UJNR Aquaculture Panel

38th Scientific Symposium

Interactions of fisheries and fishing communities related to aquaculture

October 26th and 27th, 2009 at the Harte Research Institute

Texas A & M University, Corpus Christi, Texas

Contents

The Seventh Three-year Plan of the UJNR Aquaculture Panel, 2007-2009

This plan represents a change from five year planning to three year planning in order to be more responsive to rapid changes in quickly emerging issues related to aquaculture. The future success of seafood production must integrate aquaculture into coastal communities and benefit from the synergies of having both traditional capture fisheries and aquaculture, to maximize the economic value and societal benefits. Advanced technologies are being applied with great success and benefits in all areas of our lives. Aquaculture is no exception. Advances in biotechnology applied to aquaculture affects feeds, reproduction, organism health, product quality, human health, breeding, and ultimately the economics and environmental impacts of aquaculture. Further, advanced technology in culture systems, such as open-ocean, multi-tropic level, and recirculation systems, are rapidly evolving and promise to produce more product at less economic and environmental cost. The social and economic foundations of aquaculture in the US and Japan greatly impact the development and growth of aquaculture industries in both countries and will continue to be important in the future. In the present three-year plan we will address these issues to enhance the management and development of aquaculture in our countries including the implications for industry, consumer health and environmental impacts. Specifically we will focus on how advanced technologies, social and economic structure, and interactions of aquaculture and the environment impact future feeds development and invertebrate culture. The last meeting of this plan will integrate the multi-faceted aspects of fisheries and fishing communities relating to aquaculture.

・Aquaculture Technologies for Invertebrates. (Durham, New Hampshire, October 2007)
Culture systems for mollusks, crustaceans, echinoderms, and other invertebrates with commercial importance will be considered.

・The Future of Aquaculture feeds. (Yokohama, November, 2008)
Sources for essential nutrients for aquatic animals, the tailoring of feeds for special life stages (larvae or broodstock), special situations (low pollution, off-shore, recirculation systems, animal health) or for enhanced product quality (human health, product stability/quality) will be investigated.

・Interactions of fisheries and fishing communities related to aquaculture (Corpus Christi, Texas,

October 2009)

The interrelated roles of fisheries and aquaculture in managing the coastal environment, economics of fishing communities, resource allocation, management costs, and how advanced technologies impact these issues will proved the focus for this last symposium of the three year plan.

Approved at the 35th meeting of UJNR**,** Mie, Japan 2006

UJNR Scientific Symposium Program

Interactions of fisheries and fishing communities related to aquaculture

October 26-27, 2009

Harte Research Institute, TAMU, Corpus Christi, Texas

Day 1- October 26, 2009

13:30- 13:45 Welcome, logistics and opening remarks- Robert STICKNEY, Texas Sea Grant Director and local host.

13:45-14:00 Opening remarks - Takaji IIDA, Japan Panel Chairman

Session 1 - Legal systems and structure of the industries in Japan and the United States
Tsutom MIYATA and Robert STICKNEY, moderators

14:00-14:25 Economic and social issues driving and affecting the development of aquaculture in the United States. Michael RUBINO (NOAA Aquaculture Program)

14:25-14:50 The legal systems of Fisheries Cooperatives and the right of fishermen in Japan. Makoto YAMASAKI (National Research Institute of Aquaculture, FRA)

14:50-15:10 Refreshment break

Session 2 – The Human Dimension
Walton DICKHOFF and Satoshi KATAYAMA, moderators

15:10-15:35 Goal of Stock Enhancement; by the people, for the people. Yuichiro FUJINAMI (Miyako Station, National Center for Stock Enhancement, FRA)

15:35-16:00 Shellfish Growers' Perceptions of Institutional, Environmental, Market-based and Climate Change Risks. Danielle RIOUX, (University of Washington)

16:00-16:25 Marketing strategy of fisheries area based on locally produced and locally consumed: Cases of oyster and sea urchin. Tsutom MIYATA (National Research Institute of Fisheries Science, FRA)

16:25-16:50 Questions and Discussion from session 1 and 2

18:30-21:30 Symposia Reception at Omni Hotel

Day 2- Tuesday, October 27

8:30 – 8:45 Opening remarks – Michael RUST

Session 3 – Making a Business Case
Yasuji TAMAKI and Michael RUBINO, moderators

8:45-9:10 Commercial Farming of the Japanese Sea Urchin, *Strongylocentrotus intermedius*, Now a Reality! Addison LAWRENCE (Texas A&M University)

9:10-9:35 Market survey for approaching to grouper aquaculture. Takashi IWASAKI (Kamiura Station, National Research Institute of Aquaculture, FRA)

9:35-10:00 Large scale indoor shrimp production (over 300 metric tons of shrimp per hectare per year), commercial farming of shrimp in Japan and US, now a reality! Addison LAWRENCE (Texas A&M University)

10:00- 1020 Refreshment Break

10:20-10:45 Role of fisheries cooperative: a case study of price determination by producers. Toshinori TAKASHI (National Research Institute of Aquaculture, FRA)

10:45-11:10 Economic analysis of offshore bluefin tuna aquaculture. Gina SHAMSHAK (Goucher College)

11:10-11:35 Valuation of ecosystem services in restocking with freshwater fish. Shin-ichiro ABE (Freshwater Fisheries Research Division, National Research Institute of Fisheries Science, FRA)

11:35-12:00 Questions and Discussion from Session 3

12:00-12:20 Group photo session

12:20-13:20 Lunch

Session 4 – Industries: local and global.
Conrad MAHNKEN and Makoto YAMASAKI, moderators.

13:20-13:45 Implications of aquaculture for wild fisheries: Case of Alaska wild salmon. Gunnar KNAPP (University of Alaska)

13:45-14:10 Revitalizing fishing villages through sightseeing fisheries in Japan. Yasuji TAMAKI (National Research Institute of Fisheries Science, Fisheries Research Agency)

14:10-14:35 Technologies to bridge the gap between fisheries and aquaculture Cliff GOUDEY (C.A. Goudey & Associates)

14:35- 15:00 Questions and Discussion of Session 4

15:00-15:20 Refreshment Break

Session 5 – Stock Enhancement, where capture and culture meet.
Shin-ichiro ABE and Michael RUST, moderators.

