Interactions of Fisheries and Fishing Communities Related to Aquaculture

Proceedings of the Thirty-eighth U.S.-Japan Aquaculture Panel Symposium

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Robert Stickney*, Robert Iwamoto, and Michael Rust, editors

Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

* Texas A&M University
Texas Sea Grant Program
2700 Earl Rudder Freeway South, Suite 1800
College Station, Texas 77845

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Gary Locke, Secretary

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Dr. Jane Lubchenco, Under Secretary for Oceans and Atmosphere

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Eric C. Schwaab, Assistant Administrator for Fisheries

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Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

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Cover photo of a south Texas fish and shrimp farm courtesy of Granvil Treece, Texas Sea Grant.

Table of Contents

Introduction

The U.S.-Japan Cooperative Program in Natural Resources (UJNR) was established on January 29, 1964. Since its creation, the UJNR has evolved to become one of the oldest and most effective cooperative agreements between Japan and the United States. In 1969, the UJNR Aquaculture Panel was created as a vehicle for scientists of both countries to meet and discuss aquaculture research accomplishments, needs, and priorities, as well as provide opportunities for cooperative research and scientific exchange.

Under UJNR Aquaculture Panel auspices, U.S. and Japanese scientists have met annually since 1971 without interruption. The venue for these meetings has alternated between the two countries. The 38th annual meeting and symposium were held October 2009 at Texas A&M University, Corpus Christi. By prior agreement of the U.S.-Japan panels, contributors to the proceedings were requested to submit manuscripts in the form of brief papers and abstracts.

Takaji Iida, **Japan Panel Chairman**
Robert Iwamoto, **United States Panel Chairman**

Economic and Social Issues Driving and Affecting the Development of Aquaculture in the United States

Michael Rubino
NOAA Aquaculture Program
1315 East-West Highway
SSMC3-Mail Code: F
Silver Spring, Maryland 20910
Michael.Rubino at noaa.gov

Keywords: sustainable aquaculture, fisheries management

Abstract

In the 1990s, rising demand for seafood, declining market share of domestically wild-caught fish, and increasing imports led to renewed interest in the potential of marine and freshwater aquaculture in the United States. In response to increased demand for seafood and a growing trade deficit in seafood, the U.S. Department of Commerce and its sub-agency, the National Oceanic and Atmospheric Administration (NOAA), adopted broad aquaculture policies in the late 1990s. More recently, several high-profile events, initiatives, and reports have helped shape NOAA's expanding role in U.S. aquaculture and bring into focus the many challenges the agency faces in fostering U.S. aquaculture as part of its stewardship mission to manage and conserve marine resources.

From a national perspective, a compelling case can be made for developing additional domestic aquaculture capacity in the United States. Aquaculture, as a complement to wild harvest commercial fisheries, can help meet the growing demand for seafood and help rebuild our wild fish stocks. Domestic aquaculture is also critical to maintaining an infrastructure in coastal communities to support both wild stock fisheries and commercial aquaculture and all of the jobs associated with the seafood industry. The potential synergies–rather than competition–among those engaged in commercial and recreational fisheries, marine aquaculture, seafood processing, and marketing are the keys to maintaining resource-dependent coastal communities and to ensuring a lead role for the United States in the global seafood market.

In order to cultivate those synergies and advance U.S. aquaculture, NOAA is focused on four specific priorities:

- **Ensure a comprehensive regulatory program for environmentally sustainable marine aquaculture that is predictable, transparent, and reflects an ecosystem-based management approach.**
- **Support research and development partnerships and conduct scientific research to increase knowledge and improve sustainable technologies for commercial aquaculture and aquaculture-based wild stock restoration.**
- **Support public understanding of marine aquaculture. NOAA is working to provide clear, accurate, and up-to-date scientific information to decision makers and the public regarding the environmental, socioeconomic, and health impacts related to marine aquaculture.**
- **Engage in international aquaculture developments and scientific exchanges.**

The challenges facing NOAA are numerous. Environmental and food safety concerns and the economic ramifications of domestic aquaculture are the subject of much debate and widely differing views. With all of these issues on the table, the United States stands at a critical juncture in the development and implementation of marine aquaculture and the new economic and environmental opportunities it can help provide for all fisheries-dependent coastal communities.

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The Legal System of Fisheries Cooperatives and the Rights of Fishermen in Japan

Makoto Yamasaki
Fisheries Research Agency
National Research Institute of Aquaculture
Nakatsuhamaura, Minami-ise
Watarai, Mie 516-0193, Japan
yama850 at affrc.go.jp

Keywords: fisheries cooperative, fishery rights, fishery cooperative act

Abstract

Japan fisheries cooperatives (FC) are organizations established under Japanese law (the Fishery Cooperative Act, 1948) to promote the development of collaborating groups among fishing communities. The Fishery Cooperative Act aims to improve the economic and social status of these communities and increase productivity within the fishing industry. Fisheries cooperatives are formed by the associates and formal membership is controlled by the period of annual operation days. The business operations of a fisheries cooperative include credit (as with banks), mutual aid (as with insurance companies), purchase operations that fishermen require in order to sustain themselves and their activities, selling the fishing products, and providing management guidance.

Introduction

A regional cooperative is a social unit, and is based on a village where a fishery has existed since the Edo period (about 300 years ago). There were 1,890 regional cooperatives in 1997, however, the number fell to 1,191 by July 2007 through active consolidation over a 10 year period. Umbrella organizations include the National Federation of Fisheries Cooperative Associations, prefectural federations of fisheries cooperative associations, and regional cooperative organizations.

Fishery rights are licensed by a prefectural governor and enable the holders to operate solely and exclusively within specific areas and to benefit from restricted access. Also, fishery rights established on the sea surface are not subject to the norms associated with land ownership. The following three types of fishery rights exist: 1) fixed-net fishery right, includes the right to lay and fix nets and other fishing gear for a specified period of time at a particular location; 2) demarcated fishery right, permits users to participate in aquatic animal or plant aquaculture within a specified demarcated area; and 3) common fishery right, permits fishing communities in a specific area to operate fisheries on a communal basis.

As for fishing communities, the most important organizations are fisheries cooperatives (FC) that consist of fishermen who are supplying fish for the nation. This paper introduces them following the consensus of the Japan panel that it is important for this symposium theme "Interactions of fisheries and fishing communities related to aquaculture" to know about Japanese FC, and with the hope that it will help promote fisheries and aquaculture of the United States.

System for Becoming a Fisherman in Japan

If you want to be a fisherman in Japan, what do you have to do? You have to be an inhabitant of a fishing village and an employee in a fishery. In addition, you have to work more than 90~120 days per year under a particular formal fisherman. The engagement period is fixed by each FC.

After more than one year of employment–a period fixed by each FC as well–the village FC will judge whether you are suitable to become a formal member of the FC. After having the approval of the FC directorate, you become a formal fisherman in a coastal fishery.

What are the Rights of Fisherman and the FC?

Fishery rights are provided in the Fisheries Law (1949). The objective of that law is to establish a fundamental management system relative to the fishery and to ensure fishery productivity with multiple layers of exploitation of the water and democratization of fishery. Some types of fisheries, for example the fixed net fishery and aquaculture, cannot be successfully prosecuted unless the areas are controlled to a certain extent. In order to adjust operations among the operators and maintain order in the fishery, a system of fishing rights in public waters has been established. The fishing right is a right with which one can operate in a certain fishery exclusively in a given area. The fishing right is established by the administrative authorities – in principle by the governors of the metropolis, Hokkaido or prefectures. However, the fishing right is not an unrestricted right. A certain area of water is demarcated, and for the purpose of optimum utilization of that area, the particulars of the right, such as target species, fishing seasons and the method of catching or farming the fish are specified. The following three types of fishery rights exist: 1) fixed-net fishery right, 2) demarcated fishery right, and 3) common fishery right.

Fixed-net Fishery Right

The fixed-net fishery rights include the right to lay and fix nets and other fishing gears for a specified period of time at a particular location. The license period is five years. The fixed-net fishery right is provided to those who actually operate the fixed-net fishery, but because it will occupy good coastal fishing grounds for a considerable period of time, there is a policy to give priority to the regional FC and other fishermen's organizations. The purpose of the policy is to allow as many fishermen as possible to participate in the management of such fisheries.

Demarcated Fishery Right

A demarcated fishery relates to aquaculture operations within a certain delineated area. In order to manage aquaculture it is essential to exclusively occupy the waters due to the nature of culture activities. For this reason, the demarcated fishery right has been established. There are three types of demarcated aquaculture:

> Type 1 is aquaculture operated by setting up aquaculture facilities within a certain area. Included are the culture of laver, oysters, pearl oysters and others using spore or spat collectors, aquaculture of oysters, pearl oysters and others using the hanging culture method; aquaculture of laver, kelp and other seaweeds using the surface floating float method; and aquaculture of yellowtail, sea bream, carp and other finfish using small net cages.
>
> Type 2 is aquaculture operated in specified areas surrounded by barriers. It is large- scale aquaculture for such species as yellowtail, sea bream and other finfish utilizing embankment and net partition methods.
>
> Type 3 is aquaculture operated in specified areas other than those of the preceding two types. This category includes the Jimaki culture method, which is to release shellfishes such as clams and oysters in fishing grounds and allowing them to grow naturally.

Of the demarcated fishery rights, those for large-scale fish farming and pearl culture require relatively large capital investments by persons who actually operate the aquaculture sites. Thus, this entitlement is similar to that of the fixed-net fishery right. Other types of culture such as seaweeds, pearl oysters, oysters and finfish in small net cages are called "special demarcated fishery right" in terms of the Fisheries Law and the right for those types of aquaculture is given to the FC, and under the management of the FC, individual members will execute the fishery right in the same way as the common fishery right. The license period for a demarcated fishery right is 10 years while that for a special demarcated one is 5 years.

The Common Fishery Right

This right permits fishing communities to operate fisheries in specified waters. The fishery right is divided into five categories according to the type of fishery and target fish species. The license period is ten years.

Because the common fishery uses the public waters in common, the fishery right is managed by the FC. In reality, the majority of coastal fishermen make their living from this type of fishery. The FC establishes rules for execution of the fishery right. The rule prescribes the eligibility (qualifications) of the person to engage in the fishery, fishing area and period, and fishing method.

With regard to the fixed-net fishery right and demarcated fishery right, the individual fishery operator who obtains the license holds the rights as previously mentioned. However, for the common fishery right and specified demarcated fishery right, the licensed FC holds the rights.

The Functions of FC

Japan FC are organizations established under Japanese law–the Fishery Cooperative Act (1948)–to promote the development of those organizations among fishermen. In so doing, the Fishery Cooperative Act aims to improve the economic and social status of fishermen and increase productivity within the fishing industry.

The business activities of an FC include the extension of credit by banks and savings and loans; establishment of mutual aid initiatives (as with insurance companies); purchasing operations required for acquiring and resupplying fuel, aquaculture feed and fishing equipment that fishermen require in order to sustain themselves and their activities; selling fishery products; and providing management guidance. Fishermen should not have any problem in conducting their fishing activities and making a living as long as they belong to a FC.

Table 1 shows the average scale of several business operations of the FCs. For example, of the 1,160 regional FCs surveyed, 932 engaged in selling fish products worth about $11.51 billion. Because the total value of Japan fishery in 2007 was $16.53 billion, almost 70% of the sales of Japan fishery products were attributed to the regional FCs.

Table 1. The average scale of several business operations of fisheries cooperatives.

Data from Fisheries Agency "Statistics tables of Fisheries Cooperatives, 2007" Converted at U.S. $1 = ¥100.

Total number of fisheries cooperatives surveyed		1,160
CREDIT		
Savings	Number of FC	237
	Total dealings	$9,145,050,000
	Average dealing	$52,560,000
Loan	Number of FC	234
	Total dealings	$2,272,800,000
	Average dealing	$9,710,000
PURCHASE	Number of FC	1,009
	Total dealings	$2,219,090,000
	Average dealing	$2,200,000
SELLING	Number of FC	932
	Total dealings	$11,515,250,000
	Average dealings	$12,370,000

The System of FC

There were 1,191 regional FCs in Japan in 2007 (as a result of a national campaign to have only one FC per prefecture). There were 1,890 FCs in 1997, so some consolidation has occurred. For example, in Chiba prefecture, located near Tokyo, there are 57 FC local units that are placed along the coast and rivers. All the local FCs form a prefectural federation of FCs, and all the prefectural federations form the Japan federation.

Fishery Adjustment Commission

In the Fisheries Law (1949), the Fishery Adjustment Commission (FAC) was formed to adjust fisheries that are composed mainly of fishery operators and employees. The FAC deals with fisheries-related matters that are established at the prefectural and national government levels. The FAC was introduced as part of a series of post-war reforms to bring about democratization of the fishing industry. The Fisheries Law states that the function of the FAC is to ensure that, "waters are comprehensively utilized, fishery production capacity is developed, and democratization of fishery is promoted." Further, the FAC works as an organization to make rulings, instructions and authorizations as well as one that holds consultations and makes proposals to prefectural governors. Therefore, the FAC has extensive and powerful authorities and functions associated with fisheries as follows:

1. Consultations: Prefectural governors are obliged to consult with the FAC before carrying out the planning of fishing ground management, awarding licenses of fishery rights, or engaging in any other administrative punishments related to fishery rights.

2. Proposals: The FAC is required to submit proposals to the prefectural governor in matters related to the establishment of fishing ground management plans and additions to restrictions or limitations of fishery rights after licenses are awarded. The FAC is responsible for actively proposing matters requiring input of the prefectural governor.

3. Decisions: The FAC acts under the law as arbitrator in cases where the parties in an aquaculture dispute are unable to reach an amicable agreement. The committee also instructs fishermen to restrict or prohibit the harvesting of certain aquatic plants and animals. They can also act on matters related to the eligibility of fishery rights applicants.

Recently, the management of fisherman and FCs has been difficult because of the low price of fish, lack of entrants into the fisheries and decreasing natural resources, among other reasons. The exclusive use of areas under fishery rights are under pressure from demands to allow the expansion of areas open to recreational fishing and leisure activities. The FCs must adjust to such pressures that arise from citizens other than fisherman.

Annotated Bibliography of Key Works

Hiroyoshi, K., and M. Sano (eds.). 2008. Fishery Economy-learn with arranged points. Hokuto-shobou, Tokyo. 285 p.

This is a textbook on fishery economics for university students. The content of the book includes production structures of fisheries and aquaculture, management, consumption, marketing, processing, and fishery cooperatives. It is only available in Japanese.

Kaneda, Y. 2005. Fisheries and fishing methods of Japan. Revised edition. Seizando Shoten Publishing Company, Tokyo. 214 p.

The fishing gear and methods used in Japan have been developed through the passage of time over the history of its fisheries. Because a large variety of fishing techniques exist in Japan, a strong need has arisen to conserve fisheries resources in public waters such as the seas, rivers, freshwater lakes, and ponds. In this book, the fishing gear and methods are outlined and the fishery management system in Japan provided as a supplement. The parts on fishery rights and the FAC in this paper are based on information in this book.

Goals of Stock Enhancement, by the People, for the People

Yuichiro Fujinami, Daisuke Shimizu, Yoshitomo Nagakura, Tsutomu Noda, and Hideaki Aono
Fisheries Research Agency
National Center for Stock Enhancement, Miyako Station
Sakiyama, Miyako, Iwate 027-0097, Japan
fujinami at affrc.go.jp

Keywords: stock enhancement, stocking effectiveness,

Abstract

The Miyako Station National Center for Stock Enhancement has been stocking marine fish juveniles in Miyako Bay. The center also conducts public relation (pr) activities on stock enhancement by holding several events such as open laboratory, field study programs, and stocking experience events. Recently, these activities have often been reported in local newspapers and on television news.

In this paper, we report on the evaluation of the effects of our pr activities by questionnaire surveys conducted in 2004, 2005, and 2009 for checking on the awareness of 1) the term "Stock Enhancement", 2) existence of our hatchery, and 3) stocking of juveniles in Miyako Bay.

The results show that the percentages of people responding to the questions "I know the term stock enhancement" and "I know a hatchery for stock enhancement exists in Miyako City" were 85.1% and 70.3%, in 2004/2005 and 72.3% and 60.7% in 2009. The awareness of levels of stocking with juveniles of four kinds increased in this survey in 2009 compared to 2004/2005.

The goals of the stock enhancement program are enhancement of the fishery stocks and the activation of the local community (for the people). To arrive at those goals, the program should be operated with fishery workers and the local residents (by the people) because stock management and conservation of nursery grounds where they are located close to populated areas are indispensable for its success. From our point of view, the pr activities are effective in promoting stock enhancement by the people.

Introduction

The stock enhancement program of marine fish in Japan has been in existence since 1963. The idea is to improve resources in coastal areas as well as ensuring income to coastal fishery workers (Imamura 1999). For the successful operation of stock enhancement, not only stocking strategy that focuses on high quality juveniles, but also conservation of nursery grounds and stock management are needed. Therefore, it is important to carry on the stock enhancement program with fishery workers and local residents.

At the Miyako Station, National Center for Stock Enhancement, we have stocked various species of marine fish juveniles into Miyako Bay. In recent years, 5,000 to 700,000 Japanese flounder (*Paralichthys olivaceus*), Pacific herring (*Clupea pallasii*), spotted halibut (*Verasper variegates*) and black rockfish (*Sebastes schlegeli*) juveniles are stocked every year. The maximum contribution rate (contribution of stocked fish in the landings) has been estimated at 52.7% for flounder (Okouchi et al. 2004), 97.0% for black rockfish (Nakagawa et al. 2006), 36.0% for Pacific herring (Okouchi unpublished) and more than 90% for spotted halibut (Shimizu unpublished). Moreover, the maximum economic efficiency (the landed value of stocked fish divided by the cost of fingerling production) has been estimated to be 2.53 in flounder (Okouchi et al. 2004) and 1.25 in black rockfish (Nakagawa et al. 2006). However, the effectiveness of stocking was hardly recognized by fishery workers and local residents.

In the late 1990s, we started a public relation campaign on the effectiveness of the stock enhancement program and the importance of nursery ground by holding several events such as open laboratory, field study programs, and stocking experience events. At the events, we inform participants about the following in plain language: 1) how fish are hatched and reared, 2) how and where stocked juveniles grow, 3) why the nursery grounds are important for juvenile growth, 4) why the marine ecosystem is important for creatures and how it is easily damaged by human activities, and 5) how stock enhancement and the stock management play important roles for sustainable fisheries.

In this paper, we show the changes of residents' awareness of stock enhancement, and discuss the effectiveness of our pr activities.

Methods

Questionnaire surveys were conducted in 2004, 2005 and 2009 at our booth in the industry exhibition of Miyako City. We handed the questionnaire to visitors of the exhibition, collected the response sheets, and compared the results between 2004/2005 and 2009. The survey items were as follows: (Q1) Do you know the term "stock enhancement?" (Q2) Do you know a hatchery for stock enhancement exists in Miyako City? Moreover, the items shown below were added in the survey of 2009: (Q3) Do you know we stocked juveniles of four kinds of species; (Q4) If your answer of Q3 is YES, how did you find out about it?

Results and Discussion

Effects of pr activities. The results showed the awareness of stock enhancement and existence of a hatchery for stock enhancement was 85.1% and respectively, 70.3% in 2004/2005 (n=148), and decreased to 72.3% and 60.7% in 2009 (n=303, Table 1). On the other hand, the awareness of juvenile stocking of four species increased. In particular, the percentage of respondents aware of Pacific herring (25.0% to 47.0%) and spotted halibut (18.2% to 33.0%) almost doubled (Figure 1). Figure 2 shows how residents came to know about our activities in juvenile stocking. The sources were mainly local newspapers or TV, followed by word of mouth from family or friends, participation of pr events and others. Recently, our pr activities have received a high degree of local media coverage. It is thought that is the reason for boosted awareness of juvenile stocking.

Goals of Stock Enhancement

In late years, some fishery workers aware of our activities voluntarily began to halt landing young black rockfish (Noda et al. 2008), or to protect herring eggs spawned on fishing nets (Nagakura and Aritaki 2009). By these stock managements, the catch of these species increased. Increase of local fishery stocks will not only increase fishery worker's incomes, but also benefit the local economy, recreational fisheries and so on. Stock enhancement is one

Table 1. The awareness by Miyako residents of stock enhancement activities and existence of the hatchery for stock enhancement in Miyako City.

	Awareness (percent)	
	2004–2005 (*n*=148)	2009 (*n*=303)
Stock enhancement	85.1	72.3
Existence of hatchery	70.3	60.7

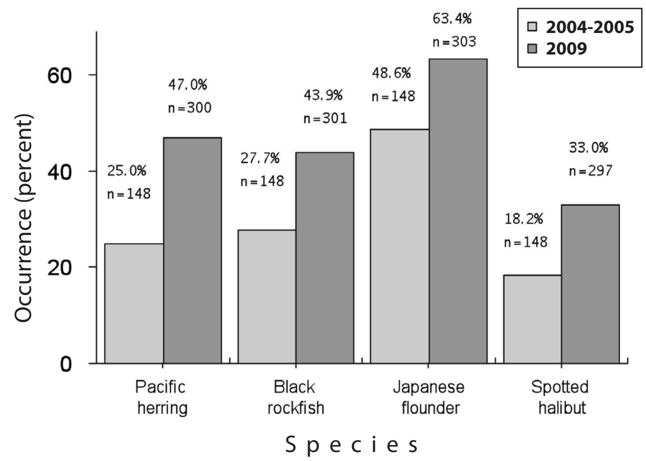

Figure 1. Changes in awareness of juvenile stocking of four species

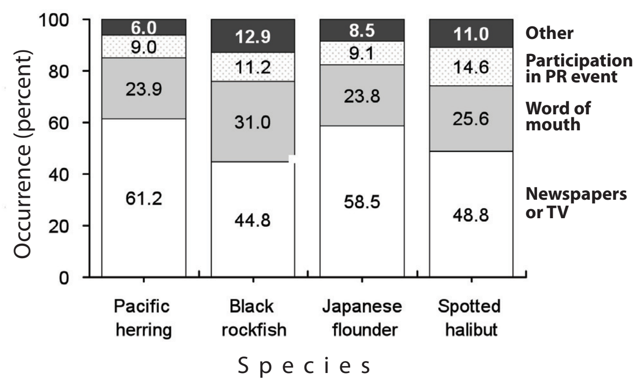

Figure 2. The response to question four: "How do you know about juvenile stocking?"

effective tool for stock management and enhancement of the fishery stock. However, for the stock enhancement to be successful, mutual understanding and cooperation among local residents, fishery workers, and researchers is indispensable, and pr activities play an important role in developing that understanding. Obviously, the goals of stock enhancement are growth of the stocks and to activate the local community. To arrive at those goals stock enhancement must be performed "by" the people. As the results, it will yield great benefits "for" the people.

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U.S. Shellfish Growers Perception of Risk: Do Shellfish Growers Feel Most Vulnerable to Institutional, Environmental, Market-based, or Climate Change Risks?

Danielle Rioux
University of Washington
School of Marine Affairs
Seattle, Washington 98122
UWShellfish at gmail.com

Keywords: risk, shellfish, aquaculture, oyster, climate change

Abstract

Currently, molluscan shellfish culture comprises two–thirds of U.S. marine aquaculture. With U.S. aquaculture expected to triple in size by 2025, it is likely that there will be marked growth in the shellfish growing sector. In order to effectively manage an expanding shellfish growing industry, it is important to understand the risks associated with it, as well as how they impact business decisions. There has been significant academic research to elucidate the scientific basis of the four main risk categories of this study, environmental and climate change risks to shellfish, as well as market-based and institutional risk. Yet little research has been conducted to assess how members of the shellfish industry perceive these risks, their financial protection from them, nor growers' perception of market demand, and their associated business decisions.

This study surveyed molluscan shellfish growers in the United States about their perception of risk to their individual businesses, to the industry as a whole, and about their business decisions. The survey asked each grower to rate the level of risk of 30 different threats from the four main risk categories. Shellfish growers are also asked about their perceived level of product demand, the history of their business decisions, and their plans for future change. The data from this survey have been quantitatively analyzed to reveal statistically significant differences in where the industry feels most vulnerable, as well as between regional business decisions.

Introduction

In this study, shellfish growers' perceptions of risk in the United States are analyzed. By elucidating which specific threats the industry perceives to have the highest associated risk, those threats may become more of a focal point in regulation and protection. Using this approach to find specific threats will allow targeted industry growth barriers to be studied and overcome.

Currently within the aquaculture industry, and shellfish culture specifically, there are few safety nets available to investors. Unlike terrestrial farms, subsidies and government insurance programs are not broadly available. There is a pilot federal insurance program for cultivated clams available in four East Coast states which is the first federal crop insurance program for aquaculture (Beach and Viator 2008). This is a small scale program, however, and only available for clams; thus growers who produce clams and other mollusks may only insure part of their businesses.

A more recent development for the aquaculture industry in the United States is a partner program between the Federal Crop Insurance Corporation and approved private insurance companies through a re-insurance program under the Federal Crop Insurance Act (7 U.S.C. 1502 § 502). Currently, however, in the United States the only private aquaculture insurer is Lloyd's of London, and very few policies have been drafted (van Anrooy 2006). It is also important to note that extensive shellfish culture is not considered insurable (van Anrooy 2006); likely because assessing all of the threats is impossible.

Currently, the main way for a shellfish grower to receive direct compensation for product loss is if the entire fishery is deemed to be a commercial fishery failure by the Secretary of Commerce, under the Magnuson Stevens Act of 1976 (U.S.C.§1861 (a)), or under the Interjurisdictional Fisheries Act of 1986 (NOAA Fisheries Office of Sustainable Fisheries 2009.

By only appropriating money when the fishery is deemed a failure, the risk for each individual aquaculturist is not mitigated. It is possible for money to trickle down to those affected. However, it has only happened twice. Both Massachusetts and Maine were considered to have fishery failures in 2005 due to a harmful algal bloom (HAB). While aid was given in 2005, those helped represent only a small percentage of aquaculture operations that have been affected by HABs over the past 30 years, and HABs are only one of the innumerable threats to marine culture. Due to the requirement that the fishery must be deemed a failure, it makes it nearly impossible for an aquaculturist to rely on government appropriations. There are many large threats to aquaculture economics, and there is currently not an effective way for aquaculturists to protect their investments.

There were three goals of this study:

1. Provide information that may aid in the understanding of where growers feel specifically vulnerable, which possibly can be used to solve this dearth of options for growers.
2. Analyze the perceived health of the industry, including perceived demand as well as associated changes in price per piece and production levels.
3. Assess the interest level in financial protection from stock mortality in the industry, through insurance programs, as well as appraise the current types of protection used.

Methods

To meet the goals of the study a voluntary, anonymous mail survey was created and sent to registered shellfish growers across the country. The first page of the survey was an invitation to participate. This letter outlined the anonymity and voluntary nature of the survey, as well as the goals of the study. In the letter a request was made that the owner or manager complete the survey, so that the answers would reflect the thoughts of someone in a decision-making role within the company.

Survey Design—The survey was designed using the basic principles of the Taylor design method (Dillman, 2007). Questions asked were worded in an unbiased non-leading manner. The order of the questions represented was strategic. Questions that the respondent would likely be least motivated to answer were asked last, thus engaging respondents before they were faced with those questions. The survey design was broken into three major components in order to efficiently answer questions related to the first three goals of the study (Figure 1).

There were also various qualifying questions asked, such as product produced, state in which production happens, size of company, as well as the respondents role in the company, and how many years they were involved in the shellfish growing industry. These questions were asked not to directly meet any of the goals, but to enable an understanding of the diversity of respondents.

Sampling Technique—The maximum survey mailing capacity of this study was 1,000 surveys sent via the U.S. Postal Service. To obtain lists of registered growers in each state, a number of avenues were used. State departments of health, fish and wildlife, natural resources, or other government offices generally hold these lists. In the few states where that is not the case, other contacts were used to obtain the lists. In order to create an even sample of each coast and to allow accurate statistical comparison, a limit of 333 surveys was set for the west, gulf, and east coasts of the U.S. In the case of Florida, each address on the list was mapped and assigned to the appropriate coast.

Data Analysis Methods—The qualifying questions of the survey were analyzed using basic descriptive statistics of means, percentages, and counts. The answers to the qualifying questions created an understanding of the characteristics of the respondents.

Goal 1: Highest Perceived Risk

Individual Threat—The first step taken to find which threat in the survey has the highest associated perceived risk within the industry was basic coding of respondent answers. The data from the risk assessment Likert Scale questions were qualitative, and these data were transposed into quantitative numerical data, using the code 1 to 5, with 1 indicating very low risk and 5 very high risk. Unknown answers were not assigned a value.

Two methods were used to find the threat with the highest perceived risk in each of the threat categories. The first method used was the Kruskal-Wallis signed rank test. The Kruskal-Wallis test is a non-parametric test to determine whether three or more independent samples are from the same population, by assessing if there is a difference in the distribution of each population (Larson, 2006). The data are first grouped into the populations for comparison, to determine the threat with the highest level of associated perceived risk; the answers for each question were a separate population. All of the data are then numerically ordered as one continuous data set, and then ranked. The mean rank or each population, as well as the test statistic is then calculated. By calculating the mean rank, it allows for comparison between different sized populations. The calculations were done using the computer software SPSS. The data used to find the largest threat in each category were considered dependent data, because they have multiple answers made by the same individual, as respondents rate each threat within a category. Since it is likely that the way respondents answer the first question in the category affects how they answer the last, the data cannot be considered independent, which renders the Kruskal-Wallis test statistic invalid in this case. Although the statistic calculated from this test is invalid due to the dependency of the data, the signed-ranks are valid and give information to answer the question in goal 1. The ranks were then verified by calculating the mean for each of the individual threats, and the same results were found.

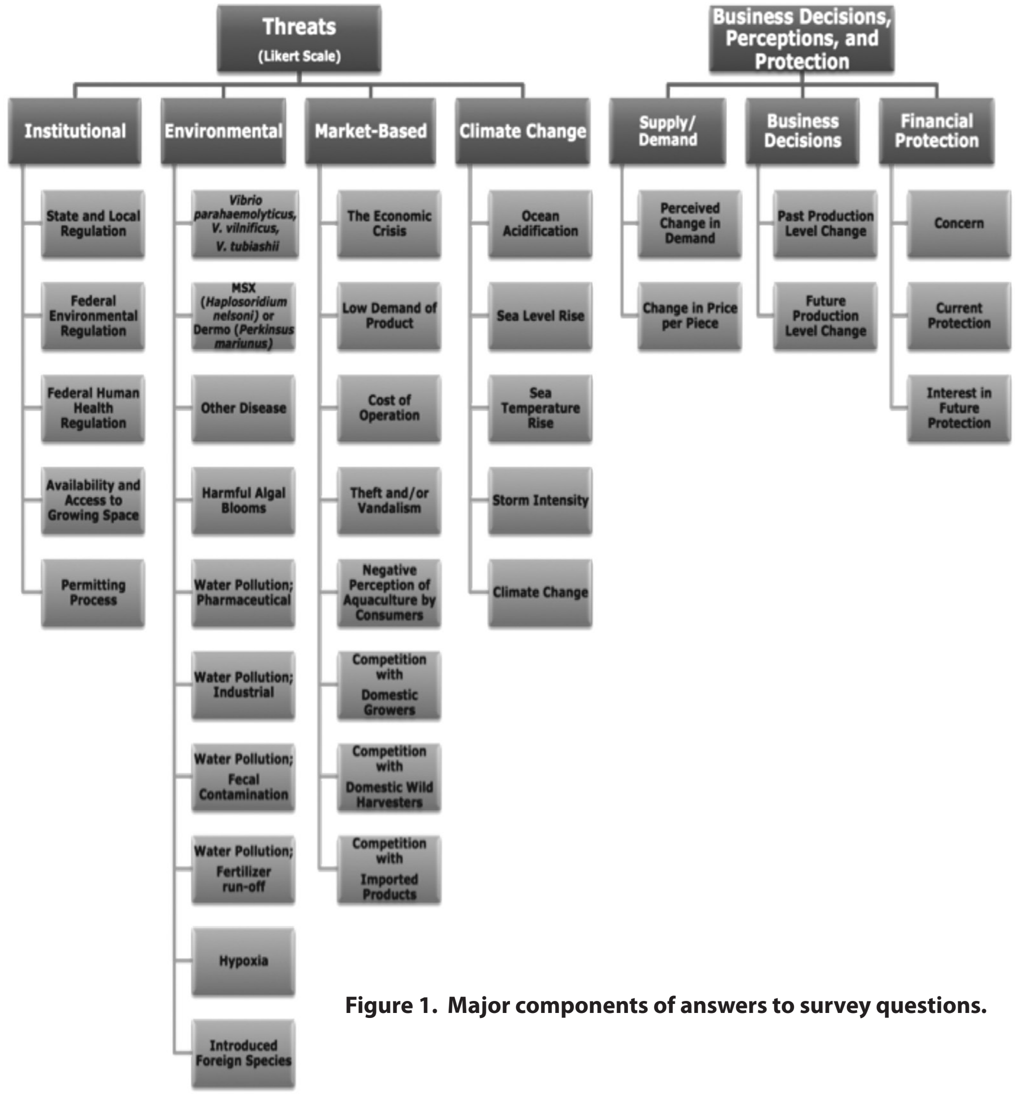

Figure 1. Major components of answers to survey questions.

The individual threat data were also analyzed to see how evenly spread the responses were to the questions. The spread data were also calculated to examine if the highest risks from the previous tests were verified by having the highest percentage of respondents rating them as very high risk. This was done by calculating the percentage of respondents answering each possible answer for each question; that is for threat x, a percent of respondents answered very low risk, b percent answered low risk, etc.

To find which category of threats had the highest level of perceived risk, a repeated Analysis of Variance test was run using "repeated measures" in SPSS. The test was run using the mean for each survey of each category.

Goal 2: Perceived Market Health and Business Decisions—This goal of the survey was answered through descriptive statistics for the questions designed to assess perceived market and industry health. Comparisons were made between the five-year and one–year time scales to appraise how the market may be changing.

Goal 3: Interest in and Current Status of Financial Protection from Stock Mortality— This goal was addressed through descriptive statistics using percent of respondents answering yes, no, or unknown. The open-ended question, which asked the respondent to describe how they had financially protected their business, was qualitatively assessed. General categories of answers were created subjectively, solely to discern if there were any definitive patterns.

The data from the market health and business decisions were transposed from qualitative data into quantitative numerical data using the code 1 for decrease, 2 for stayed about the same, and 3 for increase. Again, unknown answers were not assigned a value. Using this code, a Kruskal-Wallis signed rank test was run between the coasts for both the five year and one year time scale. The current level of financial protection from stock mortality, and interest in learning about federal and private insurance was compared between coasts using descriptive statistics calculated for each coast.

Results

Qualifying Questions—Geographic response numbers are presented in Table 1. The national response rate was 14%. The product respondent growers produces presented in Table 2. Many respondents grow more than one type of animal, which is why the number of responses is higher than the number of surveys returned. The respondents position within the business is presented in Table 3 and the size of the businesses who responded is shown in Table 4. The final qualifying question asked respondents to state how long they individually had been involved in the shellfish growing industry. The mean number of years involved was 22 years, with the fewest amount of time being one year, and the longest 55 years.

