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Seafood Waste Management in the 1980's: Conference Proceedings

Edited by W. Steven Otwell

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Coastal Plains Center for
Marine Development Services

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Report Number 40
February, 1981



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SEAFOOD WASTE MANAGEMENT IN THE 1980's:

CONFERENCE PROCEEDINGS

Orlando, Florida

September 23-25, 1980

Edited by:

W. Steven Otwell
Department of Food Science and Human Nutrition
University of Florida

Report Number 40
Florida Sea Grant College
February, 1981

CONFERENCE SPONSORS

This conference was sponsored by the Coastal Plains Center for Marine Development Services with funds granted to the Florida Sea Grant College - Marine Advisory Program for the Advisory Assistance to Florida Seafood Processors concerning Seafood Waste Disposal.

Planning for the conference has been coordinated by the Florida Sea Grant Marine Advisory Program.

ACKNOWLEDGEMENT

Production of this proceedings would not have been a success without the valuable assistance of secretary, Barbara Prichard and Sea Grant Editorial Specialist, Tom Leahy. Barbara labored long hours retyping individual manuscripts and Tom organized the basic format and printing.

COVER ART: Jeanie & Patrick Withington, 5953 Hillside Street, North, Seminole, FL 33542 (813) 392-8431

FORWARD

Seafood waste management will be a major problem facing the United States seafood industry in the 1980's. With the approach of new interim guidelines for compliance in 1984, the industry is expected to implement more stringent effluent controls. Also, the industry can anticipate more expensive pre-treatment standards for municipal facilities and stricter new source standards for new seafood processors. The cost-benefits of these future controls have been questioned. Affordable methods of seafood waste treatment seem limited and practical methods of seafood waste utilization have not developed as expected. Thus, seafood waste management and the industry's present economic status are on a collision course in the 1980's.

Concurrently, the nation's seafood industries are experiencing a growth phase initiated by the passage of the Fishery Conservation and Management Act of 1976. This Act established the 200-mile fishery conservation zone which gave the United States control over 20 percent of the world's seafood supply. The industry has responded with an accelerated growth in fishing efforts. Processing capacities must be expanded to meet the rapidly increasing harvesting capabilities. Unfortunately, new processing ventures must combat the current inflationary status in the U. S. economy and the inevitable increasing costs for fuel. Seafood waste management regulations could pose an additional impediment to the development of our nation's fisheries.

This conference on "Seafood Waste Management in the 1980's" was organized to concentrate industry and government expertise concerned with the implications of future waste management guidelines. The problems and potential solutions for seafood waste treatment or waste utilization were discussed and the legal and reasonable aspects of future regulations were debated. The conference presentations are compiled in this proceedings. These papers were edited for general format and basic grammar, but the content is the responsibility of the respective authors.

It is hoped that this proceedings will provide a basic overview of the seafood industry and associated waste management problems at the beginning of the 1980's.



W. Steven Otwell
Editor

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CONFERENCE PROCEEDINGS

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* Denotes Speaker

OVERVIEW OF SEAFOOD WASTE MANAGEMENT IN THE UNITED STATES

OPENING REMARKS

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To set the stage for the opening technical session, which I have been asked to chair this afternoon, a brief review of the Coastal Plains Seafood Processors Assistance Project is in order.

In the early 1970's, seafood processors in the Southeastern United States, as indeed elsewhere in the Nation, had experienced problems with government regulations which were constantly changing, growing in number, and becoming more demanding and technically complex. Keeping abreast of, interpreting, and complying with these regulations had been financially and technically difficult for many firms. These problems persist today, but we would like to think that we have made a contribution toward making them less burdensome, at least for many processors.

To assist seafood processors in Virginia, North Carolina, South Carolina, Georgia, and Florida in interpreting and complying with the regulations, the Coastal Plains Regional Commission funded a project which enabled the various State advisory service organizations to provide the required assistance directly to seafood processors in their respective States. Commission support provided for the employment in each State of an advisory services agent to implement the project for a two-year period.

The Coastal Plains Marine Center was assigned the role of monitoring the execution of the project and coordinating it among the State organizations involved. The Center also disseminated information to the advisory services agents and promoted the exchange of information and techniques among them so as to put the project on a mutually beneficial interstate basis.

June 26, 1974, was the date of the first meeting to discuss the project and make plans to request that it be financially supported by the Coastal Plains Regional Commission. May 2, 1975, was the date on which the Center first advanced funds to any of the States for the purpose of supporting the work of their agents. The

first agent began work on September 1, 1975, in North Carolina. The two-year periods in the various States overlapped rather than coinciding, primarily because Virginia and Florida joined the Commission several years after the other States. The last agent to complete work under Commission and Center sponsorship was your Conference Chairman, Steve Otwell, in Florida on June 30 of this year, so the total period of execution was only two months short of five years.

This conference will present some of the lessons learned and techniques discovered in the execution of the project during the last several years. This afternoon you will receive an overview of seafood waste management in the United States, with presentations by the five Coastal Plains States before the break, and by other regions of the country after the break. Hopefully we can all learn from each other.

SEAFOOD WASTE MANAGEMENT IN VIRGINIA

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It's a pleasure to be here as a participant and representative from Virginia. Clearly my newness in Virginia and perspective as an economist do not make me the "foremost" authority on this topic. However, I am apparently the only one with travel money.

It reminds me of the story of the sailor who, upon hearing that his girl back home was engaged to his best friend, quickly called her and inquired as to just what his friend had that he didn't have. His "ex" responded quite simply "nothing --but it's here!"

So with the above qualification I think that you should know that my knowledge of the seafood waste situation of Virginia is not as extensive as some other individuals -- but it's here.

First let me give a very brief overview of a description of Virginia's seafood landings. Secondly I will attempt to portray what is perhaps the most critical aspect of this general problem today. Virginia's diverse commercial fisheries may be best characterized in terms of offshore and inshore or Bay fisheries.

Levels of seafood processing in Virginia are quite significant. Combined inshore and offshore finfish landings (principally trout, flounder, croaker, spot, etc.) are in the forty million pound range annually with about a three to one ratio respectively. This volume has proven to be a blessing in terms of processing waste management as scrap is commonly sold to cat and mink food companies. Also some of the largest processors enjoy access to municipal waste treatment systems.

The State's principal offshore shellfisheries are comprised mainly of scallops and surf clams with meats processed annually at about seven million and twelve million pounds respectively.

Reportedly of these fisheries the mechanized clam processors face the probability of waste management problems in the future.

Virginia's significant Bay oyster harvest yields around five million pounds of meats yearly with the shells returned as cultch for future oyster set.

Approximately 80-85% of Virginia's commercial fishery landings are comprised of menhaden. Around 500,000,000 lbs. of this fish are landed and used in the production of fish meal. In the recent past these large reduction plants have invested substantial amounts of capital in installing stack scrubbers in attempting to reduce odors impacting local air quality. Unfortunately what has been taken from the air is now going into the water and according to State Water Quality personnel gives rise to significant levels of B. O. D.

Virginia clearly has some areas of concern in seafood processing waste management. To date, industry has taken whatever it has considered prudent steps in meeting air and water quality regulations. Our industry is probably the same as that here in Florida or on the West Coast in at least one regard and that is the uncertainty with which they view the future relating to environmental regulation. As businessmen uncertainty regarding the regulatory context within which they must produce in the future may be their number one management problem.

Virginia is fortunate, however, in that the implementation of N. E. P. A. has been delegated to our own State Air and Water Control Board. These agencies have proven to be more knowledgeable about local, site specific conditions and probably to a large extent, are responsible for Virginia's demonstrated regulatory rationality.

"NOW FOR THE BAD NEWS"

Currently the disposal of hard crab waste in Virginia and throughout the Chesapeake Bay region has manifested itself as a critical issue for this valuable fishery.

Based on an 18 year average (Table 1), Maryland and Virginia combined produced about 50 million pounds of hard crab scrap in a single year.

Problems arise because of the seasonality of landings (Figure 1 and 2) as well as their location (Figure 3).

In the recent past this scrap has been used in the production of a dried meal product. Used as an additive in certain types of livestock feed, the scrap has held value as a marketable recovered waste product.

Recently some crab meal processors have experienced problems in the rendering of the scrap into meal. Reportedly the traditional market for crab meal is no longer profitable as competitive meal

TABLE 1

Total Annual Blue Crab Landings in Lbs. for Virginia and Maryland
by Month and Estimated Solid Waste Generated
(60-78)

	Virginia	Maryland	Total
Sept.	5,069,589	4,215,256	9,284,845
Oct.	4,776,336	3,047,887	7,824,223
Nov.	2,202,381	896,099	3,098,480
Dec.	4,199,626	99,133	4,298,759
Jan.	2,705,689	1,133	2,706,822
Feb.	2,040,510	793	2,041,303
March	1,402,438	1,384	1,403,822
April	2,402,127	377,972	2,780,099
May	3,652,328	1,159,042	4,811,370
June	4,677,860	3,028,147	7,706,007
July	5,317,491	5,082,731	10,400,222
August	<u>5,666,528</u>	<u>5,124,676</u>	<u>10,791,204</u>
Total	44,112,903	23,034,253	67,147,156
*Total Scrap	30,879,032	16,123,977	47,003,009
**Total Meal	9,925,403	5,182,707	15,108,110

Source: VIMS Unpublished Data File

Personal Communication: W. A. VanEngle

*Based upon 70% scrap yield + 10-15% Meat + 15-20% Cooking Loss

**Based upon 25% yield of meal from wet waste

FIGURE 1 -

PERCENT OF TOTAL ANNUAL SOLID WASTE GENERATED
BY MONTH. (1960 - 1978 AVERAGED)

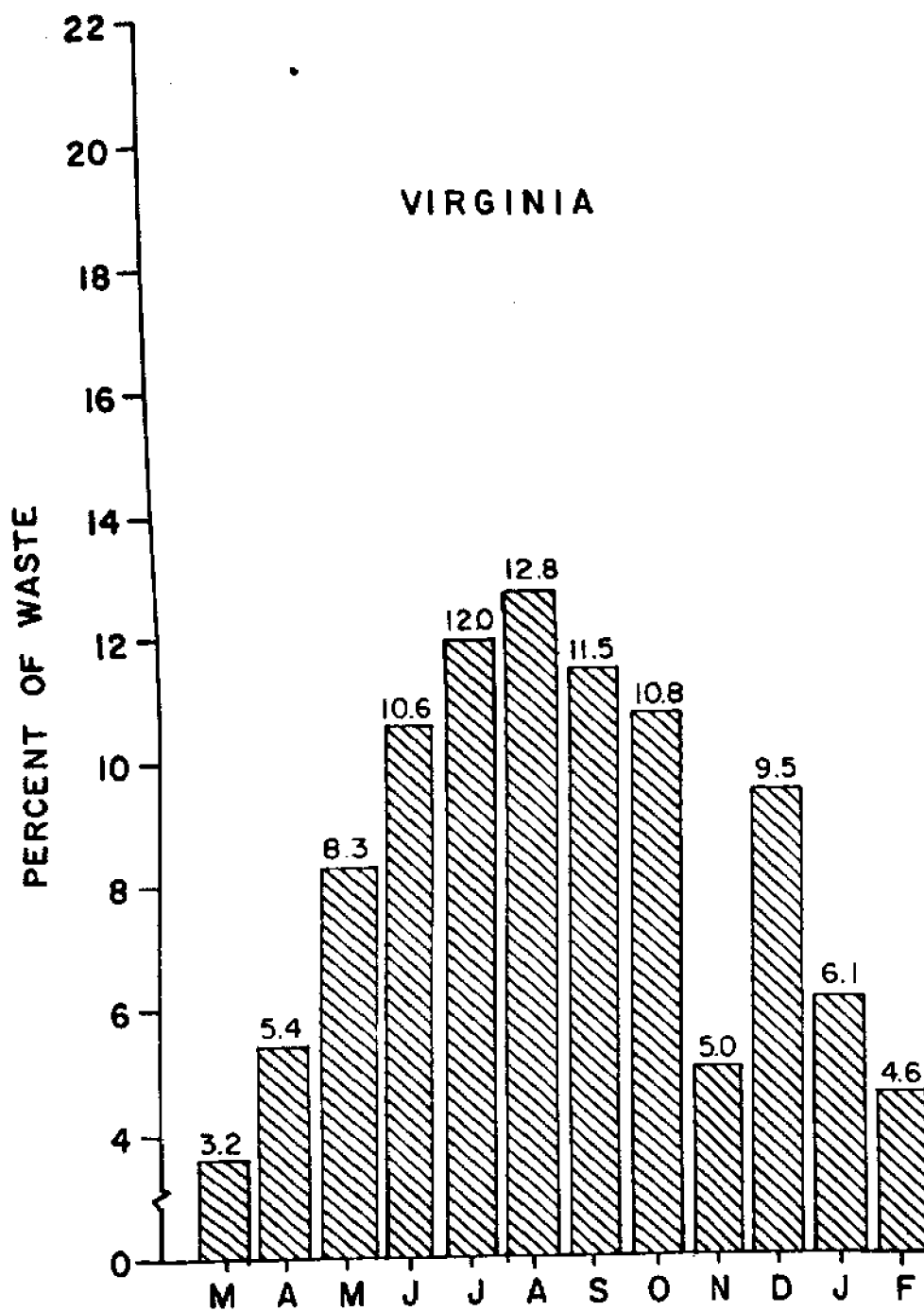


FIGURE 2 -

PERCENT OF TOTAL ANNUAL SOLID WASTE GENERATED
BY MONTH. (1960 - 1978 AVERAGED)

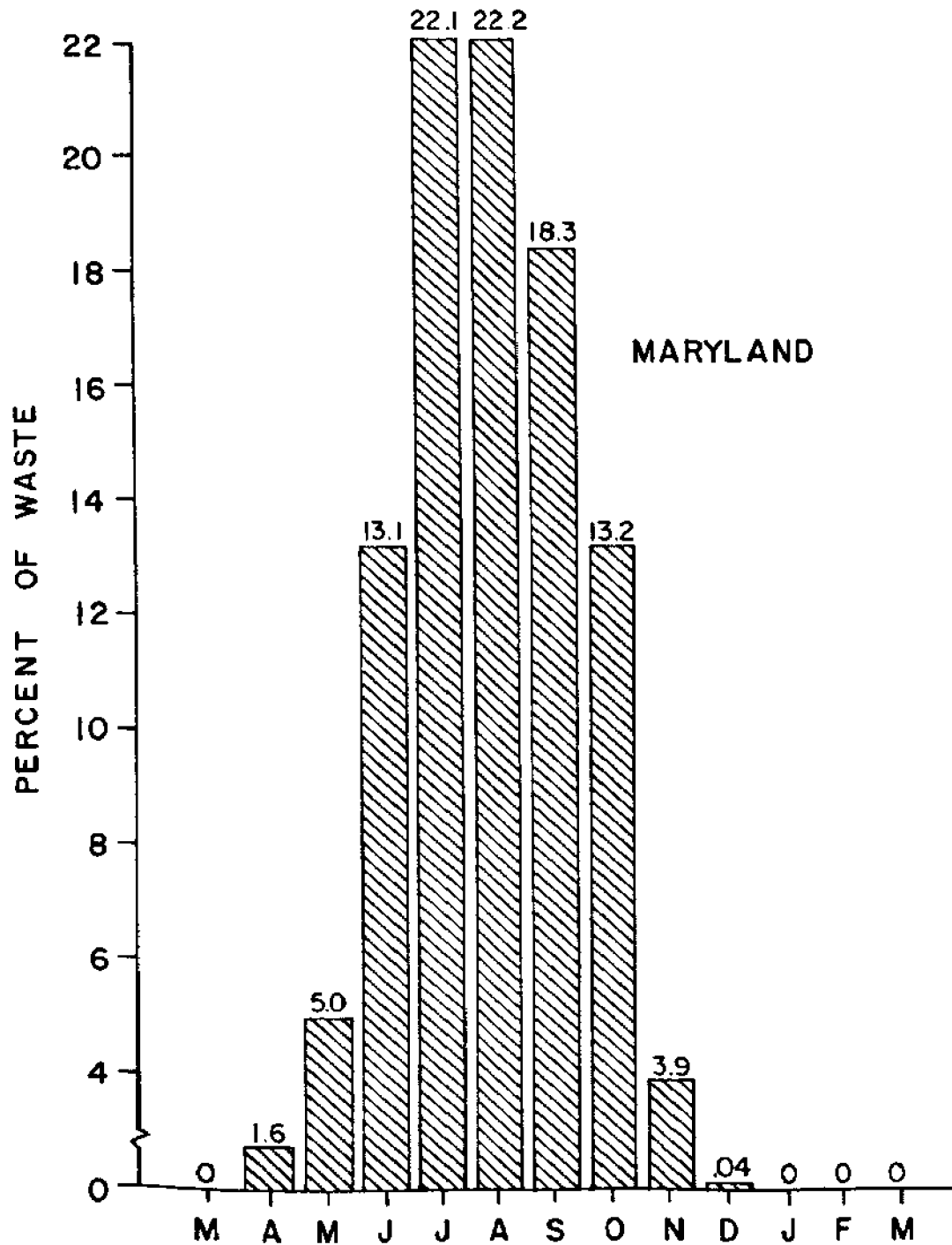
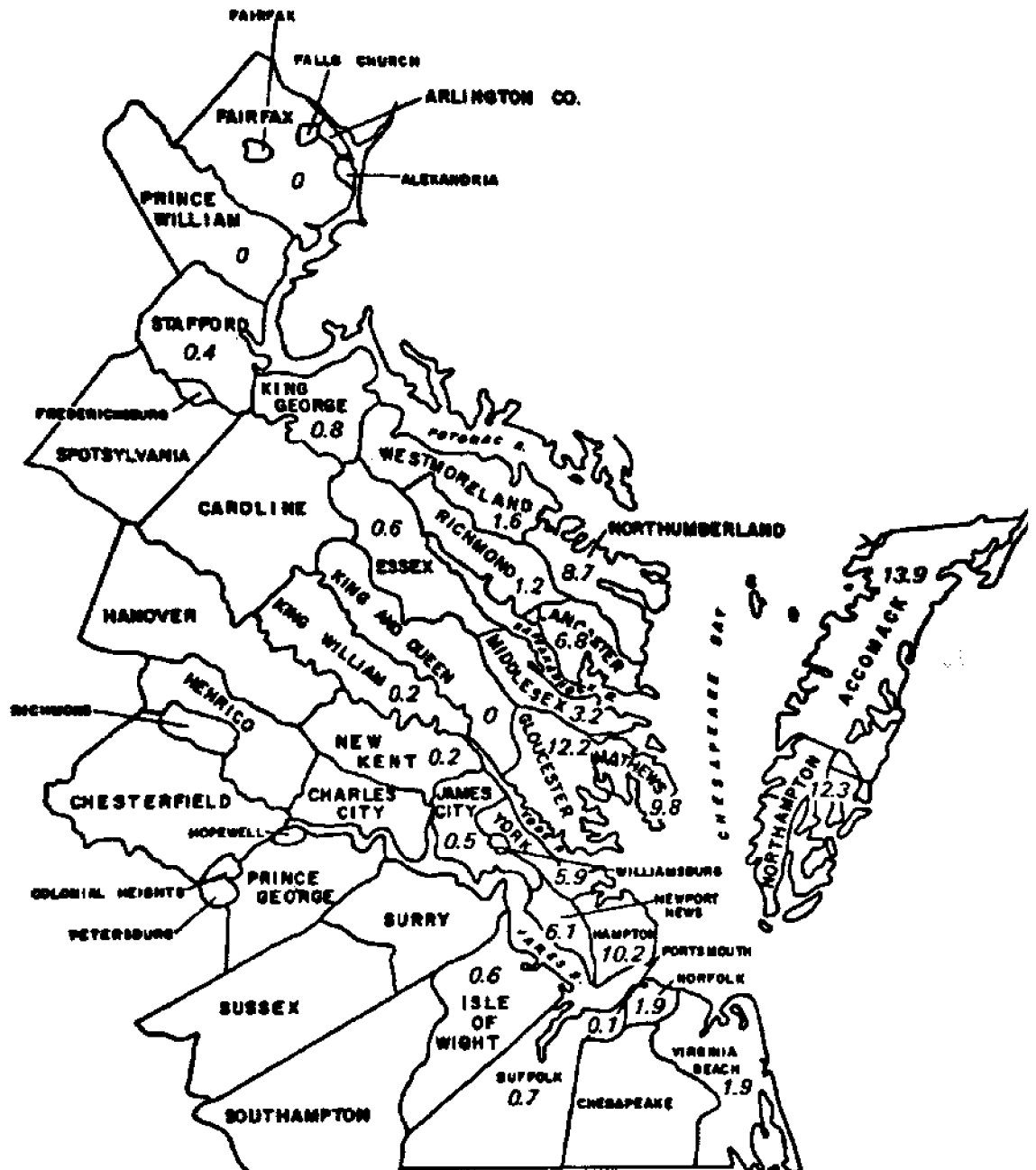


FIGURE 3

% Hard Blue Crab Landings by
County (1963-1977 Average).*



*This characterizes the location of Virginia's landings but probably does not accurately reflect the actual processing locations and therefore the true concentrations of hard crab wastes.

products (principally soybean and corn) had experienced decreases in price, thus causing a shift by feed companies away from crab meal to the relatively cheaper grains¹.

Some meal plant operators cite the resulting decrease in final price for their crab meal in conjunction with increases in their operating expenses (principally energy) as the source of their problem.

Unable to meet even the variable costs of operation meal plant operators have shut down or drastically curtailed operations to a "day to day" basis.

Without the recovery of the crab waste into a meal product, crab packers are faced with the dilemma of disposing of large quantities of wet solid crab waste in order to continue producing.

Contacts with feed company's representatives have indicated a willingness to utilize the crab meal product - at the right price. However, past instances of undependable delivery, poor product quality, etc. have discouraged some large feed blenders on the use of crab meal in their feeds.

Irrespective of the history, present problems, and future potential of crab meal products, the need for some form of waste utilization or disposal to relieve the crab processing sector is immediate.

Presently, we are developing enterprise budgets for new crab meal processing plants and looking at the future of the crab meal market as it relates to other commodities. This analysis will assist industry in developing its best alternative to hard crab waste management today.

¹Large feed corporations used computerized formulas to constantly substitute different meal products in feed products - minimizing their costs for protein and other requirements. This is critical because fulfilling animal nutrient requirements is a major economic consideration in any modern livestock enterprise. For example, approximately 80% of the variable costs of feedlot beef, 55-60% in swine, and 50-60% in dairy and poultry are due to feed costs.

**ASSISTING NORTH CAROLINA SEAFOOD PROCESSORS IN MEETING
WATER POLLUTION REQUIREMENTS**

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and
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INTRODUCTION

Traditionally, the North Carolina seafood industry has deposited its wastewaters and solid waste into the coastal waters surrounding its seafood handling and processing plants. With the increasing emphasis on environmental concerns culminating with the passage of PL 92-500 in 1972 and subsequent amendments, it has become increasingly evident to the authors that seafood processors must curtail or modify many of their past practices because of regulatory mandates. Numerous changes in federal laws and regulations and in state laws and regulations have occurred and current trends indicate that many more changes will occur in the years to come. Therefore, this study was undertaken to assess the situation in North Carolina and to help formulate plans to assist the seafood industry as they comply with current, developing and future pollution laws and regulations.

This project was intended to accomplish the following objectives for North Carolina seafood processors, with findings and methodology applying to other states in the Coastal Plains area:

A. Federal and State Regulations:

Determine interaction of EPA, OSHA, FDA, and various state agencies in dealing with each important segment of North Carolina seafood industry.

B. Literature Review:

Collect and interpret relevant information dealing with the project.

C. Survey and Categorize:

Determine most important seafood handling and processing categories and plan to investigate eight of them in a two-year period.

D. Demonstrate and Educate:

Investigate details of each handling and/or processing category to determine seasonal availability of species, economic importance and other factors, presenting the findings to management as basis for future action and corrective measures.

E. Industry Contacts:

Prepare written releases at the end of each three-month period upon completion of a category, mail frequent releases on subject, visit individual companies, hold meetings, and in other ways employ extension capabilities to reach those affected.

F. Unscheduled Requests:

Employ expertise if requests bearing upon the subject matter of this project are of sufficient importance to require immediate attention.

During the project, there were frequent contacts with federal and state agencies through visits or by telephone. Discussions dealt with the problem of effluents generated by seafood handling or processing operations. Also, sanitation and quality aspects of seafood products and plant safety were reviewed.

The literature review involved collection of regulations and publications bearing upon the subject matter of the project. These items were systematically examined for content, then embodied in the Information Retrieval System described by Ramey (6). This paper will focus on the field work and laboratory effort concerning plant effluents as indicated by the following:

List of Seafood Plants Studied

<u>Category</u>	<u>No. Plants</u>	<u>Months and Years Involved</u>
<u>Handling Finfish</u>	26	Dec. to March, '76 & '77
<u>Processing Finfish</u>		
Alewife (Packing)	3	Year Round, '76 & '77
Eel Freezing	1	March to June, '76
Croaker, Trout, Flounders (Scaling, Heading, Cutting; Fillets)	13	Nov. to Feb., '76 & '77

Processing Crustacea

Crabs, Blue (Hand Picking)	22	Jul. to Sept., '77
Crabs, Blue (Mech. Picking)	2	Jul. to Sept., '77
Shrimp, Heading & Packing	34	June to Aug., '77

Processing Mollusks

Scallops, Bay & Calico (Shucking)	9	Sept. to Dec., '75
Scallops, Sea (Shucking)	3	Jan. to Mar., '76
Oysters, Blow Tank	12	June, '76; Mar. to May, '77
Oysters, Heat Shock	12	Mar. to May, '77

North Carolina has a long coastline of over 1000 miles with a number of bays, sounds and estuaries totalling over 2,000,000 acres that produce a variety of seafood. Webb et al (7) provided a breakdown of licensed companies engaged in handling and processing activities for seafood:

N. C. HANDLERS AND PROCESSORS, by DISTRICTS Number Concerned with Major Categories (1974)

	<u>Northern</u>	<u>Central</u>	<u>Southern</u>	<u>Total</u>
<u>HANDLERS</u>	220	128	247	595
<u>PROCESSORS</u>				
Finfish	50	69	51	170
Shrimp	25	29	21	75
Crabs	13	18	3	34
Oysters & Clams	7	22	9	38
Scallops	-	12	-	12
Industrial Fish	14	6	-	20
	109	156	84	349
TOTAL HANDLERS/PROCESSORS				944

Regulations

Congress in 1972 enacted the Federal Water Pollution Control Act Amendment of 1972 - PL 92-500. The objective of the law is "to restore and maintain the chemical, physical and biological integrity of the nations' waters." The law requires EPA to establish "effluent limitations" for all industries including seafood plants. The law also required EPA to develop and maintain a permit system for all industries that directly discharge to the surface waters of the United States.

The effluent limitations were established by the EPA after a series of studies and public comments. To-date, they have included "Best Practicable Control Technology Currently Available" (BPT), a standard which should have been met by all seafood plants by 1977;

"Best Available Technology Economically Achievable" (BAT) which was proposed to be met by 1983 and now PL 95-217 requires EPA to fix "Best Conventional Pollutant Control Technology" (BCT) which are currently being revised for the seafood industries. The regulatory process and regulations have been described by Carawan et al (2, 4) and Green and Kramer (5). However, regulatory authorities must be contacted for up-to-date information.

Effluent limitations for the seafood industries include contaminant levels per 1000 pounds of raw product plus pH standards of 6.0 to 9.0. Contaminants restricted include biochemical oxygen demand (BOD₅), total suspended solids (TSS) and fats, oil and grease (FOG). Limitations include maximum daily levels and average levels for any 30 day period.

Seafood industries that discharge to municipal systems are not required to meet these limitations or the permitting requirements at this time. However, the municipal system may require permits or limitations as described by Carawan et al (3).

The National Pollutant Discharge Elimination System (NPDES) was developed to identify and control all dischargers into public waters. Every seafood plant should have a permit. In North Carolina, EPA on October 19, 1975 transferred the permit authority and control to the North Carolina Department of Natural and Economic Resources (NER), Division of Environmental Management. Permits issued by EPA will expire in 1980 and must be renewed upon expiration. NER issues permits on computer evaluations involving such factors as federal effluent guidelines, receiving water quality and mathematical models involving the affected estuary or stream. Discharges within areas of limited tidal flow are usually very restrictive. Any discharges into waters designated for "shellfishing" are very restrictive. In fact, state computer analysis usually gives limitations that are much more restrictive than the federal limitations. Small handlers have generally been required to meet a limitation of 15 ml/l of settleable solids except where this limit could damage water quality.

Discharge monitoring reports are required of all permittees by the NER. Generally, most processors are required to file quarterly reports on flow, FOG and TSS. New permits also require BOD. Grab samples have usually been accepted by NER.

METHODS

The small size and age of the seafood plants sur-

veyed made exacting effluent measurements difficult. Samples were usually obtained by grab samples although proportional, composit samples were obtained for the plants studied in detail. Flow measurements were made using a bucket or a barrel and a stopwatch. Most plants had several drains and accurate flow measurements were not possible. Standard methods were used for the analysis, either A.O.A.C. or Standard Methods for the Examination of Water and Wastewater.

Samples were preserved in ice during sampling. If samples could not be run within 24 hours after sampling was completed, samples were frozen.

RESULTS AND DISCUSSION

Approximately 134 seafood plants were visited during this study. Accurate effluent data could not be obtained from all plants and laboratory or pilot plant processes were used to duplicate commercial efforts.

Results presented include those for plants which received more extensive investigations than a visit and a grab sample. The results presented were obtained to allow the North Carolina seafood industry to compare its effluents with EPA limitations. Although the results are as accurate as possible for the time period tested, they should not be used for standard settings or regulatory analysis because seasonal, size and even technological status are not identified.

Blue Crabs

Hand Picking. Blue crabs in North Carolina are largely processed by hand. Some 24 blue crab plants were surveyed. The average results for these plants include the following:

Average Waste Generated by Hand Picking of Blue Crabs

PARAMETER	PROCESS			BAT	
	Cook/Pick	Clean-up	Total	AV.	MAX.
	(lb./1000 lb. raw crabs)				
TS	9.6	0.3	9.9		
Ash	3.8	0.1	3.9		
OS	5.8	0.2	6.0		
BOD ₅	2.46	0.04	2.5	.15	.30
TSS	0.54	0.10	0.64	.45	.90
FOG	0.11	0.010	0.12	.065	.13
Flow	43	(gal./1000 lb. raw crabs)			
		30	73		

Most plants had good practices in regard to solid waste and economical water use. However, management

was observed to be able to control cook waters and plant clean-up wastes. Effective sweeping of solids before hosing was very effective in reducing waste load during clean-up operations. Screening (20 mesh) was not found to be effective in reducing crab picking plant waste loads. Both BOD, FOG and TSS exceeded the BAT limitations.

Mechanical Picking. Plants employing brine flotation differ from exclusively hand picking operations in that part of the meat recovery is accomplished mechanically. Several plants use this equipment to recover meat from claws. A large plant, also applying this technique to cores (from which lump meat has already been removed by hand), was evaluated, but the data required confidential handling. The following data applies only to claw picking operations:

Waste Solids Generated by Mechanical Picking of Blue Crabs

	Picking (lbs. of waste solids/1000 lbs. of raw claws)	Clean-up	Total	BAT	
				AV.	MAX.
TS	47.8	48.8	96.6		
Ash	42.0	41.9	83.9		
OS	5.9	7.0	12.9		
BOD ₅	3.5	8.9	12.4	2.5	5.0
TSS	2.6	7.4	10.0	6.3	13.0
FOG	0.6	0.6	1.2	1.3	2.6

Screening offers a promising method of reducing the waste load going into the effluent, as indicated by the following:

Settleable Solids in Crab Processing

	Picking (ml/l)	Clean-up
Before screen	12.0	58.0
After screen*	7.0	13.0

*20 mesh (Tyler)

These results are not indicative of what one might expect from a mechanical plant. These results were only for the brine flotation separation type of machine used only on cooked claws. However, the magnitude of waste load from this operation indicates this sizable load will contribute to the total waste stream from a crab plant.

Finfish Handling and Processing

Handling: Finfish handling is limited to unloading, washing and separating ice, sorting and grading and re-icing before shipping. Most of the wastes generated in handling were observed to occur during the debris and ice removal in the washing tank.

Field investigations were made at 26 of the finfish handling plants. Species included primarily flounder, croaker, trout, spot and bluefish. Average results for the rinse and wash tank include the following:

Finfish Handling - Rinse Tank

Wastewater Characteristics

<u>Parameter</u>	<u>Waste Load</u>	
	(lb/1000 lb)	
	<u>avg.</u>	<u>range</u>
Total solids	2.40	.87-4.60
Ash	1.11	.53-2.15
Organic solids	1.30	.34-2.44
BOD ₅	.23	.01-1.00
	(gal/1000 lb)	
Wastewater	110	60-180

BOD₅ from the rinse tank would be 251 mg/l with 0.23 lb. BOD/1000 lb. fish and 110 gal. wastewater/1000 lb. fish. Finfish handling has not been defined by EPA and limitations established so plants are generally required to meet the 15 ml/l of settleable solids unless water quality is threatened.

Much of the solids come from the scales removed by washing. These solids were found to be easily removed by screening with a 20 mesh screen. Results from investigations indicated the following:

Removal of Settleable Solids by Screening -

Wash Tank Effluents

(20 Mesh Screen)

	<u>Plant 1</u>	<u>Plant 2</u>	<u>Plant 3</u>	<u>Average</u>
	(ml/l)			
Raw Effluent	3.8	20.0	100	41
Screened	1.0	2.0	14	5.7
	(%)			
Removal	74	90	86	86

During unloading, scales may drop off and contribute large amounts of settleable solids. Slime, blood and sand are also a part of the wastewater problem. In order to gain an idea of the maximum materials removed from fish during unloading, we tried strenuous washing and measuring of what was removed:

Solids Generated During Strenuous Washing of Fish

	<u>Trout</u>	<u>Croaker</u>	<u>Flounder</u>
	(lbs/1000 lbs fish)		
TS	6.56	4.08	3.20
OS	4.06	1.98	1.36
Ash	2.50	2.10	1.34

Processing. North Carolina finfish processing operations use hand labor to process primarily flounder, trout and croakers. Some 13 plants were surveyed during these investigations.

Three plants in which flounder, trout and croakers were being processed in the round or fillet were studied in detail. These plants were processing between 715 to 1000 lb/hr. of fish. The raw effluent from these plants had the following average characteristics:

Raw Effluents From Finfish Processing

	<u>Rinse Tank</u>	<u>Mechanical Scaling</u>	<u>Fillet & Rinse</u>	<u>Clean-Up</u>	<u>Total</u>	<u>BAT</u>	
						<u>Avg</u>	<u>Max</u>
	(lb/1000 lb raw fish)						
TS	2.08	4.74	3.44	0.27	10.53		
Ash	0.37	2.03	1.37	0.12	3.89		
OS	1.71	2.60	2.08	0.15	6.54		
TSS	0.38	2.59	0.86	0.09	1.96	.73	1.50
DS	0.71	1.85	2.96	0.13	5.65		
BOD	0.59	0.56	0.86	0.10	2.11	.58	0.73
FOG	0.10	0.30	0.71	0.03	1.14	.03	0.04
	(gal/1000 lb)						
FLOW	544	318	457	16	1335		

All the parameters exceed the BAT limitations. Raw effluents were screened through a 20 mesh screen and although solids were separated, key parameters were not reduced.

For the three plants studied, the average water use was 1.34 gal./lb. raw fish processed. The BOD₅ load was 2.11 lb./1000 lb. fish processed. Thus, the BOD₅ concentration of the raw effluent was 190 mg/l.

Smaller processors were permitted by NER with the 15 ml/l settleable solids limitation. These processors were found to be using about 1.6 gal. of water per pound of fish processed and were not having any trouble meeting the settleable solids limitation.

Pilot plant trials were conducted with flounder, trout and croaker to examine controlled processing conditions. Even under controlled conditions, BAT limitations were exceeded. Typical pilot plant results follow:

Pilot Plant - Croaker Processing

Parameter	Raw Effluents			
	Process			
	Rinse Tank	Scaling	Fillet & Rinse	Total
(lbs of waste/1000 lbs of raw material)				
TS	1.96	1.48	0.58	4.02
Ash	1.16	0.69	0.13	1.98
OS	0.80	0.79	0.45	2.04
TSS	0.89	1.40	0.23	2.52
DS	0.57	0.78	0.71	2.06
COD	0.76	0.95	0.87	2.58
FOG	0.15	0.18	0.14	0.47
Screened Effluents (20 Mesh)				
TS	1.22	1.13	0.49	2.84
Ash	0.81	0.38	0.09	1.28
OS	0.41	0.75	0.40	1.56
TSS	0.15	0.25	0.14	0.54
DS	0.57	0.78	0.71	2.06
COD	0.34	0.62	0.70	1.66
FOG	0.14	0.14	0.13	0.41

Screening did improve the waste parameters. For example, COD was reduced by 55% and TSS by 83 % using the 20 mesh screen. However, field investigations were not conducted to confirm these pilot investigations. However, even these improved results did not meet the BAT standards.

Control of waste solids was observed to greatly influence the wastewater characteristics. Of 29 plants surveyed, 9 sent their solids for dehydration, 12 used their solids for bait and 8 disposed of all the material overboard.

Composting of raw fish frames was tried as a disposal method on a pilot basis. Grass cuttings, pine straw, horse manure and soil were mixed and composited six weeks. Then, raw fish frames were added. The fish frames were completely decomposed within 4 weeks.

Oyster Processing

Field studies were done at 24 of the North Carolina oyster processors. Extensive data was collected at three plants. Waste parameters were found to be as follows:

Effluents From Oyster Processing								
Parameter (Unscreened)	Processing Operation					BAT		
	Heat Shock Tank	Meat Rinse	Blow Tanks	Clean-Up	Total	Avg	Max	
	(lb/1000 lb oyster meats)							
BOD ₅	2.21	1.28	5.57	0.88	9.94			
TSS	0.75	1.16	2.58	0.56	5.05	16.00	23.0	
FOG	0.42	0.11	0.62	0.09	1.24	.77	1.1	
TS	11.43	5.74	36.53	5.66	59.36			
Ash	5.99	1.60	32.45	3.07	43.11			
OS	5.44	4.15	4.08	2.59	16.26			
DS	10.74	3.06	31.73	3.52	39.05			
	(gal/1000 lb oyster meats)							
FLOW	705	184	1875	193	2957			

This unscreened data can be observed to note that the FOG concentration exceeds the BAT standards. Most of the BOD (56%) and the FOG (50%) originate in the blow tank(s). Therefore, efforts may need to be directed at improving the wastes generated in this process.

About 3000 gallons of effluent would be produced with about 10 pounds of BOD₅. Raw effluent BOD₅ would be about 400 mg/l.

Limited screen testing was done with a 20 mesh screen. Although some materials were removed by the screens, data taken during screen trials did not indicate a reduction in waste parameters.

Shrimp Processing

The shrimp category received limited attention due to the nature of the shrimp industry in North Carolina. Processing consists of only heading, packaging and freezing. Laboratory trials were run to establish the performance level for shrimp processing. Shrimp were headed and washed in the laboratory with the following results:

Laboratory Shrimp Processing Effluents

<u>Parameter</u>	<u>Laboratory</u>	<u>BAT</u>	
		<u>Avg</u>	<u>Max</u>
(lb/1000 lb raw shrimp)			
BOD ₅	4.79	10.0	25.0
TSS	1.22	3.4	8.5
FOG	0.33	1.1	2.8
TS	8.83		
Ash	5.46		
OS	3.36		
DS	8.39		
(gal/1000 lb)			
FLOW	333		

During the laboratory studies, the shrimp were not washed before heading and the heads and shrimp were not water flumed. Plants that wash the shrimp as they are received and water flume either the heads or shrimp would expect higher parameters. Limited studies with a 20 mesh screen did not indicate improvements in the parameters.

The BOD was found to be 4.79 lb./1000 lb. of shrimp processed which would be contained in 333 gal. of water. The raw effluent would have a BOD₅ = 1724 mg/l. Of course, many plants would use more water than used in these laboratory studies and the concentration would be reduced.

Scallop Processing

Field studies were conducted at a number of scallop processing plants in North Carolina. When

raw materials have been available, North Carolina had 9 mechanical shucking houses and about 30 hand shucking operations for scallops. Twelve plants were examined in these investigations.

The data presented will focus on the 3 mechanical shucking houses which received extensive investigations. These scallop operations operated at 100-300 bu./hr. Results for two types of operations follow. The first is for a plant that has extensive fluming and does not control water use or wastes. The second is for a plant that does effectively control water use and wastes. In fact, a 300 gal. settling tank was used to separate gross solids. BOD was not run during the investigations and the BOD's used the assumption that $BOD_5 = 0.4 OS$. Using this assumption, the plant with the controlled water and waste practices had a 76% reduction in BOD_5 load when compared with the load from the uncontrolled plant.

Sea scallops are larger than calicos and water use for calicos is about 1.5 times the water use for sea scallops. The waste load from sea scallops was about 30% of the calico waste load in the plant with uncontrolled water use and waste.

Raw waste effluents ranged from 7,000-15,000 gal./1000 lb. scallop meats. Waste loads ranged from about 75-340 lb. BOD/1000 lb. scallop meats. Effluent concentrations ranged from 700-2700 mg/l BOD_5 .

Screening was observed to be effective in reducing the raw waste load. The organic load from shock tank discharges could be lowered by 56% by a #8 mesh screen. Eviscerator effluent could have the organic load reduced by 80% using a #8 mesh screen.

The effluents from scallop operations would vary widely by species and scallop maturity. Calicos require 1.75-3 bu./gal. meats (8 lb.). Sea scallops require 1.0-1.25 bu./gal. meats (8 lb.).

Webb, et al, (8) reported the following relationships for scallop yield:

	<u>Y</u>
Meat	4.5 - 9.3
Viscera	15.7 - 28.5
Shell	62.1 - 79.2
Ratio-Viscera/Meat	3.1 - 3.6

These ratios were found to vary seasonably in North Carolina. Thus, over 3 lb. of viscera must be disposed of for each pound of scallop meats. From the field investigations, it was discovered that one also gets 0.25 lbs. of mantle.

Thus, management must dispose of 3.25-4.0 pounds of waste plus the shell (about 7 lb.) for each pound of scallop meats.

Effluent From Calico Scallop Processing
Using Mechanical System

Process/Area	Parameter				FLOW
	TS	Ash	OS	BOD	
	(lb/1000 lb scallop meats)				(gal/1000 lb meats)
Unloading/Washing	31	3.1	28	11	1,880
Shock Room	110	82	28	11	1,030
Evisceration	965	258	708	283	9,330
Grading/Packing	112	45	68	27	1,350
Clean-Up	24	12	12	4.7	1,410
Total	1242	400	844	336.7	15,000

Effluent From Sea Scallop Processing
Using Mechanical System

Process/Area	Parameter				FLOW
	TS	Ash	OS	BOD	
	(lb/1000 lb scallop meats)				(gal/1000 lb meats)
Unloading/Washing	13	4.2	8.9	3.5	1,250
Shock Room	18	14.0	4.1	1.6	700
Evisceration	268	100.0	194.0	78.0	6,210
Grading/Packing	75	30.0	45.0	18.0	900
Clean-Up	24	12.0	12.0	4.7	1,410
Total	398	160.0	264.0	105.8	10,470

Effluent From Calico Scallop Processing Using Mechanical
System with Settling Tank and Controlled Water Use

Process/Area	Parameter				FLOW
	TS	Ash	OS	BOD	
	(lb/1000 lb scallop meats)				(gal/1000 lb meats)
Washing	13	7.5	5.0	2.0	1,500
Shock	92	47.0	44.0	18.0	3,340
Evisceration	145	9.0	136.0	54.0	3,580
Packing	22	11.0	10.0	4.1	1,370
Clean-up	17	8.3	8.3	3.3	1,000
	289	82.8	203.3	81.4	10,790

CONCLUSIONS

- A. Most seafood plants in North Carolina had no idea of their regulatory obligations to EPA or NER when this project started in 1975.
- B. The renewal of permits to BAT standards may cause serious economic and technological problems for the N. C. seafood industries.
- C. Good housekeeping measures and proper disposal of wastes can help seafood plants avoid permit violations.
- D. Cooperation is still needed between regulatory persons, seafood management and technical process specialists to avoid mistakes and misunderstandings and to eliminate unnecessary economic hardships.
- E. Manufacturers of screens and other control devices need more information about seafood effluents.
- F. Further design and commercial development is needed for devices to control seafood wastes.
- G. The quality of raw material greatly influences the effluents from seafood plants.
- H. Continuing efforts are needed to transfer pollution control technology to the smaller seafood processors.

ACKNOWLEDGMENTS

The information contained in this report was compiled from the results of a study funded by the Coastal Plains Regional Commission conducted from September 1, 1975 until August 31, 1977 by Clark Callaway and the staff of the NCSU Seafood Laboratory located at Morehead City, N. C.

ABBREVIATIONS

BOD	Biochemical oxygen demand
BOD ₅	Five day, biochemical oxygen demand
COD	Chemical oxygen demand
DS	Dissolved solids
EPA	Environmental Protection Agency (United States)
FOG	Fats, oil and grease
NER	North Carolina Department of Natural and Economic Resources
OS	Organic solids
TS	Total solids
TSS	Total suspended solids

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SEAFOOD WASTE MANAGEMENT IN SOUTH CAROLINA

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The major seafood commodities of South Carolina include: (1) shrimp, brown/pink/white primarily marketed heads off but not peeled, plus some rock shrimp with heads on; (2) blue crab usually processed into pasteurized or shelf stable canned meat, plus a relative minor proportion of basket/soft shell crabs; (3) oysters steam shucked for canning or hot water bath shocked for fresh/frozen distribution and (4) whole fish marketed to dealers with exception of dressed cat fish, swordfish and snapper. Approximate annual landings and estimated processing wastes are presented in Table 1. (C. Bearden, R. Dafler, R. Gault, G. Maggioni, J. Powers, R. Rhodes, H. Simmons, personal communications).

Geographical concentration of South Carolina's seafood processing industry is shown in Figure 1.

An overview of seafood waste management practices in South Carolina is presented in the following commodity scenarios:

A. Shrimp Processing Waste Scenario:

Annual volume of shrimp heads range from 1.5 to 6 million lb. (wet) with a long-run average of 2.7 million lb. Disposal procedures that have been utilized/attempted include:

1. Municipal Landfill: Hauling of shrimp heads to a burial site has caused public complaints because of "drip" and/or odor along transport route. Some municipalities have closed existing landfills to shrimp processors because of this and other problems; i.e., Charleston/Shem Creek area.
2. Grinding Into Municipal Sewer: Attempted at Charleston/Shem Creek site, proved unfeasible due to plugging of sewer lines precipitated by low elevation, lack of pumping station(s) and capacity of municipal treatment facility.
3. Land Application: Demonstration arranged at Hartsville in 1978 but not completed. Concept was to parallel procedures reported by Costa and Gardner (1) to evaluate the impact upon South Carolina soils.
4. Dried Meal: Shrimp heads were dehydrated and ground to a free-flowing meal. Approximate analysis of finished product is presented in Table 2. Economics of collection and transportation to a centralized

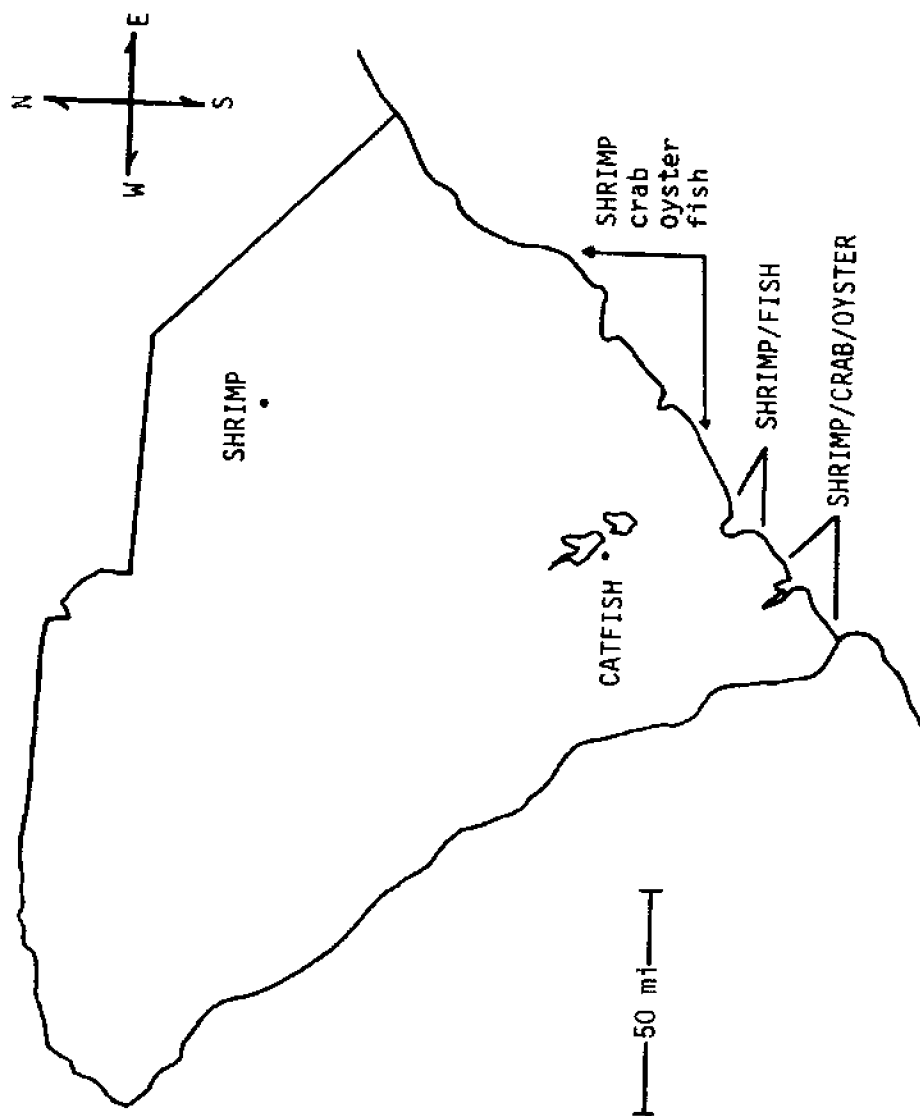


Figure 1. Geographic Concentrations of South Carolina Seafood Industries.

Table 1: Approximate Annual Landings and Estimated Wastes
from Seafood Processed in South Carolina

<u>Commodity</u>	<u>Approx. Annual Landing lb.</u>	<u>Estimated</u>		<u>Approx. Annual Waste Volume lb.</u>
		<u>% Processed</u>	<u>% Waste</u>	
1. Shrimp	5 MM	100	45	2.25 MM
-White	(3.5)			
-Brown	(1.2)			
-Pink	(<0.01)			
-Rock	(0.3)			
2. Crabs, Blue	10 MM [*]	95	52-----solid----	4.94 MM
			35-----liquid----	3.33 MM
3. Oyster Meats	1.5 MM	80	--	--
steamed meats	1.1 MM ^{**}	100	85/U.S.bu.----shell---	15.6 MM
			63.6-----liquid----	0.7 MM
other shucked	0.1 MM	100	N/S	N/S
4. Fish	3.7 MM	<1	N/S	N/S
catfish	0.21 MM	100	40	84 M

* 8 MM lb. landed + 2 MM lb. purchased out-of-state and processed in-state.

** 3.18 lb. raw meat/U.S. bu.; 36.4% yield when steamed.

Table 2: Composition of Shrimphead Meal from White Shrimp¹
Landed in January at Charleston, S.C.

<u>Approximate</u>	<u>per 100g</u>	<u>Amino Acid</u>	<u>per 100g</u>
Moisture (g)	9.36	Lysine	2.25
Fat (g)	7.38	Histidine	0.75
Crude Protein (g)	56.77 ²	Arginine	2.50
Ash (g)	25.52	Aspartic Acid	3.79
<u>Minerals</u>			
P ₂ O ₅ (g)-phosphate	3.61	Threonine	1.54
K ₂ O (g)-potash	0.85	Serine	1.58
Na (g)	2.30	Glutamic Acid	5.70
Ca (g)	7.47	Proline	1.92
Mg (g)	0.45	Glycine	3.04
Fe (ppm)	2352	Alanine	2.62
Mn (ppm)	54	Half Cystine	0.17
Zn (ppm)	170	Valine	1.92
Cu (ppm)	84	Methionine	0.87
		Isoleucine	1.54
		Leucine	2.79
		Tyrosine	1.46
		Phenylalaine	4.62

¹Grade Count: 50-70.

²not corrected for chitin nitrogen; Calc. as Total N x 6.25.

dehydration site was not favorable and confounded by seasonal availability and potential quality variability that would not seriously attract the attention of potential poultry ration processors.

5. Holding Ponds: Not being utilized; limited land availability and/or proximity to residential/resort areas precludes adoption by most shrimp deheading operations not having a disposal solution.
6. NPDES Controlled Dumping: State NPDES permits have been issued to several shrimp deheading operations to dump at designated water areas in the vicinity possessing adequate depth, flow and/or marine life to adequately absorb the solids and/or have a beneficial impact upon the surrounding eco-systems. The S.C. D.H.E.C. NPDES program should be commended for its approach and regulatory efforts in this area. However, the participating processors have found the barge/boating procedures to be time and labor intensive, and it does not offer an all-weather solution.
7. Deheading Aboard: Very few S.C. shrimp are landed that have been deheaded aboard the troller. Tradition and a "psychological fixation" that deheading shrimp is a demeaning task seem to prevail with many S.C. shrimpers. This author would like to see more dock operators promote deheading shrimp aboard the boat with price premium. Exceptions in the event of heavy catches and/or more than 50 count shrimp (approx. 13% of catch) should be considered. Even if small shrimp and heavy catch exemptions constituted 20% of the landings, up to 80% of shrimphead disposal problems (1.8 out of 2.25 MM lb.) could theoretically be eliminated in S.C. Some regions of North Carolina have demonstrated the feasibility of deheading aboard. Secondly, the future development of light weight deck deheading units may eventually make dock side deheading no longer practical for the industry.
8. End-of-dock-dumping: No comment.

- B. Crab Processing Waste Scenario:
Annual Blue Crab landings range from 6 to 10 million pounds live weight. Of this catch, approximately 45% are picked and packed as commercially sterile canned crab meat by a single firm. The same firm annually purchases an additional 1 to 2 million pounds of live crabs from outside South Carolina. This leaves approximately 50% of the S.C. catch which yields about 3.5 million pounds of crab processing wastes (1.4 MM lb. steep water/2.1 MM lb. of shell scrap) by a half-dozen, or less, other processors marketing pasteurized/fresh crab meat. This author estimates the remaining 5% of the state's catch enters the "non-waste" basket-crab market.

1. Dried Meal: Over half (55-65%) of South Carolina crab processing waste is generated at a single plant and converted, on-site, to 9-12% moisture crab meal before distribution as an animal ration ingredient. Steepwater, formed during pressure steaming, and mechanical picker separation brine is also treated on-site with a packaged activated sludge plant prior to discharge into a municipal sewage collection system.

Studies are being initiated to evaluate "Closed-Loop" discharge abatement systems to minimize brine and steepwater discharges, which will be the topic of a later presentation at this conference.

2. Septic Tank: Steepwater from one new crab processing facility, steaming 2000-4000 lb. crabs/day, is anaerobically digested through two 1000 gal. septic tanks placed in series and connected to a conventional drain field. A 4'x4'x4' underground solids pre-settling tank is located ahead of the septic tanks. Six months of continuous operation has been trouble-free for the total system. Septic tank pump-out service is scheduled annually.
3. NPDES Controlled Dumping: Similar arrangements are provided for crab scrap as for solid shrimp processing wastes outlined above. Permits are administered by South Carolina (S.C.D.H.E.C.) and the wastes are barged/boated to approved water areas possessing adequate depth, tidal flow, etc. Again, the procedure is expensive, labor intensive and weather dependent.
4. Landfill: Minimal utilization by the S.C. crab industry.

C. Oyster Processing Waste Scenario:

The equivalent of 1.3 to 1.6 million lbs. of oyster meats are harvested annually according to S.C. Dept. of Wildlife and Marine Resources (Table 1). Of this, the author estimates 1.2 million lb. represent oyster meats that are processed, the remaining harvest being marketed in-shell. Of the oysters processed, approximately 1.1 million lb. or 92%, are steam shucked and canned by one firm. The rest are usually water shocked, hand shucked and marketed fresh/frozen.

Most of the oyster shell from commercial shucking is returned to the oyster beds for clutch as mandated by state law (65 bu. shell/acre of leased ground).

Excess mud is normally washed from the "cultch oysters" as hydrolytically flushed from barges/truck dumping platforms or sack/basket dump stations when received.

Oyster steaming steepwater is estimated to total 260,000 gallons annually. Evaluation of a "Closed-Loop" recovery system to eliminate this discharge and mechanical shucking brine effluents needs to be initiated.

D. Fish Processing Waste Scenario:

Approximately 3.7 million lb. of finfish are landed annually in South Carolina. Approximately 95% of this catch is marketed whole or dressed/gutted at sea, the major exception being the freshwater catfish industry which buries 84,000-85,000 lb. of solid wastes annually.

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SEAFOOD DISCHARGES AND
SOUTHEASTERN ESTUARINE ENVIRONMENTS

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INTRODUCTION

A study to determine the impact of seafood packing and processing effluents discharged to southeastern estuarine waters was conducted during July and August of 1979 (Figure 1). The study concerned the effects of effluents on two estuarine systems: (i) a relatively undeveloped area consisting of three small estuarine creeks, two of which are normally exposed to seafood packing by-products (Figure 2), and (ii) a large commercially and industrially developed estuary that receives effluents from a seafood processing plant and three packing houses (Figure 3).

Fishing boats offload their catches at packing houses, where the seafood is washed, sorted, packed in ice, and held for shipment to wholesale and retail outlets and seafood processing plants. Most fresh products are shipped on ice with little further processing. Shrimp are normally headed at sea if time permits, but during the peak harvesting periods, at least part of the catch is brought in to be headed at the packing houses. A typical packing house employs up to 20 people, handles 1,000 to 1,500 pounds of shrimp per day (of which 60% to 70% were headed at sea), and discharges from 1,500 to 9,000 gallons of effluent (17). Seafood processing plants are much larger operations, employing several hundred workers to manufacture cooked, breaded, and frozen products. In contrast to packing operations, seafood processing plants utilize between 10,000 and 30,000 pounds of shrimp and generate from 100,000 to 300,000 gallons of effluent per day (17).

*Present Address:
P. O. Box 1837 S.S.S.
Springfield, Mo. 65805

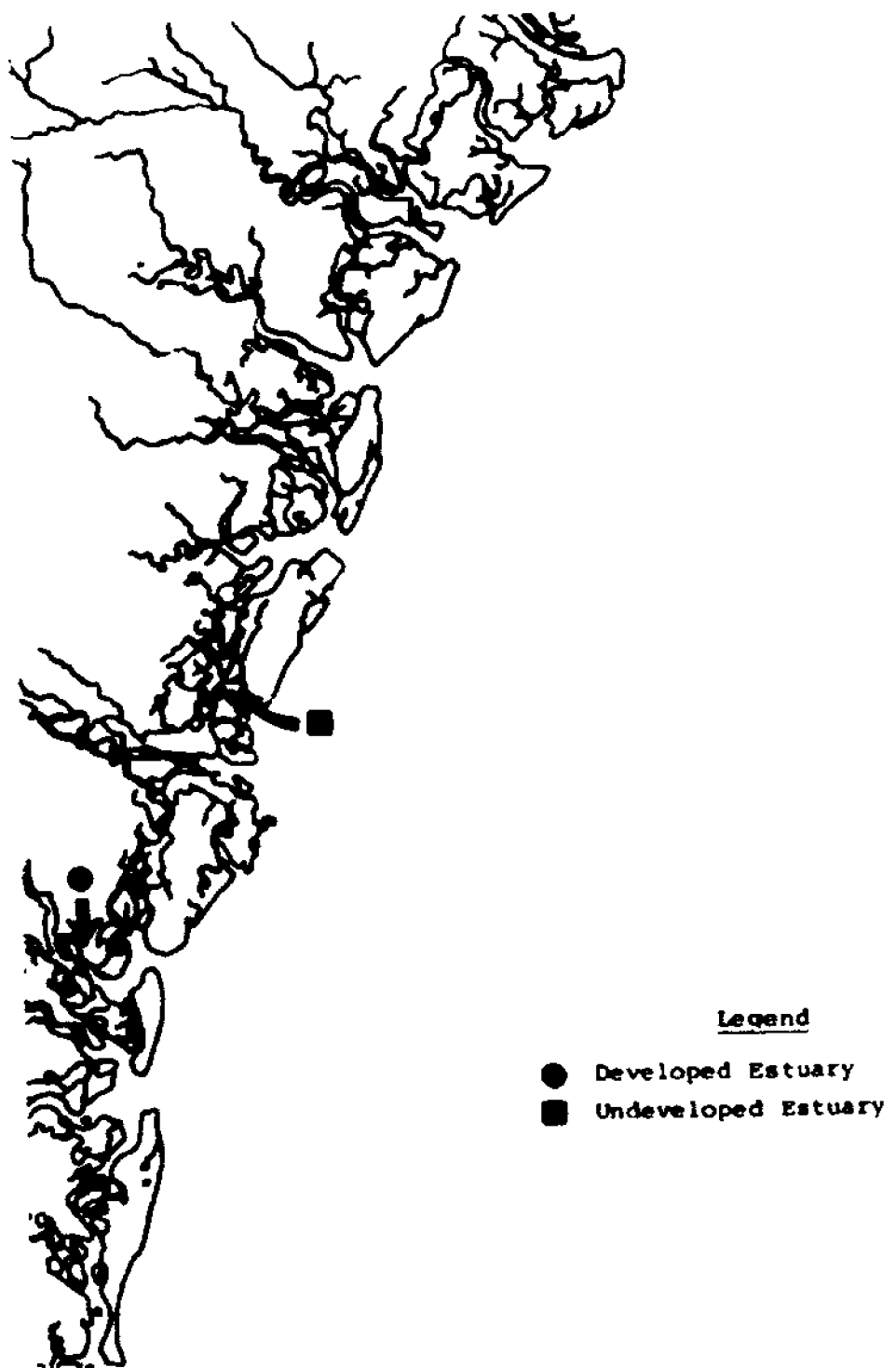


FIGURE 1. Study Areas.

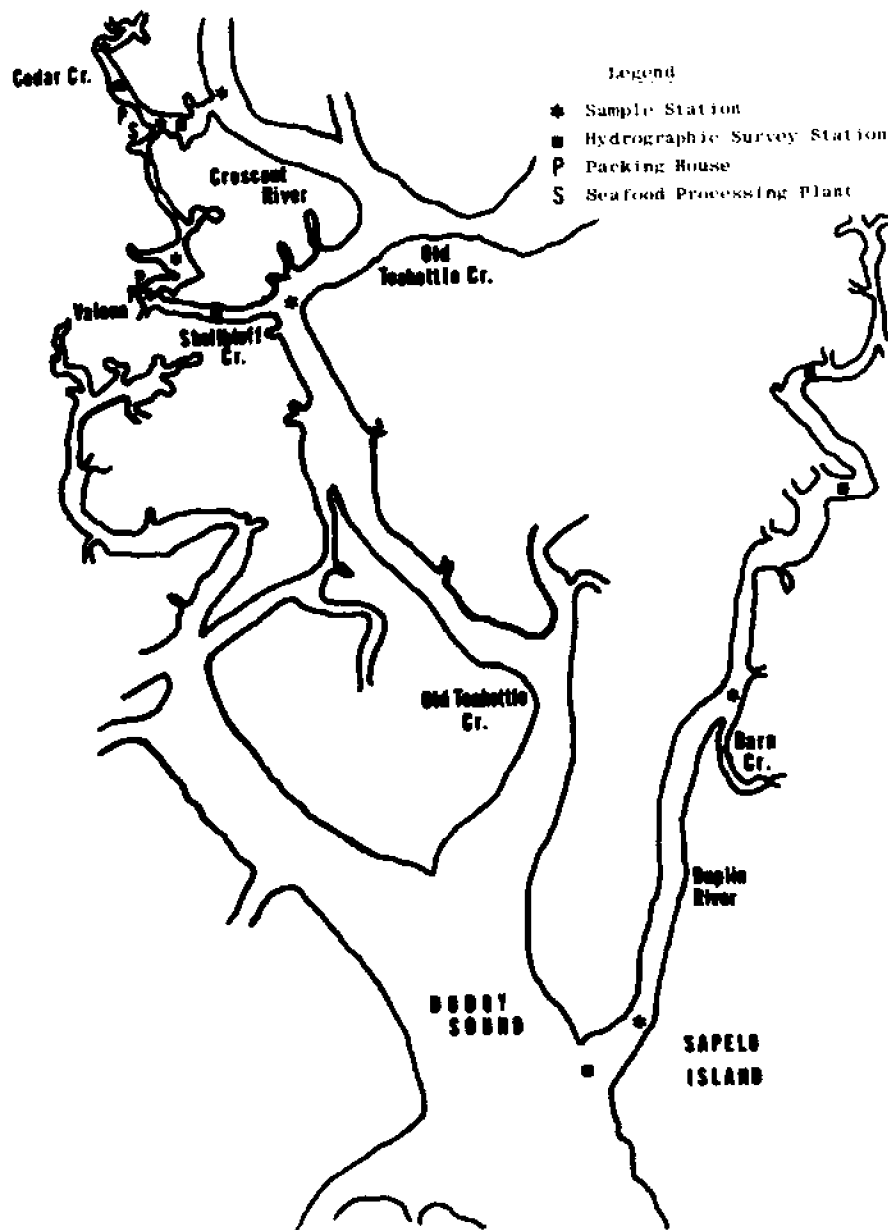


FIGURE 2. Undeveloped Estuarine System.

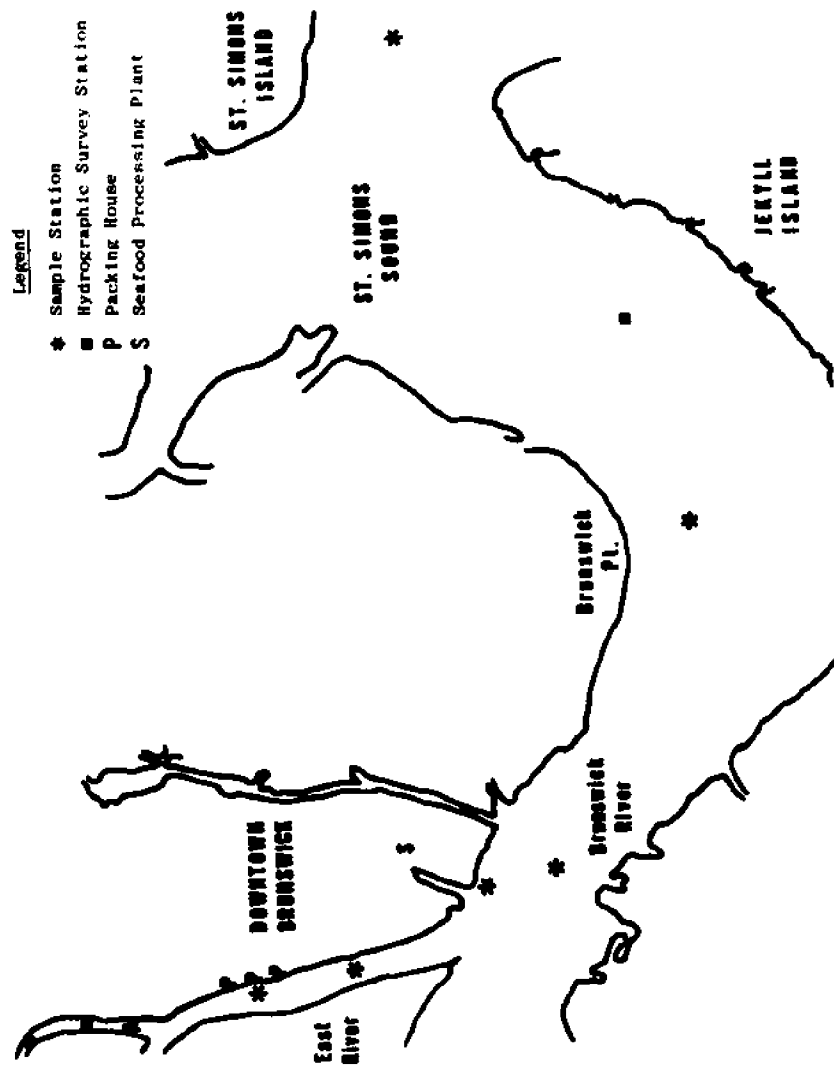


FIGURE 3. Developed Estuary.

Although 1979 was a good shrimping year, most of Georgia's summer harvest was headed at sea, resulting in little or no activity at the packing houses. During the project, the only known effluent discharged into the undeveloped estuary resulted from the heading of a single boatload of rock shrimp by a packing house. However, in July and August the processing plant discharged into the developed estuary approximately 215,000 gallons of effluent per day from shrimp thawing, peeling, sorting, and cleaning operations (any breaching remaining after dry clean-up, wash-down water, and domestic sewage were discharged to the municipal sewage plant). The effluent passed through a hydro-sieve screen which removed shrimp hulls and other solids larger than 0.02 inches in diameter.

MATERIALS AND METHODS

Eight sampling stations (including two control stations) in the undeveloped estuary (Figure 2) and seven stations (including one control station) in the developed area (Figure 3) were established upstream and downstream from the seafood packing and processing facilities. The three control stations were considered isolated from chemical and microbiological effects at the effluent discharge points. A total of four sampling trials were completed in each area. High and low tide, temperature, salinity, dissolved oxygen, pH, turbidity, ammonium nitrogen ($\text{NH}_4\text{-N}$), and biological oxygen demand (BOD) levels were determined for surface and bottom samples taken during July and August (1,2,9,11,19). Surface water and effluent grab samples were collected in conjunction with the former samples to enumerate MPN fecal and total coliform, aerobic plate count (20C and 35C), and marine agar plate count (20C) organisms (1,5,16). Data generated from the four sampling trials in each area were statistically analyzed (analysis of variance, significant at the 0.05 level) to determine any significant differences between areas, from sampling to sampling within each area, and to evaluate the impacts of sampled seafood effluents on receiving estuarine waters (14,15).

RESULTS AND DISCUSSIONS

The less developed estuarine system has the following characteristics:

- (a) is composed of three estuarine creeks (Figures 2,4,5,6), the Duplin River (receives no seafood effluents), Shellbluff Creek (receives discharges from two packing houses), and Cedar Creek (receives effluent from one packing house);

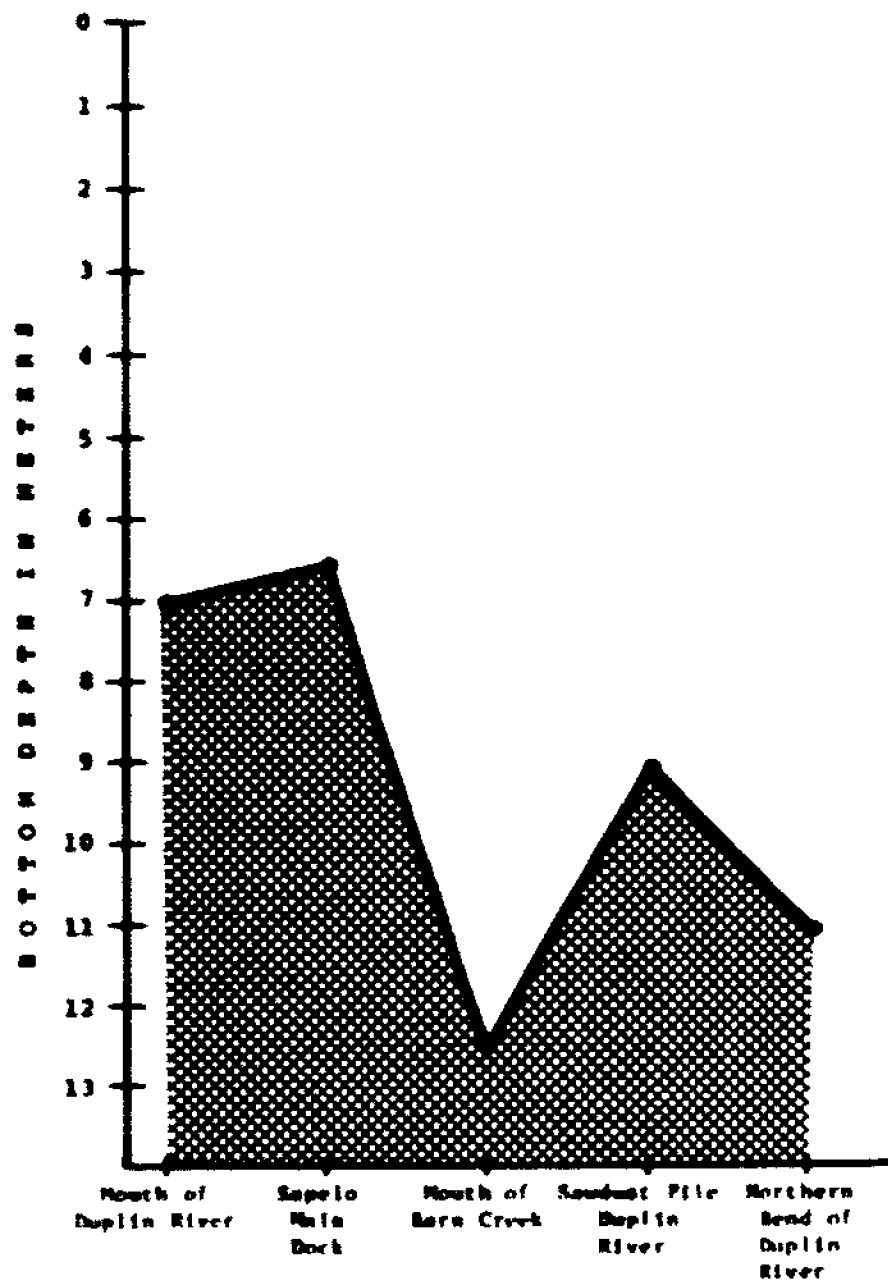


FIGURE 4. Duplin River Control Stations (Undeveloped Estuary) Bottom Profile.

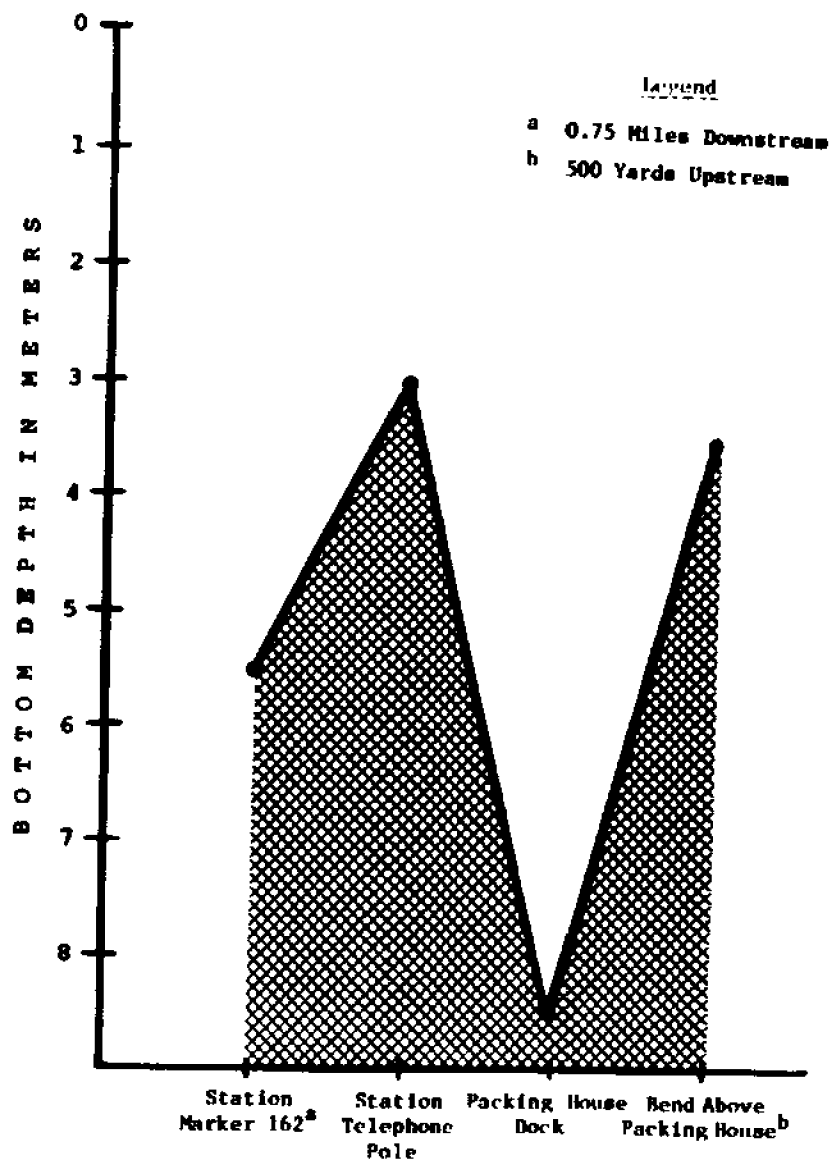


FIGURE 5. Shellbluff Creek Packing House Stations (Undeveloped Estuary) Bottom Profile.

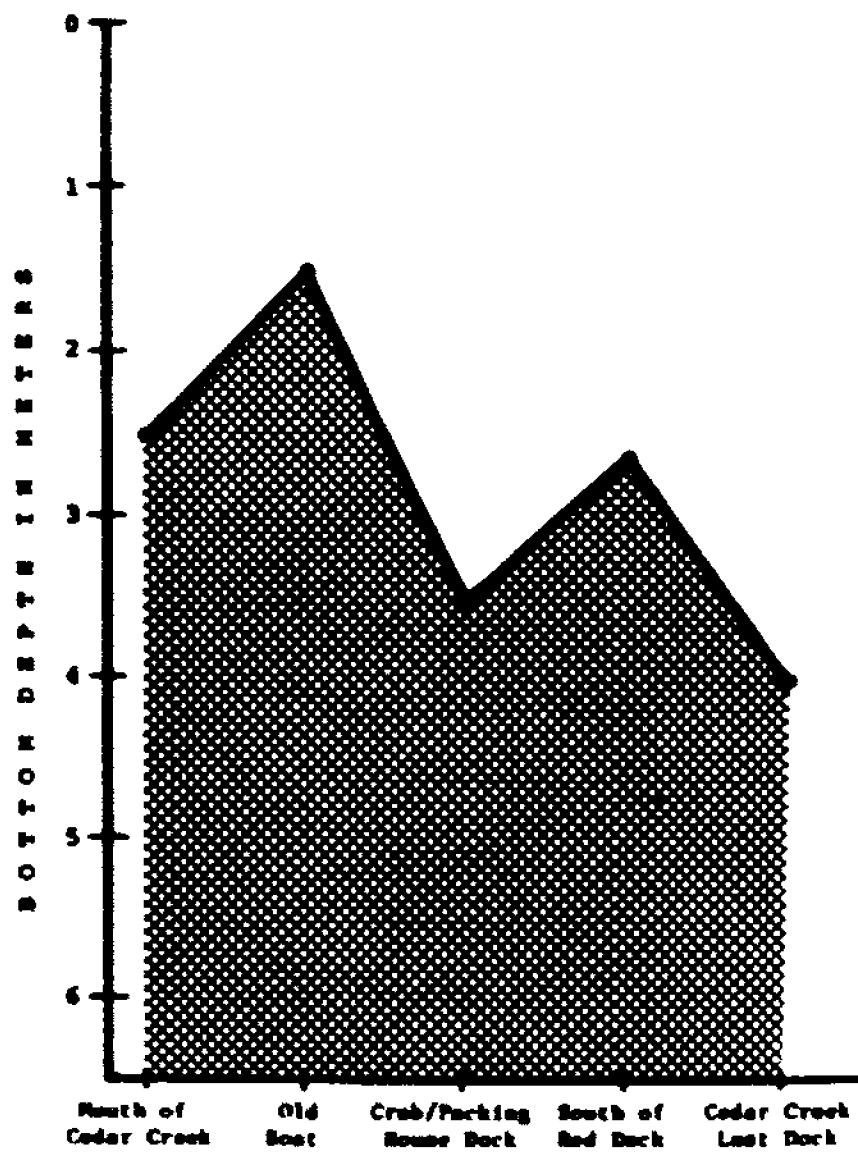


FIGURE 6. Cedar Creek Packing House and Processing Stations (Developed Estuary) Bottom Profile.

