A National Sea Grant Initiative

Ensuring Global Competitiveness

of the U.S. Seafood Industry

Sea Grant Science for the 21st Century

Contents

Ensuring Global Competitiveness of the U.S. Seafood Industry

"The seafood industry is undergoing a period of unprecedented and sweeping change. Globalization, marketplace consolidation, the rapid growth of water farming and shifting consumer demographics will shape the industry for decades to come."

– Richard E. Gutting, Jr., President, National Fisheries Institute

The U.S. seafood industry faces many challenges and opportunities as it enters the 21st century. These challenges include an increasingly competitive global marketplace, complex trade policies, strict regulations, rising energy costs and a limited seafood supply. Change, however, also brings new opportunities for expanding markets, forming strategic alliances and advancing innovations that can lower production costs, create new products, add value to existing ones, increase safety and reduce waste. In this new seafood era, science and education have become cornerstones for maintaining the vitality of the nation's $27 billion seafood industry and its 250,000 workers. Numerous research and technology transfer needs identified in the following report could help invigorate the U.S. seafood industry. The Sea Grant network is poised to help the industry increase quality and safety, add value, lower costs and expand seafood supplies and markets. Sea Grant has more than 30 years of experience working in nearly every state and involving every type of seafood product – a proven track record of collaboration by university research and extension personnel with business, government, research laboratories and consumers.

Addressing industry issues in times of change

Although science and education have the potential to increase the profitability of seafood businesses, such advances are not likely to happen without targeted intervention. The U.S. seafood industry is comprised of mostly small and medium-sized, independent enterprises that simply cannot afford research and development programs, even though they recognize the benefits of innovation. In the near future, hiring educated seafood technologists will be more difficult. The number of university-based seafood technologists is declining across the U.S., and without this base, there will be fewer students trained to meet the industry's needs for qualified professionals. With additional resources, Sea Grant could play a significant role in training new research and outreach professionals for employment in academia and seafood science, safety and technology.

Consolidation in the industry is offsetting some economic pressures and should spur technological innovations. The global seafood industry is, by its very nature, technology intensive – in part because of the sheer variety of marine species sold commercially. To put this in perspective, consider that U.S. beef comes primarily from two species of cattle and U.S. chicken from one species. Seafood, in contrast, includes more than 300 species in every imaginable size and shape, but each with specific handling, processing and packaging requirements. To fully benefit the seafood industry, expertise must be brought to bear on each and every species sold.

Another important aspect to competitiveness is the need to control costs. Seafood is already one of the most expensive parts of the American diet, but high prices do not necessarily translate into higher profit margins for businesses. Catching, transporting, processing, storing and distributing seafood are costly. Again, technology is a primary vehicle for lowering production costs and improving food safety and quality.

Sea Grant's record of success

For more than 30 years, Sea Grant has invested resources to provide high-quality research and outreach programs to benefit the nation's seafood industry and consumers — and has achieved a remarkable return on its investment. Program accomplishments include:

- Created the National Seafood HACCP* Alliance, which earned the 1999 U.S. Secretary of Agriculture's Group Honor Award for Public Service for efforts to improve seafood safety and a 1997 federal Hammer Award for "partnerships that make a significant contribution in improving the way federal agencies accomplish their responsibilities." (*HACCP, pronounced "has-sip," stands for Hazard Analysis Critical Control Point and is the federal food-safety regulation adopted in 1995 for seafood.)
- Delivered training courses enabling more than 15,000 individuals in industry to comply with the nation's first mandatory food-safety regulations based on HACCP. Eighty-three percent of American seafood businesses reported that they could not have met federal regulations without these courses.
- Reduced food-borne illnesses by 23 percent since 1996 in the United States as reported by the Department of Health and Human Services through HACCP training courses. In 1995, the Food and Drug Administration (FDA) estimated that the Seafood HACCP program would prevent 20,000 to 60,000 seafood-related illnesses a year, thereby saving as much as $115 million annually in economic losses. This program is the model now used to train U.S. processors of juice products to help them implement a HACCP food-safety system.
- Identified sources and controls for the human pathogen, Listeria monocytogenes, that allowed Atlantic crab processors to comply with federal and state regulations and meet the

needs of major commercial buyers, a $3.7 million value annually.