Goal 1: Highest Perceived Risk
Institutional Threats—In Table 5, a higher mean rank reflects a higher level of perceived risk, which is verified through the calculated mean. This information shows that the threat with the highest perceived risk in the institutional threat group is state and local regulations. The threat with the second

Table 1. Survey responses by geographic location.

West Coast		East Coast	
Alaska	3	Maine	2
Washington	45	Massachusetts	4
Oregon	4	Connecticut	4
California	6	Rhode Island	3
Total	*58*	New York	1
Response rate	*18%*	New Jersey	5
		Maryland	1
Gulf Coast		Virginia	9
Louisiana	22	North Carolina	7
Mississippi	1	South Carolina	7
Florida	7	Florida	1
Total	*30*	*Total*	*44*
Response rate	*9%*	*Response rate*	*14%*

Table 2. Survey responses by product type.

Product	Number of responses
Clams	68
Geoduck*	5
Mussels	16
Oysters	106
Scallop*	3
Abalone*	1

*Write in answer

Table 3. Survey responses by position in the business.

Position	Percent of respondents
Executive (owner, president, chair, etc.)	93
Manager	6
Other	1

Table 4. Survey responses by size of business.

Weekly production	Percent of respondents
Small (< 1,000 dozen)	52
Medium (1,000 to 5,000 dozen)	30
Large (> 5,000 dozen)	18

highest risk is federal environmental regulations. This is notable because both the mean rank and calculated means are very close between the highest and next highest perceived risk. The discrete answers are graphed as percentage of respondents answering each rating on the Likert scale (Figure 2). That figure shows that not only does state and local regulation have the highest mean rank and mean, but also the highest percentage of respondents rating it as very high risk.

Market-Based Threats—The information in the Table 6 shows that the threat with the highest level of associated risk in the market-based threat category is the cost of operation. Figure 3 shows the discrete answers and the percent of respondents who marked each Likert scale option. Figure 3 shows that although the threat with the highest overall level of perceived risk is the cost of operation, more growers actually responded that competition with imported products is a very high risk to their business than the cost of operation.

Table 5. Level of perceived risk by institution threats.

Threat	Mean rank	Mean
State and local regulations	372.82	3.74
Federal environmental regulations	350.58	3.59
Federal human health regulations	294.65	3.22
Availability and access to growing space	281.90	3.08
Permitting process	310.30	3.29

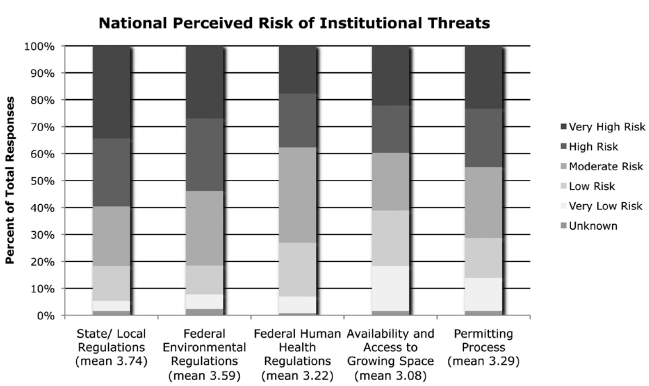

Figure 2. Likert scale of perceived risk by institutional threats.

Environmental Threats—The data in Table 7 show that *Vibrio* spp. have the highest level of perceived risk. It is also noted that the threat with the second highest level of perceived risk is fecal contamination. This gives strength to the argument that these are the two highest, because fecal contamination in part triggers blooms of *Vibrio* spp. Thus by having both rated very closely, it shows a level of understanding of the disease process within the shellfish growing

Table 6. Level of perceived risk by market-based threats.

Threat	Mean rank	Mean
The economic crisis	630.33	3.12
Low demand of product	519.89	2.69
Cost of operation	683.94	3.35
Theft and/or vandalism	487.70	2.59
Negative perception of aquaculture by consumers	454.93	2.45
Competition with:		
Domestic growers	482.63	2.54
Domestic wild harvesters	379.31	2.14
Imported products	529.12	2.79

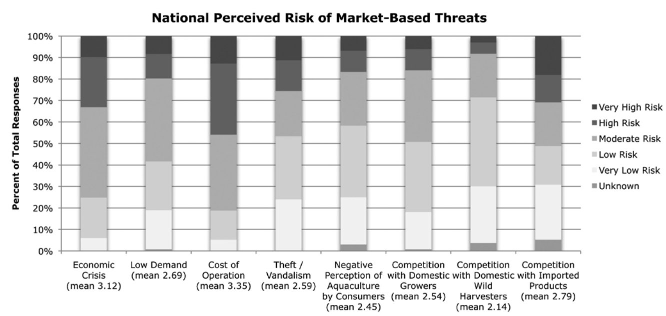

Figure 3. Likert scale of perceived risk by market-based threats.

Table 7. Level of perceived risk by environmental threats.

Threat	Mean rank	Mean
Vibrio parahaemolyticus, V. vulnificus, or V. tubiashii	711.39	3.27
MSX (*Haplosporidium nelsoni*) or Dermo (*Parkinsus marinus*)	699.11	2.88
Disease (other than above)	617.19	2.89
Harmful algal blooms	613.33	2.88
Water pollution:		
Pharmaceutical	448.65	2.27
Industrial	483.60	2.58
Fecal contamination	680.54	3.14
Fertilizer run-off	626.99	2.94
Hypoxia	530.59	2.46
Introduced foreign species	616.40	2.85

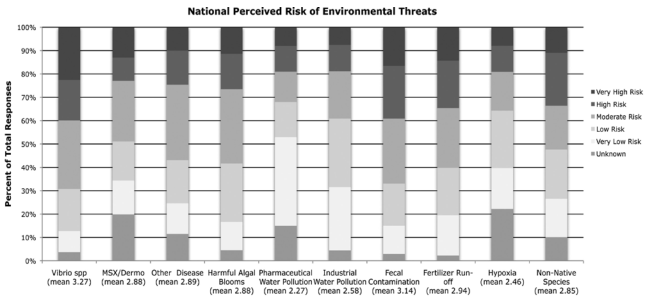

Figure 4. Likert scale of perceived risk by environmental threats.

industry. The discrete answers shown as percentages of respondents answering each Likert scale rating can be seen as Figure 4. The discrete breakdown shows the threats with the highest percentage of respondents rating of very high risk were *Vibrio* spp. and fecal contamination.

Climate Change Threats—The data in Table 8 show that the threat with the highest level of perceived risk is storm intensity. The breakdown of percent of respondents answering each Likert scale rating is graphed in Figure 5, which shows that the threat with the highest percentage of respondents rating it a very high risk is storm intensity.

Table 8. Level of perceived risk by climate change threats.

Threat	Sum of ranks	Mean
Ocean acidification	327.49	2.96
Sea level rise	251.73	2.39
Sea temperature rise	285.35	2.62
Storm intensity	358.70	3.19
Climate change	310.51	2.82

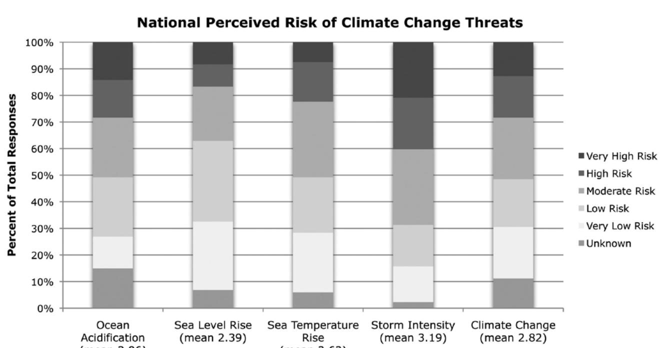

Figure 5. Likert scale of perceived risk by climate change threats.

Threat Category—A repeated ANOVA test was run between the four threat categories to find which category has the highest level of perceived risk. These data are shown in Table 9. A higher mean reflects a higher level of perceived risk. The information in Table 9 shows that the threat category with the highest level of perceived risk is institutional threats. The test statistic is 0.000, which reflects a significant difference in perception between the threat categories.

Table 9. Level of perceived risk by threat category.

Threat	Mean
Institutional	3.33
Market-based	2.71
Environmental	2.82
Climate	2.75

Goal 2: Perceived Market Health and Business Decisions

Perceived Market Health

Change in Demand—Results for perceived change in demand can be seen in Table 10.

Change in Price per Piece—The results for respondent businesses' change in price per piece are presented in Table 10. The two are very similar, except that more respondents claim they have increased their price per piece in the past year than have in the past 5 years.

Business Decisions

Past Change in Production—The data regarding past change in production is shown in Table 10. The results for both time periods are very similar and show that, nationally, the industry has increased its production in the past, although the percent of respondents stating that their production has increased is slightly smaller in the past year than the past 5 years.

Future Change in Production—The results for future expected change is production is reported in

Table 10. Perceived market health.

	Decreased	Stayed about the same	Increased	Unknown
Change in product demand in past 5 years	17	31	50	2
Change in product change in the past year (n=128)	23	38	38	1
Change in price per piece in past 5 years (n=127)	24	34	42	0
Change in price per piece in the past year (n=127)	24	24	52	0
Change in production level in the past 5 years (n=131)	18	43	39	0
Change in production level in the past year (n=130)	19	47	39	0
Future production level in the next five years (n=131)	36	6	44	14
Future production level in the next year (n=131)	6	46	38	10

Table 10. The results show that there is an overall expected increase in production within the industry from the respondents. More respondents stated that the change in production of their business is unknown in the next 5 years than the next year, which is expected, as it is difficult to forecast what will happen in the market in the next 5 years. By comparing between time scales, it can be seen that more respondents expect to increase their production in the next five years than in the next year, thus showing that growers who have planned 5 or more years into the future are expecting to expand their businesses more in the distant than the immediate future.

Goal 3: Interest in and Current Status of Financial Protection from Stock Mortality—The first question in assessing interest within the industry of financial protection from stock mortality from any of the threats surveyed is to assess whether stock mortality is a concern. Sixty-nine percent of respondents stated that they worry about stock mortality. When asked if they rely on government disaster relief programs to financially protect their business, 67% remarked that they do not.

Growers were asked if there were a federal stock mortality insurance program, would they be interested in learning about it. Sixty-seven percent of respondents stated that they would, 27% would not and 6% marked unknown. A separate question asked about their interest in learning more about a private stock mortality insurance program. Sixty-seven percent of respondents stated that they would be interested, 25% would not, and 8% marked unknown. The similar results show that the interest level is not influenced by a preference for government or private protection. Respondents were also asked how much they would be willing to pay per animal for coverage. The responses to this question varied widely, with most respondents leaving the question blank. Generally, respondents who answered would be willing to pay less than one cent per animal.

Respondents were also asked if they were currently financially protected. Sixty-seven percent stated that they were not. Those who marked that they were protected were then asked the open-ended question of how. The results varied widely, with many respondents stating through liability insurance, which doesn't cover the crop. One respondent stated that federal flood insurance covers 30% of crop loss due to flood. Five respondents stated that they were protected by the diversification of their product, three stated that they had insurance, but did not explain what kind. Twelve respondents stated that they had crop insurance, either through the pilot clam insurance for four east coast states, federal crop disaster insurance, or a private company.

Discussion

The qualifying questions in the survey play an important role in assessing whether the respondent population accurately reflects the characteristics of the entire shellfish grower population. Through discussions with experts on the industry, as well as representatives from within the industry, this was validated. The proportion of small to large companies, as well as the proportion of respondents who grow each product type, are accurate for the industry as a whole. With the mean number of years in the industry by respondents at 22, the views reflected in the results come from growers who have been in the industry long enough to have witnessed ups and downs and have an educated opinion of its current status. Ninety-three percent of the respondents are the owner of their business, and thus are in a prime decision-making role for the company.

Goal 1: Highest Perceived Risk—The primary goal of this study was to find what threat to the shellfish growing industry has the highest level of perceived risk. The first step in identifying the largest perceived threat was to find which threat within each category had the highest level of perceived risk.

In the institutional threat category, the highest perceived risk was associated with state and local regulations. This is particularly interesting because this is one of the threats that varies widely depending on location. Through discussions with growers as well as their answers to the open ended question, the tie that makes all state and local regulations, regardless of the state or locale, the highest risk is the rate at which they are changed. Growers find that state and local regulations are constantly changing and it is difficult to keep up with them.

In the market-based threat category the largest perceived risk was from the current cost of operation. The open-ended question answers helped explain this finding as well. A number of growers commented on fuel costs, as well as the fact that they simply can't get production costs down low enough to compete with imports and still make a solid profit.

The environmental threat with the highest level of perceived risk is *Vibrio* spp. This does not come as a surprise as *Vibrio* are now found on all coasts of the United States, and in almost all bays and waterways where shellfish are grown. *Vibrio* not only slow the growth of shellfish, and sometimes cause mortality, but also render the product non-marketable, as most *Vibrio* spp. cause illness in humans.

The highest perceived risk of a climate change threat was storm intensity. This is likely because storm intensity is a visible, concrete, dramatic occurrence, the results of which are immediate. The high number of hurricanes in most recent years, many with intensities above what has been witnessed previously is not possible to ignore. Other climate change threats are on a slower, more constant time scale, and may not be recognized as risks for a number of years to come.

The next step in assessing what threat poses the biggest perceived threat was to find which category of threats holds the highest level of perceived risk. This was the institutional threats category. It is not accurate to then assume that the highest perceived risk within the category, state and local regulations, is the highest overall risk. The means of all of the threats can be compared to reveal that this is in fact the case; that is the highest perceived risk to the shellfish growing industry is state and local regulations.

Additional questions associated with the threats posed by climate change were asked to form an idea of how perceptive the industry is about the potential threats posed. With an average self-rated understanding of 3.33 on a scale of 1 to 5, with 5 being complete understanding, it is now documented that the industry believes they have a moderate understanding. With that level of self-rated understanding, it is interesting that the climate change threat category has a lower level of perceived risk than not only the institutional threats, but also environmental threats. This is likely because the threats in the latter two categories are more immediate, and the growers have likely been overwhelmed by the daily threats to production and not able to look to the future and the potential threats it may hold. With a high number of respondents stating that they get their climate change information from industry publications, a direct avenue is illuminated, and it is prudent to use this route to get climate impact information to the shellfish growing community.

Goal 2: Perceived Market Health and Business Decisions—In a growing industry it is expected that demand will continuously increase over time, as will price. As demand increases, the producers are expected to increase the price they charge as well as increase their level of production. This study has revealed that the growers perceive a gross increase in demand in both the past five years and the past year. There is interesting information created by comparing the two time scales, however. In the past year a much larger proportion of respondents marked that they have noticed a decrease in demand for their product. In terms of a healthy and growing industry the opposite would be expected, with the largest demand occurring most recently. In terms of demand for shellfish, however, this can likely be explained by the fact that the past year has been plagued by a recession, and shellfish is considered by most people to be a luxury food item. In times of financial strife demand for shellfish decreases because people simply can't afford it.

The price per piece, which can be viewed as associated with, if not a direct derivative of the level of demand, however, shows a healthier industry. More respondents have increased their price per piece in the past year, than in the past five years. The data alone are a good sign, however, accompanied by the data that more growers have noticed a decrease in demand in the past year sets up an imbalanced market scenario. One possible explanation to the industry overall increasing price per piece, when a larger proportion of growers have witnessed a decrease in demand, may be that the decision is not market driven.

The biggest threat in the market-based category was cost of operation, so it is possible that growers were forced to increase their price per piece in order to maintain their business, despite the cues from the market. Also associated with the market are economies of scale and change in production levels. Growers were asked about how their level of production has changed in the past. There are many factors, but based on a very basic principle – if the cost of operation is too high per animal, increasing the production level when there are increasing economies of scale will likely solve the problem. On the ground in the shellfish growing industry it is not that simple however, and access to growing space, as well as more broodstock and processing capabilities largely limit the capacity of individual facilities.

The results of this survey show that as a whole the surveyed industry has grown in the past five years as well as the past year. Fewer respondents stated that they have increased their production in the past year than have in the past five years, which may be a sign that the growth is slowing. The other possibility is solely based on timelines and continuity, meaning that the expansion of production is not necessarily continuous but takes time and planning. Thus, an expansion may take more than one year. This idea is echoed in the results from how the growers expect to change their production levels in the future. More respondents expect to expand their production size in the next five years than in the next year. Overall, those surveyed expect to expand their production in the future, so we should see more domestically grown shellfish in our markets in the years to come.

Goal 3: Interest in and Current Status of Financial Protection from Stock Mortality— The results of this study show that the majority of respondent growers are interested in either a government or private insurance option to help financially protect their businesses from stock mortality. Although the amount they are willing to pay for coverage was not effectively answered through the study, it is noted that there is a willingness to pay. The level of coverage would certainly affect how much growers are willing to spend. As for the coverage currently used by growers, there are a few who used the pilot program created by the USDA, as well as a few who have found private coverage. The open-ended questions showed that many growers have not been able to find private coverage. Therefore, one outcome of this study is the documented need for information sharing within the industry or an outside source compiling the different options available to growers.

Conclusions

This study was created to meet three goals which will help answer the larger question of why the shellfish production industry is not growing as quickly as expected. State and local regulations have been highlighted as the largest perceived risk, and is likely due to the rate at which they change. Growers have also clearly stated that they are interested in learning more about financial protection from stock mortality, whether federal or private, and it is now clear that coverage availability is not well known throughout the industry.

The study *has* also depicted what has happened within the industry in the past, and what to expect in the future with regard to business decisions. In the past respondents have been expanding production, witnessing an increase in demand, and concurrently increasing the price per piece of the product. The past year, however shows less growth than the past five years. In the future we can expect expanding production from growers overall, with 5% more respondents claiming they expect to expand in the future then have expanded in the past.

The respondents to the survey have been ambassadors for their industry. They have made their concerns known, as well as clarified changes in production we can expect to see in the future. The next step to making sure that the shellfish industry in the United States may efficiently grow and help close the gap of seafood needs is to address some of the apprehension the growers have, focusing on state and local regulations.

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insurance program for cultivated clams. Aquaculture Economics and Management. 12:1:25–38.

One important issue affecting the continued growth and success of the aquaculture industry is risk management. Aquaculture producers face a number of production risks (e.g., weather, disease) that substantially affect their output quantity and quality. Crop insurance is one important potential mechanism for managing these risks, but aquaculture has historically had limited insurance availability in the United States, in part because of unique challenges associated with implementing crop insurance programs in aquatic settings. The Cultivated Clam Pilot Insurance Program, which began in 2000 in four Atlantic Coast states, is the first U.S. federal crop insurance program for aquaculture. This program experienced relatively high loss ratios in the early years of the program, but substantial modifications beginning with the 2004 crop year resulted in a significant improvement in actuarial performance. Experiences with clam insurance can provide insight into the potential development and application of insurance programs for other aquaculture products.

National Marine Fisheries Service Office of Science and Technology, NOAA. 2009. Fisheries of the United States 2008. Pre-publication online at: http://www.st.nmfs.noaa.gov/st1/fus/fus08/index.html

This publication is a preliminary report for 2008 on commercial and recreational fisheries of the United States with landings from the U.S. territorial seas, the U.S. Exclusive Economic Zone (EEZ), and on the high seas. This annual report provides timely answers to frequently asked questions.

van Anrooy, R., P.A.D. Secretan, Y. Lou, R. Roberts, M. Upare 2006. Review of the current state of world aquaculture insurance. FAO Fisheries Technical Paper. No. 493. FAO. Rome.

Due to the rapidly changing production processes in aquaculture worldwide (e.g. submergible cages, sea ranching, intensification, aquaponics, and recirculation systems), which sometimes increase vulnerability to disease outbreaks and which generally require large investments from aquaculturists, over the last decades the demand for insurance to share and cover the risks involved has increased significantly within the aquaculture sector. Risk management is increasingly gaining attention within the aquaculture sector, which is reflected in the development and increasing implementation of better management Practices, codes of conduct and codes of good practice, standard operational procedures, certification and traceability. Aquaculture insurance is one of the tools used in aquaculture risk management, but there is considerable ignorance within the aquaculture industry about its availability, the process of obtaining insurance cover, especially on aquaculture stock mortality, and the constraints to insurers providing its services.

This paper concludes that there is low availability of aquaculture insurance because the risk assessment for the industry is extremely complex, which makes under-writing policies difficult. This is part of the inspiration for my research, as more targeted policies for specified risks the industry feels vulnerable to, are easier to create than blanket mortality policies currently developed.

Fishery Marketing Strategy Based on Local Production for Local Consumption: Oysters and Sea Urchins

Tsutom Miyata
Fisheries Research Agency
National Research Institute of Fisheries Science
Fukuura, Kanazawa-ku Yokohama 236-8648, Japan
tmiyata at affrc.go.jp

Keywords: direct marketing, management

Abstract

Popular oyster-based dishes in Japan are fried oysters, oyster hot pot, rice seasoned with soy sauce, and boiled with oysters. These are eaten at home or at a Japanese-style bar. Since around 2000, oyster bars have been appearing in urban areas. At the same time, oyster barbecue shacks have been increasing in number in some fishery areas in southern Japan. These shacks have contributed to the increased price of oysters and had an effect on fishery-related work and on other industries in the areas where they occur. In contrast, oyster bars rarely have a significant effect on fishery areas. Furthermore, oyster barbecue shacks are beginning to spread to the north of Japan. For this new business, it is important that the shacks and oyster beds are in the same area because the tourists want to eat local seafood when they travel to the seaside. The new business is very suitable for the interest in the idea of "local production for local consumption," As a result, local oysters and those who harvest them have a great advantage over imported oysters and farmed oysters from other areas.

With regard to sea urchins, people in Iwate Prefecture in northeastern Japan have traditionally eaten fresh sea urchins in the summer, thus they prefer the sea urchins actually caught in Iwate. However, since approximately 2000 there has been a trade in live sea urchins produced mainly in Russia. Fast food sushi and conveyor-belt sushi prepared from fresh imported sea urchins have created a new submarket. Iwate fishermen were worried that local sea urchins would be forced out by Russia imports. On the other hand, processors continue to demand sea urchins caught in Iwate because of their high proportion of edible content, freshness, and because they are locally produced. Local consumers also prefer local sea urchins because of their high quality and area brand formed by a food tradition and publicity. Therefore, Iwate producers have been able to avoid the reduction in demand for local sea urchins that occurs elsewhere in Japan.

Introduction

The fishing industry, especially those in rural areas, distributes fishery products to big cities via fish markets. This is the main channel for fishery products in Japan because they are sold at a comparatively high price in big cities. However, prices have fallen as a result of such recent factors as the reduction in personal disposable income. Therefore, the fisheries must change the existing distribution structure on which they strongly depend. This is very difficult to achieve because the existing distribution channels involve many stakeholders, local distributors in particular, and are a reasonable system for the wide dissemination of marine products. Local distributors will oppose a complete change of the distribution channel because their business will decrease. Moreover, in Japan, the trade in marine products has usually been based on long-term credit transaction so the change could represent the dishonoring of business contacts.

Therefore, rather than reforming the existing channel completely, this paper focuses on a mechanism for creating new distribution channels and expanding overlooked local markets. The new channels consist of oyster barbecue shacks (OBS) that offer local production for local consumption, and the overlooked local market for local sea urchins in rural areas. The common keywords for these case studies are "local production for local consumption."

Outline of Supply and Demand for Oysters and Sea Urchins in Japan

The demand for oysters in Japan has been generally steady with a certain degree of fluctuation over a long period of time. Furthermore, the demand has remained undiminished despite the change in the quantity of imported oysters. Specifically, imports increased rapidly in 1999, 2000, and 2001, despite the demand for oysters in Japan remaining steady (Figure 1).

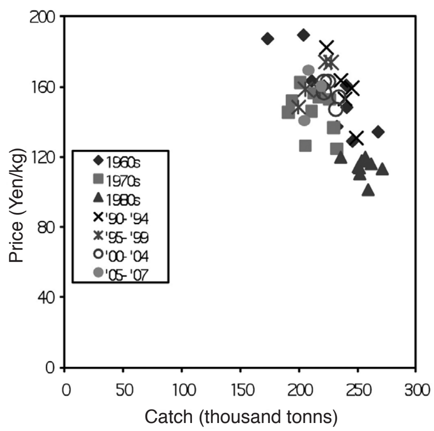

Figure 1. Trend in demand for native oysters in Japan. Note that the price is real price, which is deflated by consumer price index based on 2005. The yield is equivalent based on shell oyster. Source: Annual Statistical Report of Fisheries and Aquaculture Production (of Japan).

The demand for sea urchins in Japan increased from the 1960s to the 1980s, while the real price and the supply also increased. In the 1990s, the demand began to decrease with decreases in both the real price and the supply. Demand is still declining according to the latest statistical data provided by the Ministry of Agriculture, Forestry and Fisheries of Japan for 2000–2006. The reasons for the decline are first an increase in the quantity of imported sea urchins, second a reduction in real disposable personal income and third, a deterioration in the sense that sea urchins are luxury items that has resulted from the increase in low-quality imported sea urchins (Figure 2).

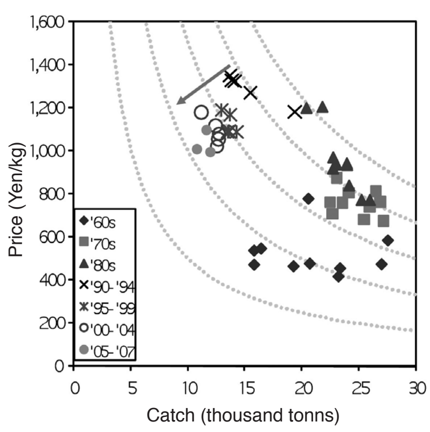

Figure 2. Trend in demand for native sea urchins in Japan. Note that the price is real price, which is deflated by consumer price index based on 2005. The yield is equivalent based on shell shucked sea urchin. Source: Annual Statistical Report of Fisheries and Aquaculture Production (of Japan).

Research Site and Methods

OBS—The research site was in Fukuoka Prefecture in Kyushu, which is in southwestern Japan. The population of the prefecture is approximately 5 million and the prefecture contains two government-designated cities (Figure 3).

Oyster production in the prefecture is less than 1% of the total production of oysters in Japan. Oyster aquaculture in the prefecture began approximately 25 years ago, so it is a comparatively new business. It was difficult for newcomers to distribute their oysters via the marketplace. In addition, the price in market place was lower than that of oysters in other areas. Therefore, the main marketing channel for the local oysters was direct marketing, including face-to-face selling and mail order selling. Several years ago, OBS emerged as a new business in the area after becoming popular in its birthplace, Saga Prefecture in the Kyushu region in southeastern Japan.

Methods used in this study included face-to-face interviews at fisheries cooperative associations and with fishermen, examination of the existing statistics from three fishery cooperative associations, publicly available statistics, and an internet questionnaire survey of Fukuoka prefecture residents.

Overlooked Local Sea Urchin Markets in Rural Areas—The research site was Iwate Prefecture in Tohoku in northeastern Japan. The population of Iwate Prefecture is approximately 1.4 million and is typically rural (Figure 3).

Sea urchin production is concentrated in the north of Japan; Hokkaido Prefecture produces 44% of Japan's catch (average for 1996–2005), which constitutes the highest yield in Japan. Second is Iwate Prefecture (11%), fourth is Aomori Prefecture (7%), and fifth is Miyagi Prefecture (7%). The total share from those four is 69%. In addition, Nagasaki Prefecture in the south of Japan ranks third (Figure 3). The main distribution channel in the study area is mostly through the Iwate prefectural federation of fisheries cooperative associations. This study employed data obtained from face-to-face hearing investigations at several sea urchin processors and fisheries, local wholesale market statistics, and public statistics.

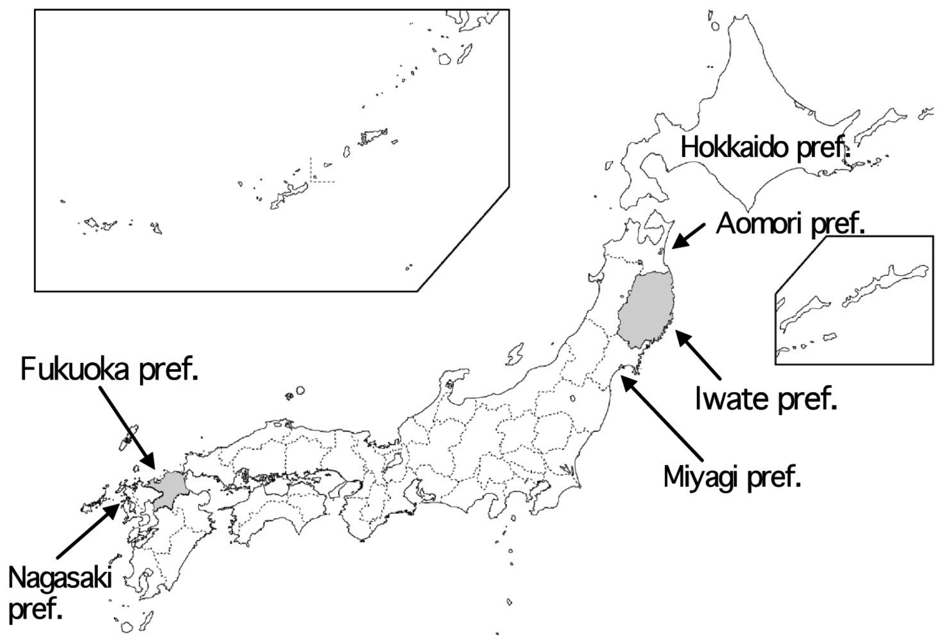

Figure 3. Fukuoka and Iwate Prefectures in Japan.

Results

OBS—OBS operate a self-service system where the customers buy shell-on oysters, charcoal, and other foods such as oysters in rice, oyster soup, and local fishery products. They then barbecue the items they have bought. OBS are run by fishermen or fisheries cooperative associations.

There are many OBS in northern Fukuoka Prefecture. Western Fukuoka Prefecture has only a few. OBS began to increase in the northern region after 2001. Big OBS in the region have been run by a fisheries cooperative association since 2003. These northern OBS have increased their sales volume.

The oyster yield in the northern region and the price are increasing. This reflects the fact that the demand for oysters is growing. In contrast, the oyster yield in the western region remains high, but the price is unchanged. As pointed out above, the demand for oysters in Japan is not increasing, but remains steady. There is more demand for oysters in the northern region than elsewhere. There is considerable validity in the belief that the high demand for the region's oysters can be attributed to the increasing number of OBS.

Why are OBSs increasing?—First, OBS as a business category is new. There has been face-to-face selling of fresh seafood from the households involved with the fishery, but there was no business where customers bought very fresh seafood and barbecued it themselves in a shack at the seaside. As a result, OBS hardly compete with other businesses close up. Second, the start-up cost of the business is low, because the shack is a plastic greenhouse or unused shack and the barbecue equipment is not expensive. Third, it is easy to keep oysters fresh. Live oysters in their shells out of the water are the same as those living in a water tank, so fisherman only need to place oysters in a refrigerator to keep them fresh for a period of time. Finally, OBSs have become very popular recently. It is not uncommon to find customers spending two hours around the entrance of an OBS every weekend.

What is the Attraction of OBS for Consumers?—First, OBS serve fresh local oysters along with other fresh local marine products. According to the results of a questionnaire circulated by the Ministry of Agriculture, Forestry and Fisheries of Japan (Fisheries Agency 2006), when Japanese people purchase fish and shellfish they place particular emphasis on freshness. Moreover, the Japanese have a strong awareness of items that are locally produced for local consumption. Thus, OBS meets the needs of the people. Second, many consumers visit OBS not only to eat seafood but also as part of a short driving trip. Therefore, it is important that OBS are located at a beautiful seaside spot where the consumers can feel a sense of nature. Third, OBS provide an opportunity for families, friends, and others to enjoy conversations while grilling and consuming their food. Fourth, the prices of oysters and other marine products are cheaper than at ordinary restaurants; e.g., the price at an oyster-bar is approximately $4/oyster; a Japanese-bar charges approximately $2/

oyster, and the cost at an OBS is approximately $0.75/oyster. Finally, the local mass media report OBS in their seasonal news every autumn, which provides OBS with publicity.

Spread of OBSs to Other Places—In several prefectures, fishermen and fisheries have recently established or are planning to establish OBS businesses. In particular, in northeastern Japan, those groups are expecting to establish successful OBS businesses. The district is a major producer of oysters in Japan. If OBS in the district goes well, oyster aquaculture in Japan will be impacted by the demand.

Competitiveness of Local Sea Urchins in Rural Areas—As pointed out above, the current demand for domestic sea urchins has been in decline since the 1970s, due to competition from imported sea urchins. This trend is the average for all the producing prefectures in Japan (Figure 2). The demand for sea urchins caught in Iwate Prefecture has hardly changed (Figure 4). Moreover, the sea urchin yield in Iwate is the second largest in Japan.

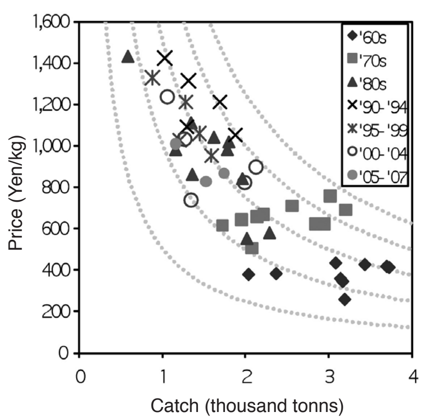

Figure 4. Trend in demand for sea urchins caught in Iwate prefecture. Catch data is weight with shell. Note that the price is real price, which is deflated by consumer price index based on 2005. Source: Annual Statistical Report of Fisheries and Aquaculture Production (of Japan).

Why is the demand in the major producing areas different from that of Japan in general? In Iwate, the local demand for sea urchins (including imported sea urchins) is not high and the local processors are not very good at selling their product, but the people of Iwate prefecture prefer locally produced sea urchins over any others. Namely, they like their sea urchins to be locally produced for local consumption.

Background on Local Production for Local Consumption of Sea Urchins in Iwate—In Iwate, the demand for live sea urchins imported from Russia has increased since around 2000 when urchins began to be sold as processed carryout sushi at supermarkets, and conveyor belt sushi (also called sushi-go-round) at restaurants. At the same time, the new submarket developed for imported sea urchins in and around Iwate. But the local consumers desire locally produced sea urchins because they realize that the quality is better than imported ones. Furthermore, local medias create a personal good image through reporting scene of catching or processing sea urchins every year. Generally, publicity is important to building a brand and promoting a good image of a product (Armstrong and Kotler 2009). Also, a brand and good image of a product is built by repeat consumer awareness (recall and recognition) of its name and image (Kevin 2000). Therefore, in and around Iwate, the good image of local sea urchins is mainly the result of the publicity provided every early summer, continuing desire to eat very fresh sea urchins and eating experience. Also, restaurant advertising in towns is important in building both the brand and good image. As a result, sea urchins imported from Russia have been replaced by those caught in and around Iwate.

Marketing/Management Strategy—Summer is the main season for catching sea urchins in Japan/Iwate, so the sea urchin yield is small during other seasons. Therefore, sea urchins are imported to provide a stable supply throughout the year. The main exporters are Chile, Canada, the United States, Korea and Russia. To make local sea urchins available throughout the year to the people of Iwate, fishermen and fisheries have been looking at ways of supplying sea urchins year round by employing preservation techniques. The work is not easy because it involves high costs and intensive labor. Furthermore, many fishermen must agree to act in unison.