- (b) drains a proportionally greater area of marshland than the commercially developed location;
- (c) experiences less complete tidal flushing than the developed area;
- (d) maintains lower oxygen values than in the developed estuary, although mean dissolved oxygen values were never found to be less than 3.0 mg/l;
- (e) maintains natural BOD loads greater than the control levels in the developed area;
- (f) was microbiologically "clean", with median coliform levels (24 organisms/100ml) qualifying the estuary as a shellfish growing area (10).

Georgia's highly productive estuarine waters normally contain substantial concentrations of dissolved and particulate organic materials (13,18). Further, naturally occurring shallow estuarine sills that reduce water exchange rates are common to the Georgia coast in river mouths which have not been channelized or dredged for navigation. Shallow sills at the mouths of the undeveloped estuarine creeks under study reduced tidal mixing and apparently resulted in increased organic loads at the packing house basins and upstream sampling stations. During seven of the eight sampling trials, the packing houses were not operating. Thus the chemical and microbiological data which are presumably attributable to natural leaching of organic material from marsh vegetation and soils can be considered baseline, reflective of natural conditions.

The estuary's ability to absorb organic by-products was estimated from the measured impact of the single packing house effluent sample collected during the study. The effluent BOD load (421 mg/l), $\text{NH}_4\text{-N}$ concentration (179 $\mu\text{g/l}$), and aerobic plate count population at 35C (1.35×10^4 org/ml) were shown statistically to be significantly greater than noted in the estuarine receiving waters (Tables 1, 2). Only the $\text{NH}_4\text{-N}$ level was significantly elevated at the discharge point, and its concentration was dissipated within 500 to 1,500 yards of the packing house. Total and fecal coliform levels in the tidal creek receiving the packing house effluent were not significantly greater on the day of the discharge than the populations enumerated for three sampling trials when the house was idle. The actual reserve capacity of the undeveloped estuaries to accept additional seafood packing plant effluent loads could not be estimated from a single sample. Additional samples collected from packing house effluents and receiving waters at normal operational levels would be required

TABLE 1. MEAN CHEMICAL LEVELS OF THE PACKING HOUSE EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS 500 YARDS, UP AND DOWN STREAM FROM THE DISCHARGE POINT (AUGUST SAMPLE, COLLECTED AT HIGH TIDE).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
<u>BOD mg/l</u>				
Surface	421 ^a	1.5	2.0	1.5
Bottom	421 ^a	1.9	2.2	2.9 ^b
<u>Suspended Solids mg/l</u>				
Surface	13.00 ^a	108.5	94.5	64.5 ^b
Bottom	13.00 ^a	116.5	124.5	104.0 ^a
<u>NH₄ µg/l</u>				
Surface	179 ^a	52 ^b	35	27
Bottom	179 ^a	46	39	45
<u>DO mg/l</u>				
Surface	4.27	3.79	3.51	4.12
Bottom	4.27 ^b	3.35 ^b	3.41	3.91

^a Significant 0.01 level

^b Significant 0.05 level

TABLE 2. MEAN MICROBIOLOGICAL POPULATIONS OF THE PACKING HOUSE EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS 500 YARDS UP AND DOWNSTREAM FROM THE DISCHARGE POINT (AUGUST SAMPLE, COLLECTED AT HIGH TIDE)

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
Aerobic 20C org/ml	3.23×10^3	1.99×10^3	1.78×10^3	676
Aerobic 35C org/ml	1.35×10^4 ^a	708	759	288
Marine 20C org/ml	1.55×10^4	2.09×10^4	2.45×10^4	9.55×10^3 ^a
MPN Coliforms org/100ml	150	24	>240	46
MPN Fecal Coliforms org/100ml	43	9.3	24	4.3

^aSignificant 0.01 level

to correlate last summer's baseline data with levels generated at full production.

In contrast, the developed area has the following characteristics:

- (a) receives the discharge from one large seafood processing plant at the Brunswick River and the effluent from three packing houses on the East River (Figures 3, 7);
- (b) is a large, well-mixed estuary that effectively dilutes most seafood processing effluent parameters at low tide within 0.5 miles of the plant;
- (c) is characterized by better water quality with seaward movement;
- (d) has a deep basin approximately 0.5 miles upstream from the processing plant that intermittently traps organic materials during flood tides, causing increased organic loads at the station;
- (e) exhibits greater microbial populations at low tide than high tide, and greater numbers of organisms than the undeveloped area;
- (f) has higher mean $\text{NH}_4\text{-N}$ levels than the undeveloped estuary;
- (g) maintains higher dissolved oxygen concentrations than the undeveloped area;
- (h) supports fecal coliform levels within Georgia EPD limits for recreational use at all stations, except the location 100 feet from the seafood processing plant discharge pipe (6).

The peeling, sorting, thawing, and cleaning operations, in a seafood processing plant discharge a daily total of 215,000 gallons of effluent, characterized as follows:

BOD (pounds)	494
Suspended Solids (pounds)	161
$\text{NH}_4\text{-N}$ (pounds)	4
Aerobic Organisms, 20C	1.34×10^5
Aerobic Organisms, 35C	1.08×10^{15}
Marine Organisms, 20C	1.08×10^{11}
Total Coliforms	7.66×10^{11}
Fecal Coliforms	5.45×10^{10}

Although BOD, $\text{NH}_4\text{-N}$, and microbial levels were significantly greater in the effluent than the receiving waters, much of the effect was rapidly dissipated (Tables 3-10). BOD loads increased by approximately

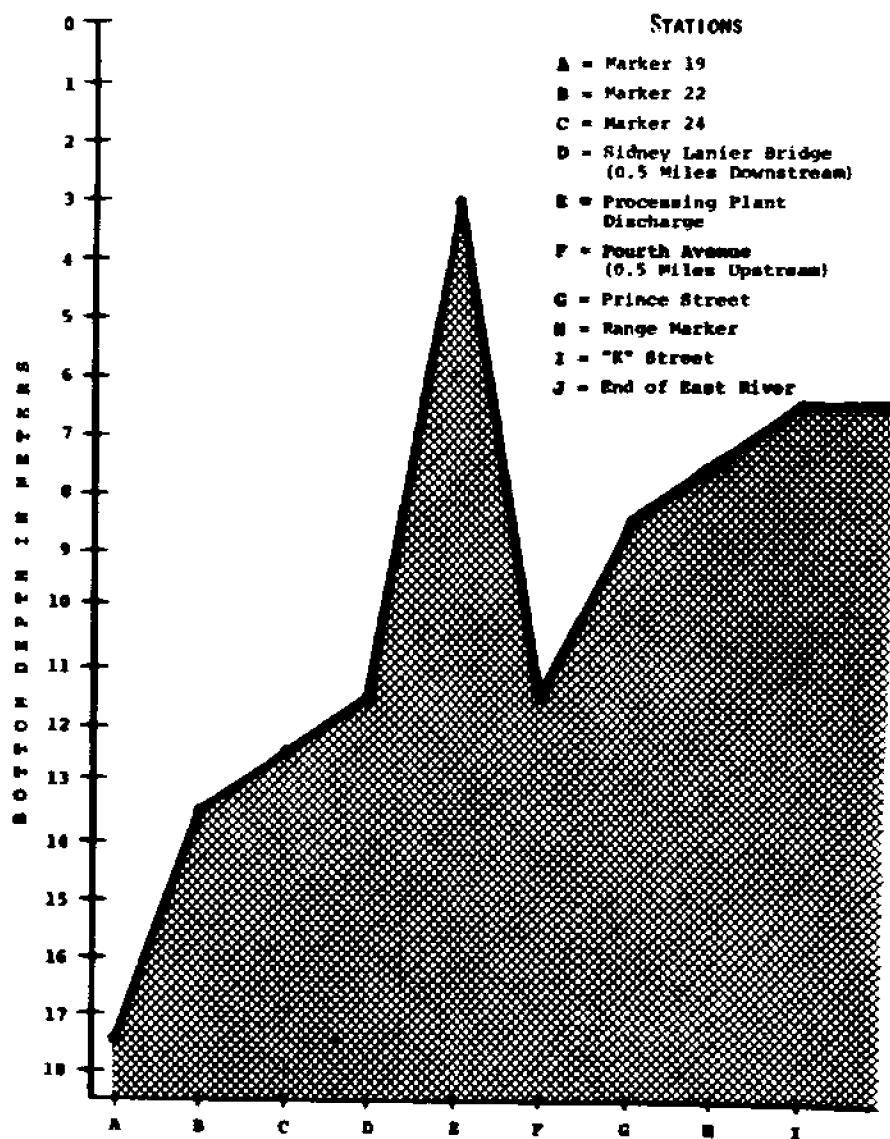


FIGURE 7. Brunswick River Packing House and Processing Stations (Developed Estuary) Bottom Profile.

TABLE 3. MEAN CHEMICAL LEVELS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (LOW TIDE, JULY).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
<u>BOD mg/l</u>				
Surface	295 ^a	1.31	1.33	1.17
Bottom	295 ^a	2.19 ^a	0.97	0.69
<u>Suspended Solids mg/l</u>				
Surface	120 ^a	93	59	55
Bottom	120 ^b	205	528 ^a	152
<u>NH₄ µg/l</u>				
Surface	2046 ^a	150 ^a	7	6
Bottom	2046 ^a	40	271 ^a	31
<u>DO mg/l</u>				
Surface	7.55 ^a	4.73	4.78	4.47 ^b
Bottom	7.55 ^a	3.79 ^a	4.91	4.31

^a Significant 0.01 level

^b Significant 0.05 level

TABLE 4. MEAN MICROBIOLOGICAL POPULATIONS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (LOW TIDE, JULY).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
Aerobic 20C org/ml	3.55×10^5 ^a	1.70×10^4 ^a	2.19×10^3	1.35×10^3
Aerobic 35C org/ml	2.24×10^5 ^a	2.24×10^4	4.57×10^3	2.63×10^3
Marine 20C org/ml	2.29×10^5 ^a	4.68×10^4 ^a	1.05×10^4	3.02×10^3
MPN Coliforms org/100ml	$>24,000$	$>2,400$	9.1	4.3
MPN Fecal Coliforms org/100ml	2,400	93	9.1	4.3

^aSignificant 0.01 level

^bSignificant 0.05 level

TABLE 5. MEAN CHEMICAL LEVELS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (HIGH TIDE, JULY).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
<u>BOD mg/l</u>				
Surface	255 ^a	0.87	0.67	1.02 ^b
Bottom	255 ^a	1.95	2.67 ^b	1.18
<u>Suspended Solids mg/l</u>				
Surface	60	65	29 ^a	87
Bottom	60	94	633 ^a	206
<u>NH₄ µg/l</u>				
Surface	1616 ^a	76	29	78
Bottom	1616 ^a	420 ^a	688 ^a	101
<u>DO mg/l</u>				
Surface	7.47 ^a	5.11	5.31	5.83 ^b
Bottom	7.47 ^a	5.23	5.36	5.28

^aSignificant 0.01 level

^b Significant 0.05 level

TABLE 6. MEAN MICROBIOLOGICAL POPULATIONS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (HIGH TIDE, JULY).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
Aerobic 20C org/ml	5.62×10^6 ^a	776 ^b	3.09×10^3 ^a	324
Aerobic 35C org/ml	1.95×10^6 ^a	537 ^b	2.04×10^3 ^a	282
Marine 20C org/ml	4.27×10^6 ^a	1.20×10^4	9.77×10^3	6.03×10^3
MPN Coliforms org/100ml	>2,400	460	15	11
MPN Fecal Coliforms org/100ml	1,100	93	15	4

^a Significant 0.01 level

^b Significant 0.05 level

TABLE 7. MEAN CHEMICAL LEVELS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (LOW TIDE, AUGUST).

PARAMETERS	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
<u>BOD mg/l</u>				
Surface	281 ^a	2.19 ^a	0.97	0.69
Bottom	281 ^a	1.31	6.41 ^a	1.75 ^b
<u>Suspended Solids mg/l</u>				
Surface	98 ^a	62	63	41
Bottom	98	121	79 ^b	128
<u>NH₄ ug/l</u>				
Surface	2446 ^a	57 ^a	7	10
Bottom	2446 ^a	49	129	39
<u>DO mg/l</u>				
Surface	5.60 ^a	3.98	3.98	4.47 ^a
Bottom	5.60 ^a	3.86	3.91	3.83

^a Significant 0.01 level

^b Significant 0.05 level

TABLE 8. MEAN MICROBIOLOGICAL POPULATIONS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (LOW TIDE, AUGUST).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
Aerobic 20C org/ml	3.98×10^5 ^a	4.17×10^3	2.45×10^3	2.82×10^3
Aerobic 35C org/ml	6.61×10^5 ^a	4.27×10^3 ^a	468	537
Marine 20C org/ml	6.46×10^5 ^a	6.17×10^3 ^a	3.71×10^3	2.40×10^3
MPN Coliforms org/100ml	$>240,000$	$>2,400$	39	24
MPN Fecal Coliforms org/100ml	11,000	93	15	2.9
^a Significant 0.01 level	^b Significant 0.05 level			

TABLE 9. MEAN CHEMICAL LEVELS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (HIGH TIDE, AUGUST).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
<u>BOD mg/l</u>				
Surface	270 ^a	1.16	1.45	0.71 ^b
Bottom	270 ^a	1.04	0.87	0.90
<u>Suspended Solids mg/l</u>				
Surface	80	82	57 ^b	102
Bottom	80 ^a	153	129	105
<u>NH₄ µg/l</u>				
Surface	2649 ^a	103 ^a	11	10
Bottom	2649 ^a	40	256 ^a	22
<u>DO mg/l</u>				
Surface	7.55 ^a	4.35 ^a	5.23	4.78
Bottom	7.55 ^a	4.63	4.75	4.71

^a Significant 0.01 level

^b Significant 0.05 level

TABLE 10. MEAN MICROBIOLOGICAL POPULATIONS OF THE PROCESSING PLANT EFFLUENT, IMMEDIATE RECEIVING WATERS, AND ESTUARINE STATIONS ONE HALF MILE UP AND DOWN STREAM FROM THE DISCHARGE POINT (HIGH TIDE, AUGUST).

PARAMETER	EFFLUENT	DISCHARGE POINT	UPSTREAM	DOWNSTREAM
Aerobic 20C org/ml	2.29×10^5 ^a	1.58×10^3 ^b	676	447
Aerobic 35C org/ml	1.23×10^5 ^a	1.78×10^3 ^b	316	309
Marine 20C org/ml	1.51×10^5 ^a	3.24×10^5 ^a	2.19×10^4 ^b	6.46×10^3
MPN Coliforms org/100ml	110,000	>2,400	23	0.3
MPN Fecal Coliforms org/100ml	2,400	460	3	0.3
^a Significant 0.01 level		^b Significant 0.05 level		

1.0 mg/l at the discharge point in 40% of the samples collected, returned to normal levels 0.5 miles downstream during ebb tides, and occasionally decreased less rapidly 0.5 miles upstream at a deep basin during flood tides (Figure 4). Mean dissolved oxygen values never dropped below the Georgia EPD 3.0 mg/l minimum water quality standard (6). $\text{NH}_4\text{-N}$ dispersion was less rapid and more intermittent than the other parameters, with levels at the discharge point elevated significantly in 50% of the samples. Bottom water samples from the basin showed elevated $\text{NH}_4\text{-N}$ concentrations in 75% of the samples. Total coliform levels of the waters receiving processing plant effluent in July and August were significantly greater than the populations determined 0.5 miles upstream and downstream from the discharge point (Tables 4, 6, 8, 10). Low tides rapidly diluted microbial populations seaward of the discharge point (75% of the samples had significantly greater populations than surrounding waters), while flood tides led to the entrapment of microorganisms in the upstream basin during July and August samplings (Tables 6, 10).

The recent proposal by the U. S. Environmental Protection Agency (Federal Register Vol. 42, No. 2, January 3, 1980) to include ammonia in the toxic pollutants list (1977 Amendments to the Clean Water Act, 33 U.S.S. 1251 etseq.) could have a serious impact upon the seafood processing industry. Pollutants listed as toxic under section 307(a) are not eligible for waivers from Best Available (BAT) standards based on water quality [section 301(g)] or economic [section 307(c)] grounds. Listing of a pollutant under section 307 may also affect the date by which BAT requirements are to be met and could lead to the immediate establishment of effluent standards under section 307. NH_3 levels were estimated from $\text{NH}_4\text{-N}$ determinations completed during monitoring of the estuarine stations and packing and processing discharges using Bower and Bidwell's (3) calculations, as referenced by Federal Register (Tables 11, 12). The tentative EPA guideline of 20 $\mu\text{g NH}_3/\text{l}$ was not exceeded at any station in either sampling area. The packing house effluent (5.75 $\mu\text{g NH}_3/\text{l}$) was well below the EPA guideline (Table 11). The processing plant discharge exceeded ammonia guidelines, with NH_3 concentrations ranging from 39.11 to 75.23 $\mu\text{g}/\text{l}$ (Table 12). The maximum NH_3 level at the plant discharge point reached 10.78 $\mu\text{g}/\text{l}$ for bottom water samples. Stations 5.75 miles and 2.75 miles downstream from the processing plant approached and exceeded the discharge point NH_3 levels, with concentrations of 10.68 and 18.04 $\mu\text{g NH}_3/\text{l}$, respectively (Tables 11, 12). Both stations were located in areas of strong tidal currents, exposed to vigorous tidal mixing with oceanic waters, and influenced little by the processing plant, as determined by other

TABLE 11. CALCULATED MAXIMUM AND MINIMUM NH₃ (ug/l) LEVELS SURFACE AND BOTTOM
NORTHERN SAMPLING AREA.

STATION	MAXIMUM SURFACE	MINIMUM SURFACE	MAXIMUM BOTTOM	MINIMUM BOTTOM
Main Dock Sapelo				
Duplin River	1.72	0.27	4.20	0.86
Duplin River Barn Creek	2.10	1.79	2.57	0.53
Shellbluff Creek Marker "162"	2.84	0.45	2.10	1.55
Packing Houses Shellbluff Creek	0.96	0.34	1.69	1.25
Bend Above Packing House	2.04	0.13	2.22	0.75
Cedar Creek Mouth	0.82	0.19	1.87	0.77
Crab Plant Dock Cedar Creek	1.04	0.31	0.94	0.34
Last Dock Cedar Creek	0.26	0.32	0.92	0.34
Packing House Effluent	5.75	----	----	----

TABLE 12. CALCULATED MAXIMUM AND MINIMUM NH_3 ($\mu\text{g}/\text{l}$) VALUES, SURFACE AND BOTTOM SOUTHERN SAMPLING AREA.

STATION	MAXIMUM SURFACE	MINIMUM SURFACE	MAXIMUM BOTTOM	MINIMUM BOTTOM
Marker "19"	2.37	0.17	10.68	0.54
Marker "24"	1.38	0.52	18.04	1.02
Lanier Bridge	2.77	0.21	1.65	0.71
Plant Discharge	4.95	1.33	10.87	0.72
4th Avenue	0.70	0.16	17.54	3.01
Prince Street	6.41	0.21	5.64	3.21
Range Marker	2.34	0.41	6.05	5.41
Plant Effluent	75.23 ^a	39.11 ^a	----	----

^a Exceeded proposed EPA guideline of 20 μg NH_3/l

monitored parameters, indicating at least occasional high natural NH_3 levels in Georgia's estuarine waters.

CONCLUSIONS

Measurable, statistically significant differences in a number of monitored chemical and biological parameters were determined between seafood packing and processing effluents (that included peeling, sorting, thawing, cleaning, and heading operations) and the receiving waters of developed and undeveloped estuaries. Generally, the effects were short lived, and rapidly dissipated with tidal flushing. Shallow sills and deep basins reduced tidal exchange and led to increased organic loads even in areas that did not receive seafood wastes. Georgia's coastal estuaries normally carry a high particulate and dissolved organic load from the natural flushing of vast, highly productive coastal marshes (13, 18). Calculations converting the seafood processing plant's daily BOD load (494 pounds) to a given weight of organic material (in terms of glucose/glutamic acids, 1:1) produced daily organic load values equivalent to the organic material discharged from a 302 m² plot (57 feet x 57 feet) of salt marsh per day (1, 13). The impact of small packing houses and processing plants discharging only seafood wastes (not breeding or sewage) is small when compared to the estuarine organic load. Natural $\text{NH}_4\text{-N}$ levels (8) and calculated NH_3 levels in marsh runoff waters (1028 $\mu\text{g/l}$ $\text{NH}_4\text{-N}$ and 20.4 $\mu\text{g/l}$ NH_3) were the same order of magnitude as the mean range of $\text{NH}_4\text{-N}$ (1616 - 2649 $\mu\text{g/l}$) and NH_3 (39 - 75 $\mu\text{g/l}$) concentrations in the seafood processing plant discharge, and both exceeded EPA's proposed 20 $\mu\text{g/l}$ NH_3 maximum guideline. In addition to a normally large organic load, Georgia's estuaries appear to have a great assimilative reserve capacity for organic materials, as indicated by three 1976 studies conducted at stations in the developed estuary (4, 7, 12). 1976 was an above average shrimping year (20), the packing houses in the developed estuary were operational, and the BOD load (900-3400mg/l) from the entire processing plant operation was being discharged into the estuary (compared with a present BOD load of 225 - 295 mg/l). River BOD levels near the present discharge pipe (600 feet from the previous discharge point) that ranged from 3.2 - 5.2 mg/l were within the 1979 range of 0.9 - 13.3 mg/l (12). The mean BOD value at the basin 0.5 miles upstream from the plant (2.93 mg/l) was slightly greater than the previous study's mean value of 1.84 mg/l, but the ranges, 1.10 - 5.70 mg/l and 0.59 - 6.50 mg/l, respectively, were similar (4). The results indicate relatively stable biological oxygen demands at different processing loads. Dissolved

oxygen values determined during 1976 were within Georgia Department of Natural Resources standards (6, 7).

The environmental impact of current seafood processing wastes on Georgia's estuaries appears to be minimal when compared with the natural organic load. One large estuary demonstrated a high residual capacity to receive processing effluents without significant change. Problems could develop from the entrapment of organic wastes in basins, and further study during periods of normal packing volume is required. BOD and $\text{NH}_4\text{-N}$ levels in processing wastes were shown to be greater than (but the same order of magnitude as) natural runoff from marshland. Calculated natural NH_3 levels in marsh runoff exceeded the proposed EPA guideline of $20 \mu\text{g NH}_3/\text{l}$ (8).

ACKNOWLEDGEMENTS

The technical assistance of Ms. Lea Dowdy, Ms. Sandy Gale, Ms. Cindy Nolen, Mr. William Stringfellow, and Mr. Marc Wright is gratefully acknowledged.

This publication is a result of work sponsored by the National Fisheries Institute, the University of Georgia, and the National Oceanic and Atmospheric Administration, U. S. Department of Commerce, through the National Sea Grant Program (Grant #04-8-M01-175). The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that might appear hereon.

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SEAFOOD WASTE MANAGEMENT IN FLORIDA

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FLORIDA SEAFOOD INDUSTRY

In 1979, Florida fishermen landed over 163 million pounds of seafood with a dockside value in excess of 124 million dollars (3). This annual harvest ranked eleventh in total production and sixth in total value amongst the seafood producing states (Tables 1 and 2). This level of production is very substantial when noting that Florida does not harvest large quantities of menhaden and tuna which are characteristic of the more productive states. Also, the average dockside prices in Florida are consistently higher than in most states because Florida waters produce a larger proportion of high valued species. Preliminary statistics for 1979 indicate there were at least fourteen Florida seafoods with a dockside value in excess of one million dollars (Table 3). Presently there are over 75 commercially important seafood species harvested in Florida

Primary reasons for valuable seafood productivity in Florida are the unique geographic features and location of the state. The extensive Florida coastline, in excess of 1,350 miles, touches two major bodies of water, the Atlantic Ocean and the Gulf of Mexico, and extends through two temperature zones. Within the state, there are over 30,000 lakes, 17,000 rivers and streams, and 200 springs. One major freshwater system, Lake Okeechobee, supports a major freshwater fishery. Thus, the extensive land-water interface combined with warm climates yields a very productive and diverse seafood industry, but for these same reasons, waste management in Florida is a large and diverse problem.

FLORIDA WASTE MANAGEMENT REGULATION

The Regulatory scheme for waste management in Florida is confused by a variety of state and federal agencies with similar responsibilities and overlapping jurisdiction. Currently, Florida

TABLE 1. U. S. SEAFOOD PRODUCTION BY STATE IN 1979

	<u>Million Pounds</u>
1. Louisiana	1,529
2. Alaska	899
3. California	728
4. Virginia	573
5. North Carolina	390
6. Mississippi	384
7. Massachusetts	375
8. Maine	232
9. New Jersey	189
10. Washington	170
*11. Florida	163
12. Oregon	128

TABLE 2. U. S. SEAFOOD VALUE BY STATE IN 1979

	<u>Million Dollars</u>
1. Alaska	597
2. California	227
3. Louisiana	199
4. Massachusetts	176
5. Texas	160
* 6. Florida	124
7. Washington	116
8. Virginia	85
9. Maine	80
10. Oregon	65
11. North Carolina	58
12. New Jersey	53

TABLE 3. FLORIDA SEAFOOD VALUE - 1979 (Preliminary)

FISH	MILLION DOLLARS	SHELLFISH	MILLION DOLLARS
Grouper	5.5	Shrimp	58.1
Red Snapper	4.3	Spiny Lobster	11.7
Mullet	4.1	Oysters	5.2
Swordfish	3.5	Stone Crabs	4.8
King Mackerel	3.2	Blue Crabs	3.0
Snapper (other)	2.3	Scallops	1.7
Spanish Mackerel	1.4	Others	.3
Seatrout	1.4	Total	84.8
Others	6.0		
Total	31.7		

Source: Preliminary 1979 statistics from the National Marine Fisheries Service.

water resource management programs are being administered by the Department of Environmental Regulation (DER), Water Management Districts, Department of Natural Resources (DNR), Department of Health and Rehabilitative Services (HRS), Department of Community Affairs (DCA), Regional Planning Councils, Department of Agricultural and Consumer Services (DACS), the U. S. Army Corp of Engineers, and the U. S. Environmental Protection Agency (EPA). The most direct regulation of water use in Florida has been divided between two main authorities. The Florida DER is responsible for regulating water quality as influenced by domestic and industrial wastes, and the Water Management Districts regulate the quantity of water used in their respective regions. This statutory division of responsibility overlooks the fact that regulation of water quality and water quantity relative to waste management are not mutually exclusive. The results can be duplication of expenses, complicated permitting, and a general prolonged regulatory process.

Actual waste treatment requirements pertinent to the Florida seafood industry are promulgated in Chapter 17-6 of the Florida Administrative Code. Florida has adopted the EPA effluent guidelines and standards set forth in the U. S. Code of Federal Regulations for Effluent Guidelines and Standards for Canned and Preserved Seafoods. These existing and changing federal regulations will apply to all new and existing Florida seafood processing operations which discharge conventional and/or toxic pollutants, and will provide pretreatment standards for processors discharging to publicly owned sewage treatment facilities. Florida has not been approved by EPA to administer the issuance of direct discharge permits under the National Pollutant Discharge Elimination System (NPDES) program. All NPDES permit applications must be filed with the regional EPA office in Atlanta, Georgia, and a duplicate application must be sent to the Florida DER for comment. The Florida DER reserves the authority to determine if the discharge guidelines in any permit could be detrimental to the current water classifications established by State Water Quality Standards. This means the Florida DER has the authority to impose discharge guidelines which are more stringent than permissible in federal effluent limitations of the NPDES permits. Thus, the process for direct discharge permitting in Florida can be confusing, requires duplication, and is time consuming.

Permitting for water consumption can also be a major obstacle for Florida processors. The Water Management Districts, which were initially authorized in 1972 and reorganized into five separate regions in 1977, have the authority to require consumptive use permitting to control water quantity as needed in their respective regions. Water is a threatened resource in many regions of Florida, and future projections indicate an ever increasing demand for water. In the 1980's, Florida's population should grow to exceed 12 million residents, making Florida the fourth most populous state in the Nation. The steady influx of new industries due to energy considerations will continue, and the annual visits by tourists will exceed 32 million. This increasing competition for Florida's limited water

resources will boost the importance of consumptive permitting. Future use of water for seafood processing may require extra permitting and costs.

In a recent outlook for Florida in the 1980's, Mr. Jacob Varn, Secretary of the Florida Department of Environmental Regulations, stated that current resource management is a "cumbersome, complex, time-consuming, costly, uncoordinated program for the State of Florida" (5). Likewise, the Florida seafood industry could view this accumulation of authority as bloated bureaucracy which offers little reason or incentive to comply with the regulatory process.

PROCESSORS PRESENT SITUATION AND FUTURE IMPLICATIONS

Currently there are over 400 individual seafood wholesaling and processing operations in Florida which generate an average annual seafood value in excess of 234 million dollars (1). These operations are scattered along the coast of Florida depending on the regional production of the various seafood species. As previously mentioned, species diversity is a unique feature of the Florida seafood industry. Likewise, there is diversity in the levels of processing per species. Some shrimp processing operations in Florida are the most sophisticated and largest of their type in the world, but within the same county a small 'cottage' type processor could be handling the same initial raw product. Regardless of their size, all seafood processors in Florida are concerned with waste management in the 1980's. Processors with the most immediate concern are those processing shrimp, blue crabs, oysters, scallops, and certain fish species.

Shrimp (Penaeus species)

Approximately 60 percent of Florida's shrimp landings are recorded along the southwest coast. Most of Florida's shrimp processors can be divided into two groups, non-breeding and breeding operations. The non-breeding operations are usually located in less populated coastal regions near Jacksonville and Cape Canaveral, or in remote areas of the Panhandle region or Florida keys. Most breeding operations are located in major metropolitan regions like Tampa, St. Petersburg, and Miami.

Both operations handle raw headless and heads-on shrimp, and use machinery for heading and peeling. The primary waste product from these operations are shrimp shell. The amount of shell generated will depend on the quantity of headless, peeled, and deveined shrimp produced. Purchasing headless shrimp can reduce the shell waste, but shrimp deheading at sea varies depending on the size of the shrimp and the work load as determined by harvest volume. A typical non-heading operation could handle 60 to 80 percent heads-on shrimp, whereas a breeding operation could handle 20 to 30 percent heads-on shrimp.

In compliance with permit regulations, most larger shrimp processors typically employ some form of screening to remove shell

and larger pieces of shrimp meat, and the remaining waste water is directed to the nearest municipal waste treatment facility. The recovered solids are loaded in dumpsters and deposited in city dumps. A few processors collect solids in large, underground settling tank which is periodically pumped to remove sludge. Most breeding operations practice some form of in-plant maintenance or dry clean-up to prevent solids from entering the waste water. The recovered breeding, batter, and shrimp bits are distributed as feed for local hog farmers.

Smaller shrimp processors and operations located in more remote regions are not always aware of permit requirements and direct discharge of shells is not atypical. Despite some practices of direct discharge, there have been no documented cases of water quality deterioration in Florida which resulted due to shrimp processing. In fact, processors in remote regions argue direct discharge is bioenhancement and they are more concerned with the problem of water consumption. This is especially true in the Florida Keys where processors have been forced to install systems for salt water utilization because of the scarcity of fresh water.

In the future, waste treatment regulations which have been implied in the recent EPA contractual study (4) will be economically overburdening to the shrimp industry in Florida. This EPA study recommends chemically optimized dissolved air flotation (DAF) treatment for pre-screened waste water generated by non-breaded and breaded shrimp operations. The DAF implementation date of existing operations is in 1984, but new operations will have to comply immediately. Although an economic rebuttal is beyond the scope of the paper, simple observations will indicate that DAF treatment is not possible for most of the Florida shrimp industry because of the lack of available land for construction of such facilities adjacent to the major processing operations.

Currently, the shrimp industry in Florida and throughout the southeastern United States is severely depressed. One of the primary reasons for this economic depression is the rising cost of diesel fuel. Harvesting shrimp is an energy intense operation. Without fuel subsidy, the shrimp industry must continue to adjust to inevitable increasing fuel costs. More stringent waste regulations could pose the additional financial burdens which will destroy various segments of the southern shrimp industry.

Blue Crabs

The distribution of blue crab processors usually coincides with the regional landings of whole crabs. Most Florida blue crab processors are located in the rural regions of the Panhandle, the Big Bend area, and along the northeast Atlantic coast. These processors are typically small scale handpick operations with highly variable production schedules. Some blue crab processors do not handle enough crabs to exceed the exemption limit for conventional blue crab production which requires compliance with EPA effluent guidelines.

Since most blue crab processing plants are located in relatively low populated regions, municipal waste water treatment facilities are not available. Most crab processors are not aware of the discharge permit requirements. Only a few processors have been issued a NPDES permit, but direct discharge of raw blue crab wastes is rare. Solid wastes, primarily the inedible shell and viscera remaining after handpicking to remove meat, is collected in dump trucks for various uses. Some processors have the raw waste disked into fields as a crude fertilizer for crops or tree farms. Some processors have used raw crab waste as a feed for catfish farms, and other processors rely on disposal in local landfills.

The small quantity of wastes that are generated by Florida blue crab processors does not warrant more sophisticated methods of treatment. Previous attempts to establish a centralized crab meal plant in the Panhandle region failed because it was economically impractical. Similarly, economic studies have indicated that the production of chitin/chitosan from crab shell could be a questionable venture in Florida (2). The feasibility of crab meal or chitin/chitosan production is even more questionable as cost for fuels continue to increase.

Future waste treatment regulations for the blue crab industry could require the use of chemically optimized DAF for mechanical blue crab processing. These requirements, which are implied in the recent EPA contractual study (4), would seriously threaten blue crab production in Florida. Presently, Florida blue crab producers are considering increased mechanization due to decreases in available labor. The productive option of mechanization would be limited by the excessive financial burden of sophisticated DAF waste treatment, and the application of DAF treatment with the highly variable production schedule would be impractical.

Oysters

Most oyster production and processing is concentrated in the Panhandle region. Approximately 95 percent of the Florida oyster production occurs around Pensacola and near the Apalachicola Bay system. The oyster producers are primarily small volume processors which generate a limited amount of waste. Their empty shell stock is collected for oyster planting operations or road fills, and the primary source of waste water comes from the washdown procedure.

In the Apalachicola region, the municipal treatment facilities are not adequate to receive additional sewage or waste water from the oyster processors and the geographic distribution of the processing plants make municipal hook-up economically impractical. Most sewage is treated in septic tanks, and waste water is discharged directly on the shore line below the plants. Recent changes in Florida DNR regulations are requiring some form of plumbing to direct the washwater away from the processing plant. Interestingly, the Florida DER is now concerned because their interpretation of the new plumbing requirements imply a need for NPDES permits. Most

oyster processors are not familiar with the EPA waste water requirements and most producers do not have a NPDES permit. Fortunately, some Florida oyster plants do not exceed the small scale production exemptions specified in the EPA effluent guidelines. Also the volume of waste water produced is small and will be discharged into a dynamic Bay system.

The future waste treatment requirements for the Florida oyster industry should be accomplished by simple in-plant measures, and there are no large scale oyster operations which warrant the DAF treatment implied in the recent EPA contractual study (4).

Scallops

Most Florida scallop production and processing is centered about the Cape Canaveral region. Bay and calico scallops are harvested in Florida, but the calico scallop is the bulk of the processing industry. The mechanized processing of scallops is a unique combination of heat shocking to remove the shell and specialized rollers and shakers to separate the viscera from the meat. The waste products are shell, scallop viscera, and associated waste water. Smaller, conventional processors rely on hand labor to recover the meats; consequently, their volume of waste water is reduced.

Currently there are no specific EPA effluent guidelines for calico scallop processing. Waste management of calico scallop waste have been municipal treatment for waste water, and landfills for shell and viscera. A recent crisis situation has developed in the Cape Canaveral region. Suddenly the local regulatory authorities have announced they will no longer tolerate the levels of seafood effluents being discharged into the local basin. At the same time, the municipal facility has indicated it cannot handle anymore seafood processing effluents. Thus, the scallop processing operations are faced with a no win situation.

This situation is a prime example of site specific crisis regulation which will be more typical in the 1980's. In this case, publicly owned waste treatment facilities have not been designed to anticipate the increasing loads due to the future influx of industry and residents. The local regulatory authorities have no specific EPA effluent standards for guidance. Thus, the result will be judgement calls which usually incite claims of inconsistent and inequitable regulation. The final decision may have to be resolved in courts and/or the processing operation could be forced to close. Hopefully, the processors can work with various local authorities and reach a compromising solution which will assure environmental protection and continued seafood production. Local economics and labor cannot afford to stifle the seafood processing industry in Florida.

Certain Fish

The level of fish processing in Florida is extremely variable depending on the fish species and season. Processing operations can be as simple as boxing and icing of whole fish, or more sophisticated with mechanization for filleting and freezing. Also, there is a limited amount of fish meal processing of menhaden harvested in northeastern Florida. Overall the fish processing industries in Florida are considered low-priority operations for waste management regulation.

The most common method of waste management is landfills for fish scrape which is collected in dumpsters. Waste water is directed to available municipal facilities. Certain fish scrape is packaged and frozen for fish chum or crab bait. Fresh trash fish and fish scrap has been used for production of pet foods. Production of fish meal is minimal and will become more economically impractical as fuel costs continue to increase. Attempts at production of fish fermentations for fish sauce, feeds, or fertilizer have only been investigated as bench top ventures.

Menhaden processors currently operate evaporation plants which minimize waste water, but future fuel costs may dictate modifications in their operations. These modifications may require new waste treatment practices, but the present fish meal waste is minimal and poses no regulatory problems.

In the future, certain in-plant modifications will be required to reduce waste loads from conventional fish processing operations. Modifications such as segregation of fish scales seem reasonable and practical, but the implied requirement of DAF for mechanized operation is totally impractical. The DAF requirement was determined based on the performance of mechanized bottom fish processing operations in Alaska (4). In Florida most fish processing schedules are highly variable due to seasonal abundance, the same plant can handle a varied number of species, and the volume of processing is much less than the typical large volume single species operation in Alaska. For these reasons, the operational requirements for DAF would be impractical for mechanized fish processing in Florida.

CONCLUSIONS

Seafood waste management in Florida will become a major problem as more stringent regulations become effective in the 1980's. This problem will be shared by the respective seafood industries and regulatory agencies. The seafood industry may be required to install expensive waste treatment facilities at the same time they are faced with increasing fuel cost, inflation, and growing competition for water resources. In certain regions of Florida, competition for water consumption could pose more serious problems than water quality regulations.

The complexity of regulations and the overlapping authority of the various regulatory agencies is confusing and offers little incentive for industry compliance. The unique geography of the state and the diversity in the seafood industry complicates regulatory responsibility. Currently the state regulatory agencies do not have the manpower or budgets to administer the existing regulations. Future regulations should not be adopted if they cannot be adequately enforced. The result will be continued crisis regulation which is inequitable and inconsistent. Crisis regulation will be more site specific and will require judgement calls. In this situation, the seafood processing industry should be considered a lower priority problem and attention should be focused on the more toxic pollutants.

Future regulations have been proposed to include total ammonia as a toxic pollutant. If this regulation is adopted, it could impose immediate requirements for advanced treatment methods for seafood waste. The EPA must reevaluate their proposal, which was based on bench top studies, and reconsider the actual environmental and economic implications of this regulation. Likewise, the implications for dissolved air flotation as a future treatment method warrant reconsideration in the light of the industry's current economic situation relative to increasing energy costs. Fuel costs for treatment construction and operation is of minor consequence when compared to the energy cost for harvest. The fuel costs for harvest is an integral part of seafood processing, especially with the lack of fuel subsidies to aid seafood production. This cost is most important to the major shrimp processing operations in the south which depend on an energy intense fishery.

Currently, most Florida seafood processors depend on municipal treatment for waste water and local landfills for depositing solids. The rapid population growth in Florida will increase the load on existing municipal facilities. The result could be increased sewage costs or no available treatment. Likewise, future resource and conservation recovery regulations may limit the use of landfills. Without available publicly owned treatment options, various segments of the Florida seafood industry may argue for ocean dumping, as recently approved for fish cannery wastes originating in American Samoa (45 Federal Register 56374-8/25/80). Remote areas of Florida, i.e. Keys, could argue for consideration as a remote section as requested by various locations in Alaska (45 Federal Register 52411-8/7/80), and some fisheries may consider more on-board processing to eliminate waste, assure better quality, and maximize energy expenditures during off-shore operations.

Unfortunately, the by-product options for waste utilization have not developed as predicted in original EPA regulations. Edible minced fish items are still experiencing consumer resistance and the mincing operation creates unique waste management problems. Pet food is not a trash food, and the pet food process requires quality fish with certain product specifications. Chitosan production has failed in the United States primarily due to high production costs,

variations in raw material supply, lack of profitable market outlets, and competition with less expensive synthetics. Chitosan production also creates unique waste management problems. Feeds and dry fertilizers produced from different seafoods have not been successful due to competition with less expensive and more available products. Increasing fuel costs limit the application of dehydration processes, thus fish fermentations and silage must be reevaluated.

In summary, the environmental attitudes of the 1970's must now contend with the energy decade of the 1980's. Future waste management regulations will be an arena for conflict between environment and energy considerations. Cost-benefit arguments will determine the fate of the industry. The United States seafood industries offer a future of increased production and labor and a potential for balancing the current foreign trade deficit. Hopefully, reasonable waste management regulations will assure water quality as well as the economic welfare of the seafood industry.

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SEAFOOD WASTE MANAGEMENT IN THE GULF OF MEXICO

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BACKGROUND

Throughout the five states on the Gulf of Mexico the major source of seafood waste comes from the shrimp fishery. The Gulf seafood industry derives its life force from shrimp. Boatyards build boats which fish only for shrimp. The majority of fishermen go out to catch one thing and that is shrimp. The packing and processing plants have most of their equipment capital invested in things that unload, weigh, grade, peel, and freeze or cook shrimp. As of the second week of this month 56 million pounds, heads-off, had been landed in the Gulf states. And this is a bad year. The figure comes from the National Marine Fisheries Service's Market News Report. They always adjust their numbers to a heads-off figure. Actually Texas is the only state that predominately lands its catch without the heads. The catch in the other states is usually landed whole; so, as far as total weight goes, that 56 million pounds is actually a low figure.

As you can imagine the solid waste poundage will reach into the millions too. When a whole shrimp is headed it will lose 33 to 37% of its weight. If the shrimp is headed and peeled then the total loss will be from 50 to 55% of its landed weight. In the Gulf packing plants the majority of the shrimp is headed and packed in five pound boxes, then it is frozen, and sold. The rest is peeled and frozen or canned. So between these two operations the production of solid waste in a particular plant parallels the production of product at a high percentage rate.

Along with these heads and shells there is a substantial volume of processing water which is generated. The heading and packing of shrimp uses a moderate amount of water. On the other hand, the peeling operation can use 75-80% more water so that a four peeler plant can discharge 100,000 gallons or more a day.

Shrimp, of course, is not the only thing which is produced in the Gulf. There is a sizeable oyster industry which operates the year-round in some places, but it is predominately a fall and winter fishery. This industry does not really have a solid waste problem because the whole animal is used. The shells have an economic value as building materials or cultch for oyster beds, so they are in demand. The waste problems of the oyster industry are confined to grit from the mud and broken shells and the organic materials dissolved or suspended in the process water.

The blue crab industry is important to those who are in it, but its volume compared to the Chesapeake Bay is fairly low. They have a substantial solid waste production because meat recovery is no more than 13-15% and the rest is shell. Water usage is low. The largest plant in Mississippi discharges 5-10,000 gallons a day. The cooking water is the only concentrated waste load that would come out of a plant. This industry still hand picks the meat.

The Gulf produces some fish, too, but it is not an item that many plants handle. Just how much is produced in the Gulf is hard to say. However, that which is handled is predominately a whole product. We do not have a fillet industry such as is on the New England coast. The most that may be done with them is heading and gutting, but the largest snapper plant in the Gulf told me that with the labor costs what they are, if his customers will not take the whole fish he will not sell to them.

The menhaden industry is in a special category by itself. Several years ago EPA singled them out for particular attention due mainly to their oily discharges. As a rule the plants now collect all their incidental process water, such as that which comes out of the boats when they are unloaded and cleanup water, and then it is evaporated which leaves a residue of the soluble organic materials. That has an economic value. So they have their situation pretty well in hand, even through 1984's projected regulations.

There is one more fishery which is unique to the Gulf of Mexico that ought to be mentioned. That is the crawfish industry in Louisiana. This is a winter and spring fishery which generates a tremendous solid waste load and very little liquid waste. I was told that in a good year there could be 25-30 million pounds to be disposed of. The crawfish is in the same class as the crab as far as weight of meat ratio to the weight of the disposable shell.

As you know the seafood industry is still operating under the 1977 BPT regulations. For the Gulf fishery this is predominately screening and water management. The various state pollution control agencies have written specific parameters into their permits but they are in fact quite similar throughout the Gulf region. All require that the pH be within the ranges of 6 to 9. They also require weekly sampling of either suspended solids or settleable solids. And everyone must monitor the discharge flow rate.

Another common feature in the region is that municipal sewage treatment capacities are increasing or they are in the planning stages. Whenever these expansions are completed then the plants will be required to connect to them. That will in effect bring about the concept of zero discharge which is the basic goal of the wastewater regulations.

PRESENT SITUATION

Looking at the various states: Texas seems to be moving along with its municipal sewage expansion program. The seafood plant permits are all due to expire when municipal hookups are possible. Some plants will be connected this year and others will continue to be added through the next three years. In the meantime the majority of the wastewater is going back into the waters of the bays and harbors. There are dumps available for the solid waste for those who can haul it off. Texas does not have a peeled shrimp segment of the packing industry

so its water usage and waste loads are low compared to what it could be if there were peeling operations.

Louisiana does have peeling operations and lots of them. The greater part of them are located in the New Orleans area. There the city sewage system can accept the wastewater and landfills are accessible for those who want to use them. There are shrimp packing plants throughout the state and every local situation is different but in all, the big problem is with the solid waste. There are a few parish landfills but the shells also go in a lot of open dumps which are in the process of being closed. Where neither is available there is some dumping off the side of the roads. Outside of the larger cities the general flow of wastewater is into the bayous and bays. This wastewater can contain solid waste too. Throughout the state there are a very large number of small unloading docks on the sides of the bayous where shrimp buyers unload a boat, box the shrimp, and load them into trucks. The wash tank water of course goes directly back into the bayou. These places are so small that it is out of the question to think of sewage hookups for them.

In Mississippi the largest number of the state's seafood plants are located in a county which has a contract with a company to run the garbage collection but that company will not haul the solid waste from the plants. That leaves them in a pretty bad fix. Some have been fortunate enough to find agricultural interests who will come and get it or will let it be put on their land, but that is not very many out of the total. In another county the same company is required to haul off the shells because of a clause in their contract with a different town. Mississippi has a large number of peelers so the volume of shells is large. A very few plants send their wastewater to a treatment facility. The rest discharge it overboard.

The major seafood packing town in Alabama required the plants to send their wastewater to the treatment facility. Now, due to industry expansion, the facility is completely overloaded so that it is no more than conduit for the waste pumped into it. Its outfall is in a bay so there have been no water quality problems. In the meantime a moratorium has been imposed on the plants which prevents them from installing any more peeling machines until the treatment facility can double in size. The solid waste is contracted to a single firm who collects it and hauls it to a county landfill.

On the Florida west coast the story is more of the same. Landfills or overboard discharges account for solid waste disposal. In the larger towns the wastewater is taken by the sewage treatment facilities but other than that it goes back into the surrounding waters.

FUTURE IMPLICATIONS

So, here we are at the start of the 1980's, three years after the first set of regulations went into effect, three maybe four years away from another set, and where are we? What has been accomplished? In my part of the country we are about where we were three years ago and we are no worse off for it.

I want to say right off that I like the seafood industry. I believe that environmental legislation is needed, but the tone and intent to which it has been applied to the seafood industry is uncalled for due to the nature of their waste products. You hear

everyone talking about preserving the marshes because of the nutrients they produce for the sustenance of the estuary. Well, what do you think comes out of a seafood plant's drain pipe? It is pure nutrition. It is not some toxic substance that will make fish have five eyes and sea birds lay eggs like marshmallows. It won't stay in the bottom mud for the next thousand years. No, it feeds these animals and for the most part it is eaten within a few hours.

I have been working with seafood plant waste effluents for over two years. And I just do not view it as being a hazardous material. It can be a nuisance no doubt, but never a threat. And that very fact brings up the question of the real need for such uniform, detailed regulations for an industry which if it has problems, those problems are particular to its location and not to the national industry as a whole. If you have a major fishing port with a lot of packing plants along a small bayou such as in Bayou la Batre, Alabama, then there can be a need for wastewater regulations to prevent water quality deterioration. On the other hand, if you have another major fishing port on a waterway which has never experienced any dissolved oxygen problems such as Delcambre, Louisiana, then why should Delcambre have its plant wastes regulated to the same degree as Bayou la Batre?

I know EPA has had this matter brought up to it before. Right now is the time, I think, to get this thing stirred up again because we have seen what BPT is like and some of us after reading the E.C. Jordan report have a fair idea of what the BCT regulations may be like. And I just can't see the need for it. I believe we are getting into the realm of regulation for regulation's sake and not regulation to correct an evil.

EPA's viewpoint has been that since the industry is so diverse and scattered throughout the coastal states then they cannot possibly get to each location to have a look. Well, there is no real reason why they should. If they trust the state pollution agencies to carry out the provisions of the NPDES system why can't they be trusted to make decisions as to the application of the regulations on a case by case or regional basis?

Is there any real chance of altering the forward march of the regulations? Remember that PL 92-500 and the Clean Water Act of 1977 were both amendments. The space of time between now and 1984 would be a good period to adjust the things that need adjusting and generally get the law in a more reasonable condition as far as seafood goes.

There has always been a basic difference of thought between the regulators and the regulated. The whole thought behind PL 92-500 was that the waters of the nation were polluted and BPT and BAT were only steps toward the elimination of all industrial discharges. It was the idea of Congress at the time that all discharges were pollutants. The seafood industry has known for years that their discharges could not be detrimental pollutants otherwise catches would have declined and the industry would have declined instead of there being the growth which has actually been the case. The law talked of the "protection and propagation of a balanced population of shellfish, fish and wildlife" (1) as if they were in danger all over the country. That has not been the case. The law was passed on the wrong assumption. EPA had the right idea in 1975 when they published the interim final rules for effluent guidelines and standards for canned and preserved seafood processing in the Federal Register (2). They said "ocean

discharge of fish wastes does not subject the marine environment to the potential hazards of toxicity and pathogens associated with the dumping of human sewage sludges, municipal refuse and many industrial wastes. The disposal of seafood wastes in deep water can be a practical and possibly beneficial method of ultimate disposal" Why does the Agency think it suddenly becomes nonbeneficial in the estuaries near shore? That is where the majority of your seafood grows up and is caught, not out in oceanic waters.

The work of Dr. Soule in Los Angeles harbor concerning tuna canneries wastes is quite well known by now. During now and 1984 that work should be added to by data from other parts of the country and it should be taken seriously by EPA. It substantiates what every seafood packer I've ever talked to believes. There will never be any more than grudging compliance to any environmental law by the industry which disregards the bioenhancement aspect of their waste material. Part of the charge to EPA made by Congress to undertake the Section 74 study was to "examine technologies which may be used in [seafood] processes to facilitate the use of the nutrients in [untreated natural] wastes or to reduce the discharge of such wastes into the marine environment"(3). I would say that the animals in the water can facilitate the use of the nutrients quite nicely without any technology. If you reduce the discharge then you create a solid waste problem which technology has not solved. The EPA has always considered a solids reduction facility as a viable method of dealing with screened effluents but that is just not how it is. The operating costs are too high and the market potential for the meal is too low.

Everyone in the industry had really hoped that when the BCT standards were being revised some serious consideration would be given to bioenhancement. It appears that most of the attention has been given to reevaluating industry vs. municipal treatment costs. This is particularly disturbing from the viewpoint of the Gulf seafood industry. The Agency has had a cavalier attitude about the consequences of their regulations. Referring back again to that 1975 Federal Register they wrote, "a number of small plants are projected to be adversely affected by these regulations, but the domestic industry capacity is not expected to be affected by the potential closure of these particular small plants"(2). I must strongly differ with such a statement. The domestic capacity will be affected because there are very few shrimp businesses in the Gulf states which could be considered large. There are hundreds whose annual sales are less than \$300,000 or between that and \$1 million. If those get knocked out of production the whole system gets disrupted. If you deal in terms of absolutes then that is what you get.

This country needs the EPA. But it needs them and their expertise where there is a definite threat to human health and wildlife. The cover story in this week's Time magazine (Sept. 22, 1980) will tell you about that. The article states that EPA has estimated that there are 50,000 toxic chemical dump sites and they have located 181,000 chemical waste lagoons. A very large percentage of these are improperly constructed and pose a danger to ground water supplies and public health. In addition to that the Agency estimates that more than 77 billion pounds of hazardous chemical wastes are produced each year with only 10% being handled safely. About 40% is being handled

improperly and 50% is just being dumped in waterways and on the land. There is a bill in Congress now which would create a fund for the Agency to use to neutralize these dump sites and lagoons all across the country. And there is also the matter of overloaded or improperly operating sewage treatment plants which just pass along disease organisms into the water. The Gulf states have a lot of those. That is the kind of work that the Agency should be supported in. A seafood plant's effluents of BOD and Suspended Solids seems a mighty small matter beside the destructive powers of those 77 billion pounds of chemical wastes and pathogenic viruses and bacteria.

Comparison of risks is a phrase being used around Washington now. Congress seems to be getting interested in it as it relates to federal regulatory actions. Representative Don Ritter (R-PA) has introduced legislation which provides a mechanism for assessing risks in an effort to make regulations objective. Representative Ritter states that "comparison of risks is a way for regulatory agencies to reform themselves, to set priorities, and to do a better job of protecting the public. In short, comparison of risks helps set priorities and, thus, helps bring government regulation into the 1980's"(4).

The threat to the health of the bayous and estuaries along the Gulf of Mexico in the 1980's in my view does not come from seafood plants. It is just the opposite. Without them I would expect the productivity of the waters to go down. I don't think it is coincidental that after 14 years of trawl sampling at the same stations along Mississippi's coast, the area which has been shown from catch data to be the best nursery ground is also the bay where the greater number of our seafood plants are located.

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SEAFOOD WASTE MANAGEMENT IN THE NORTHWEST AND ALASKA

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INTRODUCTION

Waste! That word signifies the major product of the fishing industry and could sum up our future. We must change our thinking on the entire sequence of harvesting, transporting, processing, and marketing of seafood products as related to "total utilization," not waste. Otherwise, ten years from now we will be duplicating, as we have done for 20 years, this conference with the same papers, the same unsolved problems, and the same glorious plans for the future.

There is no such thing as "waste" in seafood as it comes from Mother Nature. This wide range of resources is a combination of primary and secondary raw materials. We are so tuned to inefficient use of foods from the sea that often nothing beyond the historic conventional product, a small percentage of the edible portion, is considered by the processor. Also, the makers and enforcers of our federal, state, and local laws are tinged as well with the same misconception. No one seems to relate to the fact that waste is our creation, not our destiny. During the balance of the conference we are scheduled to reiterate the plans for Seafood Waste Treatment and Utilization and their regulation, often based on insufficient knowledge of the industry, inaccurate data, and lack of realization that the future survival of mankind is not dependent on processing waste but on producing food.

It was interesting to review the subjects of papers being presented at this meeting that involve utilization. At the University of Washington, we participated in building the first chitosan pilot plant, and have engineered and developed pilot plant facilities for many forms of edible recoverables including batter and breaded formulated foods, dried products, and various forms of extracted proteins. In fact, as a licensed engineer who has long been active in seafood processing plant design and construction, I would be willing, today, to undertake a project resulting in a successful plant for economically utilizing the processes or producing the products that will be presented by the various speakers. The processes for utilizing "secondary raw materials" are available but

we are not paying enough attention to the limiting problem of logistics. Logistics! Not raw materials, not processing techniques, not salable products, not markets, not waste disposal, but logistics of economically collecting, handling, holding, and insuring adequate high quality secondary raw materials is the overriding factor in the "Total Utilization" of seafood.

CHANGING FISHERIES OF THE NORTHWEST AND ALASKA

Understanding the major trends taking place in the North Pacific fisheries is important in the logical planning for maximum use of the resources and for realizing the important relationship between the Pacific Northwest and Alaska. Due to the magnitude of the potential U. S. catch from the Fishery Conservation Zone and the accompanying logistic requirements, the changing fisheries are much more important to future waste management planning than a recap of the present operations.

High Cost of Present Products

Since shortly before the turn of the century, salmon has been the dominant seafood in the Northwest and Alaska. This much sought after fish has also dominated the thinking of the fishing industry, the state, federal and local bureaucracies, educational institutions, and the public. In Alaska, king crab became a major industry during the 1960's, followed by tanner crab and shrimp. Halibut, of course, has been the major long-line fishery, regulated by the international agreements between Canada and the U. S. Dungeness crab, oysters, clams, and relatively small volumes of bottomfish round out the list of seafoods that have supported the industry in the past. It should be noted that most of these raw materials are processed into high-quality, high-priced products. In fact, the cost of many of these products has risen so high that consumer opposition is beginning to be felt by the industry. This trend is particularly noted in the U. S., a beef eating nation where many seafood products are priced well above beef.

Trend Toward Frozen Products

The demand for frozen salmon, crab, shrimp, and other seafoods is growing at a much faster rate than that for canned products (Tables 1 and 2). This tendency has been reflected by the rapid increase in freezing operations in Alaska. Since the seasonal nature of these fisheries greatly limits the locations where permanent shore-based freezing and cold storage operations can be built and operated economically, there has been a tremendous increase in the number of floating freezer vessels operating in Alaska. Thus, the Alaskan processing industry is becoming more mobile. This can be demonstrated by the increase in Washington Port moorage and the projected increase in large vessels over the next two decades (1) as shown in Tables 3 and 4. Furthermore, since the frozen products are in a pre-processed condition or in the final form for marketing, a greater share of the present seafood is being shipped to the

TABLE 1. ALASKA CANNED AND FROZEN SALMON PRODUCTION

Year	Canned (million lb.)	Frozen (million lb.)
1970	171.1	13.5
1971	133.4	12.2
1972	82.8	12.1
1973	55.5	16.8
1974	61.1	42.8
1975	57.0	43.3
1976	121.2	50.6
1977	140.0	76.7
1978	163.6	121.4
1979	147.9	149.2

Source: Pacific Packers Report, 1980. Supplement to National Fisherman, April, 1980.

TABLE 2. ALASKA KING AND TANNER CRAB PRODUCTION

Year	King Crab (million lbs.)	Tanner Crab (million lbs.)
1973	76.0	61.2
1974	97.1	64.2
1975	91.7	46.2
1976	106.0	81.5
1977	99.6	98.5
1978	122.9	130.6
1979	154.4	131.4

Source: Pacific Packers Report, 1980. Supplement to National Fisherman, April, 1980.

TABLE 3. PROJECTED YEAR ROUND MOORAGE REQUIRED FOR BOTTOMFISH VESSELS, 1985 TO 2000

Year	Puget Sound ^a		Washington Coast ^b		Lower Columbia ^b	
	Number of Vessels	Length Required (linear feet)	Number of Vessels	Length Required (linear feet)	Number of Vessels	Length Required (linear feet)
1985	7	1,050	1	150	1	150
1990	14	2,100	2	300	2	300
1995	21	3,150	3	450	2	300
2000	27	4,050	4	600	3	450

Source CH₂M-Hill and Pigott, 1980

^a Based on 90 percent of the total fleet visiting Puget Sound annually for maintenance and 5 percent of their annual time being spent in port.

^b Based on 20 percent of the local fleet in port at any one time.

TABLE 4. PROJECTED NEW VESSELS REQUIRED TO SUPPORT BOTTOM FISHERY EXPANSION, 1985 TO 2000

Year	Washington and Alaska Fleet ^a			Alaska ^b Fleet Only	Total
	Lower Columbia	Washington Coast			
1985	3	4		138	145
1990	6	9		275	290
1995	9	13		431	453
2000	11	19		558	588

Source CH₂M-Hill and Pigott, 1980

^a Based on a 50,000 pound per day catch rate and 50 days active fishing for Pacific whiting. Total includes two vessels that are based year-round in Washington Ports.

^b Based on 50,000 pound per day catch rate and 120 days of active fishing.

Northwest for final processing and storage. This trend is particularly important to the futures of both Alaska and the Northwest and to the relationship between these two geographic areas.

Present Fishery

Although yearly variations in catch will continue, current fisheries will not substantially increase in the future. Hence, any major increase in either Alaskan or Northwest fisheries will have to come from "cheaper" bottomfish. Ironically, many of the overfished segments of the marine waters under consideration continue to be pressed by new vessels being built for specific fisheries. Many of these vessels do not have the facilities and structure which would allow them to multifish or to be easily converted to other fisheries.

Fisheries Conservation Zone

The tonnage and total market value of bottomfish stocks within the 200-mile limit area dwarf those of the high-priced seafood now being caught in Alaska and the Northwest. However, it must be remembered that this contemplated bottomfishing is not a new fishery. Foreign fleets have been harvesting large amounts of fish on the high seas. The FCMA gives the U. S. management jurisdiction over the area, but we can only replace foreign fishery effort as we develop the ability to harvest and handle high seas fish.

New Processing Requirements

Species of fish such as pollock and hake have keeping qualities different from those of the bottomfish which Americans are used to catching and processing. While cod, lingcod, rockfish, flounder, sole, and other commonly caught species can be iced for some time prior to filleting, the largest volume of fish available to the high seas fishery have softer flesh and other biological properties that preclude handling by present methods. For example, hake and pollock must be processed to some degree soon after being caught. The minimum satisfactory processing is heading and gutting and then freezing. The best technique involves preparation of the final products immediately after catching.

Need for Long-Term U. S. Capital Investment

A major portion of the money invested over the past decade or so in the U. S. fisheries has come from foreign investors. The lack of a visible, well-planned future for fisheries has deterred U. S. investors. Meanwhile, foreign high seas fishing nations who know the future requirements for food have invested heavily in the U. S. fishing industry to preserve their present fishery resources coming from our waters. These investments include foreign ownership of a major fishing and fish processing companies; in fact, control of much of the industry, particularly salmon.

The basis for discussing the future management of Pacific Northwest and Alaska fisheries (including waste management) lie within the above factors. Each must be addressed if planning for the future is to be realistic.

WASTE MANAGEMENT - PACIFIC NORTHWEST AND ALASKA

There is no better geographical area to exemplify the problems of logistics in "total utilization" of seafoods than the Pacific Northwest and Alaska. A review of the so-called "waste management" in this widely diversified fishery must extend over many species and varying seasons for perhaps 4,000 miles of shoreline. Furthermore, there is an interrelationship between Alaska and the Pacific Northwest that is unique for two major U. S. fishing areas.

As with all processors subject to the EPA guidelines, those in Washington, Oregon, and Alaska were to have upgraded their effluent treatment to "Best Practical Technology" (BPT) by July 1, 1977, and "Best Available Technology" (BAT) by July 1, 1983. The major industry groups, salmon, crab, and shrimp, under the BAT would have to reduce waste so that the solids are passed through a 40 mesh screen and then sent to landfills or barged to sea. The possible requirement included air flotation and aerated lagoon disposal. The possible replacement of BAT by "Best Conventional Technology" (BCT) is in keeping with the present decision to re-examine the original document to determine the effectiveness or economic feasibility of the technologies. No considerations of a most important item, bio-enhancement, have been given to the preparation of EPA guidelines and regulations.

Alaska

The EPA manages the issuing of disposal permits in Alaska. The state is unique in that the discharge regulations include two subclass designations, remote and non-remote. Under BAT, remote areas can grind and discharge waste while non-remote areas must screen and barge or landfill solids. There is some confusion as to the definition of the two subclasses.

The present seafood harvest in Alaska and the estimated disposition of the various portions is shown in Table 5. At the best, these figures are estimates since no cumulative records are maintained in many areas of operation. For example, some salmon heads are shipped to Washington for pet food and some are used for crab bait; considerable waste is discarded at sea by shipboard processors and many fishing vessels (particularly those harvesting halibut and black cod) carry out some degree of butchering operations on shipboard. Also, a considerable amount of crab waste is generated in Washington where some 47,198,000 pounds of king crab and 32,305,000 pounds of tanner crab were received in 1979 for final processing. The waste figures in Table 5 have been estimated to take these facts into consideration. It should be noted that the 1979 estimate for waste handled in the plants was 41.3% finfish

TABLE 5.

PRODUCTS AND ESTIMATED WASTE DISTRIBUTION OF
ALASKAN CATCH (EXCLUSIVE OF SHRIMP, DUNGENESS
CRAB, BOTTOMFISH) IN MILLIONS OF POUNDS, 1979

<u>Species & Product</u>	<u>Catch (Landed Weight)</u>	<u>Estimated Distribution</u> ^{1/}	
		<u>Products</u>	<u>Waste</u>
Salmon	297.1		
Canned	147.9	99.1 (67%)	48.8 (33%)
Frozen	149.2	111.9 (75%)	37.3 (25%)
King Crab	154.4	84.9 (55%)	69.5 (45%)
Tanner Crab	131.4	72.3 (55%)	59.1 (45%)
Halibut	15.9	9.5 (60%)	3.2 (20%) ^{3/}
Black Cod ^{2/}	<u>7.4</u>	<u>5.6 (75%)</u>	<u>1.1 (15%)^{3/}</u>
Total	606.2	383.3 (63%)	219.0 (36%) ^{3/}
Total Finfish	320.4	226.1 (71%)	90.4 (28%)
Total Shellfish	285.8	157.2 (55%)	128.6 (45%)

^{1/}

Since there are no accurate statistics available on total product vs. waste, these figures are estimates based on knowledge of the distribution in various products and forms of products.

^{2/}

Total catch Alaska and Washington (mostly Alaska).

^{3/}

Most halibut is gilled and gutted at sea, estimated at 20% (3.2 million pounds). Likewise much of black cod is cleaned at sea, estimated at 10% (.7 million pounds).

waste and 58.7% crab waste. No effort was made to include shrimp, dungeness crab, and bottomfish in the estimates since the 1979 catch and subsequent waste is relatively unimportant compared to the other 5 species.

There have been three fish meal plants operating in Alaska: Kodiak (200 mt/day capacity), Seward (100 mt/day capacity), and Petersburg (100 mt/day capacity). These plants have been producing meal from crab, shrimp, and fish wastes while discharging the stickwater (oil and solubles) through submerged pipe outlets. Considering that some 219 million pounds or approximately 100,000 mt of waste are generated during relatively short fishing seasons, it is obvious that most of the waste from processing seafoods in Alaska is discharged to the sea.

The confusion on subclass definition is realized when it is noted that processors from Ketchikan, Anchorage, Cordova, Petersburg, and Juneau petitioned for and won a change of status to remote. The city of Kodiak did not want reclassification for fear that the bay would revert to the unbearably polluted area that prevailed prior to the establishment of the meal plant. Reclassifications of towns as remote areas was allowed in 1980 due to the record fish runs. Although this was considered a temporary change, it seems probable that it will remain on an indefinite basis. The uneconomic nature of waste processing meal plants in Alaska is exemplified by the situation in Petersburg. After the change in status to "remote", processors began grinding and discharging wastes. As a result the meal plant had to shut down due to lack of raw material.

Most remote area processors are grinding and discharging with a few plants using "gurry scows". In the past, applicants for effluent discharge permits were encouraged to discharge below seven fathoms depth. However, now realizing that depth may not be the sole factor in distributing the waste, EPA is processing permits on an individual basis with the discharge outfall being located at a satisfactory point of dispersion, regardless of depth. Likewise, a policy is evolving whereby the residual outfall is judged not by strict size standards (100 foot diameter, 6 inches deep) but by the effect of the residue on the ecology of the area.

All floating processors come under the remote classification; however, no applications are made or permits granted for foreign vessels operating under the Fisheries Conservation Zone Management Plan.

Oregon

Oregon permits are processed by the Oregon State Department of Environmental Quality. All plants in the state are operating under BPT guidelines that call for screening solids. Solids are widely used as mink food (Northwest Fur Breeders Association, using mainly offal) and fertilizer on farm land (mainly shellfish waste). A

plant in Warrenton produces Oregon Moist Pellets utilizing crab shells and fish wastes. The pellets are used widely within Oregon in state fish hatcheries.

There has been a considerable amount of planning for future plants utilizing seafood waste but the slow movement is indicative of the marginal business of reducing high quality raw material to low quality products. Meal plants have been considered for Coos Bay utilizing conventional meal processes or a new ram jet engine principle. There has also been a proposal by a California company to compost wastes with sawdust.

Shrimp waste presents the most difficult disposal problem, although these plants as well as all other seafood plants in Oregon are currently in compliance with BPT. Final solids not being utilized by feed or fertilizer manufacturers are being trucked to landfill since barging is too costly. The economics of operating marginal facilities and the lack of available land for aeration lagoons would make it extremely difficult for processors to meet the BCT.

Washington

Permit applications are processed by the Washington State Department of Ecology. Washington is currently operating with a wide variety of waste utilization or disposal techniques and does not have any outstanding conflicts with meeting regulations. The Department of Ecology protested BCT guidelines for 1983 before they were suspended and must now wait, like other states, for new rulings from EPA.

Companies in the major Puget Sound processing area extending from Tacoma to Bellingham dispose of a large portion of their waste into the municipal sewers. Each city or municipal sewage district makes its own regulations and agreements with processors as to the form and amount of waste accepted.

Large amounts of fish waste are currently being utilized in a La Conner fish feed plant that makes Oregon Moist Pellets and other formulations for State, Federal, and private hatcheries. A unique system of shellfish waste disposal has been instigated on the Southwestern coastal area. Commercial operators and farmers collect the waste and spray it in the form of a ground slurry onto farm land. This procedure has met widespread approval by farmers and the product is in demand, although the farms receive the basic material at no charge for taking the waste from the plants.

There are several small meal plants in the state that operate intermittently. There is only one major plant (located in the Seattle area) that operates solely as a full time business of processing waste. The proximity to local meat, poultry, and fish processing plants greatly simplifies the logistics of economically collecting enough raw material to allow full-time operation. However,

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a significant percentage of the raw material still must be trucked from northern Puget Sound and Southwest Washington to insure sufficient raw material for economic operation.

Approximately 10 years ago, the University of Washington, through a Sea Grant project, worked with a Seattle firm in the development of their proprietary process for producing chitin and chitosan from shellfish waste. The company has continued to develop and simplify the process in order to improve the operating economics and efficiency. As always, the final limiting factor is the logistics of supplying sufficient raw material to enable economic operation of the minimum size plant. There is much optimism that a commercial chitosan plant utilizing improved processing techniques will be built in the near future.

California

Although it is not the intent of this report to cover the southern portion of the West Coast, it might be well to point out the major differences between the warmer water fisheries of California and the northern areas. Tuna and anchovy, the predominating industries in California, operate under different guidelines than those for salmon, crab, and shrimp. Air flotation is currently required in the disposal process. The tuna plants have large continuous production and, therefore, can support meal plants in San Pedro and San Diego. Bait water from vessels delivering to ports must be hauled at least three miles off shore and such wastes from fishing vessels are excluded from the Ocean Dumping Permit Regulations.

SUMMARY

Accurate information on total waste recovery is not available and many processors are reluctant to give such information unless they are assured that their specific company's production will not be disclosed. Although there is a significant volume of material being recovered in the form of usable products, the large majority of high quality protein is being discarded or sold for "cheap" animal food. The remote areas are particularly noticeable in that the present logistics problems preclude economic recovery and processing into salable products. The remoteness of Alaskan operations and the close proximity to municipal sewers of most large plants in Washington and Oregon are currently positive factors in preventing marine water pollution.

IMPACT OF FISHERIES CONSERVATION ZONE (FCZ)

Since the 200-mile limit is having a major impact on the Northwest and Alaskan fishery, this factor must be considered in relationship to waste management. This is especially true since the FCZ species are predominantly "groundfish" or "bottomfish" and represent the large volume-low priced raw material not previously harvested in large scale.

It is a delusion to talk about an expanding bottom fishery being combined with the present seasonal industry, especially salmon, to give added stability to each. There are few areas in Alaska handling large amounts of salmon that are suitable for large scale processing of bottom fish. Furthermore, the government sponsored blue sky feasibility reports (heavy on economic input and light on technology background) on the future of the 200-mile zone are severely misleading to those trying to plan for a realistic future.

Originally, bottom fish or groundfish were designated as those caught by trawling operations that drag the bottom for such fish as cod, rockfish, flounder, and sole, usually destined to be processed into fillets. However, convention has tended to designate all fish to be filleted as bottom fish even though some of the species are actually schooled pelagic fish. Depending on the size and species, the yield of fillets varies from below 20% to as high as 35%, with approximately 25% being a good average. However, these fish have 50 to 60% flesh on the carcass meaning that one half or less of the edible flesh is utilized for human food. The result is that the "frame" or filleted carcass contains an amount of flesh equal to that removed as fillets. Unless the U. S. can utilize this fraction of the bottomfish catch for some form of human food, it is doubtful at this time that we can economically enter the tremendous market that is being filled by foreign fleets. These fleets are using the total raw material in that they are either making fish meal from the waste (Table 6) or are removing the remaining flesh from frames for surimi blocks that eventually are processed into kamoboko. Furthermore, a high percentage of the high seas catch consists of small fish that will be thrown away as too small to fillet. These fish are also being utilized by foreign fleets. Small fish can be deboned to give approximately 50% of the landed weight in minced flesh. The key to future success of the U. S. bottom fishery will be our ability to amortize the catch over total utilization of the raw material rather than 25% in the form of fillets.

One of the major considerations involving bottom fish is that the catching and shipboard handling or processing of the fish, particularly the most abundant species, pollock and hake, have considerably different requirements from the high-value species. The temperature of all bottom fish must be lowered immediately after capture in order to prevent excessive quality reduction due to bacterial and enzymatic action. Furthermore, depending on the area, hake and pollock must be headed, gutted, and frozen shortly after being caught or the flesh rapidly degrades to become unmarketable. The foreign fleets solve this problem by having large "mothership" processing vessels accompany the fishing vessels to the grounds. Catches can be transferred to the mothership soon after being caught and then processed in a manner to insure high quality. If the U. S. is going to exploit the bottom fish stocks, they must choose between supporting the expensive mothership concept or altering the concept of bottom fishing through modifications of vessel design, on-board facilities, and handling procedures. Research into methods for utilizing the large volume of deboned flesh from small fish or

TABLE 6. PROFIT FROM DIFFERENT UTILIZATION OF BOTTOMFISH CATCH

Catch Basis (lb)	Landed Cost (\$)	Product		Operating Cost			Sales		Operating Profit		
		Item	Wt (lb)	Raw Mat'l (\$)	Processing (\$)	Total (\$)	\$/lb	Total (\$)	\$/lb	Total (\$)	\$/catch
100	8.00	Fillet	25	8.00	3.75	11.75	.67	16.75	.20	5.00	5.00
		Waste	75								
100	8.00	Fillet	25	8.00	3.75	11.75	.67	16.75	.20	5.00	5.75
		Meal	15	----	.75	.75	.10	1.50	.05	.75	
200*	8.00	Fillet	25	8.00	3.75	11.75	.67	16.75	.20	5.00	6.75
		Meal	35	----	1.75	1.75	.10	3.50	.05	1.75	
100	8.00	Fillet	25	4.00	3.75	7.75	.67	16.75	.36	9.00	10.00
		Minced	25	4.00	2.50	6.50	.30	7.50	.04	1.00	
		Waste	50								
200*	8.00	Fillet	25	5.00	3.75	8.75	.67	16.75	.32	8.00	20.00
		Minced	75	3.00	7.50	10.50	.30	22.50	.16	12.00	
		Meal	20	----							

*Basis: Catch consisting of 100 lbs fish for fillets + 100 lbs too small to fillet.

fillet frames is nearing the point where large volumes of minced flesh will be in demand. Although this will essentially double the marketable portion of bottom fish, the perishable nature of the flesh (made more susceptible to degradation by the cell-rupturing deboning process) imposes further alterations to the normal preparation of the fish for final processing. Minced flesh must be formulated into final products shortly after being deboned due to its short frozen shelf-life. For this reason, a large portion of the blocks frozen at sea will consist of headed and gutted fish. The fish will be thawed, filleted and the minced flesh recovered at shore based plants that can also utilize the minced flesh for formulated products.

Shore based plants in Alaska are going to find it necessary either to prepare final formulated foods when fillets are prepared or to head and gut or fillet and mince the bottom fish and then freeze and ship the primary product. Since the utilization of minced flesh is in the form of formulated products (i.e. dried, kamoboko, batter-breaded and cooked, etc.) it is questionable whether Alaska processors should install the major processing and support facilities necessary for minced fish utilization. Hence, the raw materials for the majority of the Alaskan processing facilities will most likely be limited to nearshore trawling operations. The larger volumes of frozen-blocked fillets, minced flesh, or headed-gutted fish will be transhipped from the large catcher-processor or freezer vessels operating in extended high seas fishing to the "lower 48" for final processing and packaging.

Approximately one-half the halibut and over three-fourths of the black cod presently landed by the U. S. on the West Coast and Alaska is caught in the FCZ. Halibut will increase considerably due to the expiration of the agreement allowing Canadian fishermen to harvest one-half the Alaska halibut. Black cod will show a dramatic increase since there will be a considerable amount of this species in the trawl fishery as well as in an expanding pot and long line fishery.

PROCESSING REQUIREMENTS FOR FCZ FISHERIES

It is apparent from studying catch and potential stock data that any major expansion in the Northwest Pacific fishery is going to be concentrated in the bottom fish (groundfish), commonly considered the low-value species. As has been discussed, the catching, handling, and processing of bottom fish, particularly the most abundant species, have considerably different requirements from the high-value species. The temperature of all bottom fish must be lowered immediately after the fish are caught in order to prevent excessive quality reduction due to bacterial and enzymatic action. Furthermore, depending on the harvest area, these fish must be headed, gutted, and frozen shortly after being landed or they will continue to degrade at a rapid rate.

The nature of the FCZ fish and the distances from land at which many of the fish are caught creates a relationship between fishing vessels and shore based plants that is considerably different from the seasonal fisheries that have been the basis for the Alaskan and Washington industries. In the first place, the markets for bottom fish are such that the offshore fishery utilizing these raw materials must be developed prior to the construction of large shore-based plants.