15:20-15:45 A comparison of salmon hatchery programs in Alaska and Japan. William HEARD (Alaska Fisheries Science Center, NOAA)

15:45-16:10 Stock enhancement programs of a fisheries cooperation of a brackish lake in Japan. Satoshi KATAYAMA (Yokosuka Station, National Research Institute of Fisheries Science, FRA)

16:10-16:35 Enhancement of Texas Sciaenids (Red Drum and Spotted Seatrout). Robert VEGA (Texas Parks and Wildlife Department)

16:35-17:00 Efforts toward stabilization of Tiger puffer fishery and revitalization of tourism based on puffer stock enhancement in the Tokai region of Japan. Shigenori SUZUKI (Minamiizu Station, National Center for Stock Enhancement, FRA)

17:00-17:20 Questions and Discussion on Session 5

17:20-17:45 Closing Remarks –Robert IWAMOTO, USA and Takaji IIDA, Japan

ECONOMIC AND SOCIAL ISSUES DRIVING AND AFFECTING THE DEVELOPMENT OF AQUACULTURE IN THE UNITED STATES.

Michael Rubino

NOAA Aquaculture Program, 1315 East-West Hwy. SSMC 3 - Mail Code: F, Silver Spring MD 20910

Email: Michael.Rubino at noaa.gov

In the 1990's, 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 (DOC) and its sub-agency, the National Oceanic and Atmospheric Administration (NOAA), adopted broad aquaculture policies in the late 1990's. 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.

Annotated Bibliography of Key Works

Rubino, Michael (editor). 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities (Pre-Publication Copy). U.S. Department of Commerce, Silver Spring, MD USA. 264 pp. Available at: http://aquaculture.noaa.gov/news/econ.html

National Marine Fisheries Service (NMFS). 2007. Summary of the National Marine Aquaculture Summit. Washington, DC. Available at: http://aquaculture2007.noaa.gov/pdf/summitsum_web_1_08.pdf

Browdy, C.L. and J.A. Hargreaves (editors). 2009. Overcoming Technical Barriers to the Sustainable Development of Competitive Marine Aquaculture in the United States. U.S. Department of Commerce, Silver Spring, MD USA. NOAA Technical Memo NMFS F/SPO-100. 114pp. Available at http://aquaculture.noaa.gov/pdf/noaanistwpfinal.pdf

Rubino, M.C. 2007. Remarks: Keynote for Environmental Impacts of Coastal Ocean Aquaculture session. 137th Annual American Fisheries Society Meeting. San Francisco, CA. Available at: http://aquaculture.noaa.gov/pdf/afs_07_rubino.pdf

National Oceanic and Atmospheric Administration. 2007. NOAA 10 Year Plan for Marine Aquaculture. , Silver Spring, MD USA. Available at: http://aquaculture.noaa.gov/pdf/finalnoaa10yrrweb.pdf

THE LEGAL SYSTEMS OF FISHERIES COOPERATIVE AND THE RIGHT OF FISHERMEN IN JAPAN

Makoto YAMASAKI

National Research Institute of Aquaculture, FRA, Minami-ise, Mie 516-0193, Japan

Email: yama850 at affrc.go.jp

Japan fisheries cooperatives are cooperative organizations established under Japanese law (the Fishery Cooperative Act, 1948) to promote the development of cooperatives among fishing communities. In so doing, 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 associate and its formal membership is controlled by the period of annual operation days.
The business operations of these fisheries cooperatives include credit (as with banks), mutual aid (as with insurance companies), orchestrating sales operations that fishermen require in order to sustain themselves and their activities, and providing management guidance.

A regional cooperative is a social unit, and is based on a village that fishery was followed from the Edo period (about 300 years former). There were 1,890 regional cooperatives in 1998, however, now there are 1,191 in July 2007 after making consolidation actively in these ten years. 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 enables the holders to operate solely and exclusively within specific areas and to benefit from this restricted access. And, fishery rights, which are 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 rights; include the right to lay and fix nets and other fishing gear for a specified period of time at a particular location, 2) area demarcated fishery rights; permit users to participate in aquatic animal or plant

aquaculture within a specified demarcated area, and 3) common fishery rights; permit fishing communities in a specific area to operate fisheries on a communal basis.

Annotated Bibliography of Key Works

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

This is a textbook for university and graduate school students to learn fishery economy. Contents of the book consist of production structures of fishery and aquaculture and management, working formation, establishment, consumption, marketing, processing and cooperatives of fishery. It is regrettable that they are written only in Japanese.

GOAL OF STOCK ENHANCEMENT: BY THE PEOPLE, FOR THE PEOPLE

Yuichiro Fujinami*[1], Daisuke Shimizu*[1], Yoshitomo Nagakura*[1], Tsutomu Noda*[1], and Hideaki Aono*[1]

[1] Miyako Station, National center for Stock Enhancement, FRA, Sakiyama, Miyako, Iwate 027-0097, Japan.

Email: fujinami at affrc.go.jp

Miyako Station, of the National Center for Stock Enhancement, was established in 1979 in Miyako city (pop. ca. 58,000), located in northern Japan. In recent years, we have continued stocking Japanese flounder, black rockfish, Pacific herring, and spotted halibut juveniles in Miyako Bay. The stocking activities' effectiveness has been proven in some cases. However, these facts are known to only some researchers and fishery workers. Successful stock enhancement demands that the following information be known not only to them. This information is indispensable for residents' understanding and cooperation.

1) stocking habitat
2) stocking season, size, quality, and quantity of juveniles
3) management of the stocked juveniles

For examination of residents' awareness of "stock enhancement", questionnaire surveys of 148 residents were conducted during 2004 and 2005. Results show that the response percentages of "I know the term STOCK ENHANCEMENT" and "I know a hatchery for stock enhancement exists in Miyako city" were, respectively, 85.1% and 70.3%. The response percentages related to awareness of stocking of flounder, black rockfish, Pacific herring and spotted halibut were, respectively, 48.6%, 27.7%, 25.0% and 18.2%. These results suggest that local residents do not fully recognize stocking activities and characteristics.