Overlooking Local Markets in Rural Areas: Iwate—Local fishermen and fisheries in Iwate have assumed that the local people cannot afford to buy expensive fishery products because their income is less than that of urban dwellers. Therefore, they have been transporting their fishery products from Iwate to urban areas (Tokyo, Yokohama, etc.). As described above, the products have been sold at a comparatively high price in the big cities. This approach has led to the local rural market being overlooked. This presents the large and difficult problem of reforming the existing distribution channels (from rural to urban areas).

Discussion

The demand for marine products is increasing worldwide, thus making life more difficult for Japanese importers. Also, Japanese people are becoming increasingly aware of safety with respect to marine products, thus it is important that they can picture the fishing area, the lifestyle of the fishermen and the level of sanitary control. To this end, they want to know the origin of the marine products they consume. As a result, they are beginning to demand domestic marine products and marine products from close to where they live.

On the other hand, fishermen and fisheries, especially those in rural areas, have distributed their fishery products to big cities and have long overlooked the local market. They have assumed that this is the best approach, and it is difficult to reform the existing distribution channels. However recently, these groups have started to recognize that a business with regard to local production for local consumption is a new opportunity. This is because they can reduce the time and cost of distribution. Furthermore, in some cases, they can sell their products at higher prices than through the regular distribution channels to big cities via fish markets. Moreover, there are advantages in that the fishermen and fisheries can directly determine consumer requirements and improve their policies with regard to sales approach and product quality.

In addition, locally produced marine products tend to appear in the local media, because for example, local people can feel a sense of the season when they watch the scenery, sea urchins being caught, or scenery around the OBS. Also, this can help to establish seasonal traditions. Publicity has a beneficial impact on consumers and increases their recognition of local fishery products. In contrast, the national media do not report this type of local news every year.

Local production for local consumption of food offers benefits to consumers, because they can eat fresh and delicious seafood inexpensively at the seaside and enjoy cooking these marine products themselves. The activity will provide consumers with a pleasant experience.

References

Armstrong, G., and P. Kotler. 2009. Marketing (9th edition, International edition). Annual Report on State of Fishery. 15 p. [In Japanese].

Keller, KL. 2000. Strategic Brand Management [Japanese version]. pp. 76–86.

Annotated Bibliography of Key Works

Tsutom Miyata. 2005. Marketing strategy of shell oyster. Journal of Regional Fisheries (Japan). 46(1) 161–176.

The competitiveness of Iwate Prefectural (located in northern Japan) shell oyster depends on the brand loyalty (industrial goods), which is formed by relationship marketing and push strategy (one of promotion strategy) for jobbers and wholesaler. There are some fascinating elements of the brand. First, the read-time is short, second, the shell oyster is standardized, third, the oyster is supplied stably and so on. These practices are not easy because fisheries cooperative association gathers the oysters from many fishers and ships them to the destinations, in other words, the fishers have made a great effort to do the practices.

The shell oyster has been priced stably by the brand, and the price has brought about a motivation of fishers' effort.

Mari Hazumi. 2007. Construction of local brand in marine products and effects on local society. Journal of Regional Fisheries (Japan). 47(2–3) 217–234.

The purpose of this paper is how to build the brand which is not involved in price competition. It describes not only an individual brand but a point with advantageous being established as a local brand. The local brand is formed by the relation of regional various resources and marine products, and the organization that manages them well is necessary. It is shown that there are three types of patterns of such the local brand, and verifies some cases.

Commerical Farming of the Japanese Sea Urchin (*Strongylocentrotus intermedius*), Now a Reality

Addison L. Lawrence
Texas AgriLife Research, Texas A&M System
1300 Port Street
Port Aransas, Texas 78373
smpall at yahoo.com

John M. Lawrence
Department of Comparative and Integrative Biology
University of South Florida
Tampa, Florida 33620

Steven A Watts and Mickie L. Powell
Department of Biology
University of Alabama at Birmingham
Birmingham, Alabama 35294

Abstract

A sustainable successful commercial aquaculture industry in a country consists minimally of five economy-of-size profit centers. These are seedstock production (reproduction plus larviculture), production of marketable food animals, feed production, processing plants, and marketing companies. The Japanese sea urchin (*Strongylocentrotus intermedius*) is the most important species of the commercial fisheries for the production of uni (tongue, gonad) in Japan. Four of these five profit centers necessary for a sustainable successful commercial sea urchin farm industry already exist in Japan. However, there is no commercial dry formulated feed available for sea urchin.

A dry formulated feed for sea urchin has been developed and produced in the United States. This feed has been used to produce commercial size gonads of sea urchin in the People's Republic of China. Thus, with demonstration that a commercial dry formulated feed is available for production of sea urchin, commercial farming of the Japanese sea urchin in Japan becomes a reality. Based on existing data, commercial farming of sea urchins has a potential higher rate of return than commercial farming of shrimp.

This paper will present data showing dry formulated feeds developed and produced in the USA produce commercial size gonads for *S. intermedius* and *S. droebachiensis*. Other sea urchin species for which a dry formulated feed has been used to produce uni are *S. fransciscanus*, *Evechinus chloroticus*, *Tripneustes gratilla*, *Paracentrotus lividus*, and *Loxechinus albus*.

Annotated Bibliography of Key Works

Lawrence J.M., X. Cao., Y. Chang, P. Wang, Y. Yu, A.L. Lawrence, S.A. Watts. 2009. Temperature effect on feed consumption, absorption, and assimilation efficiencies and production of the sea urchin, Strongylocentrotus intermedius. Journal of Shellfish Research 28 (2): 389-395

The paper gives data that uni can be produced from the sea urchin, *Strongylocentrotus intermedius*, using a dry formulated feed. This paper is the first to report gonad indexes of over 30% wet body weight for the Japanese sea urchin using a dry formulated feed.

Lawrence J.M., A.L. Lawrence, S.A. Watts. 2007. Feeding, digestion and digestibility of sea urchins. J.M Lawrence, ed. Edible Sea Urchins: Biology and Ecology. Pages 135–159. Elsevier, Amsterdam.

This is a review paper that summarizes the available data of feeding, digestion and digestibility in sea urchins. It provides a summary of the requirements for commercial production of sea urchins using dry feeds.

Chang Y., J.M. Lawrence, X. Cao, A.L. Lawrence. 2005. Food consumption, absorption, assimilation and growth of the sea urchin, *Strongylocentrotus intermedius,* fed a prepared feed and the alga *Laminaria japonica*. *Journal World Aquaculture Society*. 36(1): 68–75.

This paper was the first paper to show gonad production for *sea urchin* using a dry feed. Though the gonad index was only 25% of the body weight, it did show that the dry feed was better that the natural feed. This was the first paper to suggest that a dry formulated feed could be made to support uni production from sea urchin.

Lawrence A.L., J.M. Lawrence. 2004. Importance, status and future research needs for formulated feeds for sea urchin aquaculture. J.M. Lawrence, O. Guzman (eds). Sea urchins: fisheries and ecology. DEStech Publications pages 275–283, Lancaster, PA.

This is a review paper that reviews the history for the development of technology to produce a dry formulated feed for the commercial production of sea urchins. Importantly, this paper summarizes why a dry feed is essential for the commercial farming of sea urchins and why natural foods cannot be used.

Market Survey for an Approach to Grouper Aquaculture

Takashi Iwasaki, Kentaro Ide, Ken-ichi Watanabe, and Hiroshi Y Ogata
Fisheries Research Agency
National Research Institute of Aquaculture
Stock Enhancement Technology Development Center
Saiki, Oita 879-2602, Japan
tak0829 at affrc.go.jp

Takuma Sugaya
Fisheries Research Agency
National Research Institute of Fisheries Science
Fukuura, Yokohama, Kanagawa 236-8648, Japan

Keiichi Hirasawa and Shizumasa Onoue
Fisheries Research Institute, Oita Prefectural Agriculture
Forestry and Fisheries Research Center
Saiki, Oita 879-2602, Japan

Keywords: groupers, aquaculture, market survey

Abstract

The aquaculture industry in Japan has been stagnant due to the increase in production costs and low market prices of the major culture species. Groupers, especially *Kue*, longtooth grouper [*Epinephelus bruneus]* and *Ma-hata*, sevenband grouper [*E. septemfasciatus]* have been seen as high-grade commodities due to their scarcity and palatability. Thus, the groupers are a prospective new aquaculture species in Japan. However, production and marketing strategies that would ensure successful culture have not been examined thoroughly. In the present study, surveys were conducted at wholesale markets and on local farms to review the production and marketing status of cultured groupers. Trade and price trends of cultured and wild-caught groupers were investigated at wholesale markets in Tokyo (the Tsukiji Market), Osaka, and Fukuoka. In addition, the current condition of grouper production was surveyed on fish farms in Oita Prefecture, which is an active area of aquaculture in Japan.

The results of the investigation show that cultured groupers brought a high price of at least ¥1,500/kg at the three markets, suggesting that grouper culture would be profitable. The amount of grouper trade at the Fukuoka Market was largest among the three sites, although the Tokyo Market is generally the leading market for many species in Japan.

Farmers appear to have trouble due to the lack of marketing channels. Therefore, the farmers should develop local sales channels to expand their trading ability. It is also clear that there was seasonality in the price and availability of groupers. The seasonality is advantageous to the grouper culturist, since the farmer can control the timing and amount of harvest according to the seasonality. On the other hand, technical problems such as slow growth, quality control (abnormal development and dirty coloration, etc.), along with diseases appear to constrain the expansion of grouper aquaculture in Japan. These hurdles should be overcome in order for grouper aquaculture to expand.

Introduction

Groupers, especially *Kue*, longtooth grouper [*Epinephelus bruneus*] and *Ma-hata*, sevenband grouper [*E. septemfasciatus*] are large-size marine fishes reaching more than 1 m in total length. They are commercially important species in Japan (Okutani et al. 1999). These species are viewed as high grade commodities due to their rarity and deliciousness. Hatchery production technology development for these groupers has been a subject of research by the Fisheries Research Agency (FRA) of Japan and other public research laboratories (Tsuchihashi et al. 2003, Sakakura et al. 2006, 2007, Teruya and Yoseda 2006). Recently it has become possible to produce several hundred thousand grouper fingerlings per season.

The aquaculture industry in Japan has been stagnant due to the increase of production costs and low market prices of major cultured species such as red sea bream (*Pagrus major*) and yellowtail (*Seriola quinqueradiata*). Given the current situation, farmers are looking for a new commodity and groupers are expected to become one of the new culture groups in Japan (Tsuchihashi et al. 2009). However, production and marketing strategies for groupers that will ensure success of the industry have not been thoroughly examined. Japan has no statistics of grouper production, although other Asian countries in the region have that information. The objective of this study was to determine the current state of grouper marketing and evaluate the potential of grouper aquaculture.

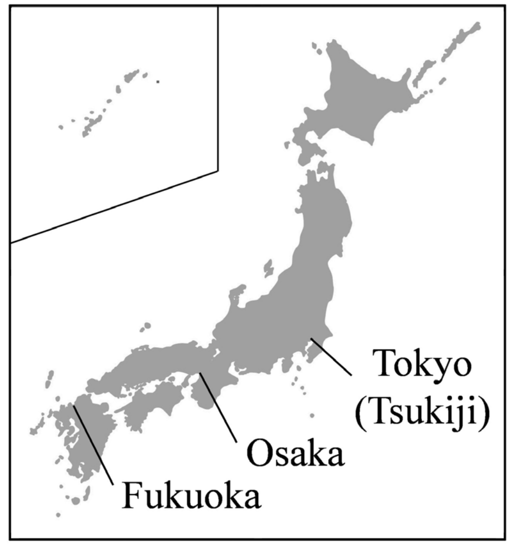

Figure 1. Location of wholesale markets in Japan.

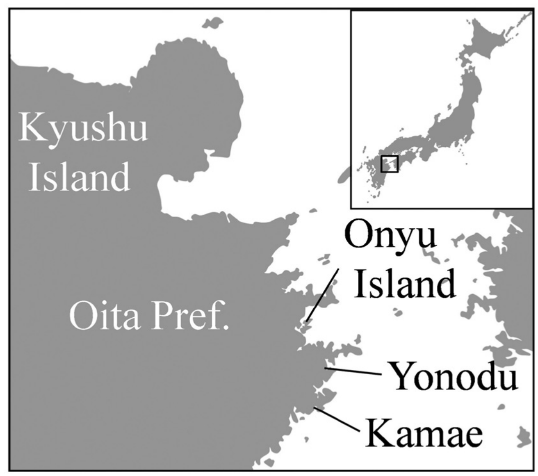

Figure 2. Location of grouper-farmers in Oita Prefecture.

Methods

The present study was divided into the two investigations: wholesale market and local grouper-farmer evaluations. The investigations were conducted from October 2008 through February 2009. Primary data were mainly collected using two methods: face-to-face interviews and market report examination.

Wholesale markets—The investigations were conducted at the three largest fish markets in Japan: Tokyo (Tsukiji), Osaka, and Fukuoka (Figure 1). Tokyo is the capital city of Japan. Osaka is the largest city in west Japan and Fukuoka is the largest city in the Kyushu region. In this survey the following points were investigated with regard to groupers in the markets:

- Volume
- Price
- Fish size
- Area of production

Investigation of local grouper farmers—The face-to-face survey was conducted with farmers who cultured groupers at three locations: Saiki, Oita Prefecture; Onyu Island, Yonodu and Kamae (Figure 2). The southern part of Oita Prefecture is one of the most active areas of aquaculture in Japan.

In this interview survey, the following information was gathered:

- Kind of cultured grouper produced
- Shipment size
- Shipment time
- Price received
- Problems with grouper aquaculture

Results

Wholesale markets—The market reports showed that there were about 100 metric tons of groupers in the Tsukiji market and about 200 metric tons in the Fukuoka market (Table 1). However, from the interview survey, dealers in the three wholesale markets mentioned that all of the groupers (captured and farmed) were not always circulated through the public markets. Therefore, it seems that the actual amount of groupers being sold is larger than that indicated by the market surveys. Figures 3 and 4 show the changes in the monthly amount of groupers handled in the Tsukiji and Fukuoka Markets. It is clear that the volumes and prices of groupers tended to increase in winter, especially in December, except in 2008 in Tsukiji. The volumes of groupers in 2008 at the Tsukiji market were very low compared with those in 2006 and 2007. Meanwhile, the prices of groupers in 2008 at the Tsukiji market were higher than those in 2006 and 2007.

Table 1. Volume of groupers sold in three markets (volume in metric tons).

Year	Tsukiji	Osaka*	Fukuoka
2002	72.4	—	—
2003	110.4	—	—
2004	125.1	—	—
2005	104.3	—	—
2006	106.6	—	220.8
2007	119.7	—	224.6
2008	82.3	—	173.9
Average	*102.9*	—	*206.4*

*Osaka data unavailable

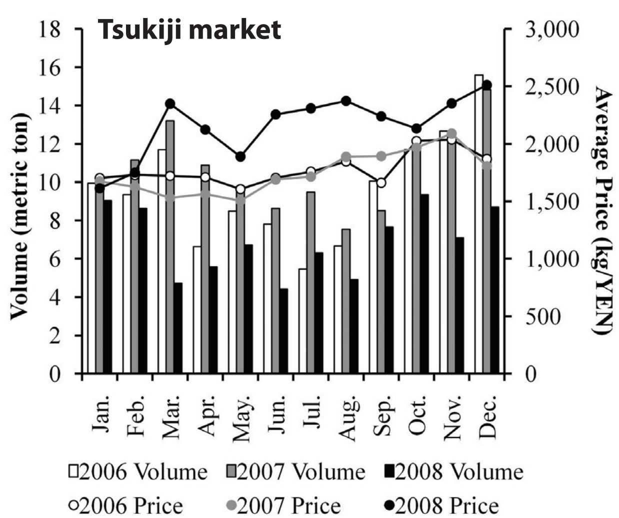

Figure 3. Monthly grouper volume in the Tsukiji market.

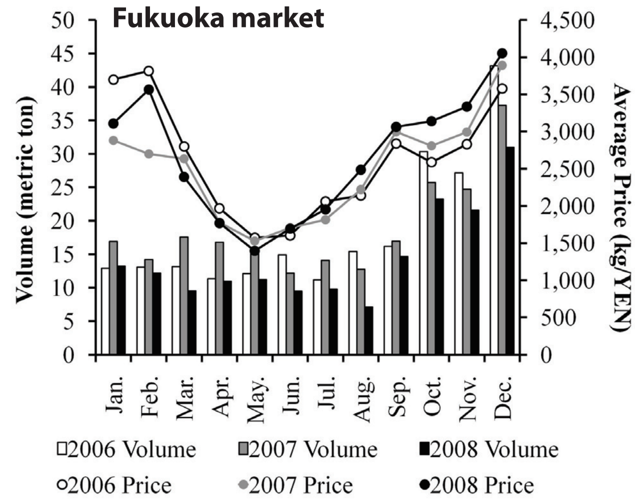

Figure 4. Monthly grouper volume in the Fukuoka market.

Figure 5 shows the imported amounts of groupers by production area in the Tsukiji and Fukuoka markets. The prefecture names indicated in bold belong to the Kyushu region. It is clear that the Kyushu region is a very active area for grouper trading.

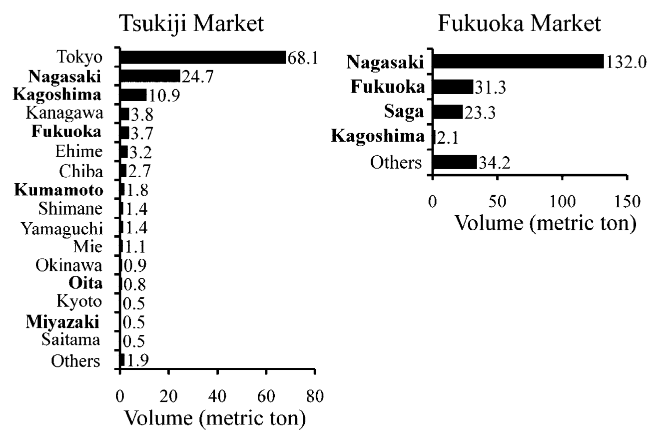

Figure 5. Imported amounts of groupers in the Tsukiji and Fukuoka markets by production area. Prefecture names in boldface are in the Kyushu region.

A face-to-face interview survey was conducted with wholesale dealers in the Tsukiji, Osaka, and Fukuoka markets to investigate the current state of grouper marketing in more detail. From Table 2 wild-caught groupers brought higher prices than cultured ones. However, even cultured groupers brought a price of at least ¥1,500/kg (about $17/kg) at the three markets. *Kue* was sold at a higher price than *Ma-hata*. Groupers at the Fukuoka market brought the highest price among the three markets.

Table 2. Price of *Kue* and *Ma-hata* sold in three markets (price in yen/kg).

Grouper	Tsukiji	Osaka*	Fukuoka
Kue (wild caught)	5,000–7,000 ($55–78)	2,500–3,500 ($28–39)	5,000–7,000 ($55–78)
Kue (cultured)	2,500–3,500 ($28–39)	2,000–3,000 ($22–33)	3,500-4,000 ($39–44)
Ma-hata (wild-caught)	3,500–4,000 ($39–44)	2,000–3,000 ($22–33)	3,500–4,000 ($39–44)
Ma-hata (cultured)	1,800–2,000 ($20–22)	1,500–2,500 ($17–28)	2,000–2,500 ($22–28)

$1 = 90 yen

Marketed wild-caught groupers were mostly larger than cultured ones in all the three markets (Table 3). Size range of the marketed wild-caught fish was wider in the Fukuoka Market than in the other two markets, that is, the Fukuoka Market traded small-size one (1.5kg) to larger one (30kg).

Table 3. Size range of Kue and Ma-hata in the three markets.

Market	Wild-caught (kg)	Cultured (kg)
Tsukiji	15–20	1.5–2.5
Osaka	5–15	3–5
Fukuoka	1.5–30	2–5

Survey of grouper farmers—Three grouper farmers were surveyed in Saiki, Oita Prefecture. All the farmers also cultured 1–3 year old *Ma-hata* and two farmers cultured *Ma-hata* and *Kue* more than 10 years old. Fingerlings of 1–3 year old Ma-hata were produced at the Oita Prefectural Research Laboratory and the more than 10 years old groupers originated from wild-caught fry imported from Korea or China. In addition, the farmers cultured grouper together with other species, such as yellowtail, amberjack (*Seriola dumerili* or *S. lalandi*), red sea bream, striped jack (*Pseudocaranx dentex*) and chicken grunt (*Parapristipoma trilineatum*). The famers cultured groupers for about 3–4 years and then shipped them mainly as 1.5–2.0 kg fish. Cultured grouper of 1.0–1.5 kg sold for about ¥1,000/kg ($11/kg). Groupers of 1.5–2.0 kg sold for about ¥2,000/kg ($22/kg). According to the farmers, the main harvest and shipping season is winter, especially December or January, corresponding with the results of wholesale market survey.

Through the interview process, various problems of grouper aquaculture also were revealed. The first problem is that the culture period for grouper is relatively long compared with other species (3 years or more). For example, yellowtail takes about 2 years and red sea bream 2 to 3 years. The quality of cultured fish due to abnormal development or dirty coloration is another problem. These characteristics in quality appear to reduce the market price of cultured fish. In addition, the occurrence of viral nervous necrosis (VNN) is a big problem. Sometimes, VNN produces mass mortality in cultured groupers. Finally, it seems that farmers have difficulties finding marketing channels.

Discussion

With low fish prices of major cultured fish species and increased production costs, farmers have tried to diversify the species available in the marketplace by seeking new commodities. Approximately 10 years ago, the culture of *Kue* or *Ma-hata* was once-popular in Oita prefecture (Tsuchihashi et al. 2009). However, it declined due to the outbreak of VNN disease. Also about 10 years ago, the source of groupers was wild-caught fry from China or Korea, which is the reason why farmers kept age 10 groupers in their pens. The supply of fry was unstable and the price was very high (¥1,000/fry or about $11). A vaccine against VNN virus is being developed (Tanaka et al. 2005, Yamashita et al. 2005), and hatchery-reared fry are replacing wild-caught ones. It now costs about ¥300/fry ($3/fry). Thus, the present situation with respect to grouper culture is considerably ameliorated than it was about 10 years ago.

The wholesale market survey showed that cultured grouper bring a lower price than wild-caught fish. Farmed fish may be inferior to wild-caught ones in quality due to abnormal development or dirty coloration, but there seems to be another reason why cultured grouper bring lower prices. Fish size may be a key issue with respect to price. Generally in groupers, the larger the size, the higher the price/weight, and the size of cultured groupers that are marketed tends to be small compared with wild-caught fish (Table 3). Generally, groupers have a large head, so that if the fish size is smaller, the edible portion becomes small on a percentage of edible tissue basis. However, even cultured groupers bring a price of at least ¥1,500/kg ($17/kg), compared with yellowtail and red sea bream (about ¥700–800/kg or $8–9/kg) as shown in Figure 6.

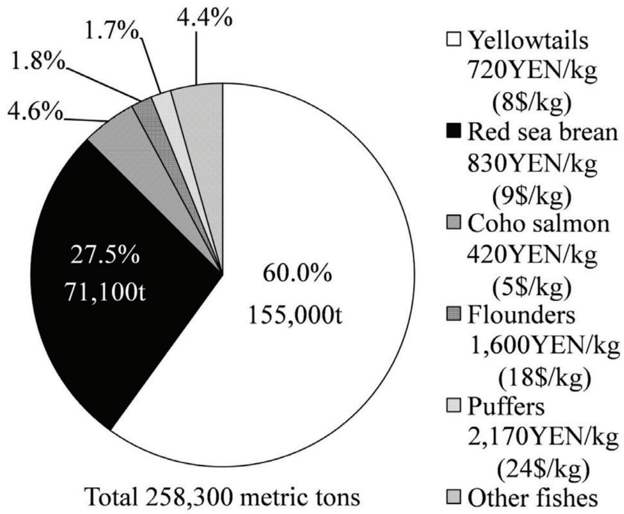

Figure 6. Production volume and average price of marine fish aquaculture in Japan.

The seasonality of cultured fish in the marketplace is advantageous to grouper aquaculturists since the time and amount of harvest from the culture system can be controlled. Incidentally, through the interview survey, market dealers stated the reason why grouper trading tends to peak for winter is because groupers are often cooked for the Nabe, a Japanese style hot pot dish that is very popular during the cold of winter. Additionally, some Japanese people eat *Kue* or *Ma-hata Nabe* in celebration of the New Year.

If the problems on culture technology and marketing are solved in the near future, grouper culture could become more profitable. To solve the problem of slow growth, feed quality and feeding methods should be improved. In addition, genetic improvement such as selective breeding could be effective to help overcome the problem. Furthermore, to expand the production of cultured grouper, mass and stable fry production technology should be also improved.

With respect to developing new marketing channels, local markets need to be created. In general, the Tsukiji market is the leading market for many species in Japan and the amount of grouper trade at the Fukuoka market is largest among the three major markets. In addition, the Kyushu region is the main grouper production area. Therefore, as a first step, the farmers of Kyushu should develop local sales channels in Kyushu to expand their marketing opportunities.

In 2008 in the Tsukiji market, the volume of groupers decreased and the price increased (Figure 3). The reason was that the demand for high quality fish in China rapidly increased due to the Beijing Olympics, and Japanese markets lost out to China markets in the competition to purchase the fish. In the present study, only Japanese markets were surveyed. However, groupers are popular in other Asian countries (Cesar et al. 2000), and those other markets also should be focused as a means to increase the market channels for cultured groupers produced in Japan.

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Tsuchihashi Y., I. Kuriyama, Y. Kuromiya, M. Kashiwagi, and M. Yoshioka. 2003. Effects of water temperature, illumination, and feed oil addition on the survival of larvae in the mass seed production of the sevenband grouper, *Epinephelus septemfasciatus*. Suisan Zoshoku 51:49–54.

Tsuchihashi, H., H. Yamashita, S. Onoue, K. Kanashiro, and H. Nakamura. 2009. Grouper aquaculture being advanced in various regions of Japan. Aquacult. Mag. 578:15–26.

Yamashita, H., Y. Fujita, H. Kawakami, T. Nakai. 2005. The efficacy of inactivated virus vaccine against viral nervous necrosis (VNN). Fish Path. 40:15–21.

Annotated Bibliography of Key Works

Teruya, K., and K. Yoseda. 2006 Successful mass production of early-stage larvae of kelp grouper, *Epinephelus bruneus* in improved rearing conditions. *Aquaculture Science*. 54:2 187–194.

The authors examined the influence of different water temperatures (24, 26, and 28 degrees celsius), rotifer densities (1, 10, and 30 ind./ml), and light intensities (<0.01, 100, 250, 500, 750, and 1,000 lx) on feeding amount, growth, and survival rate of early stage larvae of kelp grouper, *Epinephelus bruneus*, in 100 and 500 tanks. As a result of examination, authors showed that survival and growth at 26 were better than other temperatures. The higher the rotifer densities, the more larvae feed. Besides, the feeding amount of larvae increased significantly in the tanks with more than 500 lx light intensity. In addition, the authors conducted 3 trials of mass seed production of kelp grouper in 100 or 150 kl tanks. In this trial, temperature, rotifer density, and light intensity were regulated at 26, 20–30 ind./ml, and 1,100–2,500 lx, respectively, which were determined as the optimal rearing conditions mentioned above. As a result, early survival rates were improved to 50–100%, and in the 3 tanks 359,000 juveniles (final survival rates ranged between 20.9 and 29.6 %) mean total length 23.9–27.2 mm were harvested finally.

Tsuchihashi, H., I. Kuriyama, Y. Kuromiya, M. Kashiwagi, and M. Yoshioka. 2002. Control of viral nervous necrosis (VNN) in seedling production of sevenband grouper, *Epinephelus septemfasciatus*. Suisanzoshoku, Vol:50:3. pp. 355-361.

Occurrence of viral nervous necrosis (VNN) disease is a big problem in the mass seedling production of sevenband grouper. To prevent VNN, selection of spawners by PCR-based detection of the nodavirus gene, disinfection of fertilized eggs with residual oxidants in seawater, and rearing of larvae and juveniles using ozonated seawater were done. As a result of 7 trials, all trials did not observe occurrence of VNN.

Additionally, VNN occurred when cultivating juveniles of sevenband grouper with the sand filtered seawater though VNN did not occur when juveniles were cultivated with ozonated seawater. These methods are effective as VNN control measures in the mass seedling production of sevenband grouper.

Tsuchihashi, H., H. Yamashita, S. Onoue, K. Kanashiro, and H. Nakamura. 2009.
Grouper aquaculture being advanced in various regions of Japan. Aquaculture magazine 578:15–26.

This article introduces the approach of grouper cultivation done in various places in Japan. The cultivation of longtooth grouper, *Epinephelus bruneus*, and sevenband grouper, *E. septemfasciatus*, is done in Mie, Ehime and Oita prefectures. In Okinawa Prefecture, Malabar grouper, *E. malabaricus*, is cultivated. These prefectures are doing various things to make the grouper cultivation succeed. For instance, the workshops of grouper cultivation method were held for farmers who try cultivating groupers. There were lectures in the workshop from the experts about fish physiology, disease, nutrition, cultivation environment, etc. In Oita Prefecture, sevenband grouper seeds are already being sold to farmers, and the prefecture is putting out the subsidy to them. On the other hand, occurrence of VNN or iridovirus disease becomes a big problem in cultivation. Vaccine development for these diseases is being tried. Additionally, cultivation with the close circulation system on land is being researched. If these groupers are cultivated with this system, it might be useful also for the reduction in the cultivation cost and the decrease of the negative environmental impact.

Large Scale Indoor Shrimp Production (over 300 metric tons of shrimp per hectare per year)

Addison L. Lawrence
Texas AgriLife Research, Texas A&M System
1300 Port Street, Port Aransas, Texas 78373
smpall at yahoo.com

Abstract

The first production of shrimp in ponds occurred near Kogashima, Japan in the mid–1930s. Though this farm was not commercially successful, it did suggest potential for the future.

First attempts in the United States occurred in the 1950s in South Carolina. By the early 1960s, projects were also underway in Texas and Florida. Though commercial production was initiated in the late 1960s, the value of farmed shrimp was still less than $2 million per year in 1980. By 1990, with successful hatchery production of specific pathogen-free postlarvae seedstock, higher quality formulated feeds, and better pond production methodology, shrimp farms were developing exponentially. By 2000 in the United States, the production of farmed shrimp reached approximately $30 million per year, while the total for the world was more than $1 billion per year. By 2008, U.S. production decreased to less than $20 million due to increases in worldwide productivity as a result of technology transfer and longer growing periods elsewhere.

The inability for US farmers with a limited growing season to compete with the tropics with year–round growing season became evident. Evidence indicated that for the U.S. farmer to be competitive, technology would have to be developed to produce shrimp in the United States year–round, and not only on the coast, but also inland. This demanded the production of shrimp in raceways in buildings. Economic analyses indicated that to obtain a satisfactory internal rate of return on investment, a growth rate greater than 1.2 gm/week, survival above 75%, production of at least 20 gm shrimp and production levels equivalent to 150 metric tons/hectare/year had to be obtained. Initial attempts in the mid–2000s fell short of these goals. However, with continued advances in genetic selection of faster growing shrimp, higher quality feeds, and raceway production methodology, predictable levels of production meeting the minimal criteria for commercial production indoors have been obtained in the last few years. At the Texas Agrilife Research Mariculture Laboratory in Port Aransas, an equivalent production of more than 300 metric tons/hectare/year with growth rates of over 1.5 gms/wk, survival of greater than 75%, production of more than 25 gm/shrimp are being obtained. These results will be presented. The initial economic analyses of these data indicate that the internal rate of return will be between 30 to 60%. Thus, with this new technology, commercial shrimp farming in the United States and Japan is commercially feasible.

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Kuhn D.D., G.D. Boardman, A.L. Lawrence, L. Marsh, G.J. Flick. 2009. Microbial floc generated in bioreactors is a superior replacement ingredient for fish meal or soybean meal in shrimp feed. Aquaculture: 296:51–57.

A microbial floc was generated in bioreactors using tilapia waste and molasses to produce an ingredient. This ingredient replaced fish meal or soybean meal in shrimp feeds, resulting in an increased growth of more than 50%. The increased growth is critical to obtaining an adequate internal rate of return for raceway shrimp production.

Lawrence A.L., F. Castille, S. Patnaik. 2008 Effects of stocking density and water exchange on growth and survival of *Litopenaeus vannamei* in a flow through outdoor tank system. T.T. Rakestraw, L.S. Douglas, L. Marsh, L. Granata, G.J. Flick, eds. Proceedings of the 7th International Recirculating Conference, Roanoke, VA, July 25–27, 2008, 236–243.

This paper was the first to report up to the equivalent of 150 metric tons/ha/crop with growth rates above 1.5 gms/week and survival above 75%. These production levels are necessary to attain an internal rate of return above 30% for raceway production in buildings.

Patnaik S., A.L. Lawrence, F. Castille. 2008. Stocking density and feed rate effect on growth and survival of *Litopenaeus vannamei* in a recirculating indoor tank system. T.T. Rakestraw, L.S. Douglas, L. Marsh, L. Granata, G.J. Flick, eds. Proceedings of the 7th International Recirculating Conference, Roanoke, VA, July 25–27, 2008. 226–235.

This paper showed that growth rate decreased with increasing stocking density. These data provided the basis for selecting the initial stocking densities which would give both the desired production level required with the growth rate in order to obtain an internal rate of return above 30%. The results also indicated that an excess feed rate decreased production and that feed rates close to satiation were optimal.

Hanson T.R., A.L. Lawrence, B.C. Posadas. 2006. Economics of partial harvesting in super-intensive recirculating shrimp productions raceways. T.T. Rakestraw, L.S. Douglas, L. Marsh, L. Granta, A. Correa, G.J. Flick, eds. Proceedings of The Sixth International Conference on Recirculating Aquaculture, July 21–23, 2006, Roanoke, VA, USA. 15–22.

This paper provides the data indicating that the concept of partial harvest can increase production in raceways. The spreadsheet provides the sensitivity analyses methodology to estimate the production levels, growth rates, survival, and size of shrimp necessary to obtain a desired internal rate of return in raceways.

Role of Fisheries Cooperative: A Case Study of Price Determination by Producers

Toshinori Takashi and Makoto Yamasaki
Aquaculture Fisheries Research Agency
National Research Institute of Aquaculture
Aquaculture Systems Division
Minamiise, Mie 516-0193, Japan
ttakasi at fra.affrc.go.jp

Abstract

Currently, many aquaculture sectors have financial problems induced by the escalating cost of fish feed and gasoline, along with the declining value of aquacultured fish products. Although there is a need to modify business management practices through cost reduction, most of the industry involves small-scale family businesses. In this paper, we discuss how aquaculturists in local communities have cooperated through the local fisheries cooperatives and tried to better manage their feeding practices, harvesting, and sales.

Introduction

Many Japanese aquaculture households have faced crises associated with their business management practices. The crises were induced by declining price of cultured fish products and escalating gasoline and fish feed prices. In the 1980s, the price of cultured yellowtail was as high as ¥1,600/kg (Hamada, 2005). However, the value tended lower thereafter year by year. Although the price in 1993 was ¥1,200, it had fallen to 800 in 2005. At present, the price is about ¥750–850/kg. The exceptional low price is caused by several factors (Hamada, 2005). The first factor is falling demand in the market. Second is a low pricing strategy at the retail level, such as in the supermarket. Lower retail prices mean lower prices paid at the farm gate. Low prices have inflicted heavy damage on the financial management of yellowtail culturists. To increase business efficiency, fishery households have attempted to reduce and increase their scale of production. However, much of the aquaculture industry in Japan is relatively small-scale, often operated at the family level. Therefore, their efforts to increase their incomes are limited.

