Problems and Challenges of Aquaculture in Japan

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Note: parts of contents of this report have been published elsewhere

Abstract

This paper describes the present status of aquaculture in Japan. The production volumes of many of the wide variety of aquatic organisms cultured in Japan, including finfishes, bivalves, crustaceans and seaweeds, are on a continuing decreasing trend. According to the national statistical data published by the Ministry of Agriculture, Forestry and Fisheries, the total marine aquaculture production decreased by 20 % by volume in 20 years since 1996 (1.3 million t). In fed aquaculture of marine finfishes, productions of the red seabream (*Pagrus major*), Japanese flounder (*Paralichthys olivaceus*) and horse mackerel (*Trachurus japonicus*) have declined markedly in both volume and value. On the other hand, productions of Pacific bluefin tuna (*Thunnus orientalis*), which has been included in the statistics since 2012, is increasing remarkably because of the strong affinity of Japanese consumers and the dwindling wild population. Production of white trevally (*Pseudocaranx dentex*), which is recognized as a luxury foodstuff, is also increasing. Productions of yellowtails (*Seriola* spp.) and pufferfish (*Tetradontidae* spp.) are rather stable in terms of volume and value. International demand for yellowtails is growing, and the export is expanding. As for unfed culture of bivalves, productions of oysters (*Crassostrea* spp.) and Japanese scallop (*Mizuhopecten yessoensis*) were severely impacted by the Great East Japan Earthquake in 2011, and the production of the oysters, which is on a long-term decreasing trend, has not recovered to the level prior to the earthquake. Production of the major seaweeds (*Pyropia yezoensis*, *P. tenera*, *Saccharina japonica*, *S. angustata* and *Undaria pinntifida*) are all on a continuous decreasing trend both by volume and value. Inland (freshwater) aquaculture production is only about 3 % of the marine aquaculture production by volume. About 70 % of the freshwater aquaculture production value comes from Japanese eel (*Anguilla japonica*), which has been increasing since 2002 due to the increasing unit price despite the decreasing production volume. The insufficient supply of wild glass eel is a problem for the eel aquaculture.

The reduced aquaculture production is partially due to socio-economic and environmental reasons. For fed aquaculture, increasing feed cost and international competition are the major issues. Diseases also remain to be a problem. Prevalence of vaccination has reduced the disease damage from about 10 to 4 % of the total production value since around 2000, but the emergence of new diseases continues to occur. Infectious diseases have long been a problem in kuruma prawn (*Marsupenaeus japonicus*) aquaculture. Red tides still occur almost every year, causing damages mostly in western Japan.

For unfed aquaculture, the reduced production is considered to be related with oligotrophication of coastal waters. Intensive reduction of terrestrial nutrient loads by advances in wastewater treatment is thought to have reduced the seaweed productivity, as well as other primary production, resulting in reduced productivity of not only unfed aquaculture of bivalves but coastal fisheries in general. Social factors are also involved. Production declines of many of these species are partially attributed to the reduced labor force due to aging and insufficient recruitment of farmers. The number of management body of oyster aquaculture, for example, decreased from 4,349 in 1963 to 2,018 in 2013. Structure of aquaculture industry in Japan (mostly privately-owned small business) and strong Japanese currency bring about the weak international market competitiveness.

Introduction

Fish and seafood have been the staple food for the Japanese since the ancient time. Japan has a long history of aquaculture, and many novel aquaculture techniques have been invented and developed (Tanigawa *et al*., 1966). A wide variety of aquatic organisms, both freshwater and marine, are cultured in Japan, including finfishes, bivalves, crustaceans and seaweeds. Some of the major cultured species are, for example, red seabream (*Pagrus major*), yellowtails (*Seriola quinqueradiata*, *S. dumerili* and *S. lalandi*), Japanese eel (*Anguilla japonica*), Pacific oyster (*Crassostrea gigas*), Japanese scallop (*Mizuhopecten yessoensis*), kuruma prawn (*Marsupenaeus japonicus*), Nori (*Pyropia yezoensis*) and kelps (*Saccharina japonica* and *S. angustata*).