To promote our activities among local residents, we held lecture meetings, events held along with residents to stock juveniles, and cooking competitions using Pacific herring, which is a target species of stock enhancement, etc. In particular, annual events to stock flounder juveniles

with schoolchildren have been reported in newspapers and on TV. Because of our activities and because the coverage came to be known to fishery workers, the publicity activities have given rise to secondary effects: the fishery workers began spontaneously to halt landing of young black rockfish and to protect herring eggs spawned on fishing nets until hatching. We will continue such activities in cooperation with local residents and fishery workers in the future, aiming at the promotion and success of stock enhancement.

SHELLFISH GROWERS' PERCEPTIONS OF INSTITUTIONAL, ENVIRONMENTAL, MARKET-BASED AND CLIMATE CHANGE RISKS.

Danielle Rioux, University of Washington, School of Marine Affairs, Seattle, WA 98105

Email: UWshellfish at gmail.com

Currently 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 sector. To effectively manage an expanding shellfish growing industry it is important to understand the risks shellfish growers must consider in making business decisions. Significant academic research elucidates the scientific basis of, environmental and climate change risks to shellfish, as well as market-based, and institutional risk. Yet little research has been done to assess how members of the shellfish industry perceive these risks, their ability to obtain financial protection from them, their perception of market demand, and their associated business decisions. This survey fills that gap. Each grower is asked to rate the level of risk posed by 30 different threats, from major threat 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 among risks to which the industry feels most vulnerable, as well as for comparisons between regional business decisions and perceptions of risk. This study has shown that the industry feels most vulnerable to institutional threats, with climate threats having the lowest perceived risk. The results of coast to coast comparisons show that the Gulf Coast of the U.S. has the highest level of perceived risk to the threats outlined, and the West Coast has the lowest.

Annotated Bibliography of Key Works

Beach, Robert H and Viator, Catherine L. 2008. The economics of aquaculture insurance: an overview of the U.S. pilot 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 United States, 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 available 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.; Secretan, P.A.D.; Lou, Y.; Roberts, R.; Upare, M. 2006. Review of the current state of world aquaculture insurance. FAO Fisheries Technical Paper. No. 493.

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 (BMPs), 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 make 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.

MARKETING STRATEGY OF FISHERIES AREA BASED ON LOCALLY PRODUCED AND LOCALLY CONSUMED - CASES OF OYSTER AND SEA URCHIN

Tsutom Miyata

National Research Institute of Fisheries Science, FRA, Fukuura, Kanazawa-ku YOKOHAMA 236-8648, JAPAN

E-mail: tmiyata at affrc.go.jp

Foods of oyster in Japan are popular for fried oyster, oyster hot pot, rice seasoned with soy sauce and boiled with oyster, and eaten at home or Japanese-style bar.
Since approximately 2000, an oyster-bar has become recognized in an urban area. The other side, an oyster barbecue in a shack is currently increasing in some fisheries areas in southern Japan. This makes a ripple effort on oyster price of production, labor of fishery concerned and the other industries in the areas. The oyster-bars rarely make a ripple effort on fisheries areas. Furthermore, the successful business is beginning to expand to the north of Japan.
This new business method is important that the shacks of oyster barbecue and oyster ponds are the same area because the tourists want to eat local seafood when they travel seaside. Namely, the new business method can be taken place by which is “locally produced and locally consumed”. Moreover, local oysters (local fishers) have a grate advantage against import oyster and farmed oysters of the other areas.
A case of sea-urchins, people in Iwate prefecture; northeastern Japan have traditionally eaten fresh sea urchins in the summer, and prefer very fresh sea urchins caught in Iwate. However, since approximately 2000, live sea urchins produced mainly in Russia have been supplied during autumn to spring, and sea urchins have shifted from a seasonal item to one available throughout the year. Fast-food sushi and conveyor-belt sushi made from fresh imported sea urchins have formed a new market. Iwate fishers are worried that local sea urchins will be expelled by imports from Russia.
On the other hand, processors continue their demand for sea urchins caught in Iwate for their high ratio of edible tissue, freshness, and local produced and local consumed. Local consumers also prefer local sea urchins for their high quality and area brand which formed by tradition of

food and publicity (free mass media such as news). Therefore, Iwate producers have been able to avoid the decreased demand for local sea urchins seen elsewhere in Japan.

Annotated Bibliography of Key Works

Tsutom Miyata. 2005. Marketing strategy of shell oyster. Journal of Regional Fisheries (Japan), Vol:46:1. Pp161-176.

The competitiveness of Iwate prefectural* 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.
* Iwate prefecture is located in northern Japan.

Mari Hazumi. 2007. Construction of Local Brand in Marine Products and Effects on Local Society. Journal of Regional Fisheries (Japan), Vol:47:2-3. Pp217-234.

The purpose of this paper is how to build the brand which is not involved in price competition. It describes not only a 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.

COMMERCIAL FARMING OF THE JAPANESE SEA URCHIN, *STRONGYLOCENTROTUS INTERMEDIUS*, NOW A REALITY!

Addison L. Lawrence[1], John M. Lawrence[2], Stephen A. Watts[3], Mickie L. Powell[3]

[1]Texas AgriLife Research, Texas A&M System, 1300 Port Street, Port Aransas, Texas 78373, USA

[2]Department of Comparative and Integrative Biology, University of South Florida, Tampa, Florida 33620, USA

[3]Department of Biology, University of Alabama at Birmingham, Birmingham, Alabama 35294, USA

Email: smpall at yahoo.com

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 *S. intermedius*.

A dry formulated feed for *S. intermedius* has been developed and produced in the USA. This feed has been used to produce commercial size gonads of *S. intermedius* in the People's Republic of China. Thus, with demonstration that a commercial dry formulated feed is available for production of *S. intermedius*, 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. Pages 135-159 in JM Lawrence, ed. Edible Sea Urchins: Biology and Ecology. Elsevier, Amsterdam, The Netherlands.

