Comparing performance of bottom-moored, glider, and unmanned surface vehicle towed PAM platforms for marine mammal detection

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INTRODUCTION

Passive acoustic monitoring (PAM) is a more effective method of monitoring the distribution and abundance of deep-diving cetaceans than conventional visual surveys because almost all species are vocally active and sound passes effectively through sea water. The vocalizations of some species can travel large distances underwater, able to be detected up to tens of kilometers away for whales and their unique characteristics provide a means to differentiate between species and even individuals. Several PAM platform and detectors have been developed to record cetacean calls and Isolation of interested cetacean call, identification of their sources, and abundance estimates based on acoustic cues are used to track the recovery of marine mammal species after major ecological disasters, such as the recent 2010 oil spill. However, No comparative analysis of these platforms and detectors exists. Therefor, to assure the detection quality of these independent platforms and detector systems, comparing the detection performance for different PAM platform is important.

LADC-GEMM is simultaneously utilizing three PAM platforms: bottom-moored buoys (EARS), deep-diving Seagliders, unmanned surface vehicles (ASVs) to establish a precedent of long-term PAM of the marine mammal recovery after the oil spill.

EXPERIMENT
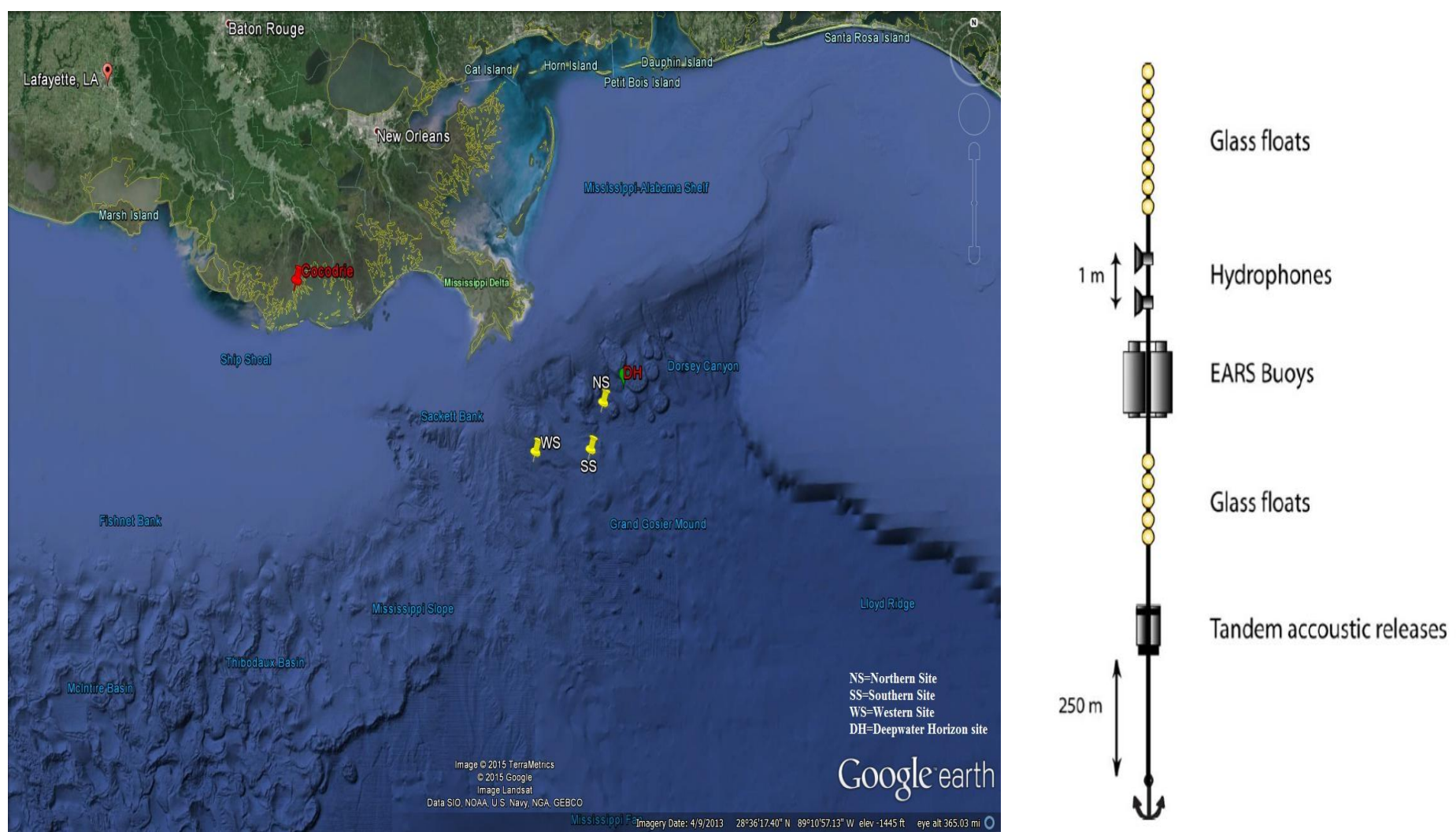
Data Collection

