Abstract of FY2011 Master's Thesis

(Department of Ocean Technology, Policy and Environment
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3D Views Generation and Species Classification Methods of Aquatic Plants Using Acoustic Images

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1. Introduction

In this study, aimed to obtain the growing information of *Chara globularis Thuillier var. globularis* (*Chara globularis*), a new survey system by using acoustic solution had been developed. The effectiveness of the system has been proved in two different field experiments. In the data processing period, a new analyze method which including generating 3D views of aquatic plants, measurement of length and volume for each waterbody has been realized. Furthermore, efforts to classify the species of aquatic plants had also been made in this study.

1.1 Background

As a member of the nature, the aquatic plants play a very important role not only to the underwater ecological environment but also to the biological diversity of the world. However, caused by eutrophication of lakes, introduction of grass carps and foreign species or other threaten created by human beings, lots of species of them become extinct or endangered. One of them is *Chara globularis*.

It is a kind of submerge aquatic plants which has been proved had the ability of purifying water in lake. In Japan, *Chara globularis* used to be found in the lakes located from Hokkaido to Honnsyuu area. The distribution of them had been recorded from 26 Japanese lakes in 1964, but only in 8 lakes among 18 lakes surveyed during 1994 to 1997. *Chara globularis* has been listed as the first class threatened plants（CR+EN)[1], who are in serious situation of being extinct.

Although habitat surveys for aquatic plants are held in many researches, manual measurements is still the main method, which is very labor intensive, and fatigue may cause low-accuracy in survey result. Furthermore, distribution results got from these researches are always in a gross scale and the growing information for each waterbody (length, width, process of growing and etc.) is hardly to know.

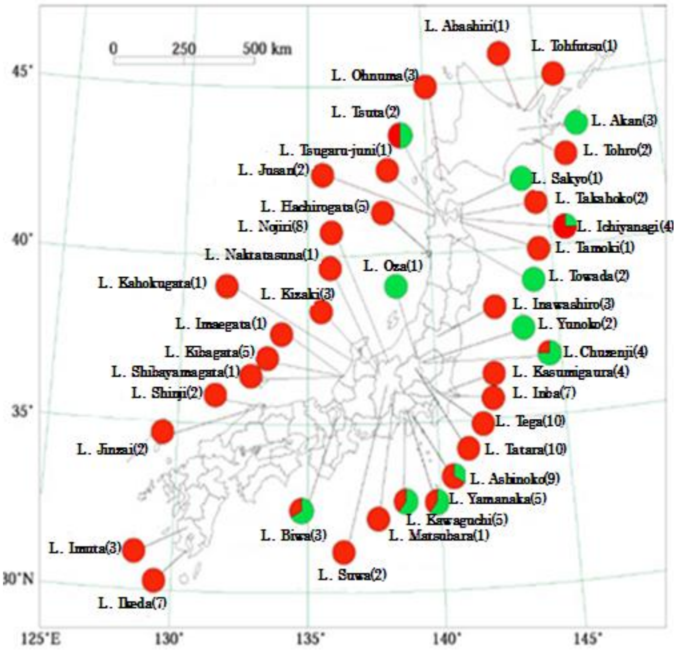

Fig. 1 Distribution of *Charophytes* (translated from [2])*Number in the () shows the species founded in the survey 1964. Red means extinct while green means existence rate in the survey 2005.

Obviously, in order to protect and revival endangered aquatic plants like *Chara globularis*, a much more efficient survey method with high-accuracy analyzing method which can give out the growing information of aquatic plants individually were required.

1.2 Aim of the study

Consider with the situation of endangered aquatic plants and observation methods used in the past surveys for them, the aim of the study was :

1. To develop a new acoustic survey system, assembled with acoustic solutions and other sensors, which provides much more reliable and high-accuracy observation data including details of each waterbody.
2. To develop suitable analyze methods including the image processing and classification of aquatic plants with the acoustic data.

2. Methodology

2.1 System design

In this study, the new survey system for endangered aquatic plants consists of DIDSON (Dual-Frequency

Identification Sonar) with concentrator lens, motion sensor, GPS, data collect PCs and optical underwater video camera. The effectiveness of the system had been proved in two field experiments. Although there were a few changes had been made in the 2nd field experiment, the main design and setting of the systems and its' image of data collection were showed in Fig. 2.

2.2 3D views generation of aquatic plants

Up to now, results of surveys for aquatic plants are always in a gross scale and the growing information of each individual could not be known easily, especially in turbid water. Thus, during the data processing, we sat 3D views generation of aquatic plants as the first mission, since it represents how each individual grows in the crowd. Since each DIDSON frame in itself is a record of 2D information, in order to generate the 3D views, it is necessary to reinforce the DIDSON frame with information of heading, tilt, and position. Fig. 3 is detail steps of the process. Fig. 5 shows an example of 3D views generated by 100 frames. Fig. 6 shows the comparison of views generated by acoustic images and the shot of underwater optical camera at same location.