The Japan Fisheries Cooperative Association (JFC) is an association organized by the fishermen. There are 1,600 local fisheries cooperatives in Japan. The JFC provides three services: providing supplies, marketing, and guidance to the members. We focus here on the marketing and guidance service as roles of the local cooperatives. Recently, many aquaculture households have been working together to improve their business management practices through the local fisheries cooperative.

Results

Yellowtail (*Seriola Quinquerariata)* Aquaculture in Tachibana Bay—The East Tachibana Bay Fisheries Cooperative in Nagasaki prefecture (Figure 1) has managed yellowtail aquaculture for seven fish households in Tachibana Bay which have been responsible for the production of 100,000 yellowtail. To improve the efficiency of business management, the fisheries cooperative has unified the rearing approach, such as feeding practices and using juveniles from the same source to produce yellowtail with the same meat quality. Secondly, they have developed new distribution routes.

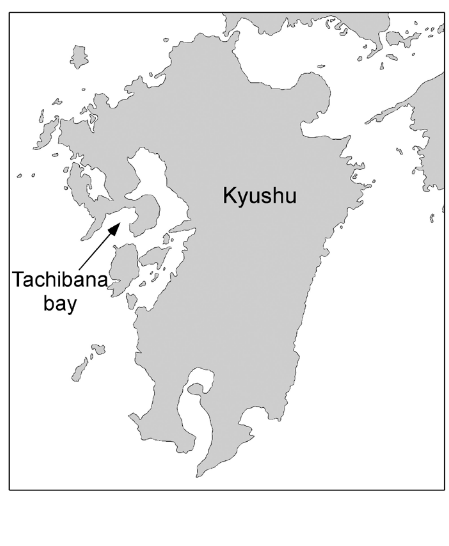

Fig. 1. The island of Kyushu showing the location of Tachibana Bay.

Feeding Practices—Before improvement in management, feeding practices varied among the yellowtail culturists, but those practices have now been unified. The farmers feed extruded pellets during the warm seasons and moist pellets when the water is cold. They make moist pellets from raw fish such as anchovy, mackerel and saury. When they make moist pellets, they change the oil content in the feed seasonally to prevent the excessive accumulation of lipid.

Harvesting—Yellowtail harvest size is 3.5 kg–5.0 kg from September to the following June. Harvesting involves a rotation system of the fish cages so the shipping plan provides fairness among the involved households.

Development of New Distribution Routes.—In the big cities such as Tokyo and Osaka, the consumption of yellowtail is high. However, the yellowtail price is often low because there is an imbalance of supply and demand dominated by those large markets. Therefore, in the 1990s, the distribution route was changed from Tokyo and Osaka to Fukuoka central wholesale to avoid competition with other regional products.

Furthermore, local production for local consumption is being promoted. Local distribution routes have been developed for such endpoints as inns, restaurants, and supermarkets. This approach enables a reduction in transportation costs and distributor margins.

The quality of meat demanded by consumers varies regionally. However, the cooperatives don't need to be concerned about that because they limit the sales market to the Kyushu region. The fish have been sold as an Unzen Brand Yellowtail.

Figure 2 indicates cultured yellowtail price and shipping amount in urban and local markets from 2006 to 2008. Both prices increased year by year. In 2008 the local market price had increased by 2.8 times compared with the price in 2006 and exceeded the price for the large cities. It is thought that the unit price increment was related to development of the Unzen brand name.

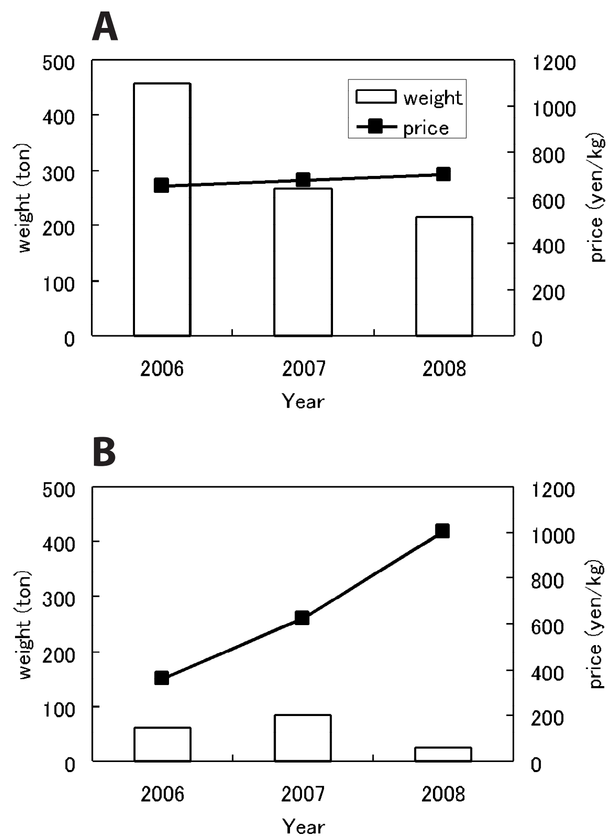

Fig. 2. The cultured yellowtail market price and shipping amount in urban (A) and local area (B) for 2006, 2007 and 2008.

Discussion

Improved management of yellowtail culture activities through a program developed in the fisheries cooperative in one part of Japan is presented in this paper. The aquaculture procedures were unified and new distribution routes were developed. Product branding helped increase the price of yellowtail. Although the price in the local area rose, the amount shipped locally was lower than that to urban areas. An increase in the price of yellowtail in urban areas is required to further increase business efficiency.

The improvements cited here have also been conducted by the fishery households in other regions such as by the Azuma-chou Fisheries Cooperative in Kagoshima Prefecture (http://www.azuma.or.jp/en/index.html) and the Hiketa Fisheries Cooperative in Kagawa Prefecture. In Kagoshima Prefecture, five fisheries cooperatives have been conducting further large-scale business management adjustments (Aquanet, 2009). The five cooperatives established a company dedicated to that end in Kinkou Bay.

In that case, they succeeded in cutting feeding and therapeutics costs through bulk purchasing. Furthermore, they manage the production plan based on market information and try to stabilize fish price. The approaches by these fisheries cooperatives are similar to those of the East Tachibana Bay Fishery Cooperative.

Fisheries cooperatives have an important role to play in improving aquaculture business management practices. Nevertheless, the financial problems for aquaculture households have not been solved. Additional business management changes are needed to resolve the issue (Hamada, 2006). For example, group ownership of feeding vessels and more attention to feeding effectiveness are also very important for business improvement.

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Hamada E., 2006. Current market and price problem of yellowtail, "Biology, Stock Enhancement and Aquaculture of Buri (Japanese yellowtail, *Seriola quinquerariata*)" (ed. by Nakamatsu M., Y. Hiyama, K. Mushiake and E. Hamada), Koseisha-Koseikaku Publishing Co., Tokyo, pp. 126–134 [in Japanese].

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Tasaka, Y. 1999, Study on the terms of brand Formation in young Yellowtail Aquaculture, Bull. Natl. Res. Inst. No.13, 37–70 [in Japanese with English abstract].

Aquaculture farmers have to possess flexibility both in production and marketing in addition to the production of high quality fish. The author clarified the business terms used by middlemen in yellowtail aquaculture. Their most important terms are "stability of supply" and "stability of wholesales price." They have other terms such as "price level," "Firm flesh," and "Size uniformity." Furthermore, the author judged yellowtail aquaculture in Japan, and made clear several problems in this paper.

Application of a Dynamic Stochastic Adaptive Bioeconomic Model to Evaluate the Economics of Offshore Bluefin Tuna Aquaculture

Gina Louise Shamshak
Goucher College
1021 Dulaney Valley Road
Baltimore, Maryland 21204
gina.shamshak at goucher.edu

James L. Anderson
University of Rhode Island
1 Greenhouse Road
Kingston, Rhode Island 02882

Keywords: aquaculture, bioeconomics, bluefin tuna, stochasticity, dynamic models

Abstract
This research presents a bioeconomic framework for assessing the economic feasibility of an offshore bluefin tuna (*thunnus thynnus)* aquaculture operation by developing a dynamic stochastic adaptive bioeconomic model of such an offshore enterprise. The bioeconomic model incorporates the biological constraints of the species, the interaction of relevant economic parameters and constraints, and stochastic sources of risk to solve for the profit maximizing behavior of a farmed bluefin tuna producer. The model identifies the optimal harvest schedule for an offshore bluefin tuna farming facility that maximizes the net present value (NPV) of the operation under a variety of economic, biological, and regulatory conditions. A variety of potential production scenarios are formulated and evaluated by comparing the expected NPV and expected internal rate of return (IRR), as well as the distribution of those values over a 10 year operating horizon. Such a model is relevant given the growing prevalence of bluefin tuna farming worldwide, the present lack of studies formally examining the economics of this form of production, and the uncertainty surrounding the economic feasibility and sustainability of farmed bluefin tuna production.

Introduction
Bluefin tuna (*thunnus thynnus)* farming is an interesting and complex form of production; however, to date there are very few published studies that empirically examine this practice. This research is a first step in filling this gap in the literature by establishing a bioeconomic framework for modeling the economics of farmed bluefin tuna production.

Specifically, this research identifies the optimal harvest schedule for an offshore bluefin tuna farming facility that maximizes the net present value (NPV) of the operation under a variety of economic, biological and regulatory conditions. Further, this research explicitly incorporates stochasticity into the model in order to analyze how the presence of risk alters the optimal harvest schedule for a producer. Very few studies have incorporated risk into the economic analysis of offshore aquaculture (Brown, Goller et al. 2002; Kam, Leung et al. 2003; Posadas and Bridger 2003; Jin, Kite-Powell et al. 2005) and none have incorporated the role of risk in the analysis of the economics of farmed bluefin tuna production. One major economic question stemming from this form of production is: how long should a producer retain and feed a given quantity of wild-caught bluefin tuna before harvesting and selling those fish? That is to say, what is the optimal harvest schedule for a producer looking to maximize profits over a farming season?

Incorporating Stochasticity into the Bioeconomic Framework
In explicitly modeling the stochastic nature of production, this model incorporates the risks associated with the offshore production of bluefin tuna, including biological, technical, economic, and regulatory sources of risk. This modeling approach is especially useful given the uncertainty surrounding the values and behavior of certain parameters associated with bluefin tuna farming. In many cases, specific knowledge of growth rates, mortality rates, input costs, and output price are unknown. However, such

parameters can be specified as stochastic within the model in order to capture the potential effect of these stochastic variables on the optimal harvest schedule and overall economic performance of the operation.

The model is a useful tool for those in the farming industry as well as investors and regulatory agencies. The model can be used to quantify the economic benefits and tradeoffs associated with the farming of bluefin tuna, in particular in situations where key variables are uncertain or are assumed to be stochastic. Furthermore, the model can be used to analyze how various assumptions regarding growth rates, water temperatures, prices, or costs affect the optimal harvest decisions and the overall economic performance of an operation.

Distinction from Previous Research

This research differs from previous studies in the field of aquaculture research with regard to the treatment of stochasticity within the model. In general, many economic optimization models solve the entire production or planning horizon once. That is to say, the optimal harvest solution is solved for across all periods given the assumptions and parameters that are specified *ex ante*. This modeling framework implicitly assumes that these parameters will not deviate from their *ex ante* values over the course of the production horizon, which may or may not be true. Employing Monte Carlo analysis is an improvement over models which are based on deterministic, fixed-point estimates of key parameters because they allow for the calculation of multiple fixed-point estimates which are chosen to hold over a production horizon.

In contrast to models which rely on deterministic fixed point estimates and which implicitly assume that the farmer would not deviate from the optimal harvest schedule in-season, the dynamic stochastic adaptive bioeconomic model developed here explicitly incorporates the adaptive behavior of the firm over the course of the operating horizon. In each period, the entire operating horizon is resolved iteratively from $t = t_1$ to $t = T$. Thus, rather than calculating and relying on one fixed optimal harvest schedule for the entire operating horizon, the model recalculates a new optimal harvest schedule each period as new information regarding the behavior of stochastically specified parameters changes over time. Thus, in the first period, expectations for stochastic parameter values are formed and are used to solve for the initial optimal harvest schedule, and the first optimal solution is executed. However, at the end of the first period, the farmer observes the actual values of the stochastic parameters, which may deviate from the expected values that were used to solve the initial optimal harvest schedule. Using this new information, the farmer updates the expectation of next period's stochastic parameters and recalculates a new optimal harvest schedule for the remaining periods in the operating horizon, given that a decision has already been made for the first period. In this manner, the farmer makes a decision period by period as new information is observed. The farmer is not constrained to stick to an optimal harvest schedule for the duration of the operating horizon. Rather, the farmer is able to resolve for the optimal harvest schedule for the remainder of the operating horizon each period, in an adaptive manner. Hence, this model is dynamic, in that it solves for the optimal harvest schedule over time, it is stochastic since it allows for the specification of stochastic parameters, and it is adaptive in that it allows a farmer to adapt to changing parameters in-season.

Such a model allows for a more realistic representation of risk and a farmer's response to risk throughout the production horizon. Compared to a non-adaptive model that solves for the optimal harvest schedule for the entire operating horizon once, the adaptive model's performance is typically higher (the NPV of the adaptive model equals or exceeds the NPV for a non-adaptive model) when operating under stochastic situations where parameter values change each period. The adaptive model performs better since it can alter the optimal harvest schedule in-season. This is in contrast to a non-adaptive model, which is limited to a single optimal harvest schedule based on *ex ante* estimates despite the fact that the values of those parameters change in-season due to the stochastic nature of the operating environment.

Basic Discussion of the Bioeconomic Model

For a more formal presentation of the bioeconomic model, see Shamshak and Anderson (2009). The objective function for a risk neutral profit maximizing offshore bluefin tuna aquaculture producer is defined as follows:

$$\text{Max}_{H_t}\ \pi = \sum_t^T \{P_t(W_t, H_t, G_{i,t})W_t H_t - C_{HC}\ H_t - C_{VC_t} N_t) \cdot \frac{1}{(1+r)^t}\} - A_0$$

Subject to:

$$P_t = P_t(W_t, H_t, G_{it})$$
$$W_t = f(FCR_t, FR_t(WT_t))$$
$$G_{i,t} = G_{t-1} + \left(\frac{W_t - W_{t-1}}{W_T - W_{(1)}}\right) \cdot (G_T - G_{(1)})$$
$$N_t = N_{t-1}(1 - M_{t-1}) - H_{t-1}$$
$$N_t, H_t \geq 0$$
$$N(0) = N_0$$

Where:

P_t Price per kilogram of an individual bluefin tuna, as a function of the weight, grade of the fish ($G_{i,t}$), and harvest quantity of fish at time *t*.

W_t Weight of a individual bluefin tuna at time *t* measured in kilograms, as a function of the feed conversion ratio and the daily feeding rate, which itself is a function of water temperature.

$G_{i,t}$ Grade of the fish at time *t*, where *i* = color, freshness, fat, and shape.

H_t Harvest quantity of bluefin tuna at time *t*. This is the control variable of the farmer.

N_t Number of bluefin at time *t*.

C_{HC} Harvesting costs ($/kg).

C_{VCt} Aggregation of variable costs at time *t* ($/kg).

FCR_t Feed conversion ratio at time *t*, which can be time invariant or a function of time.

FR_t Feeding rate at time *t*, which is a function of the water temperature (*WT*) at time *t*.

A_0 Total acquisition costs associated with acquiring bluefin tuna for farming.

M_t Mortality rate at time *t*, which can be time invariant or a function of time.

N_0 Initial starting number of bluefin tuna.

r Discount rate (weekly).

The optimal harvest schedule is solved for by maximizing the above objective function numerically through the use of a non-linear constrained optimization (Sequential Quadratic Programming) algorithm found within Matlab's Optimization toolbox. The time step for the model is weekly.

Model Implementation

The bioeconomic model has been developed and coded to be highly adaptable. All the key parameters and equations in the model can be customized by the user to reflect different locations, scenarios, and starting values. This makes the model capable of analyzing offshore bluefin tuna farming anywhere in the world. Ultimately the model will be used to analyze the economic feasibility of farmed bluefin tuna production in the United States; however, for now the model as parameterized is very general in order to demonstrate the model's performance and key features.

In the analysis that follows, the model has been parameterized with data acquired from an actual site visit to a farming facility in Cartagena, Spain, data obtained from consultation with experts in the field, and data from available peer-reviewed and gray literature. In future applications of this model, these variables will take on site-specific values; however, for now the values for key variables including the available quota, starting weight, and water temperature regime have been posited to demonstrate the performance of the model. The values of key model starting parameters are specified in Table 1. It is assumed that there is always a market for bluefin tuna at the estimated prices. Net returns are calculated before taxes are taken into account.

Preliminary Results from the Model

The power of the dynamic stochastic adaptive bioeconomic model is that under situations where parameters are not known with certainty, the adaptive nature of the model allows the farmer to adjust to deviations from parameter estimates that were specified *ex ante.* This ability to adjust to stochasticity in-season allows the farmer to identify a harvest schedule that is either equal to or superior to an opti-

Table 1. Key model parameters.

Parameter	Value	Units	Description
W_0	120	Kilograms (kg)	Starting weight of wild bluefin tuna at t_0
Available quota	800	Metric tons (mt)	Quota of Atlantic bluefin tuna available for farming purposes
N_0	6,666	Number of fish	Starting number of wild bluefin tuna at t_0
Stocking density	1,200	Kg/m^3	Stocking density in pens
Feed cost	\$0.50	USD/kg	Feed costs
FCR	20	Number	Feed conversion ratio
Acqusition costs	\$9.00	USD/kg	Cost per kg of wild bluefin tuna caught by purse seiners
Towing costs	\$6,000.00	USD/day	Cost per day paid to tug boats to tow wild bluefin tuna back to farm site
Towing days	45	Days	Number of days required to tow the fish to the farm site
Vessel payload	100	Metric tons (mt)	Payload of the vessel
Vessel speed	10	Knots/hour	Vessel speed per hour
Distance	10	Nautical miles	Distance of pens from shore
Fuel cost	\$3.00	USD/gallon	Vessel diesel fuel cost per gallon
CHC	\$1.00	USD/fish	Harvesting cost per fish
Managerial labor	\$40.00	USD/hour	Managerial hourly rate
Skilled driver labor	\$30.00	USD/hour	Skilled driver hourly rate
General labor	\$20.00	USD/hour	General labor hourly rate
r	5%	Percent/year	Annual discount rate (converted to a weekly discount rate in the model)
i	7%	Percent/year	Annual interest rate of loan used to finance initial capital expenditures

mal harvest schedule identified through a non-adaptive model. Further, it is more realistic to model the behavior of a farmer in this manner because farmers are continually observing and adjusting production decisions in response to changes in key parameters.

In the model presented here, two parameters are defined as stochastic: the weekly mortality rate and the weekly water temperature for the assumed location. Both variables will be defined by triangle distributions to capture the underlying stochasticity associated with those key parameters. In the case of the mortality rate, the farmer will form an expectation of the expected weekly mortality rate in order to solve for the optimal harvest schedule. At the end of the period, the farmer observes the actual mortality rate and incorporates this new information into the bioeconomic model by updating the expectation for next period's mortality rate. This new expectation is then used to solve for the profit maximizing harvest schedule for the remaining periods. The manner in which the farmer updates expectations can be formulated to be as simple or as complex as the user desires. In this specification of the model, the farmer updates expectations through a simple averaging of observations over the course of a farming season.

Stochastic water temperatures are incorporated into the model as follows. The farmer's expectation of weekly water temperatures over the course of a farming season will be the mean observed water temperature based on the average of five years of actual water temperature data. This information will be used to define the farmer's expectation of growth over a farming season, which ultimately influences the optimal harvest decision of the farmer. However, actual weekly water temperatures will be drawn from a triangle distribution and these values will determine the actual growth of the fish over the course of a week, which may or may not deviate from the

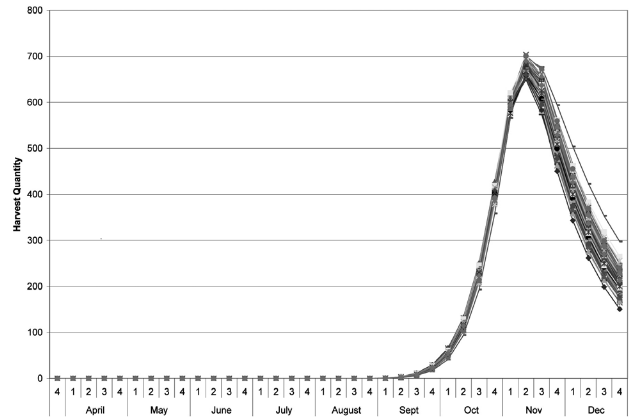

Figure 1. Optimal harvest schedules based on 100 runs.

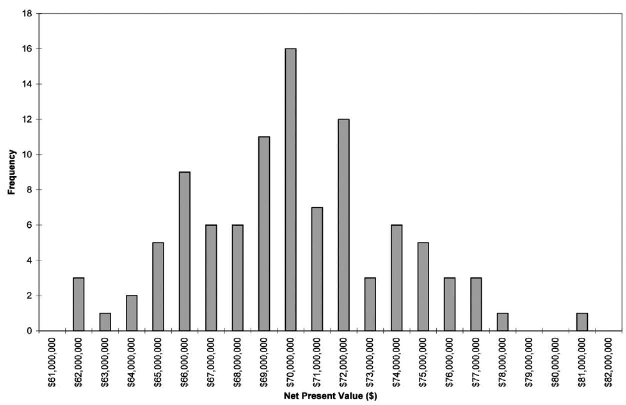

Figure 2. Expected net present value of a 10 year farming operation.

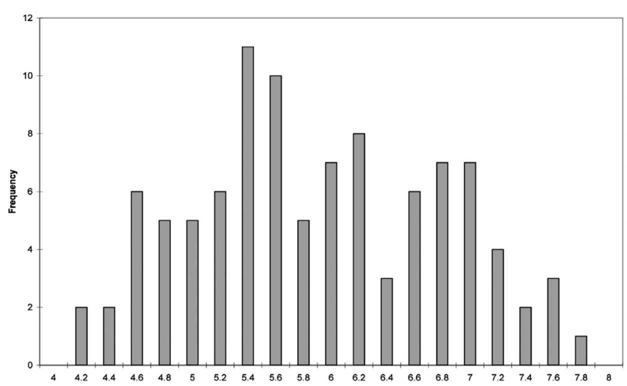

Figure 3. Expected internal rate of return for a 10 year farming operation.

expected growth of the fish for that period. Thus, the model will update the actual growth of the fish week to week to reflect actual growth as opposed to expected growth over a period. In future applications of this model, additional parameters can be specified as stochastic, including economic variables such as price and feed costs.

The bioeconomic model was run 100 times to simulate 100 different bioeconomically optimized farming seasons and their associated revenues, costs, and optimal harvest schedules. Figure 1 presents the optimal harvest schedules associated with 100 runs of the model. Since the bioeconomic model is a finite horizon model, each farming season is independent. Thus, each of the 100 runs can be viewed as a possible yearly outcome for a farmer. From these 100 possible yearly iterations, the bioeconomic model then randomly chooses 10 iterations from this larger set of 100 iterations to construct one possible representation of a 10 year operating horizon in order to solve for the expected NPV and expected IRR. This process of selecting 10 random yearly iterations to calculate the expected NPV and IRR values to simulate the performance of a 10 year operation is repeated 100 times. Figure 2 and Figure 3 present histograms of the expected NPV and expected IRR for an enterprise operating over a ten year horizon under the assumed parameter values. It should be noted that the results presented here are based on a very general and hypothetical rendering of a possible farming operation and are intended to demonstrate the model's performance; therefore, the results do not necessarily reflect prevailing industry returns.

Conclusions

This research establishes a bioeconomic framework for modeling the economics of farmed bluefin tuna production through the use of a dynamic stochastic adaptive bioeconomic model. Under stochastic conditions, the adaptive model is able to provide results that are superior to non-adaptive models that do not allow an operator to adapt in-season. The application of this bioeconomic model to offshore bluefin tuna farming allows for the quantification the economic benefits and costs associated with the farming of bluefin tuna, in particular the impact on the optimal harvest decision in situations where key variables are uncertain or are known to be stochastic. As better data becomes available, the model can be refined to reflect more sophisticated formulations and relationships among key variables. Regardless, this model is a first step in quantifying and empirically modeling the economics of this form of production. The next step of this research is to apply site-specific production parameters to the bioeconomic model to assess the economic feasibility of this form of production on the U.S. East Coast under a variety of economic, biological and regulatory conditions.

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Annotated Bibliography of Key Works

1.) This research report provides an assessment of Pacific bluefin tuna, *Thunnus orientalis*, farming as it is presently practiced in Ensenada, Mexico. This final report is available online: http://digitalcommons.uconn.edu/ecostam_pubs/1

Zertuche-Gonzalez, J., O. Sosa-Nishizaki, J. Vaca Rodriguez, R. del Moral Simanek, B. A. Costa-Pierce, and C. Yarish. 2008. Marine science assessment of capture-cased tuna, *Thunnus orientalis*, aquaculture in the Ensenada region of northern Baja California Mexico: Final Report of the Binational Scientific Team to the Packard Foundation: 94.

2.) The following are a collection of papers focused specifically on farmed Atlantic bluefin tuna, *Thunnus thynnus*, production in the Mediterranean. Growth rates, mortality rates, feeding regimes, size at capture, size at harvest, and other production parameters specific to bluefin tuna farming as it is currently practiced in the Mediterranean are available in these papers.

Aguado-Gimenez, F., and B. Garcia-Garcia. 2005a. Changes in some morphometric relationships in Atlantic bluefin tuna, *Thunnus thynnus* (Linnaeus, 1758), as a result of the fattening process. Aquaculture 249:303–309.

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Katavic, I., V. Ticina, L. Grubisic and V. Franicevic, (eds). 2003. Tuna farming as a new achievement in Mariculture of Croatia. Workshop on Farming, Management and Conservation of Bluefin Tuna. Istanbul, Turkey, Turkish Marine Research Foundation.

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3.) The following paper develops a bioeconomic production model that is applied to farmed salmon and cod production. While this paper does not focus specifically on farmed bluefin tuna production, the model and the manner in which it incorporates risk could be generalized to other forms of production.

Jin, D., H. Kite-Powell, and P. Hoagland. 2005. Risk assessment in open-ocean aquaculture: A firm-level investment- production model. Aquac. Econ. Manage. 9(3): 369–387.

Valuation of Ecosystem Services in Restocking with Ayu (*Plecoglossus altivelis*) in Japan

Shin-ichiro Abe
Fisheries Research Agency
National Research Institute of Fisheries Science
Freshwater Fisheries Research Division
Komaki 1088, Ueda, Nagano 386-0031, Japan
shinabe at affrc.go.jp

Yasuji Tamaki
Fisheries Research Agency
National Research Institute of Fisheries Science
Fisheries Economy Division
2-12-4 Fuku-ura, Kanazawa, Yokohama, Kanagawa 236-8648, Japan

Kei'ichiro Iguchi
Fisheries Research Agency
National Research Institute of Fisheries Science
Freshwater Fisheries Research Division
Komaki 1088, Ueda, Nagano 386-0031, Japan

Keywords: ayu, economics, ecosystem services, restocking, rivers

Abstract
The amphidromous fish, ayu (*Plecoglossus altivelis*), is an important fishery resource providing both commercial and recreational benefits to local communities in Japanese hilly and mountainous areas. However in most rivers flowing in these areas fishing for ayu is expensive due to the requirement of restocking with young fish because dams often impede their upstream migration from the sea. This study evaluated several non-market services provided from restocking with ayu to reveal these benefits that would otherwise remain hidden or unappreciated. Results of the contingent valuation showed that satisfaction derived from residence near rivers inhabited by ayu was equivalent to ¥58,440 (US $613.20) in annual payment per person. In addition, participation in activities related to ayu, such as releasing, lessons in angling, and observations of river organisms, would be of interest to many Japanese people and the benefit from one–time participation was estimated to be about ¥1,700 ($18) per person. Furthermore, restocking and fishing have a function of reducing the effects of eutrophication by preventing benthic algal blooms and by removing nutrients from the water. In terms of running costs of the sewage system, the annual benefits of the two functions of preventing benthic algal blooms by ayu-grazing and removing nutrients by fishing varied in rivers from ¥8.1 to ¥48.2 million (from $85 to $503,000) and from ¥0.3 to ¥213 million (from $3,600 to $2.2 million), respectively.

Introduction
Rivers and streams confer commercial and recreational benefits to human society through providing freshwater fishing, although human activities often cause fundamental changes in the fish community through river modification. Damming drastically changes the fish community in the above-dam areas (Katano et al. 2006). In Japan, ayu (*Plecoglossus altivelis,* Temminck et Schlegel) is one of the fishery resources most severely damaged by dams. Ayu is an amphidromous fish migrating from the sea to rivers annually. In early spring, ayu juveniles go up streams from the sea and grow by feeding on benthic algae until they mature and then die in the autumn (Tsukamoto and Uchida 1992). Damming cuts off upstream recruitment of the juveniles migrating from the sea and leads to the local extinction of ayu populations in above-dam areas. Therefore, in most of the rivers and streams flowing through Japanese hilly and mountainous areas where many dams and weirs have been constructed, freshwater fishery

cooperatives restock streams with ayu-young to maintain the fishery.

The action of restocking a stream with ayu not only meets the commercial and recreational fishery demands, but also restores functions of freshwater ecosystems by reintroducing locally extirpated fish. Freshwater ecosystems have functions of providing many diverse goods and services to human society (Wilson and Carpenter 1999) and these functions are mediated through the component organisms of the ecosystems. However, the ecosystem goods and services are not usually commercially evaluated and thus are seldom considered in policy decision-making. Restocking a stream with ayu will also yield benefits to the local community by restoring ecosystem functions, although these benefits may not be universally appreciated.

This study evaluated several non-market services provided from the action of restocking a stream with ayu. The services were evaluated in terms of the satisfaction derived from the presence of ayu, prevention of algal blooms, nutrients recycling, and environmental education. In this study we tried to determine a price for these services and examine the social benefits of the restocking action.

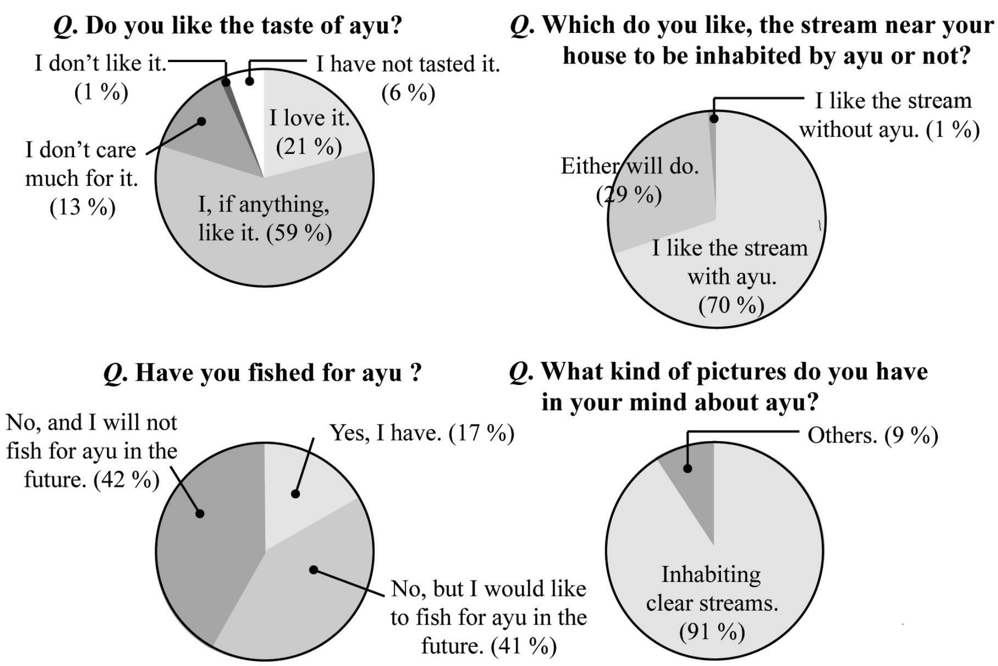

Figure 1. Results of the questionnaire survey about their preferences regarding ayu. The survey was conducted to ask questions to 1000 respondents using an internet communication service.

Value Derived from the Presence of Ayu

Before estimating the value derived from the presence of ayu, the impression of the species that Japanese people have was investigated using an Internet communication service questionnaire in November 2007 (Yahoo Japan Value Insight Inc., Tokyo). We asked 1,000 respondents about 1) preferences regarding the taste of ayu, 2) preferences about the presence of ayu in streams, 3) their experience angling for ayu, and 4) what image they had in their mind about ayu. Results showed that 80% of the respondents liked the taste of ayu and some 70% desired having ayu in the rivers near their house (Figure 1). In addition most respondents (91%) had an image in their mind that ayu inhabited clear streams and nearly half of the respondents who had no experience angling for ayu replied that they wished to go fishing for ayu in the future.

Next, the economic value of the presence of ayu in streams was estimated using the contingent valuation method (CVM). CVM is one approach to determine the economic value of non-market goods and services by asking people directly about the amount of money that they were willing to pay (willingness to pay, WTP) for specific improvements in goods or services (NOAA 1993). We asked WTP to rent a house (flat) near the rivers inhabited by ayu. A useable sample of 1,000 respondents was obtained using the internet communication service. Some 22% of the respondents refused the extra payment (i.e. WTP was ¥0). Results showed that the mean WTP per month and per year were ¥4,870 ($51.10) and ¥58,440 ($613.20).

Estimated WTP would include both use values as well as nonuse values (e.g., the satisfaction of people derived from knowledge that ayu exists). For example, WTP was greater in people who had experience angling for ayu or felt they would like to fish for ayu than people who had no desire to fish for the species. In addition, WTP was greater in people who liked the taste of ayu than those who did not like it. Furthermore, it was clear that the value of the presence of ayu would be affected by the condition of streams because many Japanese people have a mental image that ayu inhabit clear streams.

Function of Preventing Benthic Algal Blooms

Of the environmental problems spoiling the beauty of rivers and stream in Japan, eutrophication is one of the most serious human impacts on freshwaters. Eutrophication causes benthic algal blooms in streambeds which negatively affect the aesthetics of rivers and streams (Minagawa et al. 2006, Figure 2a,b). Ayu have a great ability to restrict benthic algal growth by grazing (Figure 2c). Therefore, restocking a stream with ayu has a function of also improving the riverine beauty by controlling benthic algal blooms in streams where excessive nutrients are discharged from anthropogenic sources.

