Signal Enhancement of Acoustic Signature of Lutjanidae Family Species in Indian Waters

R. Kannan, M. Prashanthi Devi, G. Karpaka Kannan

Abstract: The present study is to carry out the enhancement of the acoustic signals of Lutjanidae species often found in abundance, in tropic shallow waters. Since most of the studies on Lutjanidae is about its physical structure both internal and external, and its population in sea ie., catches in tons per year. This research work is the first attempt on the acoustical study of Lutjanidae family species call signal. Five species of Lutjanidae family are considered for this study which includes L. analis, L. apodus, L. synagris, L. griseus, and L. jocu). The earlier literature which studied the acoustic toning of marine species vocalization using empirical mode decomposition method [1]. Here in this research, (i) signals with background noise and (ii) enhanced signals are considered for comparison. The enhancement of acoustic signals of Lutjanidae family species is useful as acoustic reference for those working in the field of biological signal processing. The enhancement of the signal is achieved by the logical applications and applying Short Time Fourier Transform (STFT), inverse STFT. From the above two cases considered, the frequency range of 50 to 2500 Hz approximately is clearly noticed in the spectrogram, power spectral density and it shows the frequency of all species looks similar. By listening the sound produced by the species, it is observed to be of type knocking sound.

Keywords*: *Acoustics, Lutjanidae, signal enhancement, Indian waters.

I. INTRODUCTION

Passive acoustics provides several important benefits for fisheries research. Listening to fish sound provide a great deal to our knowledge of their abundance, distribution and behavior. Passive acoustics uses naturally occurring sounds to differentiate fishes call signals and other marine organisms, instead of using artificial sounds. Since oceans are vast, complex and optically opaque, acoustics can be used as premier tool to observe fish activity passively which in turn can be used to monitor fishes that produce sound. This provides the continuous or long-term monitoring since it is a non-invasive and non-destructive remote monitoring method. Daily and seasonal activity patterns of fishes and other marine organisms can be monitored. Listening ability to fish sounds leads to identify, record, and study about the marine species without any visual information. Combining passive acoustics with traditional fishery sampling techniques is new powerful approach. The first investigations devoted to sounds in fishes are known from the 19th century [2, 3]. Nevertheless, systematic studies of the sounds and of sound production mechanisms in fishes began later from 20th century. Over 50 years in fisheries surveys [4, 5], passive acoustics has been used to identify and recognize habitat use, monitor spawning areas, and study the fish behavior [6, 7, 8]. By using hydrophones, marine ecologists and fishery biologists recorded sounds produced by fishes and identify them [9, 10, 11], and individual species [12], signatures using signal processing algorithms. Sound truthing is important when it comes to identification and recognition of fish sound and it can be accomplished by using captive fish recordings and under natural conditions recordings. Captive fish recordings are always problematic because acoustic properties in a tank combined with unnatural behavior [13]. Fish sounds archived historically are being made available to researchers and the public through the internet [14]. The establishment of internet access to libraries of fish sounds is an important step to more widespread usage of passive acoustics in fisheries science and related fields. With the internet access to fishbase.org, the *Lutjanus* family signals collected by means of passive acoustics is used in this study.

II. SPECIES SELECTION

Considering *Lutjanidae* family species for this work is due to their abundance in shallow waters throughout tropics and they are valuable and well-regarded fishes. Distribution map and photos of Lutjanidae family species is shown in Figs. 1 and 2 respectively.

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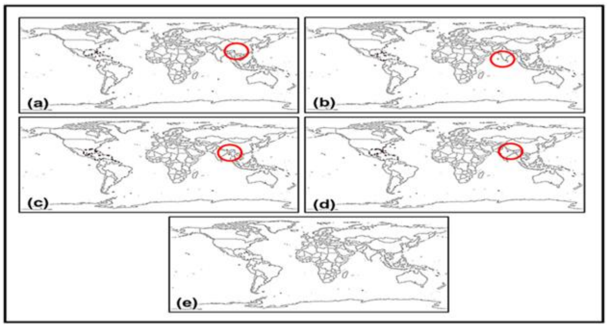

Fig.1 Distribution map of Lutjanus analis (a), Lutjanus apodus (b), Lutjanus synagris (c), Lutjanus griseus (d) and Lutjanus jocu (e)