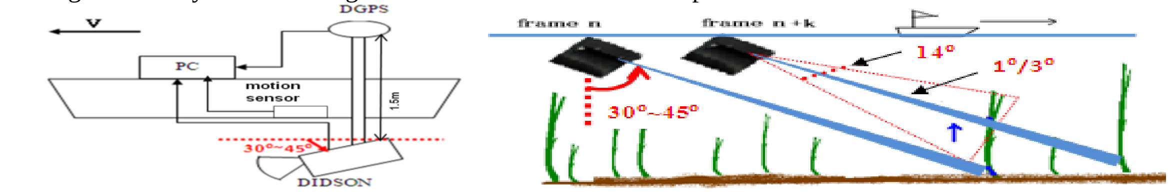

Fig. 2 Equipment setting & image of data collection of DIDSON system [3]

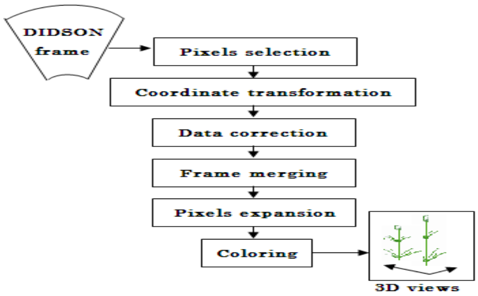

Fig. 3 Steps of the 3D views generation of aquatic plants

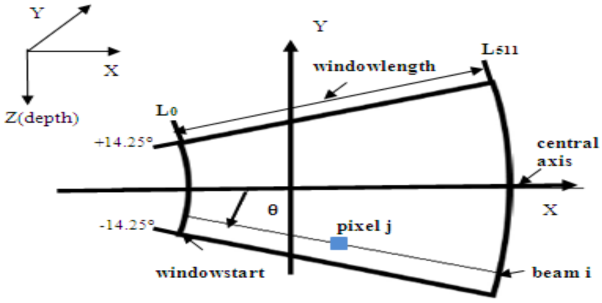

Fig. 4 2D coordinate transformation in DIDSON frame [3]

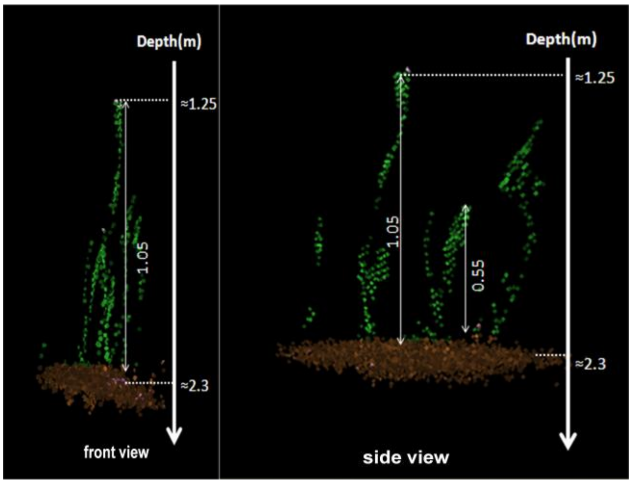

Fig.5 Front view and side view of aquatic plants generated by 100 frames[3]

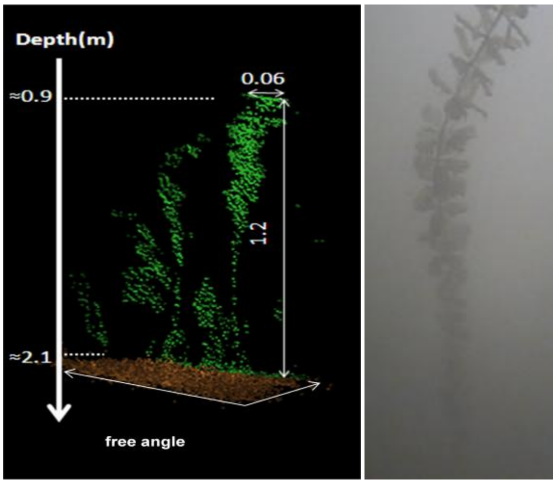

Fig.6 Compare with the Aquatic plants shot by optical underwater camera (*Myriophyllum spicatum*) at same location[3]

2.3 Methods of species classification with features in acoustic images

A much more challenged mission is to do the species classification by analyzing the acoustic data. Compared the DIDSON data and the sample of the optical underwater video camera at same locations, there were several species of aquatic plants had been found in the survey area. Among them, including the main target of this study, Chara globularis, three species had been set as the classification objects (Fig 8). Several attempts (Fig. 7) had been made to finish the classification.