This is a review paper which 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 *Strongylocentrotus intermedius* 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 *Strongylocentrotus intermedius.*

Lawrence A.L., .J.M Lawrence. 2004. Importance, status and future research needs for formulated feeds for sea urchin aquaculture. Pages 275-283 in J.M. Lawrence, O. Guzman, eds. Sea urchins: fisheries and ecology. DEStech Publications, Lancaster, Pennsylvania.

This is a review paper which reviews the history for the development of the 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*[1], Takuma Sugaya*[2], Keiichi Hirasawa*[3], Shizumasa Onoue*[3], Kentaro Ide*[1], Kenichi Watanabe*[1], and Hiroshi Ogata*[1]

[1]Stock Enhancement Technology Development Center, National Research Institute of Aquaculture, FRA, Saiki, Oita 879-2602, Japan

[2]National Research Institute of Fisheries Science, FRA, Fukuura, Yokohama, Kanagawa 236-8648, Japan

[3]Fisheries Research Institute, Oita Prefectural Agriculture, Forestry and Fisheries Research Center, Saiki, Oita 879-2602, Japan

Email:tak0829 at affrc.go.jp

Aquaculture industry in Japan has been stagnant due to the increase of production costs and low market prices of major culture species. Groupers, especially Kue (Longtooth grouper, *Epinephelus bruneus*) and Ma-hata (Sevenband grouper, *E. septemfasciatus*) have been appreciated as high-grade commodities due to their rarity value and palatability. Thus, the groupers are expected as new aquaculture species in Japan. However, production and marketing strategies of the groupers which ensure the aquaculture success have not been examined enough. In the present study, hearing surveys were conducted in wholesale markets and local farms to review production and marketing status of grouper aquaculture. Trade and price trends of cultured and wild-caught groupers were investigated at wholesale markets in Tokyo (Tsukiji Market), Osaka, and Fukuoka. Besides, the current condition of grouper production has been surveyed in fish farms of Oita Prefecture, which is an active area of aquaculture in Japan.

The result of the investigation shows that cultured groupers were dealt with a high price of at least 1,500 Yen/kg at the three markets, suggesting that grouper culture will be profitable. The amount of grouper trade at Fukuoka Market was largest among the 3 sites, although Tokyo Market is generally the leading market for many species in Japan. However, the farmers appear to have troubles in the lack of marketing channel. Therefore, the farmer should develop local

sales channel to expand their trading amount. It is also clear that there were seasonal changes in the price and dealing amount of the groupers. The seasonal changes are advantageous to the grouper culture since the time and amount of harvest in culture system can be controlled. On the other hand, the technical problems such as low growth, quality control (abnormal formation and dirty coloration, etc.), diseases, also appear constrains in the expansion of grouper aquaculture in Japan

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, Vol:54:2. Pp 187-194.

The authors examined the influence of different water temperatures (24, 26,and 28 ℃), 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 *l* tanks.
As a result of examination, authors showed that survival and growth at 26℃ were better than other temperatures. The more rotifer densities are, 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 three trials of mass seed production of kelp grouper in 100 or 150 *kl* tanks. In this trials, temperature, rotifer density and light intensity were regulated at 26℃, 20-30 ind./*ml,* and 1,100-2,500lx, 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 three 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., Kuriyama, I., Kuromiya, Y., Kashiwagi, M., 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 observed occurrence of VNN.
Additionally, VNN occurred when cultivating juveniles of sevenband grouper with the sand filtered seawater though VNN did not occur when juveniles was cultivated with ozonated seawater. These methods are effective as VNN control measures in the mass seedling production of sevenband grouper.

Tsuchihashi, H., Yamashita, H., Onoue, S., Kanashiro, K., and H. Nakamura. 2009.
Grouper aquaculture being advanced in various regions of Japan.
Aqua culture magazine, Vol:578. Pp15-26.

This article introduces the approach of groupers cultivation done in various places in Japan. The cultivation of Longtooth grouper, *Epinephelus bruneus*, and Sevenband grouper, *E. septemfasciatus*, are done in Mie, Ehime and Oita Prefectures. In Okinawa Prefecture, Malabar grouper, *E. malabaricus*, is cultivated. To make the grouper cultivation succeed, these prefectures are doing various attempts. For instance, the workshops of grouper cultivation method were held for the farmer who tries 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 have already being sold for the farmer, and the prefecture is putting out the subsidy to the farmer. On the other hand, occurrence of VNN (viral nervous necrosis) or iridovirus disease becomes a big problem in these groupers cultivation. The vaccine development with these diseases is tried. Additionally, cultivation with the close circulation system on land is 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), COMMERCIAL FARMING OF SHRIMP IN JAPAN AND US, NOW A REALITY!

Addison L. Lawrence

Texas AgriLife Research, Texas A&M System, 1300 Port Street, Port Aransas, Texas 78373, USA

Email: smpall at yahoo.com

The first production of shrimp in ponds occurred near Kogashima, Japan in the mid 1930's. Though this farm was not commercially successful, it did suggest potential for the future. First attempts in the United States occurred in the 1950's in South Carolina. By the early 1960's, projects were also underway in Texas and Florida. Though commercial production was initiated in the late 1960's, the value of farmed shrimp was still less than 2 million USD 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 farming were developing exponentially. In the US, the production of farmed shrimp reached approximately 30 million USD per year; for the world over a billion USD per year by 2000. With the tremendous increase in number of hectares of ponds in production, and transfer of the technology for production of five to ten metric tons per crop with one crop per year in the US to the tropics with two to three crops per year, the production in the US decreased to less than 20 million USD per year by 2008.

