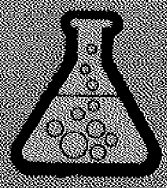

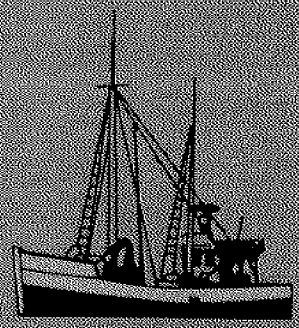

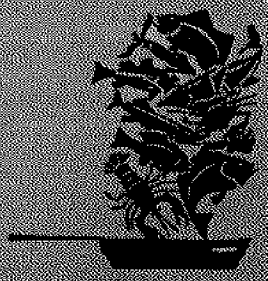

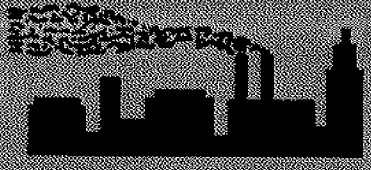

The National Sea Grant College Program Annual Report FY 89

Seafood Science and Technology

by

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

Annual Report on Seafood Science and Technology Fiscal Year 1989

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Seafood Science and Technology

Summary

The United States has enormous fisheries within its zone of extended jurisdiction along its marine coasts, yet a large proportion of the seafood sold domestically is imported. Fuller development of fisheries by U.S. fishing fleets and processors depends on stronger competition in international markets. Enhancement of their competitive position depends in part on enhancing the quality of seafood, improving the technology and efficiency of processing and handling seafood, including dealing satisfactorily with organic wastes, developing acceptable products from non-traditional species and for non-traditional markets, and assuring safe products of high quality. The 49 Sea Grant projects dealing directly or indirectly with seafood technology in fiscal year 1989 focused on these issues and helped prepare students for careers in industry and academe through advanced training. Federal funding in the amount of $1,662,000 and $1,202,000 in matching funds supported these projects. This report discusses some of the recent issues and Sea Grant advances in this field. For example, the recent rapid growth of the increasingly important soft shell crawfish industry in domestic and foreign markets results from research on intensive culture systems in the early 1980s at Louisiana State University.

Introduction

Research in this program is focused on enhancing the competitiveness of the seafood industry through improvements of processing technology and products and through development of new products and by-products. Another major part of the program is directed to issues of safety and nutrition of seafood.

The ability to capture a larger share of domestic and foreign markets and to develop new ones depends in part on technological advancements. Sea Grant's research represents a significant share of academic contributions to these developments in the United States and is important because most seafood companies are small and without components for research and development. This research also upgrades technology through the students it trains for industrial careers.

Table I shows that $1,662,350 in federal funds and $1,101,745 in matching funds, totaling $2,864,045, supported 49 projects in four broad categories in fiscal year 1989. The number of projects and level of funding were up somewhat from fiscal year 1988, but still below the record funding ($2,902,000) of 1987 and the record number of projects (50) in 1982.

This program complements related research of the National Marine Fisheries Service (NMFS) in its technological laboratories in Gloucester, Massachusetts; Charleston, South Carolina; Pascagoula, Mississippi; and Seattle, Washington. annually on seafood technology. NMFS also supports of extramural projects in seafood technology with Saltonstall-Kennedy funds.

One of the highlights of 1989 was an international workshop on depuration. Working with the National Fisheries Institute, the National Coastal and Development Institute, the Virginia Polytechnic Institute and State University, the Gulf and South Atlantic Fisheries Development Foundation, and the National Marine Fisheries Service, the Florida Sea Grant College Program sponsored the First International Conference on Shellfish Depuration in Orlando, Florida from November 5 to 8. The highly successful conference addressed a range of economic and technological issues concerning shellfish depuration. Approximately 200 shellfish producers and processors attended the meeting and more than 40 domestic and foreign experts reported on the latest technical developments in shellfish

TABLE 1
Federal Funding for Projects in Seafood Science and Technology in Fiscal Years 1981–1989
(in thousands of dollars)