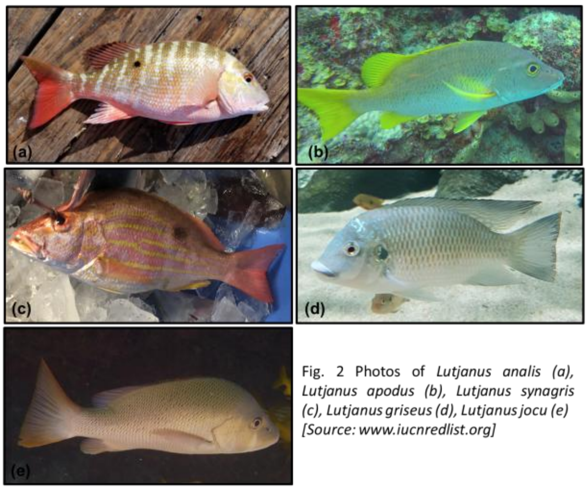

Fig. 2 Photos of *Lutjanus analis (a), Lutjanus apodus (b), Lutjanus synagris (c), Lutjanus griseus (d), Lutjanus jocu (e) [Source: www.iucnredlist.org]*

III. METHODOLOGY

To calculate the noise spectrum level, Welch's averaging periodogram method is used. Multiple spectra are obtained first by segmenting data into smaller portions, windowed with a Hamming window, and a 2048-point FFT with 50% overlap. Now the averaged spectra are used to obtain the final spectrum. The sampling frequency and the number of points in the FFTs in each power spectrum determines the frequency resolution as 21.5 Hz. Welch's averaging periodogram method is applied to the marine species considered in this study to plot the spectrogram. In this study, spectrogram of signals with background noise and spectrogram of acoustic signals without background noise. The enhancement of fish call signals has been done to clarify the time duration of each signals of each marine species [1] by the logical applications along with Short Time Fourier Transform (STFT), and inverse STFT. This methodology is used to find any variation in call signals among each species in *Lutjanidae* family.

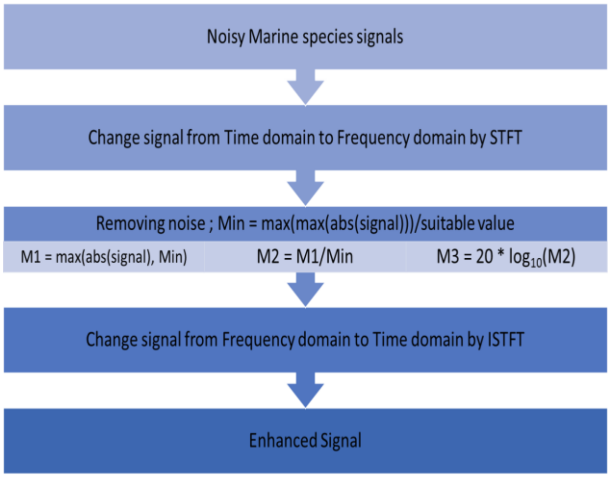

Fig. 3. Methodology flowchart to enhance the noisy signal

Flowchart of enhancement of signal is shown in Fig.3. In order to enhance the signals, it is better done in the following steps,

a) converting species call signal in time domain to frequency domain by the application of STFT.

b) If the signal presence is only in the specific frequency range, then remaining portion outside the signal frequency range set to zero.

c) In the next step, minimum value is estimated by dividing the maximum of maximum absolute signal value by suitable value.

d) Now comparison of the previous original signal values with the minimum value is done.

e) If the maximum value is higher than minimum, then it will retain its own value otherwise it is replaced by the minimum value.

f) In the next step, it is divided by the minimum value (Min) to make unwanted portion of the signal to be 1 and retains the call signal value.

g) For making unwanted portion of the signal to zero, logarithm is taken to the modified signal.

h) In the final step, for creating sound files of the enhanced signal, the signal in frequency domain are converted into time domain.

IV. RESULTS AND DISCUSSION

Spectrogram of *Lutjanus analis (a), Lutjanus apodus (b), Lutjanus synagris (c), Lutjanus griseus (d)*, and *Lutjanus jocu (e)* is shown in Fig. 4. In the spectrogram of each species, the upper one represents a noisy signal and the lower one represents an enhanced signal. It is observed from the spectrogram that the call duration of each species ranges from 0.08s to 0.1s and the frequency range is upto 2 kHz which is similar for all the species considered in this study.

By listening to the sound of each species, it is found that strong knock sound is observed for all the *Lutjanidae* family species considered. Time series of both noisy and enhanced signal of selected Lutjanidae family is shown in Figure. 5.

From the spectrogram and the time series plot, it is observed that the noise reduction is done perfectly using the methodology applied in this research and this leads to identify the call duration and the frequency range of each selected species.