In addition to these species, various other aquatic organisms are commercially cultured and consumed in Japan. However, despite the historically strong affinity of the Japanese to seafood and fish, aquaculture productions of many species are on a long-term decreasing trend. This paper describes the present status of aquaculture in Japan, and some of its problems and challenges being faced by Japan's aquaculture industry.

The aquaculture statistical data analyzed and presented in this paper are based on the national statistical data on the aquaculture production published by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). The statistical data on the aquaculture production of major species by volume and value from 1993 to 2016 for marine aquaculture and from 1998 to 2016 for inland aquaculture are available online (http://www.maff.go.jp/j/tokei/kouhyou/kaimen_gyosei/index.html). Statistical data of the Fisheries Census are available online in e-Stat website (https://www.e-stat.go.jp/en). The statistical data are made available by the Ministry of Internal Affairs and Communications to reveal the situation surrounding the fisheries industry in Japan, such as the production and employment structures of fishing communities, and distribution and processing of fishery products. The data in the census include the number of fishery cooperatives, fisheries management entities, fisheries workers and fishing vessels.

Marine aquaculture production in Japan

Although the global aquaculture production is on an increasing trend (FAO, 2018), the total marine aquaculture production volume gradually decreased from 1.3 million MT in 1996 to 0.9 million MT in 2016 in Japan (19.6 % decrease over the past two decades. It dropped abruptly to 0.87 million MT in 2011 because of

tsunamis caused by the Great East Japan Earthquake. The tsunamis struck the coastlines of central to northern Japan and heavily devastated not only aquaculture facilities but also the coastal towns. The aquaculture production resumed the long-term decreasing track in 2012.

The total marine aquaculture production value continuously decreased and hit the bottom in 2011, and then it turned to an increasing trend after 2012). The production value was JPY 510 billion in 2016. This indicates the increase in unit price per production weight due to supply shortage and/or value addition efforts. On the other hand, seafood import is on a decreasing trend in Japan.

The total aquaculture production volume of finfishes is in a long-term decreasing trend, with a drop in 2011 due to the tsunamis (0.24 million MT and 0.23 million MT in 1996 and 2016, respectively). The tsunamis did not severely devastate the production of finishes except for Coho salmon (*Oncorhynchus kisutch*), the production level of which decreased from 15 thousand t in 2010 to 116 t in 2011. Coho salmon aquaculture is conducted mostly along the northeast pacific coast close to the epicenter. The production increased to 9.7 thousand t in 2012.

Yellowtails (i.e. the statistics is pooled for *S. quinqueradiata*, *S. dumerili and S. lalandi*) and red seabream are the two major marine finfish species cultured in Japan (0.13 million MT and .06 million MT, respectively in 2016). The aquaculture productions of these two species were not severely damaged by the tsunamis. Aquaculture production of the yellowtails is rather stable, and approximately 12% of the production is exported overseas in recent years, to the U.S.A. being the largest importer. Meanwhile, the production of red seabream was on a long-term decreasing trend before the tsunamis, and it turned into an increasing trend after 2014.

The aquaculture production value of the finfishes decreased from 1997 to 2005 (JPY 190 billion). It then turned into an increasing trend reaching JPY 240 billion in 2016. The recent increase in production value is partially due to the new inclusion of Pacific bluefin tuna (*T. orientalis*) aquaculture to the statistics in 2012.

The aquaculture production of marine molluscan shellfish (mostly oysters and scallops) was relatively constant at around 0.45 million MT before the earthquake in 2011. The earthquake devastated the production in 2011 (0.26 million MT), and did not recover until 2016 (0.37 million MT). In contrast, the production of the molluscs grew by 1.7 times in value from 2012 (JPY 57 billion) to 2016 (JPY 99 billion. Japanese scallop production was around 0.23 million MT before it went down to 0.12 million MT in 2011. It recovered to 0.25 million MT in 2015, exceeding the level prior to the tsunamis. The production value of the scallop showed a jump after 2012 (JPY 26 billion), reaching JPY 62 billion in 2016. While the oyster production volume was gradually decreasing before the earthquake (0.2 million MT in 2010), it persisted even after the earthquake (0.16 million MT in 2016). The production value of oyster aquaculture increased after the earthquake to a lesser extent as compared to that of the scallop (JPY 350 billion in 2016).