Data of overlapping time of the Unmanned surface vehicle (ASVs) and Bottom moored buoys(EARS-Buoy) is collected during The LADC_GEMM 2015 Gulf of Mexico experiment from June 23 – July 2, 2015.
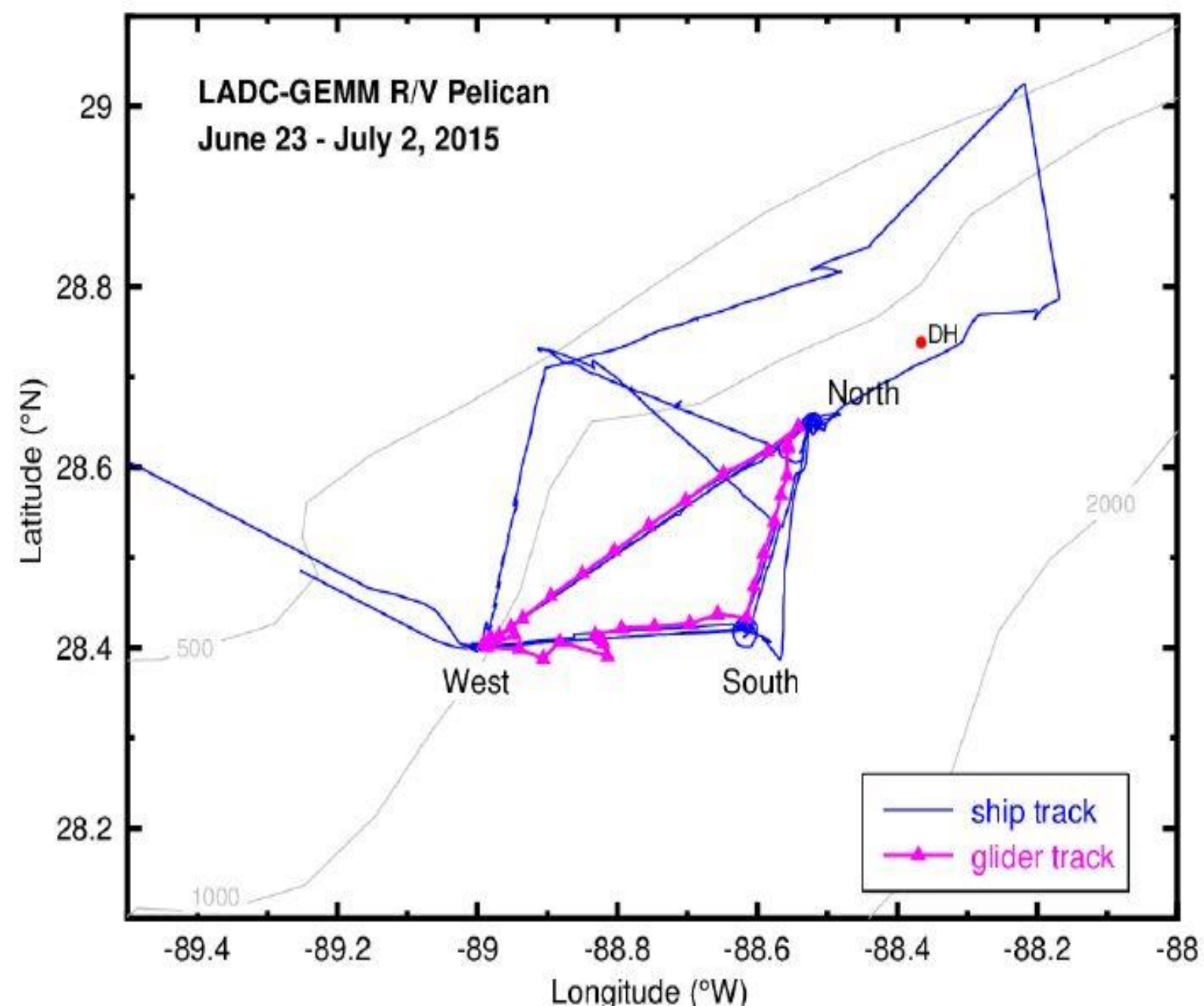

Fig: Ship Track During LADC-GEMM 2015 experiment

PAM PLATFORMS

Unmanned Surface Vehicle (ASV):

- Towed arrays consisted of two identical, spherical hydrophones, spaced 2 m apart at the end of a tow cable of 220 m in length and in-water tow lengths from the stern of the vehicle was 200 m.
- A high-pass filter (nominal 20Hz), and a low-pass anti-aliasing filter (nominal 160 kHz, 0.64*Nyquist frequency) were applied.
- Data were sampled using a National Instruments NI 9222 analogue-digital convertor (ADC) housed in a NI cDAQ89181 chassis. The sampling rate of the NI 9222 was 500 kHz per channel, 16bit sample size.
- Sound recordings were made on a mini-PC running the software Pamguard v1.13.04 running under Java Real-time Environment v1.7 (32 bit) and Microsoft Windows 7 (64 bit). These audio data were continuously recorded as 16bit wav- format (.wav) files. The individual duration varied, but the file size limit was set to 600 s for most of the survey.

Bottom moored buoys:

Environmental Acoustic Recording System (EARS) is deployed on fixed moorings approximately 300 to 550 m long and deployed in water depths between 1000 and 2000 m. Data are continuously recorded at 192 kHz sampling rate for approximately 100 days.

DATA ANALYSIS

Detection Parameters for Sperm Whale click:

1. Frequency Band: 3000-20,000 Hz
2. Click length: 12 ms

Strategy of data analysis using PamGuard:

- Process wav recordings with a Pamguard click detector
- Click classifier #1 - identify the Pelican's 12 kHz echosounder
- Click classifier #2 - identify sperm whale clicks (energy band comparison)
- Amplitude selector
- Echo detection
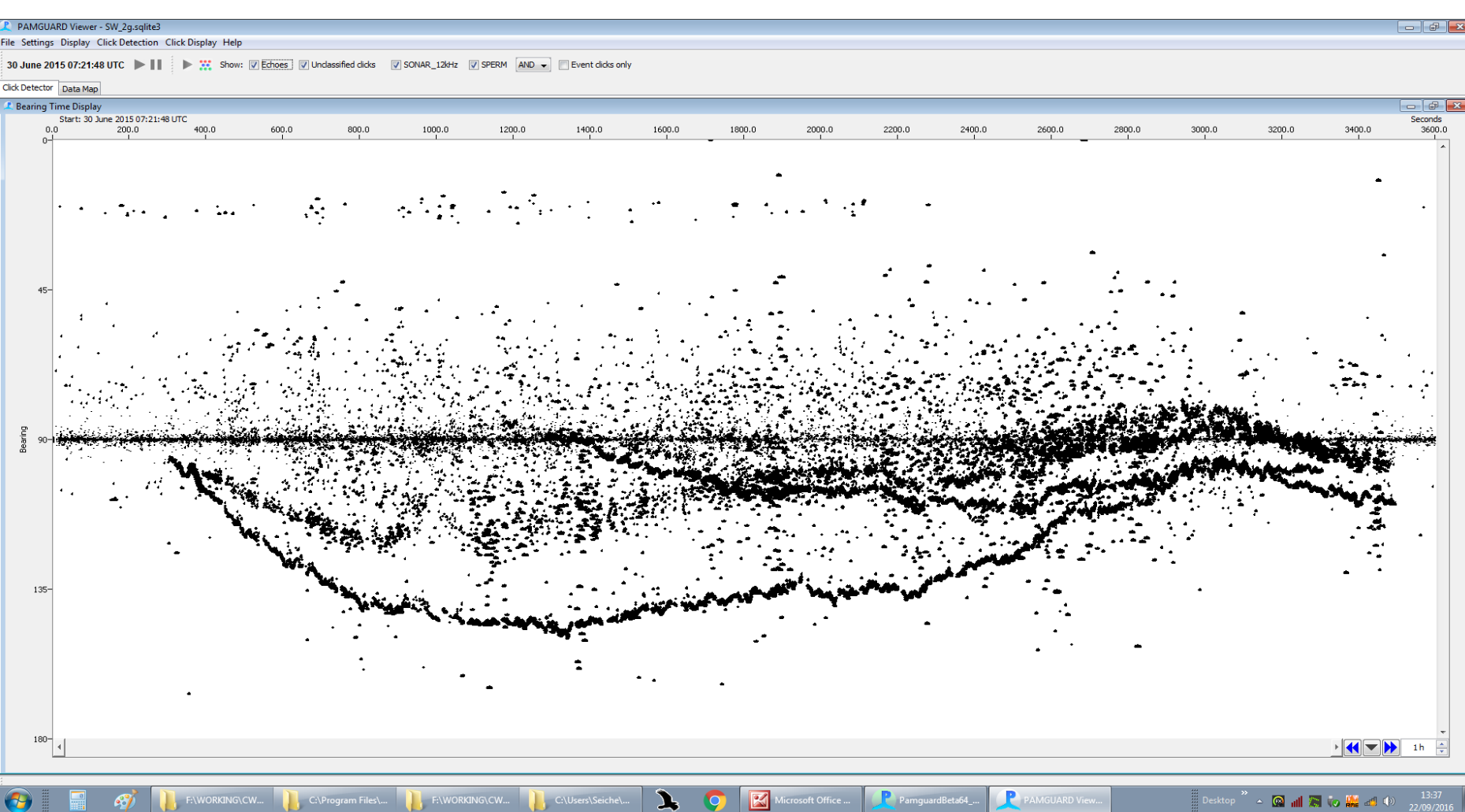- Manual exclusion of noisy time periods (e.g. USV circling)

Fig: Raw click detector output – bearing 0-180 degree on the vertical axis, time on the x-axis.
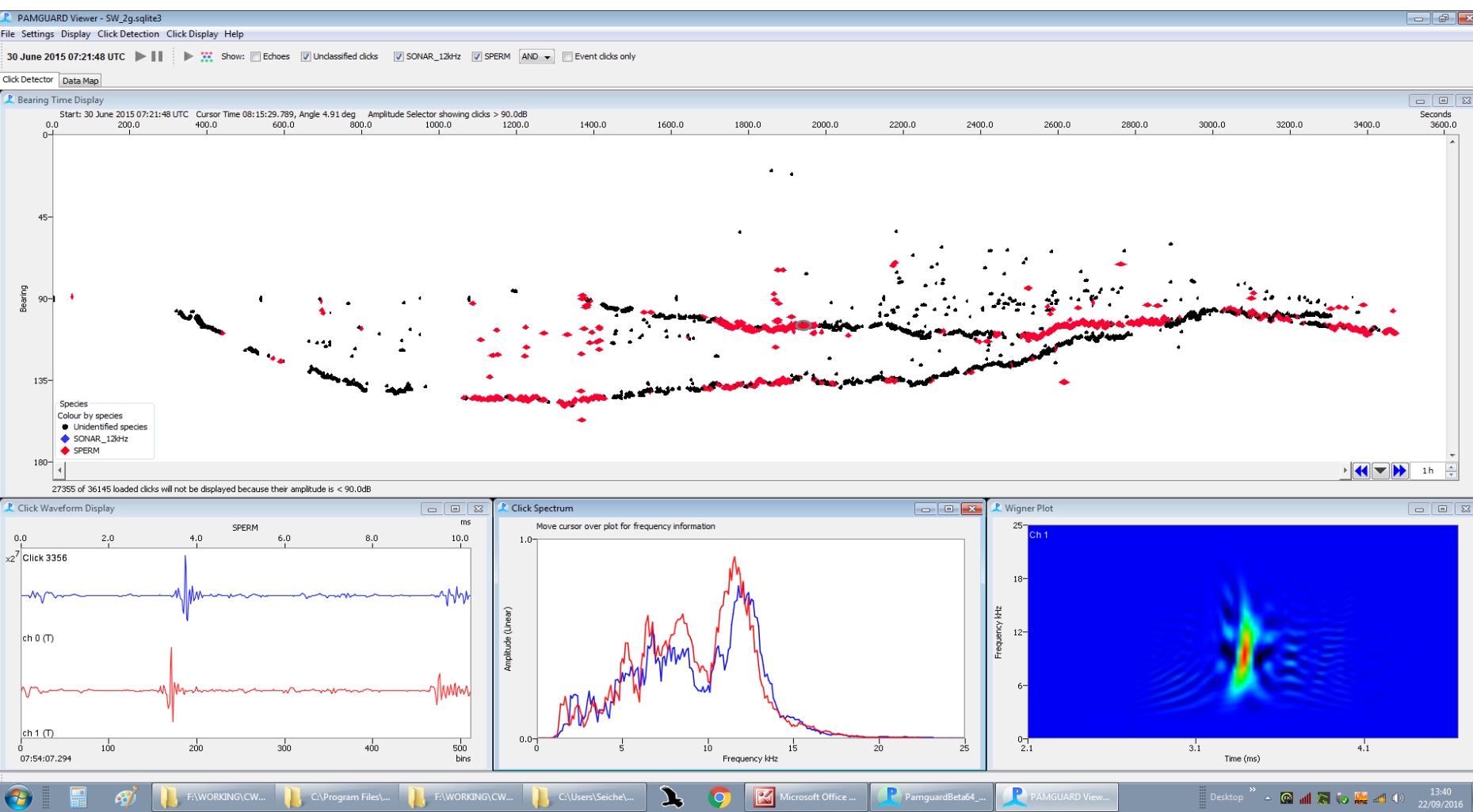

