A STUDY ON THE ESTIMATION OF FARMED MARINE PRODUCT OUTPUT USING AERIAL IMAGES —A CASE STUDY ON BUSAN LAVER FARMING—

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ABSTRACT: In Korea, the fish farming industry produces more fish resources than the general fishery, and its annual output is also on the increase, becoming the major source of the fishing industry. In particular, Korea is a world-class producer of the diverse marine products including laver, sea mustard, abalone and oyster, thus contributing to the food resources and the exporting industries. Therefore, the demand for ensuring efficient fish farm management and monitoring is increasingly being required, and to do so, there is a need to estimate the farming facility quantity and output.
The farmed marine product output data include Statics Korea's fishery production statistics and fish farming investigation results, and these statistics are the results of the full survey and sampling survey of the year-end farmed output by breed of fish in all marine farmers in the country. However, in the case of the farmed output by fish and other major breed, the output by city and province is provided, making it impossible to identify the specific output by city, county and district and the farming facility quantity of by individual unit. Thus, this study used the prior studies-proven aerial imagery-based marine farming grounds' facility calculation quantity in estimating the farmed marine product output by city, county and district and by individual farmer unit.
This study is significant in that it used the existing output statistics provided by item or area and the farming facility quantity data in estimating the output from farming facilities in particular areas and in areas required by users. The proposed method can help estimate the individual farmers' farmed marine product output in other areas as well, and it is expected to be used by people engaging in fishery and local government officials for their efficient decision making.

1. INTRODUCTION

Korea's marine fish farming industry produces more fish resources than the general sea fishery, and it increases the annual output and has now become a major pillar of the fishing industry. In particular, Korea is a world-class producer of laver, sea mustard, abalone, and oyster among other marine products, thereby contributing greatly to the production of food resources and exporting industries. Therefore, there has been a growing need for the efficient management and monitoring of fish farms, and to do that, there has been a need to calculate the farming facility quantity and output.
As part of the fisheries observation and monitoring project designed to control the supply and demand of farmed marine products, the Ministry of Oceans and Fisheries ("MOF") and Korea Maritime Institute ("KMI") conduct the fish farm reading project using the remote sensing technology based on the aerial images filmed every year (KAMI, 2015). The fish farms reading project aims to read and partition individual farming facilities so as to calculate the farming facility quantity for the target observation breeds such as laver, sea mustard, abalone, fish, oyster, mussel and sea squirt. Currently, KMI is using both local governments' farming license data and farming facility reading data in identifying and investigating illegal fishing grounds.
Many studies have been conducted to improve the facility reading accuracy using aerial images. KMI conducted research on the satellite-imagery-based farmed marine products reading and facility quantity calculation. Jo(2011) conducted research on high-resolution aerial-pictures-based effective calculation of the facility quantity for laver, laver, and fish farm. Yun Jae-ung(2016) conducted research on extracting the high-precision outline information of the marine farming cages, using the Harris Corner Detection method. Further, Lee Jang-bae(2017) conducted research on estimating the Styrofoam buoy use amount based on aerial images and image treatment algorithms, and

on analyzing the effectiveness of using aerial images for monitoring Styrofoam buoys and for analyzing the status. Previous studies on the marine farming facility quantity have focused on using the remote sensing data – satellite images or aerial pictures – in conducting passive reading and facility quantity calculation, or on monitoring facilities or buoys.

The farmed marine product output data include Statics Korea's fishery production statistics and fish farming investigation results, and these statistics are the results of the full survey and sampling survey of the year-end farmed output by breed of fish in all marine farmers in the country. The statistics can be inquired about and downloaded at the national statistics portal (KOSIS), and are also provided by e-Nara Indices. The data have been provided until now from 1998, and notably the fish farming status survey has been conducted since 2005. The output by fish and other major fish breeds of farming is provided by city and province, and the specific output by city, county and district and the facility quantity by individual farming unit cannot be known.

Thus, this study used the previous research-proven aerial images-based fish farm facility quantity calculation method in estimating the farmed marine product output by city, country and district and by individual farms.

2. RESEARCH TARGET SCOPE AND DATA

This study targeted Gangseo-gu and Saha-gu coast in Busan as the spatial scope with the focus on laver farms. The fish production statistics by Korea Statistics covers fishing types, breeds, and cities and provinces. Of the statistics, laver farming statistics covers Busan, Incheon, Gyeonggi Province, South Chungcheong Province, North Jeolla Province, South Jeolla Province, and South Gyeongsang Province. The output statistics by region does not cover the output by local government. Thus, Busan was selected because it offers well-arranged laver farming facilities and makes it easy to identify the farm status when observed from nearby Gadeokdo.

