

# Information retrieval from marine soundscape by using machine learning-based source separation

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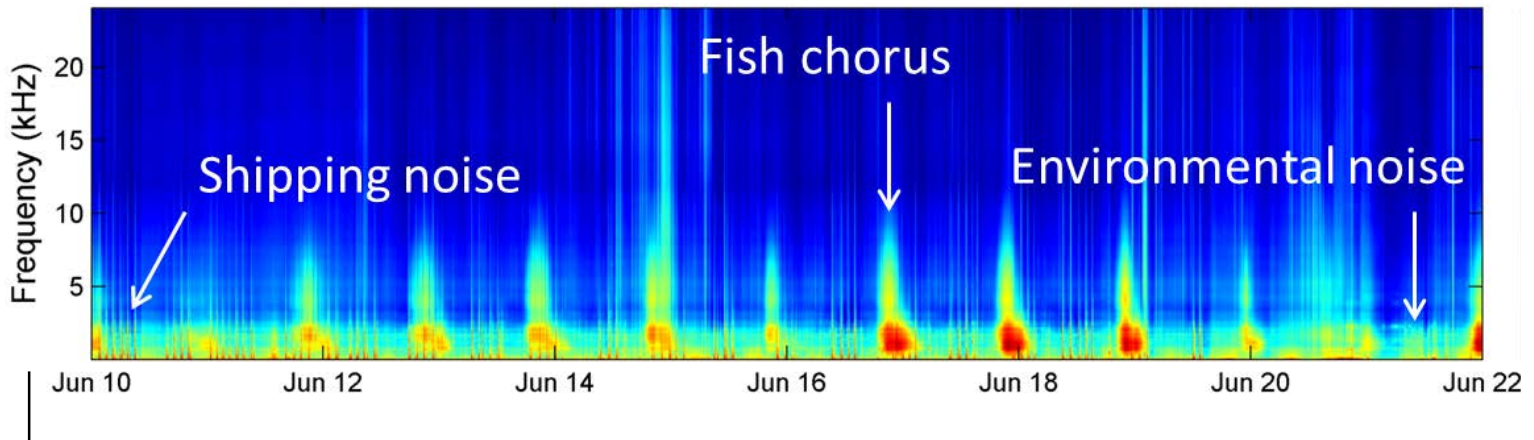
**Tomonari Akamatsu**

National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency

**Yu Tsao**

Research Center for Information Technology Innovation, Academia Sinica

# Marine soundscape: a remote sensing platform of marine ecosystems



*Quantification  
analysis*

## → Spectral-temporal variability

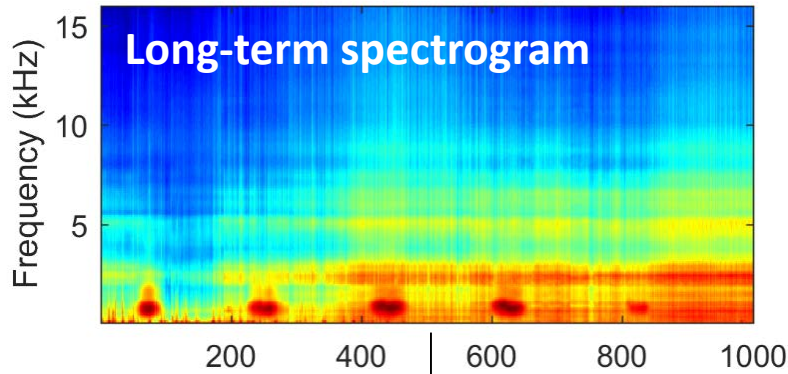
- PSD, ecoacoustics indices
- Unable to identify the contribution of each source

## → Identification of sound sources

- Manual identification, model-based approaches
- Lack of recognition database, noise interference

# Source recognition and separation by periodicity-coded nonnegative matrix factorization

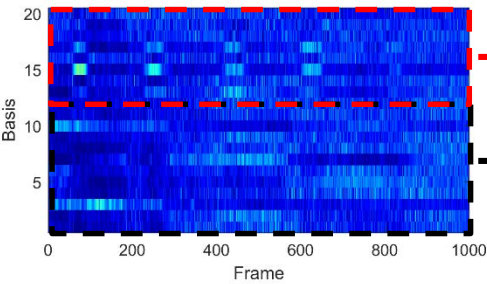
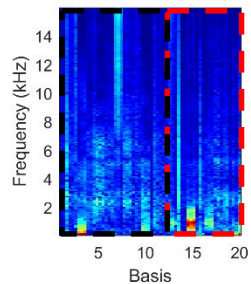
(Lin et al. 2017. Scientific Reports)



**1<sup>st</sup> NMF**

Spectral bases

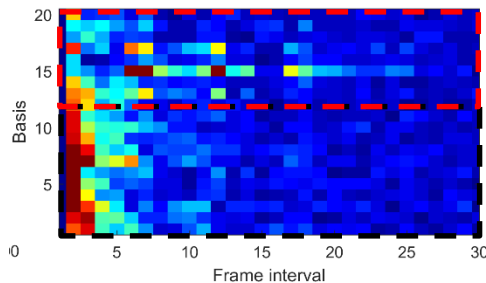
Encoding info.



