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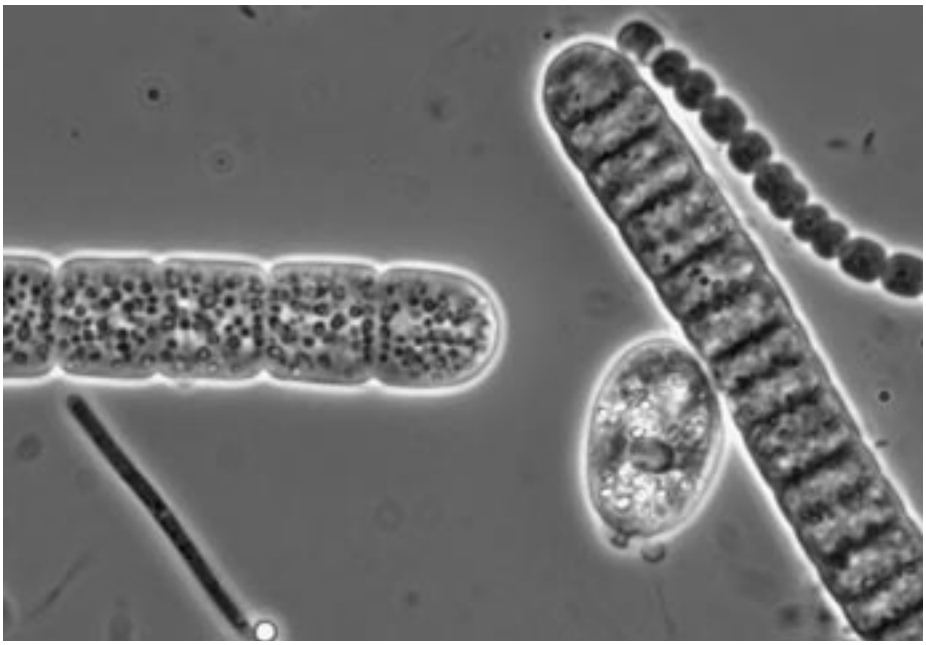
Off-Flavor Tastes in Aquaculture

Andy Lazur, Finfish Aquaculture Specialist

Summertime often means trouble with algal and bacterial growth in aquaculture ponds and tank systems. This growth, in turn, can be one key cause of "off-flavor" tastes in fish and shellfish, which pose a significant problem in the marketing of cultured seafood product. Most off-flavors are caused by compounds excreted by certain species of phytoplankton or bacteria. These compounds can be readily absorbed through the gills and enter the muscle and



fatty tissue. Because of the relatively dense phytoplankton blooms associated with intensively-fed production ponds, off-flavors are one of the most significant problems in the U.S. foodfish aquaculture industry today.

The catfish industry, the largest commercial foodfish segment, has experienced the most severe effects of off-flavor tastes. As much as 53% of the catfish

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Taste Test

Is Farm-Raised Seafood Really Better than Wild Caught?

Tom Rippen
Seafood Technology Specialist

We all know the potential benefits of aquaculture for supplying markets with consistent supplies, grades, and fresh quality, but future profits may depend on listening more carefully to customers. Worldwide, farmed shrimp from the tropics dominate the U.S. marketplace. Quality is generally very high and yet some consumers wonder why their favorite seafood does not taste like the shrimp they remember from years past. For the discriminating buyer, the mild flavor of farmed shrimp only superficially compares to the full flavored shrimp trawled from the Gulf of Mexico. These differences are not widely recognized by most consumers but they could affect future sales or margins as awareness grows.

A similar story is playing out for farmed salmon. Even as salmon reared in net pens have made these products staple items on many

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Contents

Oscillatoria spp.

Anabaena spp.

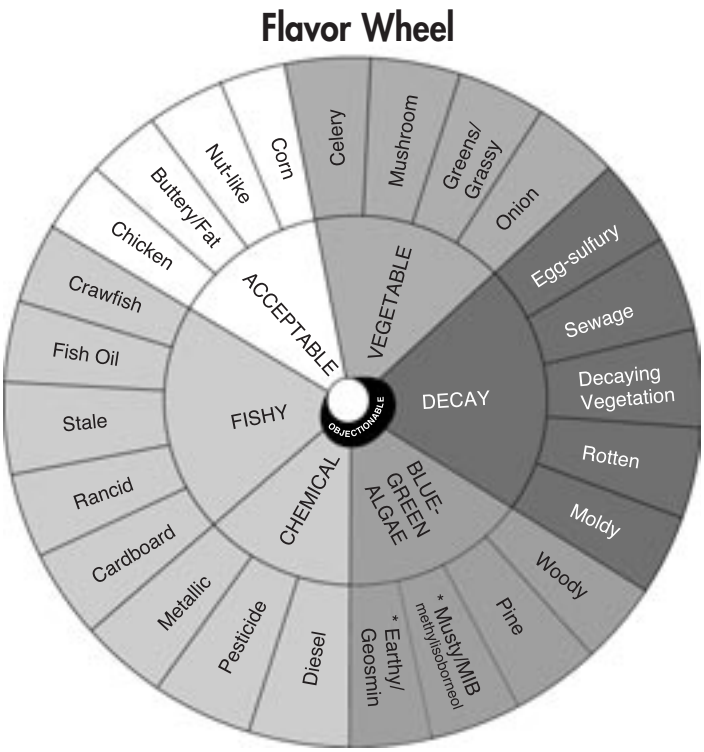
Off-Flavor, *continued*

ponds have reported delays in harvesting due to off-flavor. One estimate suggested that off-flavor problems increased the cost to the industry by 15 to 23 million dollars, an additional 3 cents per pound, annually. Although the fish are safe to eat, farmers tend to delay harvesting for market value and hold onto them until they are back "on-flavor" prior to selling, which can take anywhere from a few weeks to a few months. Holding fish creates significant economic challenges for farmers because of increased feed and management costs and the potential risk of producing fish too large for desired markets.