The research time range covered 3 years – 2015, 2016 and 2017 – for the yearly analysis, and aerial images at 25cm resolution were used as the research image data. Figure 1 shows the target research area and the research target marine product.

Further, the facility quantity herein was defined as the actual laver farming facility quantity (unit), and the output refers to an output (kg) that is estimated based on such laver farming facilities.

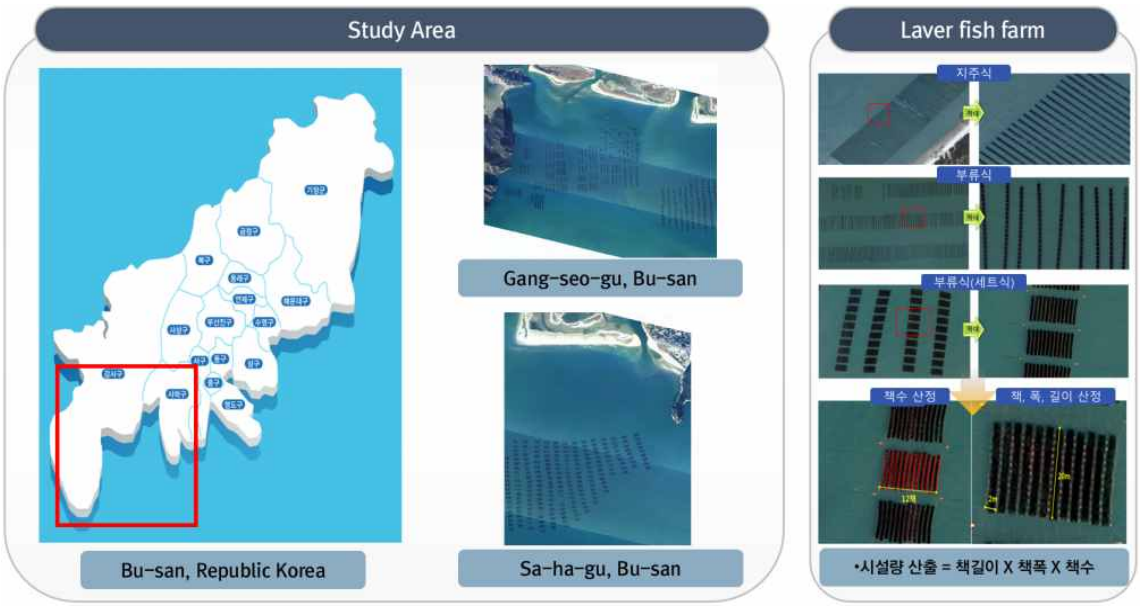

Figure 1. Target research area and marine product

3. RESEARCH COURSE AND METHODOLOGY

3.1 Study Flow

This study uses corrected aerial images in reading Busan laver farms, in calculating the facility quantity and in estimating the output so as to read individual farms, thus calculating the facility quantity and analyzing facility

changes. Then, the output in Korea Statistics' fishing statistics by city and province is estimated by dividing the earlier calculated facility quantity by individual facility's ratio so that the output is determined according to Korea Statistics' facility ratio proportioned to the yearly output by city and province. Figure 2 shows the estimation course.

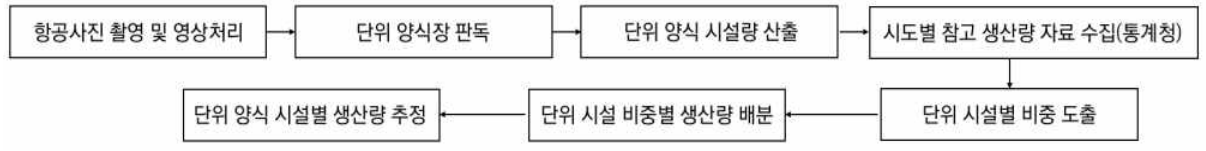

Figure 2. Study flow chart

3.2 Calculation and Analysis of Laver Farm Facility Quantity

Busan laver farms are mostly installed in the buoy style (set style), and the width per unit is 1.6～2.0m and the length is 18～23m across the farm. The laver farm facility quantity calculation method using aerial images is shown in Table 1, and Figure 3 is an example of laver farming facility.

The facility quantity DB was constructed after verifying the aerial images reading-based farming facility size and facility quantity, licensed insides and outsides, possible bigger sizes than the capacity, etc. through the field investigation, and reflecting the results.