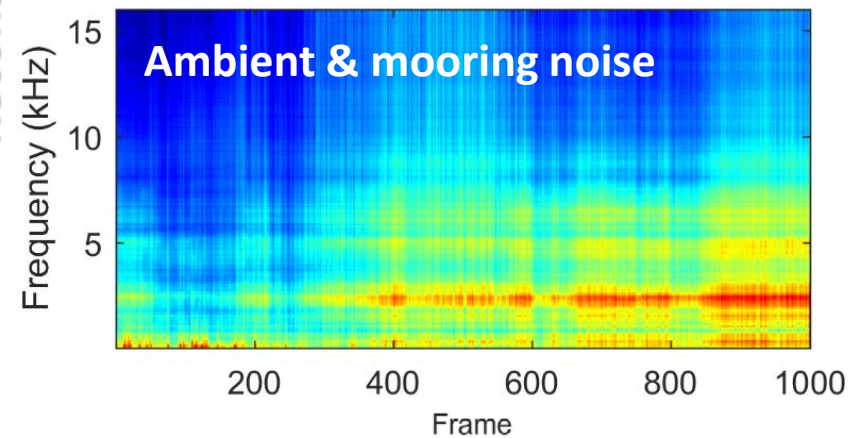
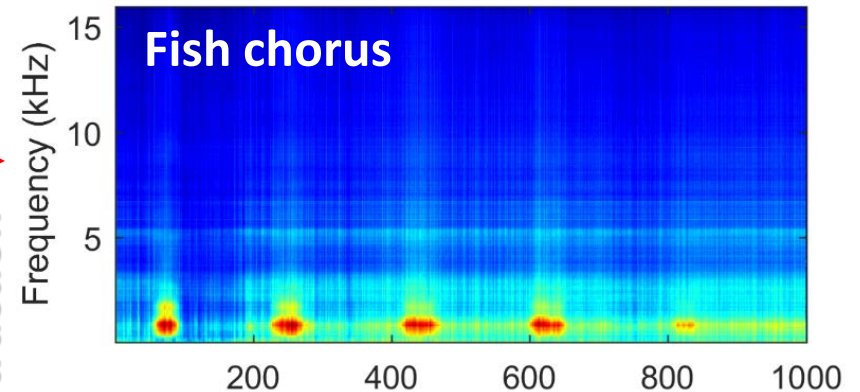
**2<sup>nd</sup> NMF**

FFT  
↓  
Periodicity

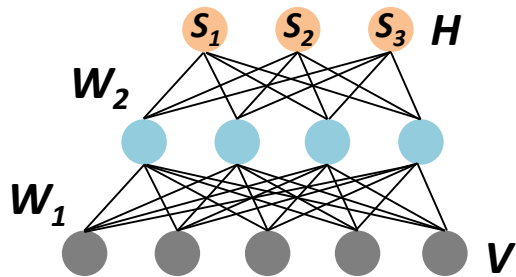
*Basis clustering*



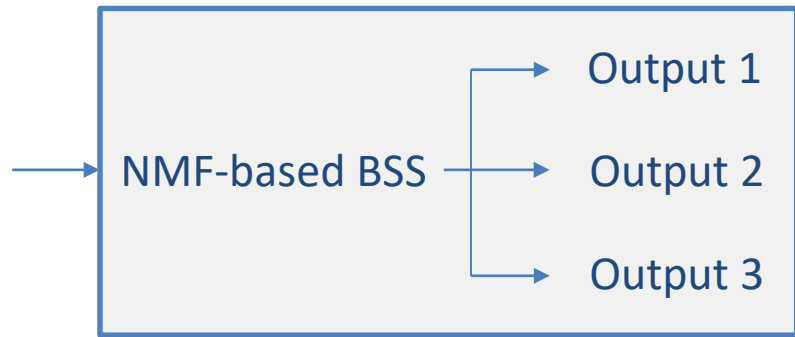
Reconstruction



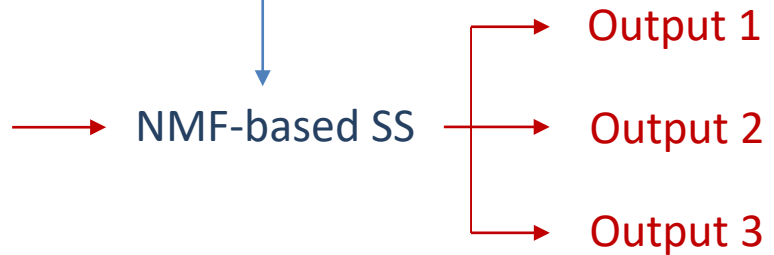
# Objectives



Testing data 1  
(no label)



Testing data 2  
(no label)