There are many types of off-flavors and associated terms to describe them: decaying, rotten, cardboard, petroleum, stale, fishy, woody, earthy or muddy and musty, to name a few. Muddy and musty are the most common off-flavors and are caused by metabolic products released from certain blue-green algal species. The metabolic products geosmin or methylisoborneol (MIB) are released from the blue-green algae *Anabaena* spp. and *Oscillatoria* spp. respectively. These compounds are absorbed through the gills and transported via the bloodstream to the flesh. As little as 0.7 parts per billion (ppb) of MIB and 6 ppb of geosmin can be detected by the human palate. The uptake of these two compounds can be relatively fast, within several hours, especially after a plankton die-off of the off-flavor-causing algal species. These compounds can accumulate in tissues and fish with greater fat content tend to accumulate off-flavors faster than leaner ones.

Populations of algae that cause off-flavor will vary from pond to pond, but are more common during summer months when feeding rates are higher and there are increased phosphorus inputs that stimulate phytoplankton production. Although most off-flavor problems occur in the summer and fall months, they do still occur at times when populations of the off-flavor algae species are low or non-existent. Occurrence of off-flavor when the causative algae species are not present results from the residual nature of geosmin and MIB. These compounds and other off-flavor compounds do break down over time in ponds and are purged from the fish when levels in the pond subside. But this can take weeks to months depending on the concentration of off-flavor compound, water temperature and quality. Cooler water temperatures slow the rate at which the compounds are purged from fish. The woody and petroleum off-flavors tend to persist longer (Note: even minor fuel spills in ponds can cause long lasting flavor problems.)

Holding fish in raceways with flow-through well water can purge geosmin and MIB off-flavors from



Flavor descriptors commonly used by fish taste panels in testing pre-harvest, pond-raised catfish. Musty and earthy are among the few flavors where the associated compound is known. GRAPHIC FROM MARTINE VAN DER PLOEG.

fish. Purging usually takes several days at a minimum and can require up to 2 weeks. This process will also increase costs due to additional harvesting and handling, tank facility overhead, water pumping, fish weight loss and mortality. Using a recirculating system for purging may reduce pumping cost, but can present additional off-flavor problems if proper filtration is not used.

Management strategies for off-flavor are limited. This is due in part due to the variety in off-flavor and causative compounds. In the case of geosmin and MIB, some recommended techniques have been developed. The first management tool for farmers is testing. Some farmers still rely on the processor to test for off-flavor. It is however, a good idea for farmers to do their own tests to be able to make decisions based on the degree and change in off-flavors. Testing fish is simple. It requires cooking the fish in a microwave and evaluating the flavor by tasting and assigning grades based on a standard grading scale of 0 to 3. On flavor is a 0, slightly off-1, distinctly off-2 and strongly off-3. Farmers should be consistent with their testing methods and record results so they can track the change in off-flavor. A pond that has gone from a distinct to slight off-flavor may indicate that the off-flavor is clearing up and fish may soon be ready for market. Begin tasting testing fish well in advance of them reaching market size and follow up with regular weekly testing. This process will aid in deciding when to market fish.

Understanding and managing off-flavor has been the subject of a great deal of recent research. Most work has focused on controlling the populations of odor-causing algae species and developing algicidal compounds. Results have not been altogether promising. To date, the recommended best management practices include: careful attention to prevent overfeeding ponds, monitoring off-flavor through testing, tank purging fish, and controlling blue-green algae with copper sulfate or diuron. Use of these two approved herbicides is not always effective and should be used only when off-flavor algae is present. In addition, there are several concerns when using copper sulfate including toxicity to fish in low alkalinity waters, build up of free copper with frequent use, and inducement of low dissolved oxygen due to dying algae and reduced photosynthetic activity.

Off-flavor can be a significant marketing and economic problem and requires consistent quality evaluation to identify the presence or degree of off-flavor. All producers of food products, regardless of the production system used, would benefit by establishing a monitoring program and management plan for the event of off-flavor occurrence.

For more information on off-flavor, check out these sources:

Johnsen, P.B. and C.P. Dionigi. 1993. Physiological approaches to the Management of Off-Flavors in Farm-Raised Channel Catfish. Journal of Applied Aquaculture 3(1-2):141-161.

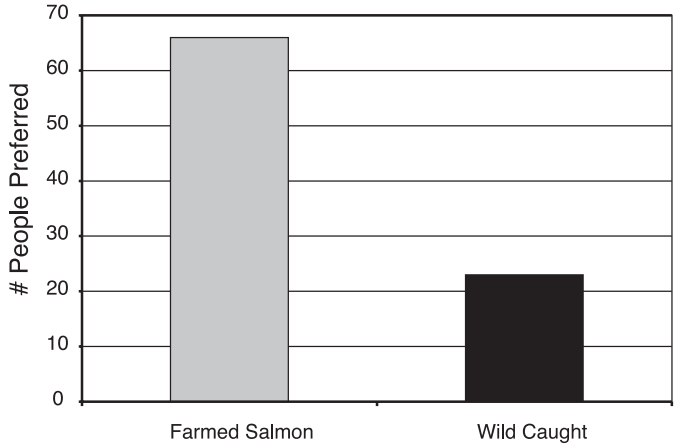
Rimando, Agnes M. and K. Kevin, eds. Off-Flavors in Aquaculture. Schrader Oxford University Press, U.S.A.

