

# Industrial competitiveness analysis among major aquaculture products and farming types in Korea

Hyun-Pyo Hong<sup>\*</sup> and Bong-Tae Kim<sup>\*\*</sup>

## ABSTRACT

In Korea, aquaculture production has drastically increased since the 1990s, and the total aquaculture output has been exceeding that of adjacent waters fisheries since 2006. The aquaculture industry has increased in importance since it creates jobs and production for Korean fisheries.

This study aims to examine industrial competitiveness among the Korean aquaculture products and farming types using the competitiveness indices, composed of assessment factors like management capabilities of Korean aquaculture producers, infrastructure and distribution, and processing capacities. Assessing different species with the indices will help understand the relative competitiveness of each species and establish more appropriate policies. This research is comprised of surveys, questionnaires, and interviews with specialists on major aquaculture species produced in Korea.

In conclusion, future aquaculture policies should be concentrated on highly competitive species such as finfish, abalone, and laver, which are expected to advance globalization of Korean aquaculture. It is also necessary to reflect the competitiveness assessment result on the policies.

**Key words** : aquaculture, competitiveness analysis

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\* Corresponding Author : Research Fellow, Fisheries Policy Research Division, Korea Maritime Institute. 1652 Sangamdong Mapogu Seoul, 121-270, Korea. E-mail : hphong@kmi.re.kr, Tel : +82-2-2105-2884

\*\* Senior Researcher, Fisheries Policy Research Division, Korea Maritime Institute. 1652 Sangamdong Mapogu Seoul, 121-270, Korea

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## 1. Introduction

The world's aquaculture industry has developed at a remarkable speed. Due to the decrease or stagnation of fish resources in many parts of the ocean, aquaculture products had become the major supply source of fishery products in the world market. In addition, with rapid development of aquaculture techniques since the 1990s, production capacity of aquaculture industry has drastically expanded. The aquaculture industry is significantly growing not only in advanced countries where aquaculture techniques and management systems are already available, but also in countries where employment and income-creating industries are still immature.

Unlike capture fisheries, the aquaculture industry is a suitable type of business for strategic industrialization in many countries because it's not a target to rigid resource restrictions and mass production is possible. However, excessive cultivation will face restrictions by the market function of "supply and demand" rather than the natural resources. Of course, the spread of environmental contamination following the expansion of aquaculture is likely to cause the productivity decline, which is another restrictive factor to be considered.

In Korea, aquaculture production has drastically increased since the 1990s and the total aquaculture output has been exceeding that of adjacent waters fisheries since 2006, becoming an important industry in Korea fisheries industry. The aquaculture industry has also created many jobs and contributed for the income of aquaculture households. With regard to the species, aquaculture was first initiated with seaweed and shellfish, but it has recently been expanding to finfish aquaculture which requires high technology. On the other hand, since business conditions such as production technology and demand structures are so diversified, it is not easy to select relatively advantageous species in the market. In other words, from the fishermen's point of view, scientific information is valuable for overcoming market restriction factors.

Thus, this research aims to suggest competitiveness indices, composed of assessment factors like management capabilities of Korea aquaculture producers, infrastructure and distribution, and processing capacities. Assessing different species with the indices will help understand the relative competitiveness of each species and the need to establish more appropriate policies. The research is comprised of surveys, data collection, and interviews with specialists on major aquaculture species produced in Korea.

## 2. Theoretical approach

### 2.1 *Concept of industrial competitiveness*

As market principles and globalization become dominant, the concept of competitiveness is more often raised as an important idea. Originally, competition has been conceptualized as a dynamic meaning in the market aspect,<sup>1</sup> while competitiveness is usually defined in aspects of nation, industry, firm, and commodity, according to the subject or category of the concept it is used in.<sup>2</sup>

First, the comparative advantages among commodities in specific local and overseas markets could be defined as commodity competitiveness, which can be revealed through commercial factors such as price (cost) and non-price (quality) competitiveness of the commodity. Such commercial competitiveness can easily be assessed by means of Revealed Comparative Advantage (RCA), which is structured with clear definitions of the concerned commodity.