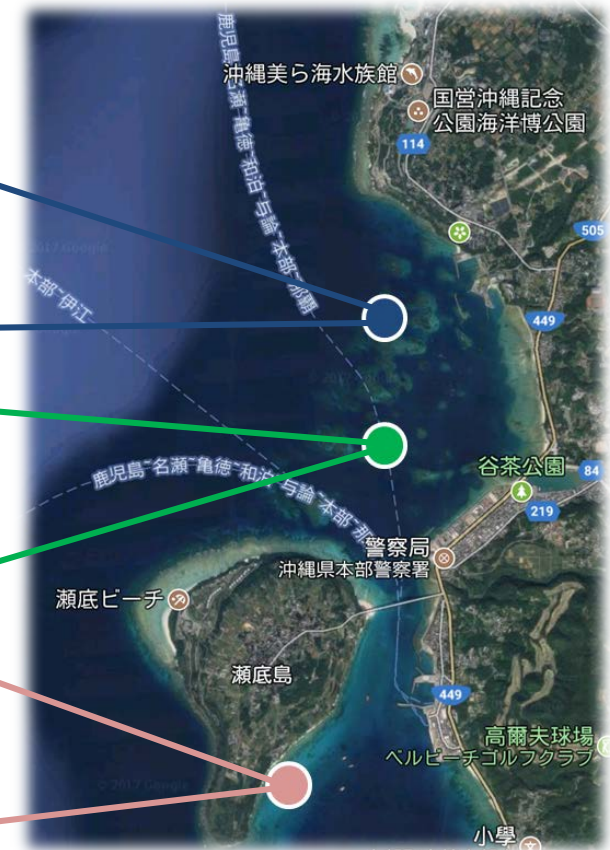
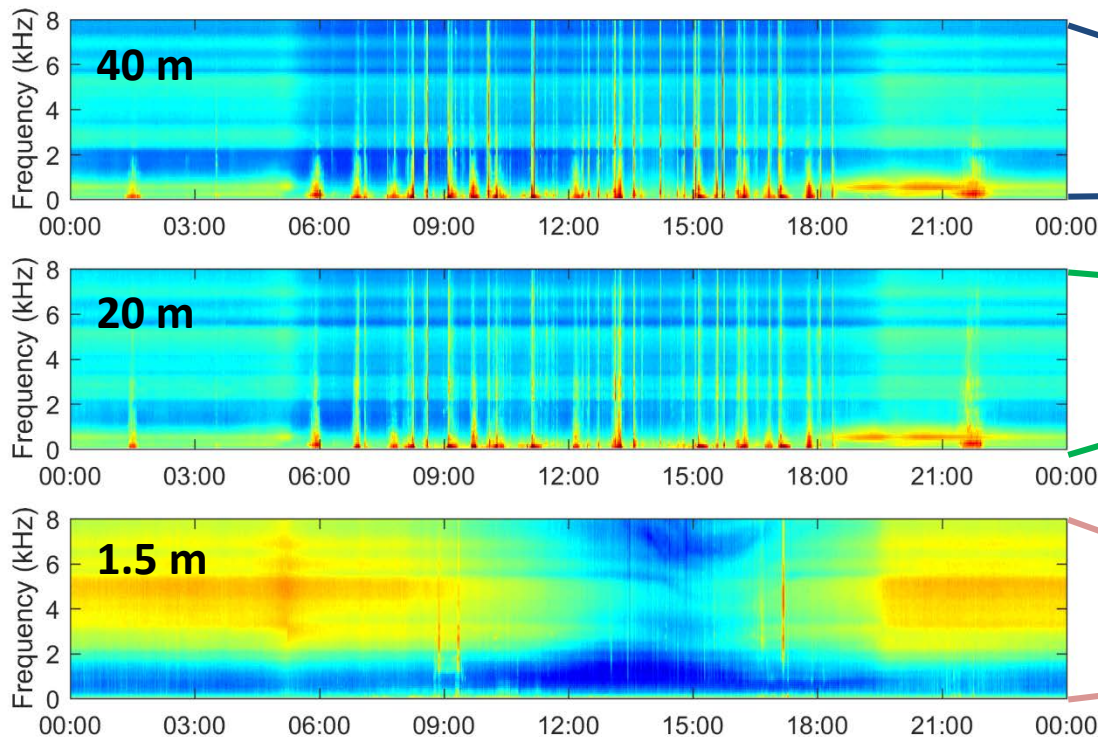
- **Analyze the soundscape variability by source separation**
  - Unlabeled long-term spectrogram
  - Blind source separation (BSS) → Supervised separation (SS)
  - Model adaptation by learning to reconstruct new testing data
- **Case study 1: coral reef soundscape**
- **Case study 2: deep water soundscape**

# Case 1: coral reef soundscape

Recordings at 1.5m, 20m, 40m

BSS Model ← Recordings at 20m  
(Fix W)