	Federal Funding/No. of Projects								
	1981	1982	1983	1984	1985	1986	1987	1988	1989
Engineering & Waste Treatment	55/4	56/2	19/1	144/4	76/2	101/6	56/2	84/3	116/3
Product Development & By-Product Recovery	444/13	335/13	406/14	444/14	403/14	324/11	545/14	572/16	330/8
Microbiological & Nutritional Quality	427/16	556/21	610/19	646/17	829/22	923/24	818/22	444/17	745/26
Handling & Processing	371/14	396/14	376/12	411/13	271/9	261/7	308/10	242/8	467/12
TOTALS	1300/47	1343/50	1411/46	1645/48	1579/47	1609/48	1727/48	1342*/44	1662/49

*NON-FEDERAL MATCHING FUNDS WERE $11,101,745 IN FY 1989; TOTAL FUNDING WAS $2,860,095. TOTAL FUNDING IN FY 1988 WAS $2,545,000

depuration in the United States, Canada, England, New Zealand, Spain, France, Denmark, Turkey and Italy.

Depuration has proven effective under a range of conditions, but further research will need to define appropriate conditions for certain target organisms, especially viral agents, and to better define economic feasibility of commercial operations.

The organizers expect to publish the proceedings of the conference by September 1990.

The following four sections provide recent examples of Sea Grant progress in research. Appendix A gives a partial listing of recent publications. Appendix B is a listing of projects funded in fiscal year 1989. The references in the text below are to papers in Appendix A, which is a listing of recent Sea Grant publications in seafood technology.

Engineering and Waste Treatment

The number of projects in this category remains low even though waste management is an important problem in the seafood industry. It is a

problem of increasing urgency. All three projects were in process engineering, but none dealt with waste treatment. The primary approach to problems of waste management is in recovery of by-products and projects of this type fall under the next category of research discussed below.

Researchers at Cornell University published a thorough review of extraction with supercritical carbon dioxide for concentration of omega-3 fatty acids from fish oil (Rizvi et al., 1988). The paper describes the various parameters influencing the purity and yield of eicosapentaenoic and docosahexaenoic acids obtained after various pretreatments of the fish oils. Special health benefits are attributed to these compounds.

Product Development and By-Product Recovery

Development of new products for both domestic and foreign markets is increasingly important for expanding commerce in seafood. Underutilized species and species traditionally used only for industrial products now are considered more seriously as viable food resources, especially for production of surimi, a form of minced fish which is an intermediate in making a wide variety of products of high quality such as simulated scallops and crab legs. The United States has rich resources of fishes that are potentially useful for these kinds of products and several projects, a few each year, have addressed these opportunities. Other projects in this category deal with other types of products and with developing by-products from processing wastes -- such things as fertilizers, animal feeds, and industrial enzymes and pigments.

Researchers at Oregon State University recently reported on some of their research on Pacific whiting as a candidate for surimi. In his thesis (Pacheco-Aguilar, 1989) a student reported on the use of low levels of bromate to effect major improvements in gel cohesiveness and elasticity of gels made from this species. Other work in the same laboratory (Chang-Lee et al., 1989) yielded washing procedures for reducing protease activity in deboned flesh. Without the addition of egg white and potato starch, however, the methods yielded only poor gels.

Like soft shell crabs soft shell crawfish can be consumed almost entirely. Because they taste somewhat like a cross between shrimp and soft shell crab, a rapid market for this product is developing. Development and testing of intensive culture systems for crawfish at Louisiana State University in the early 1980s is the basis of this commercial growth. (Thomasson and Malone, 1989; Malone and Burden, 1988). This research demonstrated that the dominant species in Louisiana, the red swamp crawfish, *Procambarus clarkii*, could be held in tanks at high densities and molted to yield a high priced product. Now, more than 250 producers sell soft shell crawfish in a variety of forms - fresh, frozen, and breaded.