“Firm competitiveness” is a concept designating the capabilities of the concerned enterprise, which can be assessed by diversification strategies such as multi-commodity production, market share or its increase rate, profitability, technological level, marketing capabilities, and ownership structure.

However, when we deal with concepts like national competitiveness or industrial competitiveness, the criteria is so vague that it is difficult to make an assessment. The idea of “national competitiveness” is defined in broad terms by focusing on trade balance, increasing rate of productivity, and infrastructure status for economic activities of a nation (McCorrison and Sheldon, 1994). In other words, “national competitiveness” as “a general capability of a nation to upgrade the competitiveness of business and industry” is compared nationally by measuring various factors that comprise the concept. Nevertheless, there are indications that it is too fictional to define widely conceptualized competitiveness as an index.<sup>3</sup>

Competitiveness of the aquaculture industry can be approached with the concept of industrial competitiveness. Industrial competitiveness can be defined as general capabilities of the corresponding industry, and in order to assess industrial competitiveness, it is necessary to measure with competitive component factors. In fact, the Micro Industrial Competitiveness Index (MICI) defined by the World Economic Forum (WEF) originated from M. Porter’s concept of industrial competitiveness.<sup>4</sup>

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1 Refer to Carlton and Perloff (2000) pp.6-10, 56-61.

2 Refer to Trail and Silva (1996) pp.151-166.

3 Refer to the research by Krugman (1994)

4 Porter (2004) suggests microscopic competitiveness as part of national competitiveness index, when his concept of “industrial competitiveness” is used.

## 2.2 *Assessment methods of industrial competitiveness*

To assess industrial competitiveness at the “industry” level, it is necessary to pay attention to the relationship between the decisive factors of industrial production capacities and the indices of industrial performance. Namely, measurement methods of industrial competitiveness can be divided into measuring the sources of competitiveness by assessing the decisive factors of industrial production capacities, and measuring the performance of competitiveness by assessing the industrial earning rate and growth rate.

According to Porter’s Diamond model, which aims to explain the overall decisive factors behind industrial productivity, the overall competitiveness level of a certain industry is decided by i) its productivity factor conditions, ii) relationship with related and supporting industries, iii) the demand conditions, and iv) the internal business conditions such as strategy, structure, and rivalry of the firm.

The MICI Model of the WEF is a very inclusive and precise model for measuring industrial competitiveness. Since 1979, WEF has annually released reports on “national competitiveness,” which is measured and assessed by two indices : the macro Growth Competitiveness Index (GCI) and the MICI.

The National Competitiveness Index of the International Management Development (IMD), another well-known organization for assessing national competitiveness, utilizes total 314 items to assess four sectors of national competitiveness, which includes i) the performance of economic operation, ii) the efficiency of government, iii) the efficiency of business, and iv) the development level of infra-structure (IMD, 2005). In fact, out of these four sectors, the business efficiency and the development level of infra-structure mostly overlap with “industrial competitiveness” factors.

## 2.3 *Industrial competitiveness assessment cases for aquaculture*

### 2.3.1 Competitiveness of salmon aquaculture industry in Canada

In the aquaculture industry, foreign countries have already positively adopted Porter’s industrial competitiveness assessment method. First, in order to assess industrial competitiveness of major salmon aquaculture industry at the British Columbia areas in the Pacific coast, Canadian government broke down Porter’s competitiveness assessment factors and compared the major aquaculture regions.<sup>5</sup>

The research used questionnaires covering the following items for competitiveness assessment of the corresponding salmon aquaculture industry :

- Governmental restrictions and related expenses for obtaining new licenses

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<sup>5</sup> Refer to Price Waterhouse Coopers (2003)

- Restrictions of the local government on the aquaculture waters
- Restrictions and taxation policies of the federal government
- Availability of financial resources and expenses thereof
- R&D basis
- Availability of human resources

To assess aquaculture industry competitiveness in Pacific coast, the same questionnaires were done about aquaculture industry of New Brunswick (Raritan River coast, east of New Jersey, US), Norway, Chile, United Kingdom and other such regions and made regional and national comparisons. According to the analysis results, the salmon aquaculture industry in the coast of British Columbia has more costly structure than other major international salmon aquaculture sites. It was inferred that the reasons were small sized businesses, insufficient circulation and distribution systems, and continuing recessive characteristics of the aquaculture species.