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Power spectral density plots are plotted for the selected *Lutjanidae* family species and it is observed that all the species showing variations upto 2 kHz in a similar manner and after that noise level is almost flat which is shown in Fig.6

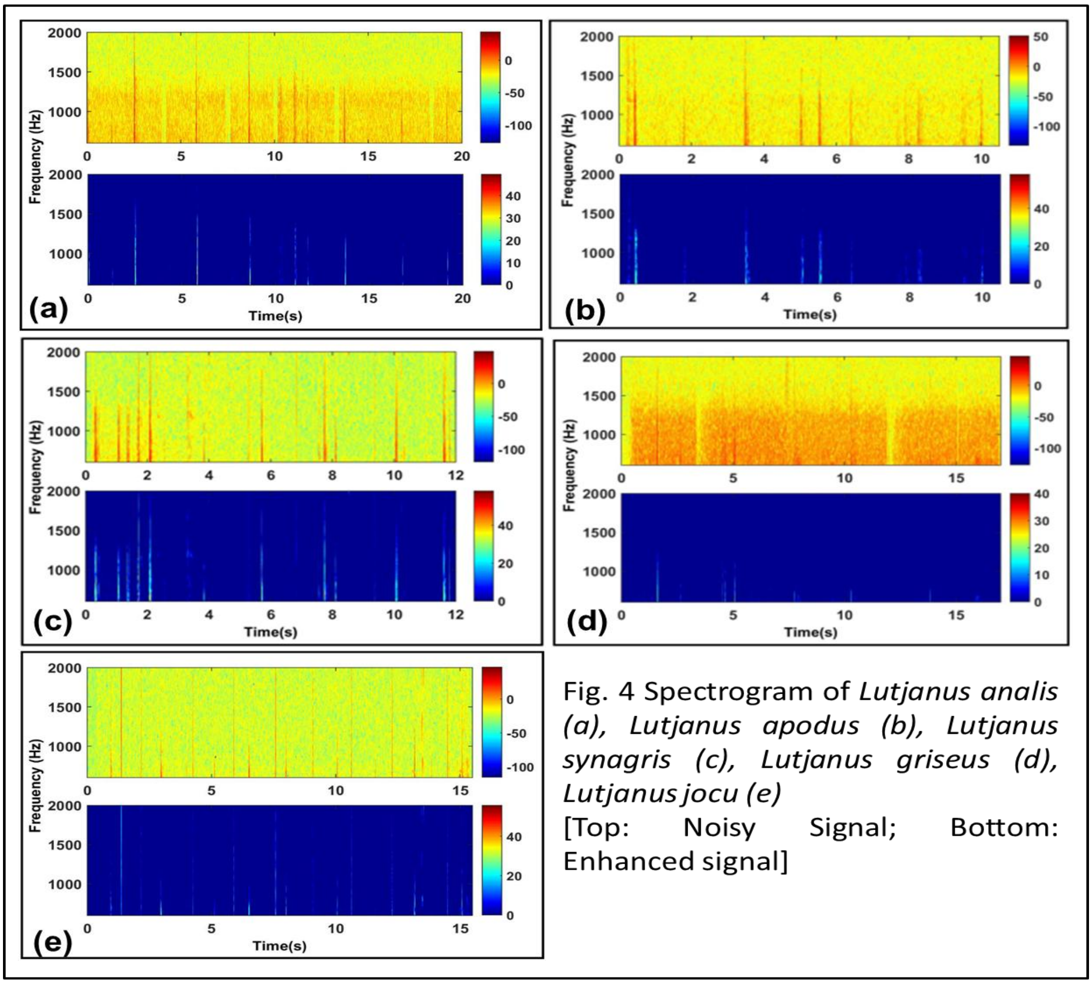

Fig. 4 Spectrogram of *Lutjanus analis (a), Lutjanus apodus (b), Lutjanus synagris (c), Lutjanus griseus (d), Lutjanus jocu (e)*
[Top: Noisy Signal; Bottom: Enhanced signal]