2.3.1 Species classification of aquatic plants with shape feature

Main step in this method was shown in the left part of Fig. 7. In this method, we tried to use P-type fourier descriptor to describes the contour of each species, unfortunately, the classification result (*Myriophyllum* *spicatum*: 60~70%, *Chara globularis*:40%~50%,*Elodea nuttallii*:40%) was not very satisfied. The low identification rate might be caused by several unavoidable steps in this method, and the species classification method of aquatic plants with shape feature in acoustic images seems not suitable for this case.

2.3.2 Species classification of aquatic plants with acoustic features

2.3.2.1 Histogram

Center part of Fig.7 shows the process in details. First, a focusing area of 128 pixels *128 pixels had been set. After the normalization, extraction of valid pixels started in the 128 pixel * 128 pixel- area beam by beam. However, since the size and intensity of aquatic plants was diverse frame by frame, the amount of valid pixels in each extraction view were not always the same, and the difference caused the height of peak in the histogram were totally different no matter they were same species or not. On the other hand, normalization before drawing the histogram made the width of mountain in histogram for each species is less depended on other conditions. Referenced with it, it could be concluded directly, that echoes of *Chara globularis* covers the smallest distribution. It indicated that echoes came back from parts of *Chara globularis* (leaves, branches and etc.) were much more similar to each other than the other two species did.

2.3.2.2 FFT analysis

2.3.2.2.1 Data set for FFT

Since the interval between two neighbor pixels in horizontal is increasing with the sample number of the pixel, normalization of the interval is necessary before doing the FFT. In the normalization, new interval in horizontal had been set as 5mm, while there is no change in vertical. Then the data collected by cutting each frame into slim slices. In each slice, there are 256 points, the center point is the one on the center line in DIDSON frame (between beam No.48 and beam NO.49, each frame contains 96 beams), and the distance between two points is 5mm, while the distance between two slices is just the same as the original distance between two samples in a DIDSON beam.

2.3.2.2.3 Relationship between FFT result and the structure of aquatic plants

By analyzing the FFT result of slice data, several parameters were seemed to indicate the structure of species.

1. Rate of High component/Low component

It was considered that the high components in the FFT result represented the fine part of the aquatic plants, while the low components stood for the coarse part. Therefore, the higher the rate is, the higher percentage of the fine part does the species contain. It can be seen from the photo in Fig. 8, in each slice data of aquatic plants, the one of *Myriophyllum spicatum* is the most detailed while the one of *Elodea nuttallii* is the lowest. And it was confirmed by the High component/ Low component of the three species. (*Myriophyllum spicatum* > *Chara globularis* > *Elodea nuttallii*)

2. Average of FFT peak position

The FFT peak position indicates the width (half of the wavelength) of the aquatic plants' fine part in the slice. Normally, the fine part of aquatic plants refers to the leaves. In the case of Myriophyllum spicatum, the mean value of the FFT peak position is 37.88, which means the half of wavelength at that position is nearly about 1.68cm, belongs to the range of leaves' width (1~1.8cm, [4]). However, since we collected the slice data with a 5mm interval between two points, which is over the leaves' width of *Chara globularis* and *Elodea nuttallii*, the mean value of the FFT peak position indicates the width of the whole body in the slice. The one of *Chara globularis* is about 2.16cm, and the one of *Elodea nuttallii* is nearly 2.83cm. Obviously, *Chara globularis* is much more slender.

3. Standard deviation of the FFT peak position

Standard deviation of the FFT peak position indicated the width distribution of leaves for each species.

2.3.2.2.4 Classification with parameters generate from FFT result

Using the parameters mentioned above as the axes of a 3D coordinate, the three species aquatic plants trend to be classified. Parameters of the same species distributed as a cluster in the 3D coordinate (Fig. 8).

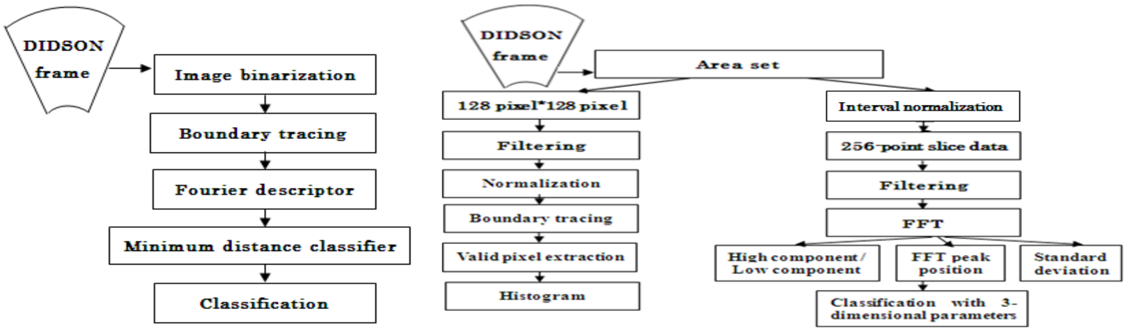

Fig.7 Steps of species classification with different features (Left: shape feature, Center: histogram .Right: FFT analysis)