Global aquaculture production of seaweeds has more than doubled since 1995 (0.3 million MT in 2016). The rapid growth in the aquaculture of tropical species (*Kappaphycus alvarezii* and *Eucheuma* spp.) in Indonesia as raw material for carrageenan extraction has been the major contributor to growth in seaweed production in the recent past

(FAO, 2018). Seaweed aquaculture is primarily directed towards direct human consumption in Japan, and they are as important as finfishes and crustaceans. Nori (*Pyropia* spp.) for example is the second-largest aquaculture product (JPY 1000 billion in 2016) following yellowtail (JPY 1200 billion) in Japan. The aquaculture production of nori is on a decreasing trend regardless of the high demand in Japanese market over the past two decades. However, the aquaculture production of seaweeds is in a long-term decreasing trend. The production volume and value of seaweeds in 2016 (0.39 million MT and JPY 1200 billion) were 26 % and 12 % less than those in 1993, respectively.

Aquaculture of kelps (*Saccharina* spp,) and wakame (*Undaria* spp.) are operated mainly in Tohoku and Hokkaido regions and were severely damaged by the earthquake in 2011. Although the production of these seaweeds recovered rapidly in 2012, the long-term decreasing trend persists until now.

Inland aquaculture production in Japan

Freshwater aquaculture production is much smaller than that of the marine aquaculture in Japan. As of 2016, the former is only about 3 % and 20 % of the latter by volume and value, respectively. Japanese consumers tend to choose seafood in preference to freshwater fish, with Japanese eel as an only exception. Culturing freshwater molluscs, crustaceans and algae is not at all that common in Japan. Globally available freshwater aquaculture species, such as common carp (*Cyprinus carpio*, 3100 t in 2016) and tilapias (statistical data available only until 2000, 434 t) are also produced in Japan, but they are not consumed in large quantities.

The production volume of freshwater finfishes, including Japanese eel, has been on a continuous decreasing trend. It decreased by 42 % between 1998 and 2018 (0.032 million MT). The production of major species, such as common carp, ayu (*Plecoglossus altivelis*) and rainbow trout (*Oncorhynchus mykiss*) are all decreasing.

Meanwhile, the production value decreased from 1993 (JPY 920 billion) to 2002 (JPY 440 billion). From then, it has subsequently been on an increasing trend, mostly owing to the increased production value of Japanese eel. The production value in 2016 exceeded that of 1993 (JPY 940 billion). Japanese eel is by far the largest freshwater aquaculture product, accounting for 70 % of the total freshwater aquaculture production value. Wild caught glass eel is used as seeds for the eel aquaculture, and the availability of the seeds is diminishing. Japanese eel has been listed as endangered species in the IUCN Red List of Threatened Species. The soaring price of the glass eel is a problem in the recent past (JPY 3.0 million/kg in 2018, Fisheries Agency, 2019). Studies on artificial spawning of Japanese eel were started in 1960s, and the National Research Institute of Aquaculture finally succeeded in the full life cycle culture of Japanese eel in laboratory scale in 2010. However, there are still methodological problems that need to be solved in leveling up the seed production to full industrial scale.

Causes of the declining aquaculture production in Japan

Aquaculture production of many marine and freshwater species in different taxa is declining by volume in Japan for the past twenty years. Great East Japan Earthquake and consecutive tsunamis devastated the production of many species in 2011.

However, the long-term decreasing trend through 2011 and thereafter is not attributed to the earthquake. Although, the production value of some species is increasing, aquaculture activities as a whole are considered to be declining in Japan.