Researchers and advisory personnel in New York in cooperation a private marina and sports store operator executed a demonstration project to help deal with the problem of disposing of processing wastes. (White et al., 1989). Their approach was to use composting with peat moss and wood chips in order to produce horticultural or agricultural fertilizer. Their work demonstrated a workable process. For some small businesses it may be too costly and messy, but for others it is expected to be a viable solution to crucial problems in managing wastes.

Microbial, Chemical and Nutritional Quality

Research in this category deals both with the quality of seafood as it comes out of the water, particularly in regard to contamination by pathogenic microorganisms, and with deterioration of quality and its prevention in transit, processing, and storage. Some projects focused on determining the environmental factors responsible for contamination of shellfish with viruses, bacteria, and toxic algae or on procedures for their accurate measurement or elimination. A large proportion of U.S. coastal waters are closed to shellfishing because of concern about bacterial, viral or algal contamination. Thus, the projects focused on important issues.

In an investigation to determine the levels of viruses associated with solids in a polluted estuary, researchers in the Mississippi-Alabama Sea Grant College Program showed that

distributions of viruses and fecal coliform bacteria are unrelated to each other and appear to be random (Ellender et al., 1989). Virus levels either did not correlate or showed a weak positive correlation with salinity, turbidity, temperature, pH, organic matter, carbonate carbon, smectite, kaolinite, illite, and mean particle size. Viral concentrations correlated with rainfall at only one sampling site. The studies showed the difficulty of identifying the sources of viruses in natural waters. Other research in this program (Cook and Ruple, 1989) showed that increases in the levels of indicator bacteria in post-harvest shellstock oysters generally were accompanied by increases in *Vibrionaceae*, but sometimes the *Vibrionaceae* multiplied in the absence of fecal coliform multiplication. Storage of oysters at 10°C prevented multiplication of vibrios and fecal coliforms, but not *Aeromonas hydrophila*.

The researchers state that increases in both fecal coliforms and *Vibrionaceae* appear to be governed by such factors as harvest and transport temperature, salinity, and possible conditions of transport sacks and humidity. Of these factors, transport temperature is the easiest to control. Therefore, emphasis should be placed on controlling the temperature of oysters from the time they are harvested until they are consumed. This will help to keep the numbers of potential pathogens low and reduce the incidence of illness resulting from consumption of shellfish. They noted that the transport trucks in their study did not always meet the requirement to maintain temperatures at or below 45°F. They noted increases in fecal coliforms and sometimes *Escherichia coli* during transport by truck.

Microbiologists at Louisiana State University have developed rapid methods for the detection of *Vibrio cholerae, Vibrio mimicus, and Vibrio vulnificus* (Adams et al., 1988, Simonson and Siebeling, 1988). The methods, which can be used to test for human and fish pathogens, are based on the use of monoclonal antibodies to flagellar antigens. Several laboratories in the United States and Canada have tested the new reagents and found them effective.

In further reports on evaluating the compounds contributing to the flavors and aromas of fish and fish oils, researchers at the University of Wisconsin showed that vacuum steam-deodorized fish oils oxidized under fluorescent light initially developed green flavors which were caused principally by *t,c*-2,6-nonadienal, but some green-type flavor notes were contributed by *t*-2-hexenal and 1,*c*-5-octadien-3-one (Karahadian and Lindsay, 1989). Diminishment of green flavor notes resulted from the depletion of 2,6-nonadienal and the formation of *c*-4-heptenal (>1 ppm) which contributed oxidized, burnt flavor notes. Concomitant formation of *t,c,c*- and *t,t,c*-2,4,7-decatrienal (>1 ppm) yielded characterizing burnt/fishy or cod liver oil-like flavors in fish oils. Two unidentified compounds exhibiting minnow-bait-bucket and trout-like odor qualities, respectively were encountered in oxidizing fish oils. Hexanal, 2,4-heptadienals and 2,4-decadienals contributed general oxidized, painty flavors to fish oils.