- Provided research and technical assistance on proper food safety and handling techniques that helped establish a fresh and frozen albacore tuna industry on the West Coast. This effort also led to updated FDA standards for tuna, which has the highest per capita consumption of any seafood product in the U.S.

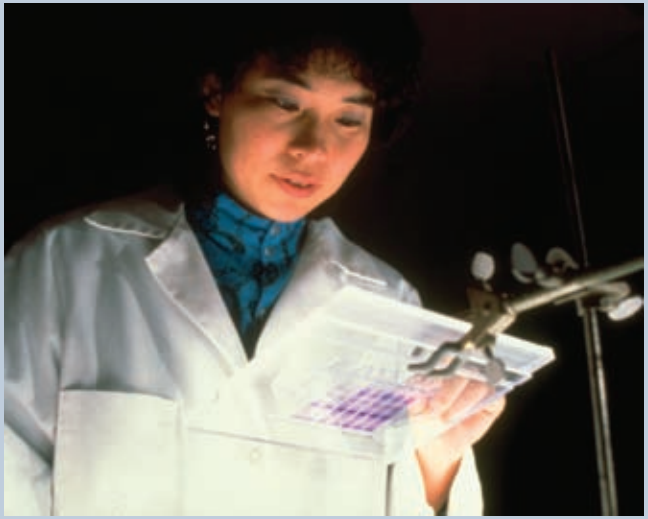
- Recommended changes at processing plants in Alaska, Oregon and Washington that are saving an estimated $1.1 million annually in reduced energy consumption, reduced waste and increased productivity.
- Developed anti-microbial treatments for shrimp, saving Florida's shrimp processors $12 million annually.
- Adapted and developed technology enabling the use of Pacific whiting as a major ingredient in surimi, the washed and frozen mince used to make seafood analogs. The new industry generates more than $40 million annually in West Coast communities hit hard by depressed salmon and groundfish harvests.
- Created a market for whiting waste as an ingredient in fertilizer, meal and compost.
- Developed heat-intensive processing techniques for surimi gels that are saving seafood manufacturers $1.8 million annually.
- Helped establish and raise funds for the $4.6-million Aquatics Food Products Laboratory at the University of Florida, fostering greater collaboration between the Florida Department of Aquaculture and the Consumer Services Seafood Bureau.
- Developed a high-value "scallop medallion" from small scallops, increasing demand for small scallops by 10 million pounds per year since 1999. The project has led to the creation of "married" shrimp and lobster products.
- Helped create the Maine Phytoplankton Monitoring Program to prevent shellfish poisoning. The program won the FDA's prestigious Team Award in 2001.

Resource needs

Through the initiative outlined in this booklet, the committee believes the Sea Grant seafood technology community is uniquely positioned to promote the sustainability of the nation's seafood industry. Meeting this goal will require a continuous commitment by Sea Grant's many partners and additional funding. An enhanced Sea Grant seafood technology program will need an additional $6 million per year over the next five years to address the many issues identified in this paper. These funds would be used to re-build the nation's university-based seafood technology infrastructure, including supporting new research faculty and graduate students, and expanding Sea Grant extension capabilities. Funds would also be made available to support and stimulate cutting-edge research and development activities through competitive, peer-reviewed grant processes. Specifically, $3 million per year is needed to provide additional research and extension faculty. The goal is to expand and enhance core seafood technology capabilities by adding at least one university-based Sea Grant seafood technology position (research and/or extension) in each coastal and Great Lakes program. In addition, $3 million per year is required to provide support for new research and development activities to be funded on a nationally competitive basis. An enhanced research and development program will support an additional 30 to 40 graduate students per year and provide industry the next generation of a trained workforce, which will be required for the seafood industry to remain competitive in the decades ahead. As shown above, Sea Grant has achieved an extraordinary record of economic and environmental accomplishments through its seafood science and technology program. An increased public investment in the seafood sciences will create new opportunities to both sustain and expand the U.S. seafood industry and create millions of dollars of new income and thousands of new jobs. Additionally, the public will benefit from an increased investment in Sea Grant seafood safety programs through assurance of a seafood supply that is steady, convenient, healthy and safe.