The inability for US farmers with a limited growing season to compete with the tropics with year around growing season became evident. Evidence indicated that for the US farmer to be competitive, technology would have to be developed to produce shrimp in the US year around, and not only on the coast, but also inland. This demanded the production of shrimp in raceways in buildings. Economic analyses indicated that to be able to obtain a satisfactory internal rate of return on investment a growth rate greater than 1.2 gms/week, survival above 75%, production of at least 20 gms shrimp and production levels equivalent to 150 metric tons/hectare/year had to be obtained. The initial attempts in the mid 2000's 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 over 300 metric tons/hectare/year with growth rates of over 1.5 gms/wk, survival of greater 75%, production of over 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 US and Japan is commercially feasible.

Annotated Bibliography of Key Works

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 over 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. Pages 236-243 in T.T. Rakestraw, L.S. Douglas, L. Marsh, L. Granata, G.J. Flick, eds. Proceedings of the 7th International Recirculating Conference, Roanoke, Virginia, July 25-27, 2008

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. Pages 226-235 in T.T. Rakestraw, L.S. Douglas, L. Marsh, L. Granata, G.J. Flick, eds. Proceedings of the 7th International Recirculating Conference, Roanoke, Virginia, July 25-27, 2008

This paper showed that the 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 optimum.

Hanson T.R., A.L. Lawrence, B.C. Posadas. 2006. Economics of partial harvesting in super-intensive recirculating shrimp productions raceways. Pages 15-22 in 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, Virginia, USA.

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*[1] and Makoto Yamasaki*[1]

[1]Aquaculture Systems Division, National Research Institute of Aquaculture, FRA, Mie 516-0193, Japan

E-mail address: ttakasi at fra.affrc.go.jp

Yellowtail (Japanese amberjack) is one of the most important commercial fish in the mariculture industry of Japan. The total yellowtail catches by capture fishery and mariculture are 230,000 tons, and about 70 % (158,300 tons) of the catches are supplied by mariculture. Furthermore, the cultured yellowtail production occupies 60 % of the total mariculture productions.
Recently, price of the cultured yellowtail tends to have lowered. Although, in the 1980s, the price of yellowtail was at a high value of about $16 per kilogram, it cheapened afterwards year by year. At the present, they are sold at low prices, about $7.5 - $8.5 per kilogram. It is considered that low price strategy by the retail store such as supermarkets is a large factor on this price. This fact has shown the situation of which the pricing power of the producer has been lost. This low price inflicts heavy damage on the financial management of fishermen who conduct yellowtail culture. To increase business efficiency, fishermen carry out management effort such as cost reduction and extension of the culture scale. However, some of fishermen close a business.
In this presentation, we introduce an example about the role of fisheries cooperative to discuss fisheries communities. In Tachibana Bay in Nagasaki prefecture, seven fishery households conduct Yellowtail mariculture. However, they have faced on the financial crisis causing the low price of cultured Yellowtail. To improve their management, the fishery households and fisheries cooperative association have conducted original approaches to maintaining profitability. The fishery households combine the Yellowtail mariculture each other and unify the feeding procedure to be the same quality of Yellowtail products. The Yellowtail is currently sold as the Unzen-brand Yellowtail. Furthermore, they create their own marketing networks such as hotels, local markets, fishery-outlet stores and internet mail-order to sell at remunerative prices.

Annotated Bibliography of Key Works

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[1], James L. Anderson[2]

[1] Goucher College, 1021 Dulaney Valley Road, Baltimore, Maryland 21204

[2] University of Rhode Island, 1 Greenhouse Road, Kingston, Rhode Island 02882 USA

Email: gina.shamshak at goucher.edu

This research presents a bioeconomic framework for assessing the economic feasibility of an offshore bluefin tuna 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 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 net present value (NPV) and expected internal rate of return (IRR), as well as the distribution of those values over a ten 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.

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-Based 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 thynnus*, Linnaeus, 1758) as a Result of the Fattening Process." Aquaculture **249**: 303-309.

Aguado-Gimenez, F. and B. Garcia-Garcia (2005b). "Growth, food intake and feed conversion rates in captive Atlantic bluefin tuna (*Thunnus thynnus* Linnaeus, 1758) under fattening conditions." Aquaculture Research **36**: 610-614.

Ikeda, S. (2003). Market and Domestic Production of Cultured Tuna in Japan-Cultured Tuna in the Japanese Market. Proceedings of the Symposium on Domestication of the Bluefin Tuna, *Thunnus thynnus thynnus*, Cartagena, Spain, Cahiers Options Mediterraneennes

Katavic, I., V. Ticina and V. Franicevic (2002). "A Preliminary Study of the Growth Rate of Bluefin Tuna From Adriatic When Reared in the Floating Cages." ICCAT Collective Volume of Scientific Papers **54**(2): 472-476.

Katavic, I., V. Ticina and V. Franicevic (2003a). "Bluefin Tuna (*Thunnus thynnus* L.) farming on the Croatian Coast of the Adriatic Sea-Present Stage and Future Plans." Cahiers Options Mediterraneennes **60**: 101-106.

Katavic, I., V. Ticina and V. Franicevic (2003). Rearing of Small Bluefin Tunas (*Thunnus thynnus*) in the Adriatic Sea- Preliminary Study. Proceedings of the Symposium on Domestication of the Bluefin Tuna, Thunnus thynnus thynnus, Cartagena, Spain, Cahiers Options Mediterraneennes

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.

Ticina, V., I. Katavic and L. Grubisic (2007). "Growth Indicies of Small Northern Bluefin Tuna (Thunnus thynnus, L.) in Growth-Out Rearing Cages." Aquaculture **269**: 538-543.

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." Aquaculture Economics & Management **9**(3): 369-387.