Tucker, C. and M. van der Ploeg. 1999. Management of Off-flavors in Channel Catfish Ponds. SRAC Fact Sheet 192.*

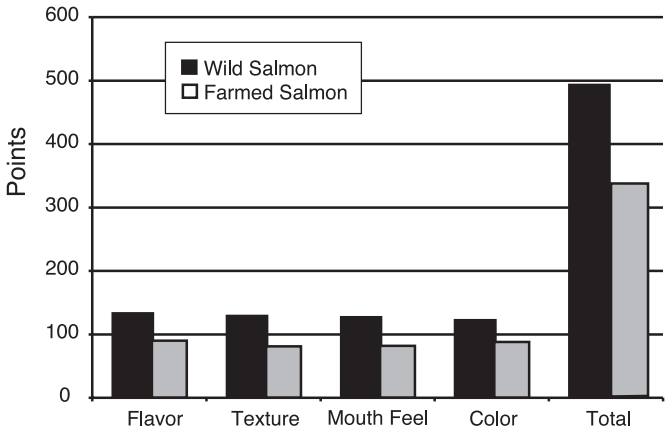
van der Ploeg, Martine. 1991. Testing Flavor Quality of Preharvest Channel Catfish. SRAC Fact Sheet 431.

* *Southern Regional Aquaculture Center.*

Opposing Views on Wild Caught and Hatchery-reared Salmon



American Culinary Federation, July 2004



Restaurant Nora, June 2000

Which Do Consumers Prefer? In a blind taste test held at the annual convention of the American Culinary Federation in July 2004, 89 culinary professionals compared farmed and wild sockeye salmon — 66 preferred the taste of farmed; 23 wild. In a similar battle of the palates, Environmental Media Services and SeaWeb held a salmon tasting in June 2000 at Restaurant Nora, a popular Washington, D.C. eatery. Each guest evaluated, on a scale from 1 to 10, the flavor, texture, mouth feel, and color of each fish.Wild salmon came out on top in all the categories, totaling 487 points out of 640 — 44% more than the farmed salmon, which scored 338 points. Survey results can be found at: www.ems.org/salmon/taste_test.html; http://www.wfga.net/news.asp?id=7157.

Taste Test, *continued*

restaurant menus and improved the diets of thousands of Americans, the demand for wild Pacific salmon has grown just as strongly. This high demand sustains retail prices for wild salmon that are more than twice as high as farmed salmon prices. Quality means different things to different people. Just as some prefer mild, flaky fish, others prefer rich, meaty fish. Premium wild chinook salmon is known for its rich, but not fishy, flavor, firm moist texture and appealing red color. These qualities are not seen in the more commodity-driven farmed salmon market.

Feed formulations are a major factor in determining the composition and taste of cultured seafoods. Adjustments to diet can significantly affect the flavor, color, fat content, texture and nutritional value of finished products. Aquaculture diet formulations based only on an analysis of cost versus animal growth may be too simplistic for the needs of some higher-end markets. Many consumers are aware of studies that report greater omega-3 fatty acid content in some wild fish compared to farmed fish. These oils are now widely recognized for their numerous health benefits. Opportunities should exist for fish farmers who recognize these market-driven concerns and manipulate omega-3 fatty acid composition appropriately. In higher-priced niche markets, careful selection of feed ingredients or growth conditions that add value to products may pay off economically.

The recent publicity of chemical contaminants in some cultured products has harmed the industry, even though levels of these contaminants are typically very low. Other consumers may turn away from certain farmed species after an unpleasant experience with off-flavors seasonally associated with some ponds. On the up side, such problems are often correctable by proper feeding and management practices and offer a level of control not possible in the wild capture fisheries. But any increased production costs associated with product improvements must be recovered. Cost recovery will be possible only by differentiating premium products from similar look-alikes, along with a targeted marketing program implemented by producers.

For more information contact: Andy Lazur, Finfish Aquaculture Specialist (410-221-8474) or Tom Rippen, Seafood Technology Specialist (410-651-6636), Maryland Sea Grant Extension Program.

How Well Does Barley Straw Control Pond Algae?

Dan Terlizzi, Water Quality Specialist

I believe it was President Harry Truman who once said that he would be able solve the world's problems if only he could find a one-handed scientist. Inevitably, scientists would present him with a technical view and follow it with the all-purpose caveat, "on the other hand." But equivocation is what makes science scientific, according to Albert Einstein, who reportedly said, "If we knew what we were doing, it wouldn't be research would it?"

These remarks well summarize the perspectives of both the public and scientists when it comes to the use of barley straw to control pond algae. Pond algae control is the major concern of pond managers in the area and the limited number of treatment methods can make this a real challenge. In the past, I have emphasized prevention methods based on water quality management, but some sort of additional direct application is invariably required. Typical treatments include copper sulfate, either Cutrine or the chelated form, or bluestone, which is mineral copper sulfate. Copper is an effective algicide but it can sometimes be toxic to other aquatic life. Recently, there has been a lot of interest in the development of alternative control methods.

