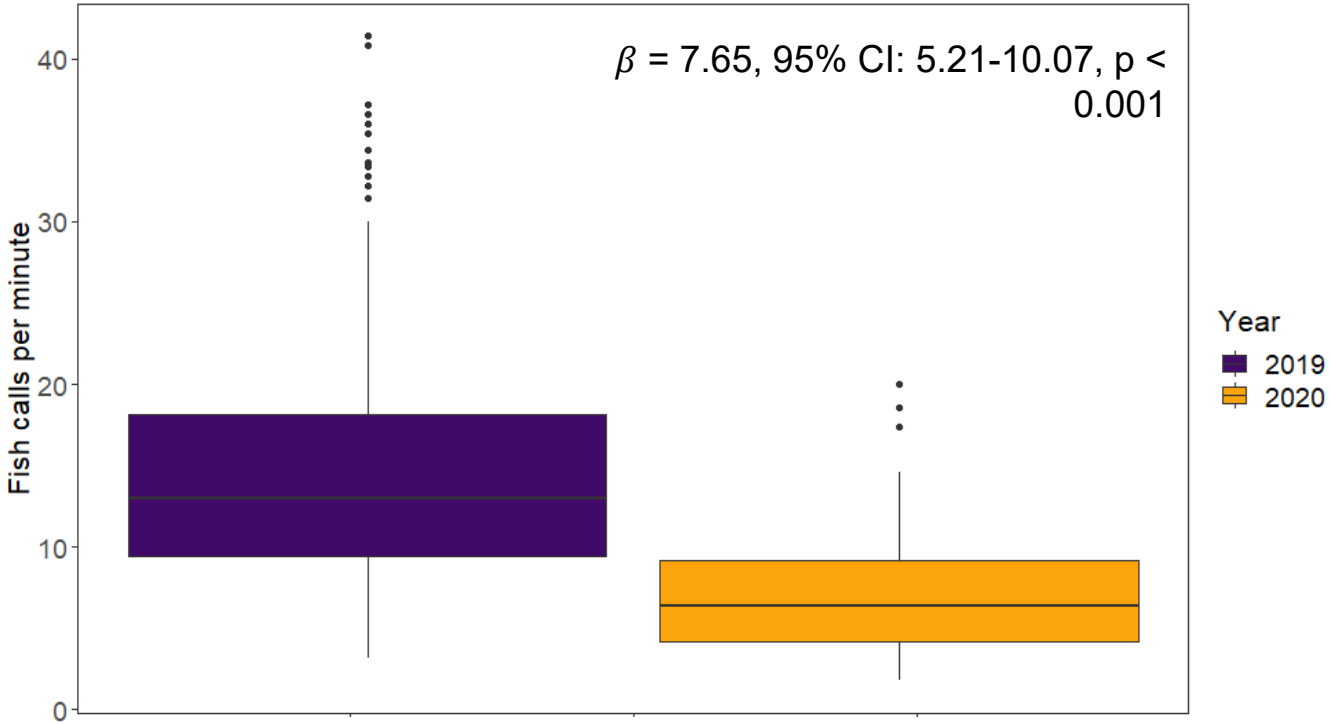


Fish called 1.88 (1.69-2.10) times less per minute during ferry passage
(p = 0.001)

Effect the same across years



During quiet times fish called less in 2020 than in 2019



Fish behaviorally responded to ferry passage

Fish reduced their calling rate when ferry noise was present by an average of 1.88 calls per minute (95%CI: 1.69-2.10)

No evidence for compensation

Next we will determine if fishes acclimate during periods of prolonged exposure

Attempts to estimate relative fish abundance need to take the effect of boat noise on calling rate into account