### 2.3.2 Competitiveness of fisheries industry in Norway and Iceland

The fisheries bureau of Norway and Iceland positively adopted and compared the assessment methods of Porter and WEF · IMD for assessing the industrial competitiveness of their overall fisheries industry.<sup>6</sup> The research was composed of six subordinate indices including macroscopic and microscopic sectors, and for assessment of the subordinate indices respectively, total 139 items were assessed. The six subordinate indices of fisheries industry competitiveness are as listed :

- Fisheries management index
- Macroeconomic management and governmental index
- Infrastructure and environment index
- Business operation capability index
- Aqua-processor index
- Marketing index

In particular, the research considered the fisheries as one of the global food industry with active international trade. Accordingly, it is noticeable that competitiveness of the fisheries industry was generally comprised of resources and fishing activities, domestic processing and export, and deep sea fisheries and foreign processing.

### 2.3.3 Competitiveness of fisheries industry in Korea

Hong *et al.* (2006) made comparison between Korean domestic industries by dividing

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<sup>6</sup> Refer to FCI Team (2005)

aquaculture industry into coastal, offshore, and aquaculture, and adopting Porter's analysis method on fisheries, agriculture, livestock industry, and food and beverage manufacturing industry. They also created the following three sector indices from macroscopic and microscopic viewpoints, and established total 39 items to assess each index.

- Macroscopic factors and governmental roles
  - Employment-related regulations and practices
  - Producer supporting systems of government
  - Governmental leadership
- Infrastructure and industrial environment
  - Human education level
  - Information-oriented level
  - Circulation environment
  - Financial support systems
  - Management practices
- Capabilities of producers
  - Producer restrictions
  - Potential capabilities of producers
  - Capabilities of processors
  - Marketing basis

According to the analysis results of the research, the competitiveness of food and beverages manufacturing was very advanced while that of fisheries was slightly higher than agriculture. Within fisheries, it was competitive in the order of offshore fisheries, aquaculture, and coastal fisheries. However, this result is insufficient since status assessment of the resources, the basis of fisheries, was not reflected. In regard to the aquaculture, producer restrictions were not so disadvantageous compared with other businesses that it was inferred to be a very suitable business in the market economy out of all fisheries industries.

### 3. Empirical analysis

#### *3.1 Empirical models*

The method of competitiveness analysis by species used in this research was developed by the research of Hong *et al.* (2006) using means of species segmentation. Analysis categories are similar to the competitiveness analysis of Canadian salmon aquaculture industry. However, it is different in that the Canadian salmon aquaculture industry is in

the form of incorporated business, and that the Canadian case did a comparative analysis with salmon aquaculture industries of other countries.

However, while the Norway and Iceland model (2005) was designed to compare competitiveness of aquacultures in the two countries, this research aims to compare industrial competitiveness by domestic aquaculture species due to limited data. Subsequently, an empirical analysis model was constructed by utilizing the competitiveness performance factor analysis, which uses quantified indices and Porter's competitiveness source factor analysis. Accordingly, the competitiveness indices ( $C_k$ ) by species ( $k$ ) are subordinate indices ( $G_i$ ) such as production management system, infrastructure and environment, and the producer's management capabilities. These subordinate indices were structured with assessment factors by group ( $F_{ij}$ ), which affected the respective corresponding index.

$$C_k = \sum_i a_i G_i$$

where  $\sum_i a_i = 1$  (total weights of each subordinate index is 1)

$$G_i = \sum_j \beta_{ij} F_{ij} \text{ (weighted mean of assessment factors in each group)}$$

$$\sum_j \beta_{ij} = \alpha_i \text{ (weight of assessment factors of each subordinate index)}$$