3. Conclusion

In this study, setting *Chara globularis* as the mainly target, a new survey system by using acoustic solution had been developed. It succeeded in collecting the echoes of aquatic plants including the ones of endanger aquatic plants which is too weak for former acoustic system to realize. The effectiveness of the system has been proved in two different field experiments at Yamanakako and Yunoko.

In the data processing period, a new analyze method which including generating 3D views of aquatic plants, measurement of length and volume for each waterbody has been realized. After several attempts to do the classification with acoustic data, using parameters generated from the FFT result was confirmed as the best solution for this study. Within the survey data, parameters of the same aquatic plants trend to distribute as a cluster in the 3-dimensional coordinate. Classification can be finished by limiting the range of parameter.

Actually, distribution of *Chara globularis* had been found both at Yamanakako and Yunoko years ago [2]. However, the acoustic of it could only be confirmed in the survey data of Yunoko which also has a trend of decline. By analyzing the acoustic data of *Chara globularis* and *Elodea nuttallii*, the two species seemed to habitat at similar area,it can make the guess that *Elodea nuttallii* has a stronger structure to endure the change of conditions and which might make it become the rival of *Chara globularis*.

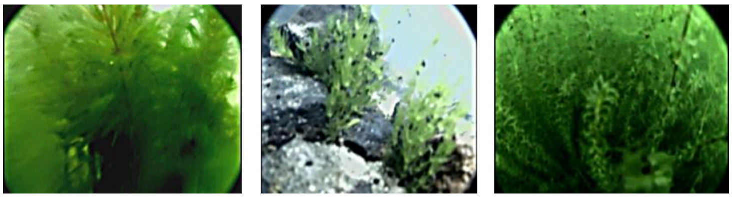

Fig. 8 Photo of classification objects (captured from sample of underawater optical video camera at Yunoko , left: *Myriophyllum spicatum* ,center: *Chara globularis*,right: *Elodea nuttallii*)

Table. 1 Parameters using in the classification

Aquatic plants	High component/ Low component	Average position of FFT peak	Range of standard deviation
Myriophyllum spicatum	4.36~5.27	27.6~51.6	17.3~27.1
Chara globularis	3.43~4.09	21.4~38.3	10.5~19.8
Elodea nuttallii	1.78~3.24	18.2~30.9	3.3~15.3

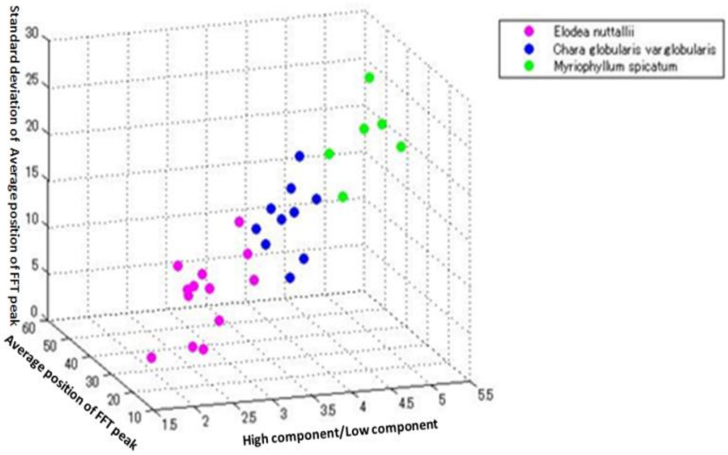

Fig. 8 Classification result by using 3 parameters

For future work, distribution map including the growing information of each waterbody is expected to be generated after the species classification by using the methods developed in the study. Furthermore, using the survey system to collect acoustic data for various aquatic plants and analyzing the growing information (3D views) and acoustic feature for each species with the methods developed in this study is also thought to be a meaningful task.

In a summery, in this study, a new acoustic survey system for endanger aquatic plants had been developed. With the data collected by it, methods of generating 3D views and measuring the length, volume of aquatic plants had been realized. By abstracting the acoustic feature, classification of different species had been succeeded by using several parameters. We hope the system and methods developed in this study will be useful in the field of research and protect for aquatic plants in the future.

4. Reference

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