Table 1. Laver farm facility quantity calculation method

Item of farming	Facility quantity calculation method	Conversion into facility quantity
Laver	No. of unit × unit width × unit length	88.0 ㎡ per unit

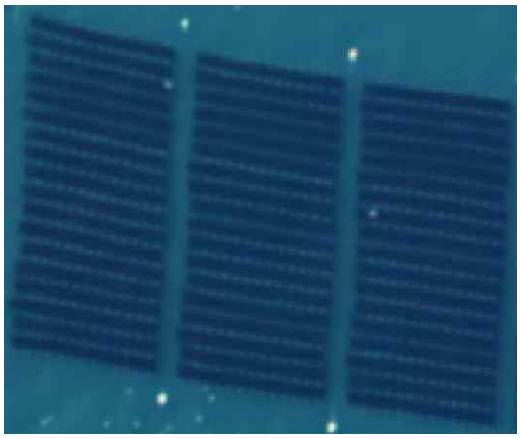

Figure 3. Aerial images of Busan laver farming

3.3 Data Collection of the Output by region and Item

Table 2. Busan natural marine fishing farm output

By fishing type	By breed	By administrative district	2015	2016	2017
			output(kg)	output(kg)	output(kg)
Natural marine fish farming	Laver	Busan	13,791,000	13,941,000	17,168,000

〈Source: Korea Statistics' 'statistics by fishing type, breed, and fishing method'〉

〈Note: Based on 2015, 2016, and 2017〉

The output by region and item was calculated by referring to Korea Statistics' 'statistics by fishing type, breed, and fishing method'.

3.4 The Individual Laver Facility Quantity Estimated Output

The individual laver facility quantity(A) was calculated. (A)'s ratio (C) was calculated based on Busan's total laver facility quantity (B). Based on Korea Statistics' annual output(D), an output was assigned according to the calculated facility quantity ratio so as to estimate the output(E) of individual farming facilities. This process was expressed in the Expression below.

$$C = A/B*100$$
$$E = D/C*100$$

4. DISCUSSIONS

Using aerial images, we read Busan laver farming facilities, calculated the facility quantity and referred to Korea Statistics' statistics by fishing type, by breed, and by fishing method according to cities and provinces. Using the actual facility quantity data and Busan's natural marine farming output, we estimated the farmed marine product output by individual unit not by city and province. TABLE 3 shows the actual facility quantity(unit) and estimated output (kg) from 2015 to 2017 in laver farming facilities in Gangseo-gu and Saha-gu, Busan.

Table 3. Busan's actual laver farming facility quantity(unit) and estimated output(kg)

Category		Actual laver facility quantity(unit)			Estimated laver output(kg)		
		2015	2016	2017	2015	2016	2017
Busan	Gangseo-gu	11,430	13,984	14,559	8,692,551	10,443,566	13,160,164
	Saha-gu	6,703	4,682	4,433	5,097,155	3,496,709	4,007,457

In the case of Gangseo-gu, Busan, over the 3 years, both the facility quantity and output actually increased sequentially. In the case of Saha-gu, Busan, however, compared to 2016, the facility quantity decreased in 2017, but the output increased. This suggests that a facility quantity increase does not necessarily lead to a proportional output, and more studies are expected to be conducted in this regard.

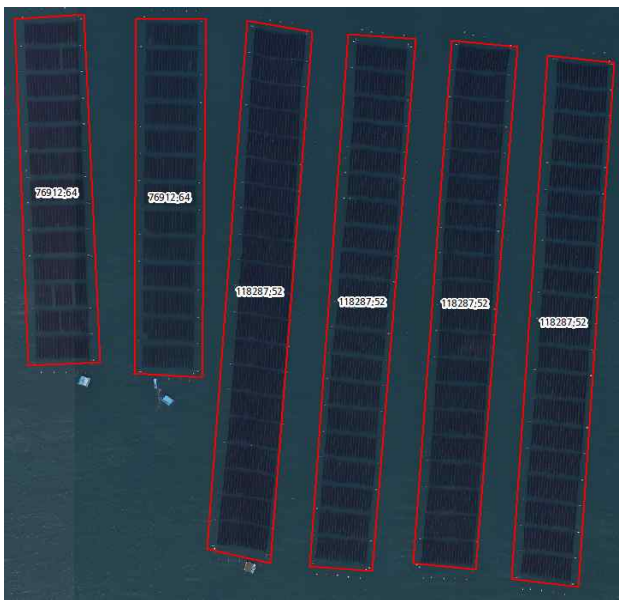

Figure 4. Aerial images of Busan 2017 yearly farmed laver output(kg)

Figure 4 shows Busan 2017 laver output over aerial images, specifying individual facilities' yearly laver output(kg). Table 4 shows the individual attributes of Figure 4. The laver facility quantity was calculated by multiplying number of unit, unit width, unit length and unit row. Based on the facility quantity, individual facility ratio was determined, and considering Korea Statistics' output, the output per individual farming facility was estimated.
Figure 5 shows an analysis of the density of Busan 2017 yearly laver farming output. The darker the red color, the denser the output, revealing that the laver farming facilities at the bottom near Gadeokdo offer an high output.