The present discussions by a portion of the fishing industry and University and Government consultants concern whether off-season salmon and crabbing vessels can be utilized to fish for near-shore bottom fish. These vessels would be used to create a base for supplying shore-based plants with fresh fish for processing. Unfortunately, this procedure will not be the basis for a large new industry.

At the present time, the United States has a "zero base" production of fillets as compared to the volume of fillets being consumed in the country. In off-season vessels are used as the backbone of a "new" fillet industry the production of products will vary considerably throughout the year as these fishing fleets are entering and leaving the fishery. Furthermore, during years when seasonal fishermen have outstanding catches and income, they will not fish the more rigorous fishery. During these years there will be little, if any, fishing effort from seasonal fishing vessels. This practice is not compatible with the market for fillet fish. The large users of fillets, namely the fast food chains, supermarket chains, and some other institutional groups, operate year-round. The sales volume, cost of advertising, and many other factors related to a profitable consumer oriented business cannot tolerate an inconsistent or intermittent supply of product. The only solution to this problem that will allow the U. S. fishing industry to supply large volumes of fillets to the present buyers (who are purchasing more than 80% of their fish from foreign countries) is to have full time, year round fishing and processing operations. This is not compatible with extensive use of off-season fishing vessels.

If a large, continuous supply of fillet products is being produced by the United States, then the relatively small volume of products produced by off-season fishing could be absorbed into the market. Hence, the requirements for fishing fleets and shore-based processing operations must be considered in relationship to the nature of the raw materials and the markets for products, not the desire to create large processing plants. Furthermore, Alaska, where most of the FCZ expansion will take place, must be taken into consideration when looking at the future of Northwest Public Ports since much of the logistic and shipping support must come from the Northwest.

Shipboard Processing or Preprocessing

The nature of the fish and the distances from shore preclude taking large percentages of offshore caught fish to shore-based plants prior to some type of preliminary or final processing. Several different organizations of fishing efforts will most likely be used in FCZ fishing. The specific solution to the catching and rapid handling of delicate fish will depend on many factors such as location of the fishing grounds, type of vessels being converted to the new fishery, ability to finance new vessels designed for the specific operations, the specific mix of the species landed, the access to transshipping sites (particularly in remote areas of Alaska), cost of fuel and other controlling operating costs, and present and future environmental and regulatory restrictions. All of the following high seas operations will probably develop in response to various FCZ situations:

1. Mothership fleets whereby fishing vessels deliver to a central processing ship that periodically takes accumulated product to shore or transfers it to pick-up vessels. This procedure has been the necessary organization of foreign operations since they were operating so far from home base. The motherships are not only factory ships but supply the needed logistic support to the fishing vessels.
2. Mothership type of operations whereby the factory ship is a permanently moored barge to which the fishing vessels deliver the catch.
3. Catcher-processor vessels that both harvest and process the fish. The degree of processing will again depend on many factors but can vary from heading and gutting followed by freezing to complete filleting lines.
4. Fishing vessels that freeze fish in the round or hold in refrigerated brine or ice until shoreside delivery can be made.

The specific type of operation in Alaska is not important to the volume of product that will be handled by Northwest ports. The first three types will most likely result in transshipment directly to other ports. The fourth option will include both some FCZ product and the developing inshore products that will be processed in shore-based plants and then shipped to other areas.

An important consideration in planning of the processing facilities on shipboard is the market for which the fish are being prepared. Regardless of whether the final product is ready for use (fillets) or must be reprocessed (headed and gutted blocks), the volume of fish being handled in limited shipboard space determines that most of the output will be in the form of frozen blocks. This automatically predetermines that products processed on the high seas will be competing for the high volume, low cost markets where

fast food chains are buying blocked fillets or where reprocessors are thawing and processing the fish into products for retail and institutional markets. The current price for blocked fish, as determined by foreign competition, ranges from \$0.65 to \$1.00 per pound, depending on the species and form of product.

Shoreside Processing or Reprocessing

Once the United States is firmly entrenched in the FCZ fisheries, new inshore fillet plants can develop in both Alaska and the Northwest. The use of off-season fishing vessels, however, will have to be supplemented by a portion of the effort coming from trawlers that are operating on an all year basis. Again, this is necessary to stabilize the shipping of product to markets that require constant supply. The shore-based plants can be designed and equipped with facilities to produce finished fillets and by-products for the higher priced fresh and frozen items sold to retail outlets and restaurants.

The large volume of blocked fish from the FCZ and Alaska that will be delivered to market through Northwest ports and the landings from developing near shore operations offer outstanding potentials for development of processing plants in the Northwest. There are several opportunities, all of which will most likely be taken by industry. These include:

1. Thawing frozen blocks of fillets, followed by either packaging for retail or other markets, or by preparing finished items such as batter and breaded fillets.
2. Thawing frozen blocks of headed and gutted fish for subsequent filleting and reclaiming of the remaining flesh for formulated products. Although the minced flesh can be refrozen for other reprocessing companies, the best products and the most profitable operation is to have both a filleting line and a formulated product facility in the same plant.
3. Filleting fresh fish landed by the nearshore fishery followed by deboning and formulated product manufacture. Although this operation is similar to item 2 above, there is an additional market in the growing demand for fresh seafood items in the United States.

CONCLUSIONS

The key to the future of both waste management and expanded seafood sales is in "total utilization" of raw materials. In many instances the amount of presently discarded edible flesh is greater than the product marketed. The use of this portion will greatly reduce the disposable solids and create an economic base to allow recovery of remaining solids for products of commerce. The trend for the expanding FCZ fisheries is to discard some waste at sea

and land a preprocessed frozen block that requires minimal disposal facilities in the processing plant. The development of minced flesh formulated products (i.e. dried, batter-breaded, portion control, etc.) will be stimulated by the total utilization of low priced fish from the FCZ. This in turn will create markets for products from currently discarded portions of high priced fish. These developments and much of the accompanying research must be directed toward utilization of the entire raw material and designing logistic supports into the processes that give the processor an economic incentive rather than a regulatory compliance date.

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FISHERY WASTE MANAGEMENT IN THE GREAT LAKES

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INTRODUCTION

Prior to passage of environmental legislation in the mid 1960's and early 1970's, few people were aware of the effect pollution was having on the Great Lakes ecosystem. As a result of public hearings and debate on the subject, citizens of the Great Lakes basin were made aware of the Great Lakes resources and the role they play in the economy and quality of life in the region. The lakes and their water sheds had served as a source of water for heavy industry, electrical generating facilities, potable water for food processing and drinking, recreational opportunities, food fish production, a transportation network and were used as a sink for waste disposal. The indiscriminant use of Great Lakes waters changed with the realization that environmental quality, and in particular, Great Lakes water quality were declining. A majority of the people in the region viewed the promulgation of regulations as positive and needed steps to preserve these bodies of water for the future.

The regulations established to deal with environmental quality are similar from state to state. In general, the laws define what constitutes a potential pollutant and outlines the restrictions for handling and disposal of the material. The laws are specific in matters concerning the direct introduction of foreign or deleterious substances into the aquatic environment and do not allow for direct dumping of any material into the lakes.

The industrial and public sectors have expended large amounts of time and money installing and operating the waste treatment facilities needed to meet the established environmental guidelines. As a result of coordinated efforts by both sectors, new and innovative approaches to waste management and treatment have been adopted and

put into practice. Although the fishery considers itself as part of the industrial sector, it follows the point of view that fishery waste management is not an industry problem but a problem of the individual, and as such, must be handled by the individual as best he can. By adopting this attitude toward waste management, the fishing industry has left itself vulnerable to criticism in the future. A clean aquatic environment is necessary to insure the stability of the ecosystem and is in the industry's interest that it be maintained. It would seem more appropriate that the Great Lakes fishing industry take a more active role in looking to the problems associated with the wastes it generates.

Great Lakes Fishery Waste

The Great Lakes fishery is essentially a day fishery meaning a producer leaves port in the morning and is back in port the same day. A typical days' catch can range from 100 pounds to two thousand pounds plus of fish. The catch may be brought back in the round and dressed ashore or, to save time, dressed aboard the boat on the trip back to port. Once the product is ashore, it is usually shipped to the processor as soon as possible. After shipping, any waste produced is the responsibility of the person receiving the fish.

The quantity of waste generated by the Great Lakes fish producers and processors is small compared to that produced by the marine fishery. Pileggi (2) lists the 1975 total U.S. Great Lakes fish production at 60.6 million pounds. If the 1975 alewife production used for fish meal and animal feed were subtracted from the total, it would leave approximately 25.4 million pounds of human food fish produced for that year. The 1975 Wisconsin commercial food fish production for 1975 was given by Pileggi as 7.3 million pounds. Stuiber et al (3) had estimated that the waste generated by the Wisconsin commercial fishery in 1975 ranged from 2 to 3 million pounds. Using this range as a base for other commercial fisheries in the region a simple calculation gives a range for the total waste generated from U.S. Great Lakes food fish production in 1975 of from 7 to 10 million pounds. This amounts to a substantial quantity of waste which must be disposed of within the region.

Typical fishery waste have been analyzed for protein content and the results are presented in Table 1. Examination of the table shows that fishery waste materials are high in protein content. This type of waste spoils rapidly, produces offensive odors and requires special care when being stored or disposed.

Sample Description	% Nitrogen	% Moisture	% Solids	% Crude Protein
2-1 Viscera- Frame	2.17	63.1	36.9	13.6
1-2 Viscera- Frame	2.27	63.9	36.1	14.2
1-0 Viscera- Frame	1.98	62.7	37.3	12.4
80% Racks 20% Viscera Commercial Plant	1.37	61.7	38.3	8.5
Viscera Commercial Plant	2.00	71.6	28.4	12.5

Table 1. Crude Protein Content Of Fishery Waste

The type of waste generated aboard the boat would consist primarily of visceral material. If large fish such as lake trout are included in the catch, they would be gilled or headed and these items included in the waste. In addition to what can be considered as onboard processing waste, there may also be whole non-commercial fish species and fish of questionable value being discarded.

Wastes being generated in a shore based processing facility would be of a more complex nature than the wastes generated by a fish producer. The waste produced in a plant handling fresh and frozen fish would normally consist of scales, viscera, frames, and trimmings. In addition, these may also be included, smoked fish scrap, waste batter and breading and waste material produced from the handling and processing of other food products.

Great Lakes Fishery Waste Handling Practices

In a discussion of fishery waste management, Green and Mallick (1) state that "Important considerations limiting investment in fishery processing waste elimination, are the small size and seasonal nature of most seafood plants." Although the authors were describing the situation as it exists in the marine fishery area, the description more accurately describes the situation existing within the fresh water fishery. The present situation is such that the Great Lakes fishery does not have an established fishery waste management program nor is there any consideration being given to the development of one. The fact is

that methods employed to deal with Great Lakes fishery wastes vary from area to area and with the people involved in the fishery.

Fish producers from the Great Lakes region have long been accustomed to dumping shipboard wastes over the side. Since dumping is no longer allowed, waste disposal for some fishermen has become difficult. However, the law is also difficult to enforce and not all fishermen comply with it. It is common practice by a good number of fishermen, when well out from port, to slip the waste over the side. The ever present gulls make short work of any floating waste material while the more dense material sinks leaving no trace. In most cases these fishermen will bring back a container or two of waste as a hedge against the possibility of someone spot checking the boats upon their return. The amount of waste brought back is usually only a fraction of the original quantity generated and is readily disposed of by shore burial.

Those fishermen bringing all their shipboard generated waste back to port find the disposal of such waste to be costly in terms of both time and money. These fishermen have a narrow selection of methods from which to choose for disposal of the waste material. The method of choice, when available, is the dumping into the local landfill site. Local regulations dealing with the dumping of material such as fishery wastes and other highly perishable organic matter are usually restrictive and the waste has to be covered to control flies, stench and access to it by local wild and domestic animal life.

The management and supervision of dump sites requires the presents of personnel and equipment to facilitate the daily operation of the landfill site. In many of the smaller communities labor and equipment costs have been responsible for restricting type and quantities of waste allowed in the landfill as well as the hours which the site is operated. These practices have resulted in eliminating the public landfill disposal method as a viable option for many of the fishermen.

A less acceptable but available option is the use of privately owned and operated refuse collection and disposal facilities. This approach is used, but not extensively, since it involves an added cost factor in a fisherman's business operation and can result in the creation of a non-competitive situation for the individual in the marketplace.

A number of producers have the opportunity to use municipal sewage treatment facilities as a waste disposal

method. Pre-treatment of the waste involves grinding to reduce waste particle size. The resulting slurry is flushed down the drain with large amounts of water to eliminate the possibility of plugging the drain. It should be pointed out that not all sewage districts will allow this practice.

Great Lakes' fish processors experience similar problems and limitations associated with handling waste as do the producers. If one were to compare the degree of difficulty of the producer's problems to that of the processors, it would seem that the processors would have the more difficult task. In some ways the problems of the processor are more severe since the quantities of waste generated are larger. However, the larger volumes of waste open up several additional waste disposal alternatives.

Rendering and meat scrap processors are constantly looking for sources of high protein animal waste and will pick up fish scrap and process it. The key to being considered for this type of treatment is the quantity and quality of the waste. Fishery waste should be relatively fresh and show no sign of excessive lipid oxidation or putrefication. Most renderers see an advantage in using fishery scrap since it helps increase the protein content and quality of their meat and bone meal.

A few processors in the Great Lakes region have developed markets for their waste. These individuals freeze the waste material and market it to fur farmers. The practice is very limited and seems to be phasing out due primarily to chlorinated hydrocarbon microcontaminants associated with Great Lakes fish and a reduction in fur farming in the region.

Another waste handling alternative used by several processors involves converting fishery waste into liquid fish fertilizer. To date, the procedure has proved to be both a successful method for processing fish waste and economically beneficial to the individuals using it. Although this procedure is attractive and could be used by many persons in the industry it is not a suitable alternative for everyone. The process requires capital investment and takes additional time and effort to develop and maintain markets for the fertilizer product.

SUMMARY

It should be evident that no one particular waste handling method can be identified as "the method" used by members of the Great Lakes fishery to handle and treat fishery wastes. The waste handling practices employed

are selected on the basis of what method can be used and it's cost and not what method would be the most convenient to the user. This situation leaves much to be desired and has prompted some fishery personnel to request that the situation be investigated and methods developed which are flexiable, efficient and less costly. Until a larger segment of the fishery assumes this posture, the situation will remain static and could eventually harm the industry.

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SEAFOOD WASTE TREATMENT

OCEAN DUMPING OF SEAFOOD WASTES AS A WASTE MANAGEMENT ALTERNATIVE

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INTRODUCTION

Fish wastes, seafood wastes, fish parts, culls, or unedible species have been discarded into the sea or at sea since the time that man began to fish. The preservation of fish with salt and the processing of whales at sea enabled man to extend his fishing range and follow migrations of underutilized or nonutilized fishery resources. However, only the most marketable or profitable portion was preserved and transported to shore, the remainder discarded to the sea at the site of the catch. Shrimpers and trawlers have always culled their catches between trawls. The discarding of these wastes at sea has not been legally considered as ocean dumping because ocean dumping is defined as the transport of a waste to sea for the sole purpose of disposal.

HISTORICAL PERSPECTIVE

In the United States 224,000 tonnes (246,000 tons) of cannery wastes (from six East Bay fruit and vegetable canneries) were transported and dumped offshore from San Francisco between 1960 and 1972 at an annual rate of 20,000 tonnes (22,000 tons) per year. The disposal site was over a depth of about 80 meters (260 feet) at a location approximately 32 km (20 miles) offshore (34°35'N and 122°50'W). Ocean dumping of this waste was terminated in 1972 because of increasing costs associated with monitoring requirements (Reed, 1975). Fish wastes have been ocean dumped (transported to sea for disposal) in recent years in the Gulf of Mexico. Louisiana menhaden fishermen for many years have ocean dumped "bailwater," which is wash water, fish oil, and residue left over after the fish are pumped from storage holds. Originally, this waste was dumped in local bayous; however, the State of Louisiana, realizing the high oxygen demand of these wastes, required them

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to be dumped offshore 5.6 km (3.0 nautical miles). The dumping of these wastes offshore then created several false oil spill alerts for the U.S. Coast Guard because of the surface sheen from the fish oil.

The U.S. Environmental Protection Agency's (EPA) position that these fish wastes can be ocean dumped without a permit stems from the exclusion clause in EPA's rules relative to P.L. 92-532 that "fish wastes" do not require an EPA Ocean Dumping Permit (see the following section on Legislation/Regulation). EPA Region VI under the mandate of these rules and regulations did not require an ocean dumping permit for these menhaden wastes because there were no additives. But they used the discretionary judgment clause as to where the waste can be dumped with suggestions as to the minimum distance offshore or water depth for dumping. Another case on record was a request to EPA Region VI by a barge line that wanted to ocean dump a load of rancid fish meal because the company wanted to scrap the barge (Robert L. Vickery, personal communication).

In the Caribbean fish wastes are ocean dumped by Starkist 11.1 km (6.0 nautical miles) south of Ponce, Puerto Rico, under EPA (Region II) exclusion clause for fish wastes and with a Commonwealth Permit of the Environmental Quality Board of Puerto Rico. This waste contains only cooker juices and no additives (Peter W. Anderson, personal communication).

In Alaska, seafood wastes are discharged under EPA National Pollution Discharge Elimination System (NPDES) Permits through outfalls (pipe lines) from land based plants or over the sides of moored processing vessels. There are 139 individual NPDES Permits issued for these discharges. The disposal of these wastes has not required EPA ocean dumping permits because they were not transported to sea specifically for ocean disposal. Discharges permitted under NPDES Permits are a function of receiving water quality standards and are usually less stringent than those for ocean disposal (Maas and Champ, 1978).

The only seafood waste ocean dumped under an EPA Permit is reflected in the recent August 25, 1980, notice in the Federal Register by EPA Region 9 to grant a special Ocean Dumping Permit to Starkist Samoa and VanCamp Seafood in American Samoa to ocean dump 389,230 liters (101,200 gallons) per day of fish cannery wastes generated in American Samoa. These wastes contain 1) dissolved air flotation (DAF) cell sludge, 2) stickwater or cooker juice, and 3) press liquor. Because there was not an approved EPA ocean dumpsite for these waste materials, EPA designated an interim ocean dumping site, 1.8 km (1.0 nautical mile) in diameter with its center located at 14°22'S and 170°41'W, 5.4 km (2.9 nautical miles) offshore of Tutuila Island, American Samoa, in depths that exceed 1,200 meters (4,000 ft.). Following 24 months of permittee monitoring and studies and the completion of an Environmental Impact Statement (EIS), a determination will be made as to whether or not the site is suitable for permanent designation.

The waste contains stick water, or cooker juice, which is formed in the precooking process where live steam contacts the fish, and the resulting wastewater contains high concentrations of natural organic material from the fish. Press liquor results from the compaction of recovered fish waste solids in the fish meal process.

The interim permit was approved by EPA for five reasons: 1) the wastes had been ponded in two landfill sites which were subject to poor soil percolation and over 500 cm (200 inches) of rainfall annually with minimal evaporation and on two occasions had been the source of two unauthorized discharges of sludge into Larsen Bay when disposal pond dikes failed, 2) the ponded wastes had become sources of noxious odors and disease vectors, hazards to human safety, and potential sources of contamination of drinking water wells, 3) the addition of flocculating agents - alum (aluminum sulfate) and poly anionic polymers to the waste, 4) if these wastes were discharged at a rate of no greater than 2000 liters (500 gallons) per minute from a vessel moving at a rate of 5 knots, the resultant water quality in the mixing zone meets the water quality standard of at least 80 percent oxygen saturation in the water column subsequent to dumping at the dumpsite, and 5) bioassays found low toxicity with mortality due presumably to high oxygen demand and low pH, both of which would be sufficiently mitigated by a low discharge rate and dispersion of the waste (Christopher L. Vais, personal communication).

CHARACTERIZATION OF WASTE

Canned and preserved seafood wastes originate from eviscerating, cooking, pickling, preserving, and packaging. The waste is characteristically high in proteins, fats, dissolved and suspended organic materials, and odors (Anderson et al., 1979). Water quality parameters affected by ocean disposal of these wastes are biochemical oxygen demand (BOD), total dissolved solids, chemical oxygen demand, oil and grease, pH, and turbidity (Canadian EPS, 1975). Table 1 presents chemical analysis of the fish wastes to be ocean dumped off American Samoa.

Table 1. Chemical Analysis Data for Seafood Wastes to be Ocean Dumped off American Samoa (EPA Permit No. OD 79-01/02-Special).

Volume/composition

DAF sludge	195,700 liters/day
cooker juice	97,434 liters/day
press waster	90,052 liters/day

Characteristics

1. DAF sludge
 - pH - 5.8 to 6.2 standard units
 - bulk density - 0.773 to 1.017 g/ml
 - suspended solids - 9.6 to 21.4 percent wet wt.

volatile solids - 79.4 to 96.5 percent of
 suspended solids
 Total Organic Carbon (TOC) - 456 to 799 g/kg
 dry wt.
 Total Phosphorus - 739 to 1,031 mg/kg
 Total Kjeldahl Nitrogen - 587 to 769 mg/kg
 NO₃ and NO₂ - 0.77 to 1.24 mg/kg
 BOD₅ - 105,200 to 258,000 mg/l
 Protein - 1.48 to 4.72 percent wet wt.
 Fat - 5.80 to 6.50 percent wet wt.
 Methylene Blue Active Substance (MBAS) - 6.5
 to 13.4 mg/l
 Al - 711 to 10,400 mg/kg dry wt.
 Cd - 1.3 to 6.4 mg/kg dry wt.
 Hg - 0.011 to 0.050 mg/kg dry wt.
 DDT - N.D.
 DDE - N.D.

2. Cooker juice
 - Fat 1 percent volume
 - Moisture 93 percent volume
 - Solids 6 percent volume
3. Press water
 - Fat 12 percent volume
 - Moisture 76 percent volume
 - Solids 12 percent volume

LEGISLATION/REGULATION

Federal regulation of the dumping of materials into navigable waters first came into being in the U.S. with the passage of the Rivers and Harbor Act of 1899 (Section 10 of the Act: 30 Stat. 1151j 33 USC 403). In the early 1970s environmental legislation was enacted that created the necessary statutory framework for preserving and enhancing the air and water environments. In response to maintaining environmental awareness, Congress passed the National Environmental Policy Act of 1969 (NEPA-Public Law 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Public Law 94-52, July 3, 1975, and Public Law 94-83, August 9, 1975. This enactment set forth a clear statement of the U.S. national policy on environmental quality (Sec. 101) and created the Council on Environmental Quality (CEQ) (Sec. 202) within the Executive Office of the President. It also required a statement of environmental impact for every proposed Federal project and all proposed legislation significantly affecting the quality of the human environment (Sec. 102) and formal coordination (review process) between Federal agencies for major actions undertaken (Sec. 103, 104). The Council on Environmental Quality (1970) recommended a comprehensive national policy on ocean dumping of wastes to end unregulated ocean dumping and the prohibition of ocean disposal of any materials harmful to the marine environment.

On October 18, 1972, the U.S. Congress enacted Public Law 92-500 entitled "Federal Water Pollution Control Act Amendments of 1972." It is commonly called the "Clean Water Act." The objective of this Act was to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The statute, administered by EPA, set into effect a massive effort to clean up the nation's waters. Its central theme was a permit program calling for stringent control of all effluent discharges. Excerpts pertinent to the control of marine pollution from the Act include a water quality surveillance system for monitoring the quality of and promulgation of ocean disposal criteria and issuance of a permit for lawful ocean disposal when in compliance with such guidelines (Sec. 402, 403). Critical aspects of Section 403 are:

"(a) No permit under Section 402 of this Act for a discharge into the territorial sea, the waters of the contiguous zone, or the oceans shall be issued, after promulgation of guidelines established under (c) of this Section, except in compliance with such guidelines. Prior to the promulgation of such guidelines, a permit may be issued under Section 402 if the Administrator determines it to be in the public interest.

"(b) The requirements of subsection (d) of Section 402 of this Act may not be waived in the case of permits for discharges into the territorial sea.

"(c) (1) The Administrator shall, within one hundred and eighty days after enactment of this Act (and from time to time thereafter) promulgate guidelines for determining the degradation of the waters of the territorial seas, the contiguous zone, and the oceans, which shall include:

"(A) the effect of disposal of pollutants on human health or welfare, including but not limited to plankton, fish, shellfish, wildlife, shorelines, and beaches;

"(B) the effect of disposal of pollutants on marine life including the transfer, concentration, and dispersal of pollutants or their byproducts through biological, physical, and chemical processes; changes in marine ecosystem diversity, productivity, and stability; and species and community population changes;

"(C) the effect of disposal of pollutants on esthetic, recreation, and economic values;

"(D) the persistence and permanence of the effects of disposal of pollutants;

"(E) the effect of the disposal at varying rates of particular volumes and concentrations of pollutants;

"(F) other possible locations and methods of disposal or recycling of pollutants including land-based alternatives; and

"(G) the effect on alternate uses of the oceans, such as mineral exploitation and scientific study.

"(c) (2) In any event, where insufficient information exists on any proposed discharge to make a reasonable judgment on any of the guidelines established pursuant to this subsection, no permit shall be issued under Section 402 of this Act."

The primary legislation for ocean dumping was the enactment by Congress of P.L. 92-532, entitled "Marine Protection, Research, and Sanctuaries Act of 1972." It is commonly called the "Ocean Dumping Act." The Congress declared that it is the policy of the United States to regulate the dumping of all types of material into ocean waters which would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities.

To implement the U.S. policy, the Act regulates the transportation of material from the United States for dumping into ocean waters, and the dumping of material transported from outside the United States, if the dumping occurs in ocean waters which the United States has jurisdiction or over which it may exercise control, under accepted principles of international law, in order to protect its territory or territorial sea.

The Act prohibits the dumping of high-level radioactive wastes and all biological, chemical, and radiological warfare agents into the ocean. The dumping of other wastes (except dredged spoils regulated by the U.S. Army Corps of Engineers) is strictly regulated by the U.S. Environmental Protection Agency.

Title II of the Ocean Dumping Act is called "Comprehensive Research on Ocean Dumping." It reads as follows:

Sec. 201. The Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the (EPA) Administrator, shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters where the tide ebbs and flows or into the Great Lakes or their connecting waters and shall report from time to time, not less frequently than annually, his findings (including an evaluation of the short-term ecological effects and the social and economic factors involved) to the Congress.

Sec. 202. (a) The Secretary of Commerce, in consultation with other appropriate Federal departments, agencies, and instrumentalities, shall, within six months of the enactment of this Act,

initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, overfishing, and man-induced changes of ocean ecosystems. In carrying out such research, the Secretary of Commerce shall take into account such factors as existing and proposed international policies affecting oceanic problems, economic considerations involved in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind.

To implement the Section 201 mandate, National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce established the Ocean Dumping Program on October 1, 1976.

On January 11, 1977, the U.S. EPA issued "Ocean Dumping: Final Revision of Regulations and Criteria." The EPA rules and regulations describe in detail, considering the state-of-the-art of the oceanographic and technological knowledge, the operational procedures to be followed when an ocean dumping permit is sought.

Of major importance to the seafood industry is Sec. 220.1 (c) which excludes "fish wastes" as requiring a permit for its dumping at sea with EPA discretion as to where dumping will be prohibited (harbors, etc.). See below:

(c) Exclusions. (1) Fish wastes. This Subchapter H does not apply to, and no permit hereunder shall be required for, the transportation for the purpose of dumping or the dumping in ocean waters of fish wastes unless such dumping occurs in:

(i) Harbors or other protected or enclosed coastal waters; or

(ii) Any other location where the Administrator finds that such dumping may reasonably be anticipated to endanger health, the environment, or ecological systems.

Of specific scientific interest to the seafood industry is the specific criteria for dumpsite selection. The factors considered include:

1. Geographic location;
2. Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile;
3. Location in relation to amenity areas such as swimming beaches;
4. Types, quantities, packing, method of release of wastes;

5. Feasibility of surveillance and monitoring;
6. Diffusion, dispersion, mixing;
7. Previous dumping effects including cumulative effects;
8. Interference with shipping, fishing, recreation, mineral extraction, desalination, aquaculture, areas of specific scientific importance, and other legitimate use of the ocean;
9. Water quality and ecology of the site;
10. Potentiality for the development or recruitment of nuisance species at the site;
11. Cultural or historical site.

On May 8, 1978, the U.S. National Ocean Pollution Planning Act, P.L. 95-273, was enacted by the U.S. Congress. The purposes of the Act are as follows:

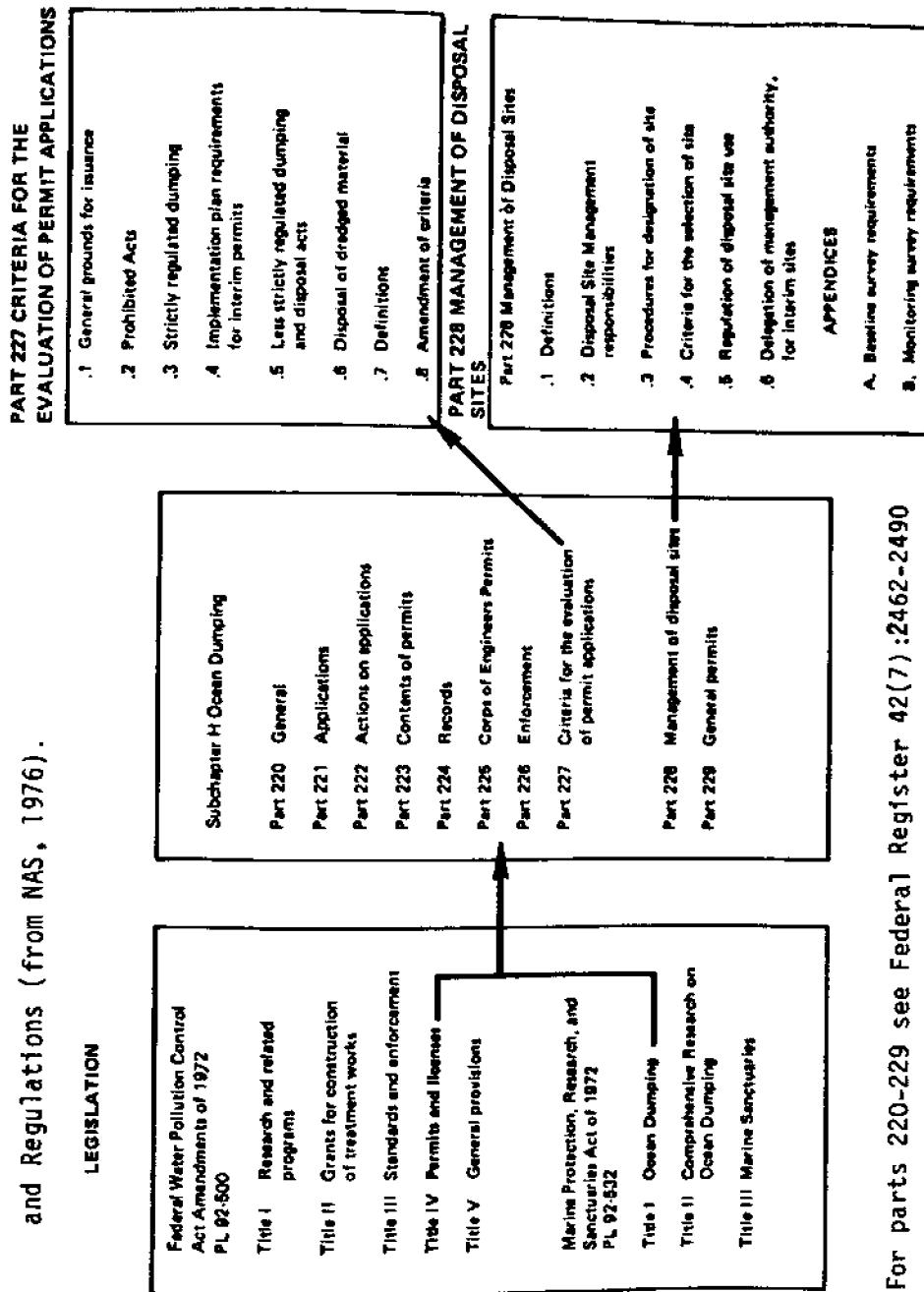
1. To establish a comprehensive 5-year Plan for Federal ocean pollution research and development and monitoring programs.
2. To develop the necessary base of information to support, and to provide for, the rational, efficient, and equitable utilization, conservation, and development of ocean and coastal resources.
3. To designate NOAA as the lead Federal agency for preparing the comprehensive 5-year Plan and to require NOAA to carry out a comprehensive program of ocean pollution, research and development, and monitoring under the plan.

PERMIT PROCESS

A good summary and review of the EPA ocean dumping permit process with an outline of the format for requested information is given in Hann et al. (1976) for ocean dumping in the Gulf of Mexico. Figure 1 presents a schematic conception of how the legislation and regulation processes interface for the evaluation of ocean dumping permits and the management of disposal sites. Figure 2 follows with a generalized flow diagram of the EPA permit decision making process from the receipt of an application to the issuance or denial of a permit.

There are five different types of ocean dumping permits: General, Special, Emergency, Interim, and Research. EPA granted a Special Permit for the fish wastes at American Samoa. Special permits are

Figure 1. Ocean Disposal Legislation



For parts 220-229 see Federal Register 42(7):2462-2490

Which replaces 38(198):28610-28621.

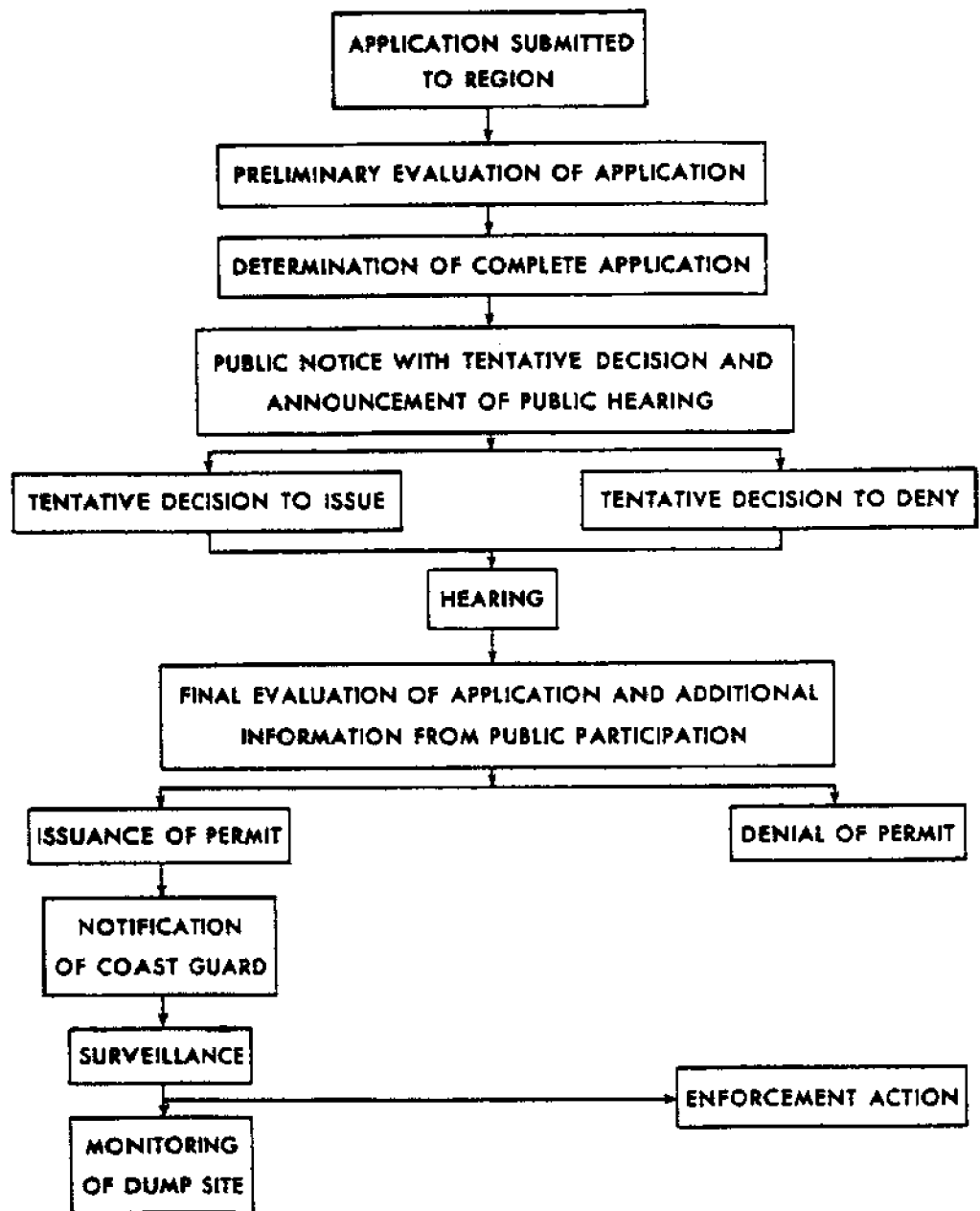


Figure 2. Generalized Flow Diagram of the EPA Ocean Dumping Permit Decision Making Process (Modified from Hann et al., 1976).

issued for waste disposal of materials which could not be considered under a general permit (burial at sea, target ships with no renewal) but do meet the ocean dumping criteria. Unpolluted dredge spoils are usually cited as an example. Special permits have a fixed expiration date (3-year maximum) and specify the exact quantities and location of the dumpsite and may be renewed.

We would like to emphasize that no EPA permit is required for returning fish parts to the sea. However, a permit has been required if the waste includes process water that contains additives as in the case of American Samoa fish cannery waste.

OCEAN DUMPING COSTS

Projections of economic costs associated with actual dumping depend upon 1) ownership or leasing costs for barge and tug and 2) round trip distance from barge loading facility to dumpsite. There are no readily available actual cost, annual costs, or general estimates for barging fish wastes. Therefore, an extrapolation must be made using existing costs for sewage sludge or dredged material with fixed distances. The most recent estimate for sewage sludge to the 20 km (11 nautical mile) New York Bight sewage sludge dumpsite is \$1.37 per wet tonne (\$1.25 per wet ton), (EPA, 1978). If sewage sludge from New York were barged to the 106-mile site, 210 km offshore the costs are estimated at six to eight times higher. In 1977 NL Industries estimated its ocean dumping costs for acid wastes at \$2,900 per trip (with 640 trips) to the adjacent acid waste dumpsite in the New York Bight. Allied Chemical has estimated its costs at five times NL Industries cost, with \$14,167 per trip with 12 trips, in the same period. These costs include tugs, fuel, maintenance, and associated shore facilities. These costs do not include costs associated with permit analytical requirements, reporting, and alternative studies required by current permit conditions such as site monitoring and bioassay costs. Monitoring surveys by both companies have been estimated at \$17,000 each (EPA, 1979).

SUMMARY

Fish wastes, as defined for ocean dumping, are the returning to the sea any unadulterated (without additive) seafood wastes. The returning to the sea of heads, tails, viscera, blood, scales, and washwater associated with fish processing has not required an EPA ocean dumping permit because arguments in favor of this option center around the fact that it returns nutrients to the sea for the further support of marine life and that the process recycles products from the sea in a manner similar to the natural process of death and decay. The argument for processing wastes to be considered similarly has some validity, particularly cooker juices or press liquor because the denaturation of proteins is similar to short-term high heat or longer term dehydration. The interpretation that sludges, which have chemical additives for enhancement

of flocculation, should require an EPA ocean dumping permit and be disposed of in a regulated manner, provides the degree of protection to the marine environment that Federal legislation requires of all industrial wastes. EPA's philosophy is that ocean dumping is not the preferred alternative method of waste disposal just because convenience or economical (may be cheaper than new plant construction) or social benefits (unpleasant odors associated with ponding, etc.) are gained. Ocean dumping is the last resort alternative. The dumping of these wastes into the ocean has only limited recycling value as compared to the use of fish wastes in the U.S. for pet food and in many foreign countries for fish meal for human consumption.

Fish processing plants located on islands in the tropics have limited land available for land treatment, high rainfall, poor soil percolation, a limited pet food market (high costs of shipment and small local pet population) and a low consumer preference for fish meal (because of high availability of local fishery resources).

The impacts from ocean disposal of "fish wastes" can be: 1) high oxygen demand on receiving waters, 2) visible surface slick, 3) turbidity plume, 4) organic enrichment, and 5) the attractant of undesirable predator species (i.e., sharks). The oxygen demand of ocean dumped fish wastes will present a unique research opportunity to assess the natural oxygen regeneration process. Especially in the tropics where warmer water temperatures (with lower oxygen saturation levels), higher metabolic rates, and less dense phytoplankton populations yield greater oxygen depletion risks and resultant bioturbations. Studies of the decomposition process of these fish wastes in the deep ocean will yield a great insight into the assimilative capacity of the ocean for naturally occurring compounds.

In Canada observations made by scuba divers indicated that the fish species most commonly associated with processing plants in coastal waters were flatfish, cunners, tom cods, sculpins, and wolfish. Also, large schools of herring or mackerel were observed to have feeding forays into the effluent for periods of time (Canadian EPS, 1975). It will be difficult to predict or detect the effect of ocean disposal in deep waters. The attraction and possible retention of large numbers of sharks in a given area should be expected. The turbidity plume or eutrophication caused by nutrient enrichment can be very deleterious to coral reefs. However, these impacts, except for the sharks, can be reduced by 1) the selection of a dumpsite, 2) determining the loading-assimilative capacity of the dumpsite ecosystem, and 3) determination of proper discharge rate. Monitoring programs are necessary for the detection and early warning that an alteration of the ecosystem is occurring in time to prevent irreversible deterioration.

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REMOVAL OF SUSPENDED SOLIDS FROM SEAFOOD PROCESSING WASTEWATERS

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INTRODUCTION

There are at least four reasons why suspended solids should be removed from wastewater being discharged by seafood processors. First, discharge of fish processing wastes into harbors and estuarine areas has caused significant pollution problems. In Alaska, waste products from canneries created unpleasant conditions in Kodiak Harbor in the early 1970's (Buck, 1975). Since then, the situation has markedly improved with the installation of screens. Second, by-product recovery can help feed the hungry of the world. For example, over 70% of the Alaskan king crab catch is discarded (Jensen, 1965). While thirty percent of the world's seafood catch is now converted into fish meal (Idyll, 1978), much more could be recovered. Third, there are many other uses for recovered by-products such as chitin (Sea Grant, 1977). These include contaminants from water. Fourth, solids removal is one step toward making water reuse possible. The latter is desirable to minimize intake water required per given amount of product. Even Alaskan processors could benefit from reducing their intake water requirements because of periodic localized water shortages. In Kodiak, for example, the canneries were shut down for an extended period during the winter of 1971 because of a low water supply (Collins, 1977).

The recovery of suspended solids is important for Alaska because Alaska's contribution to the national seafood industry is very significant. In 1972, 86% of all the salmon harvested in the United States were caught in Alaska and processed in 43 plants there. All of the king crab and much of the scallop harvest originates in Alaska. In addition, Alaska accounted for 69% of the West Coast halibut harvest in 1969 (U. S. E. P. A., 1975).

We therefore initiated a project in 1977 relating to suspended solids removal from seafood processing wastewater streams. One particular device for removing suspended solids, the hydrocyclone, has been emphasized in this study. As shown in Figure 1, the hydrocyclone utilizes pressure forces to cause rotation of a fluid and hence create centrifugal forces. These forces separate particles with specific gravities greater than the carrier fluid. The suspended solids (S. S.) migrate outward toward the conical wall

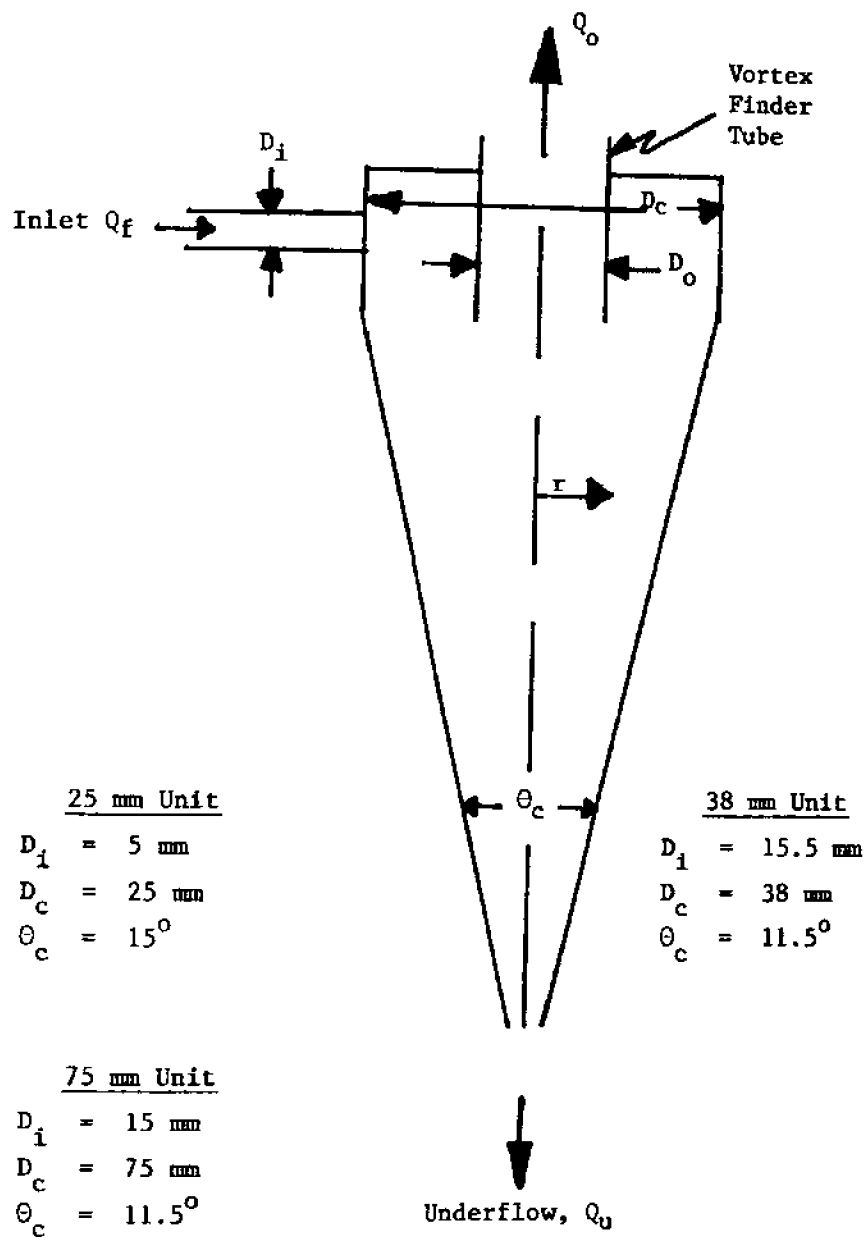


FIGURE 1. CYCLONE GEOMETRIES FOR 25, 38, AND 75 mm CYCLONES

wall of the cyclone and are removed in the underflow stream. The clarified liquid leaves via the overflow. Cyclones have been widely used by various industries including mining, pulp and paper, chemical, and food (Bradley, 1965).

LABORATORY RESULTS

A laboratory test loop capable of processing flows up to 2.5 l/s (40 gpm) is shown in Figure 2. This loop consists of a 2.5 horsepower jet pump, cyclone, pressure gauges, and calibrated collection tanks for the feed, overflow, and underflow. The three different cyclones tested in this loop were a 25 mm (1 in.) Doxie and 75 mm (3 in.) NZ from Dorr-Oliver and a 38 mm (1.5 in.) device manufactured by Krebbs. Initial tests were performed using a simulated wastewater obtained by adding fragments from king crab claws to water (Figure 3). These fragments ranged in size from about 50 to 750 μ . The mass-averaged shell size, d_m , was about 180 μ .

$$d_m^2 = \frac{\sum N_i d_i^2}{\sum N_i} \quad (1)$$

Here, N_i is the number of fragments of size, d_i . And d_i is a geometric mean size of the flat surface of the platelet-shaped shell. The platelet thicknesses are assumed to be a uniform 20 μ . Hence, d_m is a mass-weighted characteristic size.

Test results (Table 1) indicate high removal of S. S. Here, the intrinsic separation efficiency

$$\epsilon^1 \equiv \frac{\epsilon - R_f}{1 - R_f} \quad (2)$$

where ϵ is the mass of shells in the underflow divided by the mass in the feed, and R_f (Figure 1) is the underflow to feed flow split. The intrinsic separation efficiency is a measure of the ability of a cyclone to separate over and above that attributable to hydrodynamic entrainment alone. The concentration factor, CF, is the ratio of solids concentration in the underflow to that in the feed. The larger it is, the less energy has to be devoted to transporting the underflow, which contains the solids, to a by-product processing plant. For these laboratory results, S. S. are those particles retained by Whatman number 40 filter paper.

The next series of tests were conducted using wastewater obtained from a shrimp processing plant in Kodiak. As shown on Figure 4, the particulate matter in this wastewater consisted of both fleshy and chitinous matter having a wide range of shapes and sizes. To avoid clogging the inlet orifice of the 25 mm Doxie, hydrocyclone tests were performed only after matter larger than 4000 microns had been removed by screening. The particulates retained on the screen were then added to water and processed by a

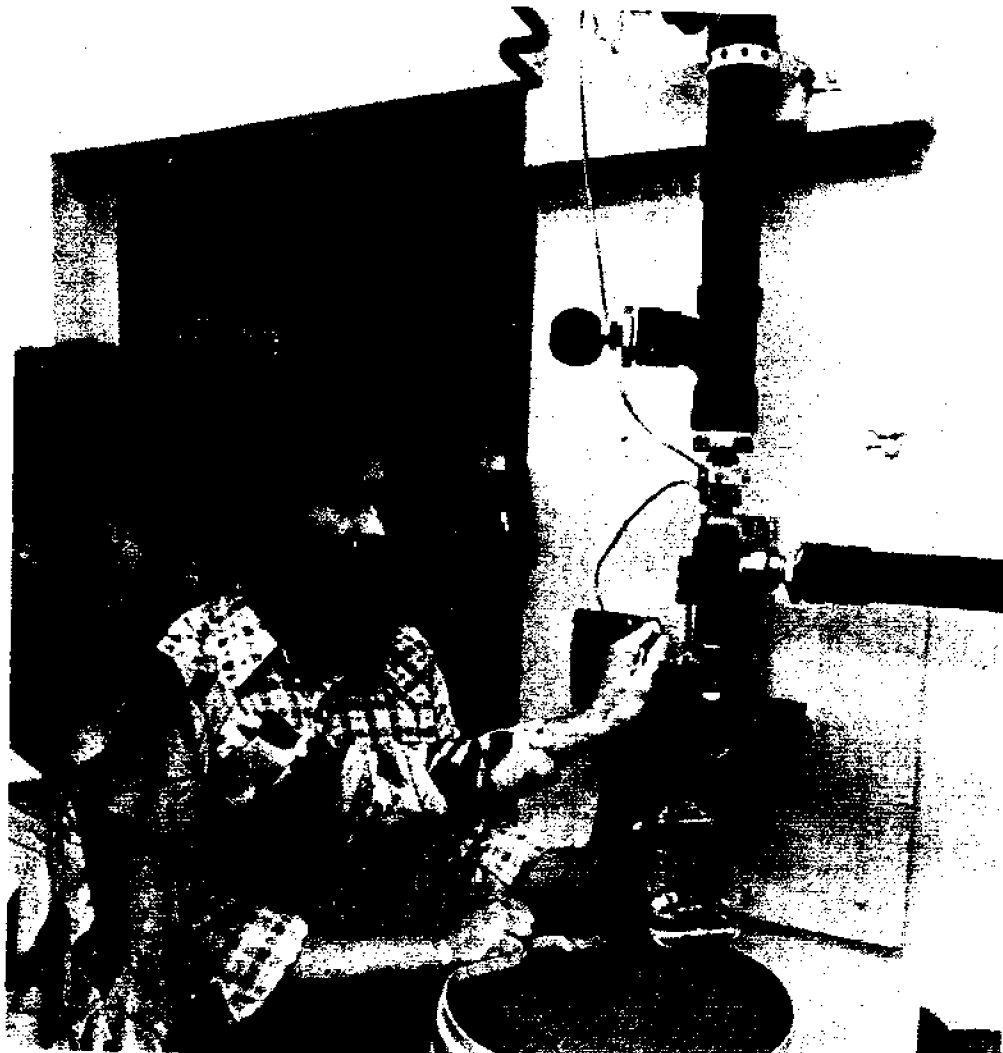


FIGURE 2. LABORATORY TEST LOOP

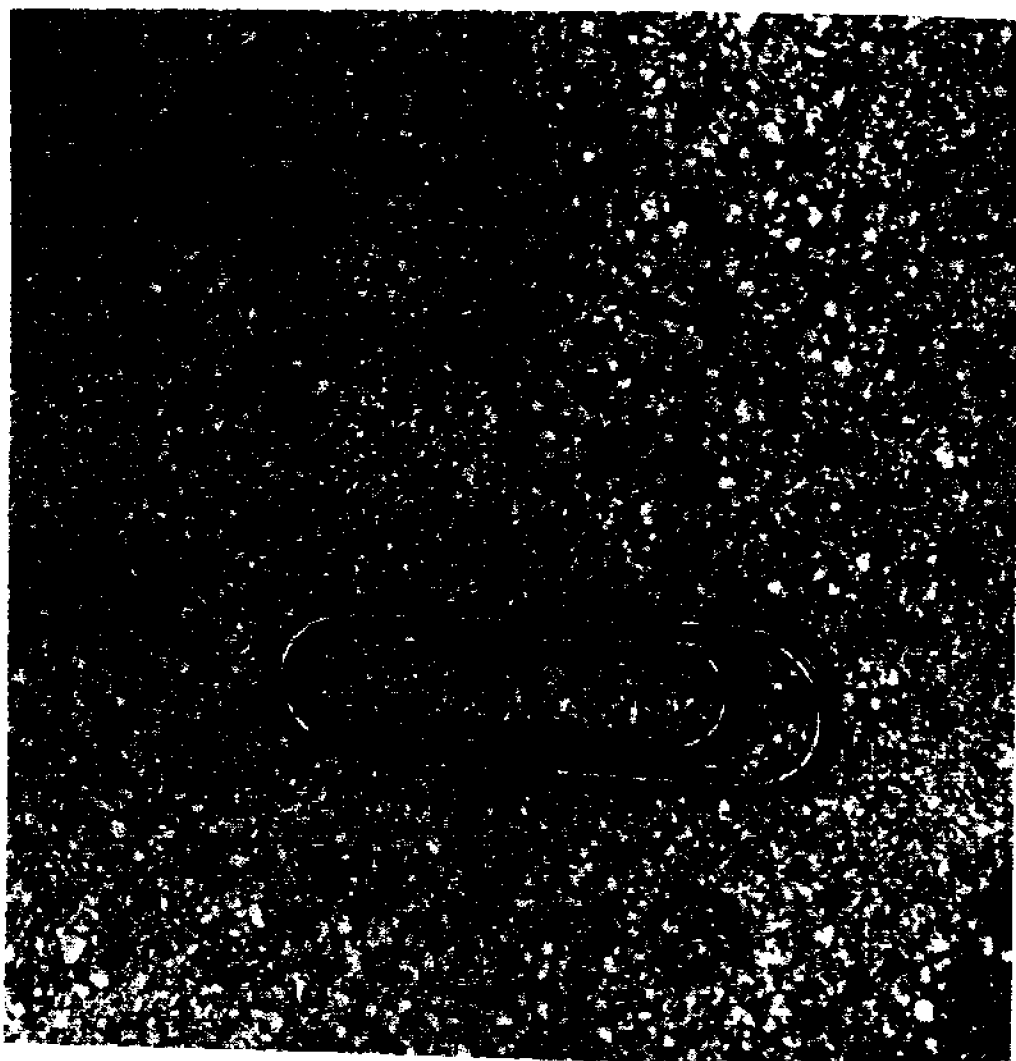


FIGURE 3. KING CRAB FRAGMENTS

TABLE 1. DATA SUMMARY

<u>Laboratory Results</u>		Cyclone size, D _c , mm	Efficiency ε, %	Concentration Factor, CF	Settleable solids rmvl, %	Turbidity rmvl, %	Feed concen., mg/l	Characteristics particle size d _m , μ
<u>Feed Material</u> no. of runs								
<u>King crab shell</u> 4		25	95	5			75	180
<u>King crab shell</u> 2		38	92	7			89	180
<u>Shrimp waste</u> 2		25	81	4	97	62	686	445
<u>Shrimp waste</u> 1		75	85	4	66	64	555	445
<u>Salmon waste</u> 3		25	84	4	83	81	1500	
<u>Salmon waste</u> 1		75	57	2	60	38		

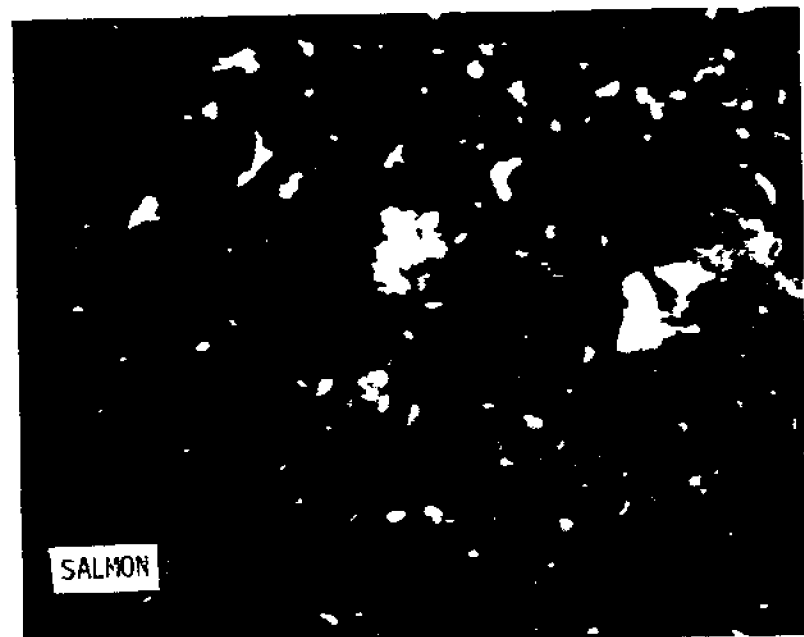


FIGURE 4. PHOTOMICROGRAPHS OF SHRIMP AND SALMON FEED.

3-inch NZ cyclone from Dorr-Oliver. For the three runs involving these two cyclones, the intrinsic separation efficiency, ϵ^1 , averaged 82%. The average turbidity and settleable solids reductions were 62% and 87%, respectively.

Tests on wastewater from red salmon processing produced similar results with ϵ^1 averaging 83% for the 25 mm Doxie cyclone at the natural flow split, R_f of 0.30. This wastewater did not have to be prescreened because the largest particles were less than 1,500 microns. The efficiency decreased when either R_f was substantially reduced, the 75 mm cyclone was used, or the larger particles were removed prior to a run. Both the shrimp and salmon wastes were frozen before shipment to the laboratory. The wastewaters were created by thawing the samples and adding water until the desired solids concentrations were obtained.

DISCUSSION

This study has demonstrated that cyclones are capable of efficiently separating shell fragments smaller than 100 μ in size from water. This should be contrasted with 40- mesh screens now required as solids-removal devices for most U. S. seafood processors. These will typically only remove solids down to 400 μ in size. Since considerable amounts of chitin and protein may be found in shell fragments smaller than 400 μ , a cyclone would allow recovery of more by-products than a standard screen. In fact, Chaney (1979) reports that 60% of the S. S. from one shrimp processing plant were particles less than 400 μ in size.

To understand the laboratory results in greater detail, we used particle size distribution data obtained from photomicrographs plus available cyclone efficiency correlations (Bradley, 1965; Johnson, 1976) to analyze the data.

$$d_{50} = 3\gamma D_1^2 \left[\frac{\nu(1-R_f)\tan \frac{\theta}{2}}{D_c Q_f (\rho_s - 1)} \right]^{1/2} \quad (3)$$

Where d_{50} is the diameter of a particle such that $\epsilon^1 = .50$. Bradley and Pulling (1959) found γ is an empirically determined constant depending on viscous losses, ν is the kinematic viscosity, and ρ_s is the specific gravity of the solids. The other geometric quantities are defined in Figure 1.

To complement equation 3, a relationship is needed for the intrinsic efficiency. By curve fitting data presented in Bradley (1965), one finds that

$$\epsilon^1 = 1 - \exp \left[- \left(\frac{d}{d_{50}} - .255 \right)^{5/4} \right] \quad (4)$$

for a particle of diameter d .

Equations 3 and 4 can be combined with the particle size distribution in the feed to predict the overall intrinsic efficiency. If $f(x)dx$ is the fraction of particles having diameters between x and $x+dx$, the overall intrinsic efficiency is

$$\epsilon^1 = \frac{\int_0^{d_1} x^3 f(x) \epsilon^1(x/d_{50}) dx}{\int_0^{d_1} x^3 f(x) dx} \quad (5)$$

Here, d_1 is the diameter of the largest particle in the feed. For a more complete discussion of the theory, see Johnson (1976).

To the authors' knowledge, these equations have not been used to analyze data involving the separation of seafood S. S. from water. The constant, γ , has been found to vary between about 0.4 and 1.4 for a variety of other particles. We have used the data on crab and salmon wastes to infer values of γ for these two materials. A computer program was written to enable us to calculate a theoretical ϵ^1 for a given d_{50} and particle size distribution in the feed. This involved using equations 3 through 5, plus knowledge of the particle size distribution and specific gravities in the feed. The program was run several times for different values of d_{50} until the calculated efficiency equalled the measured value. Then γ , as calculated from eq 3, was found to equal 0.4 and 3, for king crab shells and salmon waste materials respectively. The results for the shrimp are inconclusive because of insufficient particle size distribution data. This indicates that existing solid-liquid separation correlations can be used to predict cyclone performances for seafood processing, providing appropriate values for γ are used. Of course, we have only verified this correlation for one size cyclone. While more work remains to be done to extend these correlations to larger sizes, the cyclones value reported here could be used as a first approximation for anyone designing a solids-separation system employing cyclones.

The specific gravities, ρ_s , of the various particles were determined by weighing and volumetric displacements of water. The values were 1.580, 1.025, and 1.010 for the crab shell fragments, shrimp, and salmon respectively.

PILOT PLANT RESULTS

A pilot plant was constructed in January, 1980, at a seafood processor in Kodiak, Alaska. The system consisted of a 1,000-gallon collection tank, a 15-horsepower centrifugal pump, three cyclones, and the associated plumbing (Figure 5). The concentrate is processed by a 75 mm type NZ cyclone plus a 25 mm Doxie cyclone, while the overflow passes through two 75 mm cyclones. The recycled flow consists of the overflow from the 25 mm unit plus the underflow from the second 75 mm unit. All three cyclones were made by Dorr-Oliver. The typical flow splits, R_f , were 0.07, 0.34, and 0.39 for cyclones one, two, and three, respectively. Standard operating conditions consisted of 2.5 l/s (44 gpm) leaving the collection tank comprised of 1.3 l/s (24 gpm) entering from the processor's wastewater line plus 1.2 l/s (20 gpm) of recycled wastewater. The concentrate and final overflow averaged 0.063 l/s (1 gpm) and 1.3 l/s (23 gpm) respectively. These splits were achieved by using a 2.54 cm (1-in.) vortex and .63 cm (.25 in.) apex on the 75 mm cyclone closest to the feed and a 1.52 cm (.626 in.) vortex and 1.27 cm (.50 in.) apex on the second 75 mm cyclone.

Results to date indicate the S. S. from tanner crab, salmon, and shrimp wastewaters are being efficiently removed by this pilot plant. Efficiencies comparable to those attained in the laboratory loop have been obtained for the shrimp and salmon on material collected from a 0.03 inch Baker hydrasieve. The pilot plant removed two-thirds of the solids passing through the hydrasieve for tanner crab wastewater. Although CF's up to a factor of 30 were achieved, the underflow was still too moist to be acceptable by a by-product recovery plant. The final data reduction on all these results is now being completed. The economic implications of this technology are also being addressed. Preliminary calculations indicate the O and M costs for cyclones of around 5¢/1000 gals. are only a small fraction of a processor's operating costs.

CONCLUSIONS

1. Hydrocyclones can efficiently remove particulate matter from seafood processing wastewaters.
2. The costs of operating and maintaining the cyclones are orders of magnitude less than the operating costs for the processor.
3. For Tanner crab processing, 3 inch cyclones served as excellent polishing devices for the effluent from a Bauer hydrasieve.
4. Although the cyclone overflow might be sufficiently clean for discharge into receiving waters, the underflow may have to undergo additional concentration before it can be usable by a by-product recovery operation.

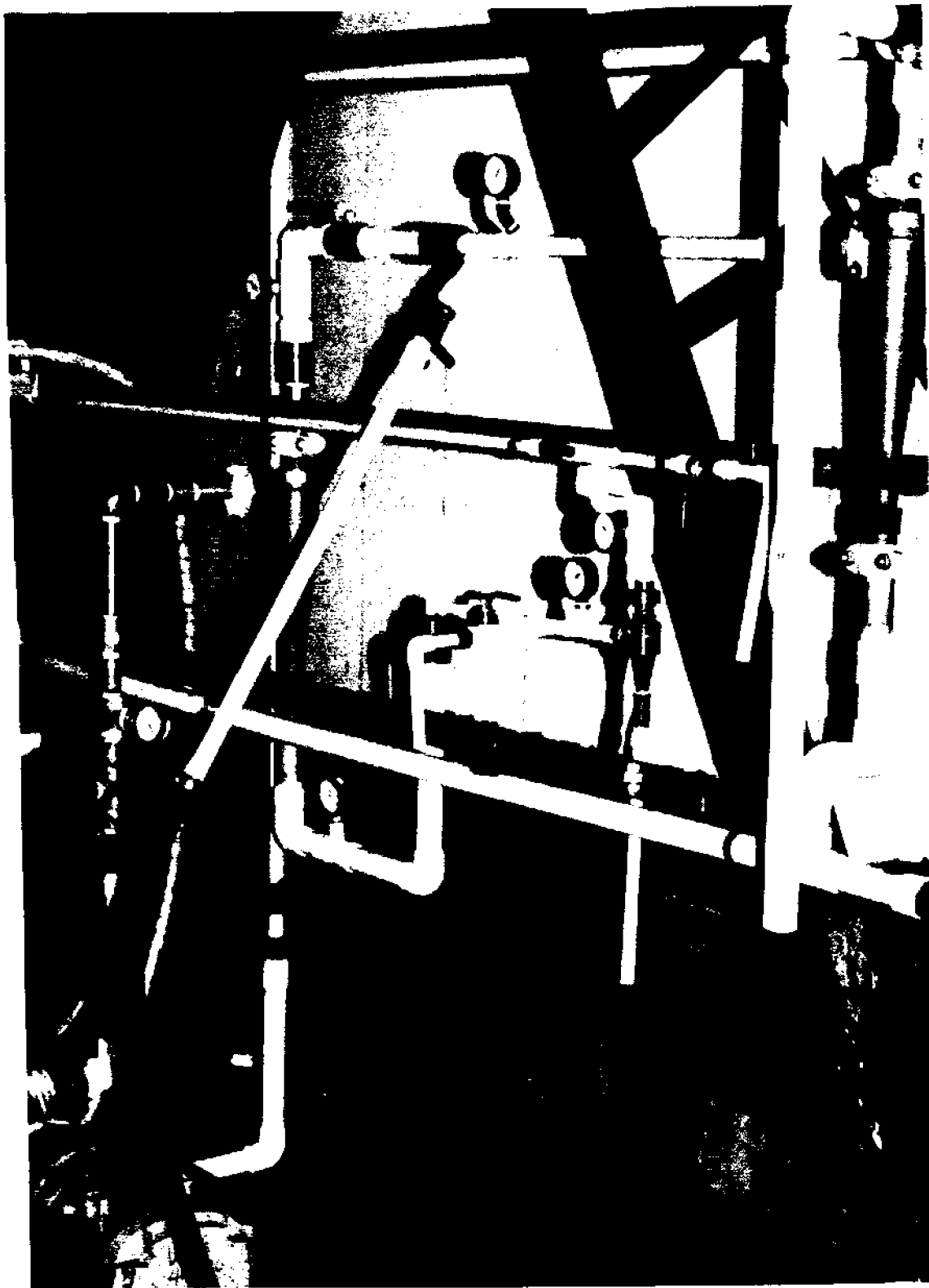


FIGURE 5. PILOT PLANT

ACKNOWLEDGEMENTS

This work is the result of research sponsored by the Alaska Sea Grant Program, cooperatively supported by NOAA National Sea Grant Program, Department of Commerce, under grant number NA79AA-D-00138 and by the University of Alaska with funds appropriated by the State of Alaska.

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LAGOONS AS A TREATMENT FOR SEAFOOD WASTES

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Lagoon systems are one of the more widely used waste treatment processes. The advantages of this system is its being relatively maintenance free and able to handle moderate shock loads, hydraulically and organically without loss of waste removal performance. Lagoon systems are commonly found in rural areas where land is available and the local population is low. Generally, lagoon systems are utilized either as an aerobic lagoon, a facultative lagoon, or an anaerobic lagoon.

Aerobic lagoons are used primarily for the treatment of soluble organic wastes and effluents from wastewater treatment plants. The facultative lagoon or aerobic-anaerobic lagoons are the most commonly used type and have been applied to the treatment of domestic wastewater and a wide variety of industrial wastes. Anaerobic ponds are especially effective in bringing about the rapid stabilization of strong organic wastes.

Aerobic Lagoons

Aerobic lagoons are generally subdivided into two groups:

1. Shallow lagoons, with depths ranging from 2.5 feet to 4.0 feet. A stabilization lagoon is a relatively shallow body of water contained in an earthen basin of controlled shape, which is designed for the purpose of treating wastewater.
2. Deep lagoons, 7 to 10 feet deep, with aeration devices included to ensure maintenance of aerobic conditions.

An alternative to the shallow lagoon is the deep, aerated lagoon. These deeper lagoons can operate at greater surface organic loadings than shallow lagoons and yet maintain higher organic removals.

Stabilization Lagoons

The design of this lagoon requires that the depth of the water be no less than 2.5 feet and no more than 5 feet. The lagoon may be operated in series or parallel. If the lagoon system is located in an area where soils may allow percolation and subsequent contamination of ground water, the retention basin must be sealed with bentonite clay or a plastic liner on the bottom and sides of the pond to prevent seepage into the soil.

These lagoons are designed to take advantage of the effect of sunlight, algae, and oxygen to improve the quality of the wastewater. Algae uses carbon dioxide resulting from the decomposition of organic matter, and it releases oxygen. Aerobic bacteria are multiplied extensively by this oxygen release; they digest the organic waste. The sunlight penetration provides for the life and growth of algae. The light penetration to the lagoons may reach a depth of three feet, which helps in this process of stabilization. When lagoons are properly controlled and used in conjunction with other treatment processes, they become very effective.

The term "oxidation pond," often used, is synonymous with stabilization lagoons. Stabilization lagoons have become very popular because their low construction and operating costs offer a significant financial advantage over other recognized treatment methods. Lagoons of this type are now serving such industries as slaughterhouses, dairies, poultry-processing plants, and rendering plants.

In operation, the pond loading is adjusted to reflect the amount of oxygen available from photosynthesis and atmospheric reaeration. The efficiency of BOD conversion in a stabilization lagoon is high, ranging up to 95 percent; however, it must be remembered that, although the soluble BOD has been removed from the influent wastewater, the pond effluent will contain an equivalent or larger concentration of algae, which may ultimately exert a higher BOD than the original waste.

Aerated Lagoons

An aerated lagoon is a basin in which wastewater is treated on a flow-through basis. Oxygen is supplied usually by means of surface aerators or diffused aeration units. The action of the aerators and that of the rising air bubbles from the diffuser is used to keep the contents of the basin in suspension. Generally, the lagoon depth is between 10 to 12 feet and can handle between 1 to 15 lb. BOD/1000 cu. ft./day. Aeration requirements are the same as for an activated sludge system, that is dissolved oxygen levels of 1 to 3 mg./l. Approximately 0.2 pounds of sludge solids will be produced for each pound of BOD applied to the system. Therefore, a quiescent zone at the end of the lagoon, or a polishing pond should be used in conjunction with the aerated lagoon operation to remove the suspended solids and reduce BOD in the final effluent. In the treatment of most wastewaters, only 7 to 10 days is needed.

Types of Aerated Lagoons

Depending on the amount of mixing, lagoons are often classified as either aerobic or aerobic-anaerobic, Figure 1.

The contents of an aerobic lagoon are completely mixed, and both the incoming solids and the biological solids produced from waste conversion do not settle out. In effect the essential function of this type of lagoon is waste conversion. Depending on the detention time, the effluent will contain about one-third to one-half the value of the incoming BOD in the form of cell tissue. Before the effluent can be discharged, however, the solids must be removed by settling (a settling tank is a normal component of most lagoon systems).

In the case of the aerobic-anaerobic lagoon the contents of the basin are not completely mixed, and a large portion of the incoming solids and the biological solids produced from waste conversion settles to the bottom of the lagoon. As the solids begin to build up, a portion will undergo anaerobic decomposition. Thus the effluent from this type of lagoon will be more highly stabilized.

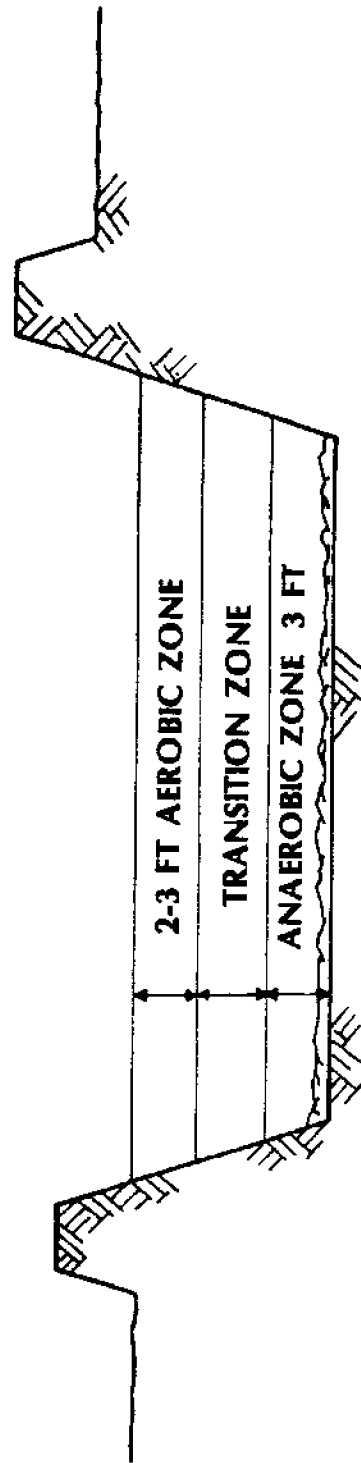


Figure 1. Typical Cross Section of a Facultative Lagoon.

Use of Aerated Lagoons in Seafood Processing

Documents covering blue crabs and bottom fish, respectively, indicate that aerated lagoons are the technological basis for the effluent limitations. However, the National Commission on Water Quality Report noted that:

The use of aerated lagoons to achieve five-day biochemical oxygen demand removals in the range of 75 to 97% for BAT for the catfish and crab processors is not realistic. Secondly, since the vast majority of the crab processing plants are in non-remote coastal areas required acreage for lagooning was assumed to be restrictive. Consequently, the use of aerated lagoons, being deemed physically and economically prohibitive, was not considered as a viable treatment alternative."

The above rationale applies to the blue crab processing plants in Maryland, except that they are, for the most part, located in remote areas. Nevertheless, land availability and use restrictions, as well as economic considerations, severely limit use of aerated lagoons.

Facultative Lagoons

Three zones exist in a facultative or aerobic-anaerobic lagoon, Figure 2. They are (1) a surface zone where aerobic bacteria and algae exist; (2) an anaerobic bottom zone in which accumulated solids are actively decomposed by anaerobic bacteria; and (3) an intermediate zone that is partly aerobic and partly anaerobic, in which the decomposition of organic wastes is carried out by facultative bacteria. Because of this, these lagoons are often referred to as facultative lagoons.

In practice oxygen is maintained in the upper layer by the presence of algae or by the use of surface aerators.

In these lagoons, the suspended solids in the wastewater are allowed to settle to the bottom. The maintenance of the aerobic zone serves to minimize odor problems, because many of the liquid and gaseous anaerobic decomposition products, carried to the surface by mixing currents, are utilized by the aerobic organisms.

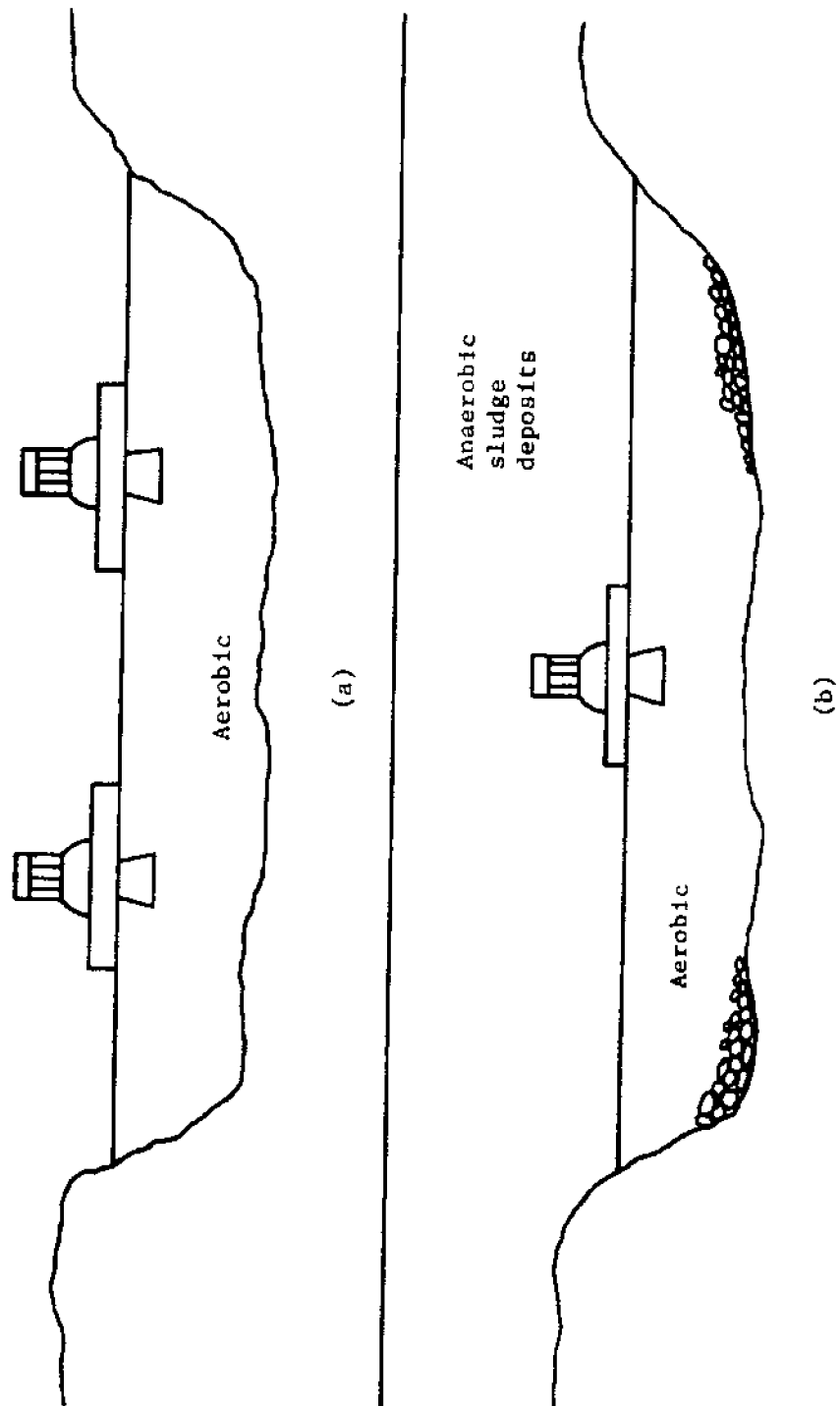


Figure 2. Schematic of (a) An Aerated Lagoon and (b) An Aerobic-Anaerobic Lagoon.