Likelihood of shipping noise & biological chorus



## Long-term spectral median

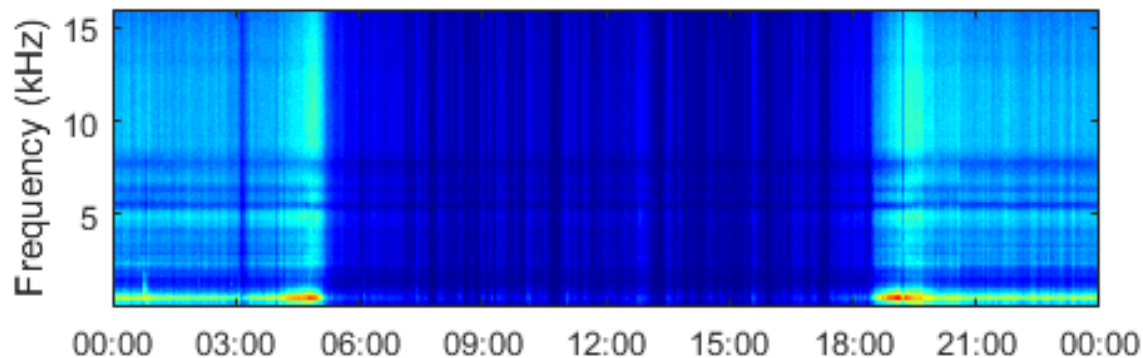
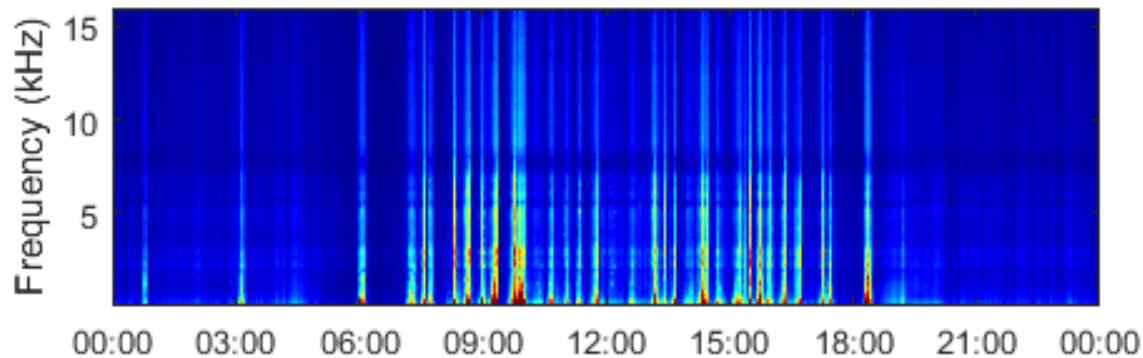
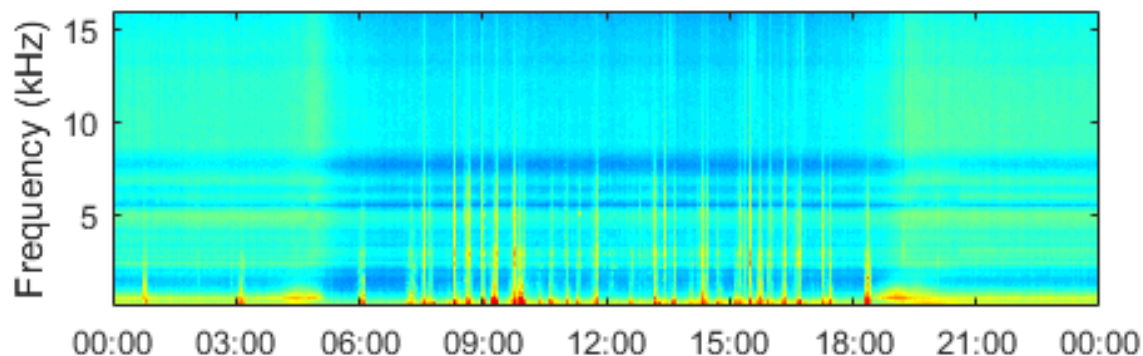
*NMF-based BSS*

→ **Shipping noise**

→ **Biological chorus**

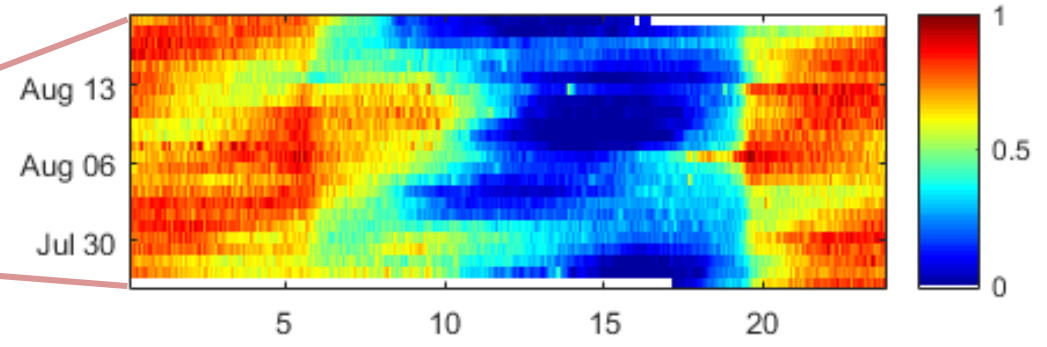
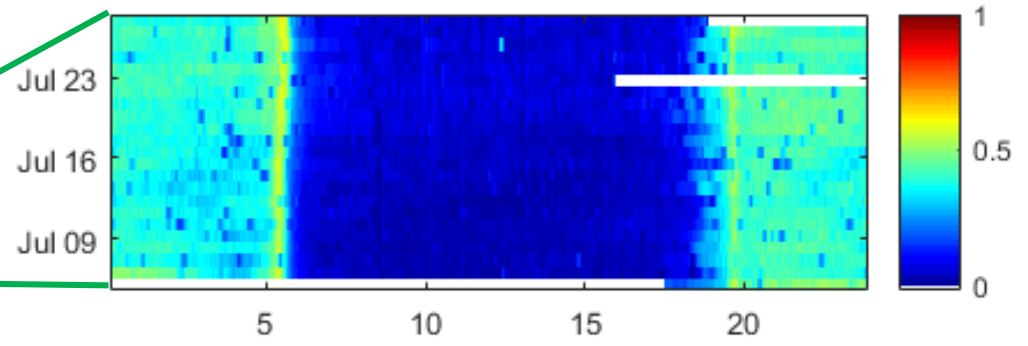
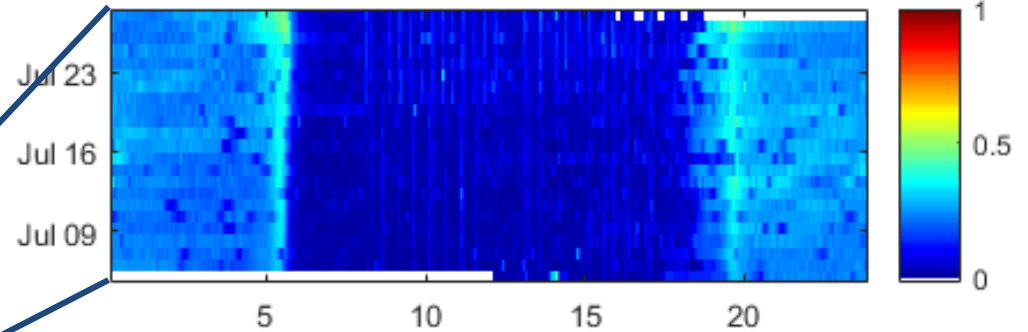
- Low-F fish chorus
- Broadband shrimp snaps