We evaluated the function of preventing benthic algal blooms in fishing areas for ayu in the Masegawa, Uketogawa, Yahagigawa and Uonogawa streams in 2008. The fishing areas evaluated were located in

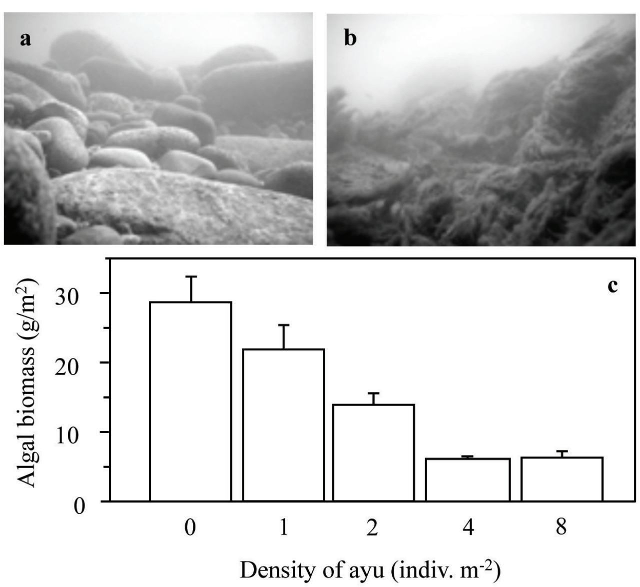

Figure 2. Views of streambeds with thin (a) and thick (b) benthic algal mats. Benthic algal biomass (c) established experimental streams with different densities of ayu (0 to 8 indiv. m^{-2}) after 2 weeks from stocking the streams with ayu. The biomass is expressed as the ash free dry mass. Vertical bars indicate the standard error.

above-dam areas maintained by restocking. Economic values were expressed as the running costs of the sewage system to keep the same benthic algal biomass as that in the presence of ayu by lowering the phosphorus concentration, which is usually the principal factor limiting benthic algal growth in streams. Evaluation involved two steps.

Step 1. Estimation of the benthic algal biomass in the presence and absence of ayu

To make this estimate the algal biomass (chlorophyll a content) and biomass-specific primary productivity (BSPP) were measured in the field using the half-rock scrape technique (Stevenson 1990). Benthic algal biomass in the presence of ayu was expressed as the mean biomass in the field. The biomass in the absence of ayu was expressed as the maximum biomass of benthic algal mats because if ayu were absent in streams, the algal mats would increase their biomass exponentially until reaching a maximum. The maximum biomass was estimated from the relationship between the benthic algal biomass and BSPP. BSPP decreases lineally with increasing benthic algal biomass; therefore, maximum biomass was estimated as the biomass in which BSPP was zero (Abe et al. 2002).

Step 2. Estimation of the necessary reduction of phosphorus and the costs

The necessary reduction of phosphorus (R) to keep the same biomass as that in the presence of ayu was calculated using the following equation:

$$R = (TP_a - TP_p) \times d \times L,$$

where TP_a and TP_p are the total phosphorus concentrations (μg l^{-1}) that would achieve the benthic algal biomass in the absence and presence of ayu, d is discharge (m^3 day^{-1}) and L is the growth periods of ayu from April and September (183 days). TP_a and TP_p were estimated using the equation developed by Chételat et al. (1999):

$$Log\ TP_{a\ (p)} = (\text{Log Ba (p)} - 0.490)/0.905,$$

where $B_{a\ (p)}$ is the benthic algal biomass in the absence (presence) of ayu (mg chl. a m^{-2}).

Economic values were calculated by multiplying the running cost (¥147.5 million per metric ton of phosphorus) by the necessary reduction of phosphorus. The necessary reduction of phosphorus ranged from 0.06 to 0.33 t per year per stream. The economic values attached the function of preventing benthic algal bloom varied in streams from ¥8.1 to ¥48.2 million (from $85 to $503,000) per year per stream and had a tendency to increase with the discharge and nutrient status of the streams (Figure 3).

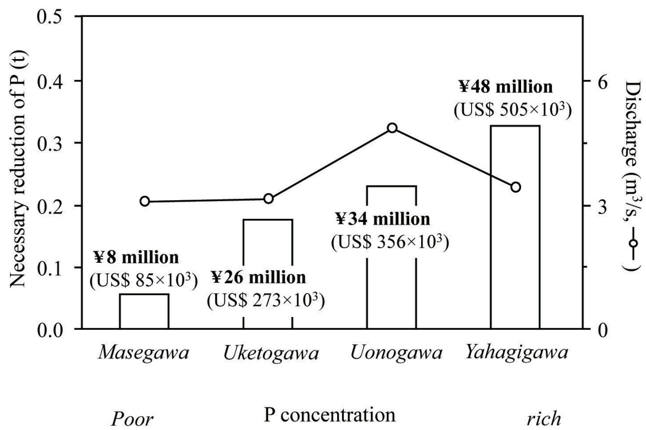

Figure 3. Economic value attached to the function of preventing benthic algal blooms in the four rivers restocked with ayu. Discharge, necessary reduction of phosphorus, and costs of sewage are indicated.

Function of Nutrient Cycling

Fishing has a function of recycling nutrients (nitrogen and phosphorus) from streams to the human society (Abe et al. 2006). Excessive nutrients discharged from anthropogenic sources cause eutrophication. In a sense, these nutrients are accumulated in benthic algae and then fish. Therefore, ayu angling is a method of removing the nutrients from stream water and then effectively utilizing them.

The economic value of this function was estimated as the running cost of the sewage system to remove the same amount of nitrogen contained in the annual production of ayu. The economic value was estimated from the annual catch of ayu, the percentage of edible mass (55%), and the nitrogen content (2.93%) of ayu against the running costs (¥21.3 million per metric ton of nitrogen). We could not obtain the data of annual catch in the local fishing areas that were restocked, so we used the data of annual catch in river systems, which are annually reported by the Ministry of Agriculture, Forestry, and Fisheries of Japan.

In 2006 the annual production of ayu varied in river systems from 1 to 621 t, corresponding to the removal of 16.1 kg to 10 t of nitrogen. Thus, the economic value ranged from ¥0.3 to ¥213 million (from $3,600 to $2.2 million) per year per river system. In this study the annual products of recreational ayu fishing were not included. Angling for ayu is a popular sport activity among the Japanese people (3.4 million people in 2003 according to the 11th fishery census conducted by Ministry of Agriculture, Forestry, and Fisheries of Japan). Thus, the function of nutrient removal would be underestimated in this study.

Environmental Education

Recently, members of freshwater fishery cooperatives have been active in environmental education through releasing young ayu into streams or observing stream life with children (Tamaki 2007). In addition, some local groups give courses in ayu angling for beginners. These events provide an opportunity for getting close to stream life and thinking about human impacts on the natural environment. We estimated the economic values of events that involved releasing ayu into a river, short courses in ayu angling and observations of stream organisms using CVM.

First, the demand for these events was investigated by surveying 1,000 adult men and women using an Internet communication service (Yahoo Japan Value Insight Inc., Tokyo) in December 2008 whether they would let their children or grandchildren participate in the events. The results of the survey showed that more that 90% of the respondents took an interest in the events (Table 1). Next, we asked WTP as an expense to join or a transportation expense. WTP for the events was estimated at ¥1,640 to ¥1,717 (from $17.2 to $18.0) per person per event (Table 1).

Table 1. Economic value of releasing ayu into a river, short course of ayu-angling, and observation of stream life as an educational opportunity for children. Economic values are estimated as the mean values of the willingness to pay as an expense to join[1] or as the transportation expense[2].

Event	Participation (%) Yes	No	Willingness to pay
Releasing ayu into a river[1]	92	8	¥1,665 ($17.50)
Short course of ayu-angling[1]	91	9	¥1,640 ($17.20)
Observation of stream life[2]	93	7	¥1,717 ($18.00)

Discussion

In this study we put a price on several non-market services provided by restocking a stream with ayu (Figure 4). From the questionnaire surveys, it was recognized that Japanese people have high use and nonuse values for ayu. The presence of ayu provides the opportunity for environmental education and a feeling of satisfaction for many people. Furthermore, many people associate beauty of the natural environment with ayu, while ayu also enhance the beauty of rivers by preventing benthic algal blooms and recycling excessive nutrients from streams to human society via fishing.

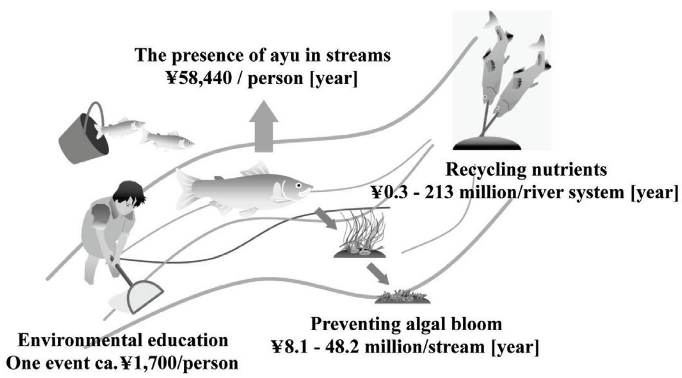

Figure 4. Price of ecosystem services provided by restocking a stream with ayu.

High use and nonuse values for ayu suggested that the action of restocking a stream with ayu will produce benefits in enhancing the attraction of local areas. In fact, ayu have been used as a tourist attraction in many places. Traditional ayu fishing using cormorants or a trap called "yana" and fresh ayu dishes are a major attraction for tourists and residents as summer activities. However, the attraction of ayu may change in response to riverine beauty because many Japanese people have a mental image that ayu inhabit clear streams. To enhance the attraction of ayu, it is important to maintain the environmental quality of streams and rivers.

The results of the questionnaire survey showed that there are many people wishing to become ayu anglers in Japan. Increasing the number of anglers will enhance the benefits attached to restocking a stream with ayu, whereas the number of ayu anglers has decreased gradually year by year. Although there are various opinions about the cause of the reduction in number of ayu anglers, the retirement of elderly persons and expensive fishing gear for beginners are considered to be the main causes of the reduction. To utilize the functions associated with ayu practically, it is important to create conditions that allow elderly persons and beginners to fish easily.

This study evaluated the functions of a freshwater fishery that is not commercial in nature. To make the best use of these functions, it is necessary to propose the ideal fishery management strategy and to find the social and geographical conditions that will enhance the functions. Finally, we have great expectations that the social benefits derived from stream life and a controlled freshwater fishery as estimated in this study will allow previously ignored factors to be incorporated into decision making in river management projects.

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Freshwater fisheries have a function of removing nitrogen and phosphorus from inland waters where the excessive nutrients are discharged from human society. This study estimated the economic value attached to this function of Japanese freshwater fisheries using the replacement cost method. The economic value was estimated as the running cost of a sewage system to remove the same amount of the nutrients contained in annual products of freshwater fisheries. In addition, the efficiency at which freshwater fisheries removed the nutrients was expressed as the percentage of the amount of the nutrients contained in the annual products to the annual loading of the nutrients in 23 rivers and nine lakes in Japan. The amount of the nutrients removed by freshwater fisheries was highest in 1981, reaching 1,132 t of nitrogen and 105 t of phosphorus, and evaluated at ¥23.3 billion as the economic value. However the economic value was reduced to ¥9.1 billion in 2003 with the decreasing annual catch. Furthermore, freshwater fisheries removed phosphorus at a higher efficiency than nitrogen in the rivers and lakes. The highest efficiency was estimated in the Ogawara Lake.

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Preference for streambed conditions was inquired of 91 test respondents (a teen to persons in their sixties) who were shown streambeds with different benthic algal biomass levels in an experimental stream and the Sinsakaigawa stream. The results showed that streambeds with lower periphyton biomass were more visually attractive and a permissible amount was below 5 g m^{-2} in ash free dry mass (20 mg m^{-2} in chlorophyll a).

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Freshwater fishermen's activity were investigated by a questionnaire survey for 895 Japanese freshwater fishery cooperatives in December 2005 in Japan. The questionnaires were collected from 342 cooperatives (38% of the total). Economic values of their activities to preserve the environments (e.g., riverside cleaning, extermination of alien fish, and watching for water quality and unlawful dumping) were estimated as labor costs and evaluated at ¥2,166 to ¥3,248 million. Economic values of their activities to exterminate alien fish were evaluated at ¥368 to ¥552 million as labor costs, though the nonuse benefits of exterminating exotic fish that Japanese people had were estimated at ¥29.9 to ¥108.4 billion by the contingent valuation method in a questionnaire survey in December 2005 using an Internet communication service. In addition, the economic values of two anonymous riverine fishing spots were estimated at ¥250 and ¥229 million by the travel cost method.

Implications of Aquaculture of Wild Fisheries: The Case of Alaska Wild Salmon

Gunnar Knapp
Institute of Social and Economic Research
University of Alaska Anchorage
3211 Providence Drive
Anchorage, Alaska 99508 USA
Gunnar.Knapp at uaa.alaska.edu

Keywords: Wild salmon, Farmed salmon, Alaska salmon

Abstract

Worldwide aquaculture production is growing rapidly. The experience of Alaska with wild salmon *Oncorhynchus spp.* suggests that aquaculture may have significant and wide-ranging potential implications for wild fisheries. Salmon farming exposed wild salmon's natural monopoly to competition, expanding supply and driving down prices. Wild salmon has faced both inherent as well as self-inflicted challenges in competing with farmed salmon. The economic pressures caused by competition from farmed salmon have been painful and difficult for the wild salmon industry, fishermen, and communities, but these pressures have contributed to changes that have helped make the salmon industry more economically viable. Farmed salmon has greatly expanded the market and created new market opportunities for wild salmon. Farmed salmon has benefited consumers by lowering prices, expanding supply, developing new products, and improving quality of both farmed and wild products. Salmon farming has had no apparent direct effects on Alaska wild salmon resources, but could have indirect effects on wild salmon resources that might be positive or negative. The experience of Alaska wild salmon suggests that anyone interested in wild fisheries should pay close attention to what is happening in aquaculture. No wild fishery market–especially for higher-valued species–should be taken for granted.

Introduction

An aquaculture revolution is happening in the world seafood industry. Aquaculture accounts for an ever-growing share of world seafood production. One of the most important questions facing wild fisheries is how they will be affected by the development of aquaculture.

Salmon *Onconhynchus spp.* are species for which the growth in aquaculture production has been most dramatic. Alaska is the world's largest producer of wild salmon *Onconhynchus spp*. Between 1980 and 2004, farmed salmon's share of world salmon supply grew from 2% to 65%, and Alaska's share fell from 42% to 15% (Figure 1).

The experience of the Alaska wild salmon industry during this time provides insights into how aquaculture may affect wild fisheries. In this paper, I first briefly describe the Alaska salmon industry. I then suggest 10 lessons from the experience of the Alaska wild salmon industry about how aquaculture may affect wild fisheries.

In recent years annual Alaska salmon harvests have averaged about 350,000 metric tons. Over the past two decades, harvests in most Alaska salmon fisheries have been very strong. Alaska wild salmon fisheries are certified as sustainable by the Marine Stewardship Council.

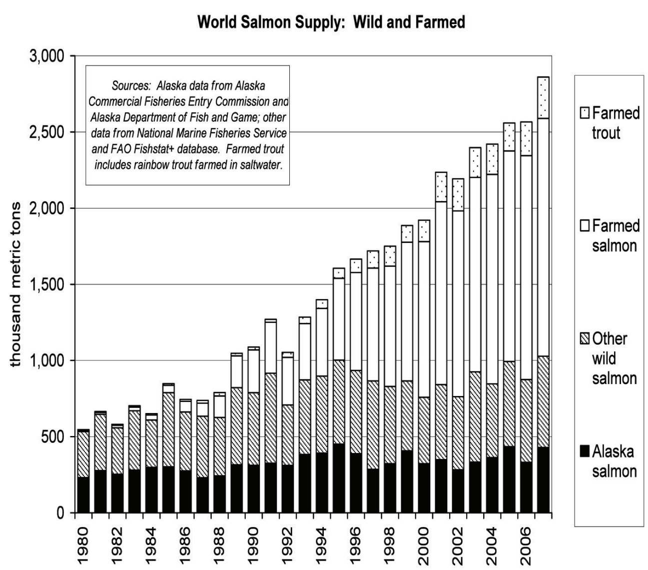

Figure 1. Growth in world farmed salmon supply from 1980–2007.

Five species of Pacific salmon are harvested in Alaska. Pink salmon *O. gorbuscha* accounts for the largest share of volume, followed by sockeye *O. nerka*, pink, chum *O. keta*, coho and chinook *O. tshawytscha*. Sockeye salmon, which commands much higher prices than pink or chum, accounts for the largest share of ex-vessel value.

Alaska wild salmon are processed into four major primary products: frozen salmon, canned salmon, fresh salmon, and salmon roe. These products are sold in worldwide markets. In recent decades the most valuable markets have been the Japanese frozen salmon market (sockeye salmon), the European and U.S. canned salmon markets (sockeye and pink salmon), the U.S. market for fresh and frozen salmon, and the Japanese market for salmon roe.

Alaska wild salmon are harvested in 26 gear and area-specific fisheries by small boats utilizing four major types of fishing gear (seine, drift gill net, set gill net, and troll). Participation is restricted by a limited entry management system. About 20,000 fishermen work seasonally in Alaska. Alaska's coastal communities are heavily dependent on salmon fishing for fishing and processing jobs and for tax revenues.

There is no salmon farming in Alaska. All finfish farming is banned in Alaska, partly to protect wild salmon resources and partly to protect fishermen from economic competition from farmed salmon.[1]

For many or most Alaska salmon fishermen, salmon fishing is more than just a job. They love salmon fishing in part because it allows them the chance to work and live independently in remote places of great beauty. In the late 1980s, Alaska salmon fishermen enjoyed not only these benefits but also unprecedented higher prices and incomes.

Ten Lessons from the Experience of the Alaska Wild Salmon Industry

1. Aquaculture can have rapid and dramatic negative effects on markets for wild fisheries.

Competition from farmed salmon was the most important cause of a dramatic decline in Alaska salmon prices from the late 1980s to 2002. By 2002, real (inflation-adjusted) ex-vessel prices for most Alaska salmon species had fallen to about one-third of average prices during the 1980s (Figure 2)[2].

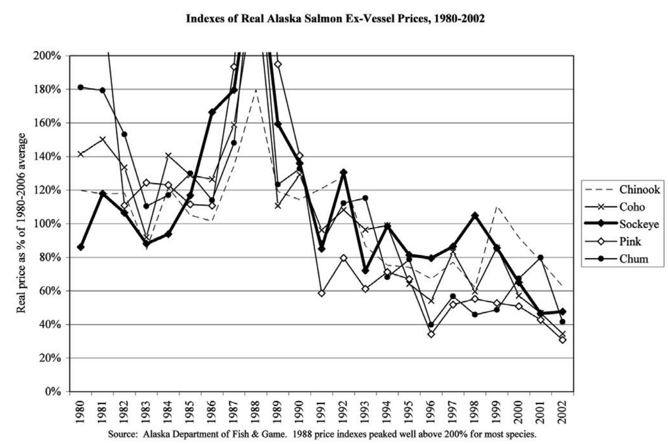

Figure 2. Ex-vessel prices of Alaska salmon from 1980–2002.

For example, during the 1990s, farmed salmon rapidly replaced wild sockeye as the dominant product in the Japanese market. As the total supply of salmon to the Japanese market increased, the Japanese wholesale price of Alaska sockeye salmon declined dramatically (Figure 3). As the wholesale price in Japan declined, the price to the Alaska fisherman also declined (Figure 4).

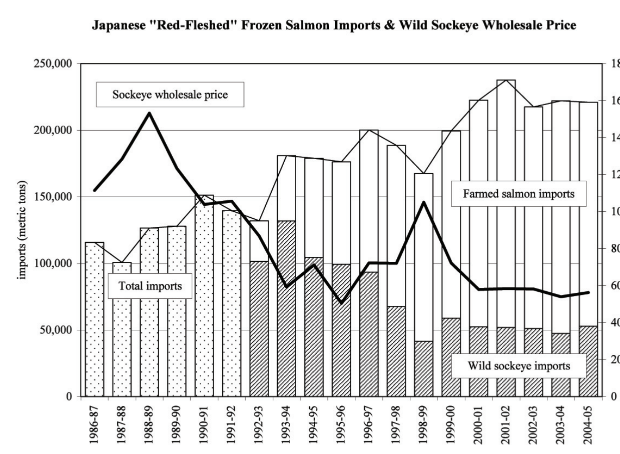

Figure 3. Japanese frozen salmon imports and wild sockeye wholesale prices (1986–7 through 2004–5).

[1] Although salmon farming is banned, Alaska does have a large-scale salmon hatchery program. Hatchery releases account for about one-third of Alaska salmon harvests.

[2] Farmed salmon was not the only cause of the decline in prices for wild Alaska salmon. Many other factors also contributed to the decline, including large Alaska salmon harvests, growing exports of Russian salmon, a recession in the Japanese economy, and stagnant consumer demand for canned salmon.

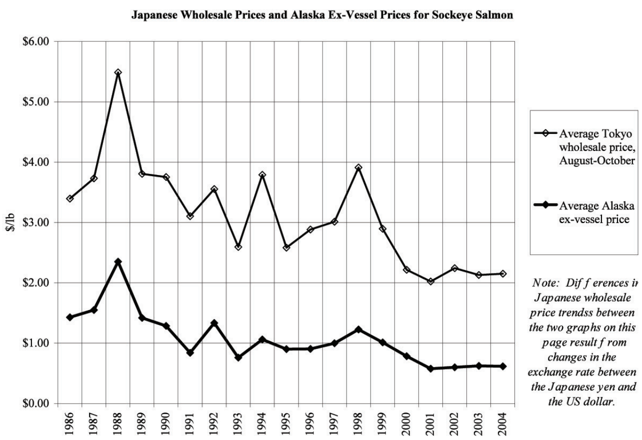

Figure 4. Japanese wholesale prices and Alaska ex-vessel prices for sockeye salmon for the period 1986 through 2004.

2. Changes caused by competition from aquaculture may be painful and difficult for those who depend on wild fisheries.

There were many difficult adjustments for Alaska fishermen as they experienced increasing competition from farmed salmon. As salmon prices declined so did incomes, as did the value of fishing boats and limited entry permits. Many fishermen lost their markets as declining profits resulted in the closing of many processing plants. Fishing communities experienced a loss in fishing taxes and population as processing plants closed and fishermen moved away. There were also social stresses, such as alcohol abuse. The political influence of the salmon fishing industry declined, and pressures grew to reallocate salmon from commercial fisheries to other uses such as sport fishing. Many Alaska salmon fishermen blame these problems upon competition from farmed salmon. They view farmed salmon as an inferior product that has harmed them. They believe that salmon farming in other places is harmful to the environment and unfairly subsidized. Car bumper stickers such as these are commonly seen:

It is typical and natural for people who are suffering economic harm from competition to look for someone to blame—and to ask their government to help and protect them. However, when you are facing competition, I think that the only real long-term solution is to understand better what your customers want and to work even harder to provide them what they want.

3. In an increasingly globalized economy, the market effects of aquaculture on wild fisheries occur regardless of where the aquaculture is happening.

Alaska wild salmon are sold in global markets. The decline in Alaska sockeye salmon prices was caused by farmed salmon production in a foreign country for export to another foreign country (Chilean and Norwegian exports of farmed salmon and trout to Japan). Banning salmon farming in Alaska didn't keep it from happening. Banning U.S. farmed salmon imports wouldn't have kept it from happening.

4. Wild fisheries may face significant inherent challenges in competing with aquaculture.

These challenges derive from the fact that aquaculture producers have much greater control over production. Inconsistent and unpredictable supply makes it much more difficult for wild salmon producers than for farmed salmon producers to meet buyers' supply needs and to plan for marketing. Alaska wild salmon catches vary widely from year to year, and often vary widely from the pre-season catch predictions. In contrast, salmon farmers know exactly how many fish they will have to process and to market–and can choose when to process and market them.

The seasonality of wild salmon fisheries increases production costs relative to farmed salmon, and makes it relatively more difficult to market wild salmon. Sometimes so many wild salmon are harvested in a day that there is no practical processing option other than canning. There aren't enough planes to fly the salmon to a fresh market, and there aren't enough freezers to freeze them. Wide variation in sizes and quality increases costs of processing and marketing wild salmon relative to farmed salmon.

5. Competition with aquaculture exposes not only inherent but also "self-inflicted" challenges in wild fisheries.

There are significant quality problems in many Alaska salmon fisheries resulting from practices at many different stages of fishing, tendering, and processing. These include, for example, bruising which occurs as fish are removed from gillnets, poor handling as fishermen focus on working fast rather than handling fish carefully, long delivery times between when fish are caught and when they are processed, and lack of refrigeration or icing on fishing boats. In some Alaska salmon fisheries there are many more boats fishing than are needed to catch the fish.

Competition with aquaculture exposes these self-inflicted problems. When customers for Alaska salmon have alternative sources of supply, they are less willing to accept quality problems with Alaska wild salmon. When prices fall, it is harder to ignore how traditional ways of fishing add to costs.

6. Economic pressures caused by aquaculture may contribute to changes which make wild fisheries more economically viable.
In the Alaska salmon industry, as fishermen and processors have left the industry, costs have fallen and efficiency has increased. Quality has improved in many fisheries. Marketing efforts have expanded. The salmon industry has worked harder to understand and meet the needs of customers.

7. Over the longer term, aquaculture may benefit markets for wild fisheries by expanding markets and creating new market niches for wild fisheries.
As salmon farmers have expanded world supply of salmon, they have also greatly expanded world demand for salmon. Salmon farming has made salmon much more widely available–in more countries and more stores, throughout the year. Salmon farming has created new salmon consumers and new product forms. Growing demand is creating growing niche market opportunities for high-quality wild salmon. Since 2002 strong demand has contributed to a rebound in prices for both farmed salmon and Alaska wild salmon.

8. Aquaculture benefits consumers by lowering prices, expanding supply, developing new products, and improving quality of both farmed and wild fish.
Since the development of salmon farming, both farmed and wild salmon have become cheaper and available more consistently, over a far larger geographic region, in more stores and restaurants and in more product forms.

9. Aquaculture may have both direct and indirect effects on wild fishery resources, which may be either positive or negative.
The experience of Alaska wild salmon suggests that aquaculture may affect wild fishery resources in several different ways. Salmon farming critics have pointed out the potential for salmon farming to introduce diseases among wild salmon populations, or for escaped salmon to introduce non-native salmon species or to affect wild salmon genetic diversity. However, because there is no salmon farming in Alaska, none of these direct effects have occurred in Alaska.

Aquaculture proponents have suggested that fish farming may benefit wild fishery resources by lowering prices and thus fishermen's incentives to over-exploit wild fishery resources. However, because Alaska salmon fisheries are well-managed, they are not over-exploited, and there is little evidence that lower prices have significantly reduced fishing catches or benefited salmon resources.

A potential indirect effect of competition from salmon farming is that lower salmon prices may reduce economic and political incentives to protect salmon resources and the environment on which they depend. When Alaska wild salmon were very valuable, there was a very strong commitment protecting salmon resources and the environment upon which salmon depend. But as the economic value of salmon has fallen, funding for salmon management and research has fallen, and there is greater support for proposed mining and oil development projects in salmon producing regions.

10. The experience of Alaska wild salmon suggests that anyone interested in wild fisheries should pay close attention to what is happening in aquaculture. No wild fishery market–especially for higher valued species–should be taken for granted. Aquaculture will continue to grow rapidly because it can meet market demands for predictable, year-round and growing supply of high-quality seafood. The challenges to wild fisheries posed by aquaculture will increase over time.

Effects of Salmon Farming on the Alaska Salmon Industry: Two Contrasting Perspectives
It is useful to contrast two different perspectives about how the Alaska wild salmon industry has been affected by salmon farming. The first perspec-

tive, which I call the "popular/green/Alaskan" perspective, is often reflected in the press and is commonly heard in Alaska:

> Unfairly subsidized and inferior farmed salmon harmed the environment and wild stocks in producing nations, and flooded world markets, depressing wild salmon prices and significantly harming Alaska fishermen and fishing communities.

My own perspective, which I call the "economic perspective," is different:

> Salmon farming exposed a "natural" monopoly to competition, benefiting consumers by expanding availability, lowering prices, spurring innovation and market development, and leading to a more efficient wild salmon industry more focused on meeting market demands.

I do not mean to imply that competition from salmon farming has been easy for the Alaska salmon industry. It has not. It has been very difficult. But in the end, I think the Alaska salmon industry can and will change, survive, and compete successfully in the very different world salmon market that salmon farming is creating–and will better serve the world's consumers.

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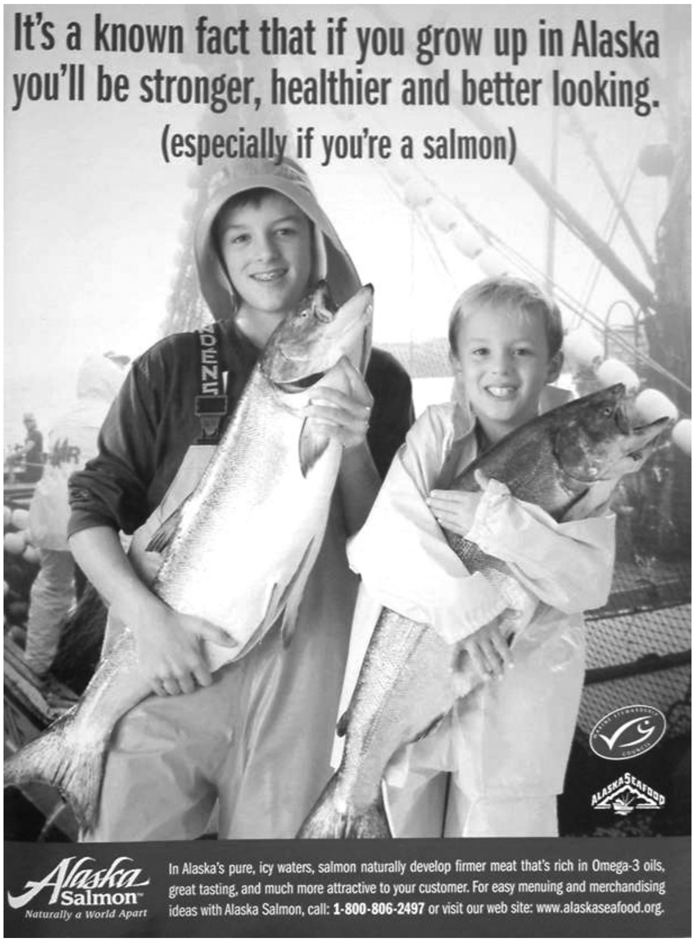
Full report available online at: www.iser.uaa.alaska.edu/iser/people/knapp



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Revitalizing Fishing Villages Through Sightseeing Fisheries in Japan

Yasuji Tamaki
National Research Institute of Fisheries Science
Fukuura, Kanazawa-ku
Yokohama, 236-8648, Japan
tamakiy at affrc.go.jp

Keywords: sightseeing fisheries, marine tourism

Abstract
In Japan, the use of beach seining, set netting, gill netting, small-scale trawling, and the use of basket nets or pots are major types of sightseeing fisheries. Aquaculture also promotes exchange between urban and fishing villages. This paper introduces a case study in Japan and discusses the role that sightseeing fisheries serve in the revitalization of fishing villages.

Sightseeing fisheries can be divided into three categories according to participation. First is on an individual basis. This type includes trips that do not use fishing boats, but collect shellfish and seaweed; trips offered for fishery experience using small boats; and trips that provide individuals with omnibus-style boarding on large ships to experience large-scale set net operations. The second category is families and small groups. This type operates small-scale trawl nets and small-scale set net fishing on a charter basis in which the customer keeps all that is caught and uses ships that can accommodate a fair number of people. The final category is large groups. Its main operational areas are those that require large numbers of participants, like beach seining; those that do not use ships, such as barrier net fishery; and large-scale set net fishery operations on a charter basis.

The individual category is the cheapest and is often provided free to overnight guests as a courtesy. For families and small groups, the price will be at the same level as for a day's income from fishing or higher, since the catch is given away to the customers. The large group category carries the highest overall charge, since it requires manpower, but when recalculated on a per-person basis it turns out to be comparably inexpensive.

Sightseeing fisheries can bring in larger incomes for shorter operating hours and smaller landings than commercial fishing. This lowers the risk of overfishing and the consequent depletion of marine resources. In addition, it lightens the workload of the workers. It can also have an overall effect on the local economy by increasing sales of alcohol and other beverages. This type of project can also have a promotional effect on consumers by encouraging them to consume more fish. One of the goals of a sightseeing fisheries business is to educate the consumers about how the fish and shellfish we consume daily are caught.

Introduction
Fisheries in Japan are now faced with serious problems such as declining profitability, decreasing numbers of fishermen and an increasing proportion of aged fishermen. In 2003 the number of workers in coastal fisheries had declined by 12% over a period of five years, falling nearly 200,500. The Fisheries Agency predicted that the number will fall to 117,000 in 2017 (Figure 1). Forty-six percent of male fishermen were aged 60 or older in 2003 (Figure 2).

Given the serious situation, in order to revitalize fishing communities, diverse efforts in fields other than fishing have been made by fishery cooperatives and fishermen. This paper is intended to outline revitalization programs taken in those fishing communities through sightseeing fisheries and to evaluate the outcome from those programs. The results are based on an interview investigation in the fishing communities, by examining documents, and a search of the Internet.

Results
Revitalization of fishing communities through the development of sightseeing fisheries can benefit through

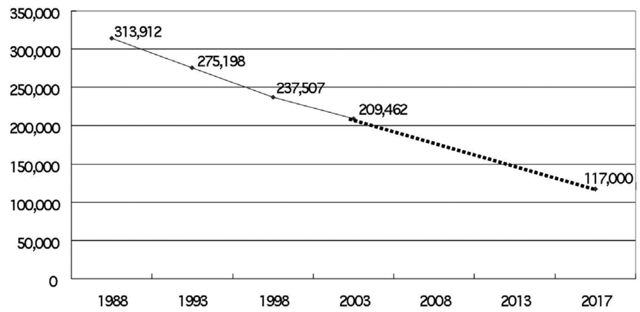

Figure 1. Change and prediction of number of coastal fishermen.
Source: Fishery Census (MAFF 2005) and Production structure and the management prospects of fishery (Fisheries Agency 2007).

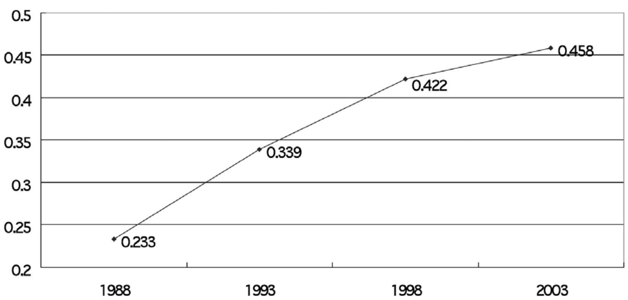

Figure 2. Change of the male fishermen ratio over 60 years old.
Source: Fishery Census (MAFF 2005).

a direct economic effect from user fees and from visitor expenditures not directly related to fisheries. Another advantage is to help city dwellers to better understand fishing and fishing villages. The two economic effects can be classified as facility-oriented measures and activities without specific facilities (revised Tamaki 1996).

Facility-oriented measures contain management of marinas and yacht harbors, inns and private guest houses, direct sale outlets for fishery products, seafood restaurants, fishing cages (fishing ponds) and rafts, glass boats, and fisheries processing experiences. Activities without specific facilities include guides for recreational fishing, guides for recreational clam digging, diving services, whale and dolphin watching, and sightseeing associated with commercial fisheries and aquaculture.