Scope of the five-part initiative

Sea Grant, with the assistance of industry, academic and government partners, has identified five key areas where it could contribute to increased productivity and profit for the U.S. seafood industry:



- Ensuring safety of seafood
- Ensuring quality of seafood
- Improving seafood processing technology
- Adding value to seafood products, and
- Expanding supplies and markets.

These topics are interconnected and focused on two main issues – ensuring seafood safety for the consumer and helping businesses prosper. Safety encompasses issues such as assisting the FDA in developing appropriate regulations, helping businesses comply with FDA regulations, educating consumers about buying and preparing seafood, educating industry workers about handling and sanitation, and developing improved processing procedures. Prosperity will come from continuously developing and employing cutting-edge science and technology: creating new products and processes, improving quality, and expanding markets and the base of seafood-eating customers. In the following pages, Sea Grant puts forth its recipe for continued prosperity of the U.S. seafood industry.

Ensuring safety of seafood

In 1995, the FDA enacted food-safety regulations geared specifically to the seafood industry. The regulations require all seafood processors in the United States (and in foreign countries that export seafood to the United States) to apply a food-safety control system known as Hazard Analysis Critical Control Point, or HACCP, to their operations. Pathogen control during seafood processing is one of the major food-safety issues addressed under HACCP.

To enable industry to comply with these new regulations, Sea Grant created the National Seafood HACCP Alliance. To date, this government-academic-industry partnership has produced a 500-page manual and trained a staggering 90 percent of the nation's seafood processors in compliance techniques. In 1999, the Alliance received the U.S. Secretary of Agriculture's Group Honor Award for Public Service for efforts to improve seafood safety. Currently, HACCP training is supplemented with a course in sanitation control. These programs are supported with manuals, Web-based courses, extensive reference material, model HACCP plans and downloadable presentations.

Health agencies and professional organizations are key partners in Sea Grant's food-safety programming. Many of these groups are responsible for setting guidelines, policies or regulations that greatly impact seafood establishments and consumers. Communication among organizations is often inadequate, resulting in research that neither answers regulatory questions nor is recognized by international bodies. Sea Grant facilitates the wide exchange of scientific information among these many stakeholders.

The industry employs scientists to evaluate additives and ingredients as well as to implement

innovative process technologies to improve seafood safety. These include high pressure; pulsed electric field; e-beam radiation; ultraviolet and pulsed light; oscillating magnetic fields; microwave, radio frequency, ohmic and inductive heating; ultrasound; and X-ray treatments.

Improvements are also needed in many conventional technologies, such as depuration, hot-water pasteurization, anti-microbial additives and treatments, traditional thermal processes, and reduced-oxygen packaging. Computerized systems for tracking and monitoring the status of sensitive products throughout the distribution stream are becoming commercially feasible. Processors will need considerable technical assistance to evaluate and validate procedures that will ensure product safety and marketability.

Some sectors of the seafood supply chain are exempt from federal HACCP regulations: harvesting vessels, food services and retail operations. However, there are illnesses attributable to these sectors, which could be reduced by using the National Seafood HACCP Alliance program as a template for training workers.

Research and outreach needs

Sea Grant food scientists and technologists are uniquely positioned to:

- Control food-borne pathogens by developing intervention strategies and transferring the strategies to user groups.
- Enhance safety and quality by developing innovative uses for modified-atmosphere packaging and anti-microbial treatments for seafood products.
- Develop rapid-testing methods for hazards, including toxins and pathogens.

- Improve product-tracking systems and time-temperature monitors.
- Validate pathogen growth models in commercially produced seafood.
- Ensure that significant seafood hazards are controlled from harvest to consumption by creating and coordinating educational and training programs and national certification courses.
- Validate HACCP and sanitation models under commercial conditions to determine their effectiveness, reliability, and the cost and benefits of investment in equipment and instrumentation versus manual controls and monitoring.
- Enhance the surveillance of imported seafood through evaluations of product-testing methods; foster international agreements on methods for validating technologies; and facilitate foreign training opportunities.
- Develop improved on-board handling methods to improve food-safety assurance and consistent raw-product quality.