Fig: Sperm whale clicks trains after running click classifiers

DATA ANALYSIS

Strategy of data analysis using LADC-GEMM energy detector:

1. Feeding ASV data with LADC-GEMM detector system
   - Modify the detector due to
     - Sampling frequency is different
     - Data recording length is not fixed
     - Data format is different
   - Identify sperm whale clicks with LADC_GEMM energy detector
   - Estimate false positives
   - Manually check noisy time periods
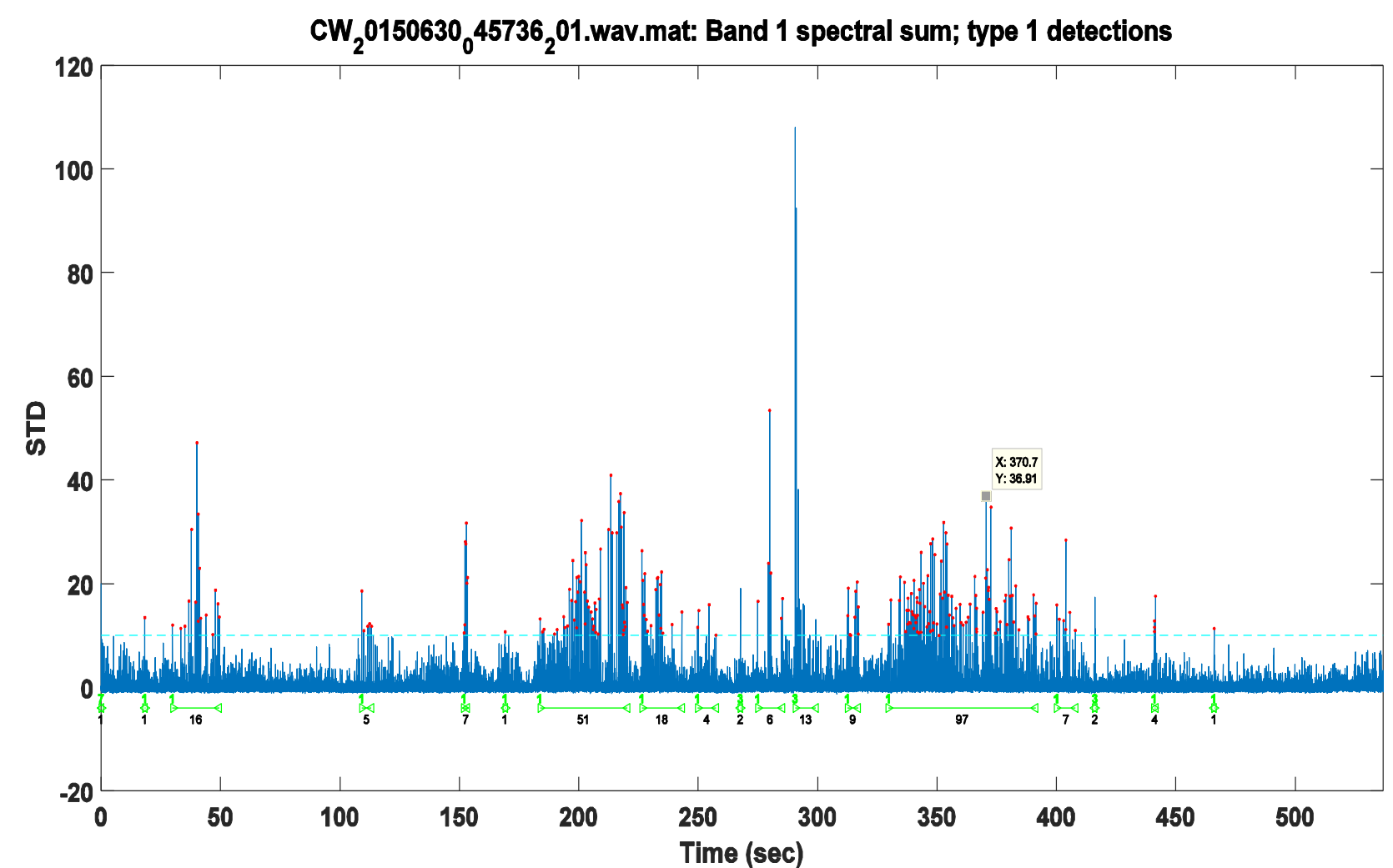2. Analyze EARS-Buoy data for the of overlapping time with ASV