↓  
**Other sources**



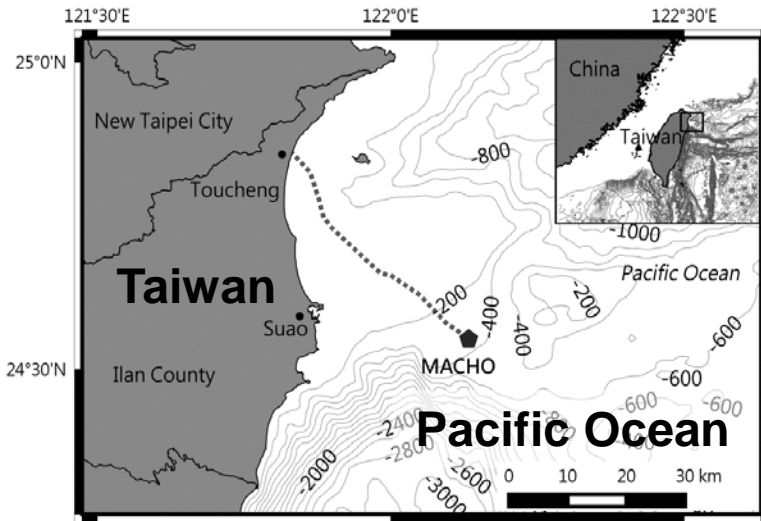


# Biological chorus





# Case 2: deep water soundscape



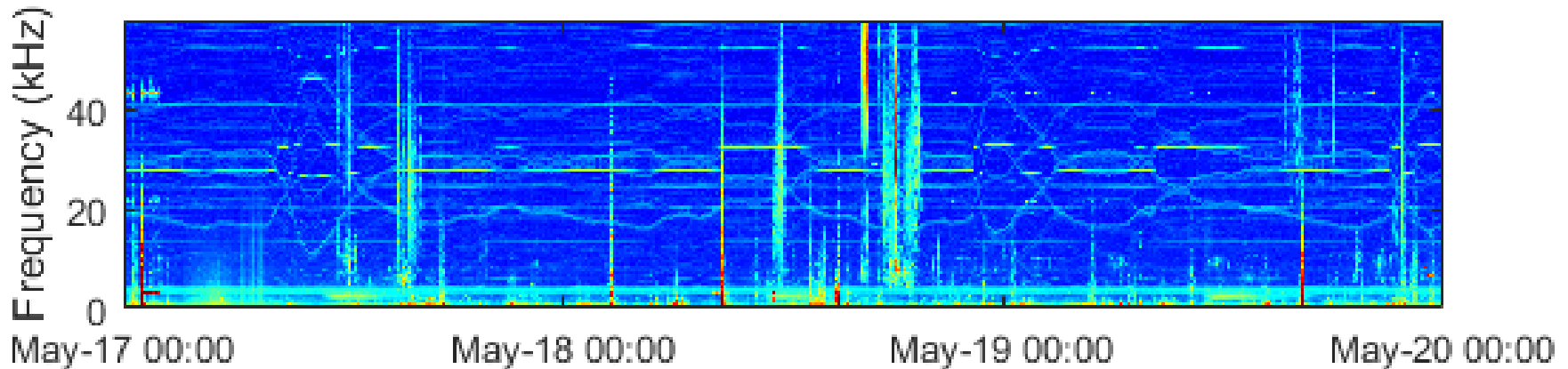
Recordings from Nov 2011 to May 2014

*BSS Model*  
(Fix  $W$ )

Recordings from  
Nov 2011 to Oct 2012

*k-means clustering* ( $k=2$ )