Ensuring quality of seafood

Although seafood safety has taken center stage with the implementation of HACCP, seafood quality drives the markets. The health-conscious American public wants alternatives to meat. Affordable, quality seafood products with extended shelf life for convenience are an answer. The seafood processing industry needs new technologies to enhance quality, detect decomposition and extend product shelf life while adding minimal cost. Seafoods are especially perishable and vary in composition because of differences in species, age, size, and season of harvest. Maximizing quality by selecting only the best specimens for harvest, as is done for aquaculture-reared animals, is impossible in ocean fisheries. Variability in handling, processing and packaging methods further contribute to variability in quality. Therefore, quality-control techniques are critical to the growth of the industry. Government mandates to continually monitor both the safety and quality of seafood products from water to table are on the horizon. Optical image analysis and "electronic nose" equipment could be teamed with computer artificial intelligence to improve the speed and accuracy of quality-measurement systems. Data entry would be automatic and reliable. New software will be needed to collect and manage data to allow a reliable prediction of remaining quality shelf life under controlled conditions.

Research and outreach needs

Sea Grant food scientists and technologists are uniquely positioned to:

- Develop rapid, simple quality-detection methods.

- Characterize how new technologies such as high-pressure, ohmic or microwave rapid heating can enhance product quality.
- Improve product quality by demonstrating how the interaction of animal physiology, harvest methods, and post-harvest processing can be better managed.
- Prevent product degradation by protecting seafood proteins during processing until adjustments in pH can be made.
- Extend product shelf life by developing "smart" (active) packaging and edible films.
- Improve the quality of existing products and contribute to new product development by isolating and applying naturally derived additives from ocean sources.

- Determine the mechanisms and natural characteristics that enable some species to maintain stable quality during freezing and frozen storage. Then use these mechanisms to stabilize freezing and storage of more sensitive species.
- Improve the yields and quality of thermally processed products by seeking new methods to process and package seafoods. The retort pouch introduced recently to replace canned tuna is but one example of how packaging innovation can impact an industry.
- Facilitate development of global standards for seafood quality by creating international research programs and coordinating regulatory practices.
- Improve understanding in retail and consumer sectors through training and education programs that emphasize the nutrition inherent in seafood and proper storage and preparation to retain quality.

Improving seafood processing technology

The productivity and competitiveness of seafood processing depends not only on the sources and costs of raw materials, but also on the influence of other costly resources: energy, water, labor and waterfront space. Large amounts of energy are required for thermal operations such as refrigeration, cooking, and retorting. There are opportunities for conservation through energy audits and demonstrating new technologies at processing plants. Primary processors are located in the same coastal areas facing increased population density and tourism, all of which place high demands on limited supplies of fresh water. As just one example, it takes about 40 gallons of water to process one pound of Pacific shrimp. Improved management, education and technology-transfer programs could achieve significant reduction in water use, resulting in financial and environmental benefits. The once cheap and convenient disposal of seafood wastes into adjacent harbors and channels is not environmentally sound and faces increasing restriction under coastal water-quality standards. The first step toward minimizing solid wastes is to improve processing yields, as shown by Sea Grant's contribution to the development of U.S. surimi processing. Sea Grant could develop and demonstrate new technology to recover and use seafood by-products to increase profitability and decrease waste. For example, processes that produce fillets and portions generally leave a significant percentage of edible muscle tissue unused. Some success in recovering that protein has been achieved by mechanical de-boning to produce minces, but more could be done. International competitiveness requires optimal productivity, quality and value of products, and development of new products from traditional raw materials,

underutilized species and waste streams. Innovations in processing to address these needs could also decrease operating costs and increase profits.

Research and outreach needs

Sea Grant's food scientists and technologists are uniquely positioned to:

- Optimize quality and food safety by exploring new pasteurizing technologies, such as high-pressure processing, e-beam, and internal heating by electric fields.
- Reduce the use of energy and fresh water in seafood processing through education, training, and demonstration of new processes and technologies, including water recycling.
- Diminish waste streams by increasing process yield and by developing new uses for by-products.
- Support coastal community development of seafood processing, storage and marketing centers by developing economic decision models.
- Enhance product development, marketing, and productivity by demonstrating new technologies such as water-jet cutting of frozen portions and innovative packaging systems.
- Preserve and expand access to the literature of seafood science, safety and technology.