VALUATION OF ECOSYSTEM SERVICES IN RESTOCKING WITH FRESHWATER FISH

Shin-ichiro Abe*[1], Yasuji Tamaki*[2] and Kei'ichiro Iguchi*[1]

[1] Freshwater Fisheries Research Division, National Research Institute of Fisheries Science, Fisheries Research Agency, Komaki 1088, Ueda, Nagano 386-0031, Japan

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

E-mail: shinabe at affrc.go.jp

Ayu (*Plecoglossus altivelis*) are the important fishery recourses providing the commercial and recreational benefits to the local communities in the Japanese hilly and mountainous areas. However in the most of the rivers flowing in these areas the fishing sports for ayu are kept expensively by restocking with ayu-young because a series of dams often impede their upstream migrations. This study valuated the several nonmarket services provided from restocking with ayu to reveal these benefits that would remain hidden or unappreciated. Results of the contingent valuation showed that the satisfaction derived from the residence near the rivers inhabited by ayu was equivalent to \ 58,440 (US $ 613.2) in annual payment per person. In addition the entertainments using ayu, such as ayu-releasing, lessen in ayu-angling and observation of river organisms, would be interested by many Japanese people and the benefit for one time participation was estimated about \ 1,600 (US $ 18) per person. Furthermore, ayu-restocking and ayu-fishing have a function of improving eutrophication by preventing benthic algal bloom and by removing nutrients from the waters, respectively. In terms of the running cost of sewerage system, the annual benefits of the two functions of ayu-restocking and ayu-fishing varied in rivers from \ 8.1 to 48.2 × 106 (from US $ 85 to 503 × 103) and from \ 0.3 to 213 × 106 (from US $ 3.6 × 103 to 2.2 × 106), respectively.

Annotated Bibliography of Key Works

Abe S., H. Saito, H. Sakano and Y. Tamaki. 2006. Economic evaluation of freshwater fisheries providing the function of nutrient removal from Inland waters in Japan. Aquaculture Science 54: 553-560 (in Japanese with English abstract).

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 replacement cost method. The economic value was estimated as the running cost of sewerage 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 9 lakes in Japan. The amount of the nutrients removed by freshwater fisheries was highest in 1981, reaching 1132 t of nitrogen and 105 t of phosphorus, and evaluated at 23.3 billion yen as the economic value. However the economic value was reduced to 9.1 billion yen 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.

Minagawa T., S. Fukushima and Y. Kayaba. 2006. A study on visual assessment of periphyton for flow management. Civil Engineering Journal 48: 58-63 (in Japanese).

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

Tamaki Y. 2007. Case study of valuating the multiple functions of freshwater fisheries and fishery villages in Japan. Journal of the North Japan Fisheries Economics 35: 215-226 (in Japanese).

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 cost and evaluated at 2166 to 3248 million yen. Economic values of their activities to exterminate alien fish were evaluated at 368 to 552 million yen as labor cost, although the nonuse benefits of exterminating exotic fish that Japanese people had were estimated at 29.9 to 108.4 billion yen by the contingent valuation method by a questionnaire survey in December 2005 using internet communication service. In addition the economic values of two anonymous riverine fishing spots were estimated at 250 and 229 million yen by the travel cost method.

IMPLICATIONS OF AQUACULTURE FOR 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

Email: Gunnar.Knapp@uaa.alaska.edu

Worldwide aquaculture production is growing rapidly. The experience of Alaska wild salmon 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 salmon.

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.

Annotated Bibliography of Key Works

Knapp, G. 2008. Potential Economic Impacts of U.S. Offshore Aquaculture. In NOAA Aquaculture Program, Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities (Pre-Publication Copy). http://aquaculture.noaa.gov/news/econ.html.

Knapp, Gunnar; Cathy A. Roheim; and James L. Anderson. 2007. The Great Salmon Run: Competition Between Wild and Farmed Salmon. 301pp. TRAFFIC North America. Executive Summary available at http://www.traffic.org/fish/. Full report available at www.iser.uaa.alaska.edu/iser/people/knapp.

Asche, Frank; Atle G. Guttormsen; Tom Sebulonsen; and Elin H. Sissener. 2003. Competition between farmed and wild salmon: The Japanese Salmon Market. Centre for Fisheries Economics, Institute for Research in Economics and Business Administration, Bergen, December 2003. Working Paper No. 44/04. http://bora.nhh.no:8080/bitstream/2330/418/1/A44_03.pdf

REVITALIZING FISHING VILLAGES THROUGH SIGHTSEEING FISHERIES IN JAPAN

Yasuji Tamaki

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

In Japan, beach seine, set net fishery, gill net fishery, small-scale trawl fishery, basket net or pot fishery are major types of sightseeing fisheries. Aquaculture also promotes exchange between urban and fishing villages. About these, I introduce a case study in Japan and I discuss the role that sightseeing fisheries serve as in fishing village activation.
Sightseeing fisheries can be divided into 3 categories according to participation style. (1) is on an individual basis. This type includes trips that do not use fishing boats, but collect shellfish and seaweed, trips offered by tourist home 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. (2) is for families and small groups. This type operates small scale trawl net and small-scale set net fishery on a charter basis, in which the customer keeps all that is caught and uses ships that can accommodate a fair number of people. (3) is for large groups. Its main operational areas are those that require large groups of participants, like beach seine, those that do not use ships, such as barrier net fishery, and large scale-set net fishery operations on a charter basis. As for the charge, type (1) is the cheapest and is often provided free by tourist home to overnight guests as a courtesy. As for type (2), the price will be at the same level as for a day's income from fishing or above, since the catch is given away to the customers. Type (3) has the highest charges, since it requires manpower, but when recalculated on a per-person basis it turns out to be comparably cheap.
Sightseeing fisheries can bring in larger incomes for shorter operating hours and smaller landings. This lowers the risk of overfishing and depletion of marine resources, and 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.

Annotated Bibliography of Key Works

Yasuji Tamaki. 2003. Evaluation of the fishing village activation effect by a fishing ground creation and urban interchange. Bull. Fish. Res. Agen. No. 8: 22-111.