Table 4. Attributes of Busan 2017 yearly laver output(kg)

NO.	Attribute name						
	Unit length	Unit width	No. of Unit	Unit row	Facility quantity	Facility quantity ratio	Individual output
1	20	1.6	18	13	7,488	0.448	76,912.64
2	20	1.6	18	13	7,488	0.448	76,912.64
3	20	1.6	18	20	11,520	0.689	118,287.52
4	20	1.6	18	20	11,520	0.689	118,287.52
5	20	1.6	18	20	11,520	0.689	118,287.52
6	20	1.6	18	20	11,520	0.689	118,287.52

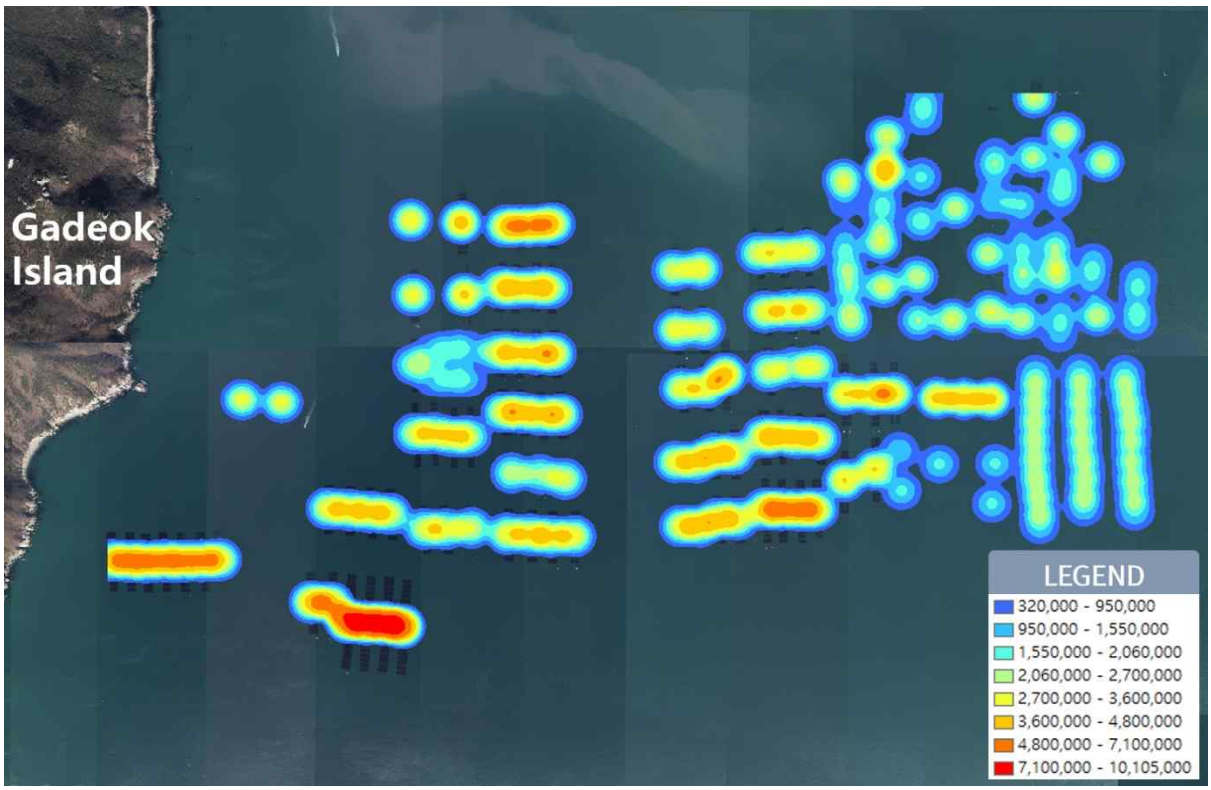

Figure 5. Analysis of density of Busan 2017 yearly laver farming output(kg)

5. CONCLUSION

Differently from the conventional way of using only aerial images to estimate the facility quantity, this study used not only aerial images but also Korea Statistics' "statistics by fishing type, by breed, and by fishing method" in estimating the farmed marine product output. It is significant in that it estimated the output in a certain area and in

farming facilities in an area desired by a user using both the existing output statistics by breed or by region and the farming facility quantity. The proposed method herein can be used to estimate the individual farmed marine product output in other regions, and the data are expected to be used for effective decision making by people engaging in fishery and local government officials.

The method has to depend on Korea Statistics' output statistics, limiting its application, and more studies on the estimation of individual units' farming output using the facility quantity should be conducted. Further, studies, which apply the proposed method to other farming areas in addition to Busan and to other breeds, are expected to continue so as to ensure a more accurate estimation of individual farmed marine product output.

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