Processing and Handling

Research in this category ranges over a variety of approaches to improving quality of seafood and the efficiency of its production--in some ways the bread and butter issues in Sea Grant because the results are frequently directly useful to agents and specialists in Sea Grant Extension Programs. Recent projects have dealt with a variety of issues in processing and storage of fish.

Researchers at Oregon State University have published a manual for using a mathematical model to evaluate retort operations for the processing of seafood in cylindrical or oval-shaped cans (Simpson et al., 1989A,B). Since several seafood products are processed overseas in oval-shaped containers, there was a need to develop a model to include this type of container. This is particularly important for U.S. companies that purchase or process seafood products overseas.

The authors state that sterilization provides a good example of the benefits that can be gained from modelling. "First, all mathematical equations for the physical laws involved are well known. Moreover, experimentation with computer-supported models offers practical advantages over canning experiments, which are expensive and time consuming."

The mathematical model was based on a finite difference approximation of the differential equation for transient heat conduction in three dimensions. A large number of container locations were considered for average bacterial lethality and

quality retention calculations. The reliability of the numerical method was evaluated by comparing computer predictions with published experimental data for the retention of thiamine, chlorophyll, and betanin in several food products.

The computer program was written in BASIC and can be used with any IBM-PC™ compatible computer. Computing time (IBM PC AT) was approximately 3 minutes per minute of real process time. Current research efforts are aimed at reducing computational time.

Researchers in New York have demonstrated that the trimming techniques that have been suggested to reduce the amount of chlorinated hydrocarbons in the edible flesh of other fishes produced a significant reduction in the level of PCB residues in bluefish (Armbruster et al., 1989). A relatively large proportion of PCBs in bluefish is in the skin. Their work suggests that vaporization of PCBs during cooking may account for a far higher proportion of loss that extraction with fats liquefied and drained away during cooking.

Discussion and Special Issues

Last year Sea Grant's level of effort in seafood science and technology declined sharply. Although it is up considerably this year, some of the research and advisory specialists active in this field are concerned that the level of effort is too low to meet the wide range of problems and opportunities facing the industry and insufficient for training the personnel needed in industry and academe. For example, if inspection of seafood is made mandatory as expected, a range of education to institute procedures in hazard analysis and critical control points (HACCP) will be required. Much of this education would be the logical responsibility of universities.

Increasingly difficult problems with waste disposal in the seafood industry, increasing public concern about quality and safety of seafood, and advancements in molecular biology that could have academically interesting and important applications in research dealing with seafood suggest that the trend should be toward increased efforts in this field. There may be special opportunities for improving efficiency of seafood processing through new and better technology for by-product recovery, for recovery of such things as flavoring components and amino acids.

Over the next few months the National Sea Grant Office is planning to work with the Seafood Technology Group of the Institute of Food Technologists and with the seafood industry to develop a strategy document or white paper that will enunciate the rationale for a coherent national program and for additional effort in research, demonstration, and advisory service.

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Appendix B
FISCAL YEAR 1989 PROJECTS

B. SEAFOOD SCIENCE & TECHNOLOGY

TITLE/INVES./INST.	FEDERAL FUNDS	MATCH FUNDS
1. Engineering & Waste Treatment		
Design & Development of a Sea Urchin Processing System R. Paul 30 University of California Sea Grant College Program	19,535	24,144
A Biotechnological Application of biogenic Ice Nucleator for Energy Saving and Improved Quality in the Freezing of Seafood T.C. Lee 35 New Jersey Marine Sciences Consortium Sea Grant Program	23,000	43,400
Development of Coastal Fish Oil Resources for Potential U.S. Health Industry J.G. Turcotte 12 Rhode Island Sea Grant College Program	73,070	27,098
SUBTOTAL:	$115,605	$94,642
PASSTHROUGH:	0	

TITLE/INVES./INST.	FEDERAL FUNDS	MATCH FUNDS
2. Product Development & By-Product Recovery		
Control of Surimi Functionality Through Modification of Protein Composition J.S. French 35 University of Alaska Sea Grant College Program	39,100	6,100
Salmon Meal as a Fertilizer S.D. Sparrow 35 University of Alaska Sea Grant College Program	17,500	0
Potential Anti-Tumor Drug from Marine Waste By-Products K.P. Wong 12 University of California Sea Grant College Program	39,608	31,756
Fish Myofibrillar Protein as a Food Ingredient D. Hamann 35 University of North Carolina Sea Grant College Program	5,145	40,211