### 3.1.1 Production management system

Production management system of aquaculture is more important than that of other industries in that aquaculture start with governmental licenses on the public waters. Government is obliged to manage the waters, a common property, so that it could harmoniously be utilized and developed in various ways. The management includes aquaculture licenses, aquaculture environments, safety of aquaculture products. "Management" could also include governmental support to the aquaculture such as national-level research and development program and aquaculture outlook program. The following are the assessment items reflected in the indices of production management systems.

- Assess how well willful secession from licensed areas, illegal aquaculture, and such aquaculture licenses are managed.
  - Measure the degree of excessive facilities and willful secession from licensed areas for specific species perceivable by the satellite picture data.
- Assess how well the aquaculture environment is managed.
  - Check how effective the governmental management of aquaculture environment (such as the clean-up operations of fishing ground) is.

- Check how well the aquaculture sites are cleaned as regulated in the fishery management act.
- Assess how well safety of aquaculture products is managed. This includes management of fishery medicines and chemicals.
- Assess how well aquaculture technologies are developed and propagated by the government.
- Assess governmental efforts to supply market information on aquaculture products through aquaculture outlook program.

### 3.1.2 Infrastructure and environment

Infrastructure and environment that form the basis of aquaculture can be viewed in two ways. First is the bio-geographical condition for aquaculture. Since live organisms are the objects of aquaculture, physical environment or ecological characteristics are considered as key factors for competitiveness of the business. The representative factors include the contamination level of aquaculture sites, environmental carrying capacities, and sensitivity of aquaculture species on environmental changes or contamination. A geographical condition of the aquaculture location is also included. For example, the competitiveness of the fishery varies depending on whether the aquaculture site is located in the basin or in the open sea, or on how frequently natural disasters occur.

Second is the macroscopic management environment of aquaculture, such as the supply and demand situation of the market, import and export trends, and future market prospects. The supply condition of quality seeds and food can also be included as a major assessment index. This research deals with the seeds supply of all species but the matter of food supply for finfish and abalones was excluded.<sup>7</sup>

- Assess the physical environment of aquaculture such as aquaculture sites and characteristics of the species. Detailed items are as follows :
  - How much is the site contaminated?
  - How sensitive is the product to environmental changes or contamination?
  - What is the environmental carrying capacity of the sites?
  - How exposed is the site to disasters?
  - What are other operational advantages and disadvantages of site location?
- Assess the market environment of aquaculture products and production factors. Detailed items are as listed :
  - How excessive or insufficient is the product amount or the production facilities?

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<sup>7</sup> For abalones, due to difficulties for food supply per area, it was dealt as part of the operational performance of the management capabilities in this research. In other words, operational performance was good in the areas of easy food supply.



- How much will the future demand increase or decrease?
- How can sufficient quality seeds be secured?

### 3.1.3 Management capabilities

If these production management systems and infrastructure and environments are macroscopic factors for measuring competitiveness, the producer's capabilities are microscopic factors. It can be measured in two ways. The first method is by measuring the achievements of operational activity performances. The operational achievements could be assessed using general operational analysis indices like capital-asset ratio, profit-loss ratio, activity ratio, and debt-equity ratio. In this research, after considering data availability, earning rate was set up as standard criteria with the productivity, which could be the core performance of operational activities. Out of various earning rates, this research uses the ratio of net profit to net sales. Productivity is usually the value-added production rate against input labor or input capital, but since it is difficult to measure input labor, input capital, and value-added production, this research uses proxy index as the ratio of net profit against the size of the operational aquaculture site. At the same time, other factors including the present industrial competitiveness recognized by the producer and the price elasticity of supply, which is the adjustment rate of product amount or production facilities to changes of the market price, could also be used as indirect indices of the performance reflecting the current operational status.