The author did a chief ingredient analysis using six indexes related to economic performance and six indexes 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. It became clear that it profits to add it with store of an example investigation, effective, think about a regional activation policy though getting typical method by means of many indices grasps a regional characteristic.
As one of regional activation method, though the fishing ground creation of an artificial reef establishment is enforced with every land. The author did an example analysis of an artificial reef. Fishermen do a resources management spontaneously and restrict a fishing term, fishing method with an artificial reef range with this example for an artificial reef establishment in an opportunity. It became obviously that this attained a large part for an effective utilization of an artificial reef. And, it is not long since an artificial floating reef was established, actual situation solving of utilization, a management and an economically effective evaluation weren't done enough until now. The author did an example analysis. The result, establishment of an artificial floating reef brought about a direct effect called an increase of a catch quantity and revealed many indirect effects such as a profits increase of a fisheries cooperative association, in oil reduction of fishermen, operating hours shortening, extension of a fishing term further. The result, artificial floating reef made to bring about 2 ~ 5.6-times effect of the cost that needed for an establishment and a maintenance. At a distant island, fishery plays a great part at a regional economy. While bottom fish resources decrease, collect of a migratory fish an establishment of a artificial floating reef, is valid as a regional activation measure.
A fishing village has for various valuable regional resources that there isn't for a city. By an interchange, a corporation with an urban resident by a valid application of regional resources, a trial to plan an activation of a fishery area is done in many fishing villages. Next the author did a statistical analysis and questionnaire survey analysis about a fishermen's inn to be able to

become a nucleus of an interchange. The number of people and experience menu that 1 fishermen's inn can correspond is a few. However, it can correspond to various needs of urban residents, by corresponding to it in the fishing village whole area and be related with an activation of the fishing village whole area. Further, the author analyzed about fishing village activation by an experience fishery by a fishing method. As being uselessness for a special facilities establishment for an experience fishery, a fishery person can easily do. In recent years, a guest number for an experience fishery is decrease by a depressed influence. On the other hand, a school to do fishery experience as a general learning increases.

TECHNOLOGIES TO BRIDGE THE GAP BETWEEN FISHERIES AND AQUACULTURE

Clifford A. Goudey [1]

[1] C.A. Goudey & Associates, 21 Marlboro Street, Newburyport, MA 01950 USA

Email: cliffgoudey at gmail.com

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 through retraining programs.

The problem may rooted in the introduction of forms of aquaculture that merely compete for space while not presenting opportunities that take advantage of fishermen knowledge and skills or allow the continued use of their existing investments in operational assets. By factoring these aspects into aquaculture development, not only can the conflicts between these sectors be reduced, but also both sectors can benefit from a synergy that results in stronger seafood markets and more viable business ventures.

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 the most 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 others besides fishermen.

This paper will discuss historical examples of fishermen/aquaculture conflict and cooperation by siting examples from New England and the tropics. Also presented will be recent developments related to mobile cage technology and how such advanced technologies can allow the large-scale expansion of fish farming. Recent full-scale self-propulsion tests of a 3,250 cu m. sea cage will be described and prospects for mobile cage operations will be discussed.

Annotated Bibliography of Key Works

Goudey, C.A. 1998. Model Tests and Operational Optimization of a Self-Propelled Open-Ocean Fish Farm, in Proceedings Offshore Technologies for Aquaculture, ed. A. Biran. Haifa, 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, D. Leavitt. 1998. Sea Scallop Enhancing and Sustainable Harvesting, The Seastead Project. Report from Westport Scalloping Corporation 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 nine-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 JAPAN AND ALASKA

William R. Heard

NOAA/NMFS Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Pt. Lena Loop Road, Juneau, Alaska 99801

Email: bill.heard at noaa.gov

Japan and Alaska have two of the largest and most developed Pacific Rim salmon hatchery programs. These programs vary considerably in complexity with diverse objectives and operational procedures but still have many similarities in common. 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.

Private groups of fishermen operate most hatcheries in both countries including Prefectural Fisherman Cooperatives in Hokkaido and Honshu and Private-Non Profit Regional Aquaculture Associations in five major regions of Alaska. In both countries salmon catches are taxed under a user-pay system to help pay cost of hatchery operations. Both systems focus on pink or chum salmon production and both systems extensively use short-term rearing of these fry to improve marine survivals.

Several important exchanges between Japanese and Alaska scientist helped forge some of these similarities in the two hatchery programs. The Governor of Alaska sent his Chief of Staff and four others to participate in the 1982 UJNR Meeting in Tokyo and to tour hatcheries on subsequent field trips. Another exchange between these salmon hatchery programs occurred in 1993 during the 23rd UJNR Meeting in Homer, Alaska when scientists from both countries reviewed Alaska's hatcheries together. Other exchanges occurred in 1976 and from 1982-1984

when scientist and engineers from Alaska Department of Fish and Game studied many Japanese salmon hatcheries on Hokkaido and Honshu.

There also are many differences between hatchery programs in Japan and Alaska. Japan's salmon production, almost totally dependent on hatchery production, has eliminated many wild or native populations, caused in part by wide spread egg transplants between hatcheries. Alaska's salmon production strives for a balance between wild and hatchery production with a priority given to protecting and maintaining wild stocks. Closely regulated egg transfers in Alaska are limited to local hatcheries within a limited region where brood stocks originate from wild stocks in the same region.

In 2007 over 70% of 5 billion juvenile salmon released into the Pacific Ocean were from Japan (2.01 billion) and Alaska (1.6 billion). For the first time ever the commercial catch of Pacific salmon reached 1 million tonnes in 2007 and Alaska and Japan accounted for two-thirds of this total catch. Over 90% of Japan's catch was hatchery chum salmon while Alaska's chum and pink salmon catch was 67% and 43% respectively of hatchery origin. Increased world wide production of farmed salmon has impacted economic viability of hatchery production of salmon in both Japan and Alaska.

Annotated Bibliography of Key Works

1. 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.

2. 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 > 5cm 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.

3. White, B. 2009. Alaska salmon enhancement program 2008 annual report. Alaska Dept. Fish and Game, Fishery Management Report No. 09-08. Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1565. 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. Private non-profit (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.

4. Kaeriyama, M., and S. Urawa. 1993. Future research by the Hokkaido Salmon Hatchery for the proper maintenance of Japanese salmonid stocks, pp. 57-62 *in* 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. 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 over 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.