The reduced aquaculture production is due to socio-economic and environmental reasons. For fed aquaculture of finfishes and shrimps, soaring feed cost (Demura, 2010) and international competition are some of the major issues. Surge in the price of fishmeal, which is the main ingredient of compound feed for aquaculture, is putting pressure on the profits of aquaculture business worldwide, and Japan is not an exception since fish meal is mostly imported in Japan. The use of plant protein alternative to fishmeal is still limited.

Diseases also remain to be a problem in aquaculture. In marine fish aquaculture, such diseases as streptococcosis and pseudotuberculosis became widespread in the past. Today, vaccines for major diseases have become available, and the occurrence of fish diseases, as well as the use of antibiotics decreased dramatically (Fisheries Agency, 2014). Prevalence of vaccination has reduced the disease damage from about 10 to 4 % of the total production value since around 2000, but emergence of new diseases continues to occur. Infectious diseases, such as white spot disease, have long been a problem in kuruma prawn aquaculture. Invertebrates lack any form of immunological memory similar to that found in finfishes, making effective vaccination of invertebrates difficult.

With the implementation of the Total Pollutant Load Control System (TPLCS) to mitigate eutrophication of coastal waters in 1979, terrestrial nutrient (nitrogen, phosphorus and COD) load to enclosed sea areas (Tokyo Bay, Ise Bay and Seto Inland Sea) has been reduced. While the mitigation efforts have suppressed the occurrence of red tide drastically, red tides still occur sporadically almost every year, causing damages to fish and bivalve aquaculture mostly in western Japan.

For unfed aquaculture of bivalves and seaweeds (referred to as extractive species), the reduced production are considered to be related with the oligotrophication of coastal waters. Intensive reduction of terrestrial nutrient loads by advances in wastewater treatment under the TPLCS and other mitigation regulations have caused shortage of nutrient supply to algae, and it is thought to have reduced the seaweed productivity, as well as other primary production. This in turn has resulted in reduced productivity of not only unfed aquaculture of bivalves but coastal fisheries in general. Bleaching of nori thalli due to lack of nutrient supply has been a big problem in many parts of Japan, reducing the value of the products (i.e. darker color fetches higher price). “Suisan yousui kijun” (fisheries water standard, Japan Fisheries Resource Conservation Association, 2018) suggests the lower limit for total nitrogen and phosphorus be 0.2 mg/L and 0.02 mg/L, respectively, in coastal sea for sustainable primary production. Recently, some prefectural governments are experientially deregulating nutrient release from sewage treatment facilities in an attempt to improve coastal unfed aquaculture and fisheries productivities.

Social factors are also involved in the reduced aquaculture activities in Japan. Production declines are partially attributed to the reduced labor force due to aging and insufficient recruitment of farmers. The number of management body of oyster aquaculture, for example, decreased from 4,349 in 1963 to 2,018 in 2013. As of 2016, fishing industry employed 166,00 people, that was about half the number in 1993 (325,000 people). Decline of labor force is

not an issue particular to fisheries industry such that workers with a high education level being reluctant to be engaged in menial jobs. However, it is also related to the demographic challenges Japan is dealing with. Japan's fertility rate was 1.43 children per woman in 2017, and the population growth rate has been negative since 2011 (Ministry of Health, Labour and Welfare, 2018). The average age of the fishing industry employees was 56.7 years old in 2016.

The structure of aquaculture industry in Japan is mostly privately-owned small business, and it is economically less competitive than enterprises with a large capital. Traditional fishery systems including the fishery rights system and fishing license system hold back new entrants to aquaculture business. A Demarcated Fishery Right gives a fishery cooperative or an individual fisher the right to engage in coastal aquaculture in Japan, and it is traditionally hereditary. The Fishery Act and Fishery Cooperative Act were drastically revised for the first time in 70 years in 2018 to promote fisheries and aquaculture industry. The revision includes transparency of licensing process of fishery rights.

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