Another method is to measure the potential with current operational activities. This is the source of competitiveness. One example is research and development activities of the business entity. Unlike the government level research and development as mentioned in the index of production management systems, it refers to business or industry level activities to raise competitiveness in order to maximize profit. The next is marketing endeavors to sell product at a stable, high price. Even if the product quality is excellent, competitiveness of the corresponding aquaculture could vary depending on the effort made on distribution and sales. It could be further extended to the point that the competitiveness level may vary according to how tight and stable the cooperation between pure production sector and related forward and backward industries of aquaculture such as the distribution system.

On the other hand, reliance on governmental support is also presented as an index for indirect measurement of competitiveness sources. So far, government has supported aquaculture industry as an alternative to shrinking catch fisheries. Moreover, various policies have been adopted to reduce operational risks of small businesses that are easily exposed to disasters or excessive production. Consequently, the aquaculture industry is heavily reliant on the government. This tendency could become a damaging factor to the competitiveness of aquaculture industry in the long run. Therefore, measuring the reliance on governmental support can be an index for competitiveness as well.

- Assess the factors related to producer’s operational performance. Detailed items are as follows :
  - What is the profit (net profit per net sales)?
  - What is the productivity (the net profit per unit area)?
  - What is the competitiveness level recognized by the fishermen?
  - What is the price elasticity (the price sensitivity) of supply?
- Assess the factors of the producer management potential. Detailed items are as listed :
  - How active is the research and development?
  - How active is the marketing effort?
  - How stable is the cooperation with related forward and backward industries?
  - How reliant is the business?

**Table 1.** Assessment factors and methods of competitiveness index

Assessment element		Assessment method
Production management systems (7 items)		
Production management of aquaculture	Cultivation license management (illegal fisheries, etc.)	Survey
	Relocation of licensed area, excessive facility ratio	Data collection
	Environmental management of aquaculture sites	Survey
	Fishery cleaning system	Survey
	Sanitation-safety management (fishery chemicals, etc.)	Survey
Aquaculture fishery support	Development & spread of aquaculture technologies	Survey
	Provision of market information	Survey
Infrastructure and environments (8 items)		
Bio-geographical conditions	Contamination level of aquaculture sites	Survey
	Environmental sensitivity of aquaculture organisms	Survey
	Environmental carrying capacities of aquaculture sites	Research
	Disaster occurrence frequency & damage to fishery sites	Data collection
	Other location-specific conditions of aquaculture sites	Survey
Macroscopic operational environments	Amount of excess of product and facilities	Survey
	Future demand prospects	Research
	Supply of qualified eggs or seeds	Survey

Assessment element		Assessment method
Management capabilities (8 items)		
Operational outcome	Profits (the ratio of net profit to net sales)	Data collection
	Productivity (the ratio of net profit to the size of farm site)	Data collection
	Competitiveness level recognized by farm managers	Survey
	Price elasticity of supply (price sensitivity)	Survey
Management potential	Research & development activities	Survey
	Marketing efforts	Survey
	Cooperation between aquaculture and related industries	Survey
	Non-reliance level on governmental supports	Survey
Total 23 items		Survey 17 Research 2 Data collection 4

### 3.2. Data and methods

Each index for competitiveness analysis is yielded from the results of questionnaire surveys, related researches, and data collections and investigations. As indicated in (Table 1), out of 23 detailed items, there are 17 surveys, 2 researches, and 4 data collections ; surveys are used the most. This is because existing statistics and data on Korean aquaculture is very limited, and instead the researchers had to quantify what is recognized by the fishermen on each item. This could be pointed out as the limit of this research, but could also be a method to better show the realities of the site, especially under the unsatisfactory accuracy of the statistics.