Functional Characterization of Surimi Waste Stream T. Lanier 35 University of North Carolina Sea Grant College Program	56,163	4,671
Microencapsulated Diets for Intensive Production of Molluscan Shellfish C. Langdon 03 Oregon Sea Grant College Program	64,200	37,300
Crab Shell Chitosan, its Mode of Gene Activation L.A. Hadwiger 13 Washington Sea Grant College Program	65,600	17,600
Chitosan Delivery Systems for Medicines G.G. Allan 13 Washington Sea Grant College Program	42,600	21,600
SUBTOTAL:	$329,916	$159,238
PASSTHROUGH:	0	

TITLE/INVES./INST.	FEDERAL FUNDS	MATCH FUNDS
3. Nutritional, Microbial & Chemical Quality		
Extending Prime Quality Market Life of Seafoods N. Haard 35 University of California Sea Grant College Program	10,216	17,965
Collagenolytic Activity in Skeletal Muscle of Fish N. Haard 35 University of California Sea Grant College Program	31,649	30,189
Oxidative Metabolism of Polyunsaturated Fatty Acids in Fish J. Bruce 35 University of California Sea Grant College Program	19,142	21,026
Detection and Survivability of Some Pathogenic Enterobrac I. Radolfo 45 University of Southern California Sea Grant Program	43,639	40,642
Develop of DNA Probes - Pathogenic Marine Bac H. Shizura 45 University of Southern California Sea Grant Program	39,574	37,113

Consumer Preferences and the Economic Consequences of Safety Program for Shellfish Products J.W. Milon 14 Florida Sea Grant College Program	30,800	27,800
Identification of Fish and Fishery Products By Monoclonal Antibody Techniques II C. Wei 35 Florida Sea Grant College Program	39,600	24,200
Detecting of Vibrio cholerae 01 Cells In Shellfish Meat Homogenate Meat Enrichment Broths by Dipstick ELISA R.J. Siebeling 35 Louisiana Sea Grant College Program	42,814	24,543
Hydrographic Localization of Toxic Dinoflagellate Blooms in Coastal Waters D.M. Anderson 07 Woods Hole Oceanographic Institution Sea Grant Program	60,000	19,525
Immune Response in Great Lakes Fisheaters M. Sowers 45 Michigan Sea Grant College Program	63,911	16,563
Siderophore Production in the Red Tide Dinoflagellate Protogonyaulax tamarensis G.L. Boyer 07 New York Sea Grant Institute	23,028	23,160
Siscowet Trout as a Source of Antithrombotic, Hypocholesterolemic Fatty Acids for Human Medicine P.B. Addis 12 Minnesota Sea Grant College Program	4,970	4,020
Causes and Mitigation of Toxics Contamination of the Fishery in the St. Louis River/Duluth-Superior Harbor, Fishery Nursery A G. Rapp 44 Minnesota Sea Grant College Program	24,000	5,790
Uptake and Retention of Contaminated by Fish Maintained on Artificial Diets in Lake Ontario J.K. Buttner 02 New York Sea Grant Institute	32,344	20,208