Fig: Detected clicks from a ASVs wav data file- red dots are representing the sperm whale clicks
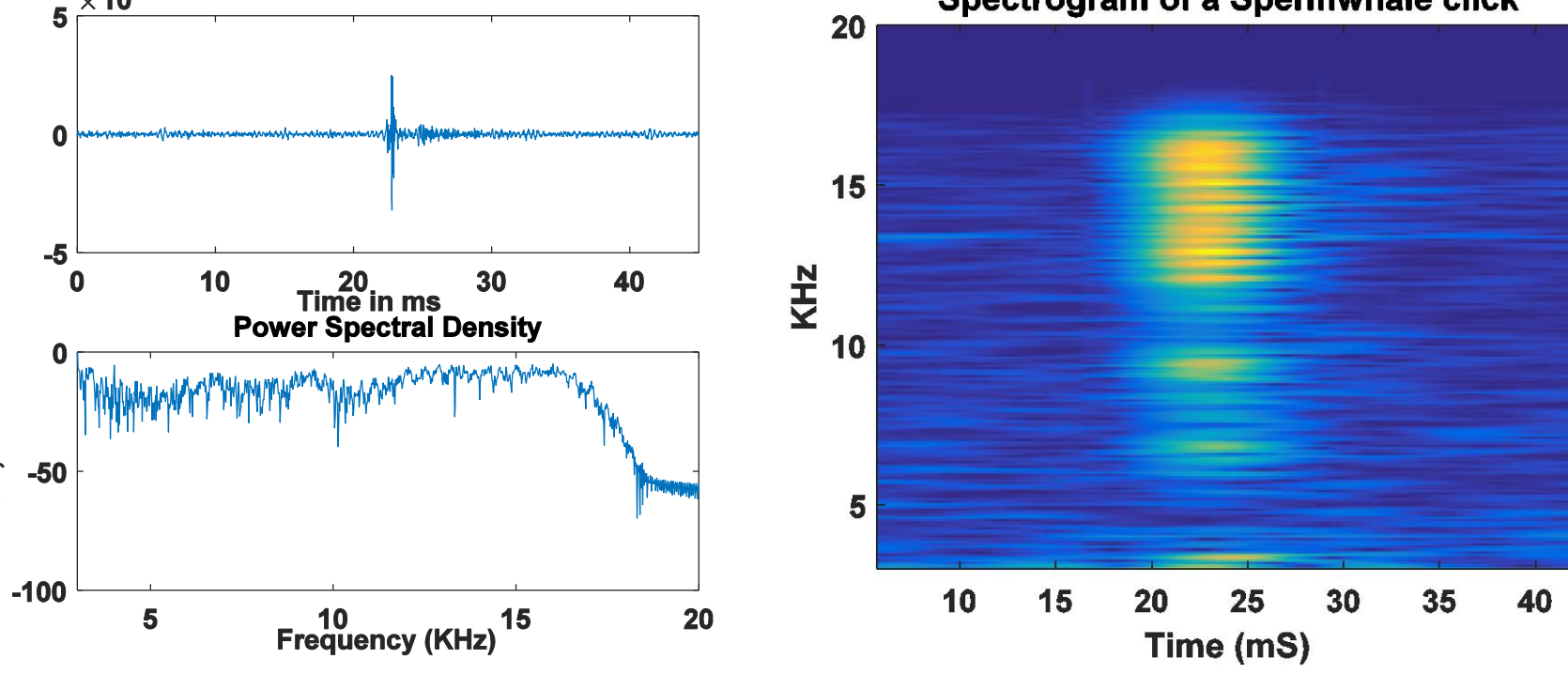

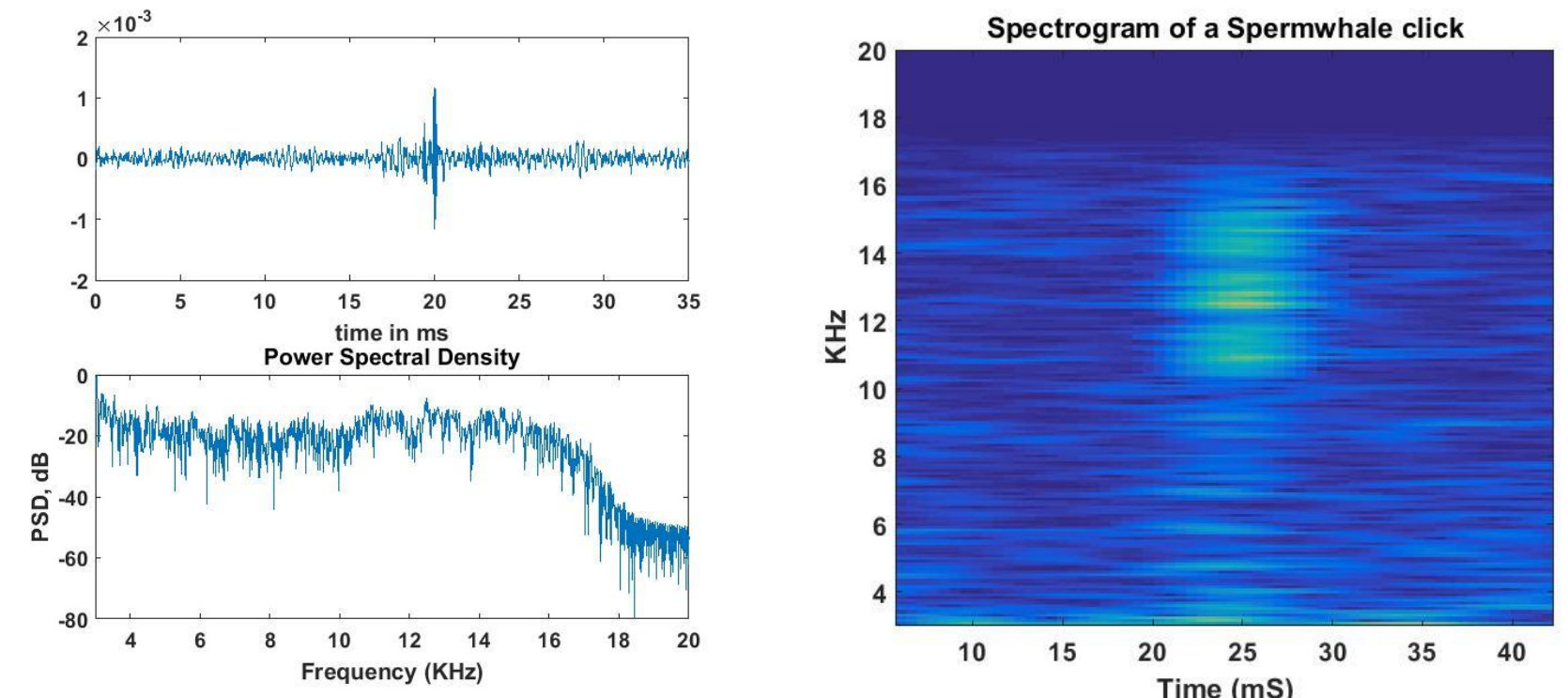Fig: Waveform signal and spectrogram of a detected sperm whale click