The questionnaire surveys were performed by species on 17 items from February to March, 2007 to 521 farmers of major sites. Related research include two existing ones : Research on Demand and Supply Status and Prospects, and Research on Environmental Carrying Capacity Assessment of Fishery Sites by the former Ministry of Maritime and Fisheries (2008). The data collection and investigation are comprised of other related statistics or our own investigation. From our own investigation, there are four items that include the ratio of willful recession from licensed areas and excessive facilities, obtained by analyzing the satellite observation data of the Fisheries Outlook Center ; disaster frequency and damage to the aquaculture sites, obtained by analyzing the administration data of related cities, countries, and areas ; and the profit and productivity obtained from the operational surveys of Aquaculture. The operational status survey by aquaculture by species was carried out from March to April, 2007, to 123 fishermen of major aquaculture sites by species.

To calculate competitiveness indices with the collected data, it was ranked, weighted

for add-up, and assessed out of 100 points. In order to avoid the value of each item from affecting the average values of all the species were adjusted to be the median. Consequently, after competitiveness index value becomes 50 points adding up the adjusted value of each item.

Finally the weight per index referred to the research by Hong *et al.* (2006), and production management systems, infrastructure and environment, and management capabilities were each set up as 20%, 30%, and 50% in this research.

### 3.3 Results

#### 3.3.1 Assessment results by major species

According to the results measured by the models and data introduced in the above, the most competitive species for Korean aquaculture was abalone followed by warty sea squirt (*styela clava*), and cockle. On the other hand, competitiveness of oyster, ark shell, and sea squirt were lower than the total average, and the finfish, scallop, lavers, sea mustard, and kelp (sea tangle) were close to the average.

Abalone is a recently developed species and its produce has drastically increased, but is still at a growing level. It was best assessed for competitiveness due to high earnings and bright future demand prospects. Warty sea squirt is also high in the rank because it has better earnings than other species, and because there is more demand than supply. Cockle was classified as a highly competitive species despite dim demand prospects due to high earnings.

**Table 2.** Competitiveness analysis results per species

Species	Total	Competitiveness index			Remarks
		Production management systems	Infrastructure and environments	Management capabilities	
Finfish	52.0	11.3	15.7	25.1	Cage culture
Oysters	45.3	13.3	13.4	18.5	Hanging culture
Abalone	61.5	10.0	17.6	33.9	Cage culture
Cockles	54.5	9.8	14.3	30.4	Sowing culture
Scallops	52.0	9.7	16.8	25.5	Hanging culture
Ark shells	41.5	9.4	13.3	18.8	Sowing culture
Warty sea squirt	54.8	8.1	15.1	31.6	Hanging culture
Sea squirt	45.0	9.1	13.8	22.1	Hanging culture
Laver <sup>1)</sup>	52.9	10.7	15.5	26.7	Seaweeds
Sea mustard <sup>1)</sup>	53.4	7.6	16.2	29.5	Seaweeds
Kelp(Sea tangle) <sup>1)</sup>	49.3	7.0	17.3	25.0	Seaweeds
Total (mean)	50.0	10.0	15.0	25.0	

**Notes :** <sup>1)</sup> the assessment is concentrated in Wando county

On the other hand, oyster, ark shell, and sea squirt were classified as not so competitive species due to overcrowded aquaculture cultivation, frequent occurrence of massive unexplained death, obsolete aquaculture facilities, and environmental changes. In particular, oyster aquaculture has been suffering from declining exports and over production, and sea squirt production has declined due to a tissue softening disease while imports from Japan increased, resulting in low earning.

Finfish has been showing average level of competitiveness due to ever worsening competition with imported Chinese products, and worries of excessive production. The seaweed such as laver, sea mustard, and kelp are traditional aquaculture species and did not suggest any disappointing factors in competitiveness. Scallop was also assessed to be in the average level as they are recovering from difficulties due to sharp increase of massive death in the past.