The use of barley straw to control pond algae was pioneered in the 1980s in Great Britain, following the serendipitous observation that bales of barley straw that fell accidentally into ponds seemed to reduce algal growths. After several years of research overseas, it was evaluated by researchers in the U.S., including Bryan Butler and myself in a collaborative project with Hood College in Frederick, Maryland. Our combined results were far from conclusive. In laboratory studies, some types of algae could be controlled effectively by barley straw extracts, but the main target, green mat-forming algae, did not seem to be inhibited. On the other hand, (forgive me, Mr. President) barley straw did control several species of microscopic algae that often cause unusual odors or flavor in pond-cultured products. In follow-up studies, we have also found that some dinoflagellates — the single-celled phytoplankton that have been associated with fish death in the Bay and elsewhere — are inhibited by barley straw.

These results paint a somewhat confusing picture of how well barley straw controls pond algae. Field researchers studying pond-wide algae control in the U.S. have been largely frustrated and suggest that barley straw has no value in controlling pond algae. By contrast, a survey of pond owners conducted by Butler and several different reports over the past few years indicate that the majority of people using barley straw are happy with the results.

Recently, Tim Weybright, a Masters student working at the Natural Products Laboratory at Fort Detrick, Maryland, completed a study to detect the presence of certain chemi-

cals which can inhibit algae in barley straw. Using an assay based on *Microcystis*, a cyanobacterium consistently sensitive to barley, Weybright studied various chemical fractions of the barley straw extract and began a characterization to find out which chemicals acted as inhibitors. Through a series of extractions and size-based filtrations, he found that the responsible chemical fit the profile of polyphenolic compounds such as tannins, but of a larger size than has been previously reported. However, it appears that the presence of polyphenols alone does not explain barley straw's reported effects on algal growth.

Further evidence that barley straw may not be a golden algal management panacea has also recently emerged from the regulatory community. A lake manager in Minnesota — the Land of 10,000 Lakes (and 10,000 management problems) — who is happy with barley straw, recently queried the Environmental Protection Agency (EPA) about any permits he should be aware of in using barley straw treatments. EPA concluded that barley straw is not registered as an algae control treatment and thus the use of barley straw to control algae is not technically legal. I don't think that anyone really expects this to become an enforcement priority, but unfortunately, considering the expense of getting a treatment approved by EPA and the legitimate questions arising about efficacy, I am not optimistic about its future approval.

Pond Aeration Basics

Andy Lazur, Finfish Aquaculture Specialist

Aeration is a fundamental management tool for fish culturists and for commercial, recreational or water garden pond owners to provide a healthy environment and optimize fish growth. This is especially true during the warmer months of late summer and early fall. During this time, fish feeding rates tend to be at their highest and, combined with high water temperatures and subsequent high respiration rates, pond oxygen levels may reach stressful levels. There are several conditions that contribute to low oxygen in all types of ponds and, fortunately these can be remediated by the use of aerators.

A pond is a dynamic, living ecosystem with a variety of organisms that all interact and influence the daily oxygen budget. Plants, either microscopic phytoplankton or larger macrophytes, are the primary source of oxygen through photosynthesis but are also major consumers of oxygen via respiration. Bacteria, zooplankton, insect and fish all respire and depend on plant photosynthesis and diffusion to meet their oxygen requirements. Fluctuations in the key requirements of plant growth — sunlight, temperature and nutrients — will influence oxygen concentrations. For example, several cloudy days in a row are sufficient to reduce photosynthetic activity and cause lower oxygen concentrations. Suboptimal nutrient levels limit beneficial plant growth, causing low oxygen and excessive nutrients (primarily from overfeeding), and can lead to dense plankton blooms which cause extreme respiration rates and create low-oxygen situations.

As fall approaches, cool fronts can cause deeper ponds to turnover or destratify, resulting in mixing of the deeper and cooler, low-oxygen water with the warmer and more oxygenated surface waters. Depending on the volume of the deeper, low-oxygen layer, destratification can result in a major reduction in oxygen levels causing fish stress and mortality unless proper aeration is used.

The use of aerators is especially important to reduce low-oxygen periods caused by heavy algae blooms induced by high feeding rates, plankton die-offs and pond turnovers. There are many types of aerators suitable both for recreational, hobby or aquaculture production ponds. These include the paddlewheel aerator, vertical pump or fountain type aerator, propeller aspirator pump, and the diffused air system. These aerators are usually available in single phase or three-phase electric floating models and use different mechanical means of exposing water to air, involving

New Herbicide for Aquatic Weed Control

Don Webster, Marine Agent

Choices of herbicides for treating nuisance aquatic weeds in ponds have become quite limited in recent years, since the removal of several products from the market for economic reasons. With only a handful of approved chemicals available, pond managers have limited options to draw upon for their chemical control programs. During the last year, however, a new herbicide was listed and is available for use.

Triclopyr, (3,5,6-trichloro-2-pyridinyloxyacetic acid, triethylamine salt) is a product of Dow AgroSciences LLC that is now being marketed by SePRO as Renovate† 3. The company adds this to its existing line of aquatic herbicides that are available to treat a range of problem plants. This product is for use in controlling immersed, submerged, and floating aquatic plants in lakes, reservoirs, ponds, ditches, and non-irrigation canals that have little or no outflow in some instances. It may also be used in marshes and wetlands, and on woody and broadleaf plants on shorelines and banks near these aquatic sites.

The product is a selective systemic herbicide that enters the plant through its leaves and stems, and is translocated down to the roots, disrupting metabolism. While systemic herbicides tend to act at a slower rate than contact substances, they are also highly useful in controlling plants. The addition of an approved nonionic surfactant can enhance the herbicide's efficacy and is recommended by the manufacturer for better effect.