Fig: Waveform signal and Spectrogram of a detected click similar to sperm whale click which is excluded during false positive estimation
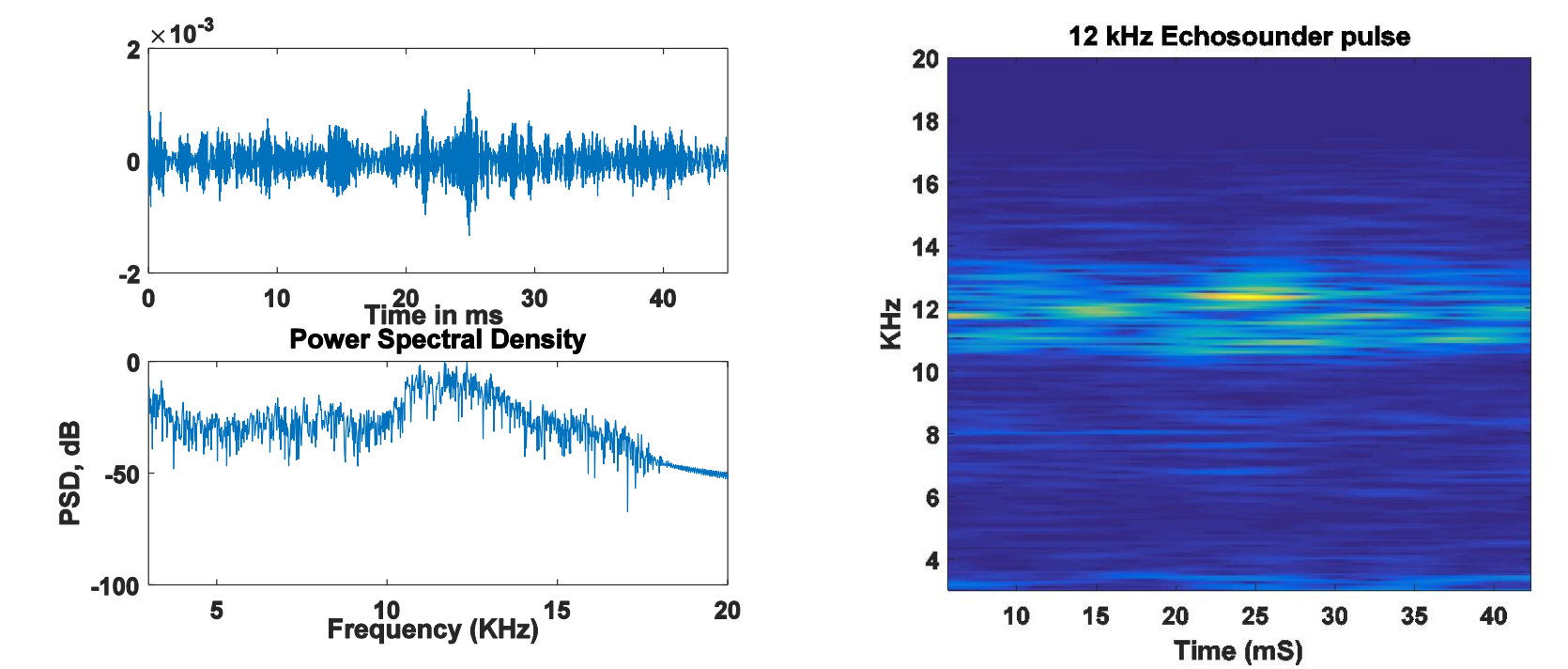

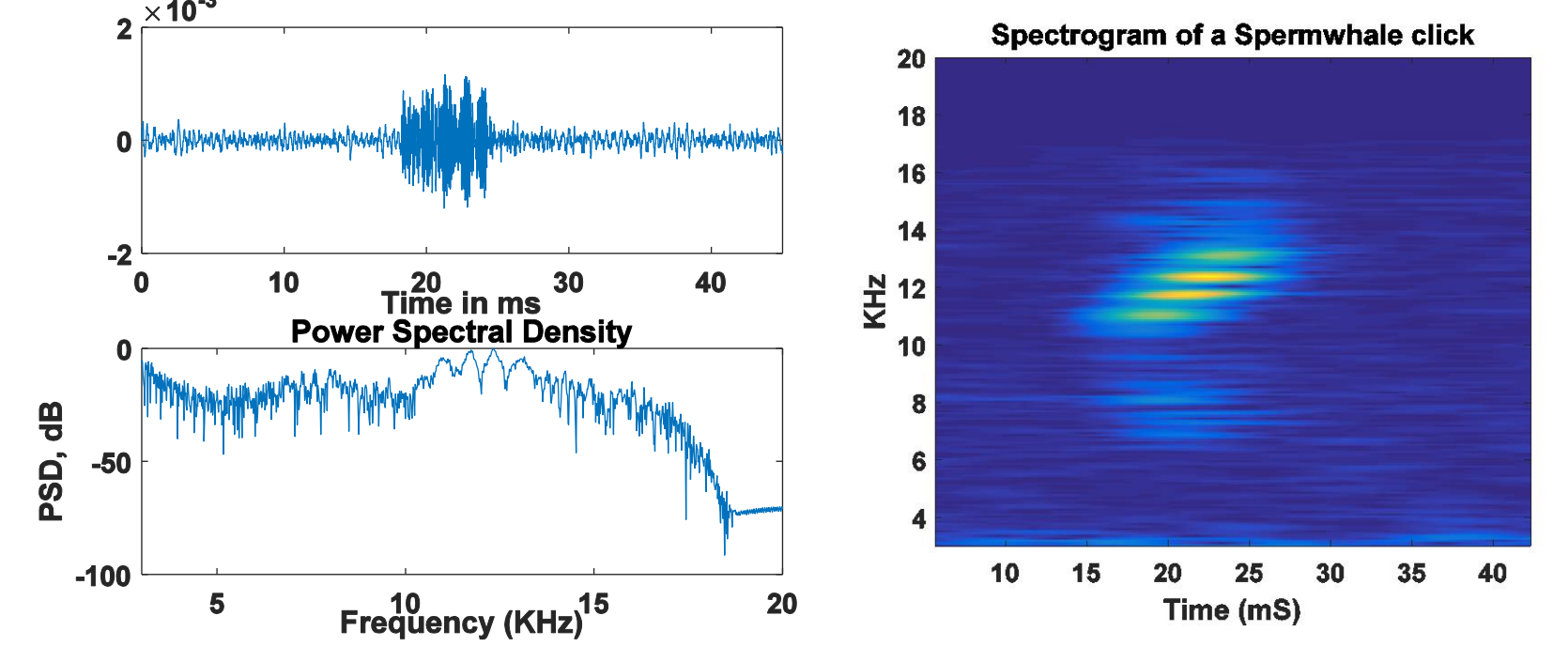Fig: 12 kHz sonar pulse from R/V pelican echo sounder