In this paper, I focus on sightseeing. There are many economic impacts associated with this activity. Sightseeing in relation to fisheries and aquaculture can bring in larger incomes for those involved in the industry while requiring shorter operating hours and smaller landings. This lowers the risk of overfishing and depletion of marine resources, while lightening the workload of the workers. It can also have an overall effect on the local economy by increasing sales of alcohol and other beverages. This type of project can also have a promotional effect on consumers by encouraging them to consume more fish. One of the goals of a sightseeing business is to educate the consumers about how the fish and shellfish we consume daily are caught.

Table 1 shows the number of municipalities engaged in sightseeing fisheries. Two hundred municipalities are engaged in shore seine fisheries, while set nets are second with 97 municipalities. Aquaculture is the third with 73 municipalities. Gill netting and small scale trawling come next. Figure 3 shows the

Table 1. Number of municiplaities engaged in fisheries experience (revised Tamaki 2007a).

Fishing method	No. of municipalities
Shore seine fishery	200
Set net fishery	97
Aquaculture	73
Gill net fishery	52
Small scale trawl fishery	36
Shellfish and seaweed collection*	29
Barrier net fishery	22
Cage fishery	20
Squid fishery	18
Octopus pot fishery	15
Longline fishery	8
Sea bream surrounding seine fishery	8
Dip net fishery	7
Seine fishery	4
Drift net fishery	4
Others	23

*Excluding recreational clam digging

(revised Tamaki 2007a)

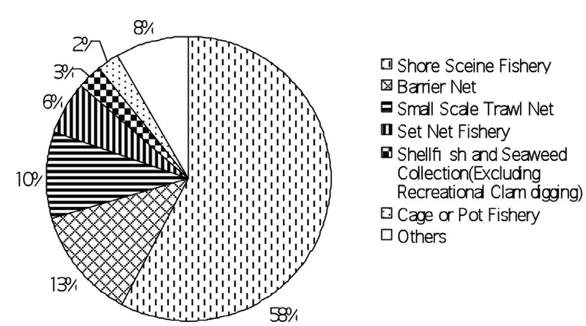

Figure 3. The ratio of number of participants in sightseeing fishery programs in Japan (revised Tamaki 2007a).

ratio of the number of participants in sightseeing fishery programs. The shore seine fisheries lead with 58%, followed by barrier nets at 13% and small scale trawling at 10%.

Shore Seining—This type of fishery is rarely economically viable as a fishery business in Japan, so it is usually operated solely as a tourist attraction. It is not classified as a recreational guide boat business in Japan. If there is a beach, all that is needed are a net and a boat for placing it. Wild catches continue to fall, so expenditures for purchasing fish to put into the net have become a necessity. Of the 23 locations I visited for interviews, only two were operating their shore seining activity on a commercial basis. Two were catching wild fish, so they did not need to purchase fish, while the remaining 19 were all putting purchased live fish (mainly cultured red sea-bream) into the net. The operation fee of each ranged from ¥35,000–300,000. Nets were usually purchased using subsidies from the local prefecture and municipalities. Some seiners offered up to 50 to 60 events per year, while 60% of those offered fewer than 10.

There are two types of shore seine fisheries. Those near large cities have customers that are day-trippers, with most coming from local elementary and junior high schools. Thus, there is no problem associated with a shore seining fishery being the only fishing experience available. The second type is found on isolated islands where the bulk of the participants are overnight guests on junior high and high school excursions. In the case of isolated islands, it is necessary to combine various other options in addition to shore seining.

Set Net Fisheries—There are a number of set net fisheries that have provided sightseeing opportunities. With respect to large-scale set net fisheries, the visitor pays a fixed rate per person and boards the fishing boat or a different boat and watches the whole fishing process from close at hand. In some locations, a gift of fish or a light meal after the tour is included in the cost. In Hokkaido, sightseeing of salmon set nets is carried out. Almost all salmon are hatchery-produced and then released. Since a large-scale set net fishery can expect large landings, earnings from offering a fishing experience are marginal compared to those from sales of fish. However, if the catch is huge, having customers on board walking around can become a burden. Moreover, due to the auction times at fish markets and the side businesses of set net fishery operators, the nets are landed early in the morning, making it difficult for customers to take part unless they are staying overnight. The number of annual participants varies greatly due to these constraints. According to Matsuura (2002), of the 30 interviewed municipalities that were offering a set net sightseeing experience, the maximum number of customers was 700 and the minimum was around 10. There were only 8 municipalities that had more than 100 customers.

The second type of set net fisheries is small in scale. In that case the boat is chartered on a per-boat basis and the customer usually takes back everything that is caught.

Gill netting—Gill netting activities can often be viewed by tourists free of charge. The presence of a large number of tourist lodgings offering this type of experience can be explained, presumably, by the fact that the gill nets are usually set up in the afternoon and landed in the early morning, making it possible to have the fishery located adjacent to the lodgings. Moreover, setting up and releasing fish from the net are easily managed fishing experiences.

Small-Scale Trawling—This type of sightseeing fishery occurs in 36 municipalities, 80% of which are distribute in the Seto-Inland Sea and other places in the bay area (Tamaki 2003). In the Seto-Inland Sea, kuruma prawns, swimming crabs and flounder fingerlings are stocked. Customers prefer these high value species. Trawlers sail in the morning, operate until noon, return to port and then provide lunch either on board or at a resting place on shore. They usually allow the customers to take home all the fishes caught during the operation. Some small-scale trawlers offer recreational fishing as part of the package. To cope with unexpected low catches during the tour and for meal preparations, in some areas the fishermen sail out prior to boarding customers and catch fish in advance, while some others hold the catch from the previous day. In most areas offering small scale trawling for sightseers, the fishery was operated with only one fisherman, while in four towns it was operated by a husband and wife team. The busiest time for most municipalities was from June to September, and about half did not offer sightseeing opportunities during the winter season when the sea was likely to get rough. Those offering an all-year-round service had fewer customers during the winter season. The typical price ranged from

¥50,000–60,000 for a fixed number of participants, with an extra charge for each additional person. Average cost per customer was about ¥6,000.

As a public relations campaign, invitations were sent out to the media so the opening ceremony could be broadcast, handouts were distributed in urban areas within the prefecture and cooperation with tourist associations and municipalities was sought. As for school excursions and field trips for junior high schools, some fishermen pursued the business aggressively, while others distanced themselves for fear that it might be too dangerous for children and that they did not have enough ships to handle everyone who might be interested. However, when they did accept children, they usually charged half the normal price, made only one trawl and retained the catch.

There are some conditions that need to be met for successful sightseeing in conjunction with a small scale trawl fishery:

1. Landing yield per day during the height of the tourist season from June through October is under ¥40,000–50,000 .
2. Fishing grounds should be in the inland sea or inner bay area where waves tend to remain moderate, even in rough weather.
3. There should be a facility for taking telephone inquiries and reservations during the season.
4. Fishing trips can be operated when demand is high on both weekends and holidays.
   The fishery operator should have the necessary customer relation skills to deal with customers.
5. Parking spaces should be available near the port, since customers usually come by car so they can take home their catch.
6. The fishing locations should be easily accessible from large cities.

Basket and Pot Fisheries—These types of fisheries do not harm the captured species, so unlike gill nets fisheries, the catch can be left inside the apparatus with the expectation that it will be alive when the nets or pots are raised. On Kamagari Island off the coast of Hiroshima Prefecture, the local tourist lodgings put up about 100 customers per day, mainly during the weekends in May and June, to experience cuttlefish cage fishing. The fishery offers tourists the experience of catching broad-mantle squid and golden cuttlefish that come to spawn on the twigs set in the cage. Sightseers are charged ¥5,000 for adults and ¥3,500 for children and are offered a full course lunch of cuttlefish on the beach after the fishery experience. A tourist-oriented octopus pot fishery is also available.

Categories of Visitors Partaking of Sightseeing Fisheries—There are three categories associated with those involved in sightseeing fisheries: individuals, families and small groups, and large groups. Individual opportunities for sightseeing include trips that do not use fishing boats but collect shellfish and seaweed, trips offered by tourist lodging facilities for experiences using small boats and trips that provide individuals with omnibus-style boarding on large ships to experience large-scale set net operations. Families and small groups can be accommodated by small-scale trawl and set net fisheries on a charter basis, in which the customer keeps all that is caught and uses ships that can handle a fair number of people. Finally, for large groups, the main opportunities are shore seine fisheries and others that do not use ships, such as barrier net fisheries and large-scale set net operations using charter boats.

Aquaculture—Sightseeing in association with aquaculture can involve:

- Watching feeding (fish)
- Observing a culture operation (bivalves, seaweed)
- Observing cultured creatures suspended in the sea (bivalves, seaweed)
- Watching the insertion of a nucleus in pearl oysters

Aquaculture facilities are often owner operated and managed. For example, an oyster owner may purchase ropes that have oyster spat attached to them, hang the ropes and harvest the oysters when they reach market size. In the case of pearl oysters, the owner may insert nuclei in pearl oysters, allow them to grow and then recover the pearls that are formed.

Table 2 shows the number of fishery districts that have sightseeing aquaculture and aquaculture activities along with the number of owner-management sites. Oysters are the most common species involved in both activities.

Other examples of relationships between urban and fishing communities include small restaurants that serve grilled cultured oysters in Kagawa, Okayama, Fukuoka, Saga, Nagasaki and Miyagi prefectures. In Mie and Hyougo prefectures, fishermen provide cul-

Table 2. The number of fishery districts that carry out sightseeing aquaculture and number of owner -management sites.

Species	Sightseeing aquaculture	Owner sites
Oyster	12	16
Scallop	9	2
Sea mustard	7	5
Sea bream	6	1
Yellowtail	4	1
Sea squart	3	0
Tuna	2	0
Laver seaweed	2	0
Nemacystus algae	2	0
Pearl	1	7
Kelp	1	4
Tiger puffer	1	1
Amberjack	1	0
Abalone	0	2
Black lockfish	0	1
Kuruma prawn	0	1
Other fish	5	0

tured fish to stock cages and fish ponds. In Ishikawa prefecture, oyster culture rafts are provided for sport fishing. In Shimane Prefecture, a fishery cooperative takes anglers aboard recreational fishing boats to the waters near their aquaculture grounds. In freshwater, fishery cooperatives release cultured fingerlings for sport fishing (revised Tamaki 2007).

Discussion

To be able to launch an urban-rural interchange project such as sightseeing fisheries it is first necessary to identify the local resources. Questions to be asked are:

- What are our marine resources?
- What are our strengths compared to other areas?

The four most basic concepts for the utilization of local resources are selling fisheries products, serving seafood, showing fisheries activities, and providing an experience. Learning from successful cases is important; however, it takes more than mimicry to succeed.

To develop prospective customers based on regional characteristics, there should be fishing communities located fairly close to highly populated areas. Most visitors are day-trippers, so it may be useful to target local elementary and junior high schools.

If the sightseeing fishery is located on an isolated island, luring ordinary visitors by making the fishery experience the key attraction is not likely to succeed; therefore, it is recommended that programs should be developed that can be offered along with other tourist attractions, to devise programs tailored to school excursion needs and to prepare backup plans, such as food preparation and cooking experiences that can be conducted indoors in case of bad weather.

Those interested in developing sightseeing fisheries should be careful not to rely too heavily on the efforts of particular groups or members of the group. Work on a volunteer basis does not last long. Hard workers should be paid. Making good use of subsidies and grants may be necessary, but careful consideration should be paid so as not to overinvest. Starting with a small initial investment and enlarging it as the business develops is the most prudent way to proceed.

With regard to marketing, there are a few questions that should be addressed:

- How far can our market reach?
- When and whom should we target?
- What kinds of transportation will they use?
- What should be with respect to public relations?

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Tamaki, Y. 2003. Evaluation of the fishing village activation effect by a fishing ground creation and urban interchange. Bull. Fish. Res. Agen. No. 8:22–111 [In Japanese].

The author did a chief ingredient analysis using six indices related to economic performance and six indices related to fishery performance. As a result, two chief ingredient scores to represent the vitality of the fisheries and economic vitality were calculated. Using these scores, Japanese coastal municipalities are divided into five types.

As one of the regional activation methods, fishing ground creation through artificial reef establishment should be widely enforced. The author did an example analysis of an artificial reef. Fishermen in the example develop a resources management plan spontaneously and restrict the fishing season and fishing method with this example of establishing an artificial reef. It became obvious that this approach would lead to effective utilization of an artificial reef. In the analysis, the establishment of an artificial floating reef brought about a direct effect by increasing catch quantity and revealed many indirect effects such as an increase in profits of a fisheries cooperative association, oil reduction by fishermen, operating hour reduction, and extension of the fishing season. The result, establishment of a floating artificial reef returned 2~5.6-times the cost needed for establishment and maintenance.

In isolated islands, fisheries play a large part in a regional economy. While bottom fish resources decrease, collection of migratory fish through establishment of an artificial floating reef is valid as a regional activation measure.

A fishing village has various valuable regional resources that don’t exist in a city. The author did a statistical analysis and questionnaire survey analysis about the ability of a fishermen’s inn to become a nucleus of an interchange between the fishing community and a large city. The number of people and menu that a single inn can provide is limited. However, the inn can meet various other needs of urban residents by using the fishing village as a whole and the tourist opportunities provided therein. Further, the author analyzed fishing village opportunities in relation to local fishing methods.

In recent years, the number of guests for an experience fishery has decreased due to a depressed economy. On the other hand, the number of schools that provide a fishery experience as a general learning activity has increased.

Technologies to Bridge the Gap Between Fisheries and Aquaculture

Clifford A. Goudey
C.A. Goudey & Associates
21 Marlboro Street
Newburyport, MA 01950
cliffgoudey at gmail.com

Abstract

The conflicts between fisheries and aquaculture range from mere perceptions to legitimate issues. This paper discusses and dismisses many of the traditional arguments against aquaculture that seem to emanate from the wild-harvest sector. A basis for overcoming the remaining issues is presented using offshore aquaculture technologies that provide a logical basis for cross-sector cooperation.

Introduction

In many cases, the growth of aquaculture is perceived to be at the expense of traditional fisheries and as a result, conflicts have arisen between these two sectors of the seafood industry. Opposition from fishermen has come in spite of explicit attempts to involve them in new aquaculture projects and through retraining programs.

Conflicts—Real or Imagined?

Fisheries/aquaculture conflicts come in many forms with some being real and some merely constructs of those opposed to aquaculture for other reasons. Much has been made of the concern over price and market competition. There may have been a day when this was a legitimate issue. However, nearly all seafood markets are driven by global market prices and the growth of local aquaculture would have little direct effect on local prices. Indeed, there is good reason for fish farmers to focus on supplying product at low points in the cyclic supply of wild-caught fish in order to fetch a better price. In doing so, the farmed product maintains market opportunity that would be at risk of dwindling under an uneven supply scenario.

Environmental concerns are often cited as reason for opposing aquaculture. In particular, the use of forage fish, the risks of escapes, and habitat impacts seem to be a common theme within these arguments. However, most forage fisheries are managed and their abundance is heavily dependent on environmental variables and natural cycles rather than pressure from industrial fisheries. In addition, the impacts from escapes have little evidence to support the idea of escaped fish ever displacing or interbreeding with a local stock. Other than the economic loss to the fish farmer and a sudden boost in local angling, these risks remain conjecture.

Discharges from aquaculture operations can cause localized impacts, as with most human activities, fishing included. However, these effects are very limited in area and generally confined to the seabed directly beneath a net-pen operation. Furthermore, the measurable impacts rapidly diminish once the operation ceases or the site is allowed to fallow. Site selection is an important part of keeping these impacts at an acceptable level and in general, higher-energy sites are preferable.

The competition for space is more imagined than real. The space required of aquaculture is small, representing less that one percent of the area needed to produce the same amount of fish within a wild system. In addition, since most wild fish migrate, an area rendered unfishable due to the presence of an aquaculture operation is of little consequence. Indeed, biological monitoring activities undertaken in compliance with aquaculture permit requirements almost universally report an increase in the abundance and diversity of wild fish as a result of the placement of the culture operation. This is especially true in oceanic waters where the nutrient stream from the cultured biomass is assimilated by the local ecosystem and results in a productivity boost across many trophic levels.

The competition for workers may represent a real basis for conflict, but less so for the fishing crew and more so for boat owners and the leaders of commercial fishing organizations. The former would prefer not to lose skilled workers to a competing seafood sector. Industry spokespersons always seem to oppose anything that might reduce their constituency. The growth of the aquaculture sector, even though it presents a new and motivated voice for caring for our oceans, might be viewed as a diminishment of the political or economic clout currently enjoyed by commercial and recreational fishing sectors.

So in general, there is little basis for the opposition to aquaculture that is often attributed to the fishing industry. The explanation for the notion may be rooted in the early introduction of forms of aquaculture that failed to present attractive opportunities for fishermen. Land-based and sheltered-water aquaculture can take little advantage of fishermen knowledge of the sea and presents a mismatch of skills. Furthermore, these near-shore operations cannot make economical use of their existing investments in operational assets such as vessels.

The Fishing/Aquaculture Nexus

By factoring fishermen's existing skill sets and extant capital investments into the aquaculture conversation, not only can we reduce the conflicts between these sectors, but we can also provide benefit to both sectors from a synergy that provides stronger seafood markets and more viable business ventures.

Offshore aquaculture requires navigation, seamanship, rigging, net mending, and gear deployment and retrieval skills – all essential to success at high-energy aquaculture operations. Figure 1 shows an example of fish farming technology suitable for an open-ocean setting.

Offshore fish farming can require sporadic but long and multiple days away from home–something fishermen are used to. Fishermen are not risk averse, a trait essential in aquaculture. What are needed to realize the potential synergies are technologies that utilize fishing assets and operational paradigms that exploit fishermen's skills and their work ethic.

Another example of offshore fish farming technology is the Aquapod, a spherical sea cage. The geodesic design provides a cost-effective culture volume over a range of cage sizes from 115 to 11,000 m^3. Figure 2 is a photo of a 3,600 m^3 Aquapod being assembled in South Korea.

The deployment, towing, placement, and integration of such a cage in an ocean setting demands many of the skills that are also pre-requisites for fish farming.

Offshore aquaculture, more than any other form, offers business opportunities for fishermen. Not only can fishermen provide essential logistics support for such operations, but they can also be pivotal in site selection, environmental data collection, facility installation, and environmental monitoring. Fishermen can also identify species opportunities and provide insight on seasonality, pricing trends, assist in marketing, and perform broodstock collection.

The emerging concept of mobile cage operations may present a compelling opportunity for fishermen to get directly involved in fish farm ownership and operation. The far-flung nature of these operations will require mobility and a level of regional ocean knowledge that is held by few besides fishermen. An operational paradigm that would especially benefit from fishermen involvement is mobile, high-seas operations.

Figure 1. (Left) A typical offshore array of submersible cages–SeaStations from OceanSpar, Bainbridge Island, WA. The photo at right is a surfaced 6400 m^3 cage.

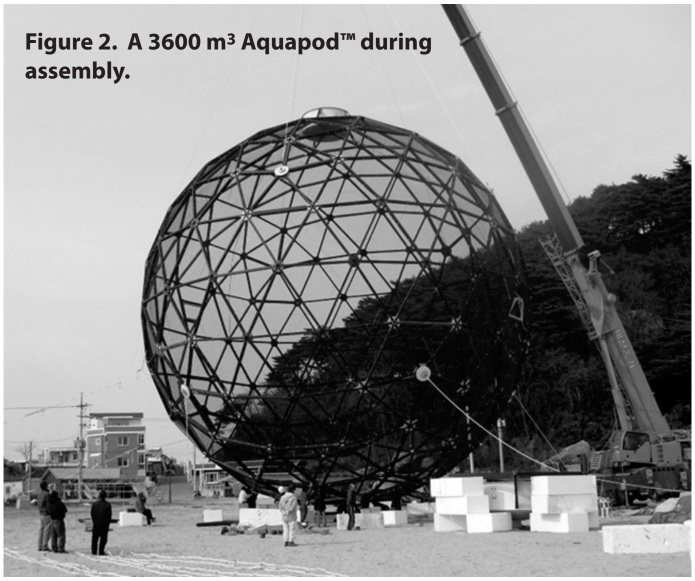

Figure 2. A 3600 m³ Aquapod™ during assembly.

Figure 3. A self-propelled Aquapod™ during sea trials.

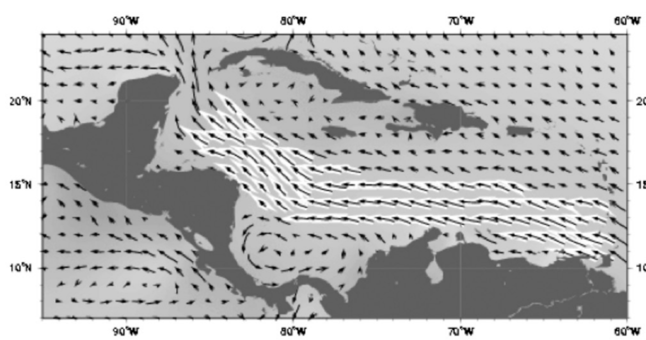

Figure 4. Oceanic currents present trade routes for mobile fish farming.

The concept of self-propelled, mobile sea cages was demonstrated recently in a NOAA-sponsored project. Pictured in Figure 3, a 3,250 m³ Aquapod was outfitted with a pair of 2.4-m diameter thrusters. During sea trials of this system in Culebra, Puerto Rico, speeds in excess of 0.25 m per sec were obtained with a power of only 10.4 kW.

Opportunities for such types of operation exist globally, wherever oceanic currents provide the conveyer from source to market. Figure 4 shows an excellent example of this, where the Caribbean current provides a ready path from the Windward Islands to Miami.

Re-purposing Trawlers

Consider the plight of overcapitalized fisheries–one example being the shrimp trawling fleet in Ecuador. On Sept. 11, 2009, Fish Info & Services Co. Ltd. published a story titled, "Final countdown for trawl fishing." In the story we read, "Shrimp trawl fishing fleet will gradually disappear from Ecuadorian waters in a span of three years, announced the Subsecretariat of Fisheries Resources (SRP).

"The primary target of this measure is to protect the future of bioaquatic resources in the zone where those vessels operate, explained the head of the SRP, Guillermo Moran.

"What the national government is looking for is the application of ordinance policies that guarantee responsible fishing and respect for the species and their habitats, the official contended.

"In addition, the executive branch plans on funding the scrapping of the fleet, investing USD 40 million in fishing gear, purchasing vessels and re-training, among other things, he indicated.

Later in the story we read, "The state will buy the trawl fishing vessels and sink them," Moran disclosed (see Figure 5). This scenario is being played out in other fisheries and in other countries resulting in huge social costs and a squandering of tangible resources. It would be far better to use these fishing assets in other more sustainable activities, such as offshore aquaculture.

The re-use of such fishing trawlers as aquaculture service vessels is simple enough to conceptualize but required the right grow-out systems and the proper incentives. For example, utilizing small to modest size cages (200–500 m³) and low-volume, high-density culture methods, a strong case can be made.

Figure 5. A typical Ecuadorian trawler.

Figure 6. Micopods™ in Panama.

Figure 6 shows a cluster of recently assembled and launched Aquapods in Panama. There are two sizes in the figure: one 225-m^3 cage in the foreground and two 115-m^3 cages in the background.

These cages offer both a convenient size and a level of robustness that enables whole-cage harvesting, eliminating one of the most vexing problems in cage based fish farming, that of partial harvest.

In Figures 7 a–c, the concept of the repurposing of a trawler to handle such cages is portrayed.

Conclusions

The key to reducing fisheries/aquaculture conflicts is to bring fishermen into the aquaculture sector so they can directly profit from it. This will be possible if that form of aquaculture values their knowledge and skills and allows them to utilize their investment in operational assets.

Through the use of existing and emerging offshore aquaculture technologies, we can unite the sectors and demonstrate that seafood production can be ramped up, providing high-quality protein to the world's population and offering solid economic opportunities to both fishermen and fish farmers and the coastal communities that depend on them.

Figure 7a. The Aquapod is secured to a robust A-frame using the five bridles from its single-point mooring.

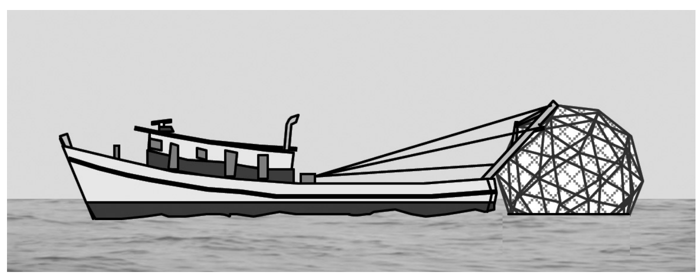

Figure 7b. Tight to the A-frame, the cage is pivoted over the deck of the service vessel.

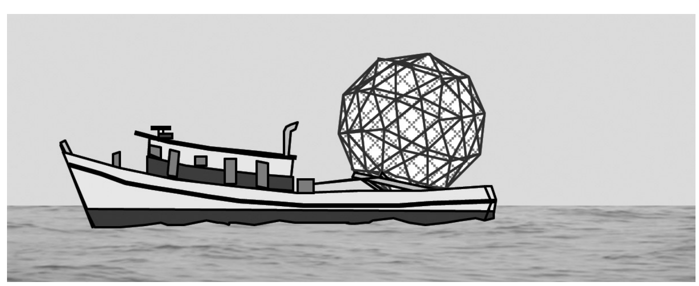

Figure 7c. Secured over the deck, the stock is emptied into the hold, the cage is pressure washed, re-stocked, and re-deployed.

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Goudey, C.A. 1998. Model tests and operational optimization of a self-propelled open-ocean fish farm. Proceedings Offshore Technologies for Aquaculture, A. Biran. Haifa, ed. Israel.

This paper describes scale-model tests of a self-propelled sea cage conducted at the U.S. Navy's David Taylor Model Basin. Test results include cage speed vs. power and drifting behavior vs. sea state. Performance predictions are discussed including maneuverability and the energy implications of intermittent powering in predictable ocean currents.

Smolowitz, R., C.A. Goudey, S. Hendriksen, E. Welch, K. Riaf, P. Hoaglund, H. Kite-Powell, and D. Leavitt. 1998. Sea scallop enhancing and sustainable harvesting, the seastead project. Report from Westport Scalloping Corp. to NOAA Award No. 66FD0027.

This report presents the findings of a two-year project aimed at evaluating the idea of sea scallop culture in an offshore setting. The SeaStead project was conducted in a 9 square mile area south of Martha's Vineyard, Massachusetts. It became the first commercial aquaculture operation in U.S. federal waters. Culture experiments included suspended cage culture, bottom cage culture, and bottom seeding. The growth results and economic potentials of each method are compared. The project was responsible for the identification of large scallop sets in the New England groundfish closed areas, which resulted in the development of rotational management schemes for that fishery.

A Comparison of Salmon Hatchery Programs in Alaska and Japan

William R. Heard
NOAA/NMFS Alaska Fisheries Science Center
Auke Bay Laboratories
17109 Pt. Lena Loop Road
Juneau, Alaska 99801
bill.heard at noaa.gov

Keywords: salmon hatcheries, fisheries, Japan, Alaska

Abstract

Japan and Alaska have two of the largest and most developed Pacific Rim salmon *Oncorhynchus spp.* hatchery programs. These programs vary considerably in complexity with diverse objectives and operational procedures but still have many similarities. Alaska's modern salmon hatchery system started in the 1970s and grew out of depressed fisheries that reached record low harvest levels. At the same time a century old Japanese salmon hatchery system was undergoing dramatic improvements in performance with record high marine survivals of young salmon, increased releases of up to 2 billion juveniles per year, and returns of adult chum salmon ranging from 40 to 60 million fish annually. These impressive results caught the attention of emerging Alaska salmon hatcheries, consequently, considerable Japanese influence is found within the Alaska salmon hatchery system. Similarities between the two systems involve hatcheries operated by private fishermen groups where salmon catches are taxed under a user-pay system to help defray cost of hatchery operations. Both systems focus on pink or chum salmon production and utilize extensive short-term rearing of fry to improve marine survival.

Important exchanges between Japanese and Alaska scientists, fishermen, and industry helped forge some of these similarities in the two hatchery programs. There also are differences between salmon fisheries in the two countries. Commercial salmon fisheries in Japan are largely dependent on hatcheries while Alaska fisheries depend on a careful balance between wild and hatchery production.

Introduction

Japan and Alaska have two highly successful hatchery programs for Pacific salmon *Oncorhynchus spp*. These two programs while varying considerably in complexity with diverse objectives and operational procedures still have many similarities in common. This report briefly examines certain aspects of these systems with a focus on the similarities along with some of the differences between hatchery programs and salmon fisheries in the two countries.

Similarities in the two systems include primary operation of hatcheries by groups of fishermen, prefectural fisherman cooperatives in Japan (Nasaka 1988) and regional aquaculture associations in Alaska (McGee 2004). In both countries commercial salmon catches are taxed under a use-pay system to help defray the cost of operating hatcheries. A large portion of salmon hatchery production in both countries is focused on pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon and both countries utilize various methods for short-term rearing of fry of these species to improve marine survival. In Japan additional hatchery programs involves cherry (*O. masu*) salmon and a limited amount of sockeye (*O. nerka*) salmon hatchery production. In Alaska additional hatchery production is focused on sockeye, coho (*O. kisutch*) and Chinook (*O. tshawytscha*) salmon.

While there are many similarities between hatchery programs and commercial salmon fisheries in Japan and Alaska, there also are significant differences. Japan's salmon fisheries are largely dependent on hatchery production. Many wild or native populations in Japan have been severely reduced or eliminated with weirs across the stream mouth (for collecting hatchery brood) and widespread egg transplants between hatcheries and fry plants in different streams. More recently, however, Japanese scientists have begun programs to reestablish self–perpetuating natural runs of salmon and to reexamine potential roles of natural production in some rivers (Kaeriyama and Urawa 1992, Morita et al. 2006, Miyakoshi et al. 2009).

In contrast Alaska's salmon production is based on a structured balance between wild and hatchery production with a priority focus given to protecting and maintaining wild stocks (Heard et al. 1995, Homes and Bukett 1996, Heard 2003, McGee 2004, Smoker and Heard 2007). Many Alaska hatcheries are located on non-anadromous streams or water sources and egg transfers are limited to local hatcheries within a limited region where brood stocks originate from wild stocks in the same region.

Most commercial fisheries for pink or chum salmon in Japan utilize coastal trap nets operated by prefectural cooperatives while Alaska fisheries utilize a wide variety of commercial gear types including drift gill nets, set gill nets, purse seines, troll, and in a few instances fish wheels on large rivers.

Hatcheries in Japan and Alaska

Japanese salmon hatcheries have had a long history with a significant milestone occurring with development of the national Chitose Salmon Hatchery on a tributary of the Ishikari River in Hokkaido in the late 1880s (Moberly and Lium 1977, Kobayashi 1980, Kaeriyama 1989). Over much of the next century, many private and a few public hatcheries were built on Hokkaido with lesser numbers being built on northern Honshu. During much of this period, especially between 1900 and 1970, the average number of adult chum salmon returning to Japan remained at about 3 million fish per year (Kobayashi 1980, Kaeriyama and Urawa 1992).

Beginning in the 1970s, however, average return rates of released juvenile chum salmon in Hokkaido began increasing significantly from around 1 percent or less to more than 2 percent. This increase in return rates was occurring concomitantly with rapid increases in the numbers of juvenile chum salmon released from hatcheries throughout Japan. A consequence of these developments is that by the 1980s and continuing to the present, Japanese salmon hatcheries have been highly successful in releasing around 2 billion juveniles per year with annual harvest of adult chum salmon reaching 40 million to 60 million fish (Kaeriyama and Urawa 1992, NPAFC 2008).

According to Nasaka (1988) there were 148 salmon hatcheries on Hokkaido and 165 hatcheries on Honshu in 1986. The hatcheries on Honshu were all operated by private fisheries cooperatives while those on Hokkaido were a mixture of national government, prefectural government, and private hatcheries. More recently Morita et al. (2006) reported there were 16 national, three prefectural, and 117 private hatcheries on Hokkaido.

Alaska also has a long history of salmon hatcheries, beginning in the late 1800s. Many of these early day Alaska hatcheries ceased to operate by the 1930s for lack of funding support or from failure to successfully demonstrate their effectiveness. The early Alaska hatcheries focused mostly on sockeye salmon that required a more complex freshwater biology than pink or chum salmon. A detailed account (Roppel 1982) reviews many of the political and philosophical issues associated with Alaska salmon hatcheries during this early period.

Modern Alaska hatcheries began in the 1970s after salmon harvest reached record low levels. A program created by the Alaska State Legislature in 1971 was intended to rehabilitate depleted salmon fisheries and indirectly help rebuild depressed runs by taking some fishing pressure off of wild stocks. The Alaska hatchery program was not designed to rehabilitate depressed wild stocks of salmon by supplementing or integrating wild runs with hatchery fish.

A new division within the Alaska Department of Fish and Game (ADF&G), the Fisheries Rehabilitation, Enhancement, and Development (FRED) Division, was charged with developing new hatcheries within a coordinated salmon enhancement program designed to protect wild salmon stocks. To accomplish this lofty goal, policies were put in place that required a rigorous review of potential hatcheries that considered genetics, pathology, location of hatcheries relative to adjacent wild stocks, use of local brood stocks, marking of hatchery fish, and research on basic problems that might limit sound development of hatcheries (Meyers et al. 1988, Davis et al. 1989, Homes and Bukett 1996, McGee 2004).

Additional legislation also authorized the concept of private-non profit (PNP) hatcheries and the formation of regional aquaculture associations. Over the next several years a large hatchery program emerged in Alaska consisting primarily of state and PNP hatcheries, although one federal hatchery is located on the Annette Island Reserve and another experimental federal hatchery is located at a NOAA Fisheries Marine Station. Initially ADF&G operated a number of state hatcheries that have since been contracted to be run by regional aquaculture associations.

Presently there are five active regional aquaculture associations in Alaska operating salmon hatcheries. These include two in the Southeast Alaska region, one each in the Prince William Sound, Cook Inlet and Kodiak regions. Collectively these associations operate 17 hatcheries including several former state hatcheries now under contract to the associations.

Not all PNP hatcheries are required to be part of regional associations. Alaska statutes allow for individuals or small corporations to build and operate hatcheries at specified sites with production levels that are carefully reviewed and approved through detailed regional planning processes with oversight by ADF&G. There are 11 non-association hatcheries in the southeast region, the largest is Douglas Island Pink and Chum (DIPAC) that operates 3 of these 11 hatcheries. There are two non-association PNP hatcheries in other regions plus an ADF&G hatchery complex in the Cook Inlet region. Collectively there are 31 active production salmon hatcheries in Alaska under ADF&G oversight (White 2009).

Since development of the modern salmon hatchery program in Alaska, beginning in 1988 commercial landings of salmon have ranged from 100 million to 221 million fish per year with an average annual harvest of 165 million salmon. Because of the well developed hatchery marking and fishery harvest reporting system, fishery managers in Alaska are able to separate the proportion of the commercial catch from hatchery and wild origins (White 2008). Over the past 21 years the proportion of hatchery-origin fish in the total Alaska commercial salmon catch has ranged from around 15 percent to almost 40 percent (Figure 1).