Renovate† 3 may not be applied to salt water bays or estuaries or to freely flowing rivers or streams. Care should also be taken to ensure that it does not flow into waters that are used for irrigation. There is a 120-day waiting period for these waters, or the level may be tested by laboratory analysis to check residual level. Aside from this, Renovate† 3 does not carry use restrictions for recreational purposes such as fishing or swimming or on livestock watering from the treated water. Among the aquatic plants that are listed for control by the product are alligatorweed, American lotus, Eurasian watermilfoil, pickerelweed, water hyacinth, water lily, and water primrose.

Permits must be obtained prior to use of this product and all of the usual stipulations exist. The applicator must first properly identify the problem plant, then choose the herbicide and application method that will deliver the most effective results. All safety equipment should be used and proper application and cleanup methods should follow. Continue monitoring the results to ensure that the intended plants have been controlled. When applied to ponds with significant coverage of problem plants, care should be taken to insure that decomposing plant material does not adversely affect dissolved oxygen concentrations in the body of water and lead to a fish kill.

There have been many changes in the stock of herbicides available over the years for treating aquatic weeds. This addition will be welcome as an alternative to the other products on the market. While we have not had personal experience with the product in Maryland as yet, other applicators and Extension specialists have spoken very positively about the results they have observed.

varied degrees of water movement. Matching aerator type and pond application to pond size, water depth, fish stocking and feeding intensity is essential for success.

Electric aerators and access to an additional emergency aerator for backup are recommended for commercial aquaculture ponds. Ponds with common stocking and feeding rates generally require a minimum of 1-2 horsepower per surface acre. The paddlewheel is used as a standard in large commercial ponds because of its relatively high oxygen transfer efficiency and ability to move large volumes of aerated water into the ponds. Vertical pump sprayer aerators that utilize a propeller to lift and aerate water are effective for smaller commercial ponds — two acres or less in size. In cases of heavier than normal stocking and feeding rates or ponds with species with reduced tolerance for low oxygen, such as hybrid striped bass, a greater horsepower rate per acre is recommended.

It is important to consider factors other than motor size and fish production criteria when selecting aeration equipment. For example, the depth of a pond will alter the effectiveness of an aerator. Ponds with water depth greater than five to six feet present a challenge in water quality and aeration management. The water mixing ability of many of the type aerators discussed earlier are ideally limited to water depths of up to six feet. Deeper ponds will often stratify and water quality can benefit from a destratifying type aerator such as a diffused air system or water blender.

Pond shape can also affect the type and amount of aeration. Long, narrow ponds can be difficult to aerate with one unit because the area of influence of an aerator is limited. In this case two or more aerators spaced equally apart may be required to adequately aerate and mix the pond.

Recreational ponds, with low stocking rates and little or no supplemental feeding, may not exhibit low oxygen conditions as frequently as production ponds. However, these ponds can experience oxygen problems due to destratification and plankton die-offs. In this case, fish loss can occur directly from the lack of oxygen or from related stress-induced parasitic or bacterial infections without supplemental aeration. Vertical pump sprayers are typically available at 0.5 to 2 horsepower and are a common choice for recreational ponds.

Shallow water pumps or the practice of flushing ponds with well water are often used as a less-expensive means to aerate ponds. But these methods are not effective. Pumping water or adding water through a sprinkler device provides very low oxygen transfer. Additionally, well water lacks oxygen to begin with and pumping is a less efficient means of exposing water to the air, the fundamental process of aeration. Water gardens are one exception, however, where healthy oxygen levels of 5 parts per million or higher, can be provided by an adequate population of aquatic plants and a simple pump driven waterfall which provides opportunity for atmospheric oxygen to diffuse into the water.

Since the daily oxygen cycle of ponds results in lower concentrations during the night-time hours, using electric timers to automatically operate aerators during the hours of midnight to 8:00 am is an effective way to improve aeration. But it does not eliminate need for routine visual inspection of timers to ensure proper time setting and aerator operation.

The benefits of aeration have long been demonstrated in many pond applications and are a fundamental tool in water quality management. The relative low cost of aeration is well rewarded with enhanced water quality and fish production for all types of ponds.

For more information on aeration:

Jensen, G. L., J.D. Bankston, and J.W. Jensen. 1989. Pond Aeration. SRAC Fact Sheets 370 and 371.*

http://srac.tamu.edu/370fs.pdf
http://srac.tamu.edu/371fs.pdf

* *Southern Regional Aquaculture Center.*

Aquaculture in Micronesia

Don Webster, Marine Agent, and Don Meritt, Shellfish Aquaculture Specialist

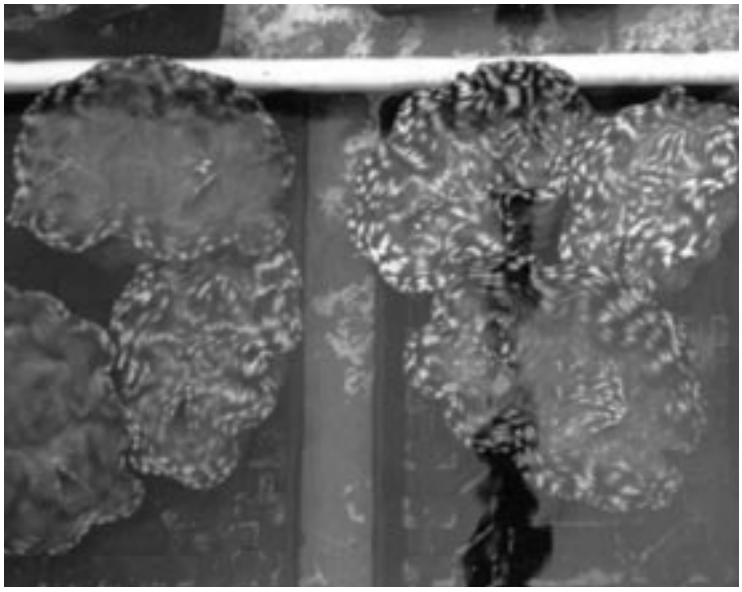
Lifelong learning is a key concept in Extension education. Going to other areas and absorbing different cultures is a way to broaden one's horizon and understand how different societies face change and cope with a world that seems to move at an increasingly rapid pace. In 2003, the authors had an opportunity to travel to Micronesia, a nation of island groups in the western Pacific, to observe its growing aquaculture industry. Since then, the authors have spent a great deal of time reading and learning about the history and social evolution of these islands, in the hope of returning again with an enriched knowledge of the people, their history, and challenges.