Fig: Unknown noise which is detected as a click excluded manually
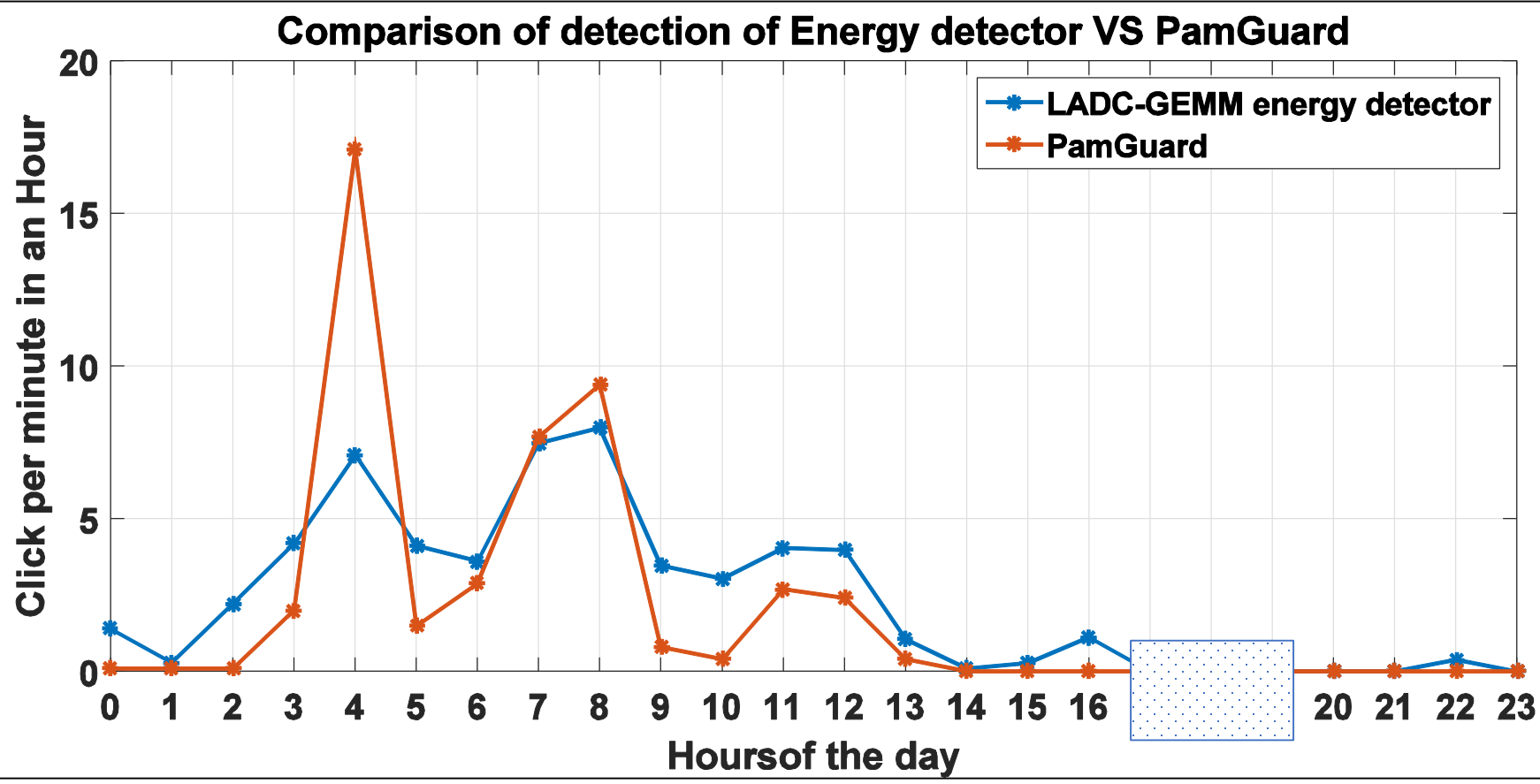
RESULTS

Fig: Detection of ASV data analyzed using LADC-GEMM energy detector and PamGuard.
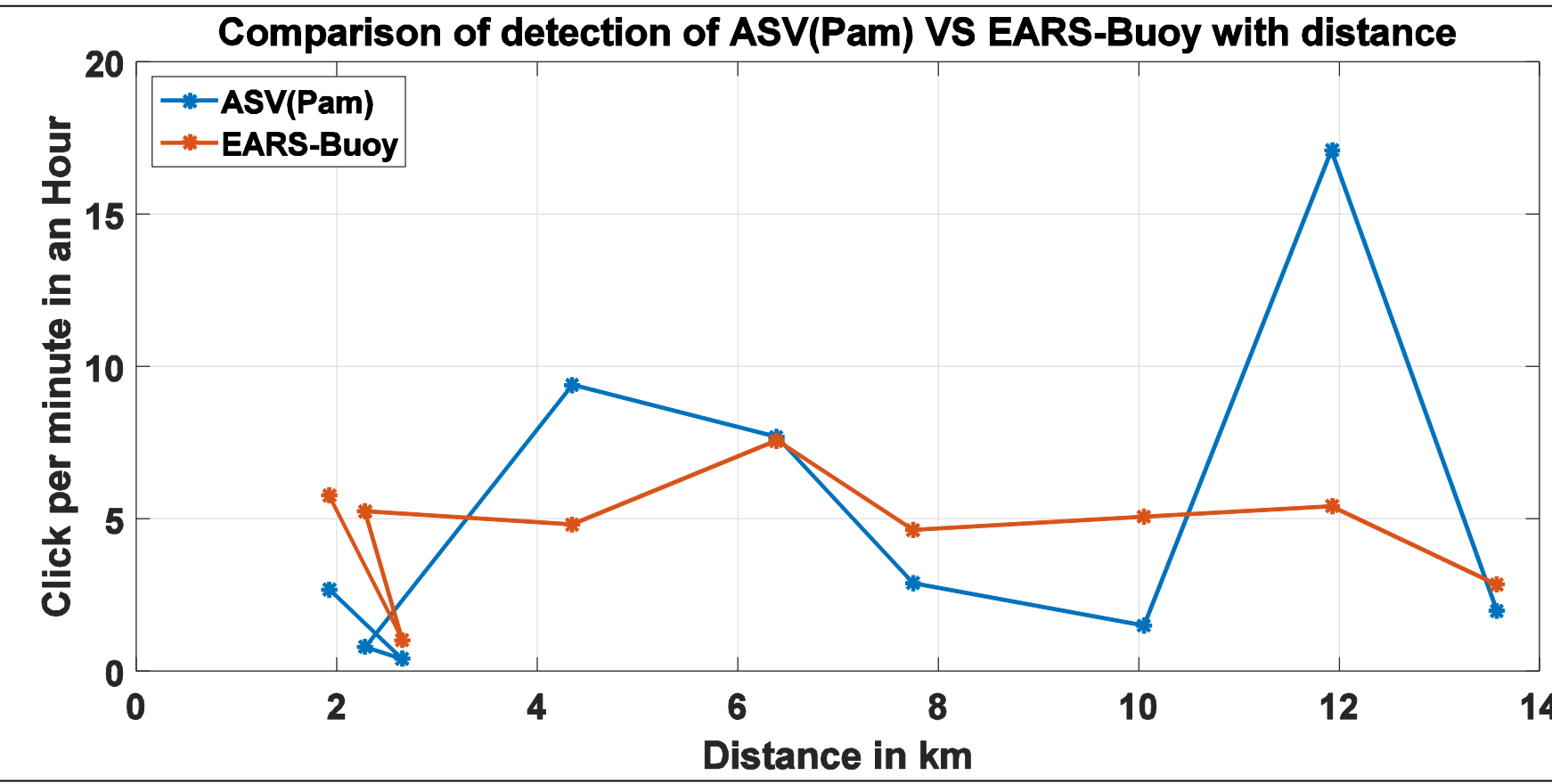