Absence/presence of soundscape  
components



*Data collected by Taiwan Central Weather Bureau*

## Long-term spectral average

*NMF-based BSS*

### → Cetacean vocalizations

- Mid-F tonals
- Broadband clicks

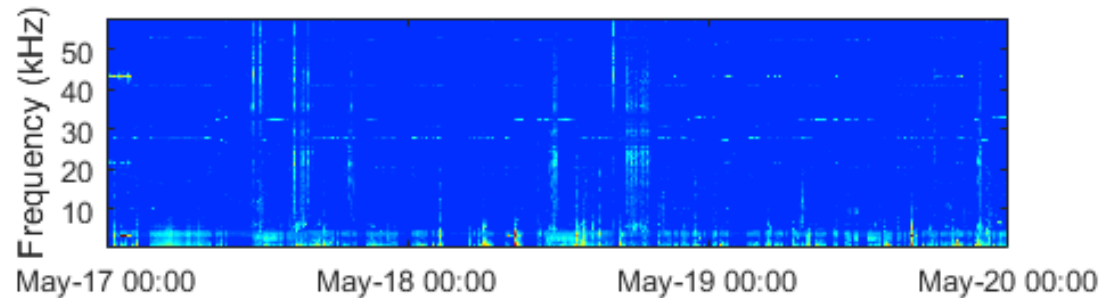
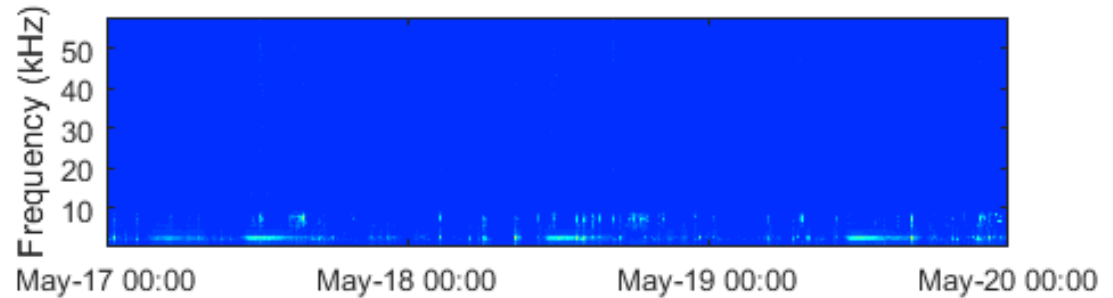
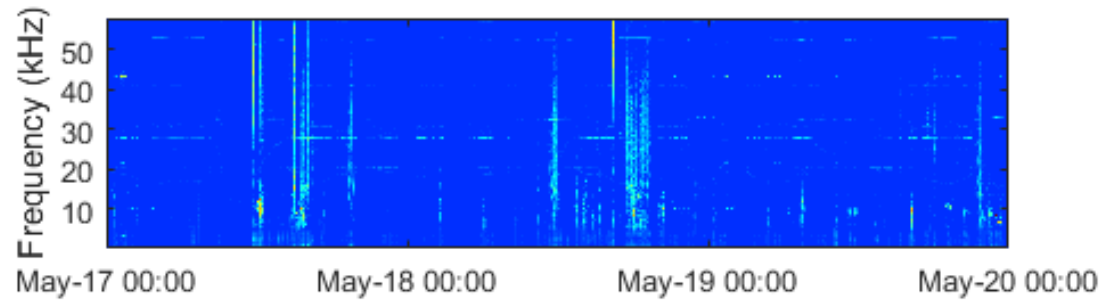
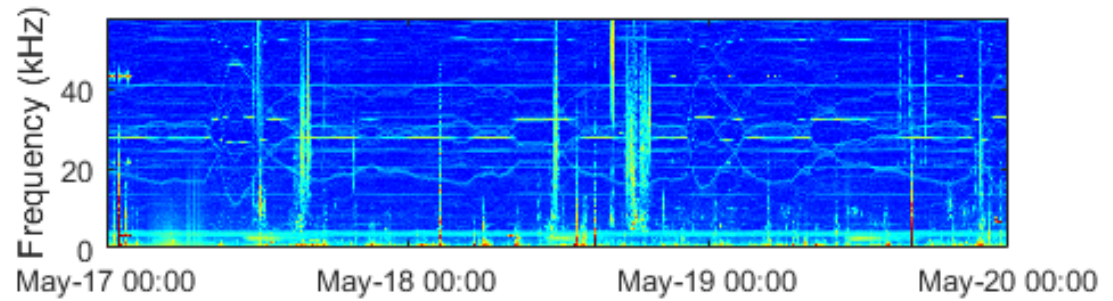
### → Biological chorus