Micronesia's Place in the World

Micronesia consists of groupings of 607 islands located slightly above the Equator in the western Pacific. Ranging some 1,700 miles from east to west, the total landmass comprises only about 270 square miles. The Federated States of Micronesia (FSM) is made up of the four states of Yap, Chuuk, Pohnpei, and Kosrae. Each is culturally distinct — there are eight primary languages spoken throughout the range, with local dialects even noticeable between islands in a group. Human habitation occurs in varied environments, from small cities to farmsteads, with residents often commuting from rural outer islands to the more inhabited ones in open, outboard-powered boats. It is not unusual to see a family heading across a lagoon with children dressed for school and parents bound for shops or jobs.

The western Pacific experienced heavy fighting during World War II and many islanders suffered greatly during the last years of Japanese occupation. In the state of Chuuk in February 1944, United States Navy pilots carried out Operation Hailstorm, sinking the largest tonnage of shipping in history in a two-day period. Chuuk, also known as Truk, is now considered one of the premier wreck diving locations in the world, with more than forty ships resting within diving range in its large lagoon. The shallower wrecks are becoming reefs rich in biological life and it seems strange to see brightly colored coral and reef fish on items that, a half-century ago, were built for war.

Micronesia has been under the control of many nations over the years, including Spain, Germany, and



Eileen Ellis and Donald Meritt (left) at clam culture facility in Micronesia. Cultured *Tridachna* spp. (above). MICRONESIA PHOTOGRAPHS BY DON WEBSTER.

Japan. After World War II, the area was known as a "Trust Territory" of the United States and was administered by the United States Navy and the Department of the Interior. Today, citizens of the FSM rule themselves, under the umbrella of the Compact of Free Association with the U.S., which provides for U.S. economic assistance, defense, and other benefits in exchange for certain U.S. operating rights.

Aquaculture Goals and Tools

We arrived in the state of Pohnpei, the capital of the FSM, in April 2003 with the objective of seeing how aquaculture is being developed in the islands and how local citizens are being trained to participate in it. Because the contemporary lifestyle of Micronesian citizens still relies to a great extent upon natural resources, food production aquaculture does not mesh with the population's economic needs or societal institutions. Fish are readily available to local consumers at low prices so there is not a strong local market for cultured products. Importing feeds would be very costly due to the high price of transporting pelletized formulas from the point of manufacture to grow-out sites. Although there are several fish culture projects in trial stages, wild-caught fish are still an important food source.

Currently, most aquaculture in Pohnpei is directed towards the aquarium trade. Among the projects underway at the primary facility, the Marine and Environmental Research Institute of Pohnpei (MERIP) — part of the Pacific Agriculture and Trade School (PATS) — are efforts to investigate and teach the culture of the giant clam (*Tridachna* spp.), soft corals, and pearl oysters. Advances in culturing these animals have provided an income-producing enterprise for local people and are helping to conserve natural resources that have been harvested from natural reefs to supply a growing global demand.

Giant clam and coral production in Micronesia aims at supplying ornamental animals for the aquarium trade. The largest species of giant clam, *Tridachna gigas*, is currently extinct in the islands due to overharvesting in years past. Although there have been attempts to capture the spawn of these clams from their natural habitat to culture *T. gigas*, with the hope of trying to propagate them in local waters again, these efforts have been largely unsuccessful. Aquaculture of other species within the genus has been much more effective. At small sizes, these species are ideal for culture within saltwater aquaria and have encountered a ready market when available for sale.

Pearl oyster culture has been a lucrative industry in Japan for some time and, more recently in Australia, where oyster farms raise high quality pearls for the jewelry trade. Micronesia is in the early stages of developing a pearl oyster culture industry. Pearl oysters require infrequent maintenance and care and they are fed mostly through the natural populations of phytoplankton. During our

visit, the pearl oysters at the school were nearly large enough for insertion of the nacre — the substance naturally secreted by the mantle of certain mollusks to form a pearl — used in aquaculture to seed growth. While the oysters at PATS would not be ready to harvest for some time, another commercial venture on the island has already demonstrated that pearl oyster culture can be successful in Micronesia.

The MERIP facility provides lab and field support for education, while conducting these research programs in the development of aquaculture technology. Located on the coast, and constructed in 1998, MERIP contains both research and teaching laboratories, along with conference and equipment rooms and a SCUBA compressor room and dive locker.

For aquaculture, there are six 10,000-liter raceways, two 29,000-liter grow-out tanks, algal culture and specimen holding facilities, and a pearl oyster hatchery. The lagoon next to the institute serves as a demonstration area for new projects. The main pumping system delivers sand-filtered seawater.