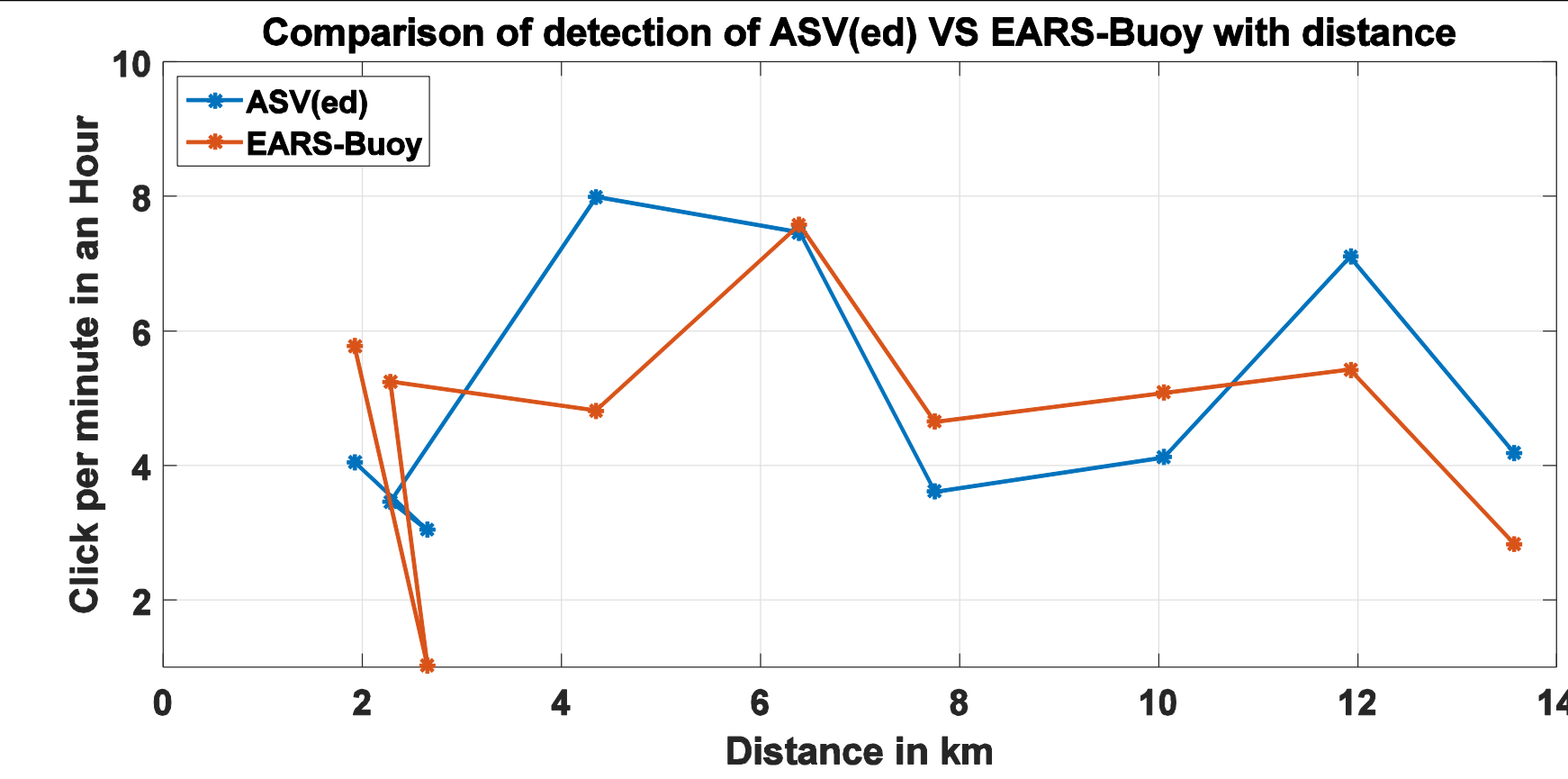Fig: Detection of ASV and EARS-Buoy data of overlapping time using their independent detectors.

Fig: Detection from ASV and EARS-Buoy data of overlapping time using LADC-GEMM energy detector.

CONCLUSION

- Detection rates from ASV and EARS-Buoy data using their individual detectors and a common detector are comparable.
- The efficiency of detecting sperm whale presence in the area is similar.
- The difference in detection rates could be resulted from a whale relative position to the ASV and EARS-Buoy. Future investigations are planned.
- ASV data contain more noise than the EARS-Buoy data. Average false positive for ASV is 44% where for EARS-Buoy it's 13%.
- The efficiency of two platforms to estimate regional population estimates will be investigated.

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