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By JUDITH H. DERN

Aquaculture Overview: Blue Revolution or Murky Waters?

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This is the first of two *Food Forum Quarterly* articles about the fish industry. A second article will focus on the status and current issues of wild fisheries.

Walk into almost any supermarket these days and you'll find an array of sleek fish arranged over ice or neatly packaged in portions ready to take home to cook for dinner. In larger cities, groceries may provide a fishmonger to slice specific portion sizes or remove the skin just for you. Some of us have the luxury of a favorite fish vendor at the local farmers' market or at a small shop. Almost all of us have lost our apprehensions about cooking fish at home or ordering it when we eat in a restaurant.

Fish is hip, trendy, and healthful. Think fish tacos, shrimp, and sushi. In the U.S., we now spend an average \$110 per year on fish and shellfish per person, and eat 15.2 pounds; 68 percent of this amount is imported, according to the U.S. Department of Agriculture's 2000 statistics. Overall, worldwide consumption of fish as food has more than doubled, from 40 million tons in 1970 to 86 million tons in 1998, according to the Food and Agriculture Organization (FAO) of the United Nations. But is all the fish we eat caught by fishermen plying their nets and boats in the deep blue ocean?

Not any more, and that's where the story of aquaculture starts. It's a story of tremendous potential for a promising new food source, and at the same time, a cautionary tale of possible long-term ecological damage and health risk. It's a story of the future of a vital component of the food system that has its roots in the past.

Aquaculture Yesterday

Aquaculture is an ancient farming system that probably began in Asia about 3,500 years ago. While its precise origins are unknown, farmers in China have long raised a fresh water carp as a protein source using a land-based, sustainable polyculture system with ponds and diversified fish species integrated within the ecosystem of small family farms, according to "Murky Waters: Environmental Effects of Aquaculture in the United States," published in 1997 by the Environmental Defense Fund.

Egyptians also farmed fish and Romans carried the concept back to Europe. In the Middle Ages, monasteries cultivated pond-raised carp to meet the Roman Catholic Church requirements for abstaining from meat on holy days. In this era, Southern Germany and Bohemia became a hub for carp farming in Europe as husbandry practices improved and provided a reliable source of food for growing populations.

But in contrast with land-based agriculture, aquaculture has evolved slowly. The lifecycle mysteries of ocean organisms and the strength of wild fisheries kept it from being considered as a significant food resource. Only in the past 30 years have factors combined to generate a boom in aquaculture. These factors include the depletion of ocean stocks—now diminished 47 percent according to FAO reports—through overfishing and pollution; increased attention in Western cultures to the health benefits of eating fish; world population growth; more sophisticated fishery breeding practices; and a market economy offering good return on investment from fish and shellfish farms. As a result, the practice of commercial aquaculture has surged, often in places where once only traditional wild fisheries existed.

Aquaculture Today

The FAO defines aquaculture as the “farming of aquatic organisms including fish, mollusks, crustaceans, and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated....”

Many believe the practice offers a solution to the dilemma of depleted oceans, expanding protein sources, or augmenting small runs of native fish with hatchery fish.

Today, aquaculture has become the fastest growing source of fish worldwide—the “Blue Revolution”—and has an industrial face with multinational players. Consider that in 1970, aquaculture operations worldwide contributed 3.9 percent of all fish production. In 2000, this percentage had increased to 37.3 percent, a growth rate of 9.7 percent annually, according to the FAO. Similarly, SeaWeb, a nonprofit organization that promotes sustainable aquaculture practices, reports that one fish in four eaten today is farm-raised (www.aquacultureclearinghouse.org). Despite this growth, aquaculture has not become the predicted large-scale food source for areas of the world suffering most from lack of food.

Asia remains the aquaculture giant, raising 70 percent (by weight) of the world’s farmed fish and shellfish. Rebecca Goldberg, a senior scientist with the Environmental Defense Fund, says, “More than 200 species of shellfish and fish are raised in China, primarily on small scale farms, with carp and tilapia the number one fish sold for modest sums to feed poor people, although larger-scale operations are growing.” Along with fish and shellfish, Asian aquaculture farmers also traditionally harvest various seaweeds and vegetables.