Reaching Communities

Outreach and education are a crucial component of the aquaculture program in Pohnpei and PATS has been a force in education since it was established in 1965 by the Jesuits. The school teaches a variety of trades to high school-age students from Micronesia, the Marshall Islands, and other Pacific islands. The aquaculture program began operating in the 1990s with funding from the USDA Center for Tropical and Subtropical Aquaculture (CTSA). Educator Eileen Ellis directs this program, in which students learn subjects ranging from chemistry, biology, ecology, oceanography, and facility maintenance, to SCUBA skills for fieldwork. They gain hands-on experience in the hatchery and nursery areas with several products.

The integration of aquaculture research with solid teaching at high school age has been important in effecting social change. With more than two-thirds of Micronesians never completing high school, the graduates of PATS programs have become leaders in the society and are today are engaged in a range of vocations. The school stresses the importance of education in specific disciplines. While doing so, the school also seeks to train graduates who exhibit a concern for others, respect traditional values in this very interesting society, and develop leadership skills that stress service to the island nation.

Island-wide Impacts

MERIP Extension projects such as giant clam and pearl oyster culture are helping Micronesia change from subsistence to a market economy. Local projects have targeted species that are able to be cultured with low technology but yield a high value per unit of production. Similar to many such nations, Micronesia faces problems of rising population and a lack of real economic opportunity. Combined with a growing awareness of opportunities available in other parts of the world, citizens of the islands have begun to develop higher material expectations. At the same time, the islands have faced an exploitation of natural resources and a decline in the very species that have formed the basis of the tourism and fishing industries, which have historically provided the primary income source. Extension projects that help lower these pressures on natural resources and simultaneously outline alternative pathways to increased economic opportunity for rural island citizens should help to bring about long-term economic success.

Unique in the Pacific, the Pohnpei Agriculture and Trade School will likely make a difference in the history of the islands as well as the lives of its citizens. In a world that seems increasingly smaller with each passing year, it will be interesting to see how aquaculture evolves to help those on these islands connect with others and build an economy based on low-impact, sustainable culture methods.

Book Review

Shellfisheries History

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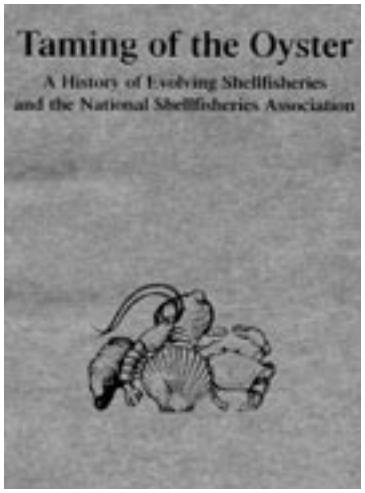
Taming of the Oyster: A History of Evolving Shellfisheries and the National Shellfisheries Association
Melborne R. Carriker, 2004
National Shellfisheries Association
ISBN 0-9752881-0-5, 264 pages, $25.00,
sandra.shumway@uconn.edu



Renowned malacologist and educator Melborne Carriker generously embraced the thorough researching and writing of this highly readable history of the first century of the National Shellfisheries Association (NSA), its predecessor, and affiliated shellfish industry organizations dating to the beginning of the 20th century. As the literate proprietor of the best and longest NSA corporate memory, possessor of first-hand knowledge of most NSA principals since the early 1940s, and first editor of the society's journal, Dr. Carriker was well recruited for the job. His subsequent and comprehensive gleaning among the entire range of relevant East Coast library archives fully expanded the author's already deep personal knowledge of his subject.

This affordable, softbound book traces the history of the U.S. oyster industry, and its pioneers, managers, and especially its scientists. Thoughtful and informed references to social, political, and biological conditions consistently frame oyster research initiatives in proper and informative historical perspective. That context includes effects on oyster production and markets by several major and minor wars, the Great Depression, periodic typhoid and other human disease epidemics, and recently, prominent effects of widespread oyster diseases and cumulative oyster habitat degradation.

The volume is amply illustrated by more than one hundred high-quality, archival photographs of individuals and facilities associated with the development of the U.S. oyster industry and the NSA. Vivid descriptions of the pioneering research and personalities of NSA giants Victor Loosanof, Paul Galtsoff, and Thurlow C. Nelson are peppered with illuminating personal anecdotes. The same intimate knowledge enlivens descriptions of the many other dedicated, "plucky" individuals (Melborne Carriker prominently included), whose persistent and thoughtful efforts elucidated the fascinating mechanisms of oyster

Thurlow C. Nelson, President (1931-33) of the National Shellfisheries Association on his boat in Delaware Bay named after his father Julius. PHOTO COURTESY OF J. KRAEUTER.

biology and reproduction that, in turn, gave rise to hatchery techniques that enabled and empowered the emerging U.S. and international mollusk aquaculture industry.

This work specifically highlights the early contributions of women scientists, including a unique closing chapter by NSA honored life member Dr. Susan Ford on the significant and growing contributions of women scientists to mollusk research and NSA leadership functions. Finally, for those interested in detailed references by year for NSA officers, committee chairs, honored life members, Thurlow C. Nelson award recipients, *Journal of Shellfish Research* page charges, etc., this information is conveniently tabulated in a series of appendices. Careful, copy-editing has rendered this book largely free of typographical errors. However, first printing editions unfortunately lack a bound copyright page, which is separately provided for pasting to the inside of the front cover.

This book is an essential, affordable, and entertainingly readable reference on the American oyster industry through the focus of the NSA. It deserves prominent space on the shelves of those interested in oyster biology and fisheries, and of those concerned with the social and political aspects of the oyster's ascendancies and declines.

