Three dimensional mapping of aquatic plants at shallow lakes using 1.8 MHz high-resolution acoustic imaging sonar and image processing technology.

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1. Motivation

Aquatic plants play an important role in underwater ecosystems and have an impact on the biological diversity of the world. However, many aquatic species are decreasing in number [1].

A very accurate mapping and monitoring system to assess the well-being and distribution of aquatic plants is needed.

Table 1. Current survey methods.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Diver</th>
<th>Satellite</th>
<th>Acoustic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>✗</td>
<td>☀</td>
<td>○</td>
</tr>
<tr>
<td>Turbidity</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Classification</td>
<td>☐</td>
<td>△</td>
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</table>

In this study, we proposed a new observation method and an image processing technique to assess the individual spatial distribution of aquatic plants in mixed communities.

4. Acoustic image processing

Characteristics of leaves and rods of aquatic plants were different between the species. It was seen in the acoustic images as differences in intensity and shape. The classification and 3-D [2] mapping of aquatic plants methods based on spectrum analysis with DoG (Difference of Gaussian) filtering and difference of intensity were developed and tested in this study.

DoG = G(u,v) = G(u,v) - G(u,v) = \frac{1}{2\pi \sigma^2} \left( e^{-\frac{1}{2}(u^2+2uv+v^2)} - \frac{1}{\sigma_2^2} e^{-\frac{1}{2}(u^2+4uv+4v^2)} \right)

\sigma, \sigma': dispersion

\mu, \mu': position

Frame rate: 8 fps
Range: 5-10 m
Frequency: 1.8 MHz
Tilt angle: around 40°
Pixel count: 96(H) × 512(V)
Beam width: 29(H) × 3(V)

Fig. 1 Observation site

In this study, we applied the proposed acoustic image processing to high-resolution acoustic image (resolution: 5 mm ~ 2 cm) and 3-D mapping of aquatic plants was reconstructed. The distribution of three types of aquatic plants including two endangered species was visualized with the values of water depth and volume. Chara globularis was distributed at shallow area (1 - 3 m), Elodea nuttallii was mainly middle area, and Nitella flexilis was deep area (5 - 7 m) but competing with Elodea nuttallii. Thus, this measurement system, based on high-resolution acoustic imaging, can be useful for assessing the status of lakes and the distribution of aquatic plants.

5. Classification and 3D mapping in mixed community area

The results of our study demonstrate that imaging sonar can be used to reconstruct the underwater status of lakes. The high-resolution acoustic images obtained allowed us to identify individual aquatic plants with high accuracy. At the mixed community area, our proposed processing method could classify two species of aquatic plants and help us to understand the spatial distribution of them.

Fig. 2 Experimental set-up

6. Conclusions

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References

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