Anaerobic Lagoons

The retaining basin of an anaerobic lagoon is usually constructed with a minimal depth of 15 feet and a reduced surface area allowing for the development of a cover which is derived from the fats, oils, and greases in the wastewater. This cover also functions as a thermal insulator and to prevent the escape of objectionable odors to the atmosphere. When a cover does not develop, then it may become necessary to place an artificial cover over the lagoon. To assure a 75% BOD removal, a nutrient loading of 20 lbs./1000 cu. ft./day should be maintained. This system can be functional at 25 degrees C but higher temperatures favor the biological activity of the system. Since approximately 25% of the BOD still remains in the wastewater, there is usually an aerobic waste treatment step that follows the anaerobic lagoon. After adequate BOD reduction under aerobic treatment, the treated wastewater enters a polishing or facultative stabilization pond where the suspended solids are permitted to settle and the residual organic matter to stabilize prior to discharge to the receiving body.

Design Considerations

Factors that must be considered in the process design of aerated lagoons include (1) BOD removal, (2) effluent characteristics, (3) oxygen requirements, (4) temperature effects, and (5) energy requirement for mixing. Lagoon design parameters are provided in Table 1.

Application

Lagoon systems provide a very effective technique for the treating of food processing wastes in general, and they can be an effective technique for treating seafood processing wastes in particular. However, to utilize lagoon systems effectively and economically each potential application must answer certain questions, such as:

1. Is adequate land (acreage) available for the treatment facility?
2. What zoning restrictions are present for the proposed site?
3. What is the land cost per acre?
4. What is the soil composition, will it percolate, will it require lining?

It is easy to see that the answers to these questions can severely limit the application of lagoon systems for individual processors in the seafood industry. As new goals and standards for waste treatment in the seafood industry are promulgated, and the industry is expected to implement effective effluent controls, new approaches to providing these controls will have to be evaluated such as cooperative or regional treatment facilities.

Table 1. Design Parameters for Lagoons.

Parameter	Type of Lagoons			
	Aerobic	Aerobic-anaerobic	Aerobic-anaerobic	Anaerobic
Flow regime	Intermittently mixed	-----	Mixed surface layer	-----
Pond size, acres	10 multiples	2-10 multiples	2-10 multiples	0.5-2.0 multiples
Operation	Series or parallel	Series or parallel	Series or parallel	Series
Detention time, days	10-40	7-30	7-20	10-50
Depth, ft.	3-4	3-6	3-8	8-15
pH	6.5-10.5	6.5-9.0	6.5-8.5	6.8-7.2
Temperature range, °C	0-40	0-50	0-50	6-50
Optimum temperature, °C	20	20	20	30
BOD, loading, lb/acre/day	60-120	15-50	30-100	200-500
BOD, conversion	80-95	80-95	80-95	50-85
Principal conversion products	Algae, CO ₂ , bacterial cell tissue	Algae, CO ₂ , CH ₄ , bacterial cell tissue	CO ₂ , CH ₄ , bacterial cell tissue	CO ₂ , CH ₄ , bacterial cell tissue
Algal concentration, mg/liter	80-200	40-160	10-40	80-95
Effluent suspended solids, mg/liter	140-340	160-400	110-340	260-300

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DISSOLVED AIR FLOTATION FOR TREATMENT OF SEAFOOD WASTEWATER

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INTRODUCTION

Wastewater from seafood processing may be effectively treated by Dissolved Air Flotation techniques. There are now several installations which have been reported in the literature (1), primarily as applied to wastewaters from tuna, other fish, and shrimp. This paper will specifically report on a system installed to treat shrimp and oyster wastewaters from a Gulf coast cannery.

Demonstration and research projects were sponsored by the American Shrimp Cannery and Processors Association with EPA assistance. First, a wastewater characterization and DAF pilot plant study was funded in 1972 (2). Then, in 1974 a full scale plant demonstration was authorized and it was completed in 1978 (3).

The Gulf seafood processors and canners have been, typically, family or small group ownership, seasonal, small business enterprises located along the shoreline or on the banks of waterways. Available land is extremely limited and residences and business have been crowded around the plants. As development occurred, waterway use for recreation and for the discharge of other wastewaters increased. Over the years some waterway flows were diverted, cut off or changed appreciably by flood control, road or navigation projects. Also, seafood processing volumes increased. Most processors discharged the wastewaters directly into the adjacent waterway from which the catch was taken. Some were connected to public sewers, but the small systems could not handle the intermittent high volumes and heavy organic loads. Some seafood processors needed to find a solution to the wastewater discharge problem.

Due to the seasonal, intermittent and extreme variation in flow volumes and the unavailability of land area, biological treatment methods were not considered viable alternatives. The more adaptable dissolved air flotation (DAF) system was the method which seemed to offer better possibilities in the 70's, and it was chosen for the demonstration project.

MATERIALS AND METHODS

Characterization of wastewaters was the necessary first step in determining the effectiveness of DAF treatment. Detailed flow

measurement, sampling, and laboratory analyses of wastewaters from the various unit operations in the processing plant and of the total wastewater flow were undertaken at the study plants: the Robinson Canning Company in Westwego, Louisiana, during the pilot program and the Violet, Louisiana plant of Southland Canning & Packing Company for the plant scale project. In addition, wastewater samples were analyzed from other plants in the New Orleans area, in the Biloxi, Mississippi area and in the Bayou Grand Caillou area of Louisiana. The general processing schematic diagram is shown as Figure 1. Wastewater flows and analyses are typified in the table below.

WASTEWATER DATA, GULF SHRIMP CANNERY

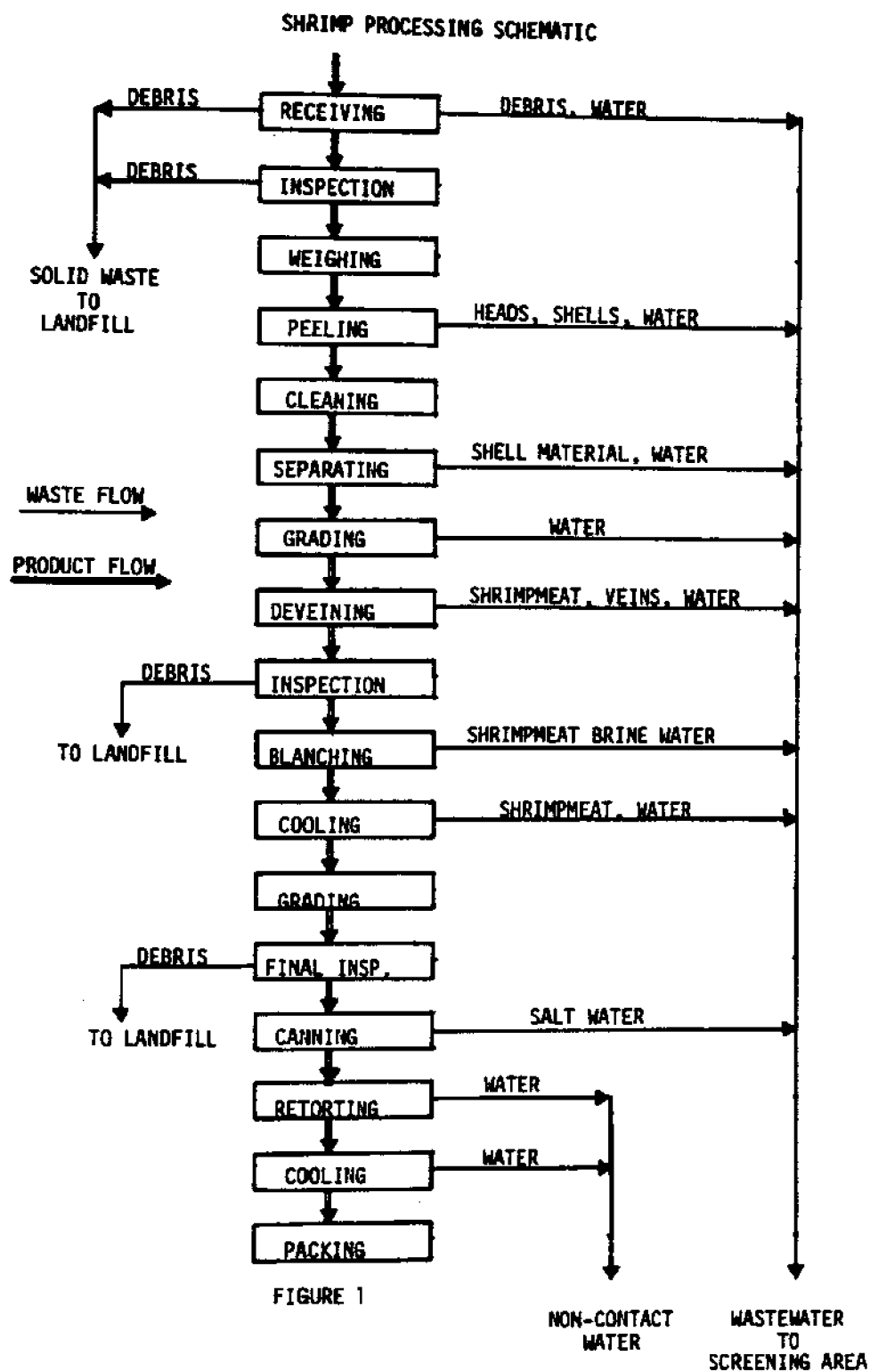
Process	Flow		Concentration-mg/l		
	Gallons/ 1000 lbs.*	% of Total	BOD5	O & G	TSS
Receiving	143	1.9	4,278	650	1,711
Peelers	2,825	38.0	2,375	257	963
Separators	572	7.7	899	34	401
Graders	237	3.2	395	12	190
Deveiners	1,289	17.3	366	14	211
Canning Room	2,373	31.9	781	17	329
Plant Discharge	7,730	100.0	1,070	115	555

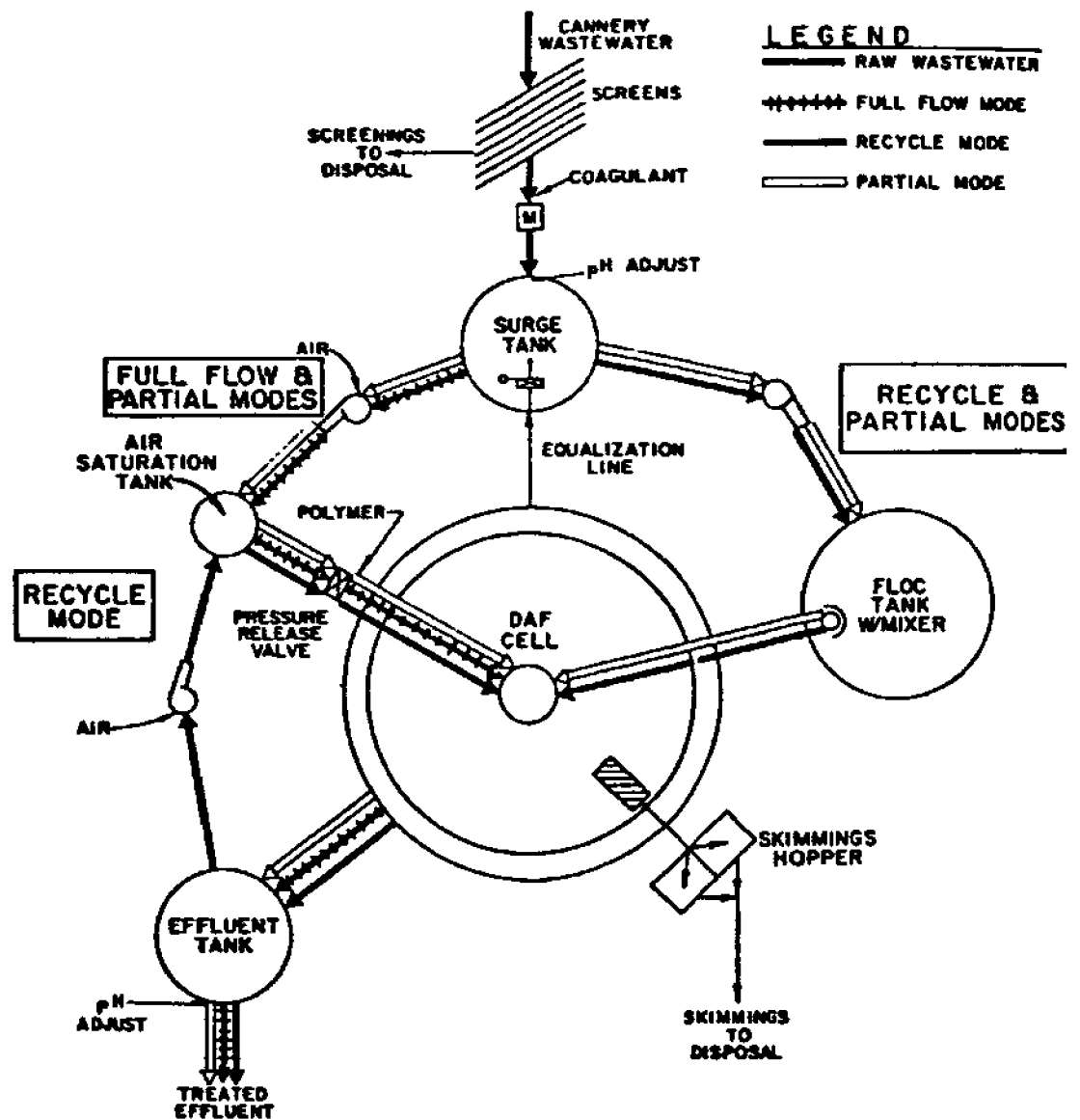
*Raw shrimp processed

Numerous bench scale jar tests were performed to determine chemical coagulant and coagulant aid dosages and pH conditions for maximum removal of suspended solids. These were then transferred to the pilot scale treatment system for evaluation. Further jar testing was done during the plant scale project, also.

The data collected during operations in 1972-73 were used in evaluating the pilot system, and it was concluded that DAF showed promise as a shrimp processing wastewater treatment method. The plant scale demonstration project then followed. A DAF system was designed which would permit it to be operated in either of the three modes: (i) full flow pressurization, (ii) partial flow pressurization, and (iii) recycle pressurization. The flow schematic is shown in Figure 2.

In conjunction with the development of wastewater data, a study was made of possible water conservation and control procedures. Subsequently, a wastewater management plan was developed and





DAF TREATMENT PLANT SCHEMATIC

Figure 2

instituted at the project processing plant. Wastewater flow volumes were reduced from 7,730 gallons per 1000 pounds of raw shrimp processed, in 1975, to 4,420 gallons per 1000 pounds, in 1977. This 43% reduction in wastewater flow was accompanied by a significant reduction in total pollutants discharge, also.

Especially during the pilot study, but also during plant scale operations, the effectiveness of screening as wastewater treatment was evaluated. Removal of larger suspended solid matter is the practicable limitation of this process.

The DAF system was purchased in late 1975, but because of installation and start-up problems too numerous to mention here, it did not function effectively in the May-July, 1976 season. Although it was more functional by the fall season, it was not until 1977 that performance was reliable.

The DAF treatment plant was first operated as a physical treatment system, without any chemical addition. Limited removals of BOD5 and oil and grease were accomplished, and solids existing in suspension were effectively reduced. Removals attained were:

BOD5	- 3.5%
Oil and Grease	- 10.5%
TSS	- 69.4%

Physical-chemical treatment was the primary objective and most efforts were directed toward obtaining optimum performance. In all circumstances, pH was controlled between 4.5 and 5.0 by the addition of sulfuric acid to the influent. Coagulants were added to the system influent stream and coagulant aid was injected into the pressured flow entering the flotation cell and/or into the flocculation tank. Effective pH control and coagulant-coagulant aid additions resulted in significant removals of the conventional pollutants. Full flow pressurization mode average removal performance levels are shown in the following table by types of coagulant applied. PRA-1 is a ligno sulfonate by-product of the timber industry. Coagulant aids 507C and 835A are long-chain polymers. Alum is filter alum, aluminum sulfate.

COAGULANT COMPARISON FOR DAF TREATMENT OF GULF SHRIMP WASTEWATER

Coagulant Dosage (mg/l)	Coagulant Aid -Dosage (mg/l)	Per Cent Removal			No. Test Runs
		BOD5	TSS	O & G	
PRA-1 60	835A 2.5	56.7	73.3	67.7	3
507C 300	835A 5.0	68.5	56.8	71.1	2
Alum 219	835A 3.9	48.5	62.7	87.3	23

Pressurization modes were compared using alum and polymer. Influent flow pH was adjusted to 5.0, alum was added to the influent, and polymer was added to the pressure control valve discharge. These data were collected under carefully controlled operating conditions and reflect maximum attained results, as follows:

MODAL COMPARISON, DAF TREATMENT OF GULF SHRIMP WASTEWATER

Mode	Average Alum (mg/l)	Average 835A (mg/l)	Percent Removal		
			BOD5	TSS	O & G
Full Flow	219	3.9	48.5	62.7	87.3
Partial	345	6.1	55.0	72.6	83.4
Recycle	283	7.5	64.6	64.8	83.6
Overall Average	271	5.8	56.5	65.6	85.0

Computations were made of costs of DAF system installation and operation to treat Gulf shrimp processing wastewaters. These end of 1977 costs ranged from \$0.38 to \$1.03 per case of 24-4 1/2 oz. (128g) cans of shrimp, depending upon the annual production. Costs for a typical 8-peeler cannery were from \$120,000 to \$132,000 per year, varying with the number of days of operation, the amount of production processed and the volume of generated wastewater to be treated. Current cost estimates would have to be updated to reflect the extreme increases in the costs of fuel, power, chemicals, equipment, labor, etc.

The shrimp wastewater DAF treatment system was utilized to treat wastewaters from oyster processing and canning for a four week period in early 1977. Flow rates were about one fourth as great as while processing shrimp. Screened oyster wastewaters contained higher suspended solids and lower concentrations of oil and grease and biochemical oxygen demand. Mean values were:

BOD5	-	510 mg/l
O & G	-	37 mg/l
TSS	-	2,280 mg/l
Settleable Solids	-	30 ml/l

Operating without pH adjustment but with alum and polymer as coagulants, the DAF system designed for shrimp cannery wastewater

treatment was effective in reducing the discharged pollutants. Mean percentage removals attained were:

BOD ₅	- 43%
O & G	- 56%
TSS	- 89%
Settleable Solids	- 99%

The steamed oyster processing flow schematic is shown in Figure 3.

RESULTS AND DISCUSSIONS

Operations of the pilot and demonstration plants were handled directly by technical personnel consisting of graduate and professional engineers assisted by graduate students in environmental sciences. Their full time duties were to operate and maintain the treatment system and to analyze samples in the on-site laboratory. It is concluded that the results obtained are idealized and would probably be difficult to reproduce on a day to day industry installation utilizing available personnel.

The pollution abatement achievements at the demonstration plant are illustrated in the table below and in Figure 4.

POLLUTION ABATEMENT ACHIEVEMENTS VIOLET PACKING COMPANY 1975-1977

Abatement Measure	REMOVALS -%		
	BOD ₅	TSS	O & G
Water and Wastewater Management (1)	60.1	12.9	39.8
Screening (2)	7.1	45.4	17.5
DAF-FFP	14.8	18.4	32.2
DAF-Recycle (3)	18.3	18.3	30.8
DAF-No Chemicals	1.0	28.9	4.5
Accumulative Total (Sum of 1, 2, and 3)	85.5	76.7	88.1

Solids developed by flotation separation and skimming from the surface of the dissolved air system main cell consisted of about 6% solids, air, and liquid. These solid wastes were highly odorous and objectionable and were difficult to store and handle. Bench scale tests were made to concentrate the solids by centrifuging,

GENERAL PROCESS SCHEMATIC OYSTER CANNING

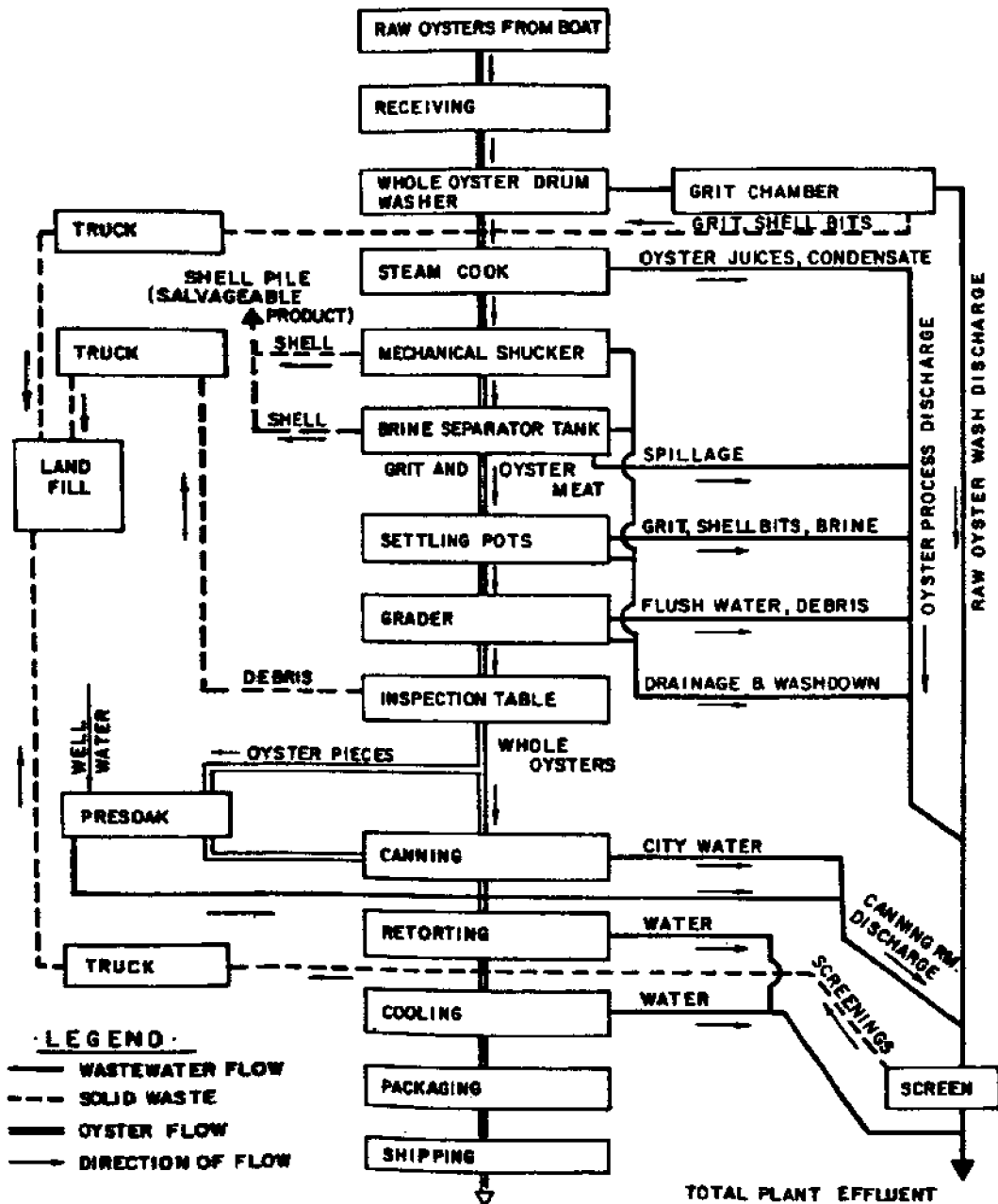


Figure 3

POLLUTION CONTROL ACHIEVEMENTS **VIOLET PACKING CO., 1975 - 1977**

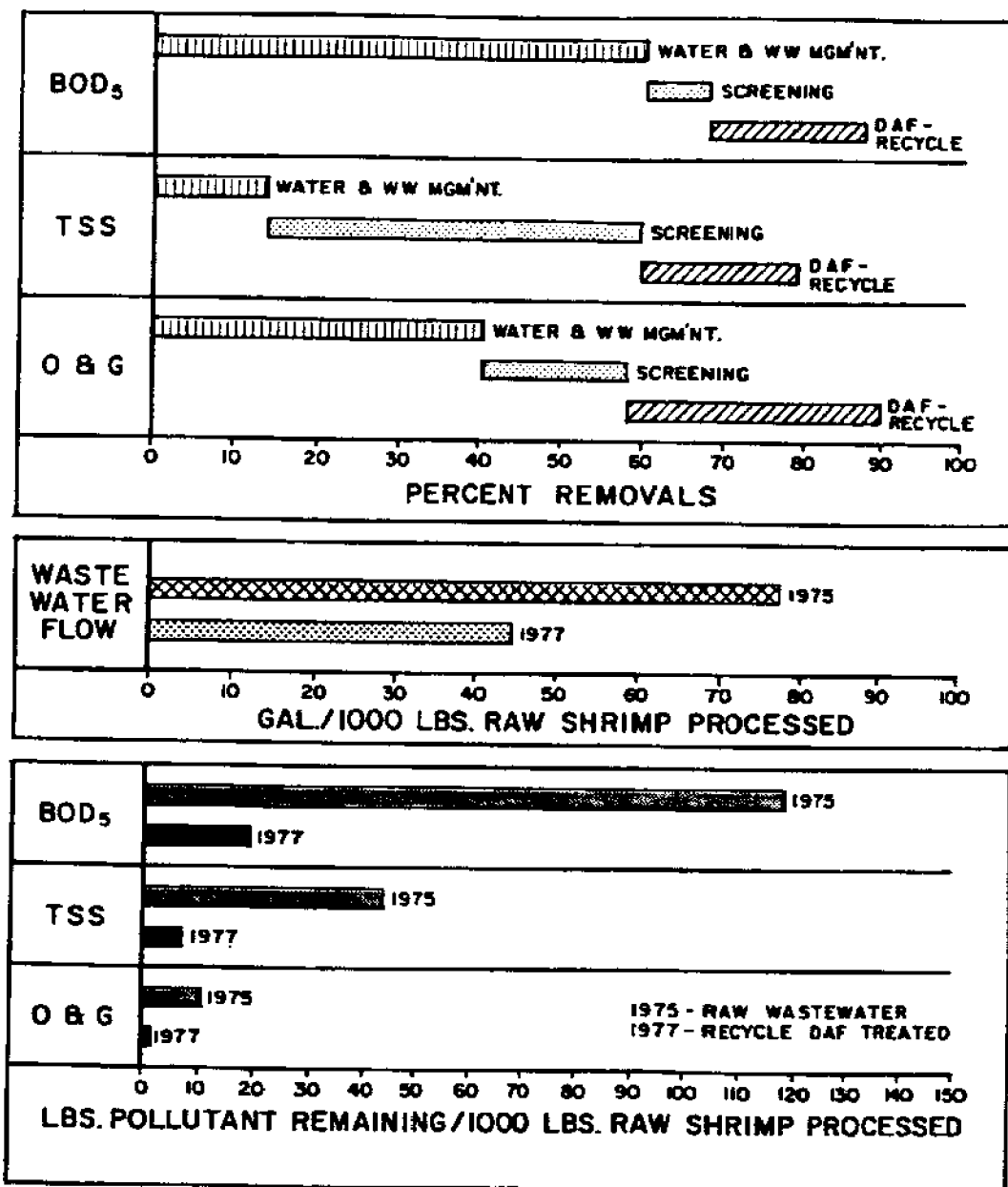


FIGURE 4

by heating, and by gravity. Chemical conditioning with a bench scale Purifax unit demonstrated a degree of stabilization. From operation of a pilot scale evaporator-dryer unit by Convap, it appeared that skimmings concentration to about 25% solids might be possible, with a corresponding three fourths reduction in volume. More investigation is needed on the handling, concentration and use or disposal of separated solids from seafood wastewater screening and wastewater treatment. Cost data are also needed.

CONCLUSIONS

Effective operation of a DAF physical-chemical treatment system will significantly reduce the pollutants in the discharged wastewaters. In order to obtain effective operation of a DAF system, qualified and trained personnel will be essential and a thorough maintenance plan will be needed. Costs of the reduction should be evaluated to determine whether the benefits are truly economically justifiable. Of several abatement procedures discussed conventional pollutant removed is greatest in the DAF process.

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DISSOLVED AIR FLOTATION FOR TREATMENT OF SHRIMP WASTE

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The speaker before me and I are here to share our observations made in regard to the DAF treatment of wastewater of a Shrimp canning plant.

I worked with Mr. Szabo very closely through the years; you heard his factual presentation about the technical findings of an EPA/industry sponsored, plant-scale demonstration project utilizing a DAF system.

The only reason I am here today is that I am connected with the plant that was selected by the shrimp industry to undertake the project and I was designated by our Association, the American Shrimp Cannery and Processors, to act as the project manager during the three years it took to complete the project.

The livelihood of our industry depends on the environment and proper handling of our natural resources. Without it, the Shrimp industry could hardly survive. Through the years, we have been in the foreground to protect our marshlands and estuarine areas against all encroachments--which if preserved will stay for decades to come the nursing ground of the Shrimp--the most valuable seafood resource of the country.

It will only take me one minute to summarize what the Shrimp processing industry is.

On the average, the Gulf produces approximately 200,000,000 lbs. of heads-on Shrimp a year and this is handled by approximately 150 plants, located all the way from Brownsville, Texas to Key West, Florida.

Since the Shrimp is only caught during certain periods of the year, we can figure on the average appr. 120-150 operation days per plant.

If you divide the production, it comes down to an average of 1,300,000 lbs. per plant per year, divided by 150 days represents less than 9,000 lbs. per working day per plant.

I am only talking about averages--some plants process more, some less--but I would like to point out that basically the daily waste load that could be returned by the average plant to marine waters is a rather limited, non-toxic quantity.

During the past eight years, our industry has learned a great deal about its wastewater. Our Association has undertaken two EPA/industry sponsored research projects. The first one, completed six years ago, analyzed the characteristics of the wastewater of a Shrimp canning plant. The second one--a plant scale, demonstration project using dissolved air flotation system-- was completed two years ago.

The goals of this second project were to find out whether the limits set for the Shrimp industry for 1983--the so-called BAT-- could be achieved; we found it could not. In the meantime, due to the 1977 Clean Water Act, BAT for the industry was suspended and now we are awaiting the publication of BCT to be applied from 1984 on.

Actually, the demonstration project consisted of two phases:

First, better water management and screening of solids, which was very successful.

Second, operation of a DAF system, which is technically feasible, but we in the industry feel it is too costly to be considered for Shrimp plants.

Through the years it was the habit of all plant operators to use as much water as necessary to maintain a fast, clean, sanitary operation. The knowledge we gained through this project about water savings was an eye-opener.

When the project started, the plant was using over 700 gallons of water per minute and, after completion of the water management studies, through installation of all kinds of water saving devices and through educating people in water savings, the water usage decreased dramatically. Today, this same plant that used to run 700 gallons of water per minute is using approximately 450 gallons, representing a savings of well over 40% and there is still room for further improvement.

We experienced quite a bit of success by installing a more refined screening system which resulted in better removal of the solids.

In regard to the operation of the DAF system, you received a very precise technical presentation. Here I just would like to bring certain points to your attention.

Our operation is intermittent--we do not work every day. We work if and when the boats come in. There are many days when the average plant works only four, five or eight hours. By having this

intermittent operation, we found:

1. Start-up time is approximately two hours; it takes that long just to fill the tank.
2. Only then could the engineers start to activate the system.

We observed that their work involved making continuous adjustments and the readings--most of the time-- were inconsistent, had tremendous variation. We know why--this is due to the nature of our product. There is no consistency in the Shrimp waste.

Some catches are two days old, some four days old or even older by the time it is processed by the plant, and depending on how old the Shrimp, different amounts of chemicals have to be added to achieve an effective treatment.

3. We observed that most of the time two graduate engineers, with tremendous interest in the project, had to work continuously to produce acceptable readings and even this way the readings fluctuated all the time.

On any given day, the Shrimp handled by the plant comes from different areas, which again can cause a variation in the wastewater.

When one day some consistency was reached, the frustration started all over again the next day.

4. When the day was over, the shut-down was a traumatic experience. For instance, on a day when the plant operated only four hours, cleanup needed at least three additional hours.

Actually, it took us considerably longer to clean the DAF system than to clean the entire plant.

5. At the end, time and again we let fresh water run through the system for three hours at a considerable labor and energy cost.
6. Last, but not least, there was the sludge, producing a watery substance that we didn't know what to do with. The project ran out of time; we didn't use a centrifuge, but even if we had, it was our understanding it would only have produced 30-35% solids and we still would have been left with the problem of what to do with it.

It is easier said to send this watery substance to a landfill than done. We are in urban areas and most of the time they do not want landfill and, if they do, they do not want the kind of landfill the sludge we were producing represented. Also, no matter how we would deliver it, it would drip all the way to the landfill.

We found the sludge was not welcome anywhere.

We are dehydrating our Shrimp hulls through a kiln. We have a hard time selling the dehydrated hulls, because the feed industry regards it to be rather low in protein.

We couldn't even think about mixing the chemically treated sludge with the Shrimp hulls because at the end it would have resulted in a completely unsaleable product. Even this way, we have to wait time and again for months before we have a taker and the value just about covers the labor and maintenance cost of the dryer.

I could go on and on, but I have limited time. I say in behalf of the industry that the sophisticated, highly complex operation of a DAF system is not suitable for a Shrimp plant. They may work in plants that day in-day out operate for long hours, particularly in plants that can operate around the clock and where the extremely costly clean-up operation only has to be performed maybe once a week--not on a day-to-day basis. This system is too sophisticated to be operated by Shrimp plants.

The results of this project indicated, as per the tables, that the greatest percentage reduction of the pollutants was achieved by good water management and screening. By using good water management and screening 67% of BOD₅, 58% of TSS, 57% of O&G was removed and, by using the costly DAF system, the additional removal was not substantial. The system--economically-- is not feasible where our industry is concerned.

As you know, by congressional directive, in 1977 EPA was instructed to conduct a seafood study to review the effects of the discharge of processing wastewater into the ocean and render a report within a year. We understand that this long overdue report will be published shortly and we hope it will not restrict itself to the study in Alaska and Oregon, but will include all processing areas and will give us insight into EPA's thinking--whether it has been adjusted to today's realities, reflecting the congressional thinking of these days--to process more instead of less seafood.

Early this year, the report of the engineering firm of E. C. Jordan Co., who was commissioned by EPA, published a reassessment of the Limitations Guidelines for the different categories.

We were amazed to see in this report that Jordan recommended treatment of Shrimp processing waste by a DAF system with chemical optimization.

Before publishing this report, all data and findings of our plant-scale demonstration project were available to them.

They accepted from this report the fact that the use of a DAF system, in principle, is technically feasible, but ignored the rest of the findings. No consideration was given to the basic problems that a DAF system represents for the shrimp industry.

1. We have a fragmented industry consisting of approximately 150 plants located along the Gulf.
2. We only have intermittent operations which is deadly for a DAF system--the plants operate 120-150 days a year.
3. Due to the nature of the raw product, there is a tremendous variation in performance of the system.
4. The range of the readings are unbelievably wide and could hardly be stabilized by continuously adjusting the dosage of the chemicals.
5. The system was operated by highly trained, research-minded engineers and they couldn't come close to the numbers that were required by the suspended BAT.
6. Not to mention the problem of the sludge.

We thought that all the problems the demonstration project pointed out would have been considered.

We feel prescribing a DAF system for the Shrimp industry does not even consider the congressional intent that there should be some kind of reasonable relationship between the cost of obtaining reduction and the effluent benefits derived.

Last week I received a copy of the Draft Document prepared for EPA by Planning & Research Associates, which analyzes the economic impact of Proposed Limitations Guidelines for the seafood categories.

Since we only had the report for a few days, we could not fully digest their findings, but we feel this is the first document coming from the Agency that states that a DAF system for the Shrimp industry may be technically feasible but economically impossible. The report states that the overall impact is greater on the Shrimp industry than on any other subcategory.

According to one of their tables, the Gulf Shrimp industry consists of 138 plants. They differentiate according to sales volume between small, medium, and large plants. Small is under one million, large is over six million, and medium is in-between.

It is their analysis, if compelled to use a DAF system, it will lead to closure of the 42 smaller plants, 37 of the medium-sized plants, a mortality of 57%.

The rest of the plants, whether at the present they have a viable operation as in the case of thirty-eight, will become marginal--some not earning any money-- some may earn a little over 1% on sales.

We should not forget that half of U. S. consumption is imported, coming from countries with hardly any environmental restrictions. Our industry so far has survived; no EPA regulations should be imposed on this industry that may close the door on a number of family operated plants and make the rest of the industry look to government handouts for survival.

I tried to be as factual as I could on this issue. I hope I was able to present the case that DAF should not be imposed on the Gulf Shrimp industry.

SEAFOOD PROCESSING WASTELOAD REDUCTION BY MECHANICAL FILTRATION

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INTRODUCTION

Under the Federal Water Pollution Control Act Amendments of 1972, effluent limitation guidelines for the Canned and Preserved Seafood Processing Industry Point Source Category were promulgated. The achievement of effluent limitations based on Best Practicable Control Technology Currently Available (BPCTCA) was required by July 1, 1977. The Act also required the achievement of effluent limitations based on Best Available Technology Economically Achievable (BATEA) by July 1, 1983.

With adoption of the Clean Water Act of 1977, discharge of conventional pollutants will no longer be controlled by the BATEA guidelines. Conventional pollutants include Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Oil and Grease (O&G), fecal coliform and pH. Control of these pollutants by seafood processors with point source discharges (those requiring NPDES permits) will be based on the implementation of Best Conventional Pollution Control Technology (BCT) no later than July 1, 1984. The EPA has indicated that final BCT limitations for the seafood processing industry can be no more stringent than BATEA guidelines, nor less stringent than BPCTCA regulations.

WASTEWATER CONSERVATION

As a result of the Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977, the seafood industry has become more aware of in-plant water and waste management and its relationship to plant effluent characteristics. There are a number of benefits which can be derived from implementing in-plant waste controls and through optimizing water use. These include decreased end-of-pipe treatment cost, decreased waste loads, improved raw material utilization, saleable secondary products and byproducts, and cost savings from reduced process water use.

A general survey of the seafood processing plants in Maryland indicates a good possibility of reducing wastewater volume by conserving water use in certain operations. Some obvious steps to reduce water usage are: turn off hoses and faucets after use, use high-pressure low volume wash-down systems, use spring loaded hose nozzles, and encourage plant personnel to minimize water consumption by eliminating other wasteful practices.

To achieve a higher degree of water management, individual unit processes require evaluation. Significant flows are usually generated during raw material unloading. Wastewater which is highly contaminated should be isolated for separate treatment and/or disposal. Cleaning tables should have provisions for controlling water flow at individual stations. Flows associated with processing equipment should be adjusted, where possible, to accommodate variable raw material quality and production levels. Raw and final product handling through fluming should be eliminated, where possible, in favor of belt or pneumatic conveying.

Based on observations, a reduction in water flow by as much as 20% can be achieved in the average processing plant without jeopardizing sanitation or product quality. Such reductions would save the processor pumping cost as well as wastewater treatment cost, particularly in those plants where treatment facilities other than screening would be required to meet future permit conditions.

EFFECTIVENESS OF CURRENT TREATMENT PRACTICES

Present wastewater treatment practices for the seafood industry are set forth in the NPDES permit which is issued to each processor as a joint federal-state permit. The permit requirements for the Maryland seafood industry include the following: solids removal by 20-mesh screens, prohibition of floating solids or foam in the effluent other than trace amounts, effluent pH in the range of 6.0 to 8.5, and disinfection of effluent with bacterial quality not to exceed a total coliform count of 70 MPN per 100 ml.

For Maryland 20-mesh static screens are considered to be fairly successful in meeting future treatment requirements. As Table 1 indicates, the hand shucked clam processors are now meeting all the 1977 and 1984 effluent guidelines. Since six of the 10 oyster processing plants are now meeting the 1977 and 1984 guidelines, it is believed

	No. of Plants Sampled	No. of Samples	BPCTA (1977)			BCT (1984)			
			TSS	06G	pH	BOD ₅	TSS	06G	pH
Blue Crabs (conventional process)	6	74	No	Yes	Yes	No	No	Yes	Yes
Non-Alaska Bottom Fish (conventional process)	2	10	No	Yes	Yes	No	No	Yes	Yes
Atlantic Oysters (hand shucked)	6 4	76 40	Yes No	Yes Yes	Yes Yes	N/A N/A	Yes No	Yes Yes	Yes Yes
Soft Shell Clams (hand shucked)	5	41	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Table 1. Maryland seafood current ability to meet EPA BPCTA (1977) and BCT (1984) effluent guidelines.

1. Brinsfield et. al., 1977.

that the other plants could meet the same guidelines simply by improved housekeeping and relatively minor modifications to the present screening system. Although the fish processors cannot meet the guidelines, both are scheduled to be served by municipal wastewater treatment systems in the near future. This leaves only the Maryland blue crab processors with the problem of meeting the 1984 guidelines. If the limitations are not raised, improved screening methods in conjunction with alternative treatment systems must be considered.

SOLIDS SEPARATION BY SCREENING

Physical Screening

Physical screening processes are defined as those processes containing elements which remove solids by virtue of physical restrictions at their surface and which have no appreciable thickness in the direction of the liquid flow. These restrictions may be due to the screening device itself or may be imparted by a thin layer of solids previously removed and deposited upon a relatively coarse substrate or fabric. Processes which fit this category are rotary screens, vibrating screens, ultrafiltration and diatomaceous earth filters, among others (3).

Microscreening

Microscreening has been a viable solids removal process for over twenty years in the area of municipal sanitation. Its use as a tertiary unit process for filtering secondary effluent dates back to the early 1950's when it was installed at the Luton Sewage Works in England. A microscrainer consists of a rotating drum with a fine screen constituting its periphery. Feedwater enters the drum through the open end and passes radially through the screen with the deposition of solids on the inner surface of the screen. At the top of the drum, pressure jets of effluent water are directed onto the screen to remove the mat of deposited solids. The portion of the backwash stream which penetrates the screen and the dislodged solids are captured in a waste hopper and removed.

The weave and shape of individual fabric wires are such that they allow the water from the backwashing jets to penetrate and detach the solids mat which forms on the inside of the screen during its passage through the feed stream. Approximately 50% of the applied washwater actually penetrates the screen. The rest flows down the outer perimeter into the effluent compartment of the structure.

The removal efficiency of the unit is not entirely due to the small openings of the microscreens. The mat of trapped solids provides the fine filtration which is characteristic of the unit. Rotary screens which are similar in principle and appearance to microscreens, are available and generally more applicable for the removal of gross solids (Figure 1).

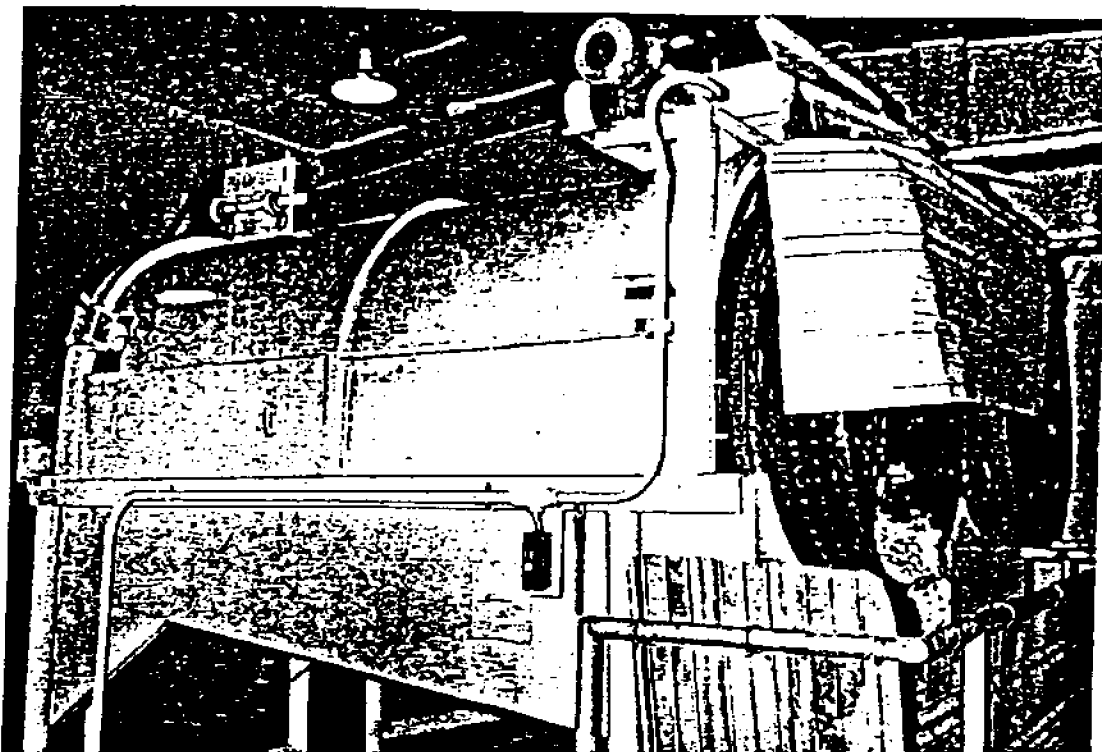


Figure 1. Typical rotary screen for wastewater processing.¹

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1. EPA, "Pollution Abatement in the Fruit and Vegetable Industry," July 1977.

Vibrating Screens

The vibrating screen (Figure 2) is a device which produces a rapid screen motion with one or more perforated or meshed surfaces for separating material according to size. Since the effectiveness of a vibrating screen depends on a rapid motion, they normally operate at speeds of 1,000 to 2,000 rpm with a horizontal motion of 0.03 to 0.13 inches.

The major functions of vibrating screens are:

- . Agitation of materials retained on the screen such that the liquid and undersize particles can pass through.
- . Movement of particles to prevent screen clogging.
- . Distribution of the materials over the surface area of the screen to insure efficient screening.

Some of the advantages of the vibrating screen over the rotary in handling seafood waste are:

- . The vibrating screen requires less floor space and less energy for operation.
- . Spray water is not needed to wash particles from the screen cloth.
- . The resurfacing cloth for a vibrating screen is less expensive than for a rotary screen and easier to install.
- . Generally the capital investment is less for vibrating screens than for other powered screening systems.

Tangential Screens (Static) Hydrasieve

The more acceptable type of static fine screens for the seafood industry are tangential (Figure 3). Tangential screens have achieved wide acceptance in the industry due to their simplicity. Flow can be delivered to these devices by gravity or through pumping. As the water moves down the face of the screen, solids are retained on the screen while the wastewater passes through. Removed solids progress down the surface of the screen by gravity and are collected. Therefore, no moving parts or drive mechanisms are involved with the actual screening operation.

Tangential devices, generally, have flow capacities based on the upper third of the screen surface with the remaining two thirds provided for dewatering of the accumulated solids. On the first (top) slope of the screen most of the fluid is extracted from the bottom of the stream traveling at 25° from vertical. When the angle of the screen changes to 35° , some additional fluid is withdrawn and the mass of solids begins to roll down the screen surface. On the final slope of the screen, the solids will hesitate for drainage but are moved off the flat surface by displacement with oncoming material. Arrangement of the wires provides a flow pattern which results in a relatively non-clogging surface.

Some advantages of tangential screening over vibrating or rotary screens are:

- . Minimum capital investment.
- . Simple installation.

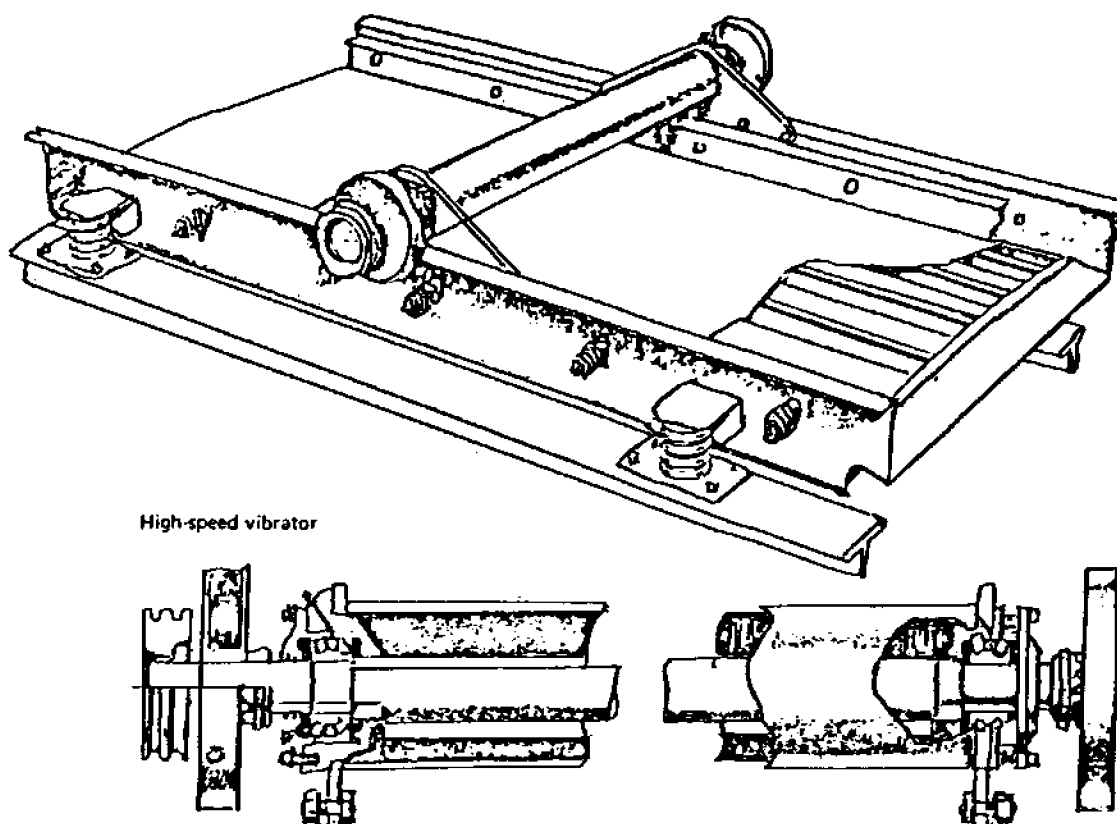
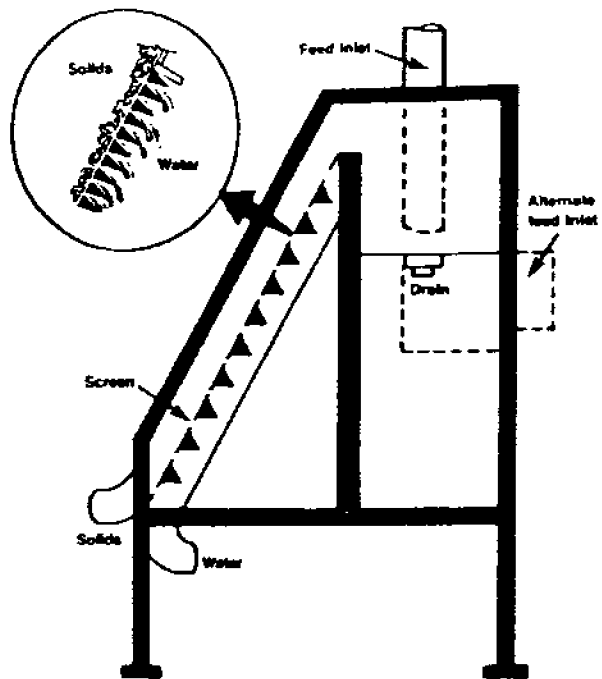


Figure 2. Vibrating screen.¹

1. EPA, "In-Process Modifications and Pretreatment," October 1973.



An example of tangential screening

Figure 3. Diagram showing path of wastewater screened by Hydrasieve.

- . No moving parts, noise, or safety problems.
- . No screens to puncture or warp.
- . Can accept wide variations in flow rate.

The delivery of wastewater to the screen headbox can be accomplished by pumps or gravity flow. The preferred approach is by gravity feed, but the use of centrifugal non-clog pumps is more common. Screen performance can be impaired as a result of the pulverizing action of the pumps on larger solids, thereby creating smaller particles that will clog the finer screens. These smaller particles can increase the waste loadings in terms of BOD₅, TSS, and oil and grease. Replacement of centrifugal pumps with positive displacement pumps may have a beneficial impact on effluent discharged to receiving waters or subsequent treatment processes (4).

The reduction of TSS will indicate the effectiveness of screening devices. Samples are taken at the screen headbox to determine influent characteristics and compared with effluent samples that have passed through the screening mesh surface. Removal efficiency is calculated by determining the difference between the two suspended solids levels. A comparison of tangential and rotating drum screens has shown that the removal of TSS to be comparable (4).

The National Marine Fisheries Service (NMFS) has investigated the relative screen performance for shrimp, salmon, tuna and bottom fish processing by comparing rotary and tangential devices with various size openings. The use of screens was shown to be applicable to several subcategories which are characteristic of the industry as shown in Table 2.

Bough and Perkins (1) have shown that screening and dry clean-up procedures have been quite successful in reducing the total waste load from shrimp processing plants. Table 3 indicates that dry clean-up procedures in conjunction with tangential screens reduced the BOD loading by 69%.

A system utilizing tangential screens will require less management than powered systems but more management than simple vertical screening systems. The following list of suggestions should result in an effective tangential screening system:

- . Keep a replacement set of screens on hand to make cleaning easier.
- . A schedule for cleaning screens should be established. The frequency of cleaning will be determined by observing the system.
- . Assign a specific person to clean and maintain the screening system. Some type of rough screening (20 mesh) prior to the tangential screens will reduce problems with clogging.
- . Use dry clean-up procedures prior to washdown.

CHEMICAL COAGULATION

Wastewaters contain many varieties of organic and inorganic suspended solids that must be removed in order to produce a high quality effluent.

Species	Screen Type	Opening Size		Total Suspended Solids Removal (%)		No. of Samples
		Inches	mm	Mean	Range	
Salmon	Tangential	0.010	0.25	9.0	-	1
Salmon	Tangential	0.014	0.35	18.6	-	1
Salmon ²	Tangential	0.014	0.35	25.0	21.6-28.3	2
Salmon	Tangential	0.020	0.51	18.6	0-53.0	5
Salmon ²	Tangential	0.030	0.76	25.6	21.2-30.6	3
Salmon	Rotary	0.010	0.25	15.4	5.9-24.7	2
Tuna	Tangential	0.010	0.25	1.2	-	1
Tuna	Tangential	0.020	0.51	25.8	0-54.8	6
Tuna	Rotary	0.020	0.51	12.6	0-25.3	2
Shrimp	Tangential	0.014	0.35	60.1	-	1
Shrimp	Tangential	0.020	0.51	36.0	30.6-41.4	2
Shrimp	Tangential	0.040	1.02	37.9	-	1
Bottom Fish	Tangential	0.020	0.51	8.8	0-19.4	4

Table 2. Fine Screen performance relative to various process wastewaters.¹

1. E. C. Jordan, 1979.
2. Data collected over the entire processing day using composite samples.
Note: Remaining data provided by NMFS-Seattle.

Operation	Before Screen	After Screen ²	With Dry Clean-up
Processing	117 ³	72	71
Clean-up	104	49	21
Total	221	121	92

Table 3. Effects of screening and dry clean-up practices on the BOD loading ratios from a breaded shrimp processing plant.¹

1. Bough and Perkins, 1977.
2. Effluent passed through hydrasieve screening which removed particles larger than 0.02 inches in diameter.
3. BOD loads in lbs/1000 shrimp processed.

Many factors affect the rates at which particles settle out of suspension. Particularly important is particle size. Small particles in the colloidal range will not settle out in a practical detention time. The chemical coagulants cause small particles to form larger particles and hasten sedimentation by electrical charge reduction, physical or chemical bridging or coagulant molecular chains between particles and by physical enmeshment of the particle. Coagulants used in wastewater treatment are alum, ferric chloride, ferric sulfate, and lime, to name a few. For each combination of coagulant and wastewater there is an optimum dosage of coagulant and optimum pH range for the reactions to occur. The addition of chemical coagulants prior to screening can significantly increase solids removal (Table 4).

INCLINED STATIC SCREENS

To determine the effectiveness of a simple inclined static screening system in conjunction with limited aeration, a research wastewater treatment system was installed and tested for one season (5). A description of the system and a preliminary evaluation of its effectiveness are presented below. The water flow pattern in the crab plant shown in Figure 4 indicates how the wastewater was generated. Water use records taken before and after the system was installed are summarized by the annual cycle graph, Figure 5. Water measurements in combination with raw product volume records were used to determine allowable pollutant concentrations for the plant.

In the direction of flow, the wastewater treatment components are a collection pit (including 40 and 60-mesh screens), sump, sump pump, aeration tank, effluent pump, and chlorination system. The collection pit was a concrete tank approximately 3 feet by 1.5 feet by 1.0 feet deep (Figure 6). The sump was a septic tank (1000 gallons) installed below grade and attached to existing discharge pipes. The aeration tank was an above-ground plastic lined swimming pool, 18.0 feet diameter, 4.0 feet deep. Air was supplied to agitate and aerate the wastewater with a simple holes-in-pipe distribution system placed on the bottom of the sump and pool. The source of air was a positive displacement rotary blower. The pumps were controlled automatically with float sensing devices.

Wastewater samples were collected before screening, after screening, sump, and aeration tank. The samples were transported on ice to the water quality laboratory and analyzed for BOD₅, TSS, and % organic residue. Observations of wastewater color, clarity and color were recorded. With an events recorder, the interval between sampling and last pumping was determined to indicate minimum residence time between sampling.

The water quality results for the system were averaged as shown in Tables 5, 6, and 7 and Figures 7, 8, 9, and 10. These values do not reflect any variations in minimum residence time or variations in temperature. There was a significant reduction in both BOD₅ and TSS across the inclined screens and after aeration. Despite the

Operating Condition	Percent Removal				No. of Samples
	BOD ₅	TSS	O&G	COD	
With Chemical Addition	49.8	62.1	60.3	42.2	5
Without Chemical Addition	16.1 ¹	34.6	14.9 ¹	23.4	3

Table 4. Performance comparison for 165-mesh screen for treating salmon cannery waste with and without chemicals.²

Note: Data provided by NMFS-Seattle.

1. Determination based on two samples.

2. E.C. Jordan, 1977.

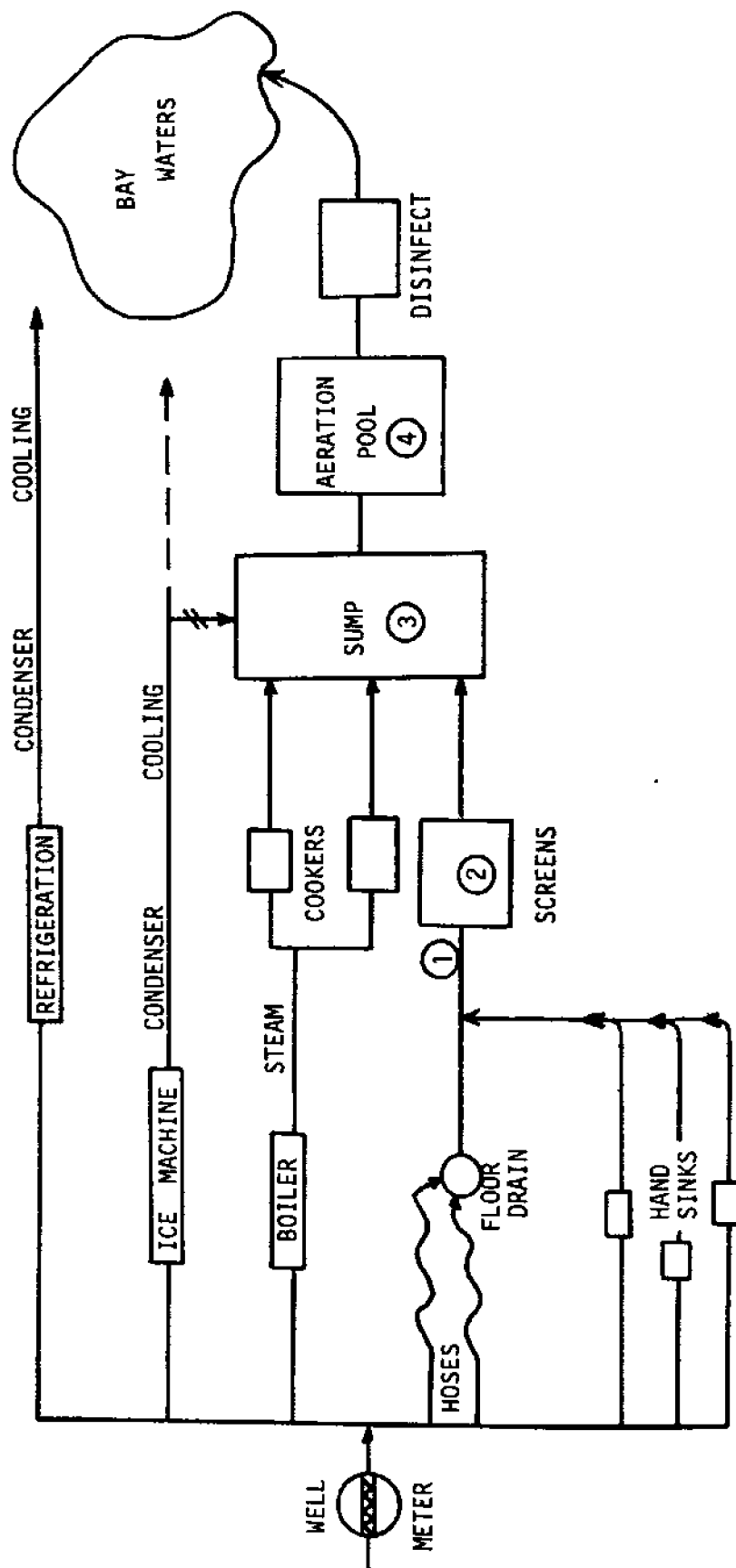


Figure 4. Water uses and flow pattern at blue crab processing plant in Maryland.

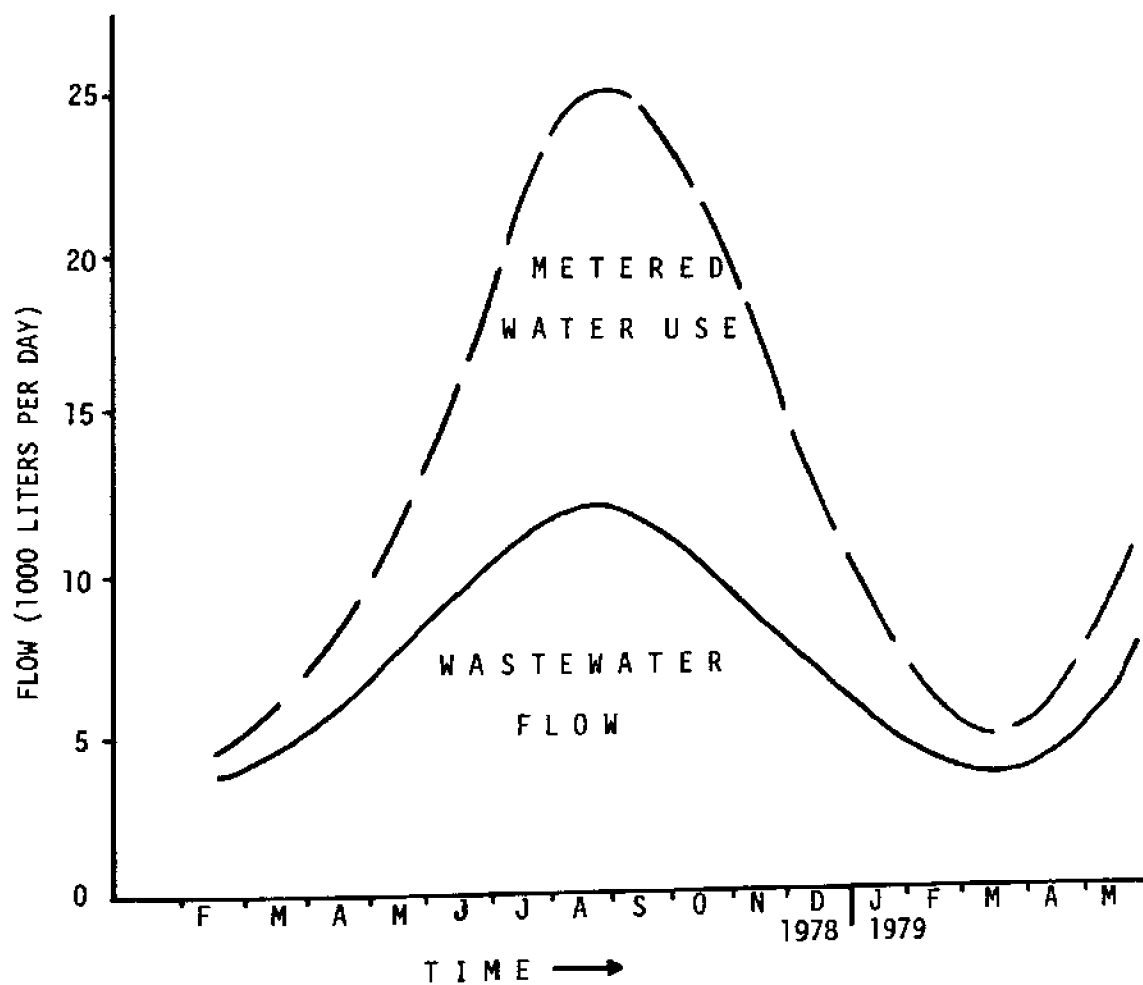


Figure 5. Daily water use for a blue crab processing plant.

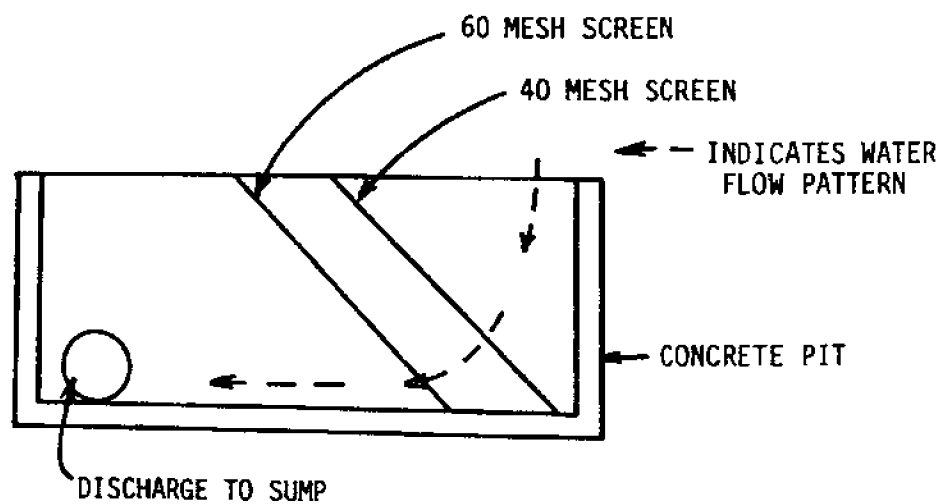
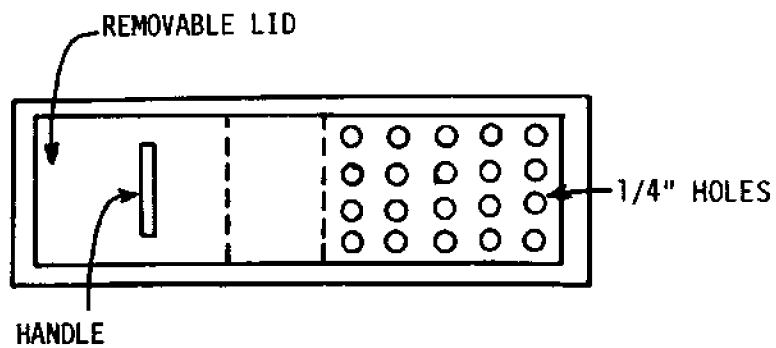


Figure 6. Diagram showing inclined static screens installed at blue crab processing plant.

Table 5. Average TSS and percent reduction as a function of sampling station within the crab plant.

Sampling Station	TSS (lbs/1,000 lbs)	% Reduction	No. of Samples
Before Screen	5.20		8
After Screen	3.15	39	8
Sump	2.43		6
Aeration Tank	1.94	20	4
Guidelines	0.75		

Table 6. Average BOD₅ and percent reduction as a function of sampling station within the crab plant.

Sampling Station	BOD ₅ (lbs/1,000 lbs)	% Reduction	No. Samples
Before Screen	1.34		8
After Screen	0.74	45	7
Sump	2.79		5
Aeration Pool	0.85	70	4
Guidelines	0.25		

Table 7. Percent organic residue in the sample as a function of sampling station within the crab plant.

Sampling Station	Organic Residue (%)	No. Samples
Before Screen	70	1
After Screen	68	1
Sump	59	1
Aeration Tank	73	1

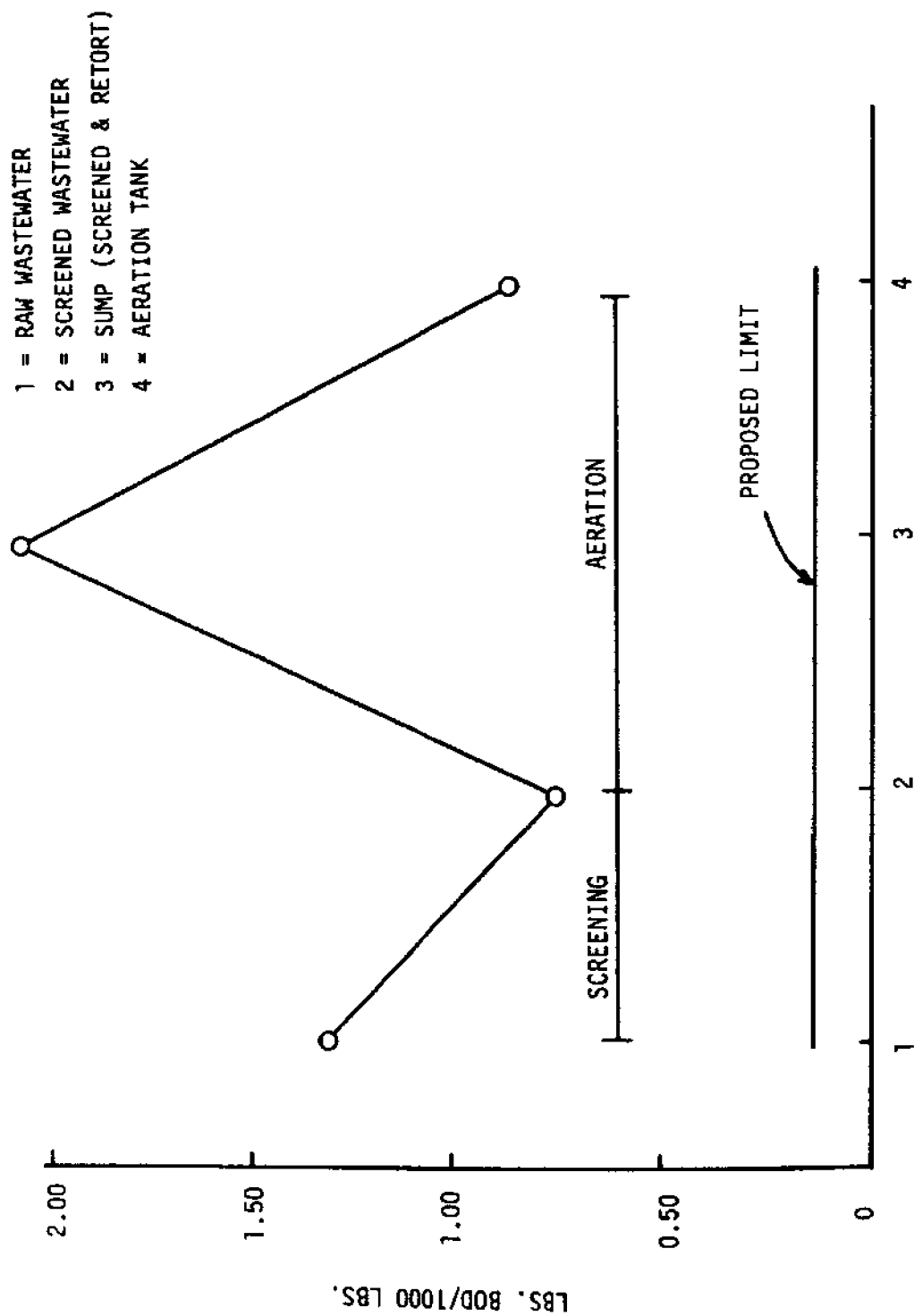


Figure 7. Average lbs. BOD/1000 lbs. crabs as a function of sampling within plant.

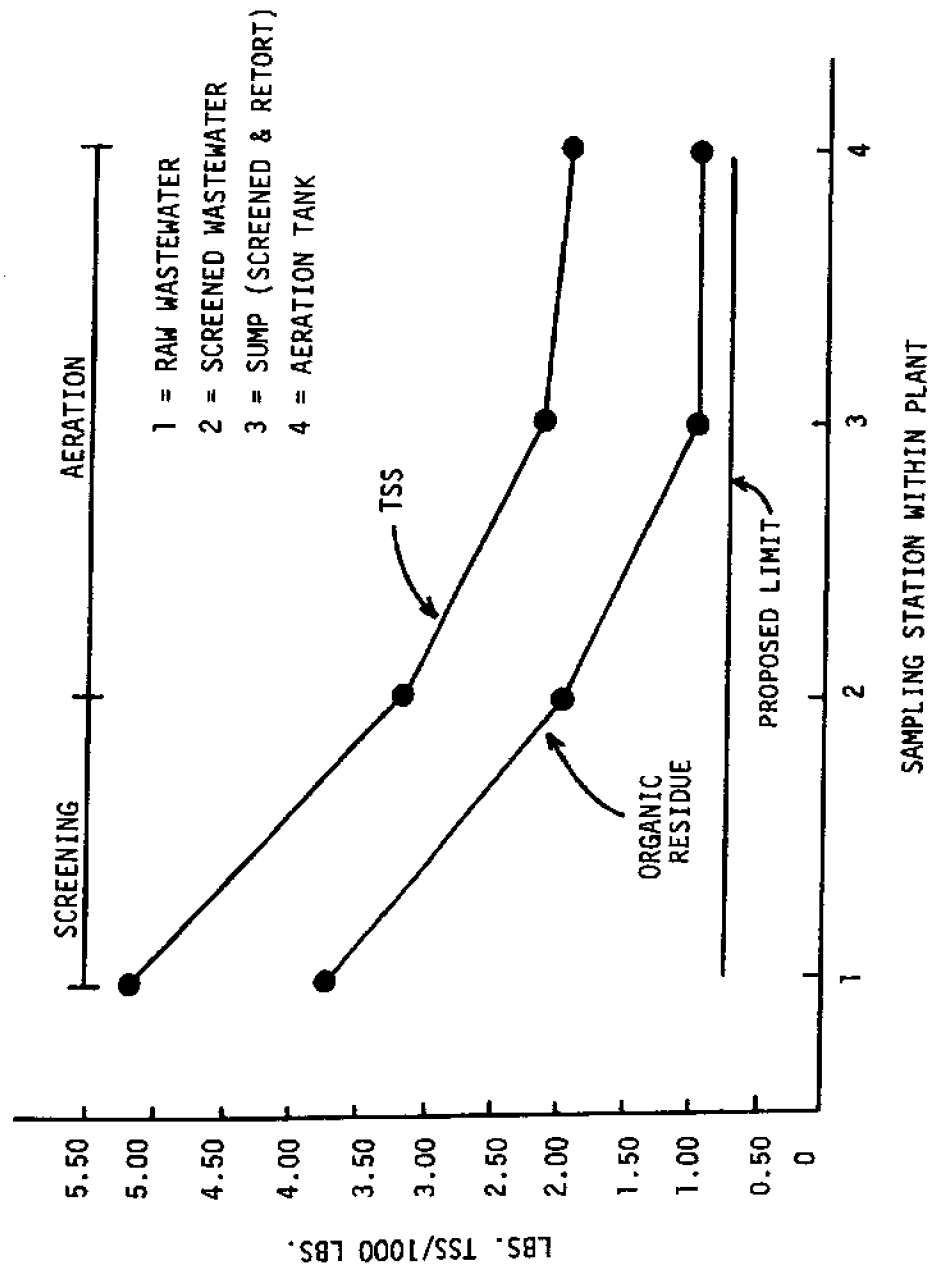


Figure 8. Average lbs. TSS/1000 lbs. and lbs. organic residue/1000 lbs. crabs as a function of sampling location within plant.

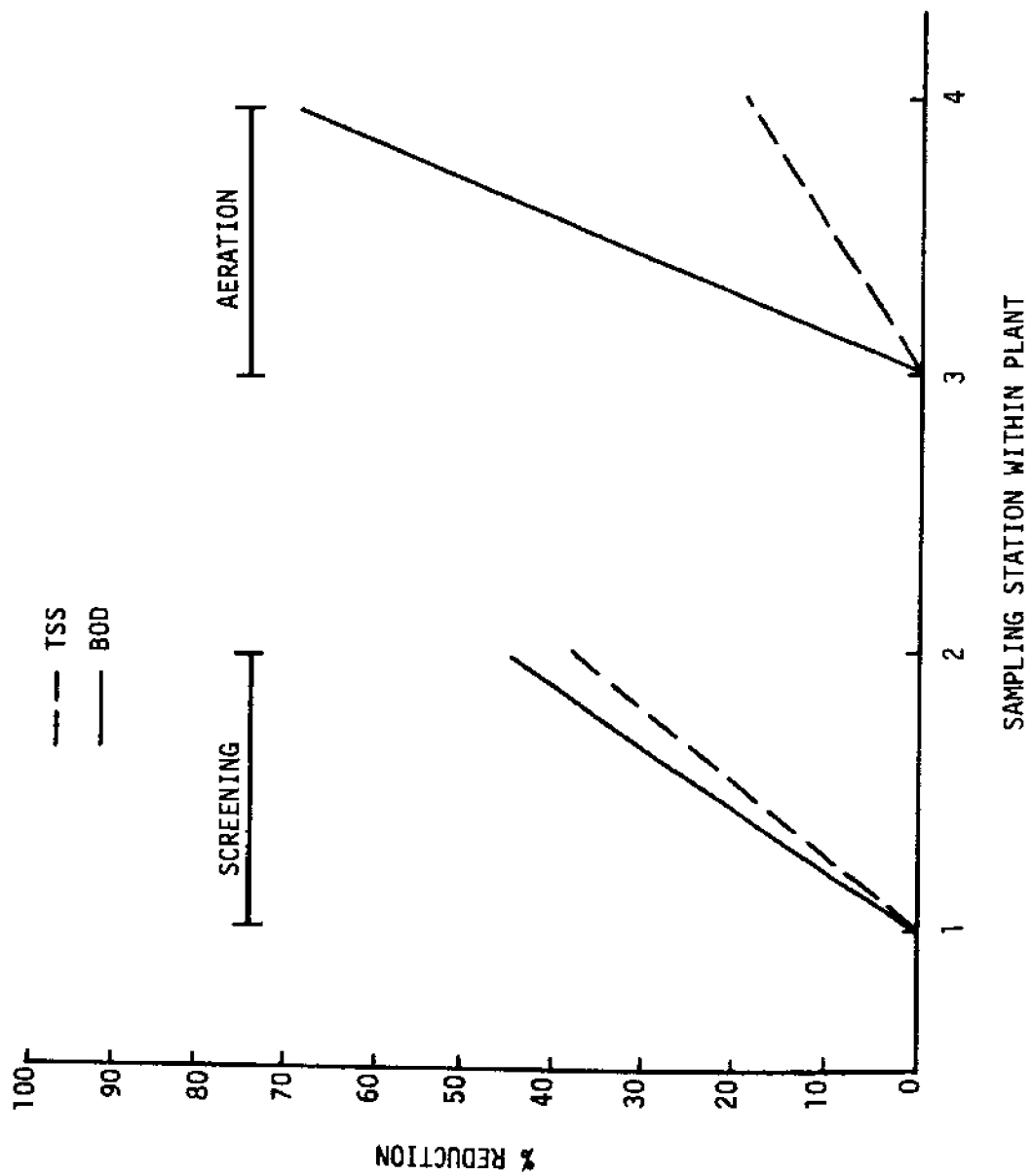


Figure 9. Average percent reduction in BOD and TSS for screening and aeration.