Adding value to seafood products

Seafood is one of the most expensive items in the diet of the Western world due to the high cost of catching, transporting, processing and storing this delicate commodity. Although profit margins are small, there are opportunities to increase product quality and profits through improved post-harvest technologies. In terms of dollar value, seafood muscle tissues are the major and most important component of seafood products. Many of their desirable properties come from their water- and fat-binding properties, which can be enhanced by non-seafood additives and novel processing techniques. Ready-to-cook and ready-to-eat seafood products require processing and storage that can reduce product quality. A better understanding of the chemical and physical properties of seafood muscle components could minimize these effects. Many fish species are not widely consumed for food because they degrade rapidly. Improved storage and processing techniques are needed, but because fish and shellfish are highly variable in their physiology, there is a need to study their properties by species. New enzymes, enzyme inhibitors and other "active" proteins, such as antifreeze proteins, could be isolated from seafood sources and used to add value to other seafoods.

Research and outreach needs

Sea Grant food scientists and technologists are uniquely positioned to enhance the value of processed seafoods by developing technologies to:

- Decrease waste, add value and create new "fresh," restructured products for the marketplace by using new enzymes or processes to bind seafood muscle portions without heating.
- Enhance the functional properties of proteins and ingredients by understanding their

behavior in such new processes as microwave heating and high-pressure treatment.

- Recover proteins from many of the low-value marine fish. Fractionation or manipulation of these proteins could render them effective additives in many types of foods.
- Sustain the water-holding capacity and desirable cooked texture of frozen and twice-frozen fish, practices which are becoming more common as fishing boats must go further from shore to catch fish.
- Increase the number of cold-water and pelagic species usable for human food by decreasing the rates of lipid and heme protein oxidation.
- Improve the handling and processing of unwashed seafood minces to stabilize proteins and lipids. This would also increase the range of food applications for minces.
- Increase edible yield from some species by improving methods for removal of dark muscle tissue from the fish flesh.
- Improve micro-encapsulation or other stabilization methods for omega-3 fatty acids to allow them to be uniformly distributed and remain stable in a wider variety of food materials.
- Develop new textures, flavors, stability or other desirable attributes by exploring new combinations of non-seafood components with seafood.
- Maximize the value of the whole animal and reduce waste streams by developing uses for by-products, such as skin, scales, entrails, and bone.
- Improve economic return from by-product streams by maximizing recovery of components for high-value foods and pharmaceuticals, and directing other components into high-volume products like meal, baits, and fertilizers.

Expanding seafood supplies and markets

The current global shortfall of and increased demand for seafood can be partly addressed by creativity in research and product development. Sea Grant's past international collaborations in research, education and professional training have involved every aquatic food product and every nation exporting these products to the United States. Foreign seafood producers have technological superiority in many areas, which the U.S. industry could learn from and adapt to the American setting. The creation of the U.S. surimi industry is an example of a new product whose sales were accelerated by the transfer of Japanese experience and scientific information to the U.S. Use of new communication technologies, such as videoconferencing and the Internet, could expand Sea Grant's scientific exchange programs to benefit the U.S. seafood processing industry and consumers.

Research and outreach needs

Sea Grant food scientists and technologists are uniquely positioned to:

- Promote the exchange of seafood products in domestic and international settings by organizing training programs for commercial and regulatory interests.
- Support internationally acceptable systems for commercial and regulatory surveillance of product quality and food safety.
- Ensure product quality and safety in international markets by collaborating with industry and regulatory agencies to merge scientific-based approaches.

Sea Grant Programs

For information about the National Sea Grant College Program, contact:

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Seafood websites:

National Seafood HACCP Alliance, http://seafood.ucdavis.edu/haccp/ha.htm
Compendium of Fish and Fishery Products Processes, Hazards and Controls, http://seafood.ucdavis.edu/haccp/compendium/compend.htm
Seafood Network Information Center (SeafoodNIC) http://seafood.ucdavis.edu
National Sea Grant Library, the official archive and searchable database of all Sea Grant publications http://nsgl.gso.uri.edu

*Brian Perkins died before this report was completed. His contributions to Sea Grant and seafood science will long be remembered.

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