### **3.3.2** Competitiveness comparison by culture type

The 11 species can be classified into four types of production methods : cage culture type for finfish and abalone ; hanging culture type for oyster, scallop, warty sea squirt and sea squirt ; sowing culture for cockle, and ark shell ; and seaweed culture for laver, sea mustard, and kelp. The following is the comparisons of competitiveness assessment results by culture type :

#### **3.3.2.1** *Cage culture*

Finfish and abalone are different species, but they are common in that the food need to be supplied, and that the cage construction on the sea is quite costly. However, compared with finfish, abalone aquaculture started recently and is in the growing stage with sufficient potential for further growth, whereas finfish aquaculture is in the mature stage with no growing demand and even needs to compete with imported products. It can easily be confirmed through the competitiveness analysis results : finfish was somewhat superior in production management system, but a bit behind in the infrastructure and environment, while abalone was firmly superior in management capabilities. In spite of rapid production increases, the fact that there is newly created demand in line with price declines, potential to the abalone consuming countries like China, and active marketing efforts by the producers, all support the management capabilities of abalone.

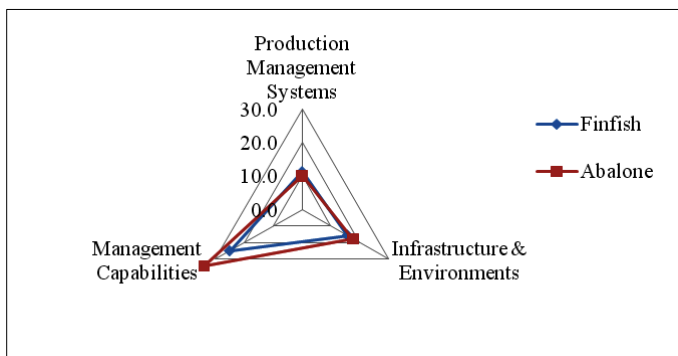


Figure 1. Competitiveness comparisons of cage culture species

### 3.3.2.2 Hanging culture (Shellfish and etc.)

The hanging culture type is for aquaculture of shellfish, other aquatic animals, and even seaweed. This research, excluding seaweed such as sea mustard and kelp, compares and analyses oysters, scallops, warty sea squirt, and sea squirt. According to the results of competitiveness analysis, competitiveness of warty sea squirt and scallop are above the average level, while oyster and sea squirt were below average. Oyster was the best in production management systems, but was poor in other categories, and sea squirt also ranked low in all categories. As for warty sea squirt, there was an increase of massive death in recent years in line with the marine environment changes due to various development projects, and complaints have been raised about the production management systems. As a result, it ranked the lowest in competitiveness of the production management system, but surpassed all three species in management capabilities, where the weight is high. Scallops, which have less production than demand, is assessed as excellent in the infrastructure and environment index.

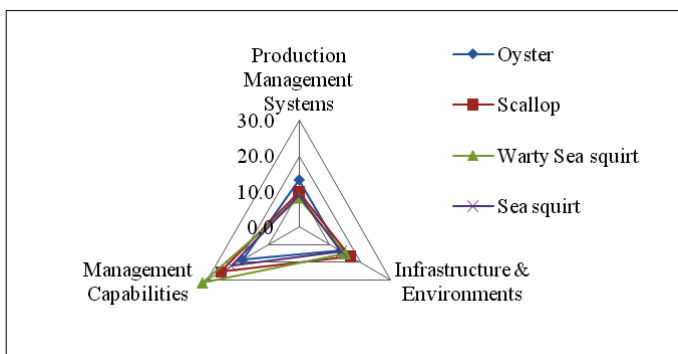


Figure 2. Competitiveness comparisons of hanging culture species

### 3.3.2.3 Sowing Culture

Among sowing culture species, the competitiveness level of cockle and ark shell were contrastive. There were not much difference in the production management systems, and the infrastructure and environment, but in management capabilities, cockle had far higher earnings than ark shell, due to better survival rate. The reason behind low earnings, which led to the reduction of management capabilities, is because over crowded culture led to low survival rate, and ark shell is sensitive to the environment to begin with.