The n-3 Polyunsaturated Acids of Marine Lipids: Determination of Biochemical Effects, Optimum Dietary Intake and Oxidative St J.E. Kinsella 12 New York Sea Grant Institute	22,275	63,576
Risk Perception and Communication Regarding Chemically Contaminated fish in Lake Ontario B.A. Knuth 29 New York Sea Grant Institute	9,523	15,474
Disposition and Metabolisms of Polychlorinated Dibenzofurans in Fish H.C. Sikka 45 New York Sea Grant Institute	50,568	26,745
Evaluation of Plasmid Profiles as a Method to Determine the Source of Fecal Pollution in an Estuary R.K. Sizemore 08 University of North Carolina Sea Grant College Program	11,515	5,252
Social and Cultural Dimensions of Consumer Knowledge Among Seafood Consumers: Consumer Education Implications D. Griffith 29 University of North Carolina Sea Grant College Program	13,459	8,932
Absorption of Ethyl Ester and Triglycerides of Fish Oil Omega-3 Fatty Acids in Man W.E. Connor 12 Oregon Sea Grant College Program	22,900	18,100
Do Dietary Saturated Fatty Acids Reduce Effects of Fish Oils on Lipid Metabolism and hemostasis W.E. Connor 12 Oregon Sea Grant College Program	35,100	28,200
Processing Crab and Shrimp Meat for Improved Product Quality and Safety D.L. Crawford 35 Oregon Sea Grant College Program	25,000	56,700
Fatty Acid and Lipid Nutrition of Red Drum: Effects on Cold Adaptation, Immunocompetency and Product Quality D.M. Gatlin 02 Texas A&M University Sea Grant College Program	35,049	19,938

Consumer Perceptions of Seafood Quality J. Anderson 20 Rhode Island Sea Grant College Program	22,762	57,253
The Role of Formaldhyde in the Textural Deterioration of Frozen Gadoid Fish Muscle K.L. Parkin 35 Wisconsin Sea Grant Institute	26,728	11,068
Third International Conference on Ciguatera Fish Poisoning T.R. Tosteson 74 University of Puerto Rico Sea Grant Program	5,000	0
SUBTOTAL:	$745,566	$523,982
PASSTHROUGH:	4,000	

TITLE/INVES./INST.	FEDERAL FUNDS	MATCH FUNDS
4. Handling & Processing		
Good Manufacturing Practices for Alaska Seafood Processing Industry J.B. Lee 35 University of Alaska Sea Grant College Program	44,400	21,800
Energy Use Assessment in Alaskan Seafood Processing Plants J.C. Nash 35 University of Alaska Sea Grant College Program	26,900	8,900
Studies Concerning the Uptake, Elimination, Retention and Depuration of Virulent, Avirulent and VBNC Forms of Vibrio vulnific G.E. Rodrick 08	22,300	57,000
Florida Sea Grant College Program Ozone-Assisted Depuration of Red Tide Contaminated Shellfish and Seawater G.E. Rodrick 35 Florida Sea Grant College Program	20,000	30,000
Development of Techniques for Increasing the Efficiency of Soft Shell Crawfish Production by Removal/Neutralization of the Ey R.F. Malone 01 Louisiana Sea Grant College Program	51,400	41,811

An Economical Analysis of the Decline in Maryland Seafood Processing I. Strand 14 Maryland Sea Grant College Program		0	5,700
Stability of Fish Oils During Production and Use H. Hultin 13 Massachusetts Institute of Technology Sea Grant College Program		50,000	18,800
Uptake and Depuration of Red Tide Paralytic Shellfish Poisoning Toxins in East Coast Bivalve Molluscs V.M. Bricelj 06 New York Sea Grant Institute		74,177	31,188
Mathematical Models for Mgmt Decisions of Fresh Seafood Quality: Combined Heat Transfer and Microbial Growth Models J.A. Torres 35 Oregon Sea Grant College Program		34,800	13,200
New Compounds for Ice Suppression on Fish Antifreeze Proteins T. Caceci 13 Virgina Graduate Marine Science Consortium Sea Grant Program		59,970	30,673
Determination of Autolytic Decomposition Rates in Selected Mid-Atlantic fish Species Stored Under Iced and Super-Chilling Tem G.J. Flick 35 Virgina Graduate Marine Science Consortium Sea Grant Program		35,135	21,378
Fishery Development D.A. Stuiber 71 Wisconsin Sea Grant Institute		48,181	43,433
	SUBTOTAL:	$467,263	$323,883
	PASSTHROUGH:	0	
	GRAND TOTAL	$1,662,350	$1,101,745