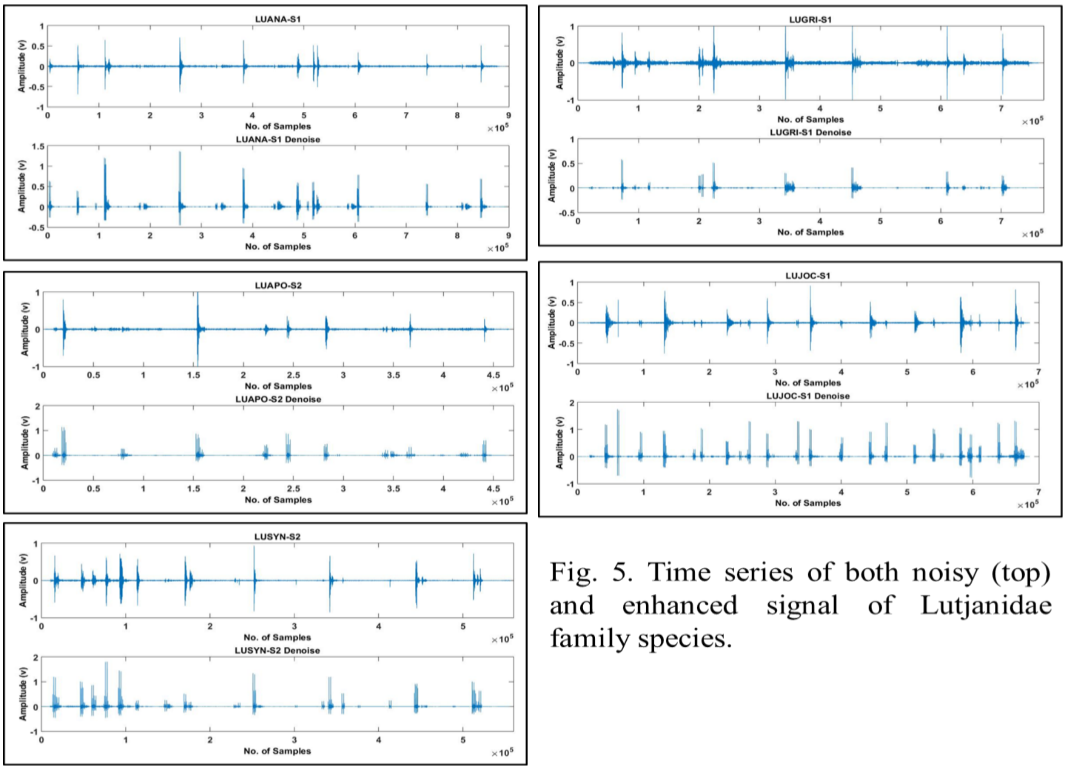

Fig. 5. Time series of both noisy (top) and enhanced signal of Lutjanidae family species.

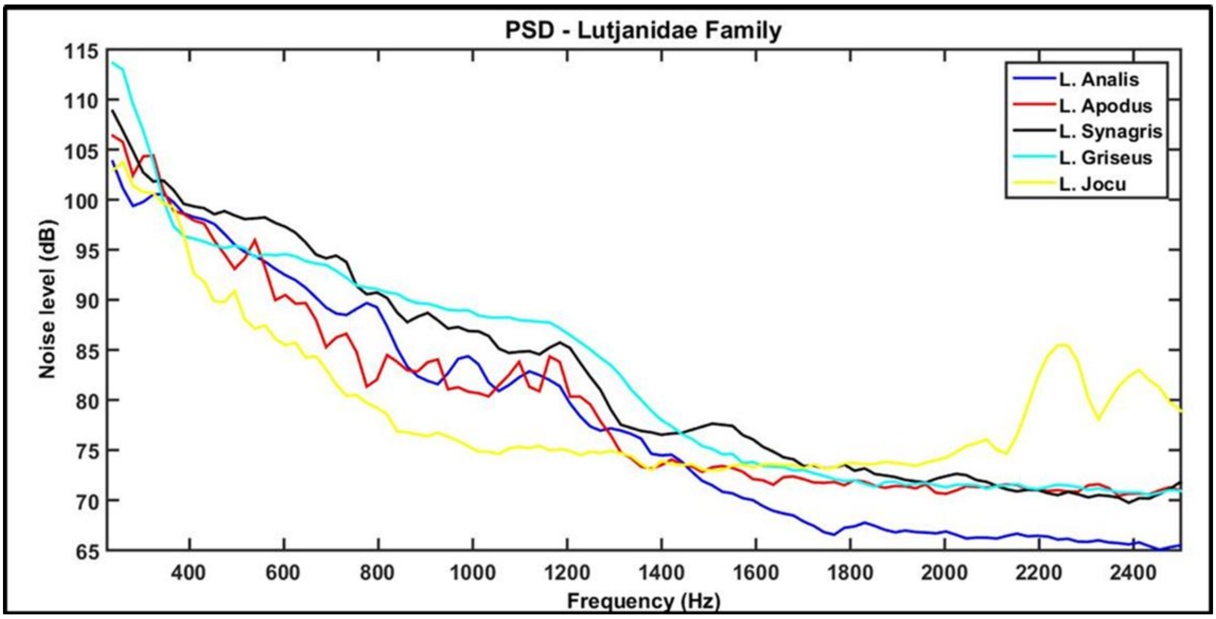

Figure. 6 Power spectral density spectrum of *Lutjanidae* family species

V. Conclusion

This study is the first attempt on the signal enhancement of acoustical signature of *Lutjanidae* species. In conclusion, the findings from this present study revealed that the variation in call duration and call frequency of the selected *Lutjanidae* species are very little. Hence, it is easy to identify the species under *Lutjanidae* family by means of acoustical signal enhancement processing. The results observed from this study can be used as an acoustical reference for *Lutjanidae* family species which is found abundant along the Indian waters.

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