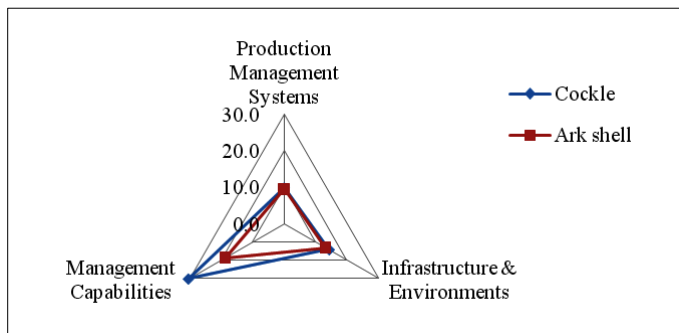


Figure 3. Competitiveness comparisons of sowing culture species

### 3.3.2.4 Seaweed

Whereas, sea mustard and kelp are cultivated through a hanging culture system, laver is cultivated through floating culture or pillar culture method. The culture methods are different, but they can still be compared in one category of seaweed. Competitiveness level of the three species are all similar and above average. Laver was strong in the production management systems, kelp was in the infrastructure and environment, and sea mustard was in the management capabilities. However, because more weight was placed in the management capabilities, the results in management capabilities ended up deciding the total rank of competitiveness.

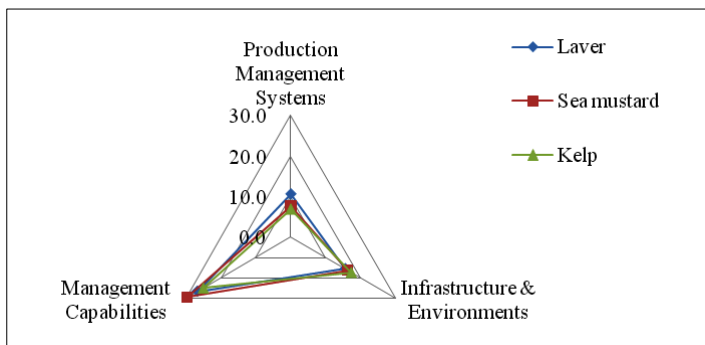


Figure 4. Competitiveness comparisons of seaweed species

## 4. Policy implications

Based on the research, the following policy implications can be derived : first, the future development potential of aquaculture industry is likely to be found in the species with a relatively high competitiveness because any nurturing and supporting policies for species with relatively low competitiveness will end up as a waste of money and time. Therefore, future aquaculture policies should be concentrated on developing the human and material resources to let the species with highly superior competitiveness lead the aquaculture industry. Finfish, abalone, and laver are estimated to have very high potential.

Second, even if the competitiveness indices are assessed to be at a similar level, it is desirable to reflect the characteristics of subordinate indices when promoting policies by species because all subordinate indices may contribute differently to the competitiveness of each species. For example, among hanging culture species, warty sea squirt was assessed relatively higher than the others in management capabilities, however, in production management systems, oysters were better than warty sea squirt. Therefore, future policies by species for the aquaculture industry should focus on reinforcing production management systems for warty sea squirt and the management capabilities for oysters.

Third, it is necessary to understand relatively weak or strong points for each assessment factors among the subordinate indices and positively reflect them on the policies. For instance, if survey shows very poor results in sanitation management level, cleaning status of aquaculture site and illegal license management practices, the policies by species must promote policies to supplement them. It is the same for infrastructure and environment and management capabilities as well.

Fourth, it is very important to assess the potential for future development as well as current operational performance of the producer's management capabilities. In particular, possibilities of cooperation and synergy creation with aquaculture related-businesses are considered as one of the key factors for successful management. Therefore, future aquaculture policies should aim at maximizing the synergy effects by dividing the roles with other surrounding industries.

Fifth, although it was not suggested in this research, these competitiveness indices can be sorted out according to producing district of the species. Thus, the results of competitiveness assessment by species and by district should be used as a basis for promoting characterization and specialization of aquaculture species by district.

Finally, globalization of Korean aquaculture can be advanced by promoting species with high competitiveness. In this regard, the government should set up and push forward positive overseas expansion policies for these highly competitive species. For example, the government should establish a comprehensive overseas expansion programs for species of which mass production is feasible and for overseas expansion market demand is predicted.



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