Web Resources

Cyber Tools for Aquaculture

Don Webster, Marine Agent

Plant Management in Florida Waters, http://plants.ifas.ufl.edu/guide/ — operated by the Center for Aquatic and Invasive Plants at the University of Florida and the Florida Department of Environment, this site is an excellent source of information on the uses of aquatic plants and the need for management. Although intended for a subtropical climate, many topics will also apply locally.

National Shellfisheries Association, http://www.shellfish.org/— provides access to the table of contents of their published journal, as well as links for many shellfish topics. While some links on this site will take the user to personal sites that may contain opinions rather than peer-reviewed science, they can be useful when searching for information. A discussion board encourages dialogue, allowing users to post questions and answers to shellfish topics.

Hatcheries & Finfish Restoration, http://www.dnr.state.md.us/fisheries/recreational/hatchery/aquaculture.html — this is a long URL, but it will take you to very useful resources. It is the Maryland Department of Natural Resources site on aquaculture, with links to state regulations and the permits necessary for operating a business. Included are applications for aquaculture permits, out-of-state supplier permits, fee fishing operations, and shellfish import permits. You will want to keep this one bookmarked for reference.

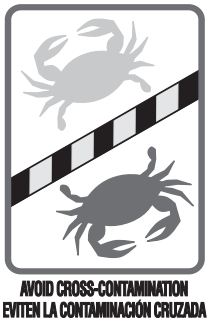
Maryland Aquafarm Products, http://www.mda.state.md.us/aqua/aquaprod.htm — want to know who's producing what in Maryland and where they are located? This website from the Maryland Department of Agriculture has listings by species and type of business service.

Aquaculture in Action, http://www.mdsg.umd.edu/Education/AinA/ — Maryland Sea Grant College, the Center for Marine Biotechnology, Chesapeake Bay Trust and the Maryland Department of Natural Resources in collaboration with Carroll County Public Schools, is creating a network of "aquaculture educators" in Maryland. *Aquaculture in Action* workshops engage educators in a "hands on" experience for five days to learn tricks of the trade for designing, building and setting up a successful aquaculture system, learning monitoring techniques, and developing grant-writing expertise.

South Carroll Aquaculture, http://www.carr.lib.md.us/schs/science/aquaculture/index.html — want to see a recirculating aquaculture system in operation and learn how to build a classroom scale unit? The students at South Carroll High School have not only designed the systems and written grant proposals to fund them, but have posted the information on how to build and operate them on their website. This is a great resource from our next generation of fish farmers.

Safe Food Depends on You

Training Guide for Food Handlers Now Available for Purchase



Safe Food Depends on You is the key component of a training program designed to teach English and Spanish-speaking workers food handling practices that will minimize the potential of foodborne illness. The manual covers important areas that workers must be aware of and practice, for example, good hand-washing techniques, the wearing of appropriate clothing and the practice of good hygiene. The underlying goal of the training program itself is to inculcate a system of values and to help the food industry meet the need for safe food and to meet new food safety regulations, which require a more formal educational program for all workers.

Cost: $14.95 (includes Training Manual, Instructional Video and nine posters). Materials may also be purchase separately. Training Manual and Video are $4.95 each and Posters are $10.00 for a set of nine.

For more information or to purchase Seafood Guide visit the web, www. mdsg.umd.edu/Extension/safe_seafood.html, or call Maryland Sea Grant, 301-403-4220, x22.

Upcoming Conferences

2nd National Conference on Coastal & Estuarine Habitat Restoration

Seattle, Washington – September 12-15, 2004
www.estuaries.org/2ndnationalconference.php

Building on last year's inaugural success, the Second National Conference aims to advance the knowledge, pace, practice and success of coastal and estuarine habitat restoration. Participants from all corners of restoration, including field practitioners, businesses, community leaders, consultants, scientists, program managers, regulators, educators and others who are involved in every aspect of coastal habitat restoration plan to attend. While addressing restoration challenges and successes around the country, the Second National Conference will also highlight the unique resources and restoration efforts in and around the Pacific Northwest.

For more information, please contact: Nicole Maylett, Conference Coordinator, 703-524-0248, or Steve Emmett-Mattox, Vice President, 703-524-0248.

7th International Conference on Shellfish Restoration (ISCR)

Charleston, South Carolina — November 17-20, 2004
www.scseagrant.org/icsr.htm

ICSR'04 will provide an opportunity for government officials, resource managers, users, community leaders, and residents to discuss approaches to restore coastal shellfish ecosystems through management, enhancement, and restoration efforts and to improve coastal ecosystem health. The conference will include speakers, a panel discussion and presentations of contributed posters and case stsudies of successful projects with opportunities for roundtable discussions.

Those interested in participating should request more information by contacting Elaine Knight: e-mail Elaine.Knight@scseagrant.org; voice mail 843-727-6406; or fax 843-727-2080.

Aquaculture America 2005

New Orleans, Louisiana – January 17-20, 2005
www.was.org/Meetings/ConferenceInfo.asp?MeetingCode=AA2005

Sponsored by the World Aquaculture Society (WAS), an international non-profit society with over 4,000 members in 94 countries, Aquaculture America 2005 will bring together students, researchers, and industry to address current advances in the field. The meeting will feature sessions on aquatic food products, focusing on value-added product development and aquatic food safety, along with a special session devoted solely to all aspects of striped bass, hybrid striped bass, and white bass culture.

For more information call the conference director at 760-432-4270.

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www.mdsg.umd.edu/MDSG/Extension/Aquafarmer/index.html

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