- 2-3 kHz

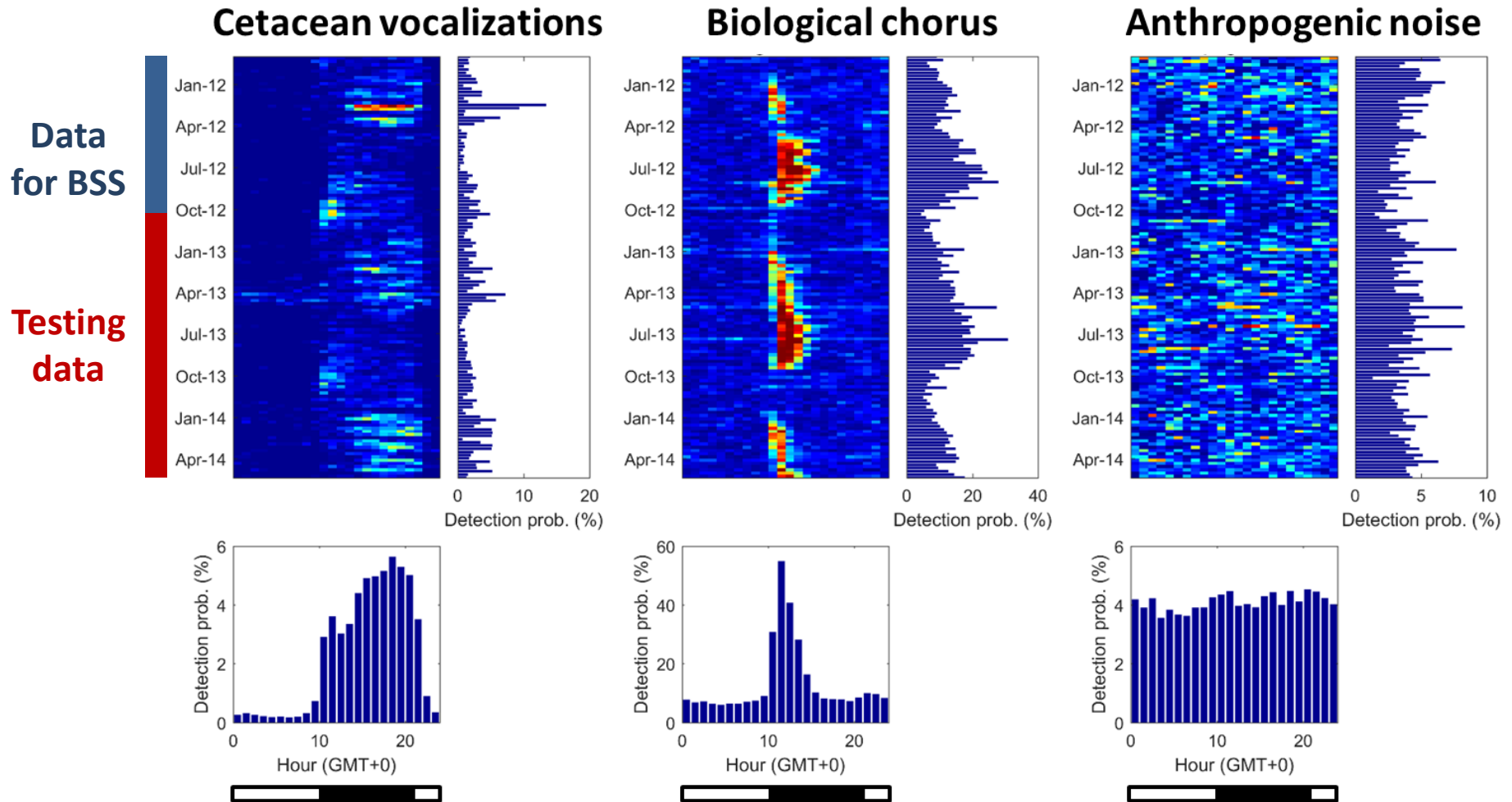
### → Anthropogenic noise

- Shipping noise
- Sonar activities

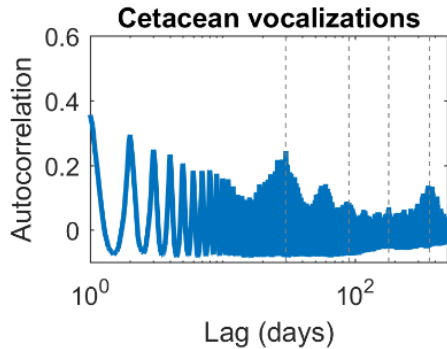
Other sources



# Temporal variability of marine soundscape



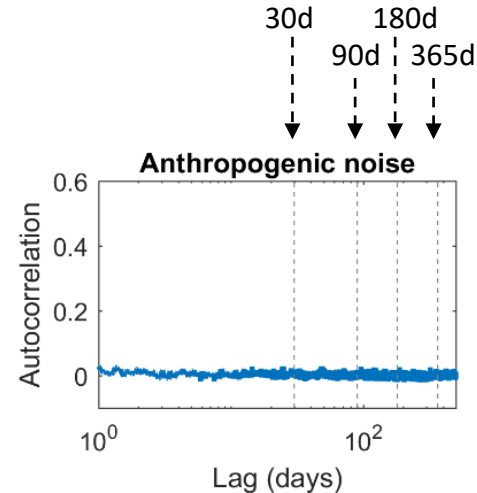
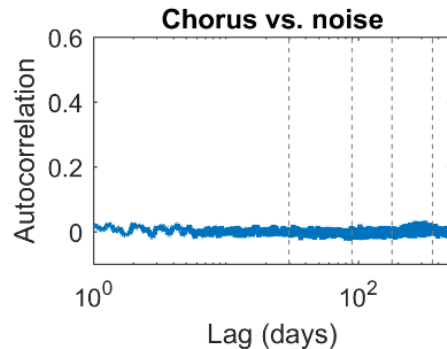
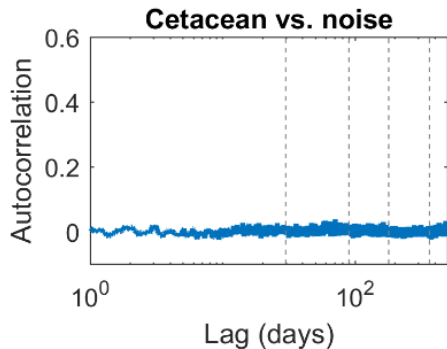
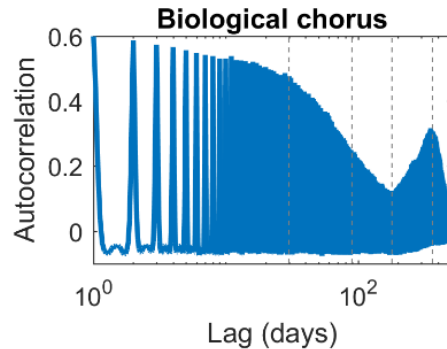
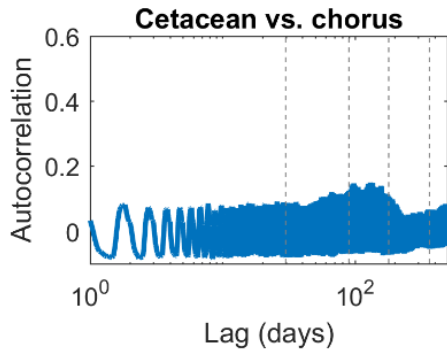
# Intra- & inter-source interactions