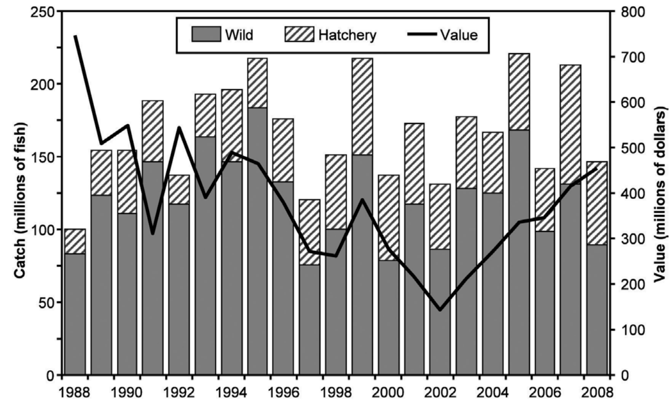

Figure 1. Total number of commercially caught Alaska wild and hatchery salmon and ex-vessel value of catch, 1988–2008.

Japanese Influence on Alaska Hatcheries

The coincidental timing of two important factors had a significant influence on salmon hatchery development in Alaska. These two factors include the sharp and sudden improvement in return rates of juvenile chum salmon released from Japanese hatcheries occurring at the same time Alaska was beginning to develop its own hatchery program. The successes of Japanese hatcheries, including impressive returns of chum salmon, caught the attention of Alaskans charged with planning and developing policy for hatcheries. Several important visits and exchanges between Japanese and Alaska scientist and policy people, including some through auspices of U.S. Japan Cooperative Program in Natural Resources, occurred during this period.

One visit occurred in the spring of 1976 when an ADF&G biologist and engineer visited 15 hatcheries on Hokkaido and 5 on Honshu, taking notes on all biological aspects, engineering specifics, and equipment used in each hatchery (Moberly and Lium 1977). Another visit occurred in 1982 when four Alaskans under auspices of then Gov. Jay Hammond's Fishery Council attended the 11th UJNR Meeting on Salmon Enhancement. The four Alaskans included the Governor's chief of staff, a commercial fisherman, and two fishery scientists. They participated in the two-day UJNR Symposium in Tokyo, then a 7-day UJNR field trip that involved 18 visits to different hatcheries, other facilities, or specific groups on Hokkaido and Honshu.

From 1992–1994 another ADF&G scientist spent parts of 3 years in Japan learning the language while working and visiting at several Hokkaido salmon hatcheries and fishery offices. He documented details of these visits that included many informal discussions with staff from federal, prefectural, local cooperatives, trading companies, processors, and academic institutions. This dedicated effort successfully provided Alaska with a broad generalized understanding and appreciation of Japanese salmon hatchery programs and commercial salmon fisheries.

In 1993 the 22nd UJNR annual meeting was held in Alaska. The program included a 10-day agenda with plenary sessions and symposia in Homer and Seward along with field trips to hatcheries and other fisheries facilities in the Southcentral part of the state. Theme of the symposium, Interactions Between Cultured Species and Natural Occurring Species in the Environment, along with field trip visits to facilities, provided both U. S. and Japanese participants with the opportunity to hear and see first hand many of the key issues, both positive and negative, about Alaska's salmon hatcheries and enhancement programs. There were many exchanges and viewpoints discussed about similarities and differences between Japanese and Alaska hatchery systems during this meeting.

Discussion

Over the past three decades the annual numbers of juvenile salmon originating from hatcheries that are released into North Pacific Rim waters have increased significantly. The estimated numbers of released juveniles increased from 2.3 billion in 1976 (McNeil 1979) to 4.4 billion in 1985 (McNeil 1988). Heard (1995) estimated the number had increased to 5.5 billion by 1992 and recommended the North Pacific Anadromous Fish Commission (NPAFC) initiate protocols to provide annual documented updates of these releases. The NPAFC Secretariat now provides estimates of juveniles released in reports of its annual meetings. In 2008 estimated releases of juvenile salmon was 5.1 billion with roughly 70% originating from hatcheries in Japan and Alaska (Table 1).

In 2007 the commercial catch of salmon around the

Table 1. 2008 Pacific Rim hatchery releases of salmon fry and smolts[1]

	Sockeye	Pink	Chum	Coho	Chinook	Cherry	TOTAL
Canada	219.66	2.15	81.64	10.62	37.56	—	371.58
Japan	0.37	141.81	1,890.49	—	—	13.72	2,046.39
Korea	—	—	16.55	—	—	0.02	16.57
Russia	10.30	401.03	598.33	4.99	0.78	1.63	927.06
US	66.12	823.33	603.61	67.24	198.41	—	1,758.71
(Alaska)	60.40	822.80	567.50	24.70	11.40	—	1,486.80
(WOCI[2])	5.27	0.53	36.11	42.54	187.01	—	271.91
TOTAL	296.49	1,388.32	3,100.61	82.84	236.75	15.37	5,120.30

[1] From NPAFC, 2009
[2] Washington, Oregon, California, and Idaho

Table 2. 2007 Pacific Rim commercial salmon catch in tons[1]

	Sockeye	Pink	Chum	Coho	Chinook	Cherry	TOTAL
Canada	1,760	11,197	4,861	812	1,324	—	19,954
Japan	1	21,380	198,260	16	45	1,133	220,835
Korea	—	—	146	—	—	—	146
Russia	30,082	259,829	54,272	3,711	801	11	348,706
US	126,800	228,993	59,201	11,290	5,000	—	431,283
(Alaska)	126,800	228,991	59,201	11,130	3,916	—	430,038
(WOCI[2])	—	1	—	161	1,084	—	1,246
TOTAL	158,642	521,399	316,740	15,829	7,169	1,144	1,020,923

[1] From NPAFC, 2008
[2] Washington, Oregon, California, and Idaho

Pacific Rim exceeded 1 million tons for the first time in history (Table 2). The catch from Alaska and Japan accounted for two-thirds of this amount. In Japan 90% of the harvest was chum salmon, presumably originating from hatcheries, while chum salmon represented only 14% of the total Alaska salmon harvest in 2007 with 67% of this amount originating from hatcheries. In 2007 pink salmon represented 53% by weight of the total commercial Alaska catch, with 43% of this amount originating from hatcheries.

Nasaka (1988) indicated Japanese programs emphasize collecting eggs from the early portion of runs while the skin color of hatchery chum salmon remains silver bright. Salmon derived from these eggs tend to return early producing bright fish which are preferred by consumers, therefore, variable market demands for different qualities of hatchery salmon can influence hatchery practices and policies. More recent anecdotal reports suggest many late run mature (darker) Japanese chum salmon are sold to China for economic consideration along with the increased Japanese preference for bright early run fish. For the most part Alaska hatcheries attempt to maintain the run timing of their brood stocks by collecting eggs proportionally from throughout the returning runs.

Regarding consumer preferences and economics related to either hatchery or wild salmon fisheries, many factors can influence market demand. Kaeyriyama and Urawa (1992) reported on instability in markets relating to oversupply and lower quality of chum salmon causing prices to drop by more than 20% in one year. The ex-vessel value of commercially caught Alaska salmon over the past 2 decades has fluctuated greatly with little or no correlation between the amount of salmon caught and the resulting value of the catch. A sharp decline in value of the Alaska salmon catch beginning in 1989 and continuing through 2002 occurred during periods when catches averaged 169 million salmon per year (Figure 1).

Although many factors can influence the economic viability of salmon fisheries, and indirectly hatchery programs in both Japan and Alaska, none likely are more significant than worldwide production of farmed salmon. Farmed salmon production has steadily increased since mid-1980s, reaching 1.5 million tons in 2007 (Figure 2). Farmed salmon production has exceeded capture fisheries for wild and hatchery salmon ever year since 2000 and shows no indication of slowing down.

Undoubtedly this trend in farmed salmon production will continue to influence hatchery practices and programs in both Japan and Alaska together with other important issues, including ocean carrying capacity for salmon and concern over potential detrimental interactions between hatchery and wild stocks.

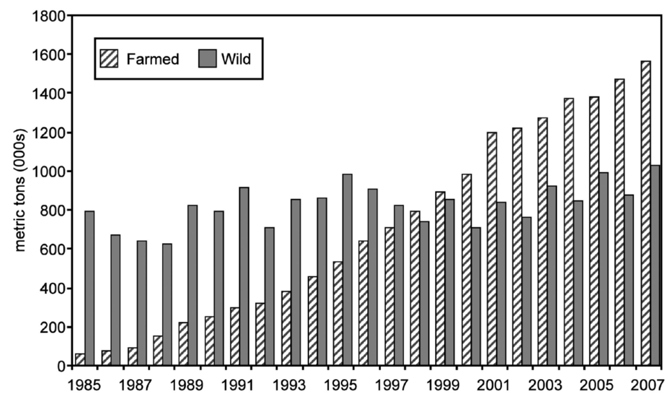

Figure 2. Total world supplies of farmed salmon and salmon caught in wild capture fisheries, 1985–2007.

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Annotated Biblography of Key Works

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. Physiol. Ecol. Japan, Spec. Vol. 1. 625–638.

The author reviews the origins and history of the development of Japan's current salmon hatchery program and the fisheries that harvest these fish. The first large scale salmon hatchery system in Japan began in 1888 when the national Chitose Central Salmon Hatchery was established on a tributary of the Ishikari River in Hokkaido. After this many other hatcheries were built and the numbers of juvenile chum salmon released increased significantly. From the late 1800s to 1970s annual catches of chum salmon in Japan ranged from 1 to 5 million and averaged about 3 million fish. Since 1971 annual catches have increased exponentially to 30 million fish as a result of increased hatchery efficiency and new technology combined with intensive scientific research. The key factor in this dramatic change in success of the Japan's salmon hatcheries was development of a post-emergent fry feeding program whereby fingerlings are fed in hatcheries to a size greater than 5 cm in fork length and allowed to migrate seaward when sea temperatures and salinities are favorable for rapid growth to a post-fingerling stage. The author carefully reviews migration and release patterns of juvenile chum salmon along with the return rates for numbers of adult returns for different regions of Hokkaido and Honshu. Size and timing for optimal juvenile releases varies according to different regions associated with prevailing sea conditions in each region.

Kaeriyama, M., and S. Urawa. 1992. Future research by the Hokkaido Salmon Hatchery for the proper maintenance of Japanese salmonid stocks. Y. Ishida, Y. K. Nagasawa, D. Welch, K. W. Myers, and A. Shershnev (eds.). Proceedings of the International Workshop on Future Salmon Research in the North Pacific Ocean. pp. 57–62. Special Pub. Nat. Res. Inst. Far. Seas Fisheries. 20. Shimizu, Japan.

These authors review how the dramatic successes in hatchery technologies have caused exponential increases in Japanese chum salmon stocks in recent decades. However, these successes in the Japanese salmonid enhancement program have raised new questions including density-dependent effects on decrease in body size of chum salmon, dependence on intensive hatchery production of chum salmon with loss of wild or native populations, and economics of lower prices paid to fishermen due to increased supplies of salmon in markets. Japanese consumers expect a high quality product such as fatty chum salmon (bright, early run fish), and because of lower quality (darker, late run fish) price of returning chum salmon dropped by more than 20% in one year. Many native chum salmon populations in Japan have been eliminated by the extensive hatchery program caused, in part, by egg transplants between hatcheries. Other effects include changes in run timing and reduction in genetic variability due to artificial selection in hatcheries. The authors propose a number of new research strategies for Japan and elsewhere to begin addressing these problems.

McGee, S. 2004. Salmon hatcheries in Alaska–Plans, permits, and policies designed to provide protection for wild stocks. Am. Fish. Soc. Symposium 44:317–331.

The author provides a detailed overview of development of modern salmon hatcheries in Alaska that began in the 1970s to rehabilitate depleted salmon fisheries. This program was designed to protect Alaska's wild salmon stocks through a rigorous permitting process that considers genetics, pathology, management reviews, policies with priorities given to wild stocks, requiring hatcheries to be located away from significant wild stocks, use of local brood stocks, requirements for marking hatchery fish, and studies on hatchery-wild stock interactions. The author reviews specific Alaska statutes and regulations that provide oversight for these hatcheries. Details of the planning and permitting process are reviewed that includes steps taken to determine production limits by species for individual hatcheries. The program is comprised of state, federal, and private non-profit (PNP) hatcheries with most hatcheries operated by PNP regional aquaculture associations. In 2002 hatcheries accounted for 22% of the salmon harvested commercially in Alaska. Alaska hatcheries produce approximately 1.5 billion juvenile salmon annually, the majority of which are pink and chum salmon. Potential impacts of hatchery salmon on wild salmon stocks is a contentious and debated issues in Alaska. Interaction between hatchery salmon and relatively smaller populations of wild salmon are unavoidable, however, obvious adverse impacts from hatcheries on wild salmon are not evident.

White, B. 2009. Alaska salmon enhancement program 2008 annual report. Alaska Dept. Fish and Game, Fishery Management Rep. 09-08. Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, 99518. 47 p.

This document summarizes results of the 2008 salmon enhancement program in Alaska. A total of 39 tables and 4 figures cover details of egg takes, released juveniles, and total returns attributed to each Alaska hatchery and enhancement project in 2008. The data provided includes adult salmon caught by species in common property and cost recovery fisheries along with brood stock numbers and escapements for each of the four major hatchery regions in the state (Southeast, Prince William Sound, Cook Inlet, Kodiak). In 2008 1.4 billion juvenile salmon were released from Alaska hatcheries, mostly pink and chum salmon. There were 133 million salmon caught in the common property commercial fishery and an estimated 45 million or 34 % were produced by the salmon enhancement program. Enhanced salmon provided an estimated $110 million or 29% of the exvessel value of the commercial common property harvest. PNP hatcheries recover their operational cost from a special harvest of returning adult fish called a cost recovery harvest. This salmon enhancement program (ocean ranching of salmon) employs hundreds of Alaskans in seasonal and full time employment and is the largest agricultural industry in Alaska.

Stock Enhancement Programs of a Fisheries Cooperative on a Brackish Lake in Japan

Satoshi Katayama
National Research Institute of Fisheries Science
Nagai, Yokosuka
Kanagawa 238-0316, Japan
skata at affrc.go.jp

Keywords: Brackish clam, pond smelt, glassfish, Lake Ogawara

Abstract

Lake Ogawara is a brackish water lake located on the Pacific side of northernmost Honshu, Japan that covers an area of 63.3 km². The northern section of the lake is connected to the Pacific Ocean by a 6 km-long river, through which sea water is brought into the lake by tidal flow, making the lake somewhat salty, 0.8–1.0 ppt. Harvest of pond smelt, (*Hypomesus nipponensis*), glassfish, (*Salangichthys microdon*), and the brackish clam, (*Corbicula japonica*), between 2002 and 2006 averaged 445, 420, and 2,156 tons per year, respectively.

Active stock enhancement has been conducted for the clam. Because the clam requires brackish water at the egg and the larval stages, the juveniles are distributed exclusively in the north part of the lake. A fisheries cooperative on the lake intensively carries out transplantation of the clam from the nursery ground (north) to the productive fishing ground (south).

For stock enhancement of the fishes, the fisheries cooperative employs two strategies based on intensive ecological surveys. One is the closed season for fishing during the spawning seasons, and another is lake preserves in the spawning areas. The latter is particularly important because the fish spawning grounds overlap the fishing ground for clam digging.

Environmental characteristics of the lake are related to life histories of the species, for example, oligosaline conditions are essential for ontogenetic development of the clam. Parts of the populations of pond smelt and glassfish display anadromous migrations through the out-flowing river, and a part of the pond smelt population spawns in the inflowing river. Fishermen have strong consciousness of the environments not only of the lake, but also adjacent areas. The cooperative leads local administration in environmental protection of the lake. Introductions from other habitats have not been carried out. The cooperative, however, maintains high fisheries production through efficient fisheries management.

Introduction

The objectives of fisheries management are to maximize yield and maintain a minimum spawning stock. Because fishing efforts tend to increase through competition among fishermen, the cooperation of fishermen is essential to conduct fisheries management and implement regulations. Also, such stock enhancement actions as hatchery-releases, transplantation, and conservation of fishing and nursery grounds need the cooperation of fishermen. This paper introduces several strategies of fisheries management by fishermen and a fisheries cooperative association on a brackish lake in Japan.

Lake Ogawara

Lake Ogawara is a brackish water lake located on the Pacific side of northernmost Honshu, Japan, and covers an area of 63.3 km² (Figure 1). The northern section of the lake is connected to the Pacific Ocean by a 6 km-long river. Sea water enters the lake by tidal flow, making the lake somewhat salty, 0.8–1.0 ppt throughout the year. The chemocline lies at 15 m, separating the circulation between surface and deep layers (Kawasaki and Ito 1995). The occurrence of oxygen depleted water in the deep layer has become a serious problem in recent years.

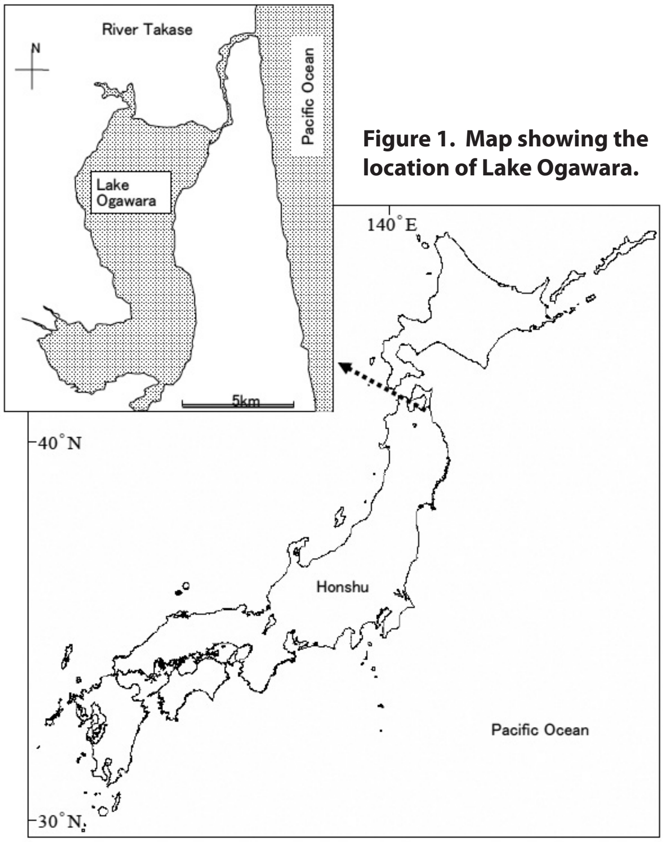

Figure 1. Map showing the location of Lake Ogawara.

Only one fisheries cooperative regulates the work of about 400 fishermen. Average harvests of the brackish clam, (*Corbicula japonica)*; pond smelt, (*Hypomesus nipponensis)*; and glassfish, (*Salangichthys microdon)*, between 2002 and 2006 were 2,046, 445, and 420 metric tons a year, respectively. The production of fisheries resources in Lake Ogawara accounts for a high proportion of each of the species named, in Japan.

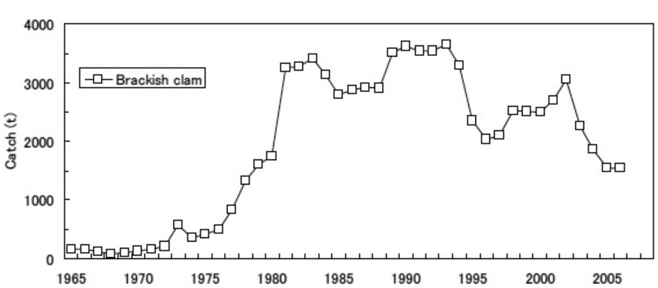

Figure 2. Change in fisheries catch (tons) of brackish clam Corbicula japonica in Lake Ogawara.

Data: Fishery statistics of Japan, Statistics and Information Department, Ministry of Agr. Fore. and Fish., Japan.

Brackish clam

This clam inhabits estuaries and brackish lakes. It is widely distributed in Sakhalin, the Korean peninsula, and the Japanese Archipelago. This clam hatches around June, grows to 15 mm shell length, and matures in two or three years. Commercial harvest by digging rose remarkably in 1970s (Figure 2) due to increased fishing effort. Harvest stabilized at more than 3,000 tons until mid-1990s. Since then it has fluctuated and has now declined to around 2,000 tons.

A stock enhancement strategy has been employed for the clam. It is known that oligosaline conditions are essential for ontogenetic development of the larval stages. After settlement, it needs low salinity for eutrophic conditions to grow. The juveniles are distributed exclusively in the salty north part of the lake, because the clam requires brackish water at the egg and the larval stages. Otherwise, the clam rapidly grows in the south part of the lake where it is eutrophic, providing high biological productivity for growth of the clams.

The fisheries cooperative on the lake has intensively carried out transplantation of young clams from the nursery ground (north) to the fishing ground (south). The transplantation contributed to the maintenance of high fisheries production until the mid-1990s. The catch then declined due to deterioration of the limnological conditions.

Pond smelt and glassfish

The pond smelt is a euryhaline fish that inhabits fresh, brackish, and coastal waters throughout the Japanese archipelago (Hamada 1961, Saruwatari et al. 1997). The phenotypic plasticity of pond smelt is the major driving force in the highly successful artificial propagation of the species in the Japanese Archipelago. Eyed eggs have been transplanted into numerous lakes, ponds, and reservoirs throughout Japan, but Lake Ogawara has never received egg transplantation from other areas.

Glassfish inhabit waters of various salinities from the Japanese Archipelago to Sakhalin, Pusan to Vladivostok (Uyeno and Aizaki 1984.). The species is an annual fish with a small, slender, translucent body approximately 10 cm long. Egg transplantation has been carried out due to its fragility.

Fisheries for pond smelt and glassfish are conducted mainly with purse seines. Commercial catches of them had increased until early 1980s. After the mid-1980s, the catches fluctuated synchronously in relation to the limnological conditions. Significant drops in production occurred during some years (Figure 3).

To develop strategies for management of the fisheries, I worked with the cooperative and examined the relationship between life history and the lake environment. We analyzed migration patterns using the strontium calcium ratio in otoliths (Katayama et al. 2000, 2008). Typical Sr/Ca ratio profiles from the core to the edge of otoltith are shown in Figure 4. The profiles are constructed in relation to back-calculated standard body length. A high ratio means that the fish lived in the saline environment. For both species, there were two patterns; the first is stable at a low level for the entire time series, indicating a resident form. The second displays a dramatic increase and maintains that high level. That was called the anadromous form. I detected the evidence of coexistence of residence and anadromy of pond smelt and glassfish within Lake Ogawara through otolith analyses. Based on these results, we recommend a secure means of the migration for the fish between the lake and the sea.

The fishermen and I worked together to find the spawning grounds of the fishes (Katayama 2001, Sakaki et al. 2008). We discovered their adhesive eggs on the surface of gravel in the shallow water areas (Figure 5). The spawning grounds of pond smelt were found not only in the lake but also in the inflowing river. We told the fisheries cooperative about the river spawning grounds and asked them not to exploit the river.

The spawning grounds of pond smelt and glassfish in the shallow water areas in the lake overlapped with the clam fishing ground. The fisheries cooperative coordinated a discussion among the fishermen, set a closed season for digging clams during the fish spawning, and established preserves of the spawning areas.

Current problems

In recent years the catches of clams, pond smelt and glassfish have become unstable and decreased suddenly. This phenomenon could be affected by the spread of oxygen-depleted water and the exceedingly eutrophic conditions.

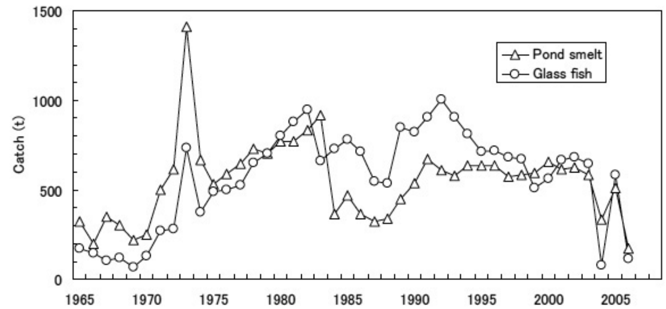

Figure 3. Change in fisheries catches (tons) of pond smelt (*Hypomesus nipponensis*), and glassfish (*Salangichthys microdon*) in Lake Ogawara.

Data: Fishery statistics of Japan, Statistics and Information Department, Ministry of Agr. Fore. and Fish., Japan.

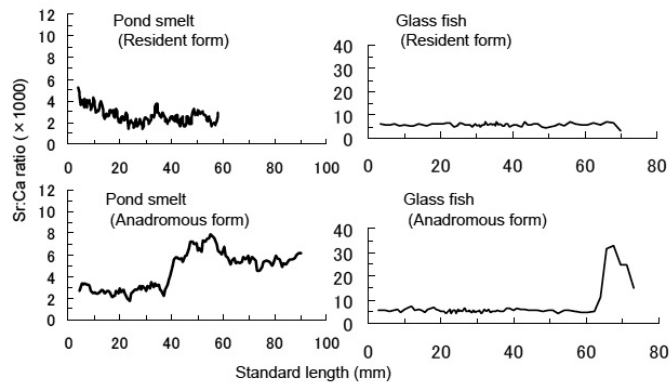

Figure 4. Sr/Ca ratio profiles from otoliths of pond smelt and glass fish.

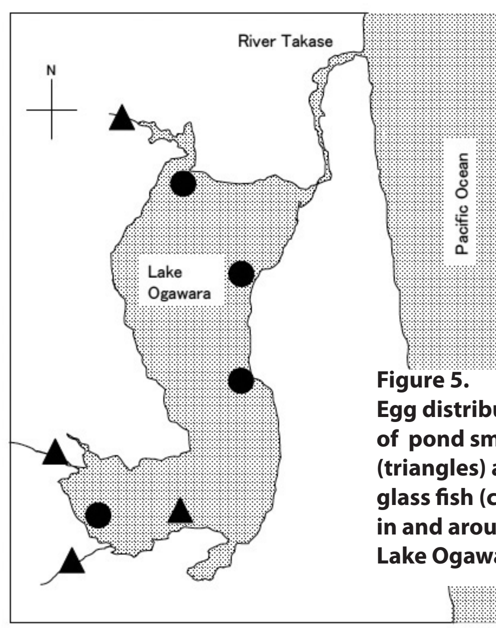

Figure 5. Egg distributions of pond smelt (triangles) and glass fish (circles) in and around Lake Ogawara.

The fishermen have a strong environmental ethic associated with the lake and adjacent areas. The cooperative leads the way in environmental protection of the lake and sets the agenda for environmental preservation of fisheries in Lake Ogawara. Members examine data on water quality and water budget, assess the environmental conditions, and discuss further management strategies.

All the programs mentioned above are based on actions of the fishermen and the cooperative. It is fortunate that one cooperative regulates the entire fisheries that are undertaken in the lake. Beside that, stable income from stable catches induce support for fisheries management. Introductions of animals from other habitats have not been carried out. Fisheries management of the lake is conducted with guidance from fisheries scientists.

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Annotated Bibliography of Key Works

Katayama, S., R.L. Radtke, M. Omori, and D.S. Shafer. 2000. Coexistence of anadromous and resident life history styles of pond smelt, *Hypomesus nipponensis*, in Lake Ogawara, Japan, as determined by analyses of otolith structure and strontium:calcium ratios. Env. Biol. Fishes, 58(2):195–201.

Anadromous and resident forms of pond smelt, (*Hypomesus nipponensis)*, were found to occur in sympatry in Lake Ogawara, Japan. Profiles of Sr/Ca ratios from individuals could be grouped to two patterns (1) a 'resident' pattern with low Sr/Ca ratios from core to edge and (2) an 'anadromous' pattern with relatively low Sr/Ca ratios near the core with abrupt increases in ratios at a location approximately 0.3 mm from the core. Spawners smaller than 60 mm standard length (SL) were resident, between 60 to 80 mm were mixed resident and anadromous, and larger than 80 mm were anadromous. Anadromous individuals first migrated after 40 to 82 days from hatching (mean ± sd, 59.1 ± 13.5 d) and 14.6 to 30.9 mm SL (22.2 ± 5.3 mm). There was no difference in SL between resident and anadromous individuals during age at first migration, suggesting that size may not be the mechanism for divergence of alternative life history styles.

Katayama, S. 2001. Spawning grounds and reproductive traits of anadromous and resident pond smelt, (*Hypomesus nipponensis)*, in Lake Ogawara, Japan. Fish. Sci. 67(3):401–407.

The objective of this study was to reveal the spawning grounds and reproductive characteristics of anadromous and resident pond smelt, (*Hypomesus nipponensis)*, coexisting in Lake Ogawara. Life history styles of females shedding in spawning grounds in the lake and its inflowing rivers were differentiated by otolith increment analysis. Size, dry weight, and water content of mature oocytes and fecundity of fish were compared between resident and anadromous fish. Both anadromous and resident fish spawned in the lake. In contrast, no resident fish were found in any of the inflowing rivers, where only anadromous fish spawned. Regression of fecundity against standard length was discontinuous with an inflection point at 63.8 mm, which is the body size that differentiates large anadromous spawning groups from small resident spawning groups. Mean oocyte diameters were not significantly different between resident and anadromous fish. The eggs of resident fish had significantly more water content and a significantly lower dry weight than those of anadromous fish. These differences might influence the growth and developmental processes of progeny.

Katayama, S., M. Sakaki, A. Tsurugasaki, and K. Numabe. 2008. Anadromous migrants shirauo (*Salangichthys microdon)*, in Lake Ogawara, as determined by otolith microchemistry analysis. Aquaculture Sci. 56(1):121–126.

To reveal the life history pattern of shirauo, (*Salangichthys microdon)*, in Lake Ogawara, we examined otolith Sr/Ca ratios in individuals from Lake Ogawara (n = 12) and its tributary, the Takase River (n = 6). Sr/Ca ratios were observed in two types of patterns: a resident pattern with low Sr/Ca ratio from core to edge, and an anadromous pattern with abrupt increases in Sr/Ca ratio. Back-calculated total lengths at the time of seaward migrations of anadromous individuals were 63.4mm–67.7mm for 5 specimens from the river, and 36.8mm-63.8mm for 3 from the lake. These findings suggest there is a wide variation in life history for shirauo, and that residents and anadromous migrants live together in the lake.

Sakaki, M., S. Katayama, A. Tsurugasaki, and K. Numabe. 2008. Spawning ground of shirauo (*Salangichthys microdon)*, in Lake Ogawara, Northern Honshu, Japan. Aquaculture Sci. 56 (1):139–140.

Spawning grounds of shirauo (*Salangichthys microdon)* were found in Lake Ogawara through an intensive survey of the distribution of eggs laid on the sandy bottom. Based on the presence and status of the sampled eggs, it was estimated that the shirauo spawned in shallow (≈ 1 m) water depths from mid-May to late June. By identifying important spawning areas, our results provide valuable information for protection of the spawning stock.

Komaru, A., K. Onouchi, Y. Yanase, T. Narita, and T. Otake, 2009. Shell strontium/calcium ratios of *Corbicula japonica* collected from brackish area with different salinity. Nippon Suisan Gakkaishi, 75(3): 443–450.

To establish a method to estimate habitat salinity of brackish clams (*Corbicula* spp.), we examined the strontium (Sr) to calcium (Ca) ratios of *C. japonica* collected from lakes with different salinity and that of a freshwater species *C. leana* with an electron probe micro analyzer (EPMA). Sr/Ca ratios in the shell of *C. japonica* from Lake Ogawara, Aomori Pref. (salinity: 0.2–1.7 psu), Lake Shinji. Shimane Pref. (3.3–15.2 psu), Lake Jinzai, Shimane Pref. (7.5–32 psu), IN River, Gifu and fresh water species *C. leana* from Hatahoko River, Iki Island, Fukuoka Pref. *C. japonica* collected from high salinity lakes showed high shell Sr/Ca ratios: 8.06 ± 0.30 from Lake Jinzai and 6.84 ± 0.21 from Lake Shinji, respectively. To the contrary, *C. japonica* from low salinity Lake Ogawara and IN River showed low Sr/Ca ratios: 3.68 ± 0.18 and 1.33 +/- 0.14, respectively. The fresh water species *C. leana* also showed low Sr/Ca ratio (1.65 ± 0.11). Thus, habitat salinity of *Corbicula* species can be roughly estimated by Sr/Ca analysis using EPMA, and such information may be useful in the determination of place of origin.

Enhancement of Texas Sciaenids (Red Drum and Spotted Seatrout)

Robert R. Vega
Texas Parks & Wildlife Department
4200 Smith School Road
Austin, TX 78744-3291
robert.vega at tpwd.state.tx.us

William H. Neill
Dept. Wildlife & Fisheries Sciences
Texas A&M University
2258 TAMUS
College Station, TX 77843-2258

John R. Gold
Center for Biosystematics and Biodiversity
Texas A&M University
2258 TAMUS
College Station, Texas 77843-2258

Michael S. Ray
Texas Parks & Wildlife Department
4200 Smith School Road
Austin, TX 78744-3291

ABSTRACT

Recreational fishing for two estuary-dependent sciaenids, the red drum (*Sciaenops ocellatus*) and the spotted seatrout (*Cynoscion nebulosus*), is of vital importance to the economies of Texas coastal communities. The Texas saltwater recreational fishery, with about 1.2 million fishermen, is presently worth $2 billion per year; of that total economic value, the recreational fisheries for red drum and spotted seatrout–the two major targeted species–are worth $350 million and $220 million, respectively.

In the 1970s, apparent abundance of red drum in Texas waters reached alarming lows. Stocking red drum fingerlings to enhance the wild population was initiated in 1975, with a large-scale stocking program coming online in 1983. To date, more than 600 million red drum fingerlings have been hatchery-produced and then released into Texas coastal bays. At least partly as a consequence of this enhancement effort, the red drum bay population in Texas waters now has rebounded to near-record highs. Estimates of the contribution made by stocked hatchery fish to total red drum numbers in Texas bays have ranged from 0 to 30%. It is increasingly apparent that the efficacy of the stock enhancement program varies widely, both from year to year and from bay to bay. But, it is equally evident that overall, the Texas Parks & Wildlife Departments long-term management plan using hatcheries to supplement natural recruitment, in concert with traditional management tools, has played a crucial role in mitigating and countering the decline of the red drum population.

During the past two decades, managers have had to implement increasingly restrictive fishing regulations for spotted seatrout, prompted by evidence of overfishing, including declines in mean size of fish caught by anglers and also in estimated spawning stock biomass. Beginning in 1993, traditional management was complemented by the stocking of hatchery-reared juveniles. Since then, more than 1 million spotted seatrout fingerlings per year have been stocked, with the cumulative total now exceeding 50 million. Currently, the spotted seatrout population is healthy along most of the Texas coast, with management concerns focusing on the middle coast. Evaluation of the success of the seatrout stocking program is on-going, with studies based on the application of genetic markers.

Fishery managers in Texas have taken the often controversial practice of stocking hatchery-produced fish and used it to the apparent benefit of the red drum and spotted seatrout fisheries. In turn, organizations of recreational fishermen have been staunch advocates of the enhancement program, providing not only invaluable political support but also $4 million in direct contributions to operation of the program. The utilization of stocking, combined with traditional management practices, has proven to be a powerful combination in managing Texas natural resources wisely. The objective of this article is to present an overview of Texas' marine stocking program as it has benefited multiple users and stakeholders, including anglers and coastal communities economically impacted by recreational fishing.