Farmed Salmon

Any overview of aquaculture eventually circles around to a discussion of farmed salmon. The surge of worldwide aquaculture began in the 1960s when Norwegian researchers investigated methods for raising salmon in pens sited in coastal fjords. By the 1970s, they had successfully perfected the husbandry of Atlantic salmon, domesticating the carnivorous, pelagic (ocean-going) cold-water species to confinement within net-pens. “The fish proved adaptable in breeding and very efficient in its weight to feed ratio,” said Pete Granger, program leader with Washington Sea Grant Marine Advisory Services, part of the National Oceanic and Atmospheric Administration (NOAA), “making it economically attractive for aquaculture development.”

By the late 1980s, Norway led the world in salmon production, creating new markets for Atlantic salmon. But the country also achieved a glut of product and incurred a U.S. trade embargo when its producers were accused of dumping product on U.S. markets. Several Norwegian companies expanded or moved operations to other cold-water regions such as Scotland, Ireland, Chile, Canada, and the northeastern (Maine) and northwestern (Washington State) corners of the U.S., often setting up farms with “gold-rush”

fever. These farms stocked Atlantic salmon since that’s where Norway had invested its husbandry efforts. In the 1990s, Chile became the country of choice for farmed salmon development due to cheap labor costs and that country’s long coastline. Production soared and farmed Atlantic salmon is now available fresh year-round in American supermarkets and restaurants, often arriving in three days from Chilean waters.

Shrimp cultivation also developed during this period and farms were set up in South America, Canada, Mexico, the Philippines, and Thailand. Both farmed salmon and shrimp products are aimed at lucrative export markets in North America, Europe, and Japan. In 2003, shrimp surpassed tuna as the most popular seafood among U.S. consumers.

Today, there are few countries and few U.S. states that do not have some form of finfish or shellfish aquaculture taking place. In the U.S., farms producing catfish, trout, tilapia, and sturgeon through closed-system aquaculture systems have become successful enterprises, particularly in the Southeast, where catfish is extensively raised.

While U.S. farmed salmon production represents only a fraction of the world’s total, there are salmon farms Down East in Maine and in Washington State, as well as on both coasts of Canada. Almost all (90 percent) of the fresh farm-raised salmon sold in U.S. markets is imported, most from Chile, according to Salmon of the Americas, an organization of salmon-producing companies in the U.S., Canada, and Chile, www.salmonoftheamericas.com. Farmed salmon is also used to make almost all smoked salmon sold in the U.S. because of its consistent oily content.

Environmental Considerations

The proliferation of farm-raised fish and aquaculture’s transformation into an aquatic version of industrial agriculture has prompted controversy and intense debates about its effects on the environment. No one is saying to stop fish farming, but concerned voices are speaking up for better management practices and the importance of developing an industry that will be both environmentally and socially sustainable in the long term. While benefits, risks, and issues vary with the management, location, and species of fish—shrimp and salmon are most often lightning rods for scrutiny—getting to the facts is often a murky business.

Consider the ecological issues surrounding shrimp aquaculture: the first shrimp farms admittedly took advantage of natural mangrove forests growing at the ocean’s edge and placed farms in coastal waters in the Philippines, Indonesia, Ecuador, and Thailand. Heavy pesticide use and antibiotics polluted waters surrounding farms for the highly profitable shellfish destroyed the habitat that was an important breeding ground for many aquatic organisms. The resulting outcry over the mangrove forest destruction that decimated the coastal fishing grounds of native inhabitants has prompted shrimp farmers in these areas to change tactics and develop a more contained system.

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Salmon aquaculture has also raised controversy. This issue hits closer to home for Americans and Canadians, particularly in the Northwest, where the salmon has icon status representing the region's cultural heritage and environmental wellbeing. Here environmental sustainability is prized, and the concept takes on added significance in discussions about aquaculture.

A survey of environmental issues associated with salmon farming starts with the fact that salmon is a carnivorous creature. While most of the world's aquaculture production—about 85 percent—involves non-carnivorous fish species produced in land-based ponds for domestic consumption, salmon production is different. The salmon eats smaller fish for food. Or, in the case of farmed salmon, it eats fish pellets or fishmeal processed from fish protein, nutrients, and fats such as fish oil, omega-3 fatty acids, and carotenoids that induce color (astaxanthin and canthaxanthin).