**Cetaceans:** diurnal, moon, & seasonal cycles

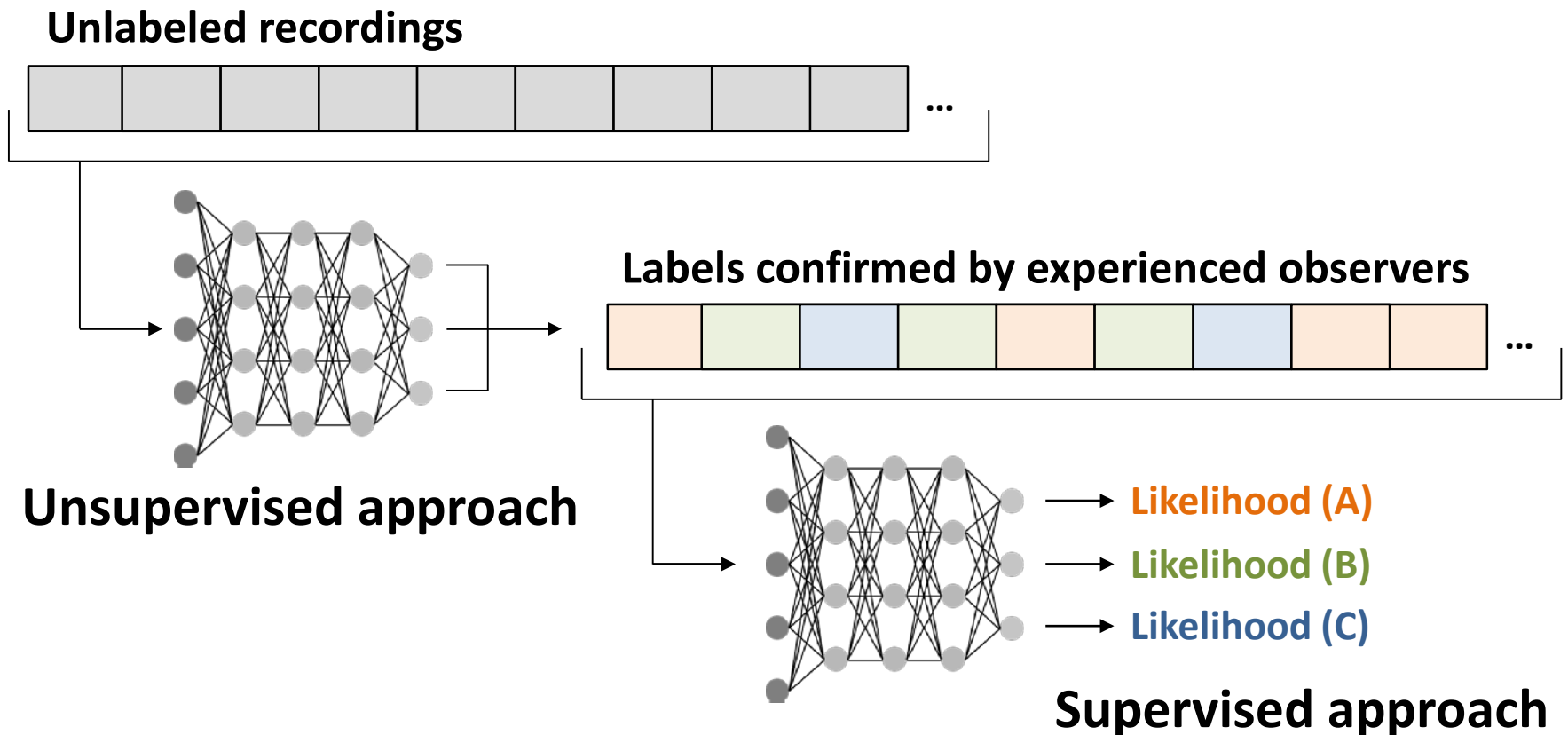
**Biological chorus:** diurnal, & seasonal cycles

**Cetacean\*chorus:** diurnal, & seasonal interactions



# Soundscape information retrieval

- Machine learning-based BSS facilitates the information retrieval when a recognition database is not available



# Conclusions

- NMF-based source separation
  - A simple solution for blind source separation
  - Establish a recognition database with minimum labor works
  - Search similar targets without a comprehensive training database
- Future application
  - Spatial-temporal variations of marine soundscape
  - Intra- and inter-source interactions

# Acknowledgement

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- Central Weather Bureau of Taiwan



A scenic view of a large offshore wind farm in the ocean under a blue sky with white clouds. The wind turbines are visible on the horizon, and the water is calm with gentle ripples. The sky is a mix of light blue and white, with some clouds catching the light.

**Thanks for your attention!**

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