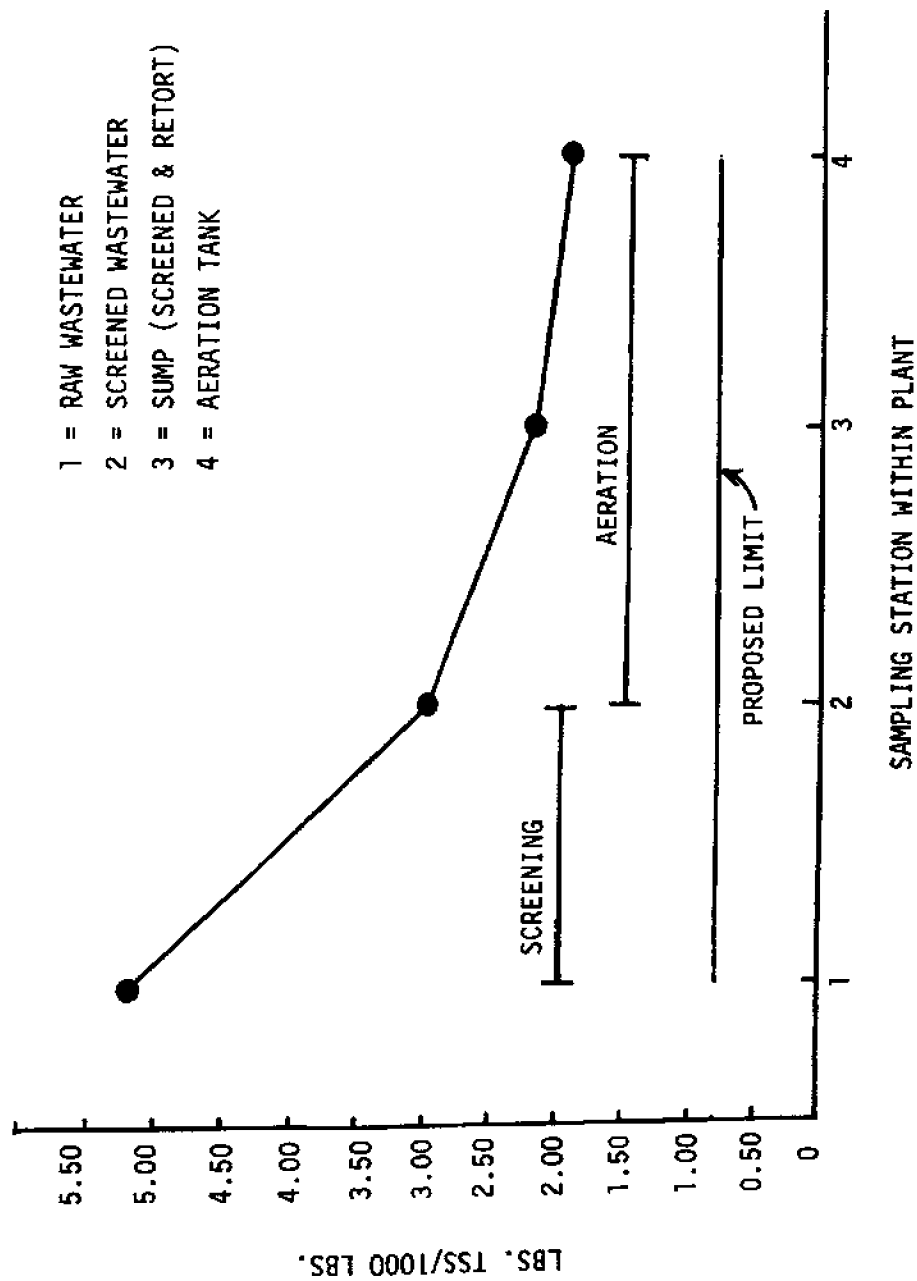


Figure 10. Average lbs. TSS/1000 lbs. crabs as a function of sampling location within plant.

significant reductions, both parameters significantly exceed the proposed EPA guidelines. The significant increase in BOD₅ in the sump as compared to the screened values results from the addition of retort wastewater to the system. Tests were also conducted to determine the percentage of organic versus inorganic residue in the TSS (Table 7, Figure 10).

Evaluation of the treatment system for factors other than water quality included odor, appearance, and management. The appearance of both the sump and aeration tank was described as cloudy gray but not unpleasant. Observations of the system suggest that excellent management practices are required to optimize system performance.

CONCLUSIONS

Although screening can result in a significant reduction in waste loading, considerable thought must be given to the selection of the device for a specific effluent characterization. Installation and proper design is paramount in order to achieve the proper screening performance with the least operational and maintenance problems. Sizing and selection of the equipment must be based on the specific wastewater characteristics. In view of the size of capital investment, simplicity, and general industry acceptance, screening has been shown to be instrumental in the reduction of waste loading and reduction of treatment cost.

Results of the experimental wastewater treatment system indicate a significant reduction in both BOD₅ and TSS utilizing inclined static screens. In addition, significant additional amounts of BOD₅ and TSS were removed by the aeration system. However, neither BOD₅ nor TSS reduction are sufficient to meet the original 1984 guidelines. Results also indicate that a significant amount of the TSS in the wastewater is inorganic residue, therefore does not contribute to the BOD₅ loading in the estuary.

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CLOSED LOOP PROCESS FLUID SYSTEM *

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The Blue Channel Corporation with assistance from the Food Science Department at Clemson University is conducting preliminary investigations of a new close-loop fluid system for treating process water used in the extraction of blue crab meat. The closed-loop system is simply a series of screens and progressively finer filters which cleanse the process water before recycling for further processing. The process water is the brine solution used in the Harris Machine for separating crab meat from the shell. In the proper brine, the crushed shell sinks and the meat is floated onto a conveyor belt for further inspection. During the brine separation process, crab meat proteins are extracted and saturate the brine at approximately two percent protein. Preliminary results indicate the closed-loop system can remove most particulates, clarifies the brine, and reduces microbial counts by 10^2 - 10^3 . The protein concentration in the brine remains near saturation and appears to prevent continued protein extraction from subsequent batches of crab meat. After processing, the brine tanks are emptied and cleaned, and the recycled brine is stored in refrigeration until further processing. Additional brine is added when needed. These initial results indicate the closed-loop system has potential as an in-plant modification to reduce waste loads in the effluent and to conserve brine solutions.

* This abstract was prepared from the authors recorded presentation by the editor to serve in the absence of a submitted paper.

RECOVERY OF BY PRODUCTS FROM SEAFOOD PROCESSING WASTES

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Government regulation of effluents from food processing plants has provided incentive to recover and utilize waste materials as one way of reducing effluents at the source. The recovered material may justify the removal process itself. Foam fractionation was used to remove potential products from effluents and implant streams. Products include enzymes, surfactants, and proteins. The surf clam and quahog processing industry will be used as an example.

INTRODUCTION

The seafood processing industry as well as the developing aquaculture systems have been confronted with the need for establishing waste water discharge control procedures in compliance with planned environmental protection regulations. There is also the need for a practical method for reusing water whenever possible.

Foaming is a common sight in the seafood industry as a result of the presence of natural surfactant materials. Foam separation is a very effective method of solid-liquid separation that has been used in non-food and water treatment areas for more than a century. Foam separation has only recently become important in waste treatment of industrial effluents. Dissolved air flotation (DAF) is related but not identical to traditional flotation processes. DAF and chemical coagulation were used by the EPA as a base for the development of the 1983 effluent limitations for shrimp processing wastes (8).

Microgas dispersions are collections of small bubbles (1-50 micrometers in diameter) linked together in an aqueous medium. Microgas dispersions (MGD) were first produced by Sebba (6) utilizing a modified venturi device. Cyclones were also used by Shaler and McLean and Shea and Barnett (7). Both the modified venturi and the cyclone provide a point for introduction of a gas into a stream of high velocity and low pressure. If the stream contains a small quantity of an appropriate surface active agent, a dispersion is formed which includes characteristic MGD bubbles. These micron sized bubbles retain their integrity, despite repeated circulation to remove undesirable bubbles, thus providing a high ratio of area per volume of bubbles charged to a flotation column. The matrix of MGD bubbles removes contaminants from a solution during its

rise to the surface of a column. Unlike traditional foams, MGD bubbles can be pumped from a generator to a column or tank for use in flotation operations (2, 5).

MATERIALS AND METHODS

The generator used for the production of MGD dispersions is shown in Figure 1. It is based on the device first used by Sebba (6). The recirculation of the surfactant solution and dispersion mixture is critical to the formation of a stable MGD. Referring to Figure 1, the liquid (A) enters the constricting region (B). Air under slight positive pressure for control enters the gap (C) and becomes entrained to form the MGD dispersion. The air pressure at (D) is used to maintain the proper level of the liquid phase in the generator.

Support apparatus, shown in Figure 2, was incorporated to maintain and monitor steady state conditions. The operation of this system was as follows: surfactant solution in reservoir (A) was fed to the pump (B) and then to the generator at (F) to form the MGD foam. The dispersion was withdrawn on demand by opening valve (D). Batch flotations were carried out in a cylindrical glass column 60 inches in height and 7 inches in inner diameter.

The column was filled with a liter of the solution to be treated and pH adjusted if necessary. An initial sample taken of both the liquid remaining and the foam after the dispersion had risen to the surface of the column. Dilution factor was used as an indication of the amount of dispersion added to the untreated solution to affect separation. Percent removal was used as an indication of the extent of removal. Foam quality, a measure of the air entrained in the dispersion, was determined by allowing the foam to settle and measuring the remaining liquid. Foam quality was the ratio of original volume-liquid volume to the original volume.

The dispersions were bubbled into the system for 12-30 seconds. Rise time was about 4-5 minutes.

Effluents and process streams were collected from local commercial clam processing plants. The composition of clam waste is shown in Table 1. The pH was 6.5 for fresh waste water. Other streams studied included the retort liquor and the debellies wash water.

Sodium dodecylbenzenesulfonate or ethylhexadecyl dimethylammonium bromide were used to prepare MGD foams using synthetic surfactants. Foam floated clam waste water provided a surfactant material suitable for producing MGD foams with a natural surfactant.

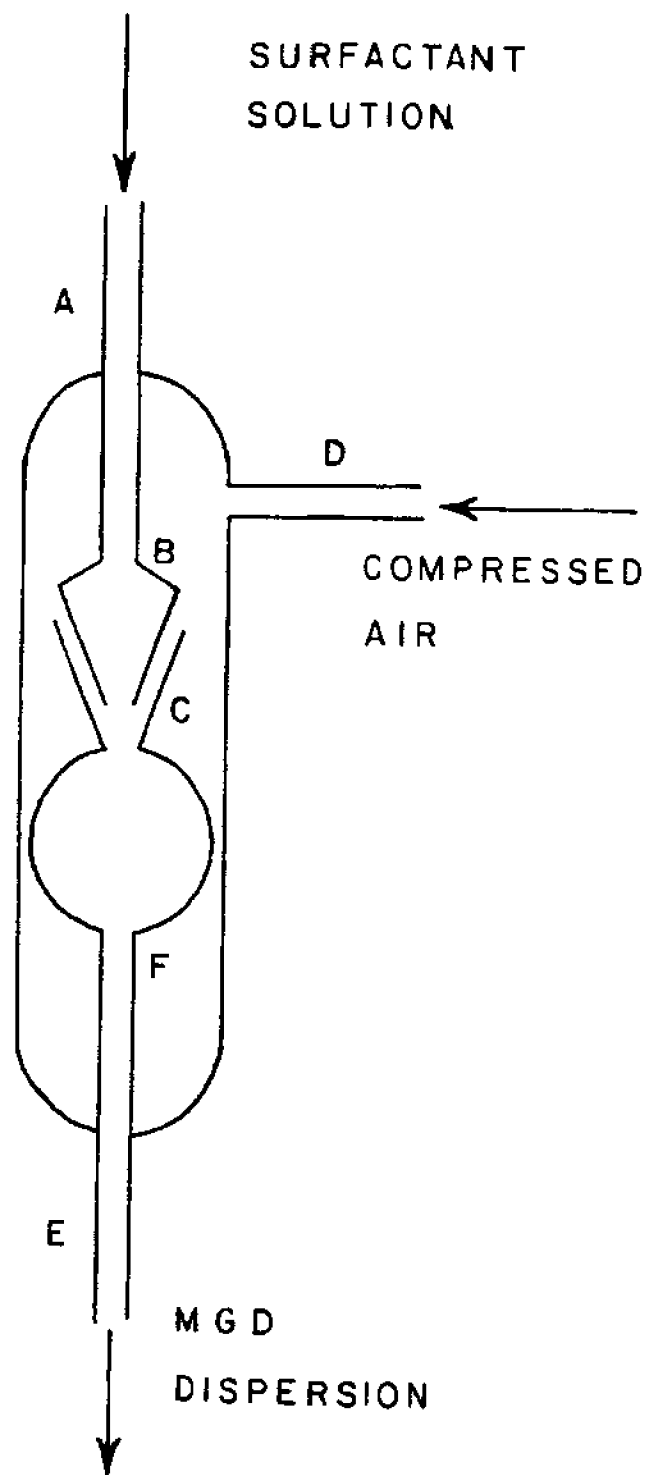


FIG. 1. MGD GENERATOR

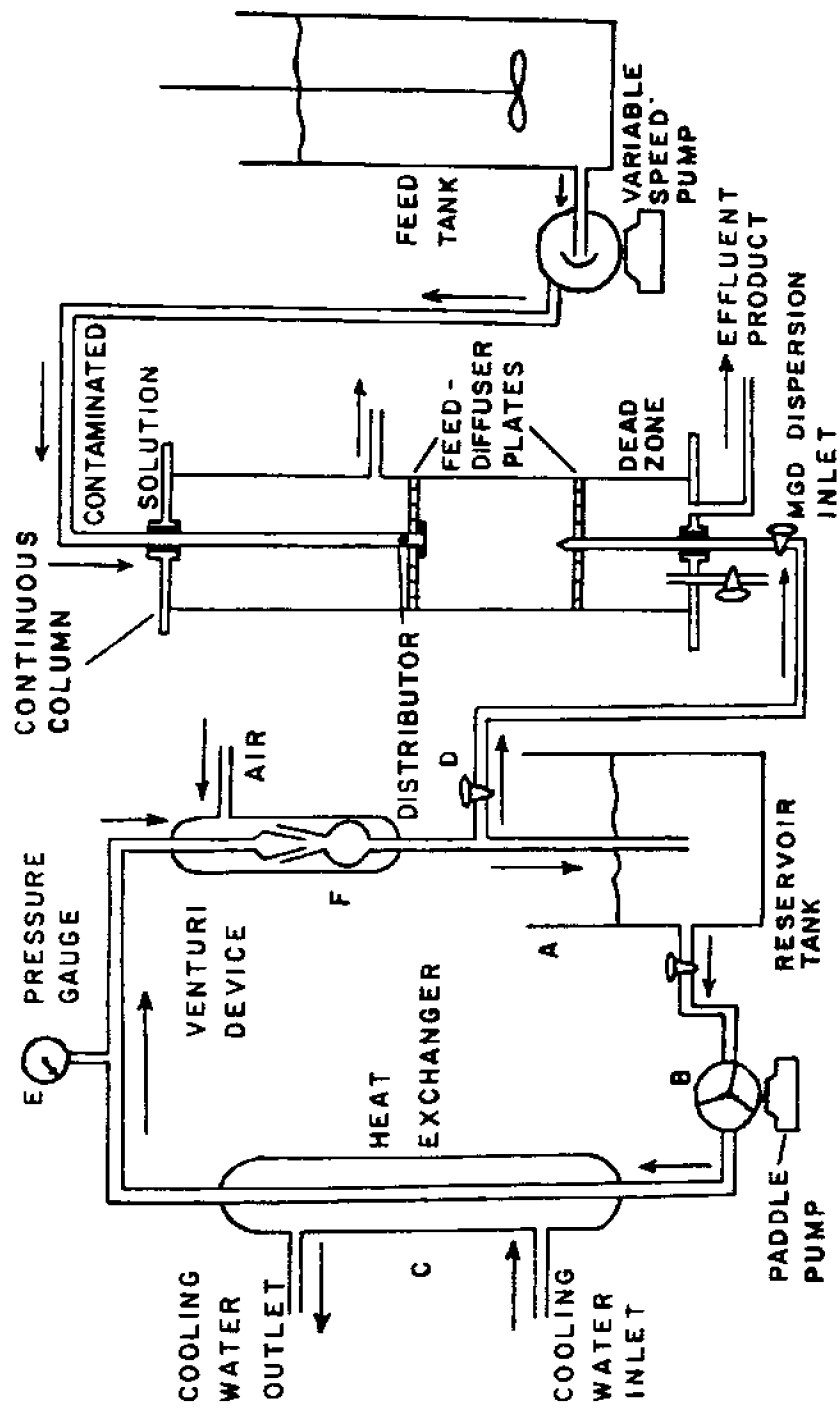


FIG. 2. MGD PROCESS STREAM

TABLE 1. COMPOSITION OF CLAM WASTE WATER AND FOAM

	Whole Waste Water*	Foam	Freeze Dried
Protein	1.1-1.6 mg/ml	1.8-4.9 mg/ml	52%
Lipids	0.65 mg/ml	1.7	7%
Sugar	5.6 µg/ml	10	--

*0.5/0.7% Solids

RESULTS AND DISCUSSION

Viscera from the seafood processing has proven useful for broiler rations (7). Waste water was also dehydrated to prepare a clam flavor concentrate by boiling and then freeze-drying, ultrafiltering, spray drying or drum drying (5). Although not yet tested for feed or clam flavoring agent, a clam waste water treated by the MGD process did yield potentially valuable products. The clam waste water had the composition shown in Table 1. The composition of a wet, but drained foam and a freeze-dried foam are also shown.

By running clam processing waste water through a foaming unit such as the MGD generator, without the addition of a synthetic surfactant, a foam was produced which after freeze-drying could be used to reform an MGD dispersion. As shown in Figure 3, both the original clam waste water and the freeze-dried material produced similar foams, based on foam quality.

The freeze-dried foam, which must be considered a surfactant, was used to remove fish waste solids from an aquaculture system. Complete removal of solids, originally present at levels of 0.2-5 ml/l were achieved, as shown in Figure 4. The full range of foam quality shown could be obtained by varying the pH or by the foam formation time.

Of particular interest, is the composition of the protein obtained from clam waste waters by the flotation method. Hang et al. (4) using an acid precipitation technique, obtained a rather poor protein according to FAO standards. An equivalent or better distribution was obtained for protein from clam processing waste waters separated by MGD flotation. Comparisons are not reported because they must be confirmed, but isolation of protein from individual waste streams before merging with other process line effluents appears to provide different amino acid patterns.

Chitosan, a by-product of seafood waste processing was used as a chelating agent for the MGD flotation process in order to remove metals from metal plating waste waters. It was planned to use chitosan as a complexing agent for the seafood protein as well, assuming the recovered protein would be used as a feed. However, due to the ease of removal of the protein from seafood waste stream, and its potential as a surfactant, a study of complexing and cross-linking agents was not carried out.

CONCLUSIONS

A process has been presented which can be used to remove proteins from seafood processing waste. Besides possible use of the protein for a feed, other products were recovered, including surfactants. Further work in this area is underway, with particular emphasis on isolation of specialty products and separate treatment of key implant streams.

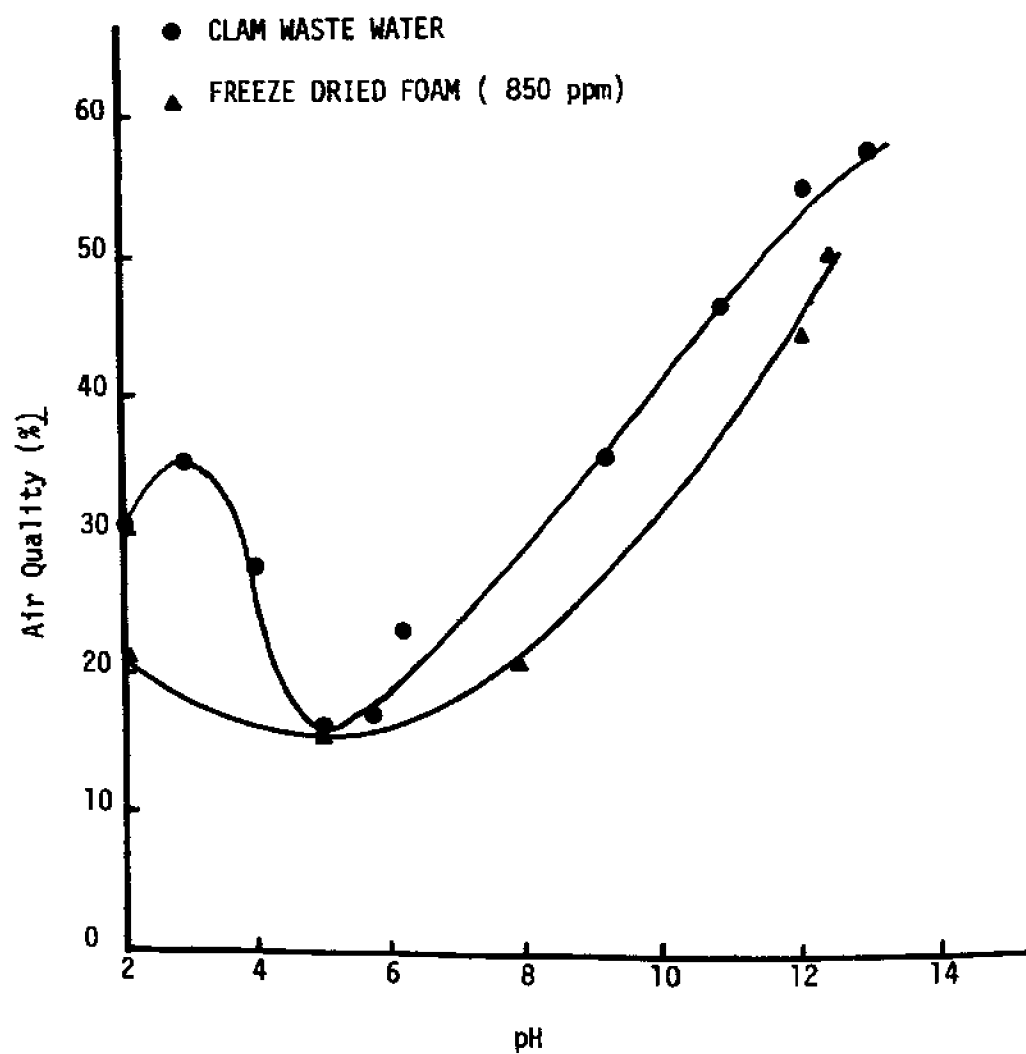


FIGURE 3. Effect of pH of Clam Waste on the Quality of MGD Dispersion.

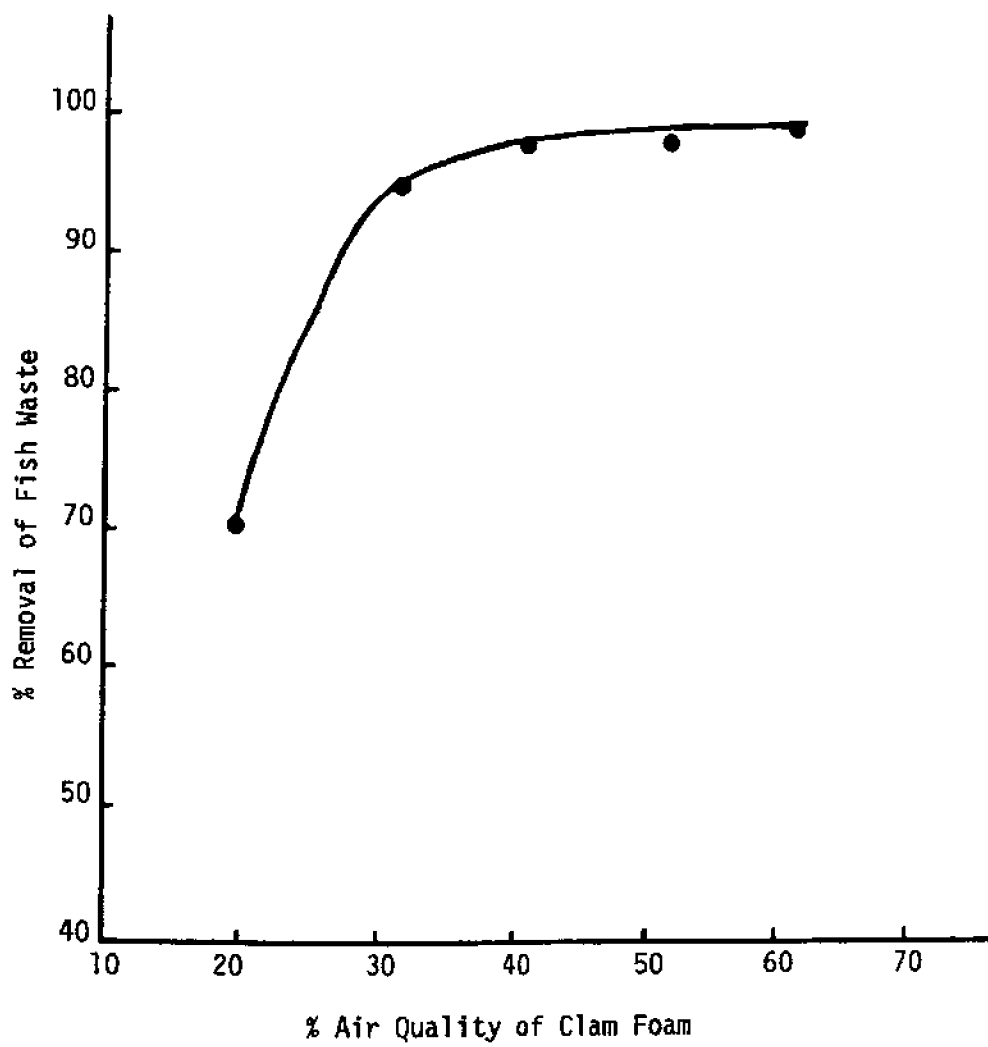


FIGURE 4. Removal of Fish Waste Using Clam Foam.

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MUNICIPAL DISCHARGE - REGULATIONS AND SURCHARGES

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INTRODUCTION

Beck (5) has explained how the Environmental Protection Agency (EPA) plans to assure that industrial users of publically owned treatment works (POTWs) pay the costs for treating their discharges. Beck concluded that EPA has evidence that municipal dischargers enjoy a degree of subsidy when compared with direct dischargers. This evidence includes the following kinds of relief: (i) financial burden of bearing the full market cost of money for treatment plant expenditures, (ii) financial burden of raising capital for treatment facilities, and (iii) substantial management, administrative and legal costs of operation and maintenance. Beck assumes that municipal systems can be built cheaper than private systems because of grants and subsidies. However, the management of many larger food plants are now finding that they can build and finance waste treatment systems cheaper than governmental units. Massey and Dunlap (10) have examined the effects on industries of federal construction grants.

PL 92-500 and PL 95-217 have given EPA the authority to develop regulations that will increase costs for seafood plants discharging to municipal systems. The requirements for industrial cost recovery, user charges and sewer use ordinances will surely affect seafood plants. Probably less than 20% of the seafood plants now discharge to municipal systems. However, with developing regulations and technologies, the future may find 90% of the seafood plants discharging to municipal systems.

The sewer use ordinance is an instrument setting forth rules and regulations governing the use of the public sewer system. In most cases, the industrial cost recovery and surcharges (user charges) may be a part of this instrument.

Seafood processors must ask themselves what is happening now and what will happen in the near future (6). Although charges for industrial wastes began as early as 1907 (7), as late as 1969 only about 10% of United States municipalities collected these charges (1). Most municipalities do not have a stringent sewer

use ordinance that is strictly enforced. Federal pressure and encouragement will surely force most municipalities to draft such an ordinance. Industrial dischargers must ask how they can get a reasonable ordinance that is mutually beneficial to the discharger and the municipality. The city system must recover its cost and be protected from toxic discharges. Unless the seafood processor has an outlet for its effluent at a fair cost, the plant cannot continue to be a productive economic influence in the community.

PL 92-500 and EPA require that municipalities institute industrial cost recovery, a system of user charges, and have a sewer use ordinance if they obtain federal funds for water or wastewater facilities (4). However, one must look carefully at exactly what is required. The initial requirements were modified substantially by PL 95-217.

DISCUSSION

The seafood industry must assist in the development of a "practical and sound regulatory ordinance fitted to local conditions" (3). The minimum number of restrictions that will protect the municipal system with minimal costs will benefit both. Any restrictions should be technically sound and rigidly enforced. Lanvin (9) related how an ordinance helped one system with enforcement.

The seafood industry is perhaps unique in that many of the seafood processing plants, especially the smaller ones, are located on docks over the water without the benefit of city sewage. However, many of these areas will receive municipal sewage facilities in the next several years.

Sewer use ordinances are largely a matter of local and state jurisdiction. However, EPA regulations contain specific requirements for a sewer use ordinance if federal monies are received for that system. Specific requirements include:

- (i) Prohibit new connections from inflow sources into sanitary sewers.
- (ii) Insure that new sewers and connections are properly designed and constructed.
- (iii) User charge system must be incorporated providing an equitable system of cost recovery, and
- (iv) Users shall be required to immediately notify waste treatment plant of any unusual discharge (flow or waste parameters).
- (v) Pretreatment of wastewaters required if they would be detrimental to treatment systems or personnel.

A number of specific requirements such as: (i) temperature less than 100°F, (ii) FOG less than 100 mg/l, (iii) BOD₅ less than 2000 mg/l, and (iv) pH less than 9.0 often appear in sewer use ordinances. These and others can present specific problems for any food plants. Most ordinances are a composite of several "model ordinances" including the following:

- (i) WPCF MOP No. 3 - Regulation of Sewer Use - 1975 (3)
- (ii) APWA - Special Report No. 23 - Guidelines for Drafting a Municipal Ordinance on Industrial Waste Regulations and Surcharges - 1971 (7)
- (iii) CWA Model Wastewater Discharge Ordinance (2).

The key to industrial input appears to be contact with the body which passes the ordinance. Most ordinances are passed relying on the advice of technical and legal consultants for the municipality. Leaders often have little understanding of the serious consequences of their actions. Industry must help these leaders realize the impact of overly stringent requirements.

Review of Proposed Sewer Use Ordinance

The best and perhaps the only time that industry can get input into a sewer use ordinance is during its development by the city council or the sewer district board, i.e., the governing body. Normally public hearings are held but everyone must be most observant for the hearing notice.

The study of a proposed sewer use ordinance requires time and expertise. However, anyone can read and understand such an ordinance with a little extra effort. The key parts of a sewer use ordinance include the following:

- . Preamble - Whereas
- . Definitions
- . Use of sewers - Required
 - Prohibitions
 - Limitations
- . Power and authority of inspectors
- . Surcharge - Sampling, analysis and formula
- . Enforcement and penalties
- . Review process
- . Effective date

A description of some of these and other key parts can be found in Table 1. Each word and sentence can have a real meaning. One should not only ask the engineer or utilities director to explain

Table 1. Some Key Parts to A Sewer Use Ordinance

Definitions	All key words should be included in the definitions. For instance: Does <u>representative sample</u> mean a grab sample, an average of 4 grab samples at 15 minute intervals or a 24 hour, proportional composit sample?
Resampling	Does the ordinance contain the specifics of resampling if industry objects to a particular sample? What are the costs of the resampling?
Mock Bill	A clause in a new ordinance can require the city to sample for a period of 6-12 months to perfect their techniques while billing you on a "mock bill" which does not have to be paid. If there are high charges, you have time to institute in-plant changes or pretreatment.
Appeal Procedure	State law probably requires an appeal if an action is considered unreasonable or unjust. However, if a procedure and time schedule for appeal is not specified, an industry may find themselves without water and sewer for an extended period while court action is followed.
Responsible Person	The individual(s) responsible for interpretation and enforcement should be specified. Everyone should be aware of any interpretable decisions that might be made.
Representative Samples	What method(s) is specified for sampling? Is the sample proportional to flow? What is the frequency of the samples? Does each sample period give a set of characteristics or are sample periods averaged to determine wastewater characteristics?
Waiver (Special Agreement)	Does the ordinance have a special clause allowing a contract or agreement between industry and the municipality to allow otherwise prohibited flows or concentrations? Who okays such a pact? Will you be able to get one approved?
Effluent Volume	There should be a clause allowing plant records or metering or engineering studies to establish a percentage of metered water which actually leaves in the sanitary sewer which is sampled. Thus a "fair" wastewater load can be established.
Pretreatment	When, by whom and how is pretreatment or flow equilization required?

what they meant to say but insist that the ordinance have language that clearly states the same. For example, does "sample manhole" refer to the manhole in the street or does it refer to a specially constructed box with a wier, flow recorder, sampler and sample refrigerator that might cost more than \$25,000? Specific problems seen in ordinances for seafood plants have included:

- Holding tanks or flow equilization being required - where are you going to put the tank?
- Control manhole or sampling facility required.
- Limitations or prohibitions on BOD, FOG, etc.
- Surcharge for industrial users only with other contributing commercial customers not charged equally.

Specific review points when considering a sewer use ordinance should include the following: (i) What's it going to cost?, (ii) Are there defacto or real limitations prohibiting discharge?, (iii) Who handles complaints and reviews decisions?, and (iv) Can you object to unreasonable bills?

Seafood plant managers must carefully consider all limitations and restrictions in a sewer use ordinance. In many cases, some sections of the ordinance may not be initially enforced. Assume that each limitation and restriction will be enforced at some time in the future. Remember that the current city engineer might leave tomorrow. Where is his promise that he does not plan to enforce the maximum FOG restriction? If it is not written, it is not the law!

If the ordinance requires a permit to connect to the municipal system, review carefully the costs and procedures. Williams (14) has described a permit system that was developed by a municipal-industry committee.

Municipal Charges

Municipal charges for industrial plants include water, sewer, surcharge (user charge) and industrial cost recovery. Most municipalities compute water and sewage charges as follows:

- | | |
|------------------|--|
| Water ... | Based on water consumption metered into the plant. Often on a declining block scale so that the cost/unit decreases as you use more water. Note that the bill is usually in hundreds of cubic feet (1 cu. ft. = 7.48 gal.). Cost usually ranges from \$0.10 to \$1.00 per 100 gallons. |
| Sewer Charge ... | Based on computed water charge and usually represents 10 to 200% of the water bill. The most common figure in the Southeast is 100%. |

Surcharge ... Based most often on metered water consumption and a parameter(s) measured in the wastewater. The most common factor is BOD₅ and usually charged at a rate of \$0.10 to \$2.00 per pound for those pounds in excess of domestic sewage. Similarly, the suspended solids (TSS) load is also used. A hydraulic load charge is sometimes included and is often used as a "demand charge" especially for seasonal operations.

Industrial Cost Recovery ... Recovery by the grantee from the industrial users of a treatment works of the grant amount allocable to the treatment of wastes from such users pursuant to section 204 (b) of the Act and this subpart. (Note that ICR is under review and there may be some changes)

Surcharges are often included in a sewer use ordinance. However, they may be included in a separate ordinance. Surcharges are usually passed because of local government's problems such as: (i) Waste treatment costs are rising, (ii) More treatment is being required, (iii) Loads are often increasing, (iv) Property tax is already overburdened, or (v) Because the municipality has received federal funds and is required to institute user charges. Washburn (13) critiqued user charges. Any food plant should keep careful records about their surcharge bill. A plant should keep up with the following information in respect to their surcharge bills:

- For which characteristics (BOD, flow, TSS) are you paying?
- How much do your monthly charges fluctuate?
- Does your flow and effluent concentration vary widely?
- How does your bill compare with similar plants?

Careful attention should be paid to the methods the city uses for calculating the surcharge, sampling and sample analysis, flow measurement and the accuracy of the results. A surcharge calculation involves flow measurement, sampling, sample preservation, sample analysis, laboratory calculation, and surcharge calculation. An error in any of these will cause an error in the surcharge bill.

A sample bill for a shrimp plant is shown in Table 2. Sewer surcharges can be reduced by modifying the charging system (11), pretreatment and/or management action (8). A poorly managed shrimp plant with little control of water use, without dry clean-up procedures and without final effluent screening may pay 500% more than a well managed plant.

Table 2. Monthly Costs for Municipal Water and Wastewater
Service for Shrimp Plant

GOOD MANAGEMENT OF WATER USE AND WASTES

(Flow = 4311 gal. BOD₅ = 6.7 lb. and SS = 3.2 lb. per 1000 lb.
shrimp processed)

Water	\$ 379
Sewer	379
Surcharge	0
Total	\$ 758

POOR MANAGEMENT OF WATER USE AND WASTES

(Flow = 9111 gal., BOD₅ = 100.4 lb. and SS = 39.8 lb. per 1000
lb. shrimp processed)

Water	\$ 802
Sewer	802
Surcharge	2024
Total	\$3628

Calculated Using:

- (a) 22 day month
- (b) Water cost \$.40/1000 gal.
- (c) Sewer cost = 100% water
- (d) Surcharge \$ 90/1000 lb. BOD₅*
90/1000 lb. SS*
- (e) Processing 10,000 lb./day of shrimp

* (In excess of 250 mg/l)

NOTE - INDUSTRIAL COST RECOVERY NOT INCLUDED

The seafood industry is affected by surcharges and sewer use ordinances because for health and sanitation, much cleaning and washing results in large amounts of organic wastes which equate to BOD₅. Also, many seafood wastewaters contain fat which is forbidden above certain levels in most ordinances. Further, much of the raw material is wasted in seafood processing. If this wasted raw material is not recovered for by-products, problems will develop.

The legal field of sewer use ordinance making is complex and ill reported. Challenges are usually settled out of court and legal records and precedents have not been established. The best defense to a badly drafted sewer use ordinance is a good lawyer and an open-minded body responsible for voting on the same. Industries faced with bad ordinances must rally their forces and present a united front.

CONCLUSIONS

A serious and detailed legal study should be made of sewer use ordinances for the seafood industry. Technical input is required if this study is to be a success. The 1975 revision of MOP No. 3, (WPCF) appears to have much technical input, but legal questions may remain unanswered. Also, recommendations concerning industrial input and assistance are largely ignored.

A pact with the city fathers allowing specific exemption for a seafood plant's wastes is a realistic alternative if an ordinance is in existence with a clause for such a pact (12). But, a seafood processor should get the best technical and legal advice before doing this. For example, exemptions could be granted for wastewaters with BOD₅ or FOG levels exceeding sewer use limitations.

In conclusion, almost all seafood plants will probably face the issues discussed herein within the next several years. The seafood industry must plan for these most serious negotiations. Managers must be alert to any indication that a sewer use ordinance is being developed or revised by their municipal system. This will take place whenever systems are modified, enlarged or replaced. EPA regulations for toxics, safe drinking water and pretreatment should also be reviewed for possible affects of municipal discharge regulations.

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SEAFOOD WASTE UTILIZATION

FISHING HARBOR WASTES AND WHAT CAN BE DONE ABOUT THE PROBLEMS

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WASTES GENERATED BY SHRIMP INDUSTRY

Domestic Type Wastes:

Domestic type wastes come from the 1000 plus employees in the area daily.

Water Borne Solid Wastes:

Solids from the processing plants; such as shrimp heads, skins, bits of shrimp, and trash fish.

Bilge Waters from Vessels:

Much of this has oil, grease, solids carried for the most part in salt water.

Solid Wastes:

Paper, boxes, oil filters, wood, broken concrete, cable, office trash, cans, brush, and a long list of discarded items. Port generated broken dock timbers, sheet sweepings, and dust add to this list.

Domestic and Water Borne Wastes including Bilge Waters:

At the Port of Brownsville these are handled through a collecting system that extends to every lessee's building and to bilge pump-out station at 100 foot intervals along the docks (Figs. 1 & 2).

Three lift stations pick up these wastes and deliver the liquid to a treatment plant. This plant has Hydrasieves, oil skimmer, flotation separation, alum, caustic, acid, polymer and chlorine treatment facilities, and delivers the effluent to an 80 acre evaporation pond. With flows ranging from 40,000 gpd to 1,100,000 gpd this system operates from a condition of bypassing the plant and delivering the flow to the ponds to a condition of full chemical treatment.

BOD's test range from 40 ppm to 6,000 ppm. The later conditions occurs when in plant heading is being done.

TABLE OF WATER AND SEWER FLOWS

	<u>F. H. Sewer Plant Flow</u>	<u>Water Used at F. H.</u>
January, 1980	4,600,000	3,457,256
March, 1980	4,710,000	2,469,272
May, 1980	4,750,000	3,158,666
July, 1980	5,120,000	3,830,408
August, 1980	4,568,000	4,002,945

The collecting system, lift stations, treatment plant, and oxidation ponding system costs \$1,4000,000 (1978 prices).

Prior to construction of the above system, all of the above wastes were likely to go into the basin. This created dissolved oxygen levels of 1 and 2, caused odors, and drove the fish out of the basin. It was a weekly or semi-weekly cleanup effort by the port to remove the oil and the trash that drifted into the corners of the basins.

After the system was installed and working and after we put steel drums on the docks for the boat trash (especially oil filters) and asked for the cooperation of the crews, the basins became very clean. So clean, infact, that the borers returned to the wood piling under the docks and have done a visible amount of damage in the past two years.

Solid Wastes:

With 88 lessees, and more than 1,000 employees, solid wastes are generated at a very high rate.

We collect twice a week with a 16 cubic yard packer truck equipped with a lift. This trash is the type that can be put into containers and drums. This amounts to 54 tons per month.

We also collect other trash, lumber, concrete, dirt, brush, nets, etc. about twice a month using a loader and a dump truck. This amounts to 20 tons per month. All trash is hauled to the City of Brownsville's sanitary landfill and covered by the landfill's operator. We pay \$4.50 per ton for this service. As yet, we do not assess the lessees a separate charge for this service.

It is expected that rising costs will cause us to put in such a charge in the very near future.

Another "waste" problem is cables. Shrimp vessel operators change their cables at regular intervals. This means they remove the old cable by going around the nearest pole (utility or otherwise) and pulling it by a car or truck. Many times this cable is abandoned on the ground and must be picked up and hauled away. Scavangers will do this for us at times.

After nearly losing some utility poles, we finally installed short pieces of vertical piling in areas where poles were being used to remove cables.

Sunken vessels and materials dumped overboard presents a different problem. A vessel sinking at the dock is usually cared for by the owner. Our people, as well as the U. S. Coast Guard, often require oil booms to be put around the vessel to stop the spread of oily waste. Usually these have little or no salvage value. Our security people watch for sinking vessels very closely.

Wire rope dumped overboard makes dredging more expensive. We try to prevent this whenever possible.

The shrimp volumes at the Port of Brownsville's Fishing Harbor.

	<u>Port Isabel-Brownsville</u>	<u>Est. Brownsville</u>
1975	14,700,000 lbs.	11,025,000
1976	12,464,000 lbs.	9,348,000
1977	16,700,000 lbs.	11,708,000
1978	14,820,000 lbs.	11,115,000
1979	13,280,000 lbs.	9,960,000

(Source - Fisheries of the U. S. A. - Current Statistics)

Leasing income from 88 lessees at the fishing harbor is \$197,696.51.

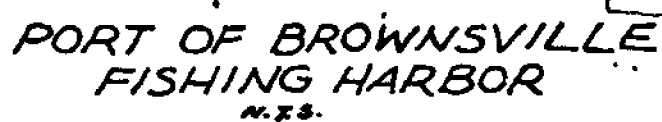
Operating costs at the fishing harbor average \$75,000 per year which includes depreciation insurance, etc.

SUMMARY

The Port of Brownsville Fishing Harbor is operated by one government agency. This keeps the pollution and waste disposal rules the same for all those people doing business at the Fishing Harbor.

It has the advantage of one agency dealing with the regulatory groups and not requiring any of the 88 lessees to deal separately with the agencies.

Its success can be measured by the fact that we have no space with docks left to lease.



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RECOVERY, UTILIZATION AND TREATMENT OF SEAFOOD PROCESSING WASTES

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INTRODUCTION

Shellfish and finfish processors are faced with increasing problems of waste handling and disposal, plant sanitation, raw material availability and cost, production efficiency, and escalating labor and energy costs. All of these factors significantly increase processing and product costs. Processors are continually looking for opportunities to increase production efficiency and profitability. Conversion of unused waste materials into marketable products not only provides such opportunities but reduces waste disposal problems.

The objectives of our work have been: a) recovery of protein, other nutrients and flavor materials from fish processing wastes, b) conversion of the recovered materials into food ingredients or marketable food products, c) development of procedures for (pre)-treating the nonrecoverable solids, and d) develop processing technologies for the improvement of seafood quality. Our goal has been to attain total utilization of seafood and its processing wastes for food or feed.

While this paper contains most of the information we previously presented at the International Conference on Fish Science and Technology in Aberdeen, Scotland in July of 1979, it has been updated to include more recent information not previously reported.

1. Preparation of Clam Juice from Washwater

Surf clams (*Spisula solidissima*) are widely utilized as a source of minced and chopped clams, clam juice (broth), and clam strips. After the clams are shucked, the meat is washed, minced and packaged for distribution (Fig. 1). It is necessary to wash the minced clams to remove the sand embedded in the tissue during dredging. The resulting washwater only contains about 0.5 - 1% solids. However, it has a distinct clam-like odor and flavor. We have developed a method for converting this washwater into a

^{1/}The original paper is published in the Proceedings of the International Conference on Fish Science and Technology, Aberdeen, Scotland.

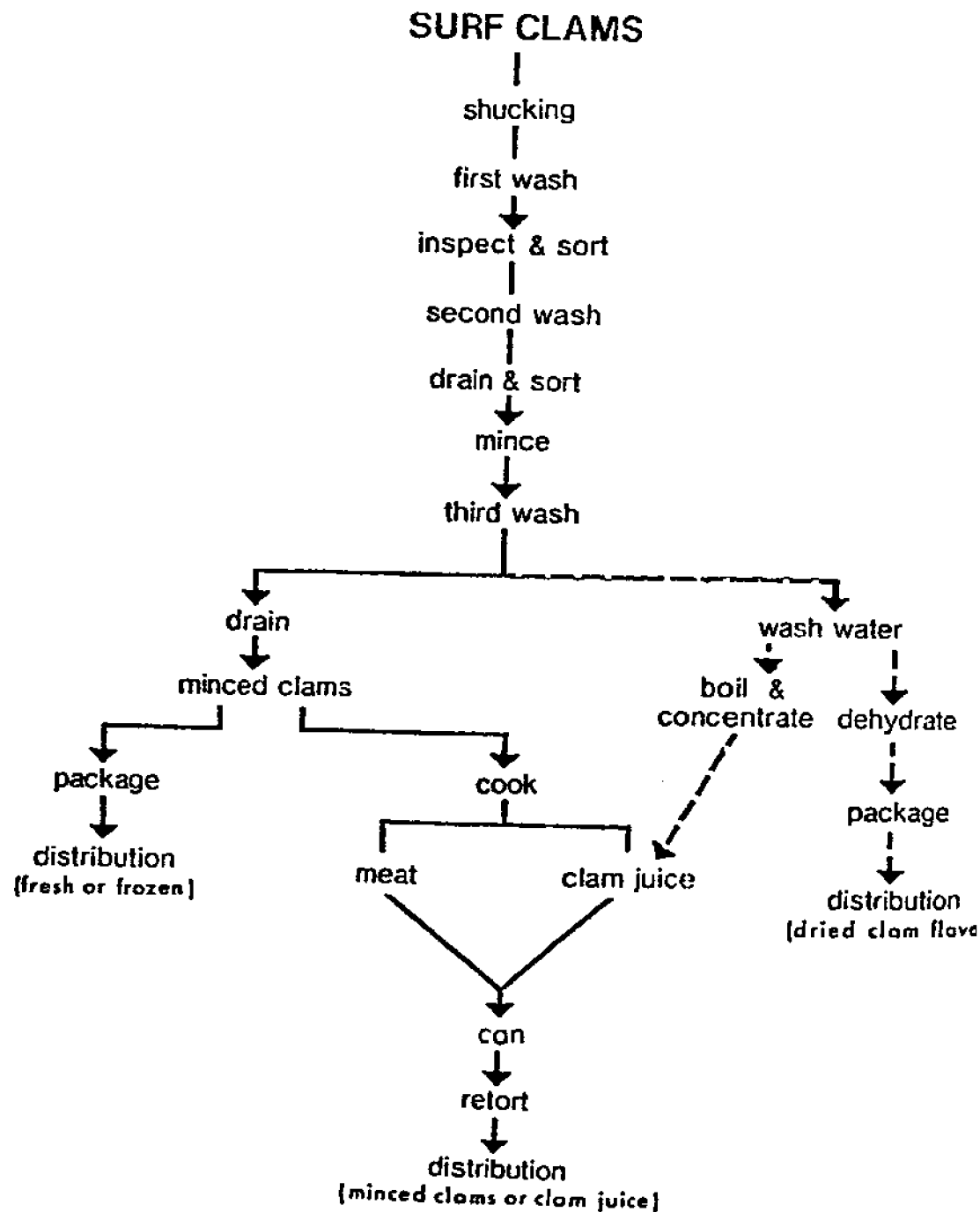


Figure 1. Flow diagram of surf clam processing. Schemes for converting washwater to clam juice or to dried clam flavor are shown on right.

marketable food product (3). The process is being applied commercially and the resulting product is being marketed as clam juice (Fig. 1).

Although the process for converting the washwater to clam juice is not a complicated one, it does include several important steps that are critical to the high quality of the finished product. The minced clams are washed in a rotating washer. After two hours, the water in the washer is transferred to a steam-jacketed kettle and boiled. The boiling step is essential to prohibit the subsequent development of fish-like flavors. It also serves to concentrate the liquid. The duration of boiling is 10-60 min., depending on the desired solids concentration in the finished product. Following boiling, the concentrated clam washwater is canned, retorted and subsequently marketed as clam juice.

In developing this process, several methods were evaluated for concentrating the washwater. These included boiling, vacuum evaporation and ultrafiltration. All of these methods were effective in concentrating the washwater to 2-3 times its original solids content. Products were judged by a five-member taste panel, trained to judge flavor, aroma and color characteristics peculiar to clam juice. Six to eight samples were evaluated during each panel session. Panelist fatigue resulted if more samples were included. The processed (concentrated) washwater was compared to commercial clam juice. Two types of evaluation forms were utilized (Figs. 2 and 3). The seven-point hedonic scale was used to record judgments on the processed washwater relative to canned clam juice. The second form asked panelists to use descriptive words to characterize sample flavor. After each tasting session, panelists discussed individual impressions and usually came to a consensus on which sample had the best clam flavor or most closely resembled commercial clam juice.

The processing methods evaluated did not yield equivalent products. In general, washwaters concentrated by vacuum evaporation or ultrafiltration were more fishy than those concentrated by boiling. Boiling at 95-100°C apparently removed most of the volatile flavors responsible for the undesirable fishy flavor. Lower temperature boiling at 50 or 80°C (i.e. vacuum evaporation) removed some of the volatiles but did not yield as good a clam-flavored product as the washwater boiled at atmospheric pressure. The condensate from the vacuum-evaporated samples tasted fishier than the corresponding concentrate. By comparing the results of these three processing techniques, it was apparent that the compounds responsible for fishy flavor in clam juice were volatile. Obviously the flavor, odor and acceptability of clam juice and other clam products are dependent upon their chemical composition and the processing treatments that they are subjected to. We are currently investigating the relationship between processing conditions and the composition of flavor constituents.

Retorting is critical to the development of optimum clam

Tasting Session I										
FLAVOR EVALUATION OF CLAM WASH WATER										
<p>Directions: You have before you 10 samples of processed clam wash water and a sample of canned clam juice "R".</p> <p>Taste the reference sample "R" first and evaluate samples 1-10 against it. Samples 1-6 are unsalted so taste these first and then proceed to 7-10, the salted samples.</p>										
Flavor attribute	Intensity rating									
	Much less -5	-4	Mod. less -3	-2	Slightly less -1	Refer- ence 0	Slightly more 1	Mod. more 2	4	Much more 5
Clam flavor										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Fish flavor										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Figure 2. Taste panel form for comparing washwater with commercial clam juice.

Tasting Session II	
<u>FLAVOR EVALUATION OF CLAM WASH WATER</u>	
<p>Directions: As you taste the following 10 samples, please jot down a few descriptive words which characterize the flavor of these samples.</p> <p>Please base your comments* on the sample with respect to "R".</p>	
Sample	Description
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

* Feel free to make comparisons such as, "f3 is more classy than f4".

Figure 3. Taste panel worksheet for developing flavor profile of clam washwater.

flavor in clam juice. It yields a sweeter, clam-flavored product than was evident in the nonretorted juice. Obviously, the process by which juices are canned and retorted for safety reasons also leads to a more highly flavored product than if the product were not retorted.

Storage stability studies have indicated that canned and retorted concentrated washwater maintains a sweet clam flavor when stored at room temperature for six months. At the end of that time, concentrated washwater was judged equivalent in flavor to commercial clam juice.

The process for converting clam washwater into clam juice is now being applied commercially. In addition to the direct economic benefits from marketing a material that was heretofore discarded, the process has resulted in a reduction in the BOD of the plant effluent and has increased the capacity for manufacturing clam juice without utilizing clams specifically for that purpose. With the price of surf clams increasing rapidly, this conversion of a waste material into a marketable food product has and will be of significant economic and pollution control benefit to the seafood processing industry.

2. Dehydrated Clam Flavor

Other uses for the clam washwater have been explored. One that is promising and should lead to substantial economic benefits for clam processors is the dehydration of the washwater to form a clam-flavor ingredient that could be used in formulated foods such as soups, dips and snacks (Fig. 1). The dried clam flavor has several advantages over the clam juice as a food ingredient. These include lower storage and distribution costs, and greater versatility. In addition, dehydrated flavors are in a different product category than the clam juice and therefore would command a higher price as a food ingredient.

Several dehydration methods were evaluated for converting the clam washwater into a dried powder (4,5). These included drum-, spray-, and freeze-drying. A trained taste panel compared the rehydrated dried washwater with commercial clam juice. All of the dehydration methods yielded a sticky, hygroscopic product. Therefore a low DE dextrin was blended with the washwater before drying. All products co-dried with the dextrin were non-hygroscopic and free-flowing. Freeze-drying produced a product that when rehydrated, had an equivalent aroma, flavor and clam flavor intensity to clam juice (Fig. 4). The drum-dried powder had a burned, caramelized flavor. In addition, it had poor solubility and dispersibility in water. Spray-drying yielded a more soluble and dispersible powder with a slightly better flavor than the drum-dried powder. Both spray-drying and drum-drying required larger concentrations of dextrin than freeze-drying in order to produce a powder with acceptable color and physical properties. The higher amount of dextrin diluted the clam flavor and a grain-like flavor resulted.

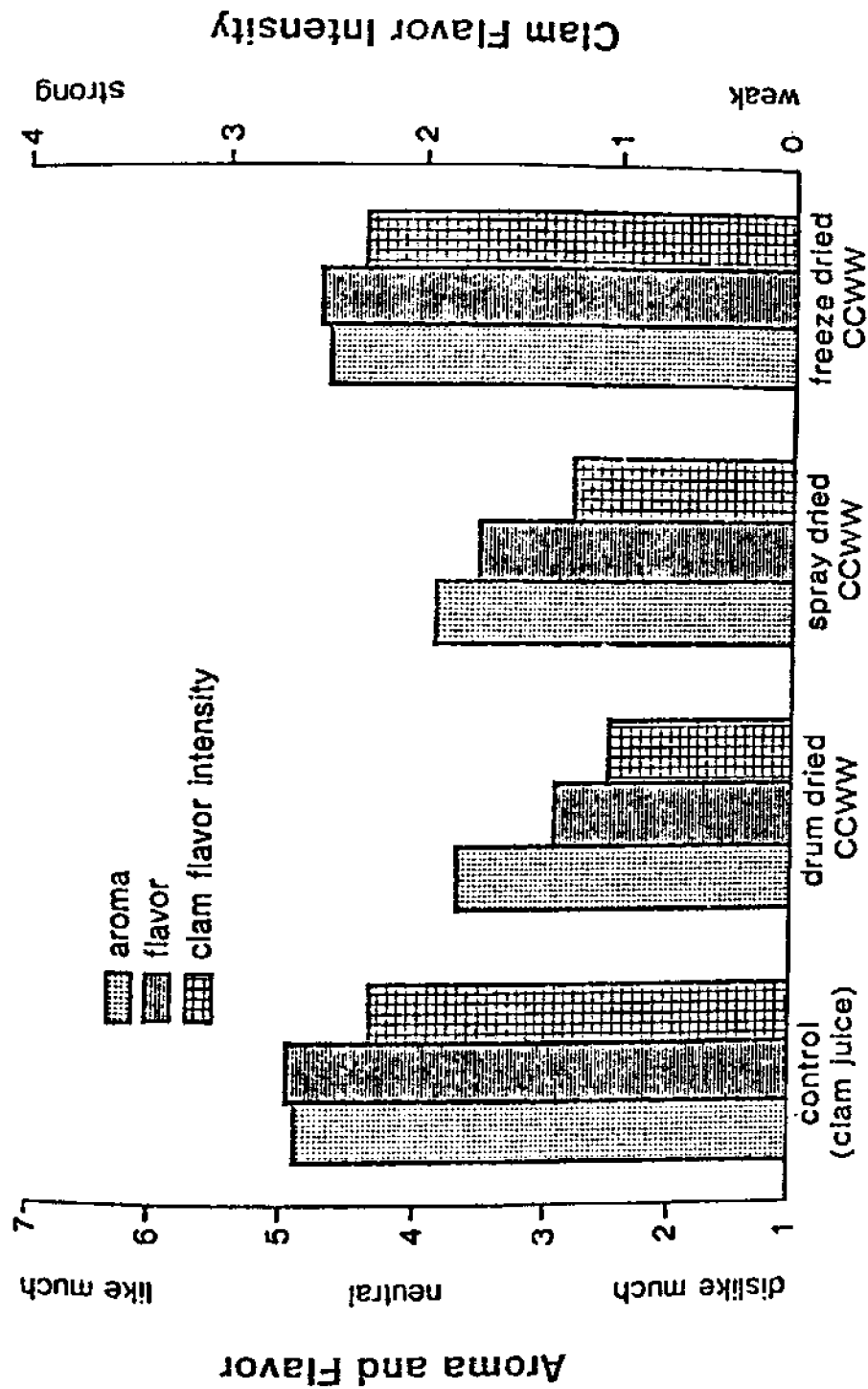


Figure 4. Effect of dehydration methods on the organoleptic quality of rehydrated dried clam flavor.

The freeze-dried clam washwater had good dispersibility and solubility. The addition of the dextrin as a co-drying agent did not appear to affect the functional properties. Nevertheless, it was essential to include it in order to reduce the hygroscopicity of the dried product. The whiteness of the product was directly proportional to the dextrin concentration. The dehydrated clam flavor was packaged in the vacuum containers and in jars and stored for 90 days at 4, 24 and 40°C. All products were judged to be equivalent after the 90-day storage period.

The dehydrated clam flavor can serve as an effective flavoring agent in seafood chowders. When 0.5% was added to chowder, the aroma, flavor, clam flavor intensity, and overall acceptability of the chowder was slightly improved (Table 1). When it was added at the 1% level, organoleptic quality of the chowders was better than the chowder containing 0.5%. The taste panel judged the chowder containing 1% clam flavor and no clam meat to be slightly better than chowder made with 3.5% clam meat. Thus it is apparent that the dried clam juice can be used as either a replacement for clam meat or a flavor enhancer.

3. Recovery of Meat from Clam Shells

In addition to the liquid effluents emanating from clam processing facilities, there are solid wastes generated such as shells, bellies, mantles, and parts of the adductor muscles. The meat represents about 30% of the total weight of the clam (Table 2). We have examined various methods for removing and recovering the clam meat that adheres to the discarded shells (2,9). There is a substantial amount of meat in this category, representing about one-third of the total edible clam meat.

In our studies, shells with adhering meat were collected before and after shell chopping and methods were devised for releasing the meat from the shell. Various techniques to accomplish this purpose were examined. They include immersing whole shells and shell parts with adhered meat fragments into boiling water with and without agitation, heating shell fragments in a muffle furnace at 200-600°C for up to 5 min., and heating shell fragments with attached meat in a pressure cooker at 121°C at 15 psi for up to 15 min. Heating in boiling water for two min. caused the mantle to be released from the shell. However, the two adductor muscles, which control bivalve action, failed to come off the shell after a 15 min. cooking period. These muscles could be removed from the shell after cooking for 12 min. if minor scraping was used to free the meat. Anterior adductor muscles were always more difficult to remove from the shell than the posterior ones. Dry heat (muffle furnace) resulted in burned meat that could not be removed from the shell.

The preferred method for removing meat from shell fragments was by heating in a pressure cooker at 121°C at 15 psi. This procedure produced a juice product in addition to the meat. Again, as in the case of other heating techniques, the anterior

Table 1. Organoleptic quality of seafood chowder made with dehydrated clam flavor^a.

Chowder	Aroma	Flavor	Clam Flavor Intensity	Overall Acceptability
A ^b	5.0±0.7	5.6±0.7	2.5±0.8	5.2±1.3
A ^c	5.4±1.0	5.8±1.0	2.5±0.9	5.4±1.5
B ^d	5.0±1.1	5.0±1.0	2.2±1.0	4.4±1.5
B ^e	4.9±0.8	5.2±1.2	2.4±0.9	4.6±1.2
B ^f	5.6±0.7	5.7±0.6	2.8±0.4	5.6±1.3

^aMean ± SD, n = 10

^bCornell Seafood Chowder with 3.5% clam meat.

^cCornell Seafood Chowder with 3.5% clam meat + 0.5% CFI.

^dCornell Seafood Chowder without clam meat.

^eCornell Seafood Chowder without clam meat + 0.5% CFI.

^fCornell Seafood Chowder without clam meat + 1.0% CFI.

Source: Joh and Hood, 1979.

Table 2. Weights of parts of the surf clam
(Spisula solidissima).

Body Part	Weight (% of total)
Shell	50-55
Juice	10-15
Meat	
Foot	11
Adductor muscle	6
Neck	2-3
Mantle	7-9
Belly	3-8

Source: Zall and Cho, 1977.

muscles were more difficult to remove than the posterior muscles. While pressure heating did free meat from shells, it also cooked the meat. Thus, the salvaged product could not be considered raw clam meat. In fact, the salvaged adductor muscle was much tougher (as measured by the Warner-Bratzler Shear Press Method) than the unheated meat.

The amount of meat, juice and shells available for recovery by pressure heating is significant. Adductor muscles alone represent about 6% by weight of the total clam and about 20% of the total edible clam meat. The value of the slightly cooked muscle might be less than that of the foot or neck parts of the clam. Nevertheless, the recovered muscle could be utilized as an ingredient in cooked clam products such as chowder.

4. Liquified Clam Bellies

Not all fishery wastes can be readily converted to human food. Often the volume of the waste is not sufficient to economically justify processing, or the nature of the waste does not lend itself easily to handling and processing. Clam bellies are an example of these types of materials. They are the intestines and other visceral wastes and represent 3-8% of the total clam (Table 2). The volumes of bellies generated are usually too low to justify any processing. In addition, they are slimy and full of intestinal contents and are difficult to handle and process. In a matter of hours after shucking, clam bellies will reach high microbiological counts, become odoriferous and must be quickly discarded. The challenge is to inexpensively stabilize clam belly waste and thereby produce useful by-products.

We have applied some of the procedures developed at the Torrey Research Station for the preparation of fish silage to the preservation and liquefaction of clam belly waste. Clam bellies were preserved from microbial spoilage by treatment with formic acid (1.3%) or sodium chloride (19.5%). Specimens were stored in sealed glass jars at 4°, 35° and 55°C for up to 155 days. Microbial populations rapidly decreased, particularly at the elevated temperatures. Thermophilic plate counts, and yeast and mold counts were negligible. In general, the brine-formic acid treatments arrested or reduced the microbial populations, thus preventing spoilage.

The use of either formic acid or brine would allow the processor to store the small daily volumes of waste in drums until they have enough by-product to economically ship to another area, to reprocess it into other products, or simply to dispose of it in a landfill site. In short, it provides a method for the short or long-term storage of fishery waste for potential utilization in animal feed or as fish bait.

The concept has been extended to the development of a commercial bait for the crab and lobster fisheries. The product is blended with a gelling agent, canned and stored for an indefinite

period. At the time of use, a hole is punched in the can, the can is placed in a trap, and the contents ooze out to attract lobsters or crabs. In addition, those animals that enter the trap can not eat the remaining bait. The latter point is important because with many baits presently in use, the first animal that enters the trap eats up all the bait and the trap can no longer attract additional animals. We ran a "taste panel" on lobsters using the canned liquified clam bellies. The canned product was equally as effective as redfish, the traditional lobster bait, in attracting lobsters into the traps. While we were unable to interview the lobsters that were attracted into the traps, they appeared content and satiated by the psuedo-redfish.

5. Utilization of Clam Shells

Clam shells are an underutilized resource. They represent about 50% of the total clam (Table 2). After the clam is shucked and the foot and mantle removed, the shells with the adhering meat and bellies are either returned to the water or are taken to an isolated location where the meat "disappears" over time. The remaining shells are pulverized and used for driveway coverings. In any case, the objective is to get rid of the shells in order to eliminate a pollution and environmental problem. Little emphasis has been placed on finding uses for the shells that would be of significant economic benefit to the shellfish processor.

In some cases, shellfish processors are located near agriculture croplands. It seemed logical to us that the shells might be useful as liming agents for agricultural lands. They are high in calcium (CaCO_3 ; carbonate equivalents is about 95%). Unfortunately, they contain very low levels of magnesium. This would suggest that the ground surf clam shells could serve as a liming material, but that additional magnesium would have to be included in some form.

The idea of using shellfish shells is not a new one. Oyster shells have been ground and used as chicken feed supplements. They are about 85-90% calcium carbonate. The feasibility of using clam, scallop or oyster shells will clearly depend upon the relative economic factors in the particular location being considered. Conversion of these shells to marketable products for the agricultural industry would result not only in economic benefits to the shellfish processor, but the correction of an environmental pollution problem. This problem is particularly significant in the summer months when the shells are stockpiled and the odor from the decaying meat becomes very objectionable.

6. Uses for Other Shellfish Parts

In addition to those already described, there are parts of shellfish that are excluded during processing and that have heretofore been discarded. One example is the mantle of the bay or sea scallop. In scallop shucking, the adductor muscle is retained as the marketable scallop meat and the mantles and bellies are

discarded. Like the clam situation, these discarded parts represent a wasted resource and a pollution problem. We have been evaluating these mantles as potential ingredients in processed seafood products such as seafood chowder.

Scallop mantles are flat, muscle-like membranes about 2 x 8 x 0.3 mm. They are often discarded with the shells in the waste stream. They are relatively easy to remove from the shell and can be chopped, washed, canned and marketed as a chowder ingredient through the same marketing channels as minced clams. A seafood chowder that has been developed by other Sea Grant researchers at Cornell University contains 10% of these scallop mantles (1). They impart a rich shellfish flavor to the product as well as contributing to the level of meat in the product. Since they are a low value product, they can compete economically with other meat ingredients (i.e. minced clams) as a chowder ingredient. The seafood chowder developed at Cornell also contains the clam juice that is manufactured from minced clam washwater. As stated earlier, it is possible to formulate this chowder without using minced clams by substituting the dried clam flavor derived from the washwater for clams (Table 1). Thus, a marketable product has been developed from several heretofore unused waste materials from shellfish processing.

Scallop mantles can also be readily converted to a puree. The puree can be canned, retorted at 121°C (15 psi) for 15 min. and kept for extended periods of time. Modified food starch and pyrophosphate-hexametaphosphate are included in the formulation. This puree could serve as a flavorful ingredient for dips, sauces and croquettes.

7. Marrying Fin and Shellfish Wastes

Often shellfish and finfish processing plants are located near to each other. The concept of marrying fin- and shellfish waste to produce marketable products is one that has not been explored in any great detail. Obviously, it would require the cooperation of the plant operators. Such cooperation would undoubtedly be facilitated by the economic benefits to be derived. For example, on Long Island, New York, there is a shellfish processor and a flounder fileting plant located one mile from each other. The fileting operation generates large quantities of frames or racks after the filets are removed. Commonly these frames are converted to fishmeal. We have been exploring opportunities for converting these racks or extracts of them into food ingredients. Obviously, food ingredients would command a higher market value than fishmeal. There has been some interest in mincing the cleaned racks and using them as a pet food ingredient. The concept that we have been investigating is to extract the flavor from the racks and to prepare a fish broth. This broth could be combined with the scallop mantles or salvaged clam meats from the clam processing to produce a seafood chowder base. Flavor problems have been encountered after retorting the fish broth. This has been the subject of a thesis problem just

completed by one of our Sea Grant trainees at Cornell University (6). From this work it was concluded that the treatment of fish racks was important to the storage stability of fish broths. The study looked at broths made from racks which had been stored in 3 different ways prior to being used: a) cleaned and used fresh; b) cleaned and frozen at -18°C for 11 days; or c) packed in ice, uncleaned, overnight. The best tasting broth was made with fresh fish racks or with frozen racks that had been first cleaned.

8. Fish Scales as a Coagulant

Fish scales represent an enormous resource for which no practical uses have been developed. They constitute about 1% of the total weight of the fish. The potential of the fish scales as a coagulant has been investigated by another Sea Grant trainee at Cornell (7,8). We see these materials as valuable aids in the pretreatment of food plant processing wastes. Chitosan has gained substantial notoriety in recent years as a flocculating agent. The results of our work suggests that dried and ground fish scales can function as effectively as chitosan as a flocculating agent (Fig. 5). Preparation of the scales was as follows. Carp and porgy scales were dehydrated at 46°C for 24 hr and subsequently milled to less than 500 micrometers. Dispersions (0.01%) were prepared and their coagulating capabilities compared to chitosan, alum and ferric chloride. Coagulating effectiveness was evaluated on egg washing and scallop shucking wastewater and on fruit juice processing effluents.

9. Brine Recovery from Fish Processing

Salt (NaCl) brines are used in many fish processing or "curing" operations. In many fresh fish fileting operations, 2.5-5% (w/v) salt brines are often used to handle and store fresh fish filets overnight. Some filets are even packed with brine. Fish fileters are under increasing pressure from municipal sewage plant operations to reduce the salt content of the fishery's waste discharge. Consequently, we have been studying methods for the reclamation of brine. Simultaneously, we have explored methods for recovering the protein from the brine solution. One process is summarized in Fig. 6.

This work stimulated some of us to look into the problem of dealing with brine solutions now being used aboard ships in conjunction with refrigeration systems. Ships are no longer allowed to discharge brine-fish debris material into harbors or bays while unloading fish catches. These brines do not have to be wasted because such fluids contain proteins, salt and fish fragments. In fact, brine solutions salt out about 2% of the fish proteins and these materials can be harvested as still another product.

Fig. 7 shows a recovery scheme which can be used on-board ships to renovate cooling brines. Such a process might be looked upon as a method to clean brine continuously much as methods which

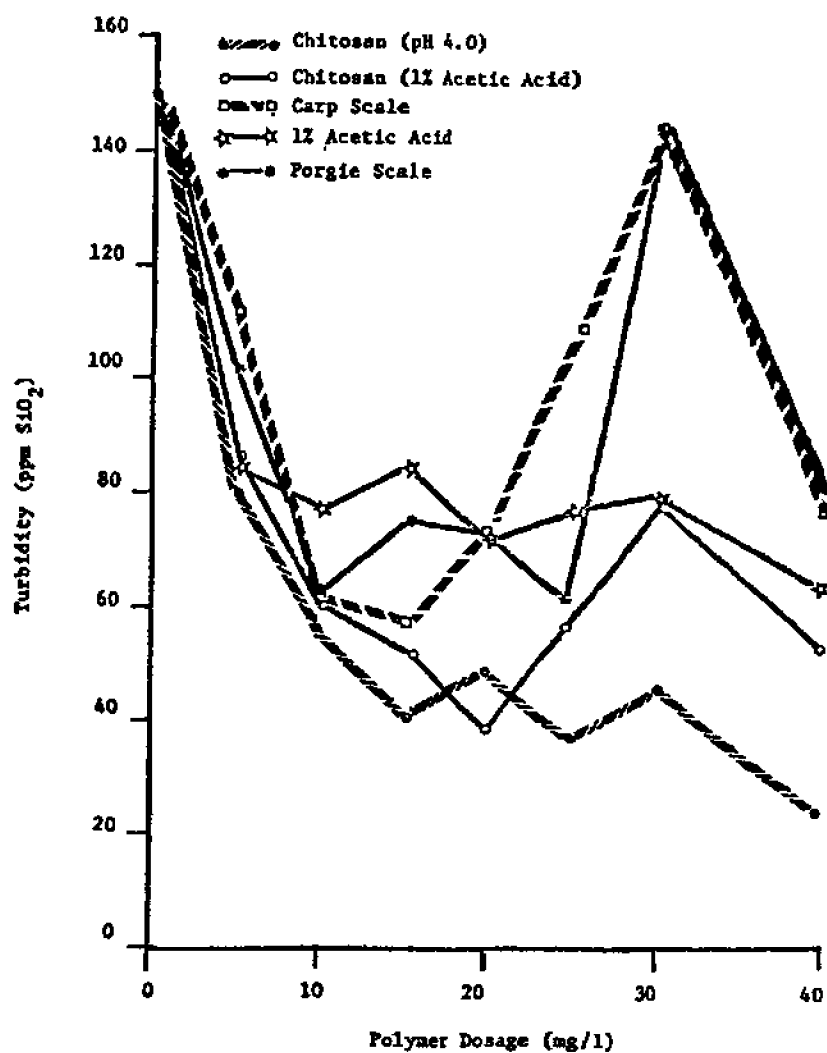


Figure 5. Turbidity-dosage results using the test coagulants, at their optimum ph conditions, to treat scallop shucking wastewater.

Source: Welsh and Zall, 1979.

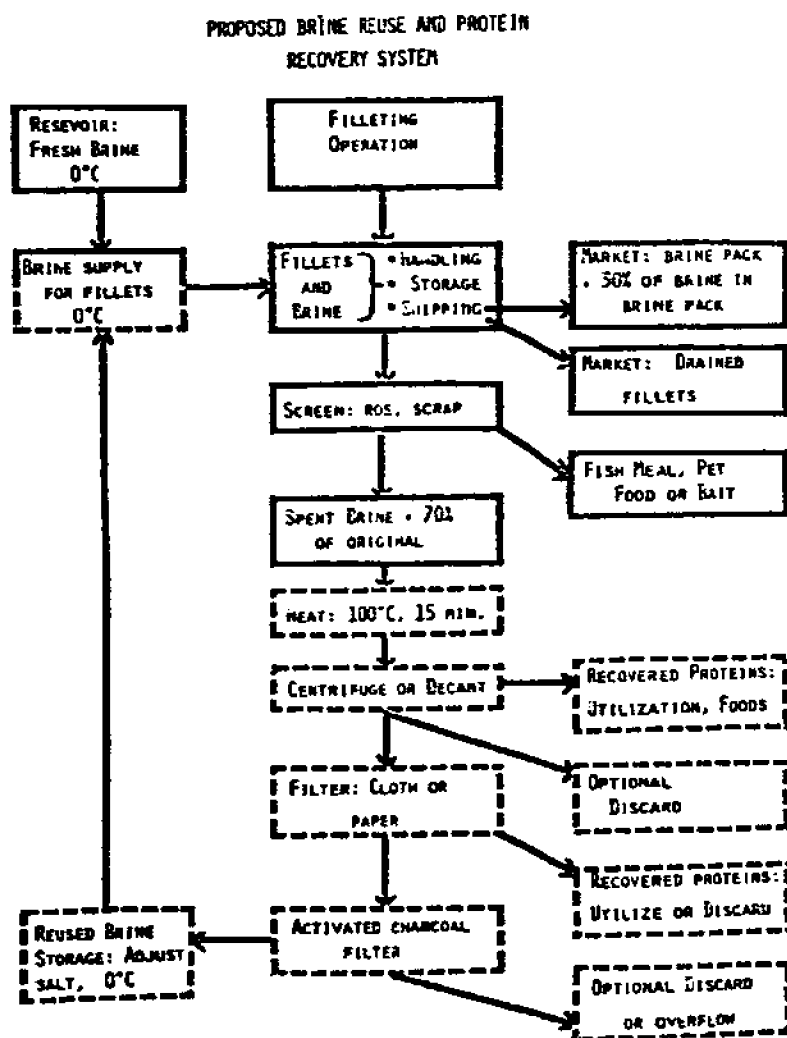


Figure 6. Proposed brine reuse and protein recovery system.

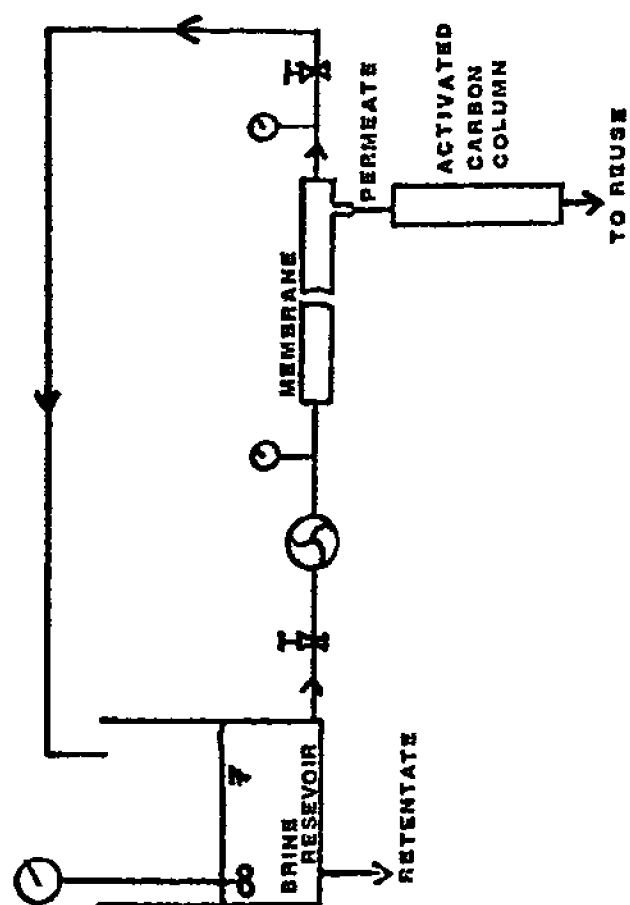


Figure 7. Schematic of the ultrafiltration-activated carbon system used to purify the brine prior to reuse.

filter swimming pool water or cheese brine. It is reasonable to believe that renovating shipboard brine liquids would also tend to improve fish quality in storage as it would remove blood and fish innards from the refrigerant.