STOCK ENHANCEMENT PROGRAMS OF A FISHERIES COOPERATION OF A BRACKISH LAKE IN JAPAN

Satoshi Katayama

National Research Institute of Fisheries Science, FRA, Nagai, Yokosuka, Kanagawa 238-0316, Japan

Email: skata at affrc.go.jp

Lake Ogawara is a brackish water lake located on the Pacific side of northernmost Honsyu, Japan and covers an area of 63.3 km^2. The northern section of the lake is connected to the Pacific Ocean by the 6-km-long river, through which sea water is brought into the lake by tidal flow, making the lake some what salty, 0.8-1.0 PSU. Harvest of pond smelt *Hypomesus nipponensis*, glassfish *Salangichthys microdon*, and brackish clam *Corbicula japonica* between the years 2002-2006 average 445, 420, and 2156 tons a year, respectively.

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

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

Environmental characteristics of the lake highly related to life histories of these species, e.g. oligosaline condition is essential for ontogenetic development of the clam, parts of the populations of pond smelt and glassfish display anadromous migration through the out-flowing river, and a part of pond smelt population spawn in the inflowing rivers. So fishermen have strong consciousness to the environments of not only the lake, but also its adjacent areas. The cooperation leads local administration and social agreement for environmental protection of the lake. All programs were independent actions of the fishermen and the cooperation. Seed release

and artificial introducing from other habitats have not been carried out. The cooperation, however, maintains high fisheries production through efficient fisheries managements promoted by fisheries scientists.

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 five specimens from the river, and 36.8mm-63.8mm for three from the lake. These findings suggest there is a wide variation in life history for S. microdon, 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 egg laid on the sandy bottom. Based on the presence and status of the sampled eggs, it was estimated that the shirauo spawned in shallow (≈ 1m) 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, 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 *Corbicula* species, 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. On 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[1*], William H. Neill[2], John R. Gold[3], Michael S. Ray[1]

[1] Texas Parks & Wildlife Department, 4200 Smith School Road, Austin, TX 78744-3291, USA

[2] Dept. Wildlife & Fisheries Sciences, Texas A&M University, 2258 TAMUS, College Station, TX 77843-2258, USA

[3] Center for Biosystematics and Biodiversity, Texas A&M University, 2258 TAMUS, College Station, Texas 77843-2258, USA

Email: robert.vega at tpwd.state.tx.us

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 (U.S.) coastal communities. The Texas saltwater recreational fishery, with about 1.2 million fishermen, is presently worth $1.7 billion per year (U.S. dollars); 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 1970's, apparent abundance of red drum in Texas waters reached alarmingly lows. Stocking red drum fingerlings to enhance the wild population was initiated in 1975, with a large-scale stocking program coming on-line in1983. To date, more than 568 million red drum fingerlings have been hatchery-produced and then released into Texas coastal bays. At least partly in 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 40%. 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, Texas Parks & Wildlife's 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 one 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 lower 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 technique of hatcheries 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 presentation 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.

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. Journal of Applied Ichthyology, 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 vs the expected fe of 36.0 (95% CI = 33.3–38.4) if reproductive success was randomly distributed among breeders. The significantly lower founder equivalent 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, and /or variable survival of families during early larval and/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 & estuaries. North American Journal of Fisheries Management, 28:1294-1304.

The stock enhancement program for red drum *Sciaenops ocellatus* in Texas annually releases from 25 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 three year-classes sampled from Galveston Bay, while a total of 11 hatchery-released fish were identified among 970 red drum belonging to four 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. Pages 53-56. In: Marcia R. Collie and James P. McVey, editors. 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. Technical report /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. TPWDs 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, pp. 11-15. In: A. K. Sparks (ed.). Marine Farming and Enhancement: Proceedings of the 15th U.S. Japan Meeting on Aquaculture. NOAA Technical Report NMFS 85. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Washington, D.C.

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 FISHERY AND REVITALIZATION OF TOURISM BASED ON TIGER PUFFER STOCK ENHANCEMENT IN THE TOKAI REGION OF JAPAN

Shigenori Suzuki*[1], Masaharu Machida*[2], and Masahiko Nariu*[1]

[1]Minami-Izu Station, National Center for Stock Enhancement, Fisheries Research Agency (FRA), Irouzaki, Minami-Izu, Shizuoka 415-0156, Japan.

[2]Miyazu Station, National Center for Stock Enhancement, Fisheries Research Agency (FRA), Odashukuno, Miyazu, Kyoto 626-0052, Japan.

Email: sshige at affrc.go.jp

Kanzanji Spa Resort, located in Hamamatsu City, Shizuoka Prefecture, once flourished and attracted many tourists during the 1970s thanks to its convenient accessibility from metropolitan areas and the existence of nearby leisure facilities. Nevertheless, the number of tourists to the Kanzanji Spa Resort has decreased since the 1980s because the mode of Japanese domestic travel has shifted from group-based trips to individual travel, and because the main motive of visiting spa resorts has changed. They 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 revitalizing this area.

Meanwhile, as a result of 1989's Tiger puffer, *Takifugu rubripes* good catch, members of Hamana Fisheries Cooperative Association in Hamamatsu City drastically began to catch for Tiger puffer, a kind of fish that had previously attracted little attention. Consequently, the Tiger puffer catches grew rapidly. However, because there was no custom by which people ate pufferfish for food in Shizuoka Prefecture, the caught Tiger puffer were rarely consumed locally. Most were instead transported to western Japan by truck. After the Kanzanji Tourist Association learned of this, they began 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. However, because the catches of

Tiger puffer off the Hamamatsu are subject to frequent fluctuations under impact from the nature environment, they concluded that supplying Tiger puffer for food was difficult, especially if they depended solely on wild stock. Therefore, large-scale production and release of the artificial seeds of Tiger puffer was started in 2002.

This presentation will present the recent progress in stock enhancement for Tiger puffer and the tourism promotion measures in Kanzanji Spa Resort utilizing the Tiger puffer.

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, Vol: 16:1. Pp 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. 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. Vol:34. Pp49-52.

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, 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 Vol:10:1. Pp 41-48.

Off the coast of Hamamatsu in Shizuoka Prefecture are known as one of the largest Tiger puffer fishing ground 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 yen 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 yen.