Introduction

Recreational fishing is a high-value business in the United States, with a $125 billion impact on the nation's annual economy (DOI 2008). Nearly 60 million anglers generate more than $45 billion in retail sales each year, and support the employment for more than 1 million American workers. Gulf of Mexico recreational fisheries generate $5.4 billion annually in economic benefits. Recreational fishing added 1,000 new jobs a year to the Texas economy from 2001 to 2006 (DOI 2008). Despite the nation's recent economic troubles, recreational fishing has continued to grow. In 2009 fishing license sales rose by 4.7 percent in 12 U.S. states (Florida, Indiana, Kansas, Louisiana, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Oregon, Texas, and Utah) (Southwick Associates 2010). On average, each angler spends $176 a year on fishing tackle and contributes more than $40 annually to conservation via license dollars and excise taxes.

The State of Texas ranks first nationally in numbers of outdoors-related expenditures and associated jobs. Some 2.5 million hunters and anglers spend $3.2 billion annually and support 106,000 jobs in Texas (DOI 2008). Saltwater recreational fishing for two estuary-dependent sciaenids, the red drum (*Sciaenops ocellatus*) and the spotted seatrout (*Cynoscion nebulosus*), is extremely important to the local resource-based economies of Texas coastal communities. The Texas saltwater recreational fishery, with about 1.2 million fishermen, is worth $2 billion annually (Southwick Associates 2007); of that total economic impact, the recreational fisheries for red drum and spotted seatrout–the two major targeted species–accounted for almost two-thirds of the more than 15 million saltwater 'fishing days' by residents and non-residents in 2006 (DOI 2008). Economically, this translates into more than $530 million per year in total expenditures (food, lodging, transportation, equipment, and other trip costs) for these two species.

The state's natural resources conservation agency, the Texas Parks and Wildlife Department (TPWD), has a stated mission to provide hunting, fishing, and outdoor recreation opportunities for the use and enjoyment of present and future generations (TPWD 2010). The agency is funded primarily through hunting and fishing license sales, state park entrance and camping fees, and a dedicated portion of the state sporting goods sales tax. Hunting and fishing license sales have increased slightly in 2009, with a total of about 1.9 million sold, despite a 5 percent increase in their cost and a slumping economy. As the state's human population continues to grow, so do pressures on natural resources and the demands of the public to access those resources. One of the agency's central challenges is to remain relevant in today's society where seemingly each new generation is more urbanized and further removed from the great outdoors (TPWD 2010).

Fishery managers in Texas have used stock enhancement in combination with traditional management practices to manage Texas' natural coastal resources wisely. Texas' marine stocking program has contributed to the recovery of Texas' marine fisheries which has benefited multiple users and stakeholders, including anglers and coastal communities economically impacted by recreational fishing. In turn, organizations of recreational fishermen have been staunch advocates of the enhancement program, providing not only invaluable political support but also $4 million in direct contributions to operation of the program.

Texas' Stock Enhancement Program

Matlock's limited recruitment theory proposes that stocking fish helps to stabilize recruitment by supplementing weak natural year classes, thus mitigating the typical marine scenario of high recruitment in a few years and low recruitment in most years (Matlock et al. 1986). If managers could bypass the high mortality associated with larval recruitment from the nearshore spawning areas into the bays and if subsequently prevailing environmental conditions were favorable for survival, then effective supplementation might be achieved by stocking relatively few red drum directly into estuaries.

TPWD initiated stock enhancement of red drum in the 1980s in response to substantial declines in red drum abundance and recruitment (Matlock 1984, McEachron et al. 1995); today, the program releases between 20 million and 30 million hatchery-raised fingerlings annually into 8 different Texas bays and estuaries (Rutledge and Matlock 1986, McEachron et al. 1998, Vega et al. 2003). Efforts to culture spotted seatrout on a large-scale for the purpose of stock enhancement have been made by TPWD marine fish hatcheries since 1993 (Vega et al. 2003). TPWD routinely utilizes stock enhancement to assist in maintaining natural populations impacted by increased recreational fishing pressure (Vega et al. 2003).

Operation of Texas' Marine Hatcheries

Complete details regarding production of hatchery-raised red drum at three TPWD marine fish hatcheries and release of hatchery fish are described in Colura et al. (1990) and Vega et al. (1995). Topics include broodfish maintenance and spawning, egg collection and incubation, and larval and juvenile rearing strategies involving semi-intensive culture methods. Briefly, the present hatchery system consists of spawning and incubation facilities with 39 ha of production ponds. Red drum broodfish are maintained in 13,000 L circular tanks, in environmentally controlled rooms. Each spawning tank contains 5 to 6 broodfish (3 females and 2 or 3 males) ranging in size from 8 to 18 kg; they are fed shrimp, squid, mackerel, and beef liver. Twenty-five percent of the broodfish are exchanged annually with wild fish to maintain genetic diversity. Broodfish are subjected to a 150–day photoperiod-temperature maturation cycle (Arnold et al. 1977, Roberts et al. 1978, McCarty 1990). Spawning occurs at a water temperature of 24° to 27° C, salinity of 30–38 ppt with 11 hours of light per 24 hour day. On average, 2 million eggs are collected each night from March through November. Eggs are transferred to 945-L incubators where they hatch within 24 hours. Within 36 to 40 hours post hatch, larvae have developed mouthparts, distinct eye pigmentation, and a complete digestive tract. These first-feeding larvae average 2.7 mm total length.

Culture of spotted seatrout for the purpose of stock enhancement has been conducted by TPWD marine fish hatcheries since 1993 (Vega et al. 2003). Spotted seatrout are similar in nature to red drum, and are cultured using methodology patterned on that developed for red drum. The main difference is that each 13,000 L circular spawning tank contains 15 to 20 broodfish (10 females). Spotted seatrout broodfish are subjected to a 150-day photoperiod-temperature maturation cycle. Spawning occurs at a water temperature of 22° to 26° C, salinity of 30–38 ppt with 11 hours of light per day.

Outdoor rearing ponds, filled 5 to 10 days earlier with filtered seawater and fertilized, are stocked with larvae when zooplankton densities reach 250 organisms per liter. A combination of chemical inorganic and organic fertilizers applied to rearing ponds produces a rapid phytoplankton bloom that stimulates production of copepods, a primary food for larval red drum. Dissolved oxygen, salinity, temperature, zooplankton densities, and fish growth rates are routinely monitored. Larvae remain in the ponds for 30 days or until they reach a target size of 30–35 mm total length. Once they reach target size, ponds are drained, fish are harvested, and they are transferred to mobile distribution tanks for transport and stocking into coastal waters. To date, 607 million red drum fingerlings and 57 million spotted seatrout fingerlings have been hatchery-produced and released into Texas coastal bays.

Contribution of Hatchery-Reared Fishes to Wild Stock

The red drum bay population in Texas bays now has rebounded to near-record highs at least partly as a consequence of this enhancement effort (Fig.1). The catch rate has remained relatively stable since 1993, presumably reflecting in part the replenishment of the offshore breeding population and a lack of any significant environmental kills since the 1989 Texas coastal freezes. Stocking was one of many actions which may have aided in the recovery of the red drum population and its specific role in the recovery is undocumented Estimates of the contribution made by stocked hatchery fish to total red drum numbers in Texas bays have ranged from 0 to 30% (Matlock et al. 1984, Hammerschmidt 1986, Matlock 1990, McEachron et al. 1995, McEachron et al. 1998,

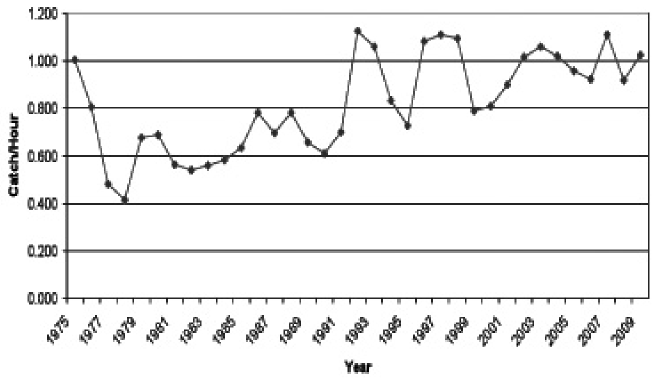

Figure 1. Gill net mean catch rate (catch/hour) of red drum collected coastwide from Texas bays during 1975–2009.

Scharf 2000, Karlsson et al. 2008). It is increasingly apparent that the efficacy of the stock enhancement program varies widely in both time and space and may be related in part to season of release and time of recapture. But, it is equally evident that overall, TPWD's long-term management plan using hatcheries to supplement natural recruitment, in concert with other management tools (e.g., banning nets, declaring red drum a gamefish, and traditional regulatory changes), has played a crucial role in mitigating and countering the decline of the red drum population. Genetics studies have been used to complement other TPWD methods (long-term fishery independent monitoring) that have been used to assess the stocking program (e.g., bag seine and gill net sampling) via estimations of relative abundances of sub-adults. Since 2004 genetic markers such as microsatellite DNA have been used to assess the contribution that hatchery-reared red drum are making to the population. Results to date confirm successful enhancement of red drum in Texas waters, measured as the proportion of hatchery-released fish among fish sampled at random from the wild. Karlsson et al. (2008) describe a recent study where a total of 30 hatchery-released fish were identified among 321 red drum (> 1 year of age) gill net sampled from Galveston Bay, while a total of 11 hatchery-released fish were identified among 970 red drum (> 1 year of age) gill net sampled from Aransas Bay. The total proportion of fish of hatchery origin was 8.5% in Galveston Bay and 1.1% in Aransas Bay. Additional genetics analysis of stocking effectiveness is underway for other Texas bays. Evaluation of the success of the seatrout stocking program is on-going, with studies based on the application of similar genetic markers.

Conclusions

Release of hatchery-raised juveniles into the wild to augment exploited marine species has increased substantially over the past few decades; in fact, such "stock enhancement" is a key strategy for restoring depleted stocks of fish, worldwide (Blankenship and Leber 1995, Munro and Bell 1997, Leber 2002, Stickney and McVey 2002, Bell et al. 2006, Kitada and Kishino 2006, Bell et al. 2008). TPWD fishery managers have used several different techniques to assess the success of hatcheries in enhancing populations (Rutledge and Matlock 1986, McEachron et al. 1993, McEachron et al. 1995, McEachron et al. 1998, Karlsson et al. 2008). The answer to the question of hatchery success is very complex with many components to address. It has taken the TPWD nearly 30 years to reach the present stage in development of its stocking and recovery program. To date, more than 600 million fingerlings have been stocked. Although controversial, fishery managers in Texas have used the release of hatchery-raised fish to augment the red drum and spotted seatrout fisheries. The innovative use of stocking, combined with traditional management practices, has proven to be a powerful combination in managing Texas natural resources wisely. Wild stocks of red drum have been enhanced through stocking to provide improved fishing success. However, the degree of improvement depends on such factors as the carrying capacity of each system, the number of wild fish present before stocking, fishing pressure, harvest restrictions, and climatic events. TPWDs long-term management plan utilizing hatcheries and stocking to supplement natural spawning has played a role in reversing the decline of the red drum population during the last three decades, and serves as a tool to ensure that Texas' fishery resources are wisely managed, and that the quality of saltwater fishing in Texas which has more than 1.6 million hectares of estuaries, bays and coastal waters continues to contribute prominently to the state's economy.

Acknowledgments

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Annotated Bibliography of Key Works

Saillant, E., M.A. Renshaw, D.M. Gatlin III, W.H. Neill, R.R. Vega, and J.R. Gold. 2009. An experimental assessment of microsatellite markers for genetic tagging of hatchery-reared red drum (*Sciaenops ocellatus*) used in stock enhancement. App. Ichthyol. 25:108–113.

Multiplexed microsatellite markers were evaluated as genetic tags for red drum (*Sciaenops ocellatus*) juveniles used in stock enhancement. Offspring were generated from spawns of nine sets of five broodfish (three dams and two sires) in individual brood tanks. Intensive sampling by trawling at 2, 7, 8, 10 and 11 days after release of 192,500 hatchery-raised fingerlings resulted in recovery of a total of 310 fingerlings. All parents and recovered offspring were genotyped for variation at 30 microsatellites combined for simultaneous assay in six multiplex panels. An optimal combination employing three of the six multiplex panels allowed unambiguous parentage assignment of all recovered offspring. Only 21 of 52 possible dam x sire combinations were represented among recovered offspring. The founder equivalent (FE) of the recovered offspring was 8.7 versus the expected FE of 36.0 (95% CI = 33.3–38.4) if reproductive success was randomly distributed among breeders. The significantly lower FE translated into reduced genetic diversity among the recovered offspring and may reflect differing contributions of individual broodfish to spawning events, differing productivity among brood tanks, or variable survival of families during early larval or juvenile stages.

Karlsson, S., E. Saillant, B.W. Bumguardner, R.R. Vega, and J.R. Gold. 2008. Genetic identication of hatchery-released red drum (*Sciaenops ocellatus*) in Texas bays and estuaries. N.A.J. of Fish. Manag., 28:1294–1304.

The stock enhancement program for red drum (*Sciaenops ocellatus*) in Texas annually releases from 25 million to 30 million fingerlings into Texas bays and estuaries and represents one of the largest such programs for marine fishes worldwide. We used 16 nuclear-encoded microsatellites and a 370-base-pair fragment of the mitochondrial DNA (mtDNA) D-loop to assign red drum sampled from two bays along the Texas coast to either hatchery or wild origin. A total of 30 hatchery-released fish were identified among 321 red drum belonging to 3 year-classes sampled from Galveston Bay, while a total of 11 hatchery-released fish were identified among 970 red drum belonging to 4 year-classes sampled from Aransas Bay. Allelic richness (microsatellites) was significantly lower among hatchery-released fish than among hatchery broodfish and wild fish. Similarly, the expected number of mtDNA haplotypes in hatchery-released fish (based on simulation analysis) was significantly lower than that expected in a random sample of both brood and wild fish. The contribution of brood dams, sires, and dam 3 sire combinations to the hatchery-released fish was nonrandom, as was the distribution of hatchery-released and wild fish with respect to sampling stations (localities) within each bay. The possibility of a Ryman–Laikre effect is discussed.

McEachron, L.W., C.E. McCarty, and R.R. Vega. 1995. Successful enhancement of the Texas red drum (*Sciaenops ocellatus*) population. M.R. Collie and J.P. McVey, (eds). Interactions between cultured species and naturally occurring species in the environment: Proceedings of the Twenty-Second U.S.-Japan Aquaculture Panel Symposium, August 21–22, 1993, p. 53–56. Tech. rep. U.S.-Japan Cooperative Program in Natural Resources No. 22. Alaska Sea Grant Report: AK-SG-95-03. Homer, Alaska.

Red drum (*Sciaenops ocellatus*) is an estuarine-dependent sciaenid that inhabits estuaries, bays, and coastal regions from New York to Mexico. In Texas, the red drum population began a dramatic decline in the 1970s, prompting the Texas Parks and Wildlife Department (TPWD) to set up a three-pronged recovery plan. Management approaches were: 1) Initiate an independent monitoring program to assess relative abundance; 2) implement restrictive regulations to reduce fishing pressure, including license restrictions, size, bag, and possession limits, a commercial quota, restrictions on netting, and a ban on commercial sale of red drum; and 3) develop and start a marine enhancement program based on the release of hatchery-reared fingerlings and assessment of subsequent survival.

Recently, the red drum population in Texas coastal water rebounded because of several factors that had a positive effect on the recovery. TPWD's long-term management plan utilizing hatcheries and stocking to supplement natural spawning played a role in reversing the decline of the red drum population. The strategy used by the TPWD can serve as a blueprint for other marine enhancement programs.

Matlock, G. C. 1990. Preliminary results of red drum stocking in Texas. A. K. Sparks (ed.). Marine Farming and Enhancement: Proceedings of the 15th U.S. Japan Meeting on Aquaculture, p. 11–15. U.S. Dept. NOAA Technical Report NMFS 85. U.S. Department of Comm.

The ability to control spawning and to rear red drum (*Sciaenops ocellatus*) in captivity has afforded managers the opportunity to use stocking to enhance native fisheries. This paper presents preliminary results of the effects of 2 years of intensive stocking in two Texas estuaries. Catch rates in gill nets fished randomly in stocked and unstocked bays in spring (April-June) and fall (September-November) were compared to determine changes in relative abundance of fishable populations. Landings by private sport-boat anglers in each bay during the low use (mid-November through mid-May) and high-use (mid-May through mid-November) seasons before and after stocking were compared for fish ~450 mm total length. Relative abundance and angler landings of red drum were higher after stocking in the stocked bay; abundance and angler landings were similar or lower in unstocked bays after the stocking dates. Additional research is needed to determine optimum stocking rates, times, and fish sizes.

Efforts Toward Stabilization of Tiger Puffer Fishery and Revitalization of Tourism Based on Puffer Stock Enhancement in the Enshu Region of Japan

Shigenori Suzuki and Masahiko Nariu
Minami-Izu Station
National Center for Stock Enhancement, Fisheries Research Agency (FRA)
Irouzaki, Minami-Izu, Shizuoka 415-0156, Japan
sshige at affrc.go.jp

Masaharu Machida
Miyazu Station
National Center for Stock Enhancement, Fisheries Research Agency (FRA)
Odashukuno, Miyazu, Kyoto 626-0052, Japan

Abstract

Kanzanji Spa Resort, located in Hamamatsu City, Shizuoka Prefecture, flourished and attracted many tourists during the 1970s by virtue of its convenient accessibility from metropolitan areas and the existence of nearby leisure facilities. Nevertheless, the number of tourists visiting Kanzanji Spa Resort each year has decreased since the 1980s because the mode of Japanese domestic travel has shifted from group-based to individual trips, and because the primary motive of visiting spa resorts has changed. Spa resorts used to be visited by workers for the sake of refreshing themselves and promoting friendships. Now people go to the resorts to enjoy seasonal and regional cuisine. Kanzanji Spa Resort has begun seeking new tourism resources aimed at revitalization.

Meanwhile, as a result of 1989s good catch, members of Hamana Fisheries Cooperative Association in Hamamatsu City began to catch many more tiger puffers (*Takifugu rubripes*), a fish that had previously attracted little attention. Consequently, the tiger puffer catches grew rapidly. However, because there was no experience with consumption of the fish in Shizuoka Prefecture, the tiger puffers that were caught were rarely consumed locally. Most were instead transported to western Japan by truck. After the Kanzanji Tourist Association learned of this situation, they started to use "high grade tiger puffer ingredients" as a new tourism resource for Kanzanji Spa Resort in cooperation with the Hamana Fisheries Cooperative Association and Hamamatsu City Chamber of Commerce. Because the catches of tiger puffer off Hamamatsu were subject to frequent fluctuations, it was concluded that supplying tiger puffer for food was difficult, especially if the supply depended solely on the wild catch. Therefore, large-scale production and release of the hatchery produced tiger puffer was initiated in 2002. Herein, we report the recent progress in stock enhancement for for tiger puffer and tourism promotion measures at the Kanzanji Spa Resort using the tiger puffer.

The Rise and Decline of Kanzanji Hot Spring Resort

The Kanzanji Spa is located in the center of Japan (Figure 1) in the Enshu region. In 1958 the Kanzanji community found a useful hot spring resource. They began to develop the area as a spa resort. A variety of facilities such as an amusement park, a zoo, a flower park, and fine beaches were established around the Kanzanji spa so travelers could enjoy their stay. Moreover, it was readily accessible via highway given its proximity to metropolitan areas such as Tokyo and Osaka. Kanzanji became very crowded with travelers during the 1970s (Figure 2). Only several tens of thousands of travelers visited in 1968, but by 1980, the community accommodated 800,000 travelers annually. Although that peak occurred at just around the end of the Japan's high economic period, Kanzanji received many group tours such as company excursions. To adapt to the increasing number of group travelers, Kanzanji had been expanding the capacity of its hotel facilities. Furthermore, they conducted standardization of the food menus and guest rooms. However, with the accelerated maturing of society, improvement in living standards, and diversified values and habits, traveling styles shifted from business-related group tours to tours emphasizing more individual visitors who focused on sharing time with family and good friends. This change in conditions dictated that existing facilities and services, chiefly targeting group travelers, did not meet the needs of the change in clientele. Numbers of travelers to Kanzanji gradually decreased. In the 1990s the annual number of travelers dropped below 600,000. Consequently, Kanzanji began to seek a new tourism resource aimed at revitalizing the spa resort.

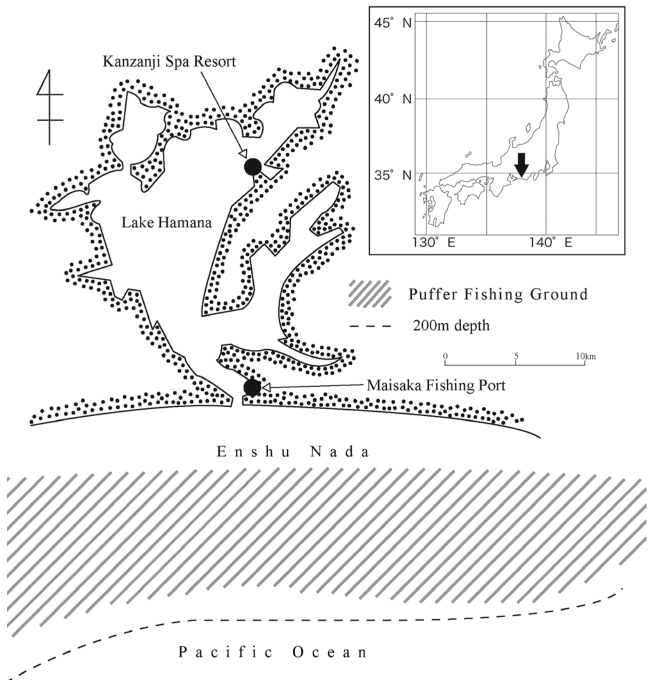

Figure 1. Locations of Kanzanji Spa Resort, Maisaka Fishing Port, and tiger puffer fishing grounds on the Pacific coast of the Enshu region.

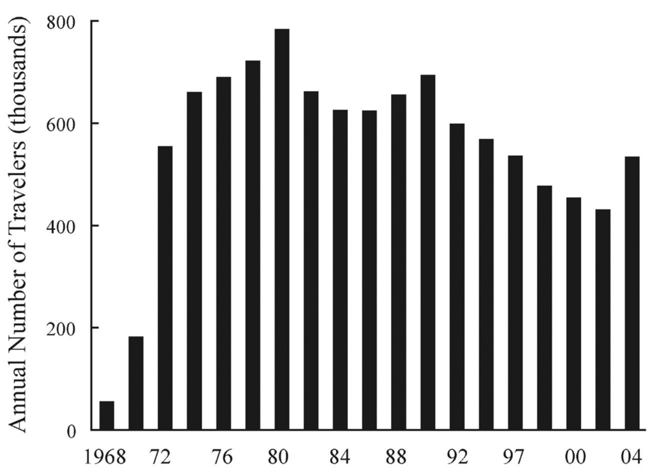

Figure 2. Changes in the annual number of travelers visiting the Kanzanji Spa.

Prosperity of the Tiger Puffer Fishery in the Enshu Region

On the Pacific coast of the Enshu region, setline fishing for wild puffers had been done since around 1960. Ten or fewer family businesses ran all of the puffer fisheries. Annual catches of puffer during the 1960s and 1970s were around 10 tons (Figure 3). However, in 1989 100 tons of puffers were caught (Tsukui et al. 1999). The port towns in the Enshu region such as Maisaka and Fukude prospered because of the good catch. That year's good catch rapidly increased the number of family-run puffer fisheries to 400. Wild puffers were traded at a high price despite changes in the catch; the puffer fishery took root as a major industry in the Enshu region. However, because the people in the Enshu region were not accustomed to eating puffer, most of the fish landed at fishing ports in the Enshu region were not consumed in the local area. Most puffers were transported to western Japan by truck. As a result, puffers landed in the Enshu region were distributed nationwide as a product of western Japan.

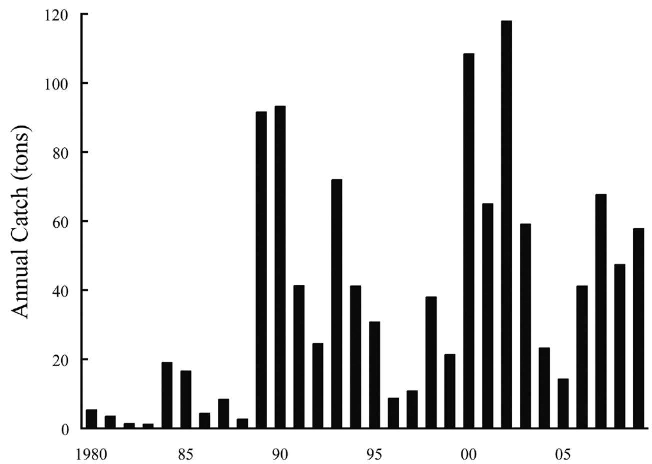

Figure 3. Changes in the annual catch of tiger puffers in Shizuoka Prefecture.

Efforts in Wild Tiger Puffer Branding

When the Kanzanji Spa Resort community recognized the situation, they consulted with the local chamber of commerce and the fisheries cooperative and decided to sell wild puffers as the new tourism resource of Kanzanji. However, it was not so well known that Enshu fisheries were producing large numbers of puffers. At that time, nearly all puffers distributed nationwide were transported from western Japan, where puffer had been consumed for a long time. General consumers believed that puffers were caught in the waters of western Japan. Therefore, the Kanzanji community began a branding strategy to distinguish their wild puffers from those from other areas (Nogata, 2005). The branding strategy began in 2003. A brand name and logo were designed. In fact, 90% of the puffers distributed in Japan were farmed fish. For that reason, wild puffers were extremely valuable. Therefore, one priority was to differentiate Enshu puffers from existing farmed puffer products. To achieve that goal, the brand name "Enshu Natural Puffer" was designed. Additionally, the industry sought to present a sense of unity for their products. An appropriate logo was designed and was printed on hotel brochures and packages of souvenirs. Next, Kanzanji undertook creation of an efficient food supply system based on natural puffers.

Puffer fish carry a deadly poison. Therefore, only licensed chefs with puffer preparation certification are allowed to prepare them for consumption. It was unrealistic for all the chefs in the Kanzanji hotels to acquire the license because of the inherent costs of time and money involved, and it might have delayed the speedy implementation of the branding strategy. Therefore, Kanzanji built a puffer processing plant at which the licensed chefs could gather and conduct primary processing. Although each hotel used the same processed puffer, the cooks were able to maintain their own cooking styles and provide consistent quality puffer cuisine efficiently.

Kanzanji was also actively engaged in a public relations campaign to disseminate the brand name. However, the Japanese people clung to the idea that western Japan was the main production area for puffers. Few people knew that puffers were caught in the Enshu region. Even the local people in the food business did not know that. Kanzanji participated in various exhibitions in many cities in the Enshu region and hosted tasting events to promote the new puffer brand. Those activities led to increasing coverage in newspapers and magazines, thereby increasing the brand popularity.

In addition to the public relations campaign, Kanzanji became involved in the development of souvenirs with local confectionary companies using puffer skins, which were difficult to use in the hotel cuisine. Reasonable prices and durability as well as puffer product recognition were indispensable conditions for the production of the products. Cookies and rice crackers adding puffer powder from the skins were developed. Then they began selling the products at souvenir counters in the hotels.

As a result of the campaigns and activities, Kanzanji hosted around 35,000 travelers during 2004, with an estimated economic effect of ¥400 million. Furthermore, the proceeds of souvenir sales were ¥10 million in 2004. The project brought positive economic benefits to the Enshu region, including job creation.

Bad Catch and Introduction of Stock Enhancement Technology

Despite the high profitability of the puffer fishery, wild puffer catches remained unstable because of environmental impacts. Puffer catches were poor in 2005 and 2006. Consequently, Kanzanji faced difficulties in providing puffer cuisine to the visitors. They came to realize it was difficult to rely only on wild puffers for their industry. Therefore, fishery experiment stations and revitalization-related organizations in Kanzanji assembled to discuss ways to stabilize the provision of the wild puffer resources. Ways were developed to meet the three conditions as listed below:

1. Minimize the impacts on the industries involved.
2. Immediate results.
3. Feasible scientific evaluations.

An approach was adopted to release hatchery fish to stabilize the puffer fishery. Therefore, we first conducted experimental verification using puffers produced by the National Hatchery, Minami-Izu Station, National Center for Stock Enhancement, FRA. We also decided to evaluate the effects of the stock enhancement. The main problem with the latter was how to differentiate between wild and hatchery fish. Wild puffer had a high market value and were in high demand. Therefore, it was considered difficult to purchase mass samples of puffers from the fish market for the research. Given the research costs and negative impacts on the existing wild puffer industry, we wondered whether it was possible to detect the released puffer at the puffer-processing plant in Kanzanji. Through a trial and error process, we developed an efficient method of detecting released puffer (Suzuki et al. 2008). Successful development of mass-collection methods for puffer otoliths was able to open the way for experimental release. All released puffers had otoliths marked using alizarin complexone. Different alizarin complexone marks were added to each release group. In all, 200,000 fish were released annually for experimental verification. We sought to determine optimal release strategies by comparing the growth and survival of respective experimental groups. The experimental verifications undertaken to date have presented us with data related to the optimal release location and size (Nakajima 2008). Based on those results, local governments began a commercialized release project. The result is that 700,000 hatchery produced puffer are now released each year in the Tokai area. Consequently, the annual catch has become stabilized at around 60 tons in Shizuoka Prefecture.

Catch Stabilization and Establishment of a Tiger Puffer Brand

With the catch of wild puffers stabilized, Kanzanji began to sell package tours jointly with travel agencies. Because the puffer used in Kanzanji hotels are caught only in Enshu waters, and because large numbers of puffer are processed at a processing plant in Kanzanji, distribution and processing costs are reduced. As a result, travelers can stay at a hotel in Kanzanji and enjoy a puffer dinner by paying what they would have had to pay for the puffer cuisine alone at an expensive restaurant in the city. The package tour with a moderate price as its main selling point was designed for individual travelers.

Future Issues

Although stock enhancement for puffer is now being established in partnership with the Enshu natural puffer industry, it remains difficult to say that Enshu natural puffer is widely recognized throughout Japanese society. For that reason, more public relation activities to disseminate the brand name are necessary. In addition, the annual release of 700,000 puffers can increase the wild puffer catch by only 15%. It is important not only to advance stock enhancement technologies, but also to protect the spawning stock through fishery management and the conservation of spawning and nursery grounds. A sustainable system to provide wild puffers will be established when these measures begin to move integrally. All companies, groups, and research agencies involved in the Enshu natural puffer industry will continue their collaborations to ensure a stable supply and to develop natural puffer as the major brand representing the Enshu region, and an aid to revitalization of the Kanzanji Spa Resort.

Acknowledgments

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Nakajima H., K. Masanobu, K. Koizumi, T. Tanaka, and M. Machida. 2008. Optimal release locations of juvenile ocellate puffer *Takifugu rubripes* identified by tag and release experiments. Rev. Fish. Sci. 16:228–234.

Nogata, H. 2005. Hearing report of Hamamatsu City and Kanzanji Hot Spring Report [in Japanese]. Economic review, Shizuoka University 10(1):41–48.

Suzuki, S., M. Machida, M. Nariu, and K. Sakae. 2008. A novel method for mass-collecting otoliths asing a portable aspirator in tiger pufferfish, *Takifugu rubripes* J. Fish. Tech. 1:77–82 [In Japanese].

Tsukui, F., and N. Yoneyama. 1999. The characteristic of the income depending on puffer long line fisheries in Shizuoka Prefecture. Bull. Shizuoka Pref. Fish. Exp. Stn. 34:49–52.

Annotated Bibliography of Key Works

Nakajima, H., M. Kai, K. Koizumi, T. Tanaka, and M. Machida. 2008. Optimal Release Locations of Juvenile Ocellate Puffer *Takifugu rubripes* identified by tag and release experiments. *Reviews in Fisheries Science* 16:(1). p. 228–234.

We identified the optimal location for releasing hatchery-produced juveniles of ocellate puffer (*Takifugu rubripes*) for stock enhancement by tag and release experiments. The fish were released at four areas; Suruga Bay, Enshu Nada, Ise Bay, and Kumano Nada along the central coast of Honshu Island in Japan from 2001 to 2005. Approximately 10,000–40,000 cultured puffer fish were released in these areas in 23 groups. Tagged fish were mainly recaptured at age 0 by small-scale trawl net fishing in Ise Bay, and by longline fishing at age one or older in Suruga Bay, Enshu Nada, and Kumano Nada. The overall average recapture rate yielded 13.0% for the Ise Bay release group compared with 2.0%, 2.9%, and 0.7% for the Suruga Bay, Enshu Nada, and Kumano Nada release groups, respectively. Even in the Ise Bay area, significant differences in recapture rates were observed among three release locations. Lower recapture rates were presumably caused by predation, because tagged fish were found in the intestines of Japanese sea bass (*Lateolabrax japonicus*). It is suggested that release locations should be carefully evaluated and chosen to reduce initial mortality even if cultured ocellate puffer are released in Ise Bay. One of the optimal release locations is specified in shallow areas, such as off Tokoname, which are inhabited by wild juvenile ocellate puffer.

Tsukui, F., and N. Yoneyama. 1999. The characteristic of the income depending on puffer long line fisheries in Shizuoka Prefecture [in Japanese]. Bull. Shizuoka Pref. Fish. Exp. Stn. 34:49–52.

In the sea area from Kumano Nada, Ise Bay to Enshu Nada surrounding Mie, Aichi, and Shizuoka prefectures, there was a record catch of tiger puffer in 1989. Since then, although the catches have fluctuated considerably, the tiger puffer fishery has become a vital industry in the Tokai region because of its high profitability. This study investigated the actual situation of tiger puffer fishery in Shizuoka Prefecture and changes in fish prices since 1988.

N. Hiroshi. 2005. Hearing report of Hamamatsu City and Kanzanji Hot Spring report [in Japanese]. Economic review, Shizuoka University 10:(1) p. 41–48.

Off the coast of Hamamatsu in Shizuoka Prefecture is known as one of the largest tiger puffer fishing grounds in Japan. However, because no pufferfish-processing facility existed in Hamamatsu region, most tiger puffer that have been caught have been shipped to the Shimonoseki region in Yamaguchi Prefecture. Kanzanji Spa Resort in Hamamatsu City began projects to assign a brand value to the tiger puffer caught in off the coast of Hamamatsu beginning in 2003. As citizens came to attach greater importance to the consumption of the locally produced food, hotels and inns in Kanzanji Spa Resort made a joint capital investment in November 2003 in the establishment of a puffer processing plant. The facility began operations, which enabled them to provide puffer cuisine locally. In 2004 the Small and Medium Enterprise Agency of Japan designated Kanzanji's project as its "Japan Brand Promotion Project," and the agency provided government grants amounting to ¥25 million to the project. Using this grant, the Kanzanji Spa Resort implemented an advertising and promotion campaign, with the goal of encouraging 40,000 visitors to come to the resort. In addition, new snacks adding puffer powder in its ingredients such as sweets, Japanese rice crackers, and cookies were produced and sold in the market. Consequently, the spa resort hosted 20,000 visitors in FY 2003 and 35,000 visitors in FY 2004. The economic effect in FY 2004 was estimated as about ¥400 million.