A series of experiments were carried out in which frozen shipboard brine from tuna fish operations was sent to our laboratory in Ithaca for recycling studies. Samples of fresh fish were placed in freshly made up cold 9% salt brine and then stored for seven days at -10°C . "Like fish" from the same catch was also stored in renovated brine solutions from west coast material which had been processed through the membrane-charcoal system as shown in Fig. 7.

At the end of seven days, brines were thawed and separated from the fish. Fish was then graded for organoleptic quality characteristics by trained taste panelists using both the FDA raw fish quality evaluation methods and by a more conventional preference test using a hedonic scale of 1-10.

Stored renovated brine from the first trial was reused again by using it again with new fresh fish and the trial in week two, etc., until the same brine was reused in different storage trials six times. Our data show that brine can be reused at least five times without impairing the organoleptic quality of fish stored in recycled brine solution (Figures 8 and 9).

A full report of this work will be available by the end of the year in the form of a doctoral thesis now being completed by F. Welsh, a Sea Grant trainee from Cornell University.

When brine cannot be recycled it still needs attention, thus we looked into the treatability of spent brine as waste. The thesis will provide useful waste treatability information for this material. The organic material in fish brine was degraded using the yeast Candida utilis NRRL Y-900 in an aerobic reactor. COD strength was reduced more than 80% within 48 hours. Fig. 10 shows the changes in COD in waste over time.

Yeast cells produced during waste treatment can then be harvested as still another food crop in the form of single cell protein. In the course of the study, brine was treated both aerobically and anaerobically in order to look at the economies of treating shipboard brine liquids in more conventional waste treatment schemes. Our data suggest that the anaerobic approach will not treat these waste sufficiently enough without additional treatment.

10. Developing Processing Technology for Improving Seafood Quality

While the methods to harvest fish are gradually improving, the innovations to keep fish longer in its fresh state are only partially successful. The seafood industry's innovations to handle fish as a long shelf-life perishable food are not as impressive as the gains food processors made in general agriculture.

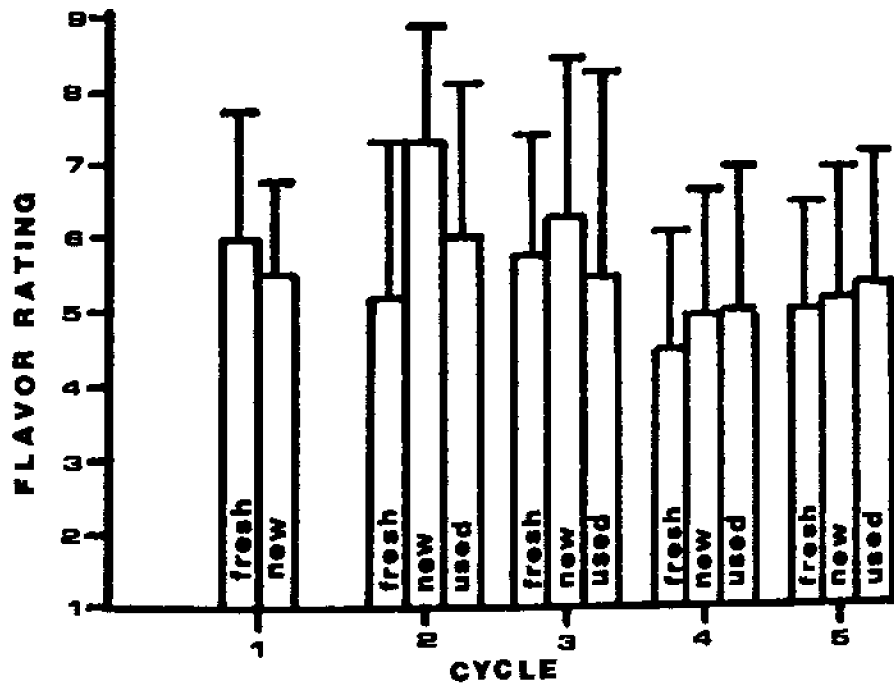


FIGURE 8. Effect on frozen brine storage of the fish carcass on the flavor of the fillet. (Scale: 1 = greatly dislike; 9 = greatly like).

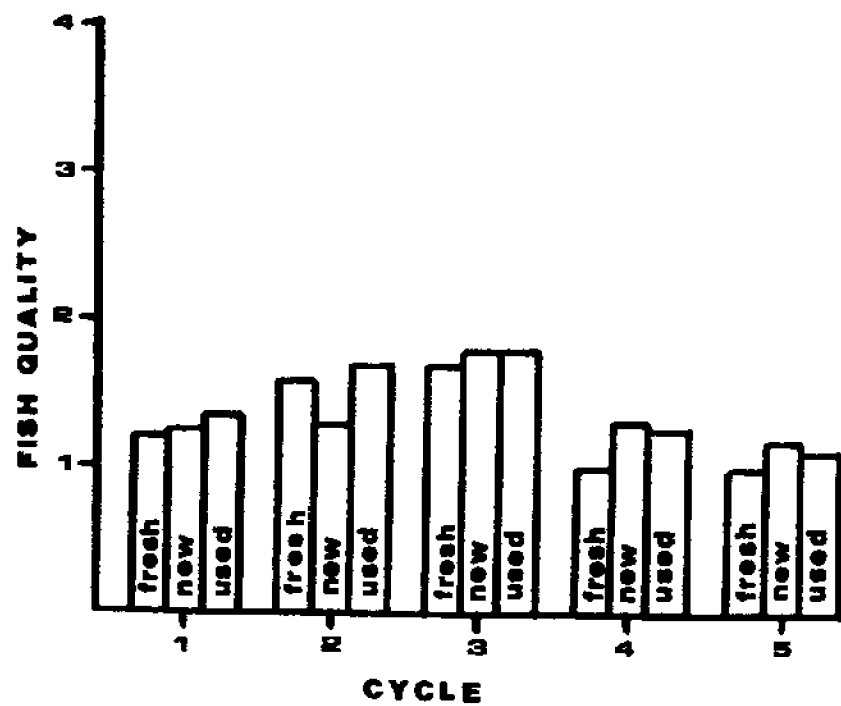


FIGURE 9. Effect of the frozen brine storage on the mackerel carcass quality. (Scale: 1 = excellent; 4 = rejectable) .

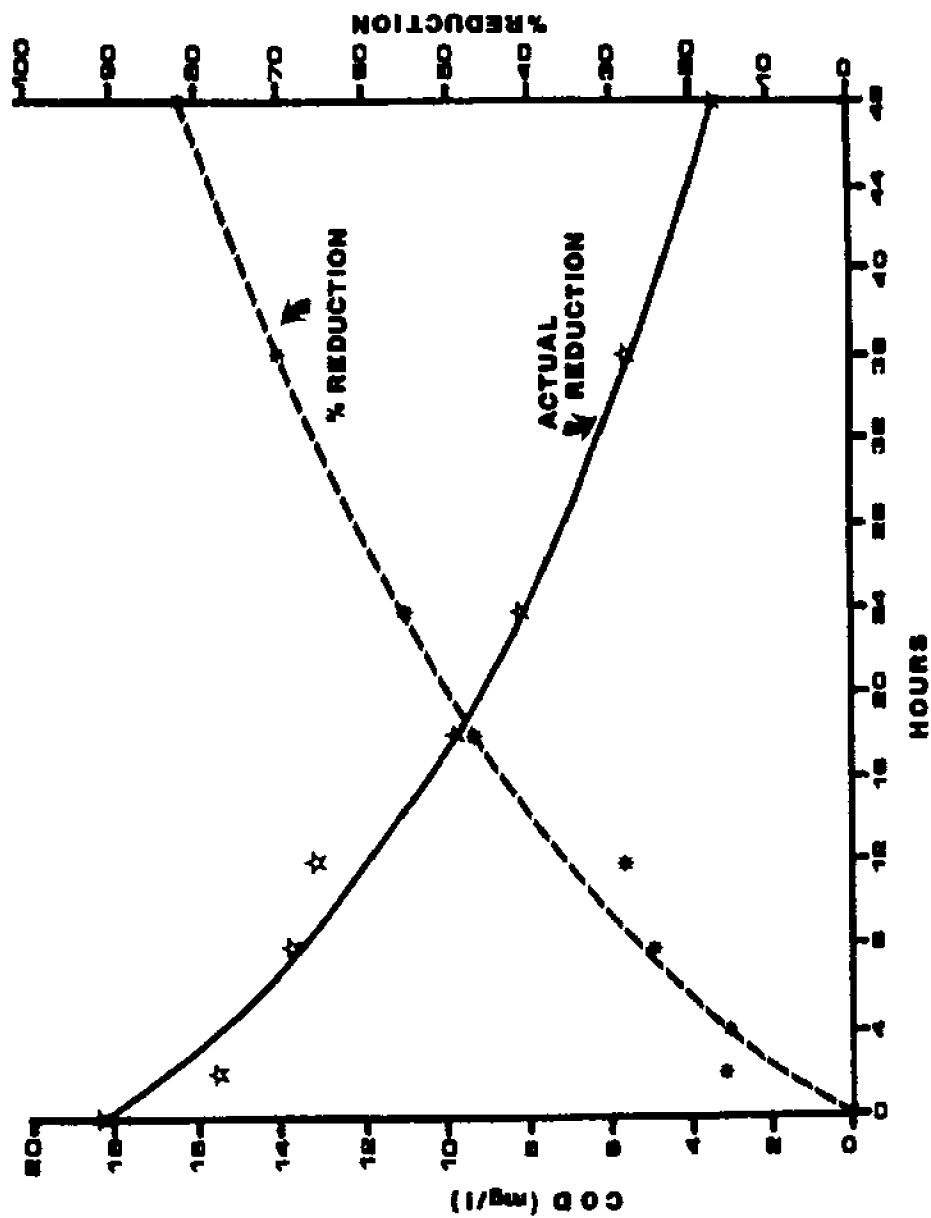


Figure 10. Changes in the COD concentration of the waste with time for the aerobic fermentation of the brine by Candida utilis NRRL Y-900.

Much of the progress toward keeping fruit and vegetable crops longer without a lot of processing can be credited to the use of blanching operations.

With this in mind, we have been studying the effects of blanching fish to control food spoilage. A review of the literature supports such a hypothesis and it appears that we are extending the life of fresh fish by using blanching methods.

Another of our Sea Grant trainees, S. Kelleher, has been blanching samples of fish both at Cornell and at the National Marine Fisheries Laboratory in Gloucester, Massachusetts. Much of the data generated from this work are very encouraging in that blanching seems to increase the shelf-life of such products. The study incorporates chemical, biological, biochemical and sensory evaluations to evaluate the blanching process.

Concurrent to this blanching work, we continue to look for quick field tests to measure seafood quality. In general, trimethylamine determinations have not served us very well at all. We have been looking at ethanol measurements as a method to monitor fish quality. Our preliminary data seem to make a strong case for using ethanol to measure fish quality. We expect to publish the results of this study in early 1981.

11. Separation of Sand from Press Liquor

There is increasing interest among fish fileters in processing the frames or racks into fishmeal because of the increasing emphasis on pollution control. In the commonly used wet-rendering fishmeal process, a press liquor by-product is produced which could be further processed by centrifugation and evaporation into fish oil and solubles. A processor who is already centrifuging press liquor has noted erosion of his centrifuge parts due to sand associated with the fish. The sand can potentially cause more economic damage to centrifuge parts than the returns from sale of fish oil and solubles. We found that the sand can effectively be removed by placing the fresh press liquor in Imhoff cones and allowing sand to settle. Separation can be accomplished with 4 hr. After that time, the concentration of total solids in the bottom of the cone is about four times greater than the concentration in the top oily layer (0.5% vs. 2% of the total solids on a dry weight basis). However, the bottom portion (settled sludge) represents only 5% of the total volume, whereas the top oily layer represents about 20-30%. The middle layer contains an average of about 1% sand (on a dry weight basis of the total solids). By allowing the bottom and most of the middle layer to by-pass the centrifuge and go directly to the condenser, more than half of the sand can be excluded from the centrifuge. This procedure saves wear and tear on the centrifuge and reduces manpower and energy requirements.

12. Characterization and Treatment of Clam Processing Wastes

Not all waste material can be converted to marketable products. For a variety of reasons, some must be discharged from the plant as waste. In some cases, it is necessary to treat the waste streams coming from plants. Municipal sewage systems may not exist, or if they do, are not capable of handling the plant effluents. Therefore, knowledge of the treatability of effluents can be a valuable assistance to the processor.

We have measured the water flow rates and characterized the waste stream from a typical surf clam processing plant and have evaluated several methods for treatment of the waste material. The washwater from the first two washing stations and after the mincing operation were analyzed for proximate composition. The following parameters were evaluated: BOD, COD, total solids, suspended solids, volatile suspended solids, TKN, NH_3 , pH and PO_4 . Effluent quality was determined by measuring turbidity, suspended solids and volatile suspended solids. The composite clam processing waste was amenable to aerobic biological treatment. After a retention time of 2 1/2 days or longer, better than 90% of the COD and BOD was removed (Table 3).

Results of these studies indicate that clam processing wastes are amenable to aerobic biological treatment. However, it would not appear to be possible to recover usable food products by the coagulation-sedimentation process using chitosan, alum or ferric chloride. Less than 10% of the total solids were recovered by chemical coagulation and sedimentation. These waste streams are quite dilute (less than 1% solids) and therefore may in part account for the ineffectiveness of the coagulating-sedimentation treatments (10).

ACKNOWLEDGMENTS

This research was sponsored by the New York Sea Grant Institute under a grant from the Office of Sea Grant, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Special thanks are due to our co-workers: D. Brown, I. Cho, R. Conway Taft, Dr. J. Green, Dr. W. Jewell, Y. Joh, S. Kelleher, Dr. W. Kim, S. Pettigrew, J. Plock, G. O'Shea, M. Switzenbaum, and F. Welsh.

Table 3. Reduction in chemical oxygen demand (COD)
after aerobic biological treatment.

Date	Solids Retention Time (SRT)			
	2.5 days	5 days	10 days	15 days
	----- % -----			
8/1		94.5	96.4	98.9
8/4		94.5	97.8	98.9
8/6		95.8	97.9	98.9
8/7		95.8	96.9	98.9
8/13	96.6			
8/14		91.9	91.2	95.1
8/15	89.7	93.4	91.2	94.9
8/18	91.3			
8/20		93.2	89.9	94.0
8/21	94.4			
Average	93.0	94.1	94.4	97.0

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EDIBLE RECOVERABLES - MINCED FISH, ETC.

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SITUATION AND PROBLEM

Did you know that each year in the United States we waste thousands of tons of fish? They are underutilized because of bones, bad naming, size or because of just plain habit. We as consumers in the United States dislike having bones in fish. Many underutilized species of fish do have many small bones, but with deboning machines today, this is not a problem.

The naming of fish in many cases was badly done. We are presently working with the white sucker, and have found that this name is unattractive to many people. In the Midwest and in Canada, the name of the white sucker has been changed to mullet, a name much more appealing to consumers. How about crappie? This is a species of fish which is very abundant, especially in Lake Erie. It is not very appealing to say, "How about coming to my house for a crappie dinner?" Other examples are: bullhead, sheepshead and cancer fish.

Many species of underutilized fish are small, and have been wasted because of the small size of the fillets. Today with deboning machines, size is not that important. Many people don't eat certain species of fish just because their parents didn't, and they feel they are not edible. Up until recently, practically no one in the United States ate squid, but for many, many years squid has been a delicacy in countries like Spain, France and Greece. Few people like carp in this country, but it is the most popular species in Israel.

Off the East Coast of the United States, fishermen state that approximately 30 percent of the catch is underutilized species. These fishermen also say they only fish in areas where the number of "trash" fish is low. According to the fishermen, there are many areas where they would catch only underutilized species; thus, they stay away. A guess is that 70 percent of the fish in the oceans are underutilized. In the Great Lakes it is estimated that approximately 80 percent of the fish are underutilized species. In most cases the fish are netted, killed and returned to the water as a pollutant.

In many of the smaller lakes, in some states, the underutilized species are caught, holes are dug by bulldozers and the fish are buried. They go through this procedure to avoid repeated catches.

It doesn't seem possible that we have wasted this excellent protein in the past. Most people know that fish are an excellent source of protein. Not only do they contain a high level of good quality protein, they are also extremely low in fat. Many species of underutilized fish contain from 1 to 3 percent fat. What is more, the fat is unsaturated.

APPROACH TO PROBLEM SOLVING

We at Cornell, along with others, are deboning these fish mechanically. We merely remove the head and entrails and wash the carcass thoroughly, and the cleaned fish is placed between a heavy plastic belt and a large metal cylinder which contains thousands of small openings. The belt and cylinder revolve at slightly different speeds which cause a scrubbing action, separating the flesh from bones and skin. The pressure from the belt forces the flesh through the holes in the cylinder, but the skin, bones, fins and scales can't get through because of their size, and come out the other side of the cylinder as waste. The degree of pressure on the belt determines the yield. From the dressed fish (minus head and entrails) we obtain yields of 50 to 75 percent depending upon the species used. The bone content is very low (under 1 percent) and the bones are so small in size that in most cases they cannot be detected. The bone content in the minced fish would be less than in fillets. The deboned fish from the machine looks very much like coarse-ground hamburger except that it is much lighter in color.

Another gigantic loss in high-quality protein in the past resulted in the filleting industry. After many popular species of fish are filleted by machine or by hand, the rack, the head and entrails are in most cases wasted. The rack minus the head and entrails can be machine-deboned. With the racks (also known as frames) we are able to obtain from 50 to 70 percent yield of flesh, depending upon the efficiency in removing the flesh from the frame when filleting.

OUTCOME

Most species of underutilized fish have a mild flavor and thus are not fishy in taste. We have found that minced fish (mechanically deboned) has a variety of uses. It can be substituted for hamburger (much lower in fat) or used in a variety of foods, including traditional dishes, for all countries. We have produced several foods including sloppy jonahs, spaghetti and fish balls, creamy fish bites, sweet and sour fish balls, lasagna oceana, stir-fried fish, chili, tacos, enchiladas, loaves, pizza, etc. It can also be used for gourmet types of fish dishes such as newburg and crepes. Many chefs have told us that the product is excellent

and saves them from grinding fillets for many dishes, including stuffed flounder.

Much of our research has been with the white sucker (mullet) which is exceedingly abundant in the Great Lakes. The minced product from the sucker contains only one half to three percent fat and thus has a very long freezer shelf-life. We have found that the white sucker plus many other underutilized species of fish produces a minced product that results in the production of better convenience foods than popular fish such as flounder, haddock or cod.

Dr. Dana Goodrich of our Agricultural Economics Department also receives research funding from Sea Grant and market tests our products. The first product market tested was minced fish in one pound frozen blocks. It was packaged in a cardboard box with a heavy waxed paper overwrap. The label served a dual purpose since it opened into a recipe book with fifteen different recipes for the use of the minced fish. The product, which was market tested in six supermarkets in Rochester, New York, sold very well; many consumers used it as an additional form of fish rather than substituting it for hamburger.

We have also market tested two seafood chowders from our laboratory, namely, Manhattan and New England. Each of the chowders contained 65 percent of seafood products that in the past were wasted. The sales were excellent. Other new products that have been market tested include Seafood Crispies, Creamy Fish Bites, and Canned Minced Fish. All of these products were popular with consumers. In the near future we will market test canned Red Hake and canned Pollock.

SUMMARY

What does this all mean? I hope it means that in the near future there will not be such a thing as underutilized fish, either in the United States or in the rest of the world. We just can't afford to waste this perfectly good food.

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UTILIZATION OF SHELLFISH MEALS IN DOMESTIC FEEDS

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The production of Alaskan marine by-products, specifically shellfish meals, is a relatively new industry in Alaska and represents the introduction of new products for livestock feeding. Waste reduction plants were constructed in 1973 and 1974 at Kodiak, Petersburg and Seward to process fish and shellfish processing wastes. These plants were the method of choice to meet the Environmental Protection Agency effluent guideline regulations for shellfish wastes set forth as a result of the passage in 1972 of the Federal Water Quality Control Act. Environmental Protection Agency guideline regulations for the handling of finfish processing wastes were withdrawn for a short interval to study economic inequities in Alaska, but a recent U.S. Court of Appeals ruling upheld EPA regulations to require processors to grind and screen seafood wastes and then haul them to sea for disposal. This ruling and the cost of disposal may result in increased production of meals and the introduction of new meals from a possible bottom fishery. Research to study the utilization of Alaskan marine by-products, specifically shellfish meals, for domestic livestock has been funded for the past three years by the Sea Grant Program.

In 1979, the total U.S. production of fishmeal was 387,000 metric tons with 4,043 tons produced in Alaska. Alaskan production included 2,482 tons of shellfish meal from crab and shrimp processing wastes and 1,561 tons from the processing wastes of halibut, herring, salmon and whitefish (U.S. Dept. of Commerce). This amount of meal is negligible when we consider that Alaska has been the number one state in dollar value of landings and that the bulk of the processed meal was produced from crab and shrimp wastes. However, if all the processing wastes from the domestic Alaskan 1979 catch had been processed into meal, the total production would have approximated 35,812 metric tons and an additional 262,500 metric tons of meal could have theoretically been produced from the foreign catch that was taken within the 200-mile limit.

The 200-mile limit was established by the Fishery Conservation and Management Act of 1976 and resulted in the State of Alaska's interest and support of a domestic bottom fishery. Bottomfish meals recently became available for evaluation as a protein supplement of livestock. When the bottomfish industry further develops, meals of unknown nutrient content and nutritional value will enter the market as potential livestock feeds. It is difficult to predict an estimate of the amount and type of bottomfish meals that will become available in the next few years. The rate at which a bottom fishery develops and the total possible catch within the near future was beyond the scope of this study. In addition, an estimate of the wastes from bottomfish processing is further complicated by variable amounts of waste resulting by differences in fish size. However, an example of the potential for bottomfish meal production in Alaska could be demonstrated by the 1977 Bering Sea total allowable catch of 850,000 metric tons of pollock. If 70% resulted in wet waste and 20% of this resulted in dry meal, a yield of 119,000 metric tons of pollock meal would be available as a livestock protein supplement. This amount would represent approximately 31% of the total U.S. domestic fish meal production in 1979. Furthermore, the restrictions of Japanese fishing brought about by the 200-mile limit may

result in increased Japanese domestic livestock production. Any increase of their domestic production will necessitate the increased importation of cereal grains and protein supplements to formulate rations. Alaskan fish meals may become a possible export product to meet the Japanese demands for protein supplements.

In 1977, Alaska produced greater than 50% of the U.S. domestic production of shellfish meals. The low price received for Alaskan crab meals can be partly explained by limited use of these meals in livestock feeds. Crab meals have been reported to be completely unpalatable to pigs (Morrison, 1959; Krider and Carroll, 1971) and until recently were not considered as a protein source for ruminant animals. The low price received for shrimp meal is difficult to explain when shrimp meal produced in the Gulf States has been reported to be an excellent protein source (Meyers and Rutledge, 1971; Meyers, 1976). Total production of these meals in Alaska is limited due to the great distances waste would have to be shipped from the primary processor to one of the operating reduction plants. Therefore, the limited production and paucity of information concerning their feeding value in livestock rations has contributed to the low economic return for these meals. Alaskan herring, halibut, and salmon meals are considered high quality meals for nonruminants and the operators of the meal reduction plants also receive a profit from the oils extracted from these processing wastes.

Palatability and the presence of large quantities of chitinous material could be serious limitations in the utilization of crab meal in livestock rations. Richards (1953) discusses the molecular structure of chitin as being very similar to that for cellulose, differing only in the substitution of an acetlyamine group for the hydroxyl group on carbon two of the glucose units. Therefore, one might anticipate that at least part of the chitinous material in crab meal would be subject to degradation by rumen microflora, similar to that observed for cellulose. Chitin digestibility from blue crab meal averaged 66% but varied from 26 to 87% when fed to ruminant calves (Patton, Chandler and Gonzalez, 1975). However, the chitin content of blue crab meal was reported to be 10% (Patton, Chandler and Gonzalez, 1975) while the estimate of chitin in King Crab meal from our laboratory using the acid-detergent fiber analysis (Van Soest and Wine, 1968) was 17 to 20%. Patton and Chandler (1975) have also reported very low rumen solubilities for shrimp meal, blue crab meal and purified chitin, 17.4%, 35.7% and 21.5%, respectively, using *in vivo* rumen fermentation studies. They concluded from these studies that the chitin molecule was a potential energy source for ruminants and that crab meal could supply some of the crude protein to ruminants when marginal protein rations were supplemented with crab meal. Alaskan crab meals are composed of shells, viscera and unextracted meat and some of the nitrogen is found as nonprotein nitrogen bound to the chitin molecule. However, the protein contributed from viscera and unextracted meat should be of excellent quality and could be readily utilized by nonruminant animals. If physical separation results in two fractions that represent the coarse shell material containing greater levels of chitin and a fine material from the viscera and unextracted meat, two products may be possibly marketed with one for ruminants and the other for nonruminants.

The continued study of fish meals as a livestock feed is of further interest to coincide with the State of Alaska's efforts in the development of agriculture as a renewable resource. The expansion of Alaskan agriculture was initiated in the summer of 1978 when the state sold agricultural rights to 60,000 acres in Interior Alaska for barley production. Land has been cleared and a small crop was produced in 1979 and farmers have contracted 15,000 acres of barley for the 1980 growing

season. The state is planning on the expansion of this project and to expand domestic milk production by financially assisting 30 to 40 potential new dairy farms. The Alaskan legislature has passed legislation to provide 660,000 acres of land for agricultural use and to promote beef and swine production within the next decade. At the present, fish meals are the only viable source of supplemental protein for livestock production and the expansion of this production would increase the demand for both finfish and shellfish meals.

This study was conducted as a multispecie approach to determine the utilization of Alaskan marine by-products, with particular emphasis on shellfish meals, as protein and energy sources in rations for domestic nonruminant and ruminant livestock. Specific objectives were: to determine the performance of lactating dairy cows, growing dairy and beef calves and growing-finishing swine fed shellfish meals as a protein supplement; to determine the effect of physical separation on the feeding and nutritional value of crab meals; to determine the relative *in vitro* digestibility of marine by-product meals by rumen microorganisms; to determine the protein quality of marine by-product meals; and to determine the digestibility of crab meal and crab meal chitin as an energy source for ruminants.

SWINE RESEARCH

Growth trials were initiated in 1976 to evaluate King crab meal (*Paralithodes camtschatica*) as a replacement for soybean meal (44% crude protein) in either barley-soybean meal or corn-soybean meal diets of growing-finishing pigs.

King crab meals were analyzed for dry matter, ether extract, ash, and acid detergent fiber (A.O.A.C., 1975; Van Soest and Wine, 1968). The chemical composition of the King crab meal is listed in Table 1. In Trial 4, King crab meal was separated through a 40-mesh sieve (Tyler Standard Soil Sieve) and the material less than 40-mesh was compared to the whole meal as a protein supplement replacement for soybean meal in barley diets. All diets were formulated to contain 16% crude protein during the growing phase for pigs 40 to 125 pound body weight when diets were then formulated to contain 13% crude protein until the pigs attained 220 pound body weight. Diets for Trials 1 and 2 are shown in Table 2A. King crab meal replaced 0, 25, 50 and 100% of the crude protein supplied by soybean oil meal in the barley-soybean meal basal diets. When pigs attained an average body weight of 125 pounds, the crude protein was reduced to 13% by increasing the barley and decreasing the soybean meal and King crab meal in proportion to maintain the same 0, 25, 50 and 100% ratios. Trial 3 was designed and conducted in a similar manner as above except that corn was the cereal supplying the energy portion (Table 2B). Trial 4 was designed in similar fashion to determine the effect of physical separation of King crab meal. Diets were as follows: barley-soybean meal basal, 50 and 100% replacement of soybean meal with King crab meal and 50 and 100% replacement of soybean meal with King crab meal that was finer than 40-mesh separation.

King crab meal could replace 50% of the crude protein from soybean meal in barley-soybean meal diets with a slight reduction in feed efficiency (Table 3). King crab meal replaced 25% of the crude protein of soybean meal in corn-soybean meal diets without either a reduction in average daily gain or feed efficiency (Table 4). The maximum level of King crab meal as a percentage of dietary intake was between 5.3 and 6.3% for corn and barley based diets, respectively. Physical separation of King crab meal resulted in similar average daily gains for pigs fed the basal, 50%

TABLE 1
Proximate composition of King crab meals, soybean meal and barley

Item	Trials 1, 2 and 3	Trial 4			Soybean Meal	Barley
		Whole	<40 Mesh	>40 Mesh		
Dry matter, %	94.3	95.6	95.4	95.6	89.5	88.6
Crude protein, %	40.1	41.7	48.1	35.7	44.0	12.8
Ether extract, %	1.4	3.0	4.2	1.8	1.3	1.7
Ash, %	36.8	36.9	31.7	41.3	5.8	2.2
Crude fiber, %	17.9	17.6	—	—	—	—
Acid detergent, %	20.7	20.6	15.6	27.4	10.1	7.8
Calcium, %	12.4	9.0	7.9	10.3	0.24	0.08
Phosphorus, %	1.8	1.6	1.4	1.7	0.66	0.4

TABLE 2A

Composition of swine diets, percent of diet, growing and finishing period,
Trials 1 and 2

Ingredient	Grower ¹			
	Basal	25% KCM	50% KCM	100% KCM
Barley	85.3	86.1	85.9	85.4
Soybean meal	11.7	8.8	5.8	—
King crab meal	—	3.1	6.3	12.6
Limestone	1.0	—	—	—
Dicalcium phosphate	1.0	1.0	—	—
Sodium phosphate	—	—	1.0	1.0
Trace mineral salt	0.5	0.5	0.5	0.5
Vitamin-antibiotic premix	0.5	0.5	0.5	0.5

Ingredient	Finisher ¹			
	Basal	25% KCM	50% KCM	100% KCM
Barley	95.6	95.6	95.6	95.4
Soybean meal	1.9	1.4	0.9	—
King crab meal	—	0.5	1.0	2.1
Limestone	1.0	1.0	1.0	1.0
Dicalcium phosphate	0.5	0.5	0.5	0.5
Trace mineral salt	0.5	0.5	0.5	0.5
Vitamin-antibiotic premix	0.5	0.5	0.5	0.5

¹Grower diets contained 16% crude protein and were fed 40 to 125 lb. body weight. Finisher diets contained 13% crude protein and were fed 125 to 220 lb. body weight.

TABLE 2B

Composition of swine diets, percent of diet, growing and finishing period, Trial 3

Ingredient	Grower ¹				
	Basal	25% KCM	50% KCM	75% KCM	100% KCM
Corn	77.2	77.9	77.5	77.1	76.6
Soybean meal	19.8	14.8	9.9	4.9	—
King crab meal	—	5.3	10.6	16.0	21.4
Limestone	1.0	—	—	—	—
Phosphate, defluorinated	1.0	1.0	—	—	—
Sodium phosphate	—	—	1.0	1.0	1.0
Trace mineral salt	0.5	0.5	0.5	0.5	0.5
Vitamin-antibiotic premix	0.5	0.5	0.5	0.5	0.5
	Finisher ¹				
	Basal	25% KCM	50% KCM	75% KCM	100% KCM
Corn	86.9	87.2	87.0	86.8	86.4
Soybean meal	10.6	8.0	5.3	2.6	—
King crab meal	—	2.8	5.7	8.6	11.6
Limestone	1.0	—	—	—	—
Phosphate, defluorinated	0.5	1.0	0.5	—	—
Sodium phosphate	—	—	0.5	1.0	1.0
Trace mineral salt	0.5	0.5	0.5	0.5	0.5
Vitamin-antibiotic premix	0.5	0.5	0.5	0.5	0.5

¹Grower diets contained 16% crude protein and were fed 40 to 125 lb. body weight. Finisher diets contained 13% crude protein and were fed 125 to 220 lb. body weight.

TABLE 3
Growth performance of pigs fed levels of King crab meal with barley (Trial 1 and 2)

Item	Diet ¹			
	Basal	(25% KCM)	(50% KCM)	(100% KCM)
Number of pigs	8	8	8	8
KCM dietary intake, %	0	3.1	6.3	12.6
Average daily gain, lb.	1.76 ^a	1.74 ^a	1.72 ^a	1.54 ^a
Average daily feed, cons., lb.	5.81	5.85	5.96	5.70
Feed: Gain ratio	3.36 ^c	3.40 ^{cd}	3.54 ^{de}	3.70 ^f

¹a,b,c,d,e values with different superscripts were significantly different (P<0.05).

TABLE 4
Growth performance of pigs fed levels of King crab meal with corn (Trial 3)

Item	Diet ¹				
	Basal	25% KCM	50% KCM	75% KCM	100% KCM
Number of pigs	4	4	4	4	4
KCM dietary intake, %	0	5.3	10.6	16.0	21.4
Average daily gain, lb.	1.87 ^a	1.90 ^a	1.65 ^b	1.67 ^b	1.47 ^c
Average daily feed cons., lb.	6.16	5.98	5.68	5.54	5.98
Feed: Gain ratio	3.31 ^d	3.25 ^d	3.60 ^e	3.81 ^e	4.13 ^f

¹a,b,c,d,e,f values with different superscripts were significantly different (P<0.05).

whole meal and 50 and 100% separated meal diets. A reduction in average daily gains resulted only from replacement of soybean meal with 100% whole King crab meal. Feed efficiency was reduced only on the diet containing 100% whole King crab meal (Table 5). Amino acid analysis of the fine material revealed that the lysine content of meal finer than 40-mesh was similar to the lysine content of 44% soybean meal, 2.70% lysine.

A study with Tanner crab meal (*Chionoecetes bairdi*) was designed and conducted as described above for Trials 1 and 2 for King crab meal for growing-finishing pigs. Results were similar and Tanner crab meal could replace 50% of the soybean meal protein in barley-soybean meal diets without a reduction in either the rate or efficiency of body weight gains. The level of dietary intake corresponded to 7.1%.

A similar study with shrimp meal (*Pandalus borealis*) that contained only 32.5% crude protein resulted in only a 25% replacement of soybean meal crude protein in barley-soybean meal diets without either a reduction in average daily gains or efficiency of gains. The level of intake was 5.9% of the diet.

Similar trials are currently being conducted with Dungeness crab meal (*Cancer magister*) and the results should be available in early 1981. At the present, these results have been used to recommend the utilization of Alaskan shellfish meals at the dietary intake level not to exceed 6% for growing-finishing swine.

DAIRY CATTLE RESEARCH

One experiment, encompassing 30 cows, has been completed and the data summarized and prepared for publication in the Journal of Dairy Science. A second experiment, encompassing 30 cows, has been completed and data are being summarized. A third experiment, which will also encompass at least 30 cows, is planned for 1980 through 1982. These experiments are relatively consistent in experimental design. All three are focused on the first four months of lactation by dairy cows because feed intake and nutritional requirements are most critical during early lactation. Cows are randomly assigned to the experiments at similar stages of early lactation. They are fed a positive control ration for three weeks and then randomly assigned to experimental rations for 9 to 12 weeks. Milk production and liveweight data during the control period are used to adjust production and liveweight data during the experimental period through covariance and adjustment.

In the first experiment, animals individually were fed pelleted concentrates and silage in separate containers to provide the maximum opportunity for independent rejection of either feed. Concentrate rations included a negative control to assess response to protein supplementation and concentrates supplemented at 2 levels with either soybean meal or crab meal on an isonitrogenous basis (Table 6).

Milk production (Table 7) was significantly greater ($P < 0.01$) when either protein supplement was included in the diet, higher at the higher levels of supplementation ($P < 0.1$), and not significantly different for the two sources of protein supplementation. Liveweight gains (Table 7) were linear for animals fed soybean meal concentrates and were nonlinear for those fed the negative control or crab meal concentrates. Cows rejected .5 and .2 kg/day dry matter of the high and low crab meal rations and rejected essentially none of the negative control or soybean meal rations (Table 8). Results from the first experiment suggest that crab meal can be used as a

TABLE 5
Growth performance of pigs fed levels of separated King crab meal with barley
(Trial 4)

Item	Diet				
	Basal	50% KCM		100% KCM	
		Whole	40 Mesh	Whole	40 Mesh
Number of pigs	4	4	4	4	4
KCM dietary intake, %	0	4.7	4.1	9.3	7.6
Average daily gain, lb.	1.60	1.53	1.62	1.25	1.58
Average daily feed cons., lb.	5.39	5.48	5.37	4.22	5.17
Feed: Gain ratio	3.31	3.59	3.30	3.79	3.42

TABLE 6

Ration components and nutrient composition for lactating dairy cows

Ingredients	Concentrate rations %				
	NEG	HSOM	LSOM	HCM	LCM
Corn	51.4	33.4	42.4	29.7	41.2
Barley	-----		15.0	-----	
Mixed feed oats	-----		10.0	-----	
Beet pulp	-----		15.0	-----	
Molasses	-----		7.0	-----	
Soybean oilmeal	0.0	18.0	9.0	0.0	0.0
Crabwaste meal	0.0	0.0	0.0	22.5	11.0
Monocalcium phosphate	0.4	0.4	0.4	0.0	0.0
Dicalcium phosphate	0.4	0.4	0.4	0.0	0.0
Trace mineral salt	-----		0.8	-----	
Vitamin A	-----		4400 IU/kg	-----	
Vitamin D ₂	-----		13200 IU/kg	-----	

Ration	Ration Composition (dry matter)	
	ME (Mcal/kg)	Protein (%)
Silage	1.99	10.7
Negative control	2.97	9.7
Soybean oilmeal	High	16.5
	Low	14.9
Crabwaste meal	High	17.0
	Low	13.5

TABLE 7
Milk production and liveweight gains for lactating dairy cows fed King crab meal
(kg)

Ration		Milk ¹	4% FCM ¹	Liveweight
Negative control		22.7	20.1	597.7
Soybean oilmeal	High	26.2	23.3	605.3
	Low	25.6	22.7	605.3
Crabwaste meal	High	26.0	23.4	592.5
	Low	23.6	21.0	611.6

¹P<0.05.

TABLE 8
Feed intake and refusal for lactating dairy cows fed King crab meal (kg dry matter)

Ration	Silage		Concentrate	
	Intake	Refused	Intake	Refused ¹
Negative control	10.3	1.6	7.6	0.03
Soybean oilmeal	High	1.5	7.3	0.03
	Low	1.5	7.6	0.00
Crabwaste meal	High	1.5	8.0	0.48
	Low	1.5	7.3	0.20

¹p<0.05.

protein supplement in concentrates for lactating dairy cows, but not without reservation relative to palatability and liveweight gain.

The second feeding experiment was designed to study two consequences of blending concentrates with forage at the time of ensiling or at the time of silage feeding to be fed as total, complete rations. Pelleted concentrates included a negative control and two levels of crab waste. This experiment has been completed and data are presently being analyzed statistically.

The first two experiments were designed to study animal performance on concentrates in which crab meal replaced 0 or 100% of the soybean meal. The third experiment is designed to study the incremental replacement of soybean meal with crab meal from 0, 25, 50, 75, and 100% on an isonitrogenous basis. It is anticipated that data from this experiment will provide first approximations of the point where further substitution of crab meal for soybean meal is inadvisable.

The concentrates formulated for the third experiment, with the exception of 50% replacement, will be fed to growing Holstein steers and heifers from age 60 to 360 days to study the efficacy of using crab meal at various levels in concentrates for young, rapidly growing ruminants.

LABORATORY SIMULATION OF DIGESTION: Eighteen protein concentrates have been subjected to sequential digestion in the laboratory to simulate stages of digestion in simple- and complex-stomached animals. The substrates included one sample of soybean meal as a standard, seven samples of different fish meals, and ten samples of king and tanner crab meals. *In vitro* dry matter, organic matter, and nitrogen disappearance, and effluent $\text{NH}_3\text{-N}$, were determined in a buffered solution, in hydrochloric acid solution, and in hydrochloric acid-pepsin solution to obtain estimates of neutral solubility, solubility in the abomasum, and solubility in the upper intestinal tract (Figures 1-4). Data on the same variables were obtained in the presence of rumen microorganisms, hydrochloric acid solution, and hydrochloric acid-pepsin solution to obtain estimates of digestibility in the rumen-reticulum, and post rumen-reticulum in the abomasum and in the upper digestive tract (Figures 5-8). Statistical analysis of these data is proceeding to define differences in simulated digestion and $\text{NH}_3\text{-N}$ for these 18 substrates. Data were pooled to provide graphic representation of sequential digestion and $\text{NH}_3\text{-N}$ for soybean meal, fish meals, and crab meals which were shown in Figures 1 through 8.

Ammonia production is negligible in the absence of rumen microorganisms. A considerable portion of the nitrogenous material in both fish and crab meal is resistant to microbial digestion and provides a source of bypass protein in rations for ruminants. Excessive microbial digestion of protein in the rumen could result in loss of nitrogen via rumen overflow of ammonia.

QUALITY CONTROL: It is also proposed to analyze chemically random samples of specific marine waste products to obtain reliable estimates of means and variance components for these products. These will provide guidelines for the waste processor and the feed manufacturing industry in making effective use of marine waste products. The processing industry should be prepared to provide the feed industry with products having recognized classifications and reliable estimates of composition and

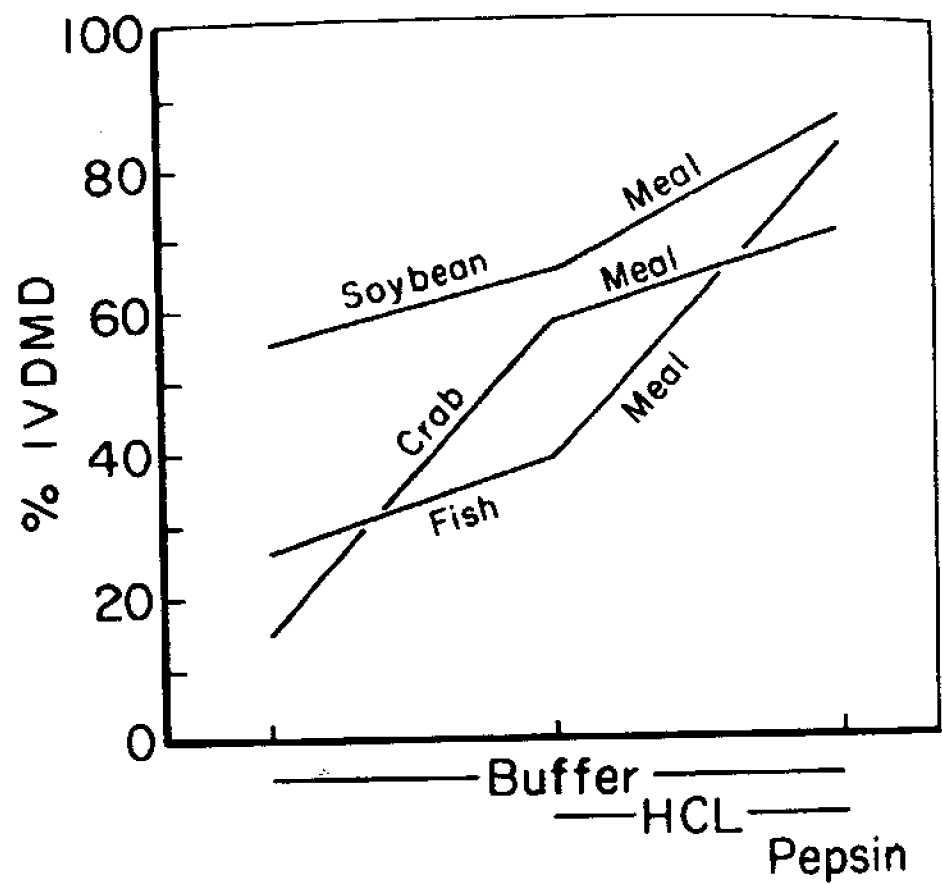


FIGURE 1. IN VITRO DRY MATTER DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES WITHOUT THE PRESENCE OF RUMEN MICROORGANISMS.

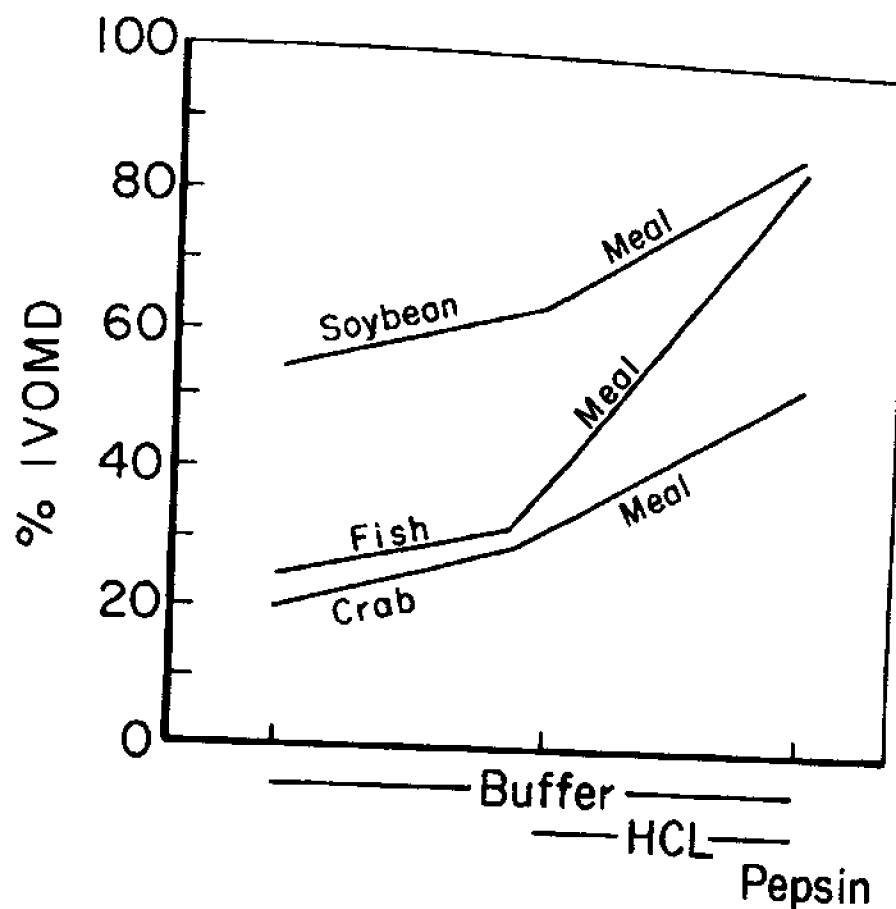


FIGURE 2. IN VITRO ORGANIC MATTER DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES WITHOUT THE PRESENCE OF RUMEN MICROORGANISMS.

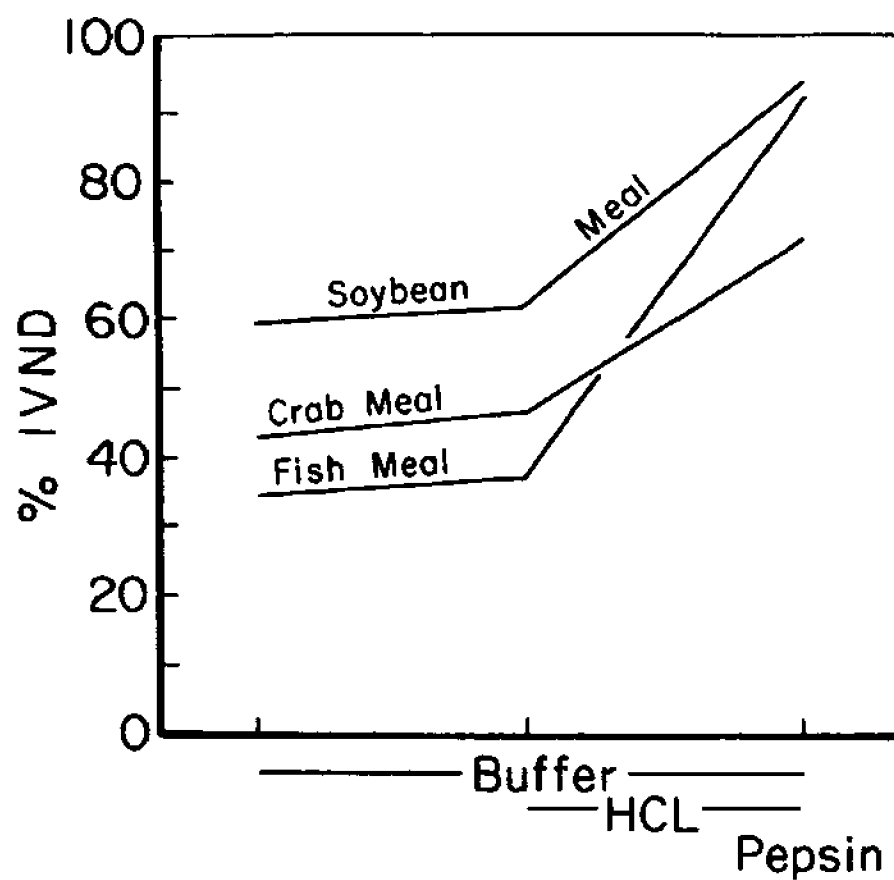


FIGURE 3. IN VITRO NITROGEN DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES WITHOUT THE PRESENCE OF RUMEN MICROORGANISMS.

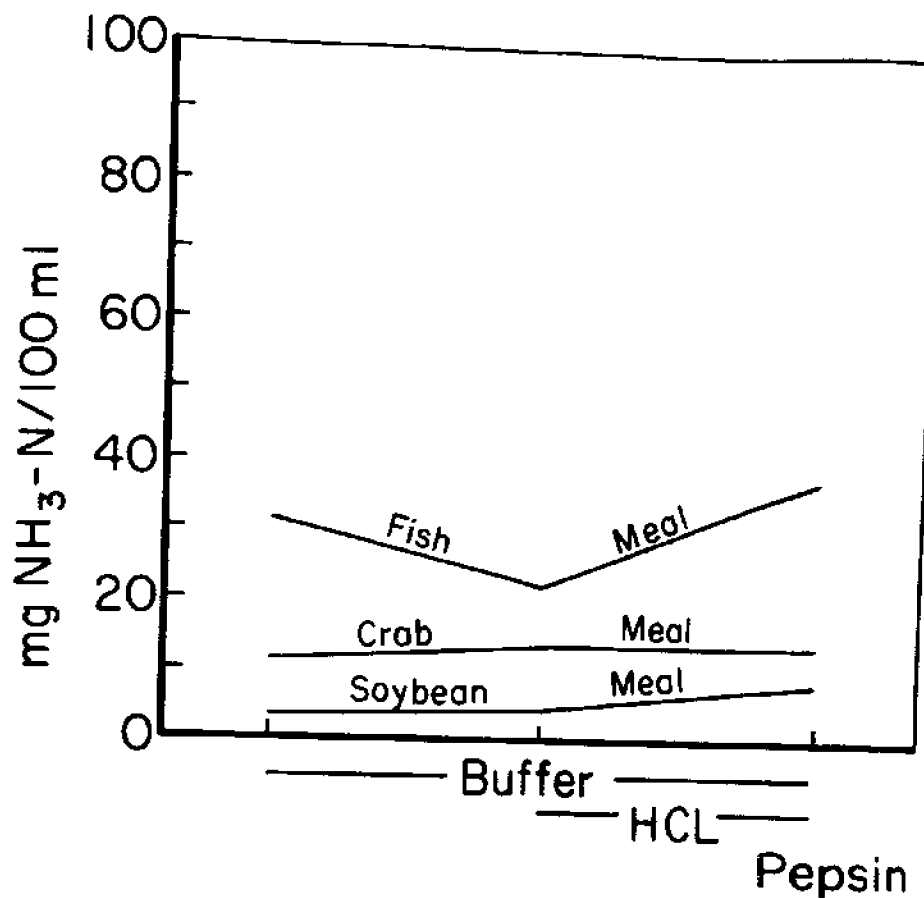


FIGURE 4. IN VITRO EFFLUENT AMMONIA - NITROGEN OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES WITHOUT THE PRESENCE OF RUMEN MICROORGANISMS.

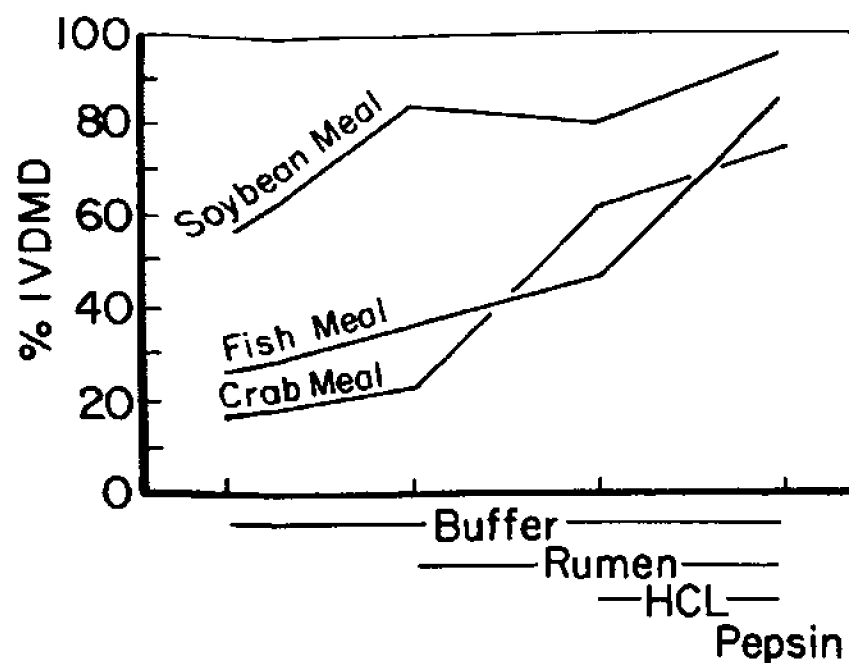


FIGURE 5. IN VITRO DRY MATTER DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES IN THE PRESENCE OF RUMEN MICROORGANISMS.

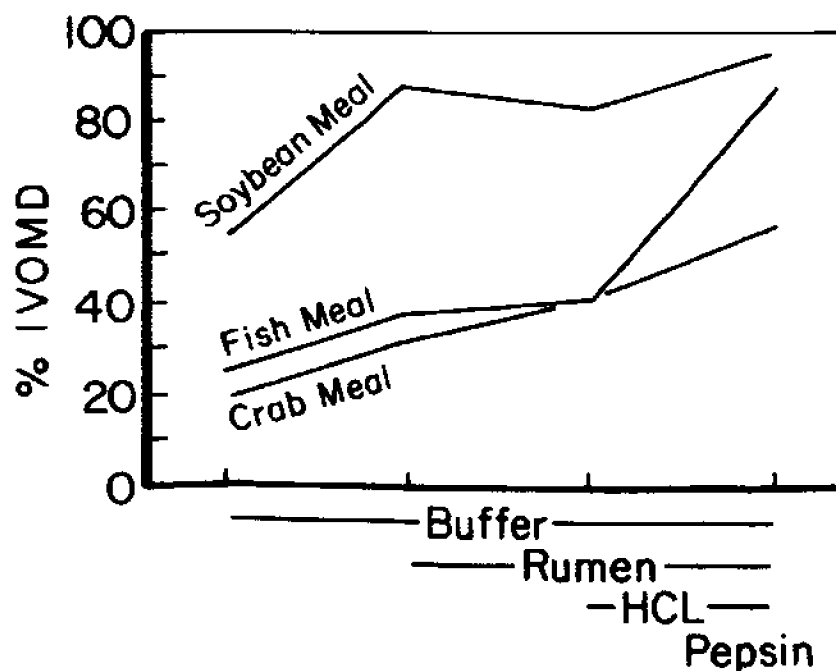


FIGURE 6. IN VITRO ORGANIC MATTER DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES IN THE PRESENCE OF RUMEN MICROORGANISMS.

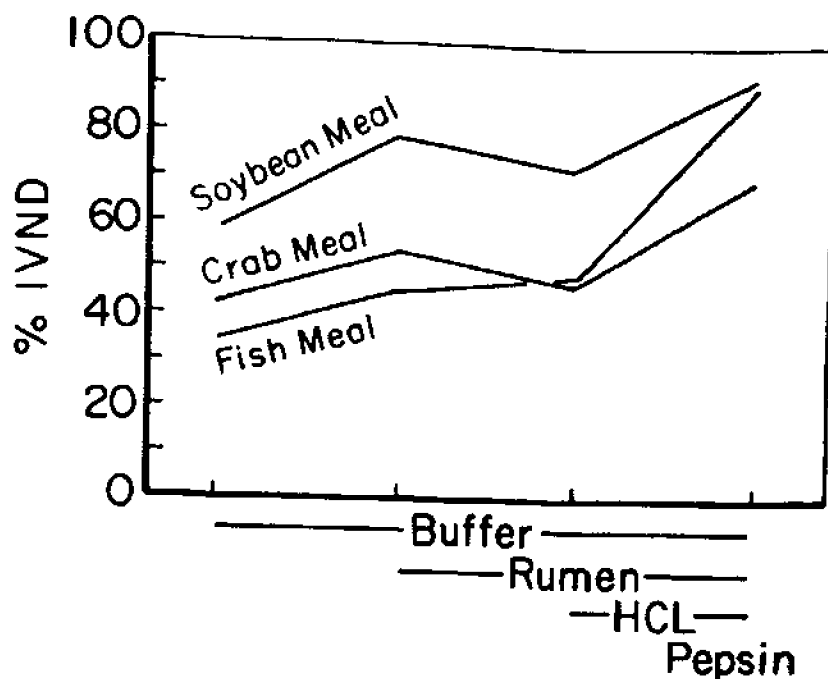


FIGURE 7. IN VITRO NITROGEN DISAPPEARANCE OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES IN THE PRESENCE OF RUMEN MICROORGANISMS.

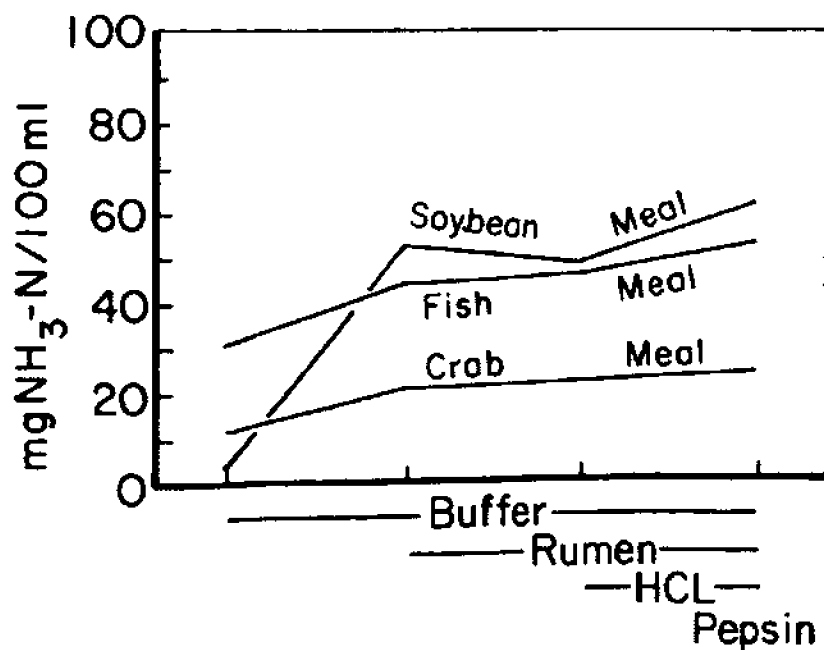


FIGURE 8. IN VITRO EFFLUENT AMMONIA-NITROGEN OF SOYBEAN MEAL AND POOLED FISH MEAL AND CRAB MEAL SUBSTRATES IN THE PRESENCE OF RUMEN MICROORGANISMS.

composition variability. Current recommendations for the utilization of crab meal in dairy cattle concentrate rations suggest that a level of 10% of the ration not be exceeded for crab meal inclusion.

BEEF CATTLE RESEARCH

Until recently, the limited use of crab meals in livestock rations were believed to be due to the high ash and chitinous material making the feeds unpalatable. The molecular structures of chitin and cellulose are very similar, the chitin molecule differing only in the substitution of an acetamide group for the hydroxyl group on carbon II of the glucose units (Richards, 1953). Therefore, one might anticipate that at least part of the chitinous material in crab would be subject to degradation by rumen microflora, similar to that observed for cellulose. Based on digestibility studies, Patton, Chandler and Gonzalez (1975) reported the chitin molecule to be a potential energy source for ruminants. However, the results of these studies were highly variable, indicating the need for further study.

The major objective of this study was to determine whether chitin from crab meal is degraded by the rumen microflora of beef cattle. Minor objectives include: (1) to determine if chitin is resistant to acid detergent digestion and therefore constitutes a fibrous component of shellfish meals; (2) to examine the nutritional effect of physical separation of whole crab meal into fine (tissue) and coarse (shell) fractions; (3) to determine if the rumen microflora can adapt to a chitin containing diet; (4) to determine crab meal chitin disappearance during selected time periods.

A trial was performed to compare the modified Welinder method (1973) and the Van Soest acid detergent fiber method (Van Soest and Wine, 1968) for estimating the chitin content of shellfish by-products. Prior to chitin, *in vivo* and *in vitro* analyses, Tanner crab meal samples were separated using a 40-mesh sieve (U.S. equivalents of a Tyler Sieve standard 420 μ m) into three fractions, whole, coarse (>40 mesh) and fine (<40 mesh). All substrates were analyzed for moisture and ash (A.O.A.C., 1975).

The utilization of Tanner crab meal (*Chionoecetes bairdi*) by beef cattle rumen microflora was determined by *in vivo* and *in vitro* dry matter disappearance; including chitin, protein and ash. Two mature head of beef cattle with rumen fistulas were fed a maintenance energy diet of brome hay during Period I and adjusted on an energy basis to 25% Tanner crab meal–75% brome hay maintenance diet during Period II. *In vivo* disappearance of Tanner crab meal substrates from nylon bags (Mehrez and Orskov, 1977) suspended in the rumen was determined over time. Rumen fluid was acquired from each animal within the same period to determine and correlate *in vitro* disappearance using the Tilley and Terry (1963) two stage digestion technique with *in vivo* disappearance.

CHITIN ANALYSIS: No significant difference ($P>0.05$) was detected between the Van Soest acid detergent fiber and modified Welinder methods for chitin determination, when Tanner crab, including whole, coarse and fine fractions, and whole and by-product shrimp meals were analyzed (Table 9). A significant difference ($P<0.05$) did exist between methods for chitin determination when Dungeness crab meal was analyzed. The acid detergent fiber analysis was originally designed to measure the cellulose and lignin fractions of plant materials. The success of using acid detergent

TABLE 9

Comparison of chitin composition by the Van Soest ADF
and modified Welinder methods¹

	Welinder	n	ADF	n
Tanner crab meal				
whole	17.4±.1	15	17.8±.4	10
coarse	21.1±.2	9	21.1±.4	9
fine	14.9±.2	14	14.9±.1	9
Shrimp meal				
whole	5.0±.1	14	5.4±.1	18
by-product	16.3±.4	18	17.1±.3	18
Dungeness crab meal ²	12.7±.1	18	13.6±.2	18

¹Data are expressed as percent chitin and are means ±SEM.

²Methods statistically different (P<0.05).

fiber analysis for chitin was probably due to the strong similarities between chitin and cellulose molecular structures (Richards, 1953). The failure to quantitate chitin in Dungeness crab by the acid detergent fiber method may be due to an unidentified species difference, such as a greater percentage of interfering proteins.

Prior to acid detergent fiber treatment per cent nitrogen in whole, coarse, and fine Tanner crab meal varied from 4.4–6.8%. Residues from acid detergent fiber analyses, presumably chitin, from crab meal substrates contained 6.6–6.7% nitrogen (Table 10). These results supported the use of the Van Soest method for chitin analyses. If the acid detergent fiber residues were composed of chitin, the nitrogen content should have been less than 7% and greater than 7% if the residue contained chitosan as reported by Muzzarelli (1977).

CRAB MEAL SEPARATION STUDY: Following physical separation of Tanner crab meal through a 40-mesh sieve (420 μ m), the material finer than 40-mesh had a 17.1% greater crude protein content and a 16.3% reduction in chitin and ash. Material greater than 40-mesh contained 21.3% less protein and an 18.5% and 17.2% increase in chitin and ash, respectively (Table 11). Whole Tanner crab meal was characterized by a crude protein content of 35%, a low ether extract, high ash and fiber contents. The crude protein was similar to the amount of protein for by-products of plant origin. However, some nitrogen is contained in the chitin molecule and may be released as ammonia when chitin is degraded and may be in a form usable by rumen microorganisms. If the finer material represented viscera and unextracted meat, then it should have had a higher crude protein content and a higher quality protein than the whole meal which contains some crude protein in the amino form on the chitin molecule. Physical separation of crab meal into fine and coarse particles enhanced *in vivo* and *in vitro* disappearance of all components for the fine fraction, while disappearance of all components of the coarse fraction were decreased.

These results may be partially explained in terms of surface area; the smaller the size, the greater the surface area available for bacterial and protozoal attack. In addition, one must consider the composition of the various fractions. The fine material contained less ash and the relatively insoluble chitin but a greater protein content, while the coarse material had a greater content of chitin, ash and the insoluble sclerotinin-arthropodin chitin bound proteins.

IN VIVO AND IN VITRO STUDIES: During Periods I and II *in vivo* disappearance for all components was greater than *in vitro* disappearance. This was expected, the *in vivo* system being an open system, and the *in vitro* system being closed. Data indicated that the relative disappearance due to treatment were similar between the *in vivo* and *in vitro* methods.

Although initial analyses indicated that Tanner crab meal was more completely digested following simulated gastric digestion, data indicated Tanner crab was utilized by rumen microflora. Dry matter disappearance increased dramatically upon addition at 48 hr. of acid and pepsin (Table 12). Further studies indicated that the increase was due primarily to an 80% ash component disappearance. The ash component was primarily composed of calcium carbonate. The acid apparently reacts with the calcium carbonate matrix of the shell releasing carbon dioxide.

TABLE 10
Comparison of hay, whole, fine, and coarse Tanner crab meal nitrogen
before and after ADF analysis¹

Substrate	n	Fresh (% N)	ADF residue (% N)
Brome hay	3	1.4±.2	0.2±.1
Whole crab meal	3	4.7±.2	6.6±.1
Coarse	3	4.4±.3	6.6±.1
Fine	3	6.8±.2	6.7±.1

¹Data are expressed as percent nitrogen ±SEM.

TABLE 11
Diet and substrate chemical composition

Ingredient	DM	Dry basis (%)			
		ADF ¹	Protein	Protein ²	Ash
Brome hay	93.8	31.8	8.9	—	6.5
Whole Tanner crab meal	94.8	17.8	35.2	27.8	40.6
coarse (>40 mesh)	96.6	21.1	27.2	18.4	47.6
fine (<40 mesh)	94.8	14.9	41.3	35.1	35.6

¹ ADF represents cellulose for hay and chitin composition for Tanner crab meal.

² Protein corrected for chitin nitrogen N = 6.7%.

TABLE 12

Periods I and II *in vivo* and *in vitro* per cent dry matter disappearance, over time, for hay and whole, fine, and coarse Tanner crab meal¹

	Hay		Whole		Fine		Coarse	
	Per I	Per II	Per I	Per II	Per I	Per II	Per I	Per II
<i>in vivo</i>								
Time ² hr								
12	31.7±0.5	35.5±0.3	28.9±1.3	29.7±0.7	33.5±1.9	37.2±2.1	23.3±0.4	24.0±0.3
24	45.7±1.5	47.8±2.2	33.3±1.8	34.8±0.7	41.6±2.4	45.4±1.0	25.5±0.7	28.1±0.5
48	59.5±2.3	58.4±3.5	43.2±0.3	42.1±0.6	53.7±1.8	55.0±0.6	31.1±0.8	33.8±0.3
72	67.4±0.8	67.6±4.0	48.9±0.9	46.1±0.7	61.7±1.8	59.9±1.0	34.6±1.1	35.4±0.6
96	69.8±1.6	63.3±2.0	50.2±1.7	46.9±0.7	66.3±1.3	61.0±0.6	38.0±1.3	35.7±0.9
<i>in vitro</i> ³								
24	30.1±1.1	29.6±1.1	20.8±1.0	18.8±0.4	24.2±1.4	23.7±0.9	15.1±1.2	14.0±0.8
48	45.6±1.0	43.9±1.0	26.4±1.1	25.3±0.3	32.4±1.7	31.6±0.8	17.5±1.0	16.9±0.6
72	55.4±1.8	56.0±1.1	75.3±2.7	81.0±1.0	81.5±0.7	85.4±1.5	67.0±1.0	73.8±1.7
96	55.5±1.1	57.9±0.6	80.6±1.2	86.0±1.1	81.6±1.0	87.4±1.2	78.1±1.0	83.7±1.2

¹Means ± SEM.

²There was a significant difference ($P < 0.05$) due to time in all sample types.

³72 and 96 hour samples represent simulated gastric digestion.

Pepsin, as would be expected, caused no additional increase in ash disappearance when added to the acid. Chitin and protein disappearance were also increased with the addition of acid but to a lesser degree than the ash. Chitin and protein disappearance increased further with the addition of pepsin to the acid as was expected since pepsin, a proteolytic enzyme, would degrade the protein fraction, and the arthropodins and sclerotins bound to the chitin, at an increased rate.

The abomasum may have significant importance to crab meal digestion not only because of its acid-pepsin qualities but it appears to also secrete a type of chitinase which could be of importance to crab meal chitin digestion (Lunblad, et. al., 1974). Additionally, it is possible that the chitin-protein complex, after passing through the acid environment of the abomasum, is more exposed and therefore more available to degradation by microorganisms in the cecum.

An indirect measure of crab meal utilization by beef cattle would be the maintenance of body weight on a energy maintenance diet between Period I (no crab meal), and Period II (25% of metabolizable energy as crab meal). The experimental animals in this study maintained body weight within very narrow ranges throughout the study. Dry matter disappearance between Periods I and II were very similar, while chitin, protein and ash were variable depending on type of substrate. Chitin being very similar to cellulose is believed to be a potential energy source for rumen microflora. Preliminary indications support this hypothesis. Period I chitin disappearance during the first 48 hours was rather low, with the greatest disappearance occurring at 48 hours for the fine fraction (Table 13). During Period I cellulose disappearance from hay was greater than crab meal chitin disappearance. After a six week adjustment to a crab meal diet chitin disappearance was significantly ($P<0.05$) enhanced in all cases, while cellulose disappearance from hay was unaffected. Coarse meal chitin disappearance from nylon bags at 48 hours increased from 2.8 to 19.8%, respectively, between Periods I and II.

It appeared that a shift in the rumen microbial population occurred once crab meal was added to the diet. Similarly, Patton (1973) observed that young growing cattle when first exposed to a chitinous diet digested the chitin fraction poorly and that the digestion was improved after the initial exposure to chitinous materials. The increase in chitin disappearance indicates a shift from cellulolytic to chitinolytic bacteria, with chitin being the preferred nutrient source. A further indication of a microbial population shift is a drop in rumen fluid pH between Periods I and I from 6.8 to 6.6. Another possible explanation for the increase in chitin disappearance between Period I and II is that the microbial chitinase enzyme requires chitin to induce its production. Jeuniaux (1955) reported that the formation of extracellular chitinase in most bacteria and fungi, was adaptive and that the chitin substrate must be present before the enzyme will be produced. A shift in microbial population would result in a demand for nitrogen for microbial protein synthesis. This may partly explain the significant ($P<0.05$) rise in protein disappearance from hay and coarse meal between Periods I and II (Table 14). The increase in protein from coarse meal may have also been due to greater availability. Once the chitin matrix became more soluble the protein bound to it would have also become more available.

This study indicated that chitin represents a fibrous component of shellfish meals and was an available source of nutrients for rumen microorganisms. Once crab meal was added to the diet rumen adaptation occurred, which was demonstrated by the increase of 17 percentage units in chitin disappearance from coarse meal (48

TABLE 13

Periods I and II *in vivo* and *in vitro* per cent chitin disappearance, over time, for hay and whole, fine, and coarse Tanner crab meal^{1,2}

Time ⁴ hr	Hay		Whole ³		Fine ³		Coarse ³	
	Per I	Per II	Per I	Per II	Per I	Per II	Per I	Per II
<i>in vivo</i>								
12	6.4±1.1	6.5±1.0	0.0±0.0	1.6±0.3	2.7±1.3	5.8±1.5	0.0±0.0	1.30±1.1
24	27.3±2.8	22.5±3.2	2.4±1.2	11.7±1.2	6.7±2.9	24.4±0.9	1.3±0.9	8.5±1.0
48	46.7±3.5	42.7±4.0	11.2±0.8	16.5±1.3	30.5±3.1	35.6±1.0	2.8±0.9	19.8±1.1
72	57.5±2.1	50.0±6.2	22.8±3.6	26.9±1.5	38.8±3.0	45.6±2.3	8.3±1.6	22.6±2.4
96	60.7±2.1	45.7±3.8	27.7±2.4	31.8±3.7	46.3±3.1	43.8±2.5	17.6±1.9	24.8±1.7
<i>in vitro</i> ⁵								
24	10.3±2.1	10.5±2.6	4.8±2.0	12.6±1.1	0.0±0.0	18.1±1.1	2.7±2.3	8.6±1.3
48	33.6±2.5	23.0±4.1	5.0±3.0	18.4±0.1	10.4±3.7	28.9±1.5	2.1±0.6	21.7±3.9
72	32.6±3.2	30.8±1.1	17.4±6.8	53.3±5.3	35.2±3.5	51.9	9.2±0.5	30.0±6.1
96	37.0±2.0	28.8±1.6	19.0±5.0	—	33.3±6.8	40.9	25.4±1.6	49.7±0.3

¹Means ± SEM. Means not sharing a common superscript are significantly different ($P < 0.05$).²Hay values represent cellulose disappearance.³There was a significant difference ($P < 0.05$) between periods I and II.⁴There was a significant difference due to time in all sample types.⁵72 and 96 hour samples represent simulated gastric digestion.

TABLE 14

Periods I and II *in vivo* and *in vitro* per cent protein disappearance, over time, for hay and whole, fine, and coarse Tanner crab meal¹

Time ³ hr	Hay ²		Whole		Fine		Coarse ²	
	Per I	Per II	Per I	Per II	Per I	Per II	Per I	Per II
	<i>in vivo</i>							
12	18.4±4.3	30.1±2.0	31.6±3.0	39.4±2.2	36.9±1.8	37.3±5.7	26.2±1.2	32.9±2.5
24	35.4±0.7	43.0±3.1	47.5±1.7	44.2±1.3	42.3±3.0	46.5±6.4	33.8±0.8	36.0±1.3
48	52.5±2.6	55.4±1.3	59.8±0.7	60.0±1.3	67.2±1.2	64.3±2.1	39.1±1.0	49.2±0.8
72	57.2±0.8	61.1±3.4	67.1±1.1	67.8±1.3	77.7±1.2	71.6±4.4	44.3±1.2	51.7±1.6
96	61.3±1.3	60.7±0.8	69.1±1.0	71.0±0.7	81.5±1.0	78.8±2.9	52.6±1.9	57.5±1.1
<i>in vitro</i> ⁴								
24	17.2±3.4	26.6±2.4	41.6±3.1	40.1±1.3	38.3±2.1	42.4±0.6	33.0±2.1	32.4±1.2
48	35.2±4.9	46.3±6.4	54.6±1.8	54.8±0.9	58.7±2.6	56.7±1.3	44.1±0.9	47.3±2.0
72	68.6±1.8	72.9±2.4	75.6±1.0	84.5±0.9	80.5±0.5	85.6±1.7	61.7±2.7	70.3±2.4
96	72.7±1.8	76.6±1.5	77.6±1.1	84.8±1.0	78.3±2.3	87.3±1.3	65.4±2.9	77.0±1.8

¹Means ± SEM. Means not sharing a common superscript are significantly different ($P < 0.05$).²There was a significant difference ($P < 0.05$) between periods I and II.³There was a significant difference ($P < 0.05$) due to time in all sample types.⁴72 and 96 hour samples represent simulated gastric digestion.

hour incubation) after a 6 week crab meal adjustment period. These results indicated that Tanner crab meal is a viable feed alternative for the incorporation into livestock rations. The separation studies may represent a marketing alternative with the less desirable shells (coarse meal) being utilized as a forage supplement, and the fines, which are high in protein, as a high quality protein supplement to the dairy and swine industries.

BEEF CATTLE FEEDING TRIALS: A preliminary feeding trial with beef calves was conducted with a ration containing 10% Tanner crab meal and barley. The growth rate and feed efficiency were comparable to results obtained on other high concentrate rations but the study must be duplicated prior to practical ration formulation recommendations are made available to cattle feeders.

Tanner crab meal was offered free choice to beef calves fed low quality forage during a recent winter-feeding trial. Feeding low quality forage often results in reduced voluntary intake due to a lack of protein to stimulate rumen microorganism population growth which are required to digest the fibrous portion of the forage. Supplementation of low quality forages with protein has been reported to increase the voluntary intake and improve feed utilization. However, crab meals have not been considered as traditional protein supplements. Therefore, a study that requires replication, indicated that calves would increase their consumption of low quality hay by 20% when allowed access to Tanner crab meal and that they would consume this meal free choice.

CONCLUSIONS

Shellfish meals can be utilized effectively in growing swine diets when the level of supplementation does not exceed 6% of the dietary intake and the physical separation of crab meal may represent an economic and nondestructive method of improving the meal for nonruminant livestock. Coarse material containing greater amounts of chitin may be a viable energy source for ruminants when a period of diet adaptation is utilized prior to prolonged feeding. Beef and dairy cattle may be able to utilize crab meal successfully at dietary levels below those studied and provide an economic source of protein in conjunction with other sources of protein to obtain more acceptable balanced rations.

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UTILIZATION OF SHRIMP PROCESSING WASTES IN DIETS FOR FISH AND CRUSTACEA

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INTRODUCTION

The application of shrimp meal and other crustacean wastes in the rapidly expanding field of aquaculture is indeed relevant to this conference on seafood waste management. Aquaculture, the culture or husbandry of aquatic animals or plants, is increasingly becoming a consideration in projections of fish, crustacean and molluscan resources worldwide. A short discussion of the implications of aquaculture is in order based on needs of this industry for readily available proteinaceous ingredients for use as dietary components in least-cost formulations. Special emphasis will be placed on shrimp and prawn culture, particularly on commercial marine shrimp of the genus Penaeus.

During the FAO Technical Conference on Aquaculture in Kyoto, Japan, in 1976 (19), it was estimated that world production through aquaculture had passed the 6,000,000 ton mark, a doubling over the previous five years. This aquaculture resource amounted roughly to 10% of world production. It has been projected that by 1985, approximately 20 million tons of various seafood products will be produced using aquaculture techniques. These projections must be considered in terms of harvesting pressures on traditional fisheries resources, along with increasing world demand for seafood products. Some countries already rely upon aquaculture for over 40% of their total fisheries supply, and such production is expected to increase. It should be noted that more than 80% of world aquaculture in 1975 was in the Indo-Pacific Region, with the highest production in the People's Republic of China, with an estimated output of 2.2 million tons. This is about 37% of the total aquaculture output and 55% of world finfish culture production. In Japan alone, from 1964 to 1974, natural fisheries landings increased 5% whereas that from aquaculture increased 240%. In 1974, 8% of the total Japanese natural catch was through aquaculture.

Aquacultural production now accounts for approximately 3% (65,000 metric tons) of total U.S. landings, and may increase to as much as 10% within this decade. It is the source of 25% of salmon, 40% of oysters, 50% of catfish, 50% of crawfish, and almost 100% of freshwater trout landings. Although aquaculture in the United States has concentrated largely on species in high demand and limited supply, it is not restricted to high-valued products. Fish,

such as buffalo fish, mullet, and various species of carp, can be reared in ponds and processed into acceptable low-priced food products. Some indication of aquaculture growth is evidenced in U.S. catfish farming, now comprising about 56,000 acres compared to 400 acres in 1960. In Louisiana, crawfish farming is a multi-million dollar industry, comprising thousands of acres of aquafarm area.

Aspects of penaeid shrimp culture have been summarized recently by McVey (7), with special consideration given to those efforts to develop a viable commercial industry through intensive and extensive practices. In addition to successful shrimp farming in various countries of the Indo-Pacific Region, especially Japan, Indonesia and other Southeast Asian areas, significant activity in shrimp culture in this hemisphere has been in Central and South America. Especially noteworthy is the commercial shrimp farming effort in Ecuador and Panama. As noted by McVey, Ecuador leads all Latin American countries in production of pond-raised shrimp, with an estimated one-third to one-half, i.e., 3-5 million pounds, of the total country production of pond origin.

Some of the incentives to shrimp culture and concurrent diet development should be noted. Among these are such considerations as increased demand and limited natural supplies, together with escalating fuel costs of shrimp vessels. There has been significant progress made in technological aspects of shrimp biology, especially that relative to life cycle control. Investigations needed for a better understanding of shrimp nutrition are receiving considerable attention (16). Intensive and extensive systems have been improved greatly and more and more of the determinants to increased productivity per unit area are being enumerated. Coupled with this increasing worldwide interest in shrimp farming is recognition of the need for more effective dietary formulations, particularly since feeds may comprise 50% or greater of the cost of the aquaculture venture.

RESULTS AND DISCUSSION

The four areas of investigation discussed in this presentation are listed in Table 1. These topics demonstrate the realistic and economically viable application of crustacean wastes. In this paper, the terms "waste" and "by-product" are used interchangeably to refer to those products from the shrimp processing industry that currently are being discarded or processed into a low cost meal. Certainly, various of the approaches used with shrimp meal, including analysis of the processing operation, are applicable to other crustacean industries.

Recovery and Application of Shrimp Wastes
Studies of the Shrimp Processing Plant
Analysis of Shrimp Meal
Extraction and Use of Carotenoid Pigments
from Crustacean Wastes

Table 1. Areas of Investigation

RECOVERY AND APPLICATION OF SHRIMP WASTES

Shellfish processing and efforts to enhance pollution abatement, together with product recovery, is well treated by Johnson et al. (4). More recently, Mauldin and Szabo (8) have focused specifically on the shrimp canning industry and analyses of liquid and solid wastes generated. Studies from our laboratory (17) have documented approaches to recovery of such organic wastes and have proposed a variety of real and potential applications for these materials (14). Other earlier work can be cited. Meyers and Sonu (15) reported on the nucleotide and amino acid levels present in shrimp blanch water and noted significant concentrations of flavor-enhancing nucleotides such as IMP and amino acids such as glutamic acid and glycine.

Analyses of shrimp waste protein (24) have revealed proximate values of protein as high as 59%. Further evaluation of such material (25) has shown that SWP has significant nutritive value, improving protein quality by 74% when soybean protein in the diet was replaced by 50% of SWP. Use of SWP in canned or processed pet foods, or as an additive to texture vegetable proteins, was projected. Further shrimp waste investigations have included studies of shrimp meal itself (11,12), including analyses of pigment properties (9).

A variety of relevant considerations must be considered in any projected recovery of crustacean wastes. These are listed in Table 2 and will be further discussed as research data are presented.

Resource Constraints	Volume/Economic Value
Ease of Recovery	Competitive Feedstuffs
Processing Requirements	Applications/Markets

Table 2. Considerations in Recovery
of Crustacean Wastes

As noted, while this discussion concerns the shrimp canning industry, clearly items listed in Table 2 are applicable to a variety of seafood processing industries in which volumes of solid waste are generated. The logistics involved in collection and concentration of the waste product are of prime economic importance. Furthermore, the volume available must be sufficient to justify the effort involved and satisfy the needs of the particular target market. The seasonality of the industry must be considered. Ideally, the by-product should meet the requirements of a specific market that can support a sound price and, if possible, is predicated on more or less unique applications. Use of shrimp meal in cultured shrimp diets is an example of such application. Resource constraints may be critical if the by-product recovery and its use is predicated on a marginal capture fishery in which poor harvest or a declining resource will have a deleterious effect on the total economics concerning the waste portion.

A summary of real and projected applications of shrimp wastes

is given in Table 3.

Livestock Feed Ingredient	Source of:
Tropical fish/bird diets	- Shrimp protein concentrate
Aquaculture formulations	- Flavor concentrates
Pet food supplement	- Carotenoid pigments
	- Chitin/chitosan
Use in fabricated shrimp products	

Table 3. Application of Shrimp Waste Products

Certain of these aspects, especially applications in aquaculture diets, will be discussed subsequently. It should be re-emphasized that the value of the particular by-product may be notably increased based on use. Examples are in shrimp diets, where the crustacean meal serves an essential need, or in salmonid diets where the feedstuff provides a valuable source of astaxanthin pigment. There is an increasing need to develop and improve aquaculture diets, based on workable feed formulation practices and good animal husbandry. More and more emphasis is being placed in aquaculture on effective use of industrial by-products or "wastes" as dietary ingredients to replace traditional feed commodities. As noted by Perkins and Meyers (17), diet formulation practices must relate to current economics of marine and agricultural feedstuffs, problems of the seafood industry, and the state of the art in processing techniques. These food/feed related considerations are important in achieving economic viability in the nutrition and diet development phases of aquaculture (16). It has been demonstrated in our work, as well as in that of others, that shrimp by-products have valuable application in fish and crustacean diets (9,15,16).

Shrimp-based flake diets (3) have been used in nutrition of various fishes, especially freshwater and marine tropicals, specialty diets to enhance pigmentation, breeding, etc., and supplementation and ultimate replacement of currently used live food in aquatic animal culture. The tropical fish market is by no means insignificant. In analyses of sales of aquarium-related products, foods of various types showed a 17.5% increase in 1973-74, from 57 to 67 million dollars. Shrimp meals and pigment-fortified marine substrates are receiving increasing attention as skin/flesh coloration agents in salmon and trout diets (9). Shrimp protein, obtained as a by-product of a chitin-recovery operation, has been effectively used as a pigment and protein source in diets for pond/pen raised salmonid fish (5).

Food applications cannot be excluded for the shrimp canning industry generates a noteworthy amount of food-grade waste meat that can be effectively incorporated into a variety of fabricated shrimp-based products for human consumption. Application of shrimp meat fragments is readily apparent in development of flavor concentrates, reconstituted shrimp and for use with texture soy protein in fabricated shrimp products. Lyophilized cooked shrimp protein concentrate has a strong shrimp flavor and a pinkish-orange color,

of waste generation, both liquid and solid, for maximal recovery of soluble and suspended organics and separation of such materials for feed and food use (17). While currently all solid waste is processed into a meal or disposed of via landfill operations, our work has also shown the presence of large volumes of readily available food-grade cooked meat currently discarded. This material, from the vibrator/blower portion of the process can be used for a variety of shrimp-based products for human consumption, including such items as a sausage product using proper extenders and binders (Hsing and Meyers, unpublished).

ANALYSIS OF SHRIMP MEALS

More effective utilization of shrimp meals, and crustacean meals in general, requires careful attention to analytical aspects of the product. Especially noteworthy are dissimilarities in chitin levels which significantly affect the final corrected protein percentage. Such variability of different shrimp meals (Table 4) is of considerable importance and has been discussed at length in our earlier studies (13).

Preparation	% Crude protein	% Chitin*	% Corrected protein
Dehydrated meal	37.3	20.6	28.5
Sun-dried meal	51.7	9.0	47.8
Machine-dried meal	44.7	12.1	39.5
Shrimp heads	58.2	11.1	53.5
Shrimp hulls	45.9	54.5	22.8

*Chitin = 6.8% N.

Table 4. Analysis of Various Shrimp Meal Preparations

These dissimilarities become even more apparent when comparison is made of shrimp hulls with the high protein value of a meal derived from shrimp heads (Table 5).

	% Protein		% Fat	% Fibre	% Moisture	% Ash	% Ca	% P
	Crude	Corrected						
Heads	55.8	53.5	8.9	11.9	3.2	22.6	7.2	1.68
Hulls*	45.0	22.8	0.4	27.2	4.0	31.7	11.1	3.16

*Shell discard from breeding operations.

Table 5. Comparison of Shrimp Heads and Hulls

A brief mention of shrimp head meal applicable to penaeid shrimp culture is in order. As commercial shrimp culture operations generate increased amounts of head waste, greater consideration is being given to utilization of such material as a dietary component. The advantages of shrimp head meal in crustacean diets have been noted by workers in the Philippines and elsewhere (18). Shrimp head meal is a good source of animal protein, serves as a valuable attractant in shrimp and prawn diets, and contains desirable levels of cholesterol as high as 174 mg %. Cholesterol has been found necessary for proper molting of the shrimp species, Penaeus japonicus (6), and it is entirely likely that comparable requirements exist for other species of penaeids. Similarly, the value of shrimp head meal in crustacean diets as an attractant cannot be minimized, for formulations devoid of shrimp meal often fail to stimulate feeding behavior by the shrimp species in question.

CAROTENOID PIGMENTS FROM CRUSTACEAN WASTES

An important component of crustacean wastes is the level of carotenoid pigments present, especially the astaxanthin percentage. The value of crustacean meals as carotenoid-containing feedstuffs has been well demonstrated in earlier studies (2,20,21,22,23). Furthermore, it is suggested that astaxanthin of crustacean origin may be more readily resorbed into fish tissues than that from synthetic sources. Cultured salmonid fish fed red crab and shrimp exhibit a reddish cast to their flesh comparable to that of wild specimens. As noted by Meyers (9), shrimp meal is widely used to impart color to the integument and flesh of various animals, including species of tropical fish. A variety of flake formulations (3,10) containing specific shrimp meals have been effective in imparting striking fin and integument color to economically valuable tropical fish species.

The carotenoid levels of various shrimp meals and a meal prepared from crawfish waste are shown in Table 6.

Material	Pigment concentration μg/g
Shrimp meal (brown shrimp)	10
Shrimp meal (white shrimp)	6
Shrimp meal - machine dried	2-3
Vacuum-dried shrimp meal (<u>Pandalus borealis</u>)	104
Shrimp head meal	31*
Crawfish meal (<u>Procambarus clarkii</u>)	153

*Based on vegetable oil extraction.

Table 6. Carotenoid Content of Various Shrimp Meals

Particular note should be made of the relatively low astaxanthin values of the commercial shrimp meals compared with a vacuum-dried product from Maine and with that from Louisiana crawfish, to be discussed subsequently.

A brief discussion of the various factors affecting pigment quality (Table 7) is relevant to use of crustacean meals for their carotenoid content.

Condition of Raw Product
Processing Conditions
Pigment Characteristics
Use of Antioxidants

Table 7. Factors Affecting Pigment Quality
in Crustacean Meals

Carotenoids are susceptible to strongly oxidizing conditions of light, heat and atmospheric oxygen and the conditions of processing, all of which affect pigment levels in the final meal. Portions of our investigations concern optimization of astaxanthin levels in crustacean wastes, especially crawfish meal. In view of the economic value of this pigment component, based on demand for a high pigment-quality meal, clearly more attention must be given to meal processing conditions. The effect of drying on carotenoid levels of shrimp meal has been demonstrated by Kamata et al. (5), who showed the value of a shrimp protein concentrate as both a pigment and protein source for aquaculture-raised salmonids.

Emphasis on the pigment value of crustacean meals has directed attention to development of methodology for effective carotenoid pigment removal and concentration. An effective process used (21) consists of milling of the crab or shrimp waste followed by heating of the material (90 C/15 min) in a cooker, and subsequent treatment in a press or continuous decanter with final clarification resulting in a carotenoid-rich oil. In our work, as well as that of Spinelli and Mahnken (21), a vegetable soy oil has been used for such purposes. The value of these pigment extracts, when incorporated into Oregon Moist Pellet diets, in enhancing flesh coloration of coho salmon was clearly shown by Spinelli and his group. The oil extraction technique (1) has various advantages compared with the standard solvent assay approach. Especially noteworthy is the oil recovery percentage as well as other desirable features in that the oil serves as a pigment vehicle and an energy substrate source. Furthermore, the partially extracted crustacean meal can be used as a separate proteinaceous material for animal feed purposes.

The effectiveness of the oil extraction process is shown in Figure 2. These values are based on use of fresh ground wastes, with the particle size being of significance in the release of the pigment component. Astaxanthin levels obtained from our crawfish wastes, even in the first stage of extraction, are in excess of values, estimated to be 60 mg/100 g oil, considered commercially

feasible. The percent of oil recovered from the crawfish meal is especially noteworthy in terms of the economics of the process.

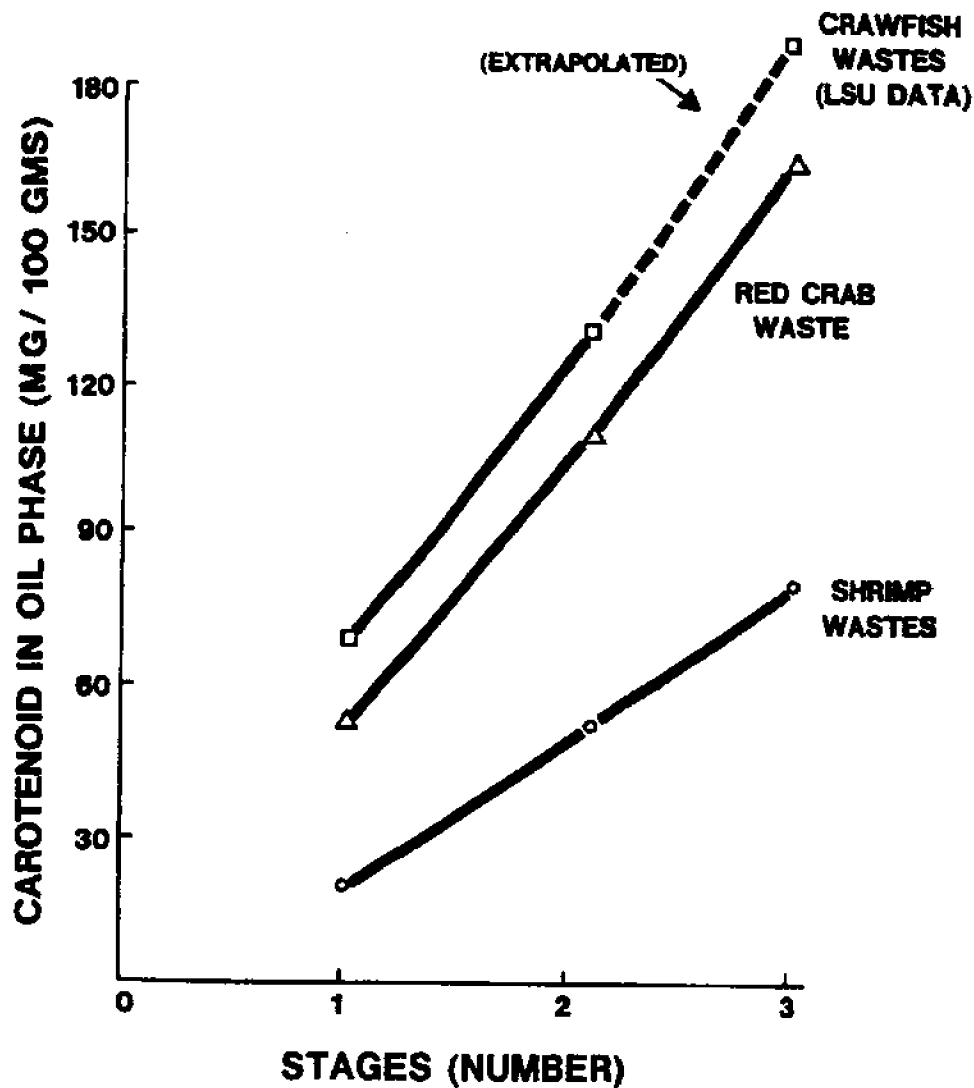


Figure 2. Carotenoid levels in oil phase of different crustacean wastes (adapted from Spinelli and Mahnken, 1978).

Preliminary data, based on studies with rainbow trout fed a 20% crawfish meal-fortified diet, have clearly demonstrated the value of the pigment-rich waste. Fifty-gram samples of the flesh of the control trout showed carotenoid levels of 0.72 $\mu\text{g/g}$ wet weight compared with concentrations of 4.2 $\mu\text{g/g}$ in the test specimens, a six-fold increase in pigment concentration over the growth period. Large-scale tests currently in progress in a commercial salmonid culture facility in the Pacific Northwest appear equally promising, especially in view of the large volumes of readily available craw-

fish wastes in Louisiana yearly. Harvests in 1977 generated in excess of six million pounds of pigment-rich waste which can be used directly as an astaxanthin source or as a substrate for pigment isolation and concentration.

APPLICATIONS OF SHRIMP MEALS

The variety of possible applications of shrimp meal in diets for both crustacea and fishes is given in Table 8. The value of the pigment component in fish diets has already been emphasized.

Formulations for:	
Shrimp	Fish
Late larval → Grow-out	Late larval → Fry
Source of:	Attractant
Protein	Growth stimulant
Non-protein nitrogen	Source of chitin
Chitin/glucosamine	
Cholesterol	Grow-out
Lipids/essential fatty acids	Source of carotenoids
Attractant	
Carotenoid level and composition	

Table 8. Use of Shrimp Meal in Aquaculture Diets

Shrimp meal is a regular component of crustacean diets, being added from 10% to as much as 30% of the ingredients present. An example of an extruded diet, widely used in our aquatic invertebrate investigations, is given in Table 9 (10).

Ingredient	Percent of formula
Shrimp meal	31.5%
Fish meal	8
Soy protein	3
Rice bran	34
Whey	5
Starch	10
Vitamin mix	2
Lecithin	1
Fish solubles	2
Alginate binder	2.5
Sodium hexametaphosphate	1

Table 9. Aquatic Invertebrate Extruded Diet

The contributions of the various ingredients used, in addition to the shrimp meal, have been described (3,10). Use of shrimp meal appears to be especially valuable in those shrimp culture facilities where little supplemental feeding is possible and where all of the animal's nutritional requirements must be satisfied by the diet itself. While shrimp meal may not be "essential" in penaeid diets, it has been shown repeatedly to enhance growth.

Pre-formed chitin, or its breakdown products, such as glucosamine, stimulate shrimp growth and serve as feeding stimulants or attractants. Workers have suggested a need by certain penaeid species for cholesterol and essential fatty acids, materials contained in the shrimp meal component of the diet. Commercial shrimp farmers in Latin America use crustacean wastes via recycling shrimp heads through feeding steps of shrimp cultivation. In Japan, tiger prawn farmers use shrimp meal to enhance both nutrition as well as the pigment characteristics of the animal at harvest. Proper coloration of the crustacean is necessary for optimal consumer acceptability. Interestingly, Louisiana shrimp meal is exported to Japan for this purpose. The value of properly prepared meal is receiving greater recognition and the market price per ton has reflected such interest and use. Indications are that the supply of good quality shrimp meal, even for the relatively limited aquaculture field, will not meet the demand. Investigations cited here all indicate the need for sources of astaxanthin-type pigments, in concentrated or inexpensive meal form, for a variety of aquatic and livestock diets. Preliminary work (Meyers, unpublished) has shown the value of shrimp-based products in dietary preparations for larval fishes and fry of various species. Evidence suggests that the inclusion of shrimp in the diet has a noteworthy chemotactic response in enhancing feed uptake and digestive efficiency.

CONCLUSIONS

Breakthroughs in shrimp culture portend a decade of economically viable growth, all requiring proper diets based on least-cost considerations. In Ecuador alone, over 30,000 hectares (70,000 acres) of ponds are in shrimp culture use, yielding an annual harvest in the millions of pounds. Feeds are critical to the economic success of the operation.

Indications are that aquaculture will continue to expand over the next five years and will increase in its contribution to our seafood economy. In the United States where private land is involved, aquaculture industries such as trout, catfish and crawfish culture will certainly expand. Expanding crawfish culture in Louisiana, already a multi-million dollar industry, is an example of an economically successful crustacean-raising industry. Systems of pen or cage culture and ocean ranching of salmon in the Pacific Northwest are producing increasing tonnages of salmon for the consumer market. Other such examples are documented by Pillay and Dill (19). Along with expansion of aquaculture will be concurrent demands for sources of feedstuffs that are nutritionally suitable and satisfy the needs of industry for waste abatement and application of the recovered product. This decade will be one of noteworthy innovations in resource development and husbandry practices,

wherein nutrient-rich fisheries by-products are recognized as a usable commodity rather than a waste product to be discarded.

ACKNOWLEDGMENT

These studies were supported by the Louisiana Agricultural Experiment Station through the Louisiana Sea Grant Program (NOAA, U.S. Department of Commerce). We are appreciative of the cooperation of the American Shrimp Cannery and Processors Association and especially the assistance of Southland Canning and Packing Co. (Violet, La.) and Cutcher Canning Co. (Westwego, La.) throughout our waste product recovery investigations. Appreciation is extended to Mr. Paul Thibodeaux and Ms H. M. Chen of the Department of Food Science for their contribution to the crawfish waste recovery and pigment analysis portion of the investigations.

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FISH AND SEAFOOD WASTES AS NUTRIENTS FOR
AGRICULTURAL CROP FERTILIZATION

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The belief that fish and fish by-products may have nutritional qualities beneficial for plant growth is an ancient one although the origin of the idea is uncertain (2). However, fish and fish by-products have been recognized and used as fertilizer (1,2,3,5).

The fish solubles (3) are produced in the menhaden industry from the stickwater following oil removal. This material is evaporated to contain 50% solid. The fish solubles are complex mixtures of mineral nutrients, amino acids, proteins, fats and vitamins present in varying proportions depending upon the kind of fish species and method of conversion from which they are derived.

In 1977, the tuna, anchovie and menhaden industry produced 978,288 short tons of stick and unloading water. Approximately 699,120 tons were from the menhaden fishery alone. On a percentage basis, the menhaden industry accounted for 71% of the total waste effluent (Tony Bimbo, Zapata Haynie Corp., private communication). A recent 1980 conference on crabwastes at Hampton, VA indicated the volume of crabwastes of processing plants in Maryland and Virginia amounted to 1.2 m kg.

Investigations into the influences and properties of fish solubles were begun several years ago to assist the fish and seafood industry with the problems associated with the disposal of solid and liquid wastes. An approach was implemented to divert the fish wastes in the form of fish solubles and other seafood wastes for agricultural crop fertilization. A general summary of the results of fish and seafood wastes on the responses of crop plants are reported herein.

MATERIAL AND METHODS

The majority of the experiments were conducted in the greenhouse in sand culture using plastic or clay pots. Both greenhouse and field plot experiments were conducted for soybean. Fish solubles were applied as freshly prepared solution. The primary method of application was as a soil drench and in some cases as a dilute foliage spray. Crop plants were sprayed at regular intervals. Crabwastes were tested by directly incorporating the fresh pulverized materials in sand for growing crops. A randomized complete block, consisting of 5-10 replicates, was used as the experimental design. The collected data were analyzed by analysis of variance procedure and treatment means compared using Tukey's test (4).

RESULTS AND DISCUSSION

The influences of fish solubles and to a lesser degree, the effects of crabwastes on the growth of crop plants are summarized in Tables 1 and 2. Fertilizing the decorative plant species, philodendrons, peperomias and schefflera regularly with 200 ml per pot of freshly prepared fish solubles at the concentrations noted over a period of several months to over a year have shown that the crop plants responded favorably to the fish soluble nutrients. The plants grew well and had a dark coloration and glossy sheen on the foliage and aged more slowly compared to plants fertilized with inorganic nutrients. The growth of vegetable crops such as lettuce and radish was also enhanced. In both crops, senescence of the foliage was delayed. The foliage of plants fertilized with fish solubles were greener than inorganic nutrients fertilization. In tomato, vegetative growth was promoted and flowering time was delayed by several days. At higher rates of fish solubles fertilization, fruit size was reduced but not at medium concentrations. Fruits ripened similar to inorganic nutrients fertilization. Tomato plants senesced more slowly when fertilized with fish solubles than plants fertilized with inorganic nutrients. Peas responded in the same manner. Peas fertilized with fish solubles produced pods with heavier seeds than peas fertilized with inorganic nutrients. Both sweet corn and field corn responded with enhanced vegetative growth to fish solubles fertilization. Foliar sprays gave relatively poor growth. Corn responded to higher concentrations of fish solubles than tomato. The higher fish solubles concentration (3X, 6X) which accelerated corn growth were injurious to tomato. Fertilization of soybeans with fish solubles under both greenhouse and field conditions significantly increased seed yield. However, the nature of the cultivar had an influence on the final yield.

The growth of corn and tomato in a sand medium containing crabwastes showed that corn was more tolerant to higher rates of crabwastes than tomato. Incorporation of crabwastes at 20-40 g per 3.5 kg of sand medium did not appreciably inhibit corn growth compared to corn fertilized with fish solubles. The same rates of

crabwastes were inhibitory to tomato growth. The inhibitory property of crabwastes may be useful and desirable in situations where excessive vegetative growth of crop plants are undesirable or to minimize lodging in cereal crops.

CONCLUSION

The comparative efficacy of fish soluble nutrients and inorganic nutrients fertilization on the growth and performance of several popular decorative houseplants (philodendron, pothos, 2 peperomia, schefflera), vegetatable crops (tomato, lettuce, radish, pea) sweet corn, field corn and soybeans have been evaluated. The crop plants fertilized with fish solubles showed healthy growth and dry matter gain comparable to plants fertilized with inorganic nutrients. The plants fertilized with fish solubles had dark foliage and showed a delay of senescence. Tomato reproductive development was delayed by fish solubles fertilization. Seed yield of soybeans was increased by fish soluble nutrients. In general, the growth appearance and quality of the corn plants fertilized with fish solubles were excellent and of marketable quality. Crabwastes showed a greater growth-inhibitory effect on tomato than corn. The growth-inhibiting property of crabwastes may be an asset to lessen lodging or to slow down excessive growth of crop plants.

The results obtained are encouraging, but additional studies are warranted to provide a sound technical and economic basis for full utilization of the fish and other seafood by-products for agricultural crops production.

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Table 1. The Influences of Fish and Seafood Wastes on the Growth Responses of Crop Plants

Crop Plant	Condition of Culture	Treatments ^a			Responses and Remarks
		Conc.	Mode	Frequency Stage	
<i>PHILODENDRONS</i>	Greenhouse (shade)	X 2X	Soil drench	W 2W	Seedling Veg. growth promotion, beneficial.
<i>PEPEROMIAS</i>	Greenhouse (shade)	X 2X	Soil drench	W 2W	Seedling Veg. growth, favorable.
<i>SCHEFFLERA</i>	Greenhouse (shade)	X 2X	Soil drench	W 2W	Seedling Enhanced veg. growth, darker foliage, glossy sheen; excellent.
<i>TOMATO</i>	Greenhouse soil & sand culture	X 2X	Soil drench	W 2W	Seedling Healthy growth, dark foliage, delay flowering and fruiting; delay senescence; favorable.
<i>TOMATO</i>	Greenhouse sand	10-40 g _b per pot	Soil	Once	Seedling Inhibitory at high rates.
<i>LETTUCE</i>	Greenhouse soil & sand culture	X 2X	Soil drench	W 2W	Seedling Good veg. growth, darker leaves, shorter petioles, delay aging; promising.
<i>RADISH</i>	Greenhouse sand	X 2X	Soil drench	W 2W	Seedling Vigorous veg. growth; larger storage roots; delay aging; favorable.
<i>PEAS</i>	Greenhouse sand	X 2X	Soil drench	W 2W	Seedling Delay senescence, greener foliage, better fruiting and seed yield, favorable.

^a X denotes 15 ml fish solubles 3.8 ℓ^{-1} of water, 2X = 30 ml fish solubles 3.8 ℓ^{-1} of water; W = weekly and 2W = biweekly fertilization.

^b Pulverized fresh crabwastes added to 3.5 kg of sand.

Table II. The Influences of Fish and Seafood Wastes on the Growth Responses of Corn and Soybeans

Crop Plant	Condition of Culture	Treatments ^a			Responses and Remarks
		Conc.	Mode	Frequency	
CORN					
Sweet corn	Greenhouse sand	X	Soil	W	Soil drench gave good veg. growth; higher conc. gave better growth with development; Foliar sprays gave poor growth. Overall growth of corn - favorable.
		3X	drench	2W	
		6X	Foliar spray	W	
				3W	
Sweet corn	Greenhouse sand	10-40 g. _b per pot ^b	Soil	Once	Slight growth inhibition at high conc. but less than tomato.
Field corn	Greenhouse sand	X	Soil	W	Similar to sweet corn; good responses to soil drench; Tassel and silk favorable.
		3X	drench	2W	
		6X	Foliar spray	W	
				3W	
SOYBEANS	Greenhouse soil	X	Soil	Once	Soil drench at fruiting gave increased seed yield; foliar spray poor.
		2X	drench		
		4X	Foliar spray		
		Field	X	Soil	Once
		2X	drench		
		4X			

^a X, 2X, 3X, 4X, 6X denote 15 ml, 30 ml, 45 ml, 60 ml and 90 ml fish solubles per 3.8 l water respectively; W, 2W and 3W denote weekly, biweekly and thrice weekly applications of fish solubles.

^b Pulverized fresh crabwastes added to 3.5 kg sand.

CRAB MEAL PRODUCTION:TRAGIC IMPACT ON
THE BLUE CRAB INDUSTRY UNLESS VIABLE
ALTERNATIVES ESTABLISHED

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Four and one half years as manager of the Hunt Crab Meal Co. plant in Hampton, Virginia has provided me with exposure to the various problems with which the blue crab industry is confronted. In October of 1979, I participated in the "Blue Crab Colloquium" conducted by the Gulf States Marine Fisheries Commission at Biloxi, Mississippi. My subject then was 'Blue Crab Conventional and Prospective Utilization'. What I discuss herein is an update of events and circumstances that have taken place during the ensuing months. The nature of these is such that I will include in the introduction the introduction presented at the Blue Crab Colloquium, since it has come to pass that it was, in effect, an accurate prophesy:

"After four years of involvement with crab scrap disposal in Hampton, Virginia, the hub of the blue crab industry in the world, two factors have become glaringly apparent. The community-at-large, most of whom consider crab meat a gourmet's delight and many of whom benefit directly from the influences of the industry in their community, have no knowledge or concern about the importance of crab scrap disposal. Similarly, crab factory owners, totally engulfed in production, processing, and sales, seem to ignore or try to forget, the tragic consequence that would ensue if their only vehicle for crab scrap disposal -- crab meal production -- were to vanish."

The edible yield from picking blue crabs is between 10 and 12 percent, the cook-loss during processing is approximately 10 percent. The remaining 80 percent is crab scrap, a combination of shell, protein, and water. The scrap is collected from factories at two to three hour intervals and is trucked to the meal plant. This routine is dictated by the need to remove the scrap from the factories before it becomes offensive or creates conditions that are not acceptable to shellfish sanitation authorities.

Once at the meal plant, the scrap is dehydrated to reduce its 65 percent moisture content to less than 10 percent. It is then ground by a hammermill and stored for shipment. Crab meal plants have historically been sources of offensive odors and emissions of particulate. Due to the municipal growth and the expansion of suburbs, meal plants that were once in the hinterlands are now in the midst of industrial and residential areas. This fact, coupled with the increasingly stringent environmental protection regulations, has obligated crab meal plants to install anti-pollution equipment and systems that are more costly than the total value of the plant for which controls are needed. This has spelled the demise of two of the three crab meal plants in Maryland and has seriously threatened the future of the Hunt Crab Meal Co. in Hampton, Virginia.

Two additional factors have jeopardized crab meal operations, the spiraling cost of fuel and the effect of the embargo imposed on grain exports to Russia in January of 1979. The only market for large volumes of crab meal is as a feed supplement for the poultry industry. The result of the embargo was to depress the price of soy meal on which crab meal prices are based. This also created surplusses of the major feed ingredients causing feed mills to eliminate crab meal from feed formulas.

During 1977 and 1978, extensive research was conducted at Hunt Crab Meal Co. in the production of chitin and chitosan and high concentrate crab protein. This research also took into account numerous other alternatives that did not show sufficient promise or potential feasibility to challenge concentrating on chitin and high protein pursuits.

By mid-March, the blue crab waste problem had reached near panic proportions in the Lower Chesapeake Bay area. The owners of Hunt Crab Meal Co. announced that they would close the plant on April 15th. Closing the Hunt plant would result in unemployment for 1,500 crab pickers, 300 watermen, the owners and staffs of 11 crab factories and cause serious losses for many related interests.

With the previously generated confidence that converting to the manufacturing of chitin could provide the solution to the problem, full time was devoted to seeking emergency, "stop gap" funds that would permit sustaining plant operations while seeking long term funds for a progressive change over from meal to chitin production.

In behalf of the owners and the blue crab industry, I proceeded to communicate with local authorities including city managers, planning and development, the Virginia Marine Resources Commission, the Virginia Environmental Development Fund (created by the proceeds of the Allied Chemical/Kepone incident), the Governor of Virginia, Congressmen and Senators. All showed great concern and willingness to cooperate, but none of these could recommend any source for emergency funds.

Since these efforts were to no avail, I carried the problem to branches of the Department of Commerce in Washington including the Environmental Protection Authority, the Economic Development Authority, the National Marine Fisheries Service, the Middle Atlantic Development Foundation, and finally, by letter to President Carter.

The result of taking the problem to Washington was that which had been a matter that seemed to be getting only luke warm attention and suddenly came to a boil. Many meetings ensued in Washington, Baltimore, and Annapolis with the crab scrap problem getting priority treatment.

The Hunt plant closed on April 15th as had been announced, and the cities of Hampton and Newport News granted temporary permission for scrap to be deposited at their landfills. One week later, the plant reopened with only a skeleton crew and on a day to day basis, since there was now some optimism over the possibility of emergency funds becoming available.

Throughout this entire period, the crab factory owners stood back in what appeared to be "lethargy" or "quandry". A number of attempts were made to urge them to voice their concern and to show some semblance of unification, but this did not and has not happened.

In mid-May, nine of the eleven factory owners did convene to be introduced to the Regional Director of the Council for the Revitalization of Labor and Industry. They were advised that each of them could be eligible for a grant of upwards to \$10,000 from the Council if they would complete applications that would document that their sales volume or revenue had been adversely effected by imports of crab meat. The Director was confident from interviews with individual owners that most of them could qualify. To my knowledge, only one made application.

Department of Commerce and Council members stressed the fact that the possibilities of gaining federal funds would be greatly enhanced if the factory owners would unite as a body with a common purpose.

I proposed to them that they accept membership in an organization to be known as The Chesapeake Blue Crab Alliance. The sole intent of forming such an alliance would be to demonstrate to prospective funding sources unification of a purpose. The invitation to membership also submitted that this could be the vehicle some time in the future whereby they could be issued preferred stock in whatever type of firm that might be established for a viable means for disposal of scrap. Prospectively, they could receive preferred stock dividends from scrap disposal profits in direct ratio to the respective quantities of scrap (raw material) that they provided for the manufacture of revenue producing end products. The result of the invitation to membership was three in favor and eight non-committed.

At the suggestion of the Council for the Revitalization of Labor and Industry, I then submitted a preliminary proposal for a start-up

chitin/chitosan plant. Under the proposal, the Hampton crab meal plant would immediately convert to mechanical separation of shell and protein. Prospective markets for high concentrate protein had already been investigated. The nearly protein free shell could then be discarded without being offensive or could be stock piled for future processing into chitin as the proposed new plant reached production capability.

To provide a clear understanding of the intent of the proposal, I quote its Preface and Summary:

"Preface: It is considered after extensive investigation of all conceivable possibilities that the only ecologically and environmentally acceptable and economically feasible alternative for the disposition of blue crab waste in the Chesapeake Bay area is in the manner that is proposed herein.

Problems regarding disposal of crustacea waste are not limited to Chesapeake Bay. They are approaching critical dimensions in the crab, lobster, and shrimp fisheries along the East Coast, throughout the five Gulf States, and in the Canadian Maritime Provinces."

"Summary: Total departure from the conventional process of dehydrating and grinding scrap into meal for uses as a poultry feed ingredient could avert the extinction of the blue crab industry.

This proposal presents preliminary data and projections for the establishing of a marine polymer (chitin/chitosan) and marine protein manufacturing plant. Its inception could resolve scrap disposal problems and its products prove useful in controlling pollution, bettering humanity, and salvaging valuable protein."

The proposal was presented to the Department of Commerce at a combined meeting of Virginia, Maryland, and Washington representatives in Annapolis on May 14th. Unbeknown to me, another proposal was being submitted at the same time from Maryland government officials for funds for a variety of feasibility studies on alternatives for scrap disposal.

The conclusion to be drawn from the meeting was that this warranted a follow-up meeting in the immediate future to determine the best course of action. To my knowledge, the chitin plant proposal was neither accepted nor denied. The follow-up meeting took place on September 9th and 10th at Virginia Beach where, I understand, it was agreed to conduct feasibility studies on such disposal alternatives as composting, fertilizer, chitin, evaluating existing plants and pursuing ways of financing crab scrap cooperatives under a grant of \$70,000 from the federal government to the Maryland Department of Natural Resources.

SUMMARY

At present, the State of Maryland has no outlet for crab scrap disposal except the landfills where availability will cease at the end of 1980. Virginia is limping along with the skeleton-crew-operated Hunt plant that could close at any time.

The blue crab fishery is not unified or with little exception, willing to support or participate in solution of their own problem. This is documented by a recent news release in a Virginia paper:

"But Virginia's push for research funds may be lagging since the departure of Kim Brown from the Hunt plant, an aide to first district Rep. Paul Tribble told the Times-Herald in a telephone interview. Since Brown "is no longer behind the project," the aide said prior to today's conference, he knows of no one actively seeking money for waste research in Virginia. Brown is now an operations manager for Fass Bros. in Greenport, N. Y."

Hopefully, before the blue crab industry withers into total extinction, some force will come forth that will cut through bureaucratic red tape and politics, impress upon the afflicted blue crab industry the utter necessity of their unifying and participating in solution of their own problems and that science and the blue crab industry can find a common ground of working relationship for the survival and furtherance of the valuable fishery.

CHITIN-CHITOSAN PRODUCTION FOR UTILIZATION OF SHELLFISH WASTES

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INTRODUCTION

The usual methods of shellfish waste disposal include dispatch to land-fill sites, discharge at sea, and conversion into meal. Dumping on land or at sea has become increasingly difficult and may be banned in the near future. On the other hand, the operators of meal plants have also faced serious problems. The market price of shellfish meal is determined by the price and availability of competing feeds, particularly soybean meal, and within the last year the meal plant in one area, near Hampton, Virginia, first closed and then reopened tentatively, when the meal operation could no longer be sustained economically (1). In addition, the meal plants suffer environmental difficulties which will raise the cost of meal production even more. The disposal of shellfish waste thus raises significant problems for the domestic industry, and a systematic approach to the handling of these wastes is required if shellfish processing is to continue here.

It is attractive to consider the possibility that the exoskeletons which remain after shellfish processing are not waste products but raw materials which can be made into valuable new products, other than meal. This possibility is realized in processes which use these shells to produce chitin and chitosan. Although chitin production may lead to other disposal problems, these are manageable, particularly in new processing plants. It thus seems, therefore, that by such a move, a waste disposal problem can be transformed into a new chemical industry with substantial additional benefits. The model for this procedure now exists in Japan, where a chitin-chitosan plant which is capable of producing about a million pounds per year of chitosan has been in operation for about a decade. Yet, the same development has not occurred in the U. S. In this paper we will examine the current prospects for the establishment of a domestic chitin industry. We will first summarize the chemical procedures which are used in the processing. The chemical and physical properties of the resultant products which are of most interest will then be discussed. The costs of production and the availability of raw materials will be discussed, and finally, we will assess the economic prospects for a substantial new chitin activity.

PROCESSING OF CHITIN AND CHITOSAN

The sequence of operations to produce chitin and chitosan from shellfish wastes is quite simple and is summarized in Figure 1. Shells are crushed and washed to remove any adherent shellfish meat. Protein values may be recovered from the initial wash. The shells are then demineralized in a weak acid, typically 0.5% hydrochloric acid, and then deproteinated in 0.5% sodium hydroxide. The remaining shell is chitin. Protein can be precipitated from the caustic solution. This processing produces chitin, protein from two sources -- the adherent shellfish meat and the protein which is indigenous to the shell -- a weak hydrochloric acid which contains substantial amounts of sodium chloride, and a weak caustic waste water. The sodium chloride can be precipitated and recovered and the resultant effluents can be neutralized and eliminated or recycled. Chitin is converted to chitosan in a deacetylation reaction with concentrated caustic, typically 40-50% NaOH, at temperatures which range from 100 to 150°C. The resultant products are chitosan and sodium acetate. The shell has not been dissolved during any of these processing steps. The reactions occur by leaching and the rates of the reaction are dependent on the particle sizes. Furthermore, it is evident that the expenditure of energy is small and the use of chemicals is modest.

The properties of the chitin and chitosan are very sensitive to the processing parameters (2) and there are considerable variations in quality, depending on the methods employed. Nevertheless, with careful control it is possible to turn out chitosan with molecular weights in the vicinity of 800,000 - 1,000,000 with consistently reproducible properties. The processing technique was presented in the original patents by Rigby (3,4) and has also been discussed by others (7).

STRUCTURE OF CHITIN AND CHITOSAN

There has been a substantial amount of work on the structures of chitin and chitosan. The basic molecular arrangements are shown in Figure 2. Chitin is an acetylated glucosamine which is structurally similar to cellulose, and, in some respects, chitin plays the same role in arthropods as cellulose in plants. Chitin is a relatively inert material. It is difficult to dissolve, resisting most acids and alkalies. There are specific chitinase enzymes which attack chitin, but the reaction is slow. Recently it has been shown that chitin can be dissolved in N, N-dimethylacetamide containing 5% LiCl (5) but even here the reaction is difficult.

Chitosan, is similar to chitin, but with the removal of the acetyl radical from the amino group. This chemical change has a profound effect on the chemical properties. Chitosan dissolved readily in weak organic acids, such as acetic and formic. It is insoluble in alkaline or neutral aqueous solutions, and insoluble in the usual organic solvents. The solubility is controlled by the degree of deacetylation and it is estimated that acetylation must be at least 85% complete in order to achieve solubility. Complete deacetylation can only be achieved at the expense of a reduction in

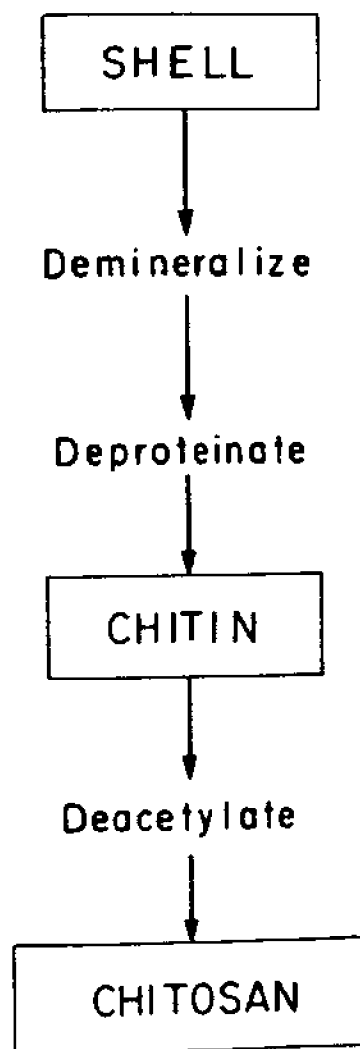
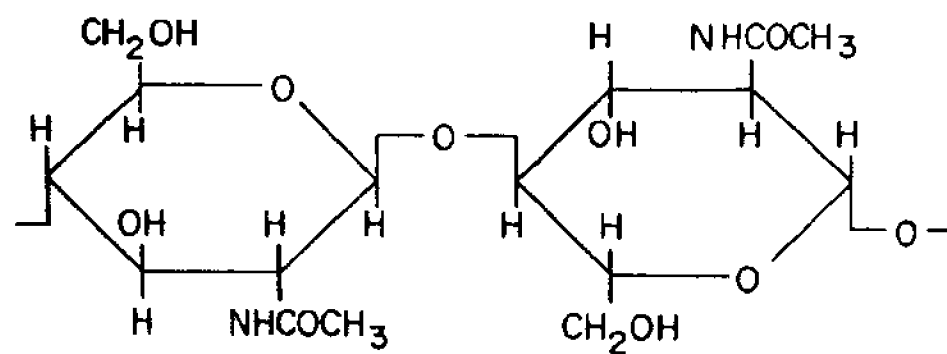
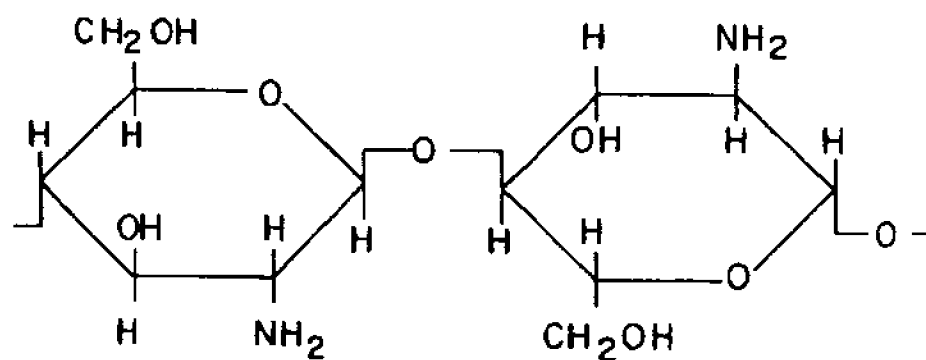


Fig. 1. Steps in the processing of chitosan.



Chitin

NaOH



Chitosan

Fig. 2. The deacetylation of chitin to chitosan.

molecular weight, and a practical compromise is achieved by producing a product with 95-98% deacetylation, which is suitable for most applications.

Chitosan is similar in appearance to chitin. Both are usually produced as a flake or granule. The particles have many interstices and openings with a large effective surface area. In solution, chitosan is a cationic polyelectrolyte. The positive charge is very effective in accelerating coagulation and the material is used at concentrations as low as 4-10 ppm (by weight). Chitosan dissolves readily in weak organic acids at a pH of approximately 4 and it will dissolve in one percent acetic or formic acid solutions on a mole for mole basis, if we consider the fundamental molecular weight of the unit structure shown in Figure 2. The full molecular weight of the polymer is retained in these weak organic solutions, and the relationship between viscosity (as determined on a Brookfield viscosimeter) and the molecular weight (as determined by high pressure liquid chromatography) is shown in Figure 3. The chemical behavior and chitosan is well summarized in two books by Muzzarelli (6,7).

SOME PROMISING APPLICATIONS OF CHITIN AND CHITOSAN

A. Polyelectrolyte-coagulant

The most common use of chitosan is as a coagulant. Almost the entire output of the Japanese plant is applied to the coagulation of sludge in activated sewage treatment plants. The chitosan is supplied as a dry flake or as a dilute solution in acetic acid. Chitosan is selected as a coagulant because it is effective at dilute concentrations and because it allows a reduction in, or the elimination of, the alum which is normally used. Chitosan competes with other polyelectrolytes and appears to be maintaining a relatively stable portion of the market. Chitosan is biodegradable and this factor may eventually lead to more widespread use in sludge treatment.

There have been several studies which show that chitosan can be used very effectively to coagulate food wastes into a product which could be returned to the food chain as a feed (8,9). There have also been rat-feeding studies which indicate that as much as 5% of chitosan in the diet of a rat can be tolerated without ill effects (10), but these preliminary findings have not been followed by the detailed testing required by the FDA to allow chitosan to be permitted as an additive.

B. Film and Fiber Forming Capabilities

Chitosan can be cast into transparent flexible membranes and fibers. The process has been studied in some detail (2), and a typical stress-strain curve for chitosan membranes is shown in Figure 4. The membranes are quite strong, with a tensile strength of 22,000 psi and with an elongation of about 40%. Membranes and fibers of chitin have also been cast by Austin and co-workers and by several Japanese investigators. These membranes are also strong and flexible, and both chitin and chitosan are excellent dye acceptors.

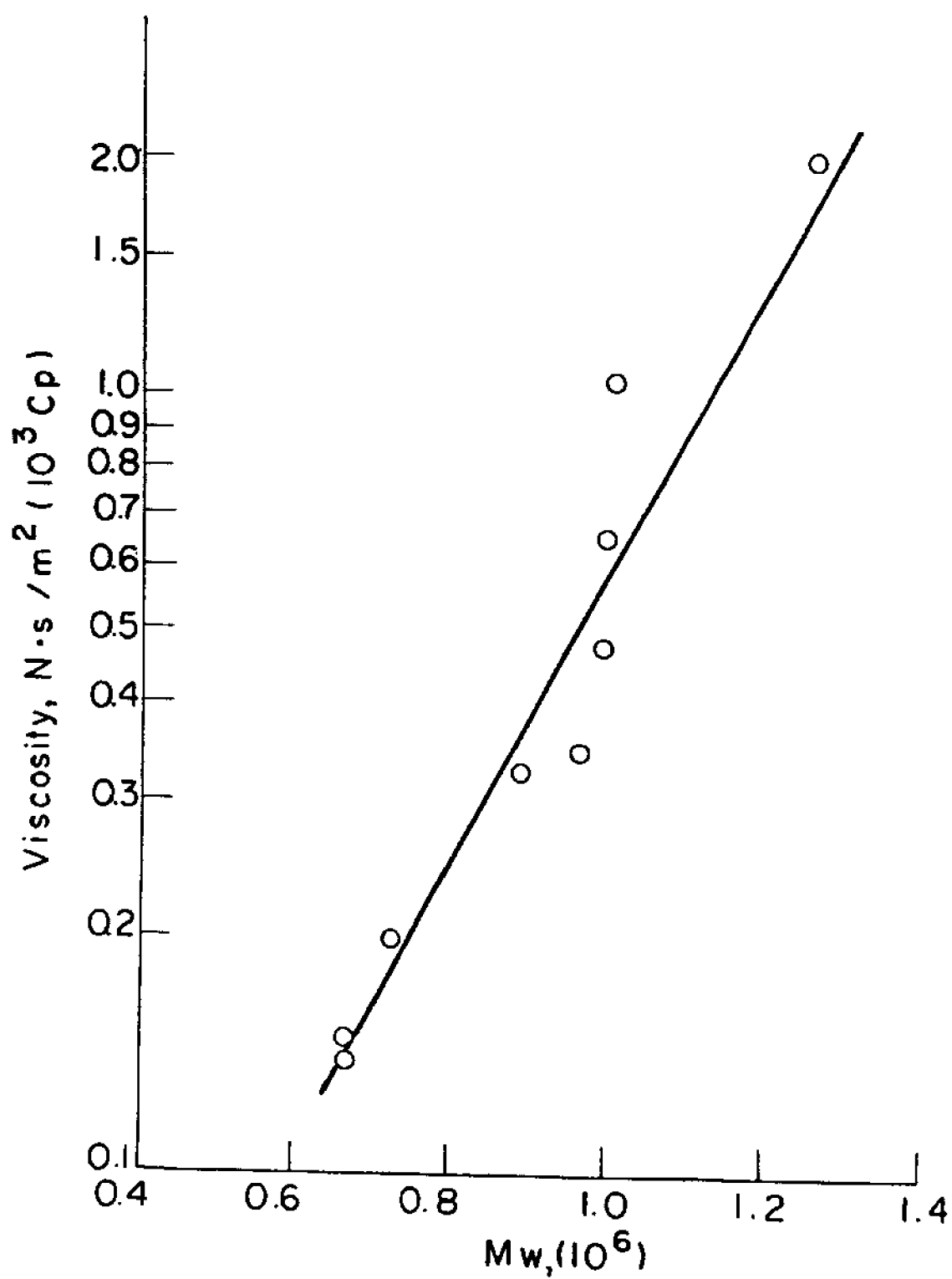


Fig. 3. Viscosity vs. molecular weight of chitosan.

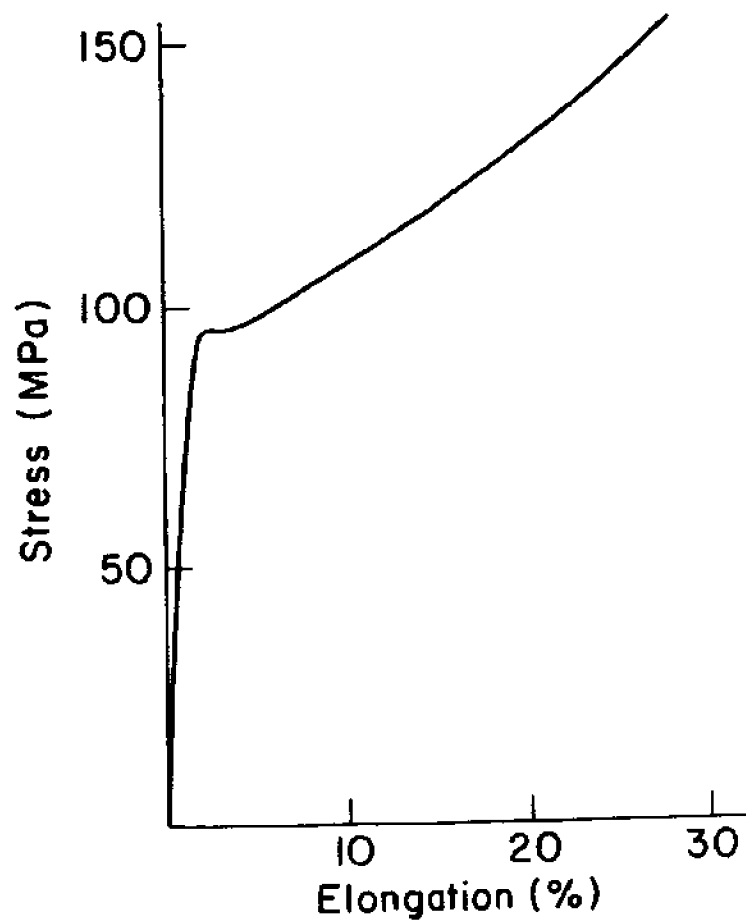


Fig. 4. A typical stress-elongation curve of a chitosan membrane, (strain rate = 0.5 per min.).

Several applications in this area have been explored. Chitin filaments have been spun into thread. Chitin and chitosan membranes have been proposed as food wraps. Chitosan has been used to finish cloth and to thus enhance the dye acceptance. The film-forming capabilities of chitosan have also been used to improve the wet strength of paper. However, none of these applications have been brought to a commercial stage.

C. Chelation of Heavy Metals

Chitosan is a very effective chelator of heavy metals. Muzzarelli and co-workers (7) have been responsible for much of the pioneer work in this area and Table 1, which is taken from his work, indicates how effective chitosan is in removing heavy metal ions from dilute aqueous solutions. Chitosan chelates almost all of the metal ions, with the exception of alkali and alkaline earth metals.

The mechanisms of the chelation reaction has been studied in our laboratory (11). Membranes of chitosan were immersed in dilute neutral solutions and then sectioned. The concentrations of metal and anion were measured by means of a microprobe in a scanning electron microprobe. Typical penetration curves for copper and sulfur (contained in sulfate) are shown in Figures 5 and 6 for chitosan immersed in a dilute solution of copper sulfate. The copper penetration appears to follow diffusion kinetics, but the sulfate penetrates much more rapidly, and the concentration appears to be controlled by another mechanism. The concentrating power of chitosan is apparent. The solution contained 10 wppm Cu. The surface of the chitosan contained 6 wt. pct. Cu, for a concentration ratio of 6000.

The chelation of heavy metals and of anion complexes is becoming increasingly important in water treatment and this application is probably one of the most important potential basis for a chitin industry.

D. Special Applications

Several applications have also appeared to be very promising (12). In the pharmaceutical area, Austin and co-workers have demonstrated that surgical sutures can be made from chitin fibers. Other investigators have used chitosan as a slow release agent for insecticides and rodenticides. There have also been suggestions for the use of chitosan as a thickener in food preparation.

E. Potential for Commercial Utilization

It is evident that chitin and chitosan have several important chemical and physical characteristics, but the commercial utilization of these products in the U. S. has been slow to develop. There are competing products for chitosan in each of the proposed applications, and chitin materials will be used only if there is a cost advantage, or if there is a unique technical feature in a given application. As we will indicate in the next section, we estimate that chitosan

TABLE 1
CHELATION OF METAL IONS BY CHITOSAN

Metallic Ion	Percentage Absorbed
antimony	100*
arsenic	100
cadmium	100
cerium	100*
cesium	100
chromium (III)	54
chromium (VI)	100
cobalt	100
copper	100
europium	45
gold	100
hafnium	65
indium	100
iron (II)	100
iron (III)	100
lead	100
iridium	43
manganese	38
mercury	100
molybdenum	100*
nickel	100
niobium + zirconium	100*
palladium	100
phosphorus	100*
ruthenium	95
scandium	100
silver	100
strontium	100*
thulium	43
tin	96
titanium	100*
tungsten	73*
uranium	100*
vanadium	100
zinc	100
zirconium	98 (on chitin)

* Special chemical conditions must be met to achieve these percentages.

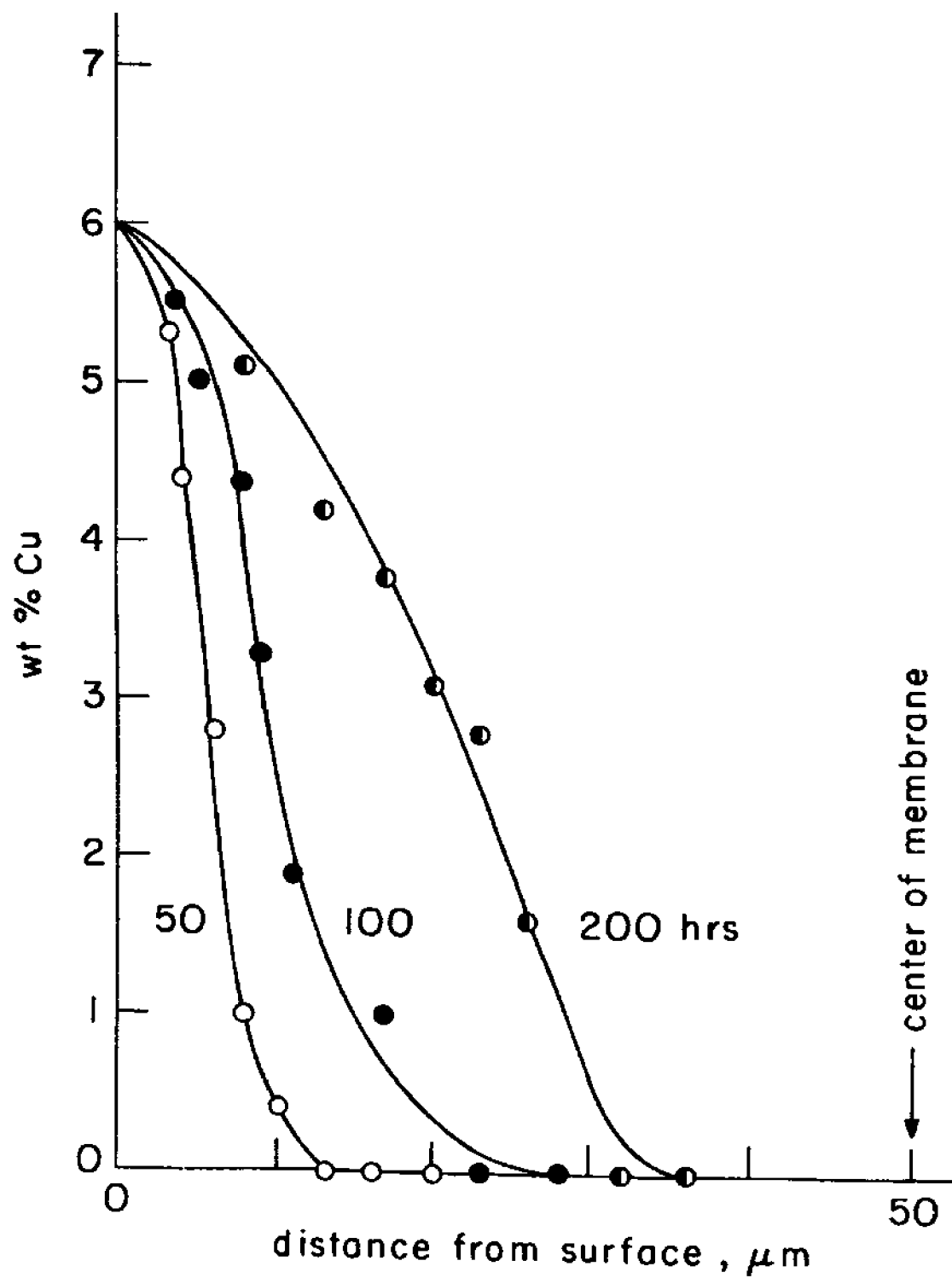


Fig. 5. Concentration of Cu with depth in chitosan exposed to Cu SO₄ solution with 10 wppm Cu.

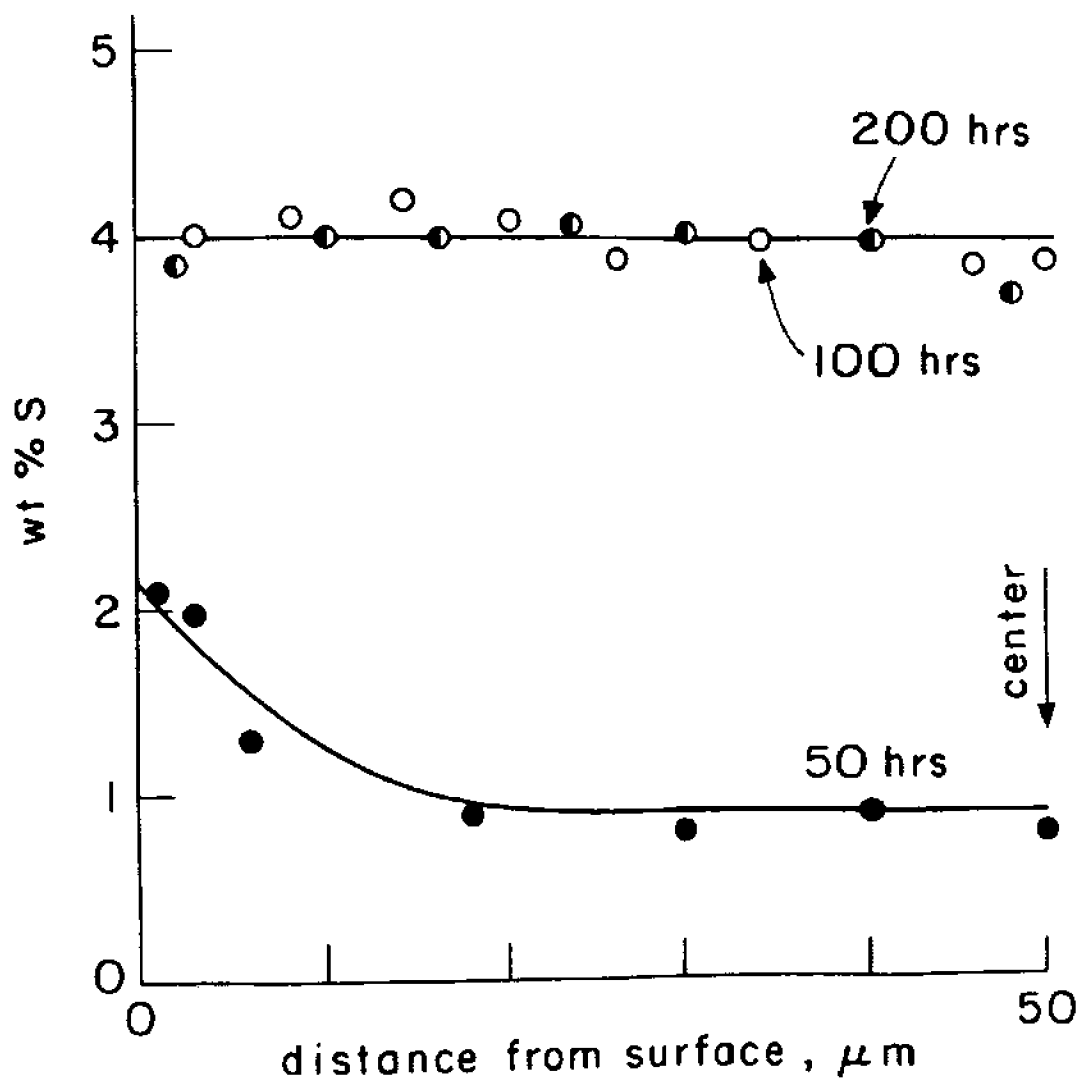


Fig. 6. Concentration of S with depth in chitosan exposed to CuSO_4 solution with 10 wppm Cu.

must sell at about \$4 per lb. and chitin at about \$3 per lb. in order to sustain a small plant, and it is evident that these materials are not inexpensive. However, there are two features which are unique to chitin and chitosan. Both products are biodegradable, and chitosan has an unusually broad range chelating ability for heavy metals and most anionic complexes. These properties suggest that chitosan could become an important chemical in water treatment, with distinct advantages over competing chemicals. In addition, since chitosan is now in commercial use as sludge coagulant in Japan, this suggests that a similar market could be developed here. We thus have two markets, water treatment and sludge coagulation, which could use a large amount of chitosan in the U. S.

The other applications are certainly of long range interest. Those which require approval by a regulatory agency will be very slow to progress because of the cost involved. Those which require a large amount of material, for example, used as a food wrap, will not develop because of the perception that the total amount of readily available raw material is limited. Others require extensive research and development and will progress at a slow pace. We thus consider the best possibilities for application of chitosan to be as a coagulant and as a chelator of heavy metals.

PRODUCTION PROBLEMS

We may consider the problems of production in two steps. First, we will estimate the costs of producing chitin and chitosan, and then we will consider the siting of a plant. In approximate terms, one tone of shells processes into 100 lbs. of chitin or about 80 lbs. of chitosan. As by-products, there will also be approximately 200 lbs. of protein, 300 lbs. of impure sodium chloride and 50 lbs. of sodium acetate. We will estimate the costs on the basis of a plant which produces 300,000 lbs. of chitosan per year. Such a plant is very small, approximately one-third the size of the Japanese plant, but a small plant may be all that can be justified until the industry is better established.

Our estimates of the costs of producing chitin and chitosan, in 1980, are summarized in Table 2. Although the raw material, shellfish shells, is considered to be a waste material which the processor must dispose of, frequently at some cost. This is not the long term situation for a chitin plant. The shell must not be considered a waste which is treated as garbage. The shells must be segregated, kept clean, and removed at frequent intervals to a cool storage area or to the chitin plant. Storage handling and transportation costs are involved and these are estimated to be about \$0.05 per lb. of chitin. The rest of the costs are based on our experience in operating a small pilot plant in Hampton, Virginia at the Hunt Crabmeal Co.* We have not taken into account the returns from the

* The author is very grateful to William P. Hunt and Peter Perceval for their sponsorship and for their efforts in establishing and running this plant.

TABLE 2
ESTIMATED COSTS OF CHITIN AND CHITOSAN

	<u>Dollars per lb.</u>
1. <u>Production chitin</u>	
a. raw material, per lb. of chitin	0.05
b. cost of chemicals, per lb. of chitin	0.60
c. labor	0.20
d. overhead	1.00
e. selling costs	0.40
f. depreciation	0.20
g. research and development	0.20
h. profit	<u>0.35</u>
Selling price, per lb. chitin	3.00
2. <u>Production of chitosan</u>	
a. cost of chemicals, per lb. of chitosan	0.30
b. labor, per lb. of chitosan	0.10
c. overhead	<u>0.60</u>
Additional cost to produce chitosan	1.00
Selling price, per lb. of chitosan	4.00

sale of protein, sodium chloride or sodium acetate, since the resultant profits will be small compared to the other costs. We conclude that in an integrated chitin-chitosan plant, that chitin will have to be sold at \$3/lb. and chitosan at \$4/lb. if the plant is to be economically viable. It is interesting to note that chitosan sells for about \$8/kg in Japan.

The location of the plant is an important factor. A plant which is to produce 300,000 lbs. of chitosan requires 3,750 tons of shells. Since transportation costs are high and freshness of the shells is important, we consider that all of the shells be available within a 50 mile radius from the chitin plant.

The capital equipment, space and power requirements are modest for a plant of this size. We estimate the cost of the equipment and installation to be about \$300,000 for a chitin plant, with an additional \$100,000 for the chitosan plant, for a total of \$400,000.

ECONOMIC PROSPECTS

There are several regions in the U. S. which could readily supply raw materials for an integrated chitin-chitosan plant (13). The Hampton, Virginia - Delmarva area, the North Carolina coastal area, the Florida and Gulf coasts, the Texas coast, and the Pacific Northwest all have regions with sufficiently concentrated sources of shells to be good sites for a plant. In order to provide an assured source, however, it would be necessary to form a cooperative arrangement, so that shells would always be available. A regional cooperative would be attractive, but it is evident that a capital outlay, which may seem large in comparison to the current value of an individual shellfish processing plant, will be necessary. The chitosan plant may solve the shellfish disposal problem, but it is evident that it will run at a loss until the market is established.

Another possibility is to defer the chitosan portion and make only chitin in a regional treatment center. There is only a very small market for chitin and it may be necessary to dispose of it as a supplement to fertilizer. Chitin does contain nitrogen and it decomposes slowly on the soil. It would thus be sold as an organic slow-release nitrogen source, but the selling price would be very low. Chitin could also be stockpiled for eventual conversion to chitosan. Chitosan could be made in a small pilot plant in sufficient quantities to develop the markets. If the production of chitin is merely a disposal procedure, a simple plant which recovers protein and produces about 300,000 lbs. of chitin could probably be built for \$100,000, but the chitin would still cost about \$2 per lb. However, since this is distributed over 3,750 tons of shells, the cost per lb. of processed meat would be very low. From this point of view, chitin is being produced to provide an acceptable method of waste disposal.

If we are to make chitin only for the purpose of providing a convenient waste disposal method, we can consider an additional

option. Each shellfish plant could be provided with chitin production equipment. Depending on the size of the plant, we estimate that \$25-50,000 would be needed for equipment. The chitin and protein recovery would be carried out with low overhead, since this equipment is only an addition to an existing plant, and would involve little additional labor. Units of this size could be easily designed, but here also, some of the smaller shellfish processors may be hard pressed to meet the cost. The larger producers, however, may find this alternative attractive.

As a last resort, we could dispose of shells by a process which does not make chitin, and only extracts protein. In this procedure, the shells would be ground and washed, and the adherent protein would be removed from the wash water. The ground shells would then be deproteinated in weak caustic, and the protein could be recovered from this solution. The resultant solid product would then be a mineralized chitin which could be safely dumped or added to fertilizer. This is a minimum shell treatment facility and would probably cost about \$25,000 for a medium-sized shellfish processing plant.

CONCLUSIONS

These estimates suggest that a chitin-chitosan industry is a special situation. We do not have an established market in the U. S. If a chemical company were to start a plant it would be faced with the uncertainties in the availability of raw materials as well as the uncertainties in the marketplace. The size of the potential market and the returns are too small to warrant a major risk.

On the other hand, if the shellfish processing industry is forced to find another method of shell disposal, a chitosan, or at least a chitin plant may become a feasible alternative. These plants will need a subsidy to survive. If an integrated chitosan plant is built, the cost is high, but there is some hope that it will eventually be profitable. If disposal is the only hope, then either a regional chitin plant, or small unit plants can be built. These convert noxious wastes into acceptable wastes and the costs will then appear in the price of the primary shellfish product.

In closing, we should describe the Japanese special situation, which is apparently successful. Chitosan is produced by a company which is a joint venture of a large chemical company and a large fishing company. That combination does not seem to exist here.

ACKNOWLEDGEMENTS

The author would like to thank the M. I. T. Sea Grant Program for their sponsorship of this research. The Sea Grant group has been very helpful and understanding. I would also like to thank R. B. Clark, Amin Nakhla, and Chee Wong, who carried out much of the work. I would also like to acknowledge several very interesting discussions with Kimball Brown, R. A. A. Muzzarelli, Paul Austin and Wayne Bough.

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SEAFOOD WASTE REGULATIONS IN THE 1980's

EPA'S REGULATORY ACTIVITIES AFFECTING THE SEAFOOD PROCESSING INDUSTRY

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EPA is currently consolidating (or will be consolidating within the next year) the operation of four federal environmental permit programs. These programs are National Pollutant Discharge Elimination System (NPDES) permits for discharging pollutants through a point source to waters of the U. S., Resource Conservation and Recovery Act (RCRA) permits for treatment, storage, and disposal of hazardous wastes, Underground Injection Control (UIC) permits for disposals of waste waters to subsurface aquifers, and the Air New Source Review permit program.

It is expected that only the NPDES permit program will have any great effect on seafood processing operations. UIC will probably have no effect. RCRA hazardous waste will only have an impact if hazardous chemicals are used to facilitate treatment of seafood wastes and end up in a treatment sludge. The Air New Source Review would probably only impact new or expanded fish meal facilities.

Facilities requiring NPDES permits have been (or will be) required to meet the following technology based effluent guidelines or standards:

(1) By July 1, 1977

- o Best practicable control technology currently available (BPT) for all pollutants.

(2) By July 1, 1984

- o Best conventional technology (BCT) for conventional pollutants (BOD, TSS, pH, oil, and grease, and fecal coliform bacteria).
- o Best Available Technology Economically Achievable for all 129 pollutants listed as hazardous or toxic in the Clean Water Act.
- o BAT for all pollutants not considered conventional or hazardous and toxic.

(3) At Startup

- o All New Sources must meet the New Source Performance Standard (NSPS).

In addition to meeting these guidelines/standards, all facilities discharging into streams (or segments of streams) where approved State/Federal Water Quality Standards (WQS) are not being met must provide enough additional treatment to meet the WQS.

Seafood processing NPDES permits in Florida are being issued by EPA. Permits in the other coastal states in Region 4 (Alabama, Mississippi, Georgia, South Carolina and North Carolina) are being issued by the states under EPA review. Permit processing steps in Florida are as follows:

- (1) Prepare draft permit conditions.
- (2) Send conditions with a request for certification to the state for review and comment.
- (3) Send conditions to the applicant for review and comment.
- (4) Issue public notice of draft permit.
- (5) If required, hold a public hearing.
- (6) After reviewing all comments, issue or deny permit.

Once issued, a permit requires the applicant to perform self monitoring activities and to report the results of the activities on Discharge Monitoring Reports (DMR's) to EPA (or the state) at periodic intervals. EPA or the state will make compliance inspections at intervals. Any permit violations found in DMR's or in during inspections are subject to enforcement action. Such action may vary in stages from a Notice of Violation letter asking for remedial action up to a referral to the U. S. Attorney recommending that criminal charges be preferred against the permittee.

"CAUTION": EPA CONTRACTOR AT WORK

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INTRODUCTION

In 1975 when the Jordan Company initiated its work for EPA's Effluent Guidelines Division, cries of "Caution: EPA Contractor at Work" resounded throughout the seafood industry. From the outset, seafood industry representatives assumed a cautious posture when dealing with EPA's "new" technical contractor. After all, amended regulations for the catfish, crab, shrimp, and tuna segments (Phase I), and interim final regulations for the remaining segments (Phase II), were just published on January 30, 1975. The passage of these regulations meant that processors, with the exception of the small manual industry segments, would be required to install either dissolved air flotation (DAF) or biological treatment systems in 1983, technologies with which most processors were unfamiliar and, for the most part, did not understand. These technologies were identified by EPA with the help of a technical contractor so why would the conclusions from a new study be any different?

Through its persistence and by working with the appropriate trade organizations, the Jordan Company overcame this obstacle. The fact that alternatives to biological treatment and additional information relative to DAF were being sought also helped to gain the cooperation of much of the industry.

The Jordan Company's study was initiated to fulfill the requirement of that portion of the Clean Water Act which calls for a review of existing effluent limitations within five years of promulgation. Although the Phase I regulations were just finalized and Phase II guidelines were awaiting publication when the technical study was initiated, EPA felt additional data on waste control technology had become available since the two original development documents were published. Consequently, EPA hired the Jordan Company to evaluate the implications of these recent advances. This premise was based on the implementation of the National Pollutant Discharge Elimination System (NPDES) and an apparent increased awareness on the part of processing facilities regarding water use and waste management practices. The seafood processing industry was now aware of EPA's

intentions to regulate pollutant discharges from operations, and the NPDES program provided the means for regulatory agencies to impose restrictions on plants' discharges for the sake of improving the quality of receiving waters.

EPA was also concerned about the applicability of biological treatment, which is space-intensive and served as the basis for guidelines promulgated for a significant portion of the industry. Originally, land availability for the installation of such systems was not considered a significant obstacle for those segments requiring biological treatment.

Since becoming involved in the study in October 1975, Jordan Company's efforts have been modified on several occasions as a result of regulatory changes and the expression of industry concerns regarding the focus of the study. The most significant regulatory change, of course, was the enactment of the Clean Water Act of 1977 (Public Law 95-217), which established Best Conventional Pollutant Control Technology (BCT) for control of conventional pollutants. Conventional pollutants are BOD₅, total suspended solids, fecal coliform, pH, and oil and grease. BCT replaced Best Available Treatment Economically Achievable (BAT) as a means of controlling conventional pollutants.

After more than four years of work and research, a technical report (1), known as the BCT report, was produced. In the early part of 1980, the report was distributed to industry representatives and other interested parties for comment.

The purpose of this paper is twofold: first, outline the role of a technical contractor in the development of effluent guidelines by EPA and, second, provide insight into the technical assessments made while preparing the BCT report. This presentation is not designed to duplicate material in the BCT report, but, instead, to supplement it. Most of you are already aware of the recommendations and their accompanying implications. Though some mention of the technical assessments is necessary, the assessments themselves are not the crucial issue here. What is important is understanding the "how and why" of the decision-making process, in addition to understanding the constraints under which the technical assessments had to be made. Once you do, you may come to feel, as we do at the Jordan Company, that these assessments are not only tenable, but essential to EPA's mission of preserving our marine environment and its inhabitants, which is mandated by the Clean Water Act.

TECHNICAL CONTRACTOR'S ROLE

As a technical contractor to EPA's Effluent Guidelines Division, the Jordan Company has assumed the responsibility for assembling the technical groundwork from which EPA must formulate regulatory options and make informed decisions regarding reasonable and achievable effluent limitations. Note, though, that the technical

contractor is not responsible for recommending specific effluent limitations for a particular industry, nor is the contractor authorized to consider the quality of the waters receiving wastes in selecting applicable control technology.

In the case of the seafood processing industry, the Jordan Company was charged with reviewing all that had been done in the way of developing and promulgating the original effluent guidelines. Based on this evaluation, a work plan was formulated to supplement this existing material and reassess the promulgation of BAT regulations in light of the revised data base. Once the Clean Water Act of 1977 was adopted and BAT guidelines were withdrawn, the Jordan Company concentrated on helping EPA to establish BCT for the industry.

Several sources of information are tapped routinely by EPA technical contractors while they are conducting their data collection program. These include:

1. literature (domestic and foreign);
2. trade associations;
3. individual plants through:
 - a. distribution of questionnaires and
 - b. plant visits;
4. field sampling program;
5. federal and state agencies;
6. EPA demonstration grant program; and
7. academic institutions.

The Jordan Company did not have the luxury of distributing a questionnaire to seafood processing plants. EPA felt that the burden of responding to a questionnaire would be too great, especially for small plants. Consequently, the Jordan Company relied on gathering information from the remaining sources.

Once the technical data base had been assembled, the information was analyzed, and several areas of interest to EPA were addressed. For the seafood processing industry, the Jordan Company (i) reviewed industry subcategorization, (ii) characterized the industry's wastewaters, (iii) identified applicable technology including in-plant controls and end-of-pipe treatment, (iv) assessed technology performance and variability, (v) evaluated residuals disposal options, and (vi) developed cost estimates for the selected technologies.

The results of these investigations culminated in the preparation of a "contractor's report," in this case, the BCT report for the seafood industry. Cost estimates for applicable control technology were forwarded to the economic contractor (Development Planning and Research Associates, Inc.), who was charged with determining the economic and financial ramifications throughout the industry should effluent limitations based on the selected technology(s) be imposed. The economic contractor's assessment is weighted heavily in EPA's rulemaking process.

TECHNICAL ASPECTS OF SEAFOOD PROCESSING STUDY

Nature of Industry

The seafood processing industry is an extremely diverse industry, divided originally into 33 subcategories. A variety of raw materials are processed into an even greater number of final products. With the exception of larger tuna and fish meal processing facilities, the industry consists of many small, seasonal, family-owned operations, most of which process intermittently depending on weather and raw material supply. These facilities are scattered throughout the United States, including Alaska, and its territories, American Samoa and Puerto Rico. For the most part, processors are located in coastal regions where land is at a premium. Traditionally, processors have discharged wastewaters into marine waters with little or no treatment, but EPA has worked to change these practices.

The adoption of Best Practicable Control Technology Currently Available (BPT) regulations in 1975 was the initial step by EPA toward controlling concentrated wastes being discharged by the industry. Although BAT guidelines were promulgated at the same time, the Jordan Company's study was initiated in 1975 to reassess BAT guidelines with a greater emphasis on the unique characteristics of the industry, which were outlined above. The study was directed toward collecting additional information pertinent to in-plant modifications and end-of-pipe treatment technology. Emphasis was to be placed on primary treatment alternatives, including sedimentation and air flotation. An effort was also made to identify facilities whose treatment systems performed consistently well.

Because shorter retention times are required, primary physical-chemical treatment is less space-intensive than biological treatment alternatives. It is also more conducive to the intermittent processing schedules characteristic of most processors since it does not rely on biomass, which requires an acclimation period. However, primary physical-chemical technology is less efficient than biological treatment. Information regarding the adoption of in-plant measures to conserve water and reduce waste loads was also sought because these are a cost-effective approach to pollution abatement.

Because the seafood processing industry generates wastes that contain proteins, the handling and disposal of treatment residues also merited considerable attention. Information regarding by-product manufacturing systems and their potential, in terms of Food and Drug Administration (FDA) requirements, was sought. This effort was necessary to determine the utility of solids which were eliminated from receiving waters and awaiting disposal.

During the course of the study, the 200-mile limit was adopted. This had a profound effect on the industry as it allowed for the processing of new marine species and spurred a trend toward mechanization to accommodate increased catches. Both of these areas were of interest to EPA in setting national effluent standards.

Data Gathering Program

For the most part, data used in developing the original guidelines had been assembled during field sampling efforts sponsored by EPA. Because the industry provided little or no treatment and therefore did not maintain central wastewater collection systems, obtaining representative samples was difficult. Often, individual unit processes were sampled and the results computed mathematically in lieu of collecting composite samples of a plant's total effluent to determine daily flows and waste loads. The data base was by no means extensive.

With the intention of determining the effectiveness of primary treatment technology, the Jordan Company set out in May 1976 to evaluate the performance of the DAF systems operated by the Terminal Island (California) tuna processors. Over the next three years, the field sampling program continued with each effort scheduled according to the processing season of interest.

As the program progressed, emphasis shifted from evaluating treatment performance to characterizing the raw waste loads (after screening) of specific subcategories. This transition was necessary since EPA-funded projects, industrial self-monitoring programs, and NPDES monitoring reports did not provide the information originally thought to be available. The occurrence of multi-product processing and major deficiencies in data collection under the NPDES program precluded the calculation of daily mass emission rates (kg of pollutant per kkg of raw material processed). To calculate the desired emission rates, the analytical results of a representative sample, total daily flow, and production are required. Unfortunately, in many cases, sample collection and analysis were inconsistent with approved methods. For example, a plant may have taken a one-time grab sample at some time during a 12-hour processing day for analysis and subsequent reporting to the regulatory agency. Since an instantaneous sample was taken, the results do not adequately characterize the wastewater generated during the entire 12-hour period and disregard the clean-up period which follows the termination of processing.

Since the demonstration projects funded by EPA after the promulgation of regulations for the seafood processing industry were directed toward the evaluation of waste control technology, useful raw waste data, including daily production figures, were not collected. In some instances however, the limited data from these projects could be compared with the established data base to further substantiate the subcategory mass emission rates.

Table 1 outlines the sources of additional data which were employed to supplement EPA's historical data base.

TABLE 1
IDENTIFIED SOURCES OF ADDITIONAL DATA

Source	Subcategory	No. of Plants
Field Investigations Funded by EPA	Dungeness and Tanner Crab	2
	Northern Shrimp	2
	Breaded Shrimp	2
	Tuna	1
	Mechanized Salmon	3
	Conventional Bottom Fish	1
	Mechanized Clam	2
	Steamed and Canned Oyster	1
Industrial Sources	Tuna	3
	Herring Fillet	1

Once the data base had been supplemented with more recent information, a methodology was sought to evaluate the data for each subcategory in a consistent manner. In addition, each plant represented by data in a particular subcategory had to be given equal weight, regardless of the number of data points. This approach provided a means of giving small plants, which tend to collect less data, parity with large plants in the assessment of each subcategory.

With subcategory averages established for raw waste loads, attention was then focussed on assessing how to better control water use and waste discharges through in-plant measures. Since comprehensive in-plant waste management programs were lacking throughout the industry, an alternative to percent reductions employed in the original study was necessary. Another objective of this effort was to provide incentives for all plants to implement such measures. Consequently, the concept of establishing baseline waste loads for each subcategory was born.

Baseline waste loads are simply "achievable" goals for plants to direct their efforts in minimizing water use and the wastes enter-

ing the plant sewer. For each subcategory, at least one plant was meeting the baseline levels for all significant parameters: flow, total suspended solids, oil and grease, and, for two subcategories, BOD₅. Three subcategories (Alaskan halibut, Alaskan scallop, non-Alaskan scallop) did not have sufficient information to establish baseline values.

Technology Assessment

As mentioned previously, during the technology assessment emphasis was placed on identifying and evaluating waste control technology indicative of the industry's nature; i.e., technology requiring minimal space and capable of functioning under intermittent processing schedules. Controlling waste at its source was also deemed a desirable method for reducing waste loads in the seafood processing industry.

Most seafood processors had installed screens to comply with the BPT regulations, which became effective on July 1, 1977. Relatively few plants had adopted water and waste management practices to reduce waste loads requiring end-of-pipe treatment. The tuna canners and fish meal plants, which are atypical of the industry, had progressed significantly along these lines. However, individual plants in other industry segments were pioneers in adopting such practices. In most instances, the concepts are quite simple and may only involve isolating and collecting gross solids at butchering tables to prevent them from entering the plant's sewer. Considerable time and effort were expended to develop these concepts for each industry segment. For each subcategory, the measures are specified as a guide to plants in helping them achieve the baseline waste loads alluded to previously. It is not expected that these recommendations be adhered to rigidly.

In-plant measures provide an incremental level of control beyond screening and yield several benefits. Benefits that can be realized from implementing in-plant measures include decreased end-of-pipe treatment or reduced user charges for POTWs, decreased waste loads, and improved raw material utilization. Additionally, saleable secondary products and by-products can generate revenues, and savings can be realized from reduced process water use.

In developing the original guidelines, information was collected for four pilot-plant studies and two full-scale DAF systems to determine the effectiveness of this physical-chemical technology. One full-scale system, which provided the largest amount of data, was a demonstration unit in Canada.

Because of BPT requirements, most tuna processors had installed DAF systems to treat process wastewaters and were operating them during the Jordan Company's study. Consequently, monitoring data collected by the tuna canners and submitted to the Jordan Company represented the best and most extensive information available for evaluating DAF treatment performance.

DAF is not a new technology. It has been around for more than 20 years and is employed by numerous food processors in the United States. In addition, seafood processors in foreign countries such as Japan and Sweden use DAF to treat their wastes. Their experience over several years also provided some insight into the capabilities of DAF to treat the industry's wastewaters. In contrast, the operation of the Canadian demonstration unit had deteriorated, as the processing plant was not required to employ DAF to meet its discharge requirements. The data acquired for this unit clearly reflected this attitude.

A demonstration study of the full-scale application of DAF for shrimp and oyster processing wastewaters was undertaken in 1976 (2). Although more performance data was generated for shrimp, this study provided sufficient information to judge the capabilities of DAF to treat both types of wastes.

National Marine Fisheries Service (NMFS) conducted a pilot-scale study of a modified air flotation system in treating various types of wastes, including those generated by the processing of shrimp, tuna, salmon, and bottom fish. Unfortunately, the data provided was not documented sufficiently and had little utility in determining specific performance levels. However, the limited information collected did indicate that the system has the capability to effectively treat a variety of seafood processing wastewaters.

Although sedimentation is not conducive to treating most seafood processing wastewaters, it was found to be effective in treating initial washwaters from clam and oyster processors. These washwaters contain grit and sediment which have high settling rates. Two processors are known to have this technology in place.

Because BPT requires catfish processors only to screen, a processor having aerated lagoon treatment could not be located. However, several plants were found to discharge process wastewater into aerobic lagoons or impoundments. This segment of the industry, having mostly inland operations, does not face the land constraints which the remainder of the seafood processing industry does. Therefore, biological treatment was believed to be an applicable technology for this industry segment.

With the exception of size, processing operations in Alaska were found to be not only similar to those located in the Pacific Northwest, but also to have similar wastewater characteristics. Further, the same control and treatment technology applicable to west coast plants would be applicable to those in Alaska. Other significant factors, however, played an important role in identifying applicable technologies for Alaskan facilities. Geographical location, shorter processing seasons, and the higher cost of constructing waste treatment facilities were found to warrant serious consideration in identifying BCT for these plants. These factors, coupled with the limited residuals disposal options available to most plants, were felt to preclude the feasibility of adopting any end-of-pipe treatment beyond screening.

Because processing plants are generally located in coastal areas and therefore discharge into marine waters, few plants are situated in water quality limited areas where state or regional authorities may require treatment beyond screening. Consequently, information relative to treatment technology, which became available since the original study for the seafood processing industry, was limited to that generated by government-funded studies and monitoring data provided by tuna canners and a herring fillet plant. As a result, use of data from pilot-plant investigations and the transfer of technology from one subcategory to another was necessary in some instances to meet the study's objectives. Great care was taken in evaluating waste characteristics in light of technology performance levels prior to concluding that technology transfer was appropriate for individual subcategories. A summary of the technology assessment is presented in Table 2.

As can be seen from Table 2, BCT as suggested is either equal to or less stringent than the original BAT. With the exception of the catfish processing segment, recommended BCT is composed of primary physical-chemical technologies which are conducive to treating the industry's wastewaters. Further, the objective of examining additional end-of-pipe treatment for those plants having relatively large operations and employing a high degree of mechanization was met. These plants use more water and generate more wastes. Therefore, the implementation of additional treatment will bring about greater effluent reduction benefits.

Residuals Disposal

From the implementation of nearly all waste management systems, solid waste residues result. This is true for the seafood processing industry regardless of whether it involves the implementation of in-plant controls or end-of-pipe treatment. The utilization or disposal of seafood residues has become a significant issue, and has great bearing on the selection of an applicable waste control technology. Without a feasible means of disposing of treatment residues, industry-wide application of any technology generating vast amounts of solids would be difficult to support.

In conducting its study, the Jordan Company, with support from EPA, expended considerable effort in investigating the utilization and disposal of solid wastes. The Jordan Company recognized the need to consider geographical factors, as well as waste characteristics.

The general utilization and disposal alternatives for the seafood industry were identified as follows: secondary product and by-product manufacturing, land application, landfiling, and barging. For Alaska, options were limited to secondary product and by-product manufacturing, and barging.

For the manufacturing of secondary products and by-products, waste materials from finfish and shellfish operations required separate consideration. Many of the secondary products and by-products

TABLE 2
TECHNOLOGY ASSESSMENT FOR THE
SEAFOOD PROCESSING INDUSTRY IN THE CONTIGUOUS U.S.

Segment	BAT		BCT	BCT Rationale
Catfish	Aerated Lagoon	Aerated Lagoon	Aerated Lagoon	Same as BAT
Mechanized Blue Crab	Aerated Lagoon	Aerated Lagoon	DAF	Technology Transfer from West Coast Crab*
Shrimp	DAF	DAF	DAF	Full-scale Data
Tuna	Roughing Filter and Activated Sludge	DAF	DAF	Full-scale Data
Mechanized Salmon	DAF	DAF	DAF	Full-scale Data
Mechanized Bottom Fish	DAF	DAF	DAF	Technology Transfer from Tuna
Mechanized Clam	Aerated Lagoon	Grit Removal and DAF	Grit Removal and DAF	Technology Transfer from S/C Oyster
Steamed/Canned Oyster	Aerated Lagoon	Grit Removal and DAF	Grit Removal and DAF	Full-scale Data
Sardine	DAF**	DAF*	DAF*	Full-scale Data
Herring Fillet	DAF	DAF	DAF	Technology Transfer from Mechanized Salmon

* Performance data was collected during a pilot-scale study.

** Treatment of fresh water streams only.

NOTE: Both BAT and BCT include in-plant measures.

noted were outgrowths of research activities. However, several approaches were identified which have been implemented on a full or pilot-scale. Examples include salmon roe, deboned fish flesh, fabricated shrimp products, petfood, meal products, fish oil, and chitin/chitosan. To implement some of these concepts, it is essential that the waste material be isolated at its source and not allowed to come in contact with the floor. The separation of gross solids at the earliest opportunity is also desirable from a pollution control standpoint.

For the purpose of addressing utilization and disposal options, residuals can be categorized as follows: gross solids, screened solids, and sludge. A summary of options available for each category is presented in Table 3. It is interesting to note that as wastes progress through the waste management scheme, options for ultimate disposal decrease, which suggests that the greatest benefits are to be realized by recovering solids from the waste stream at the earliest opportunity.

TABLE 3
UTILIZATION/DISPOSAL METHODS

Category	Method
Gross Solids (viscera, shells, scraps)	SP, BP, LA, L, B
Screened Solids	BP, LA, L, B
Sludge	LA, L
SP = Secondary products	LA = Land application
BP = By-products	L = Landfill
B = Barging	

Meal production, using both finfish and crustacean (shrimp and crab) wastes, was found to be a common practice for handling processing wastes. Producing meal from finfish wastes was generally viable in the contiguous United States. Besides fish meal and oil, solubles are sometimes produced from finfish wastes. Each of these generate revenues for the meal facility.

For the most part, meal facilities handling only crustacean wastes are not profitable and simply serve as a disposal site for the processors. In many instances, hauling wastes to a meal plant represents the most convenient manner available to the processors. The processing facilities frequently subsidize the meal plant to insure its viability as a disposal site. Recently, air pollution restrictions and energy requirements have cast a shadow over the future of such facilities.

In some areas, processors have disposed of gross and screened solids by other means. Land application has been a solution to the problem for some west coast crab and shrimp processors. In Oregon, consideration was being given to setting up a local cooperative to sell the waste materials to local farmers for soil amendment. Landfilling, a less desirable alternative, has also been adopted by some processors. As the options for the disposal of crustacean wastes become fewer, chitin/chitosan manufacturing has received increased attention. Several organizations within the United States have explored the potential of full-scale production of chitin/chitosan from shellfish wastes, but no facilities have as yet been built. Though chitin/chitosan production may be feasible sometime later, it will not be a viable solution to the problem of shellfish waste disposal in the near future.

Sludge from chemically-assisted DAF systems may be converted into animal food and, if the product meets with FDA's standards, this option may be helpful in eliminating some of the excessive waste material generated by seafood processors. FDA must approve the product on a case-by-case basis and such approval has not been granted to a seafood processor, but it should be noted that no seafood processor has ever applied to FDA for such approval. If chemical coagulants are selected carefully and the required testing yields positive results, FDA could approve the manufacture of a by-product from DAF sludge in the near future.

The adoption of Public Law 94-580, the Resource Conservation and Recovery Act (RCRA), will not only control the land application of sludges but also their landfilling. RCRA, enacted in 1976, also requires that sludges be dewatered prior to landfilling. Tuna canners have the most experience in dewatering DAF sludges. Centrifugation was initially adopted by the canners with results varying from plant to plant. However, one canner was successful in employing this dewatering technology to approach 35 percent solids. Recently, another canner installed a belt filter, which offers some operational advantages while forming a cake similar in solids content to ones formed by centrifugation. Two proven alternatives therefore are available to dewater the sludge generated while operating DAF systems. Although they have been employed exclusively within the tuna processing segment, they should be adaptable to other industry segments once the system is optimized to suit the needs of a particular facility.

In Alaska, disposal options for solid wastes greatly influence the selection of treatment technology. Essentially, barging and by-product manufacturing are the only two viable options. As a result of geographical and economic considerations, remote plants will probably continue to grind and discharge under BCT, while non-remote plants are capable of implementing in-plant controls in addition to screening. In areas that have meal plants, processors can have their wastes hauled to these facilities rather than barge.

SUMMARY

The role of an EPA technical contractor is to assemble information so that EPA may either develop, verify or update effluent guidelines for an industry. In this capacity, the Jordan Company has been involved for almost five years with the seafood processing industry, during which time the emphasis of the study has changed with Congressional actions and the evolution of political issues. Although the Jordan Company is an agent of EPA, it also has the responsibility of making sound and reasonable engineering decisions based on the available data. The Jordan Company has fulfilled this responsibility as evidenced by the BCT report.

As noted in this paper, the data base for characterizing the industry's wastewaters and assessing technology performance is not extensive. Moreover, the information which formulates the data base was, for the most part, generated by EPA technical contractors. With the exception of the tuna processing segment, very little useful data have been generated by the industry.

In conducting field sampling efforts, the Jordan Company, in cooperation with EPA, established priorities in view of the budgetary constraints set forth by EPA. Every effort was made to optimize the sampling efforts to address the areas requiring information, although changing policies and industry's petitions made this difficult.

With the issue of beneficial effects of seafood waste discharges aside, attention was focussed on selecting technologies which are conducive to the industry's nature. Moreover, the recommendations for end-of-pipe treatment focussed on large, mechanized plants which generate larger volumes of wastewater and significantly higher waste loads than small plants employing manual operations. The Jordan Company felt that the effluent reduction benefits associated with implementing additional end-of-pipe technology would be greatest for those plants with the higher waste loads. In selecting primary physical-chemical (DAF) treatment for the appropriate subcategories, Alaskan segments warranted special consideration based on the inherent geographical and economic factors which were established during the original guidelines study. Of these, land availability was a primary consideration.

Secondary product and by-product manufacturing are waste utilization alternatives common to plants both in the contiguous United States and Alaska. Seafood processing plants in the contiguous United States, however, have more solid waste disposal options than those in Alaska. Suitable means of dewatering DAF sludge and disposing of it are available at present. But, with treatment technology in-place and more rigorous restrictions on the disposal of residuals such as DAF sludge forthcoming, the industry must look more closely at ways to optimize the values of the wastes which have been eliminated from our nation's waters.

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ECONOMIC IMPACT ANALYSIS FOR PROPOSED LIMITATIONS GUIDELINES FOR SEAFOOD PROCESSORS

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U.S. Environmental Protection Agency

Introduction

This paper describes the genesis, methodology, and results of the Environmental Protection Agency's (EPA's) preliminary economic impact analysis for soon-to-be proposed BCT limitations guidelines for seafood processors. As a background to this discussion, a brief history of EPA's regulation of the seafood processing industry will be presented. This section will be followed by a general description of the role of economic impact analysis in EPA's rule-making process. Finally, the economic impact analysis will be described in detail.

Background on Regulation

Effluent limitations guidelines for the canned and preserved seafood processing industry were originally promulgated as mandated by the Federal Water Pollution Control Act Amendments of 1972. This legislation required that limitations based on Best Practicable Technology (BPT) be met by manufacturers no later than July 1, 1977. The Act also established the requirement that effluent limitations based on Best Available Technology (BAT) be met by no later than July 1, 1983. EPA promulgated these regulations for the seafood processing industry in 1974 and 1975.

The Clean Water Act of 1977 established a new category of guidelines, Best Conventional Pollutant Control Technology (BCT). Achievement of BCT guidelines is required by no later than July 1, 1984. These guidelines must be no more stringent than BAT regulations and no less stringent than BPT.

In August, 1979, the BAT regulations were withdrawn for the seafood processing industry. The economic study is being done to contribute to EPA's rulemaking for proposed BCT regulations on seafood processors.

Role of Economic Analysis at EPA

The role of this economic analysis in the rulemaking process is to predict the economic impacts of a given range of treatment technology alternatives for the seafood processing industry. The treatment alternatives and their related costs are developed by the Agency's engineering staff. The economic analysis provides the Agency the information to determine whether or not the technology on which BCT is based is economically achievable. If not, some less stringent level is selected.

After this internal Agency decision-making, a formal proposal is made available for public review and comment. All public comments received are reviewed and the Agency's supporting analyses are modified where necessary. Following this review and revision, the regulation is promulgated.

The development of BCT guidelines for the seafood processing industry is at a fairly early stage in this process. A first draft of the economic impact report has been received and is presently undergoing Agency and industry review. It will, no doubt, undergo considerable revision before it is in a final form that is acceptable to the Agency for rulemaking purposes.

At this point, I would like to focus on its methodology and results.

Economic Impact Analysis

Subcategorization and Financial Data

The first task that is required for an economic impact analysis is a comprehensive examination and characterization of the seafood processing industry. Seafood processing poses problems in this task due to the large variations in product type, process type, plant size, and plant locations. Clearly, a valid industry profile requires disaggregation of industry data by some logical means.

The industry was divided into subcategories ¹ according to the following criteria ²: 1) type of raw material used; 2) type of manufacturing processes; 3) plant locations, with special emphasis on Alaskan processors; 4) wastewater characteristics; and 5) plant size as measured by annual sales. These subdivisions are necessary to construct homogeneous groups of plants for which to analyze the economic effects.

With the industry broken down in this manner, EPA was able to construct an economic profile of seafood processors based on specialization of production rates, geographical/community importance of certain subcategories, size distribution of subcategory plants in terms of annual sales, ownership patterns, employment patterns, industry imports and exports, varying subcategory price structures, and supply and demand characteristics for each subcategory.

Model Plant Methodology

A "model plant" was constructed for each size segment of each subcategory (assuming the availability of sufficient financial data). The model plant represents the synthesis of operating and financial data of a relatively homogeneous group of plants into one "typical" plant for that group. This model plant was then tested for economic viability after the imposition of estimated pollution treatment control costs.

Economic viability was tested by employing a discounted cash flow/net present value (NPV) analysis. That is, annual cash flows were projected for each model plant for several years. These cash flows were then combined with the cash outflows that resulted from the imposition of pollution treatment control. Cash outflows are in the form of expenses related to the initial investment in pollution control equipment and the annual operating and maintenance costs associated with this equipment. Included in this model are assumptions on certain financial parameters such as the inflation rate, the cost of capital, interest rates, and so forth.

The combined cash inflows and cash outflows for the period of the study are the model plant's net present value. This figure was then compared to the present salvage value of the plant. Salvage value is defined as total fixed assets plus net working capital. If the net present value was greater than the salvage value, the plant was predicted to be a viable, ongoing operation. If, on the other hand, the net present value was less than the salvage value, a plant closure was predicted.

What this methodology does, in effect, is to compare two alternatives - whether it would be more profitable for a plant to comply with the regulations and stay in business, or to cease operations and sell its assets. If it was determined that the latter is the case, then a closure was predicted.

A negative overall plant value does not mean that all plants in that

segment will close. This is a key point. For example, if a model plant that represents a segment of thirty actual plants was predicted to close, a determination of specific plant closures was made.

This was based on an evaluation of many factors: 1) a review of the data in order to establish a distribution of financial profiles of existing facilities; 2) the degree to which some facilities have treatment in place; 3) the magnitude of the net present value for the model plant; 4) the number of plants represented by the model; and 5) the ability to pass through price changes. On the basis of a review of these factors, it was determined that a specific number of plants was projected for closure. Production loss and employment loss for those segments were then predicted on the basis of the number of closures.

Results

The results, summarized in the Appendix, are highlighted as follows:

- o total plants in sample = 1307 (although there are more than this in the industry)
- o projected plant closures = 69 (or 5.3% of plants in sample)
- o projected employment loss = 3397 (or 6.1% of employees in sample)
- o subcategories with employment loss of 100 or more:
 - shrimp (northern non-breaded, southern non-breaded, breaded)
 - canned clams
 - Alaskan salmon
 - mechanized bottom fish
 - herring
 - fish meal, without solubles

The shrimp processors are projected to be hit particularly hard, with about 60% of all predicted employment losses and 54% of all predicted plant closures occurring in this classification. Of the 199 plants that were explicitly grouped Alaskan subcategories, there were 3 (or 1.5% of Alaskan plants) projected closures. All of the projected Alaskan closures were for salmon processing plants. Other detailed effects are presented in the report itself.

There are a couple of caveats one must bear in mind when evaluating the results of this study. First, it is a first draft analysis that

will experience at least one or two potentially substantial revisions. These revisions will be based on Agency and industry comments concerning the report's weaknesses. The results, therefore, should by no means be interpreted as being conclusive evidence of the impacts of proposed BCT guidelines on the industry. Rather, this report is a reasonable first draft that gives the Agency and the industry a general indication of potential economic impacts.

Second, before promulgating BCT regulations, the economic impacts of these regulations will be well known to Agency management. If the impacts are judged to be unreasonably severe for some subcategories, the regulations will be established in such a way as to mitigate the potentially harmful industry impacts.

Summary

The draft economic impact report on proposed BCT limitations guidelines clearly indicates that certain subcategories of the industry will be affected. Naturally this is the cause of legitimate concern for the industry. However, it is too early yet to "push the panic button". Several problems with the draft report have to be eradicated, and this process may or may not change the results of the impact study. Also, EPA is keenly aware of the concerns of the industry due to the probable imposition of pollution treatment costs. Be assured that economic impacts will be carefully considered before any regulations are proposed.

OVERALL IMPACTS FOR EACH OF THE SUBCATEGORIES

Subcategory	Total number of plants (no.)	Total closures (no.)	Closures as % of total (%)	Total employment (no.)	Employment loss (no.)	Employment loss as % of total (%)
<u>Shrimp</u>						
Alaskan	6	0	0	0	0	0
Northern Non Breaded	20	4	20	1,013	120	12
Southern Non Breaded	101	21	21	3,148	370	12
Breaded	37	12	32	5,539	1,590	29
<u>Crab</u>						
Conventional Blue	170	0	0	4,723	0	0
Mechanized Blue	76	0	0	3,333	0	0
Alaska Crab	13	0	0	NA	0	0
Dungeness & Tanner	13	0	0	532	0	0
<u>Clams</u>						
Hand Shucked	80	0	0	766	0	0
Mechanized	14	0	0	1,502	0	0
Canned	13	3	23	1,240	285	23
<u>Oysters</u>						
Eastern	239	0	0	4,244	0	0
Pacific	19	0	0	552	0	0
<u>Abalone</u>	4	0	0	25	0	0
<u>Salmon</u>						
a. Hand Butchered						
West Coast	35	0	0	1,089	0	0
Alaskan	50	0	0	NA	0	0
b. Mechanized						
West Coast	12	1	8	84	10	8
Alaskan	19	2	11	NA	100	NA
<u>Tuna</u>	24	0	0	15,900	0	0
<u>Bottomfish</u>						
a. Conventional						
Atlantic	114	0	0	1,924	0	0
Pacific	25	2	8	122	10	8
b. Mechanized						
Atlantic	16	2	13	5,687	380	7
Pacific	23	2	9	603	166	28
<u>Herring</u>						
a. Sardines	14	2	14	1,017	90	9
b. Fillets	21	7	33	746	149	20
<u>Catfish</u>	19	1	5	334	7	2
<u>Fish Meal</u>						
With Solubles	17	0	0	1,472	0	0
Without Solubles	37	10	27	528	120	23
Alaska Combinations	76	0	0	NA	0	0

Footnotes

1. Reassessment of Effluent Limitations Guidelines and New Source Performance Standards for the Canned and Preserved Seafood Processing Point Source Category, Edward C. Jordan Co., Inc., December, 1979, p.8
2. Ibid., p.7

References

Economic Impact Analysis of Proposed Limitations Guidelines for the Canned and Preserved Seafood Processing Point Source Category, Development Planning and Research Associates, Inc., July, 1980.

Reassessment of Effluent Limitations Guidelines and New Source Performance Standards for the Canned and Preserved Seafood Processing Point Source Category, Edward C. Jordan Co., Inc., December, 1979.

THE UNKNOWN OF SEAFOOD WASTE TREATMENT:
COSTS, BENEFITS AND CONGRESSIONAL INTENT

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INTRODUCTION

"The United States has discovered a new disease called "regulation." It is as prevalent as athlete's foot in a locker room." So begins a discussion of the problem of Government encroachment on U. S. business in Murray L. Weidenbaum's book, The Future of Business Regulation.¹

Every day each of us is affected by Government regulation of business, from the type of gasoline we put in our cars to the ingredients of the toothpaste we use. According to Mr. Weidenbaum, this excessive regulation which is often the result of good intentions on the part of well-meaning citizens, can have a negative impact on the basic functioning of the private enterprise system—to the detriment of the public.

The pervasiveness of Government regulations is relatively new. Prior to 1946, regulations were designed to run Federal agencies. In 1918, there were only two Federal regulations governing the private sector. These dealt with service in the Armed Forces and income tax. The decade of the 1980's finds the public and industry amidst a proliferation of regulations. New decrees from Federal, State, and local governments regulate nearly every aspect of our lives, and serve as a blueprint for the structure and behavior of our world.

The implementation of regulations always involve "costs" in achieving their proposed benefits. These costs or adverse impacts are commonly grouped into direct and indirect costs.

Direct costs to business include operational expenses and associated capital investments; contractual services of lawyers, accountants, and possibly monitoring technicians; and lastly, the diversion of productive time to fulfill paperwork requirements.

Indirect costs to business include quantifiable costs such as competitiveness with imports, and market distribution between large

and small businesses. There are also psychological costs associated with regulations. The diversion of top management from planning to "defensive management" to cope with regulations can be significant. Feelings of Government harassment, fear, and anxiety are common. Identifying and quantifying regulatory impacts is indeed a difficult task.

REGULATIONS AND THE SEAFOOD PROCESSOR

As a group, seafood processors are beset with numerous regulations. Of chief concern today is the formulation of seafood waste disposal policies. The structure and function of the fishing industry are important in projecting regulatory impacts. The processor has little control over the availability and supply of fishery resources for processing, rising fuel prices which inflate the costs of raw materials and processing, and extensive competition from large imports of fishery products. The industry is facing an economic crisis which must be examined in projecting potential impacts of new regulations.

The fishing industry in the United States is composed of approximately 1,700 processing plants which employ approximately 60,000 workers. The processing sector is dominated by small businesses, half of which have gross annual sales less than 200 thousand dollars. The 100 largest plants account for 70 percent of the total sales. The industry is far from being homogeneous. There are approximately 168,000 fishermen in the U. S. fleet landing over 100 different species. Based on species, type of processing employed, and geographical location, the Environmental Protection Agency has subdivided the seafood processing industry into 39 categories for developing effluent limitations.

The problems of the seafood processor are many. Landings vary with seasonal resource abundance, prices of raw materials are escalating with dramatic increases in fuel costs. The ability of the processors to raise prices to cover costs is strongly influenced by product demand and the availability of imports which account for nearly 2/3 of the seafood consumed in the United States. There is little protection from imports. Since 1930, there has been a steady decline in tariffs. The average tariff on fishery products is only 1/2 that of agricultural imports. The processor is caught in a price squeeze over which he has little control. Amidst the present economic crisis, more regulations are being formulated--each will have associated costs to the industry and consumer. It is essential that the costs and benefits of regulations are clearly understood before the industry is placed under additional economic stress.

The mere mention of effluent guidelines evokes heated response from many seafood processors. Often the underlying point of concern is that effluent guideline rulemaking is not subject to the customary cost/benefit analyses common to other regulations. The costs of seafood waste treatment are not compared to environmental benefits of improved water quality.

The purpose of this paper is to (1) trace the origin of effluent guidelines, (2) explore the cost/benefit relationship by identifying some potential adverse economic impacts of seafood waste treatment to industry stability and fisheries development, (3) to relate these potential adverse impacts to the unknown benefits of environmental improvement, and (4) to question the intent of the Congress and its potential role in integrating effluent guidelines into seafood waste disposal policies.

The Origin of Seafood Waste Regulations

Federal regulations commonly originated from laws enacted by the Congress, from Federal agencies' directives developed under statutory authority granted by the Congress, or from court orders.

The origin of water pollution control regulations is important to the seafood processor in developing comment on the proposed regulations and in seeking modification of existing regulations.

In 1972, the Congress amended the Federal Water Pollution Control Act (P. L. 92-500) and created a new approach to protecting the Nation's water resources. Technology based effluent limitations guidelines were created to supplement existing water quality criteria, and a National Pollution Discharge Elimination System (NPDES) was created to encompass all of the regulations in granting a discharge permit.

A companion law, the Marine Protection, Research, and Sanctuaries Act (P. L. 92-532), was also enacted in 1972 to govern the ocean disposal of wastes.

A clear understanding of the wording of these laws and interpretations by the Congress and the courts is critical to addressing regulations governing the disposal of seafood processing wastes.

The Federal Water Pollution Control Act Amendment of 1972 (P. L. 92-500)

The major difference between P. L. 92-500 and earlier pollution control legislation is that effluent guidelines limitations are technologically and economically flexible and are not dependent on existing environmental quality. The paramount assumption is that effluents from the 28 processing categories chosen for effluent guidelines are harmful to the environment and, that any reduction will provide a benefit.

The law states that factors relating to the assessment of "best practicable control technology currently available shall include consideration of the total cost of application of technology in relation to effluent reduction benefits to be achieved from such applications..."

The legal interpretation of "benefits" for the purpose of establishing effluent guidelines, based on Senate Public Works

Committee reviews, is the degree of reducing pollutants in the effluent, not the benefits of such reductions to the environment. This avoids having to define the effect of each pollutant on the environment and makes treatment requirements more uniform.

This interpretation of benefits was upheld in the court case *Weyerhaeuser Company v. Costle*, 590 F.2d 1011 (D. C. Cir 1978). It has been settled, that the "effluent reduction benefits" referenced in Section 304(b)(1)(B) are not primarily water quality benefits. Effluent reduction benefit is the reduction in the pounds of wastes which are discharged into the water.

To the seafood processors this means that in theory, the technology will be required if it is economically available. National effluent guidelines promote an overall upgrading of effluent quality. They protect and preserve clean waters by preventing the discharge of untreated wastes even though the receiving waters currently may assimilate these wastes effectively. Effluent guidelines outline minimal treatment requirements. Their effectiveness, and provisions for more stringent treatment, is provided for by the use of the water quality criteria. The granting of an NPDES permit considers both effluent guidelines and water quality criteria.

The Marine Protection, Research, and Sanctuaries Act of 1972
(P. L. 92-532)

P. L. 92-532 governing the ocean dumping of waste contains a specific exemption allowing for the ocean dumping of untreated organic fish processing wastes without a permit. This exemption doesn't apply to the discharge of treated wastes such as sludge residues from dissolved air flotation (DAF) systems which contain chemical coagulants.

The Clean Water Act (P. L. 95-217)

P. L. 95-217, enacted by the Congress in 1977, modified earlier pollution control legislation and contains several provisions pertinent to developing seafood waste discharge regulations.

The economic variance clause in Section 301(c) of P. L. 92-500 was deleted and replaced by a new cost reasonableness test. This change means that 1984 effluent guidelines are not subject to modification on the basis of a processor demonstrating that the limitations are beyond his economic capability. Seafood processors and other dischargers of conventional pollutants are now excluded from the economic variance consideration because Congress felt that the 1977 requirements for best practicable control technology currently available (BPT) were reasonable, and that "the best conventional technology currently available (BCT) will not prove substantially more burdensome," Representative Roberts, 123 Cong. Rec. H. 12, 928. The significance of this change is that without exception all processors must meet the 1984 BCT limitations.

In addition to concerns over potential costs of waste water treatment, the Congress mandated in Section 74 of the Act that, among other things, EPA conduct a study to determine the environmental effects of seafood waste discharges on receiving waters, and to define the costs and potentials of byproduct recovery.

THE COST OF WASTE TREATMENT - THE UNKNOWNNS

The 1977 treatment regulations requiring best practicable technologies are now in effect and the 1984 regulations have been withdrawn and are being revised. The rulemaking process requires that EPA assess the technical aspects of seafood waste treatment including waste characterization, and the availability of treatment technologies, and associated costs. A separate analysis of the financial stability of the industry and potential economic impacts associated with various levels of treatment will then be conducted. These two studies will be the basis for promulgating new 1984 effluent limitations guidelines. A brief examination of the technical and economic factors governing the operation of the fishing industry is critical to identifying potential regulatory impacts.

Technical Aspects

The National Marine Fisheries Service (NMFS), as part of its continued effort to assist EPA in the formulation of workable effluent guidelines, critiqued the EPA contract study entitled, Effluent Limitations Guidelines and New Source Performance Standards for the Canned and Preserved Seafood Processing Point Source Category.

The report, while a good review of the state-of-the-art of seafood effluent treatment, is grossly inadequate in describing existing conditions and problems in the industry and in projecting realistic expectations for waste treatment efficiencies. The report is not the 5-year updating of data and reevaluation of waste treatment options that Congress mandated in Section 301 of the Federal Water Pollution Control Act Amendments of 1972 (P. L. 92-500).

The National Marine Fisheries Service's concerns center on five broad issues as follows:

1. the inadequate data on waste characterization and treatment efficiencies;
2. inconsistent statistical treatment of data;
3. the recommendation of sophisticated technologies in untested situations;
4. failure to address present solid waste disposal problems and optimistic projections of byproduct development which ignore fuel shortages and other economic realities; and

5. a lack of clarity in industry subcategorization, descriptions of process employed in seafood processing and associated wastes, and how effluent guidelines limitations will address multispecies processing facilities.

An integration of the above concerns leads NMFS to believe that the formulation of effluent guidelines which exceed screening requirements will be highly speculative.

The contract study starts with a fragmentary data base which cannot be statistically verified, applies limited normal distribution analyses, projects waste treatment efficiencies from limited pilot plant testing data, and finally projects these variables to processing subcategories where waste flows have not been adequately defined nor has the recommended DAF technology been tested.

Economic Aspects and Impacts on Fisheries Development

The seafoods industry in the United States has undergone considerable change since 1973 when the Environmental Protection Agency conducted the first effluent guidelines study. Significant developments in Federal policy have greatly enlarged Federal responsibility for the management of our Nation's fishery resources and have created a promising climate for industry expansion. Substantial growth, at least in the harvesting sector, has already occurred, along with restructuring in the industry to accommodate the new policies and a new order of biological, economic, and regulatory conditions that were not present in 1973.

In the policy area, the most profound changes came about through enactment of the Fishery Conservation and Management Act of 1976 (FCMA). This Act established sole U. S. jurisdiction over fisheries within a zone extending out 200 miles from U. S. shores. Under the Act, U. S. industry was given preferential access to fish that in many cases were formerly heavily exploited by foreign fleets, to the detriment of the resources, the economic well-being of U. S. fishermen, and the U. S. public at large.

Following enactment of FCMA, a new policy aimed at full development of our Nation's fishery resources was proclaimed. In May, 1979, the Administration announced a fisheries development policy initiative which would complement the management policy set forth in FCMA. The Administration's goal is to double our fisheries landings by 1990, which has the potential for creating more than 40,000 new jobs, improving our balance of trade, and providing an additional balance of trade, and providing an additional \$2 billion in new national wealth. To meet this national goal, approximately \$20 million in expenditures, annually, through 1984, have already been approved for fisheries research and development efforts. Significant contributions will also be made by other agencies, including the Economic Development Administration, and by the private sector, to develop ports and the infrastructure to support expanded fishing efforts.

One of the principles approved by the President as part of this policy is to improve the business environment by reviewing all regulations which have an impact on the seafood industry, particularly those segments which will be developed in the 1980's. Effluent limitation guidelines and new source performance standards which cannot be achieved without undue adverse production and economic impacts will seriously jeopardize the national goal of increased economic and nutritional benefits through fisheries development. Regulatory impacts can also heighten the adverse effects of the current economic recession.

Structural and Operation Changes

The U. S. fishing industry has undergone significant changes in the past 4 years. Highlights of these changes in the harvesting and processing sector include:

1. A virtual explosion in vessel construction to an increased growth rate of more than 8 percent. Unfortunately this increase has not been met with increased processing capacities. The situation is acute in New England, Alaska, and in the Pacific Northwest, and has resulted in sharp price cuts to the detriment of the industry's financial strength.
2. The FCMA and fluctuations in resource abundance have had a significant impact on the species sought and location of processing facilities. Species changes influence the character and amounts of waste generated, and the economics of waste treatment. Examples of production changes are found in the Alaskan crab and shrimp industry, salmon processing, and the development of underutilized species.
3. Escalating fuel costs are severely affecting all phases of the seafood industry. Harvesting is highly dependent on diesel fuel and prices have increased from 33 cents per gallon in 1974 to about \$1.00 in May of 1980. Profits have eroded as a result of increases in fuel and other costs, and the financial stability of the industry has been placed in jeopardy. The problem recently has been heightened by the general economic recession which has curbed consumer demand and has contributed to a sharp drop in fishery product prices. Vessels in many areas cannot meet expenses and have been forced to tie up. Some face bankruptcy or other forms of liquidation. It is estimated, for example, that between 800 and 1,000 shrimp vessels (about 20 percent of the fleet) may be forced out of the fleet by the end of 1980. Processors are also suffering losses, as inventories build up and become increasingly expensive to finance.

Fuel costs are also felt by processors. The rendering of solid shellfish wastes into crab and shrimp meal is fuel intensive.

Increased operating costs associated with fuel prices have made shrimp and crab meal noncompetitive with soybean and other protein byproducts. The blue crab industry on the east coast now faces a severe solid waste disposal problem. Approximately 80 percent of the live weight of crab leaves the plant as solid wastes and viable disposal techniques are being sought.

The economic development document must address a host of problems and changing conditions to assure that forthcoming effluent guidelines and new source standards not place undue economic burdens on seafood processors and inturn prevent the full economic and improved nutritional benefits envisioned in the Administration's fishery development policy initiative. There are many unknowns to be projected in the upcoming rulemaking process.

Yet another unknown, which is not in the realm of effluent guidelines, but which must be considered in developing seafood waste disposal policies, is the benefit of seafood waste treatment to local receiving waters.

THE BENEFITS OF WASTE TREATMENT - ANOTHER UNKNOWN

The Clean Water Act of 1977 mandated, among other things, that the Environmental Protection Agency assess the environmental effects of seafood discharges on local receiving waters.

The EPA report to the Congress has not been released, but technical support studies were provided to the industry and NMFS for comment. The general conclusion that can be drawn from the support documents is that the effects of seafood waste discharges are dependent on site specific conditions. Environmental degradation can be documented in areas of inadequate tidal flushing where organic loading is beyond the assimilative capacity of the receiving waters. In these areas, organic loading depresses dissolved oxygen levels causing local degradation. In areas of adequate dispersion and tidal flushing no adverse effects were noted. Some believe that seafood wastes are recycled and; hence, beneficial, but this aspect hasn't been clearly documented.

The assumption that seafood waste discharges are harmful and that any reduction will provide environmental benefits has been challenged. Are environmental considerations now worthy of consideration in cost/benefit analyses?

WEIGHING THE UNKNOWNNS - CONGRESSIONAL INTENT

Congressional intent is the key to redefining seafood waste disposal policies. It was the Congress, in 1972, that included seafood processors in the list of 28 manufacturing and agricultural processes to be governed by effluent guidelines.

The seafood industry was unsuccessful in lobbying to have itself removed from effluent guidelines even though this industry

is the only one which can claim that its effluents originated in the marine environment and contain no toxicants. A concession was granted, however, to allow for the ocean dumping of untreated organic fish wastes without a permit. Are additional changes in effluent guidelines now warranted? Any modification of effluent guidelines criteria will require Congressional action and legislative changes.

Compliance with new regulations always involves costs. In the case of seafood effluent guidelines the costs have yet to be adequately quantified. The industry and inturn the consumers bear the immediate costs. In the long-term, the impacts may be broader, the economy and public may not realize the full potentials of new jobs, national wealth, and improved nutrition espoused in the Administration's fishery development policy initiative.

Water quality criteria must always be met before a NPDES discharge permit is granted. Having this safeguard, can we afford to implement additional waste treatment requirements having unknown costs and with unknown benefits? The issue will most surely be one of debate.

REFERENCES

1. Weidenbaum, Murray L. (1979). The Future of Business Regulation. AMACOM, New York.

INDUSTRY'S ROLE AT THE INTERFACE OF
REGULATORY PROMULGATION AND ACTION

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Do we the processing industry have a role to play at the delicate interface of regulation and action? We must, or the loss through in-action will be real. No one wants to see a plant or business close, but enforcement of certain regulations that we have addressed at this conference could force that conclusion to a reality. As reference, I cite Development Planning and Research Associates Draft Report to EPA dated July, 1980, entitled, "Economic Impact Analysis of Proposed Limitations Guidelines for the Canned and Preserved Seafood Processing Point Source Category", in which the number of closures expected per seafood category are clearly spelled out.

Let me take you back to March 5th, 1974; the site - New Orleans, Louisiana; the occasion - the Technology Transfer Conference between EPA and this industry.

Permit me to take two quotes from my remarks to that audience:

1. "Generally, what does our industry look like-- we are made up of approximately 1,589 plants, 83% of which process less than one million dollars worth of product a year. Our 50 largest plants account for 60% of the industries processing value. That leaves 1,539 plants below that level. Imagine how small these operations actually are."

This value of course was based on 1974 dollars, inflation since then has also taken its toll.

The second quote outlined ten deep concerns:

1. I am not satisfied that we have found enough economical or practical treatment technology and methodology to handle our waste problems adequately.

2. I do not believe that EPA has properly taken into account the history and geography of our industry and what little flexibility we have of even trying to comply with some of these regulations.
3. Nowhere have I seen special consideration given to those plants that have heavy seasonal loads to process. That plant may only be busy three to four months out of twelve. Must we put in large capital expenditures to meet the specifics of a new regulation without regard to how this will affect a company's ability to earn a profit?
4. From what I have seen of estimated economic impacts on our industry, I just don't know how many of us will survive. We are not a highly capitalized industry. Where will this new money come from? Who will loan it to us? What collateral do I have? I can't show a banker the fish I expect to process because I haven't found and caught them yet.
5. All of this proposed technology will require an expenditure of energy. Will it be available?, and at what cost? I get concerned when I hear such statements as--well, convert the waste to fish meal, - have you ever tried to compete in that commodity market? Ask the crab meal fellows in Maryland and Virginia the nightmare they have been through lately. You also hear glibly thrown about, the statement--you have dissolved air flotation don't you? Yes, but in addition to extremely high costs for equipment, installation and operation, and doubtful successful application, what do I do with the solid waste sludge that I skim off the top with this treatment?
6. I must also question - is land available to adequately house these treatment schemes?
7. In the end, the consumer will be passed on the added cost of pollution control. She already is concerned with rising food costs. With these added cost burdens put on domestic producers, you unfairly give price advantages to foreign suppliers of our 65% dependence on imported seafoods.
8. The seafood industry does not have the tradition of a U. S. Department of Agriculture (like the meat industry), who have literally spent millions converting meat waste into useful new by-products. It takes money and facility that the seafood industry has never had the luxury of.

9. Other countries consider effluent impacts on a case-by-case basis rather than a set of rigid numbers. They also offer tax incentives to help implement such programs. I did not see any such considerations worked into the current proposals.
10. And finally, I must express my dismay when good advice is ignored by EPA from both its contractors and the effluent standards and water quality information advisory committee.

I concluded those remarks back in 1974 by adding, I cannot answer these questions and statement I have put before you. We are not a highly mechanized industry. Feasibility for much of what we are discussing has not been demonstrated. I'm fearful that if all of what has been promulgated is actually put into effect, that competition in the industry will be severely reduced. Putting companies out of business and reducing competition certainly was not the intent of Congress when this Act was passed.

My dear friends, those 1974 remarks are still germane today.

I maintain and will continue to maintain that except in areas of inadequate tidal flush or low dissolved oxygen, seafood wastes are food for other marine life and the technology acceptable for this industry is screening or grinding. Sophistication beyond this technology is not practical.

We have a new heritage, a chance to rebuild U. S. fisheries with the implementation of the 200-mile Bill. Many of the present effluent promulgations are an impediment to the full development and utilization of this new opportunity in fisheries.

Let me briefly outline where industry has been since 1972:

1. We cooperated fully with the first studies profiling technically the characterization of our plants and their effluents. But you know, the BCT numbers that were finally published in 1974 did not even reflect EPA's contractors' recommendations.
2. We cooperated in providing information during the first economic impact assessment studied with the EPA contractor.
3. Industry commented on the above studies in oral and written response reviewing the data for accuracy and reliance.

4. We were successful in attaching our amendment to the 1977 Clean Water Act, the now famous Section 74 study, that required EPA to conduct a one year study to determine the effects of seafood processing wastes on marine waters and to examine technologies to facilitate use of the nutrients in these wastes.

The study has been completed; but you know, the industry who requested this study has not been permitted to see a copy of the final report. I wonder why?

5. Faced with BAT (Best Available Technology) becoming BCT (Best Conventional Technology), but with little regard for re-evaluating the enforcement standards, the industry went to outside consultants for an evaluation of these new proposals and wrote a strong critique of the document. Except for some thinly veiled reference in EPA's final document, we were never accorded the courtesy of a reply.
6. Oral and written contact during all these phases has and will continue to be made to House and Senate public works committees in addition to special contact with certain key coastal House and Senate offices.
7. The industry has gone to court in the northwest and while having lost the DAF argument for the moment, they may have removed the lagoon requirement for the future.
8. The industry has painstakingly reviewed the latest E. C. Jordan technical reassessment document on the Effluent Limitations Guidelines and New Source Performance Standards for the Canned and Preserved Seafood Processing Point Source Category. It will be interesting to see what response this will generate in the final report to EPA.
9. Industry's analysis and comment on the cost reasonable tests have elicited from EPA the promise to evaluate the seafood category more carefully and to offer us further opportunity for comment when other polluting industries comment periods are closed.
10. We are about to tackle the evaluation of Development Planning and Research Associates draft economic impact analysis of Proposed Limitations Guidelines for the Canned and Preserved Seafood Processing Point Source Category document.

As an aside, I can't for the life of me see how the economic analysis can accurately reflect a correct conclusion when EPA does not even have the final technical document upon which many of the economic assumptions must be calculated.

In summation, we have no choice but to interface with the regulators. EPA regulations are not to be ignored, they are real. We in industry must see to it that those regulations are achievable and do not cause economic disruption. A continuous problem to overcome, and one not mentioned yet, is people and communication. Since 1972, there have been 33 people changes in EPA at levels that specifically impact the seafood industry. Just keeping up with the musical chairs is a job in and of itself.

We in the seafood industry believe enough data and study are in hand that we could sit down with EPA and negotiate a settlement based on simple technology, marine bioenhancement with our effluents, and site-by-site analysis for minimum economic disruption.

Without further court fights or using congressional pressure, we invite EPA to accept this invitation.

ENVIRONMENTAL REGULATORY PROGRAMS AFFECTING THE SEAFOOD PROCESSING INDUSTRY IN THE 1980s

Jack L. Cooper, Director
Environmental Affairs
National Food Processors Association
Washington, D. C.

INTRODUCTION

It is appropriate to begin a discussion of environmental regulatory programs affecting the seafood processing industry in the 1980s with a brief review of the legislative and regulatory programs that we faced in the 1970s. Probably the single most important event was the formation of EPA in 1970. Also during the decade of the 70s, the following environmental acts were passed:

- Noise Control Act
- Clean Air Act
- Federal Insecticide, Fungicide and Rodenticide Act Amendments of 1972
- Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act
- Safe Drinking Water Act
- Resource Conservation and Recovery Act
- Toxic Substances Control Act

SECTION 74 SEAFOOD STUDY

One of the amendments to the Clean Water Act in 1977 required the Environmental Protection Agency to conduct a study of the effects of seafood processing wastes on marine waters. This report was to have been submitted to Congress by January 1, 1979. Dave Ertz of the E. C. Jordan Company discussed this report with you earlier today, so I will not go into detail about it other than to say that we are hopeful that the report will form a firm foundation for the industry to go to Congress in the next session to seek modification of the Clean Water Act. Seafood processing plants should not be required to provide treatment greater than that required by Best Practicable Technology (BPT) effluent guidelines unless such additional treatment is necessary to achieve locally derived water quality standards. It is the position of the National Food Processors Association that treatment beyond the BPT level is unwarranted

unless such treatment is required to achieve water quality standards.

EPA ACTIVITIES IN THE 1980's

Looking to the 1980s, the seafood processing industry can expect EPA to .

- Continue to implement existing legislation;
- Increase enforcement against violators of NPDES permits;
- Attempt to improve the award of grants to municipalities for construction of publicly-owned wastewater facilities;
- Develop additional regulations to protect underground water supplies from contamination; and
- Increase efforts to regulate the disposal of toxic and hazardous substances.

REGULATIONS AFFECTING THE DISPOSAL OF SEAFOOD PROCESSING WASTES

Liquid seafood processing wastes are either discharged directly to surface waters after treatment, or are discharged into a publicly owned treatment works. Solid wastes that are not utilized in some manner are either discarded on the land or in the ocean.

Effluent Guidelines Development

Plants providing self-treatment of their liquid wastes must obtain an NPDES permit which will require compliance at a minimum with EPA's effluent guidelines. Currently, the only effluent guidelines applicable to seafood processing plants are those established as the Best Practicable Technology (BPT). The previously established Best Available Technology (BAT) effluent guidelines were revoked by EPA when it issued its final Best Conventional Technology (BCT) cost reasonableness test in August 1979. Also, EPA has suspended for this processing season the non-remote BPT effluent guidelines for Alaskan salmon processing plants.

EPA has initiated a rule-making effort to develop the Best Conventional Technology effluent guidelines for the seafood processing industry. The E. C. Jordan Company of Portland, Maine, has been retained as the technical contractor and the Development Planning and Research Associates of Manhattan, Kansas, has been retained as the economic impact analysis contractor. The E. C. Jordan Company has completed its draft technical report for EPA and Mr. Ertz of the Jordan Company discussed their efforts with you earlier today.

EPA has released for public comment a draft report containing the Development Planning and Research Associates economic impact analysis of the technical recommendations made by the E.C. Jordan Company. EPA's Art Burman discussed this draft with you earlier.

After accepting both the E. C. Jordan Company and the DPRA reports, the Agency will develop proposed BCT effluent guidelines for the seafood processing industry. This proposal will probably be published for public comment in the Federal Register by early 1981. The Agency probably will not be able to issue the final BCT regulations until mid-to-late 1981. Until such time as the Agency issues the final BCT regulations, the only applicable effluent guidelines are those issued for BPT with which everyone should have already complied. However, some state and EPA officials may issue BCT effluent limitations in individual NPDES permits based on their "best engineering judgment."

CONSOLIDATED PERMIT REGULATIONS

EPA in the May 19, 1980 Federal Register issued final regulations consolidating the following permit programs:

- Hazardous waste management
- Underground injection controls
- National pollutant discharge elimination systems (NPDES)
- Dredge and fill
- Prevention of significant deterioration.

NPDES Permit Program

The major permit program with which seafood processors need to be thoroughly familiar, is the NPDES. When the Agency consolidated the regulations, many significant changes were made in the NPDES permit program. There are separate requirements depending upon whether a plant is requesting a permit for a new source or an extension of an existing permit to continue operations.

NPDES Permits for Existing Plants

Existing plants requesting reissuance or modification of a permit must file an application with the appropriate NPDES permit issuing office, either the EPA regional office or state. The appropriate permitting office will then prepare a draft permit and submit it to the company for comment. Thirty days are allowed for review of the draft permit and for the company to submit any comments that it has on the draft permit. The permit issuing official will also notify the public that a draft permit is being considered for the facility and any person may request a public hearing during the 30-day comment period.

It is important that all concerns that your company may have with the permit be brought up during the 30-day comment period. After the 30-day comment period, EPA may refuse to consider any new issue.

After considering all comments, including those made at a public hearing, if one was held, a final permit will be issued. If the company objects to a provision in the final permit, an evidentiary hearing may be requested within 30 days. Issues that were not brought up during the comment period on the draft permit may not be brought up during the evidentiary hearing. Provisions that are contested are not in effect during the period of time the permit issuing office is considering the appeal.

If a company is still not satisfied after the permit issuing official makes a decision based on evidence presented at the evidentiary hearing, an appeal may be made to the EPA Administrator. If the company is still dissatisfied after the Administrator makes his final decision, the permit may be appealed to the courts.

NPDES Permits for New Plants

The NPDES permit procedures for obtaining a permit for a new plant are different from those for obtaining an extension of an existing permit. Instead of having an evidentiary hearing to review contested provisions, new plants must participate in non-adversary procedures.

As in a reissued permit, a company vice-president must apply for the permit. The permit issuing official then submits a draft permit to the company and allows 30 days for public comment on it. Again, all issues must be raised during this comment period. If requested, a panel hearing on the permit will be held, and a supplemental hearing can be held where cross examination of witnesses will be allowed. The permit issuing office will then issue a final decision on the permit. If a company is dissatisfied with the final decision, an appeal may be made to the EPA Administrator. If the company remains dissatisfied after the Administrator makes his determination, the company may appeal to the courts.

Construction Cannot Begin Until the Final Permit is Accepted (Issued) - Another significant difference between obtaining a reissued permit and a permit for a new facility is the fact that contested provisions of a reissued permit are not effective; however, when new permits are being negotiated, the company cannot begin construction of the facility until the final permit is issued.

Vice-President or Equivalent Must Sign NPDES Permit Application Form

One major change in the new NPDES regulations is that a vice-president must sign the permit application submitted to the NPDES permit-issuing office. The vice-president must certify that he/she has personally examined and is familiar with the information on the application. It is expected that the vice-president will take whatever steps are necessary to insure that the information in the application is complete and accurate. This requirement has sometimes been referred to as the "vice-president to go to jail" because the person signing the application is the one against whom enforcement action will be taken in the event the permit is violated.

Monitoring Reports May be Signed by a Plant Manager

NPDES permits require submission of monitoring reports on a periodic basis. While the permit application itself must be signed by a vice-president, the monitoring report may be signed by a plant manager or equivalent company official. If the company conducts any monitoring of parameters listed in the NPDES permit that are not required to be reported, the company still must notify EPA of the results of that monitoring. In other words, any analysis of pollutants listed in the NPDES permit must be reported to EPA whether the permit requires such monitoring or not.

Duty to Halt or Reduce Production

The new NPDES permit regulations state that a company has a duty to halt or reduce production in order to remain in compliance with its NPDES permit.

Availability of the EPA May 19, 1980 Consolidated Permit Regulations

Copies of the EPA Consolidated Permit Regulations are available from EPA's Edward A. Kramer, Office of Water Enforcement (EN-336), U. S. Environmental Protection Agency, Washington, D. C. 20460; phone 202/755-0750.

EPA PROGRAMS TO PROTECT UNDERGROUND WATER SUPPLIES FROM CONTAMINATION

One of EPA's major regulatory programs for the 1980's is to protect underground water supplies. Accordingly, seafood processing plants operating their own wastewater treatment facilities providing treatment greater than

screening and/or discarding their solid wastes onto land under their control will probably be affected by EPA and state regulations designed to protect underground water supplies from contamination.

The solid waste disposal criteria regulations issued by EPA in the September 13, 1979 Federal Register, contain the requirements for disposing of both liquid wastes in pits, ponds and lagoons and solid wastes in landfills. Pits, ponds and lagoons are subject to the solid waste disposal criteria regulations because of the broad nature of the term solid waste as defined in the Resource Conservation and Recovery Act. In this Act, solid waste is defined as any solid, liquid or contained-gaseous substance placed into or on the land for waste disposal purposes. These regulations apply only to non-toxic, non-hazardous wastes and are implemented by the states. They are not implemented by EPA.

There is an exemption in the solid waste disposal criteria regulations for agricultural wastes that are returned to the soil as fertilizer or as soil conditioning agents. This exemption, however, has been interpreted very narrowly by the Agency, and applies only to crop residues left in the field. The Agency does not consider that food processing wastes qualify for the agricultural exemption.

The solid waste disposal criteria apply to the application of solid wastes, including sludges, to crop land. The criteria also have requirements that disease-spreading vectors be controlled as well as requirements to protect the safety of persons and aircraft around the disposal site.

The criteria are designed to protect endangered species, surface waters, ground waters, and air quality around the site. Also, there are restrictions on placing solid waste disposal facilities in flood plains.

In evaluating whether a site should be allowed to be used, the following groundwater contamination parameters have been established by the Agency:

- the thickness of the water saturation zone and the type of earth beneath the site;
- the relative hazard of the waste;
- the quality and quantity of the water beneath the site.

Each of these parameters is assigned a rating of 0 to 9. The ratings are then totaled to give the contamination potential for the site. Because of the emphasis state and EPA officials are placing on the protection of underground water supplies, many plants utilizing land for disposal of solid wastes and self-treatment facilities for their wastewaters will probably be required to put in monitoring wells around their sites and to report the results to the state. Where the monitoring shows the potential for groundwater contamination, lining of the facility or abandonment of it will probably be required.

In evaluating whether a waste disposal site will contaminate underground water supplies, EPA and the states will be using the maximum contaminant levels for organic and inorganic chemicals established in the interim-primary drinking water standards. The maximum contaminant levels for inorganic chemicals in milligrams per liter (mg/l) follow:

Arsenic	0.05	Mercury	0.002
Barium.	1.0	Nitrate	10.0
Cadmium	0.01	Selenium.	0.01
Chromium.	0.05	Silver.	0.05
Lead.	0.05	Fluorine.	1.4-2.4
			(dependent on temperature)

The maximum contaminant levels for organic chemicals in milligrams per milliliter (mg/l) follow:

Endrin.	0.0002	Toxaphene	0.005
Lindane	0.004	2,4-D	0.1
Methoxychlor.	0.1	2,4,5-T	0.01

WATER QUALITY CRITERIA VS STANDARDS

The Environmental Protection Agency is in the process of developing water quality criteria for 129 toxic pollutants. When established these criteria will be the maximum levels of these pollutants in ambient waters that the Agency considers will not cause harm to public health or the environment. These criteria are set by EPA, and of themselves are not enforceable.

However, the criteria form the basis for states to utilize in establishing water quality standards for a particular body of water. The water quality standards are set after public hearings. Once established, water quality standards are enforced by state and EPA officials in NPDES permits.

It is important for the state water quality standards to be reasonable. If an unrealistically stringent water quality standard is established, the state may require municipalities to install advanced wastewater treatment and require companies to install treatment technologies greater than would be required if stringent water quality standards did not have to be met.

REGULATIONS AFFECTING INDUSTRY USERS OF MUNICIPAL SEWAGE TREATMENT FACILITIES

Pretreatment

There are no national pretreatment standards for the treatment of seafood processing wastewaters other than the general prohibitions on the discharge of substances that:

- Create a fire or explosion hazard;
- Cause corrosive structural damage;
- Have a pH less than 5.0 unless the municipal plant is designed to handle such waste;
- Are solid or viscous;
- Interfere with the operation of the treatment works; and
- Are 40°C (104°F) or higher.

However, individual communities may establish pretreatment standards on a case-by-case basis if necessary in order for the municipality to achieve effluent limitations established in its NPDES permit.

Industrial Cost Recovery

A. Recent Senate Activity

1. ICR Repeal Bill, S. 2725, Approved by Senate Committee

The Senate Environment and Public Works Committee on May 8, 1980 approved S. 2725. Section 4 of this bill would repeal the ICR requirement from the Clean Water Act.

2. Provision Prohibiting Federal Funding of Industrial Capacity in POTWs Added to S. 2725 by Senator Stafford

During the May 8, 1980 mark-up of S. 2725 by the full committee, the following amendment, known as the Stafford amendment, was approved as Section 5 of the bill:

"Sec. 5. Section 201 of the Clean Water Act is amended by adding the following new subsection:

"(k) No grant made after September 30, 1980, for a publicly owned treatment works, other than for facility planning and the preparation of construction plans and specifications shall be used to treat, store, or convey the flow of any industrial user into such treatment works in excess of a flow per day equivalent to fifty thousand gallons per day of sanitary waste. This subsection shall not apply to any project proposed by a grantee which is carrying out an approved project to prepare construction plans and specifications for a facility to treat wastewater, which received its grant approval before May 15, 1980."

a. Effect of the Stafford Amendment

As of October 1, 1980, no federal construction grant would be allowed for treatment of wastewater from any industrial user with a flow greater than 50,000 gallons per day of sanitary waste equivalent. The Stafford amendment is not intended to affect any project which received a construction grant (Step III) prior to October 1, 1980 nor any project for which construction plans and specifications (Step II) had been approved prior to May 15, 1980.

If the Stafford amendment were to be enacted into law, industrial users of publicly owned treatment works (POTWs) constructed with Federal grant funds after September 30, 1980 would be required to secure their own funding. Municipal officials would have to work with their industrial users to be assured that they secure sufficient capital to pay for the capacity planned for their use.

b. NFPA Opposes the Stafford Amendment
(Section 5 of S. 2725)

While supporting Section 4, the ICR repeal provisions of S. 2725, NFPA opposes Section 5, the Stafford amendment.

3. S. 2725 Approved 93-0 June 25 by the Senate

The full Senate on June 25, 1980 approved S. 2725, a bill containing both Section 4 which would repeal ICR and Section 5, the Stafford amendment.

B. Recent House Activities - H.R. 6667 Approved by
House Committee

On April 23, 1980, the House Committee on Public Works and Transportation passed and sent to the full House,

H.R. 6667, Section 2 of which would repeal the ICR provisions of the Clean Water Act. The bill had been scheduled for floor action during the week of September 22. It has an open rule with one hour of debate allowed.

C. ICR Moratorium Expired on June 30, 1980

On June 30, 1980, the moratorium on the collection of ICR payments expired.

D. EPA Issued Memorandum on Collection of ICR Payments

On July 14, 1980, EPA's Construction Grants Administration Division issued a memorandum to the EPA Regional Offices stating that "... effective July 1, 1980 industrial users must pay ICR charges on a current basis." The memo goes on to state: "For all industrial users which began use of a treatment works prior to June 30, 1980, the first payment by each industrial user must be collected not later than June 30, 1981 . . . This annual payment must include payment of the current ICR charges, as well as the prorated payment of any ICR charges incurred during the moratorium. . ."

E. The Current Status of ICR

The House is expected to bring H.R. 6667 up for a vote sometime this week. Once the House passes this bill, a conference is expected to be scheduled to resolve the differences between H.R. 6667 and S. 2725. Hopefully, during the conference acceptable alternatives to the Stafford amendment will be worked out and a compromise bill acceptable to both Houses will evolve, be passed and sent to the President for his signature.

Until such time as Congressional action is completed on this issue, many of you may be requested to make ICR payments. Since the law has not yet been changed, communities are within their legal rights to request this money.

Status of Municipal Compliance with the Secondary Treatment Requirements

EPA recently estimated that about 15,000 municipal wastewater treatment works provide primary or higher treatment. Only 10,000 of these were designed for secondary treatment and only 4,500 are actually achieving secondary treatment. Thus, 5,500 of the nation's municipal secondary treatment plants must be improved through minor

expansion or significant operation and maintenance improvement. Also, 5,000 plants providing only primary treatment will have to be upgraded over the coming years to achieve secondary treatment. In addition to these plants that EPA knows are providing some type of treatment, there are several thousand other municipalities that do not provide any treatment whatsoever that must move all the way from zero treatment to secondary.

EPA REGULATION OF TOXIC AND HAZARDOUS SUBSTANCES

As all of us can read in the paper practically every day, EPA and the nation's news media are preoccupied with the issue of improper storage and disposal of toxic and hazardous wastes. Fortunately, food processors do not utilize very many toxic or hazardous substances in their operations, and should be affected little by the regulations. However, some of EPA's proposed or final regulations will affect the industry to a limited degree.

EPA's Proposal to Establish Ammonia as a Toxic Pollutant

EPA in the January 3, 1980 Federal Register proposed to add ammonia to its list of toxic pollutants. Since ammonia is the normal breakdown product of protein degradation, it is present in the treated effluent of several food processing subcategories, including meat, poultry and rendering. It is not present in significant quantities in seafood wastewaters where the waste is treated by screening or by dissolved air flotation; however, ammonia will be present in wastewaters resulting from biological treatment of seafood wastes and in the sludge produced by DAF systems.

EPA's primary reason for listing ammonia as a toxic pollutant is the toxic effect that it can exert on waterways if the pH of the waterway is 8.0 or above and if the ammonia is present at 20 ppm or greater. However, most of the nation's waters do not have a pH this high. Accordingly, the industry believes that ammonia should be regulated on a case-by-case basis when needed to achieve water quality standards. It should not be regulated through EPA's national programs nor should it be listed as a toxic pollutant.

A Food Industry Ammonia Coalition was established by food processing trade associations to develop comments on the proposal. Detailed comments on the proposal were developed by the food processing industry and submitted to the EPA. The Agency is currently evaluating all comments that it has received and should issue a final decision within the next month or so.

EPA Proposal to Ban the Use of PCB-Containing
Equipment in Food Processing Plants

A proposal by FDA, USDA's FSQS and EPA published in the May 9, 1980 Federal Register would require the removal of all PCB containing equipment exceeding 50 parts per million from food and feed related facilities. It states that any final regulations resulting from the proposal shall be effective 180 days after the date of publication of the final regulations in the Federal Register or after an incinerator approved by EPA is available for disposal of PCBs, whichever is later.

The agencies involved have extended the deadline for receipt of comments on the proposal from July 7, 1980 to November 4, 1980. NFPA is preparing comments on the proposal. Anyone with information on the cost of replacing PCB-containing equipment or problems encountered with this proposal are requested to send this information to Mary E. Losikoff, Assistant Director, Environmental Affairs, National Food Processors Association, 1133 - 20th Street, N. W., Washington, D. C. 20036. Her phone number is (202) 331-5926.

The FDA proposal states that "raw materials susceptible to contamination with PCBs be analyzed as necessary" to ensure that the finished foods comply with current FDA tolerances. Both the FDA and USDA proposals utilize the words "premises" or "in or around" food and feed facilities in reference to the areas where PCB containing equipment should be removed.

NFPA has suggested that all food processors take an inventory of capacitors containing more than three pounds of dielectric fluid, and all transformers to determine their location and whether they contain PCBs at a concentration over 50 parts per million. The presence of PCBs can be verified by the manufacturer, by a service company, by a utility company, or through testing by a laboratory. Other equipment which may contain PCBs are heat transfer systems, hydraulic systems and electromagnets.

All existing equipment containing PCBs should be labeled in accordance with EPA's May 31, 1979 final PCB regulations. Copies of these regulations and additional PCB information are available from EPA's Industry Assistance Office: phone toll-free 800/424-9065.

A PCB Coalition has been formed consisting of representatives of food industry trade associations, manufacture

of transformers, and utility trade associations. This coalition is exchanging information on the proposals.

EPA has developed a booklet on the use of PCB-containing equipment in food processing plants titled "PCBs - An Alert for Food and Feed Facilities" which is available from EPA's Industry Assistance Office; phone toll-free 800/424-9065.

EPA May Require Best Management Practices to be Written into NPDES Permits

An NPDES permit writing official may write into an NPDES permit a requirement that best management practices be implemented to control the discharge of toxic or hazardous pollutants from:

- raw material storage areas;
- in-plant transfer and material handling areas;
- loading and unloading areas;
- plant site runoff; and
- sludge and hazardous waste disposal areas.

These best management practices would be designed to prevent spills or runoff of hazardous or toxic substances from the plant site to receiving waters or groundwater.

An Analysis of EPA's Hazardous Wastes Management System Regulations

In the February 26 and May 19, 1980 Federal Registers EPA issued its hazardous waste management system regulations. These regulations require "cradle-to-grave" control of all hazardous wastes. Generators, transporters, storers and treaters of all hazardous waste were required to notify EPA of their activity by August 18, 1980. After receiving the notification form, EPA will issue the company an EPA identification number. After November 19, 1980, it will be illegal to transport hazardous wastes without a manifest. The manifest must carry the plant I. D. number and list a destination which must be an EPA permitted hazardous waste disposal site.

Fortunately, no one has called to our attention any waste produced by the seafood processing industry that would be considered hazardous by the EPA regulations. If anyone knows of any such waste that may be hazardous, we encourage you to bring this information to our attention so that we can investigate whether or not the waste is hazardous according to the regulations.

Fruit and vegetable processors utilizing caustic to peel fruits and vegetables have determined that the pH of their resulting peel wastes may exceed the characteristic of corrosivity by having a pH of 12.5 or above. However, the pH of the peel waste is usually adjusted to below this level before it leaves the plant. NFPA is in the process of preparing a petition for modification to EPA on the hazardous wastes regulations.

There are two exemptions from the regulations. First, if the hazardous waste is discharged into a sewer, mixed with domestic sewage and treated at a municipal wastewater treatment facility, then the regulations do not apply. This is because the act upon which the regulations are based specifically excludes domestic sewage. Second, if the waste is recycled for a beneficial use, the regulations do not apply.

If a food processor transports a hazardous waste to his own wastewater or solid waste disposal facility, then the act of treating that waste requires the company to apply to EPA by November 19, 1980 for a separate permit for the hazardous waste treatment facility. NFPA encourages food processors not to transport hazardous wastes off of their plant premises.

Spills of Hazardous Substances

Since many food processors receive and store some hazardous substances such as chlorine and sodium hydroxide on plant premises, plant management should be familiar with EPA's August 29, 1979 regulations controlling accidental spills of these compounds. The list contains 299 substances and if a "reportable quantity" of any of them is spilled into the nation's waters, then the company is required to notify the U. S. Coast Guard or the appropriate EPA regional office of the spill within 24 hours of its occurrence. The phone number for the Coast Guard is 800/424-8802. This is a toll free number and the duty officer will refer your call to the proper person or tell you who to contact.

State/EPA Agreements

The Environmental Protection Agency is requiring each of the states, as a condition for grant support, to sign annual state/EPA agreements. These agreements identify the major pollution problems that the state intends to address over the coming year. These agreements currently cover state programs to implement requirements of the Clean Water Act, the Safe Drinking Water Act, and the

Resource Conservation and Recovery Act. Some of the state/EPA agreements include programs to implement the Clean Air Act. Information about your state's agreement with EPA is available from EPA. You should be able to get a copy of your state/EPA agreement from EPA's Water Planning Division in Washington, D. C.; phone 202/426-2522.

CONCLUSION

Environmental regulations will continue to affect the seafood processing industry in the 1980s. EPA will continue to develop its BCT effluent guidelines which, after promulgation, will have to be met by July 1, 1984. Additionally, seafood processors will need to keep up-to-date on other EPA and state programs affecting:

- Water quality standards for the body of water into which processing wastewaters are discharged;
- Programs to protect underground water supplies which may affect current liquid and solid waste disposal practices;
- Spills and disposal of hazardous wastes; and
- EPA/state pollution control agreements.

APPENDIXES

CONFERENCE ON SEAFOOD WASTE MANAGEMENT IN THE 1980's

September 23-25, 1980

Orlando Marriott Inn
Orlando, Florida

Tuesday - September 23

Afternoon Session

- 1:45 p.m. WELCOME - W. Steven Otwell, Conference Chairman,
University of Florida
- 1:50 p.m. OPENING - Stanford Beebe, Coastal Plains Commission,
Conference Sponsor

OVERVIEW OF SEAFOOD WASTE MANAGEMENT IN THE UNITED STATES

Session Chairman: Col. Beverly C. Snow, Jr.,
Executive Director, Coastal Plains Center for
Marine Development Services

- 2:00 p.m. Seafood Waste Management in Virginia
Tom Murray, Virginia Institute of Marine Sciences
- 2:20 p.m. Assisting North Carolina Seafood Processors in
Meeting Water Pollution Requirements
Roy Carawan, North Carolina State University
- 2:40 p.m. Seafood Waste Management in South Carolina
Terry Titus, Clemson University
- 3:00 p.m. Seafood Discharges and Southeastern Estuarine
Environments
Keith Gates, University of Georgia
- 3:20 p.m. BREAK
- 3:40 p.m. Seafood Waste Management in Florida
Steve Otwell, University of Florida
- 4:00 p.m. Seafood Waste Management in the Gulf of Mexico
Allison Perry, Mississippi Gulf Coast Research Lab
- 4:20 p.m. Seafood Waste Management in the Northwest and Alaska
George Pigott, University of Washington
- 4:40 p.m. Fishery Waste Management in the Great Lakes
David Stuber, University of Wisconsin
- 5:00 p.m. ADJOURN
- 6:30 p.m. Attitude Adjustment

Wednesday - September 24

Morning Session

SEAFOOD WASTE TREATMENT

8:30 a.m.	Session Chairman: Roy Martin, National Fisheries Institute
8:40 a.m.	Ocean Dumping of Seafood Wastes as a Waste Management Alternative P. Kilho Park, Ocean Dumping Program, NOAA
9:00 a.m.	Removal of Suspended Solids from Seafood Processing Wastewaters Ronald A. Johnson, University of Alaska
9:20 a.m.	Lagoons for Treatment of Seafood Wastes Joe McGilberry, Mississippi State University
9:40 a.m.	Dissolved Air Flotation for Treatment of Seafood Wastewater A. J. Szabo, Domingue, Szabo & Associates Inc.
10:00 a.m.	Dissolved Air Flotation for Treatment of Shrimp Waste Paul P. Selley, Southland Canning & Packing Co., Inc.
10:20 a.m.	BREAK
	Session Chairman: Stan Waskiewicz, Blue Channel Corporation
10:