Fish that are used to produce fishmeal are categorized as "forage fish." These are highly nutritious fish like anchovies, sardines, herring, and mackerel that are fast growing. Figures differ, but it generally takes two to five pounds of forage fish to raise one pound of farmed salmon, or said another way, it takes one pound of fishmeal to raise one pound of farmed salmon. Industry critics say this represents a "net loss" of protein in the global food supply because these small fish are no longer available to nurture wild fish populations. Aquaculture supporters point out that the fisheries supplying these fish, most in South American waters, are well maintained and not endangered.

Along with the issue of sustainability, salmon aquaculture poses other environmental risks, including three given highest priority an NOAA study in 2001 because they can negatively affect the chemistry of the surrounding fish farm sites placed in coastal estuaries and bays. They include:

- Fish wastes and uneaten food that becomes sediment and reduces organic material beneath fish net-pens.
- Heavy metals accumulating in sediment below fish net-pens, including elevated levels of zinc and copper from fish feed, that can be toxic in their ionic forms to other marine organisms.
- Therapeutic pharmaceuticals and pesticides used to ensure the health of farmed fish that can also accumulate in sediments beneath net-pens and make their way into the environment, even while closely regulated in the U.S. and used in varying amounts other locations with veterinary supervision.

While invisible to the public, these environmental hazards created in salmon aquaculture are significant enough to raise questions about their long-term effects. They are also encouraging the industry to research alternative closed systems.

Added to these concerns in the Northwest is the fact that farmed salmon is exclusively Atlantic salmon, a different species from the five native species of Pacific salmon that swim in Alaskan and Northwest waters. While substantial documentary evidence is elusive, "It's a given that fish have escaped from fish farms," says Washington Sea Grant Marine Advisory Services' Granger, "and juvenile Atlantic salmon have been found in some streams in British Columbia." The potential for interbreeding and competition with native species, while so far not evident, exists and worries fish ecologists working hard to maintain wild Pacific salmon runs. In

coastal Maine, where efforts to restore runs of almost extinct wild Atlantic salmon are underway, the presence of escaped Atlantic salmon with a different genetic structure complicates attempts there as well.

Health Risks

Farmed salmon also poses another potential risk to the health of those who consume it: the high concentration of organic toxins such as dioxins and PCBs (polychlorinated biphenyls), a family of chemical compounds that were banned in the U.S. in the 1970s and have been presumed, although unproven, to cause cancer in humans. Residual amounts of the long-lived compounds are found in virtually all foodstuffs, from butter to pancakes to steak. Farmed fish contains comparatively high amounts due to the concentration of these chemicals in feed ingredients, since these substances accumulate and travel up the food chain.

Fish farmers have known about the presence of these compounds in fish feed, but a January 2004 study reported in the journal, *Science*, put the issue back in the spotlight for consumers. The study by researchers at Cornell University and the University of New York at Albany revealed that 700 samples of farmed salmon taken from around the world had consistently higher levels of PCBs and other contaminants than wild salmon: on average 36.63 parts per billion for farmed salmon vs. 4.75 for wild salmon. In reviewing the numbers, few experts recommended that consumers be told not to eat farmed salmon since the contaminant quantities were still below U.S. FDA guidelines that tolerate 2000 parts per billion.

Taken either way, the high contaminant levels in farmed salmon could be a red flag. Informed consumers may decide that the health benefits of eating farm-raised fish outweigh the risks; they may decide to limit the amounts of farmed salmon they consume; or they may stop eating farmed salmon completely. On the positive side, "Salmon farmers have noted the issue and are taking steps to convert fish oils used in fish feed to vegetable oils," says Granger, "but the taste factor has to be worked out, since these don't impart the desired 'fishy' flavor."

Profit Motives

Underlying all the ecological issues is another that is more frequently entering discussions about farmed fish. This is the social implication of aquaculture, particularly salmon aquaculture. According to John Volpe, of the department of biological sciences at the University of Alberta, Canada, "All of the ecological issues, which can be rather esoteric to consumers, are manifestations of the underlying social issue that connects aquaculture to a market-driven economy." Making a profit when salmon becomes the "chicken of the sea" and costs \$3 a pound at retail means that only large fish farms owned by multinational corporations can stay in business. Even these operations have to maximize their use of natural resources and constantly retool production methods to reduce labor and other costs and become more efficient. "These companies have limited interest in the long-term welfare of the waters they use or the communities that support them," says Volpe. But he also believes the pendulum is swinging back to local control, as more communities and consumers realize the hidden economic implications of large salmon farms and appreciate the value of local, seasonal, sustainable products.

Where does all this aquaculture information leave the fish-loving consumer or food professional? In a word, challenged. Consumers

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who are already clued in to the politics of food will pay attention to aquaculture issues, where the fish sold in their markets was caught or raised and question sources of information. There are a host of Web sites to consult about both sides of the issue, including www.seafoodclearinghouse.org; www.tidepool.org; www.livingoceans.org; www.nal.usda.gov; www.seafoodchoices.com; www.audubon.org/campaign/lo; and www.slowseas.org. Becoming aware of the social and ecological issues involved in aquaculture and making responsible and responsive food choices will be a delicious undertaking. ■

Judith H. Dern is an independent writer based in Seattle, Wash. U.S., who writes about textiles, Scandinavia, and, of course, food. Her first fish stories and cookbooks were written on behalf of the Norway Sardine Industry. Her cookbook, *The Sustainable Kitchen: Passionate Cooking Inspired by Ingredients from Farms, Forests and Oceans*, a collaboration with Stu Stein and Mary Hinds, executive chefs and co-owners of The Peerless Restaurant in Ashland, Ore., U.S., will be published in May 2004.

Road to Success

A Chef and a Gentleman: Jacques Pépin

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Many of us who are involved in the culinary field have moments when we find it hard to reconcile our preoccupation with food—and the sheer abundance of it in our lives—with the knowledge that a billion or so people in the world are suffering from hunger. Do you ever find this juxtaposition disturbing?

Yes, I do, and particularly in the context of the way we cook. It's something I discuss a lot with young chefs. I'm especially concerned when food has to be so precious, when it is tortured so much that it is unrecognizable as food. There is something morally wrong with that. It's disturbing to me.

I know that one of your favorite pastimes is painting, so I looked on your website [www.jacquespepin.net] at some of the paintings you've produced. I thought many of them were quite whimsical and colorful, while a couple are more somber and severe. Has your painting changed much over the years?

I think most of those on the website are oils, and I paint mostly in acrylic now. But you know, I had an art show once, and one comment was that at least five different painters must have done the work! Right now I'm designing tiles. We're building a new kitchen, and I'm doing drawings for a series of tiles for it. ■

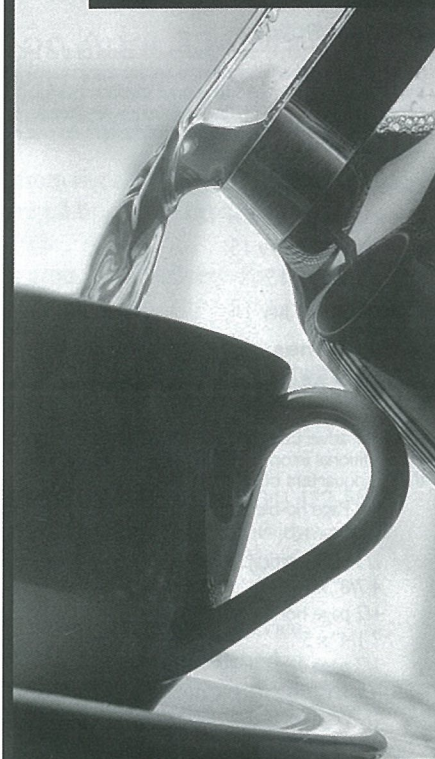
Corporate Members Update

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magazine with food and nutrition articles in every issue, which may be an opportunity for IACP members to be published," offers Landrum. "And many of the books we've published have been written by IACP members," she says. "Our cookbooks follow guidelines for reduced fat and sodium and encourage people to eat the good carbs—fruit, vegetables, and whole grains—and even good fats. Many of the books provide daily menus to teach people with diabetes how to spread their carbohydrate intake over the day to keep blood sugar levels on an even keel." To learn more about diabetes, check out www.diabetes.org or call (800) DIABETES, or (800) 342-2383. To view the ADA's book list, go to store.diabetes.org (no www required). Contact Sherry Landrum for more information at Slandrum@diabetes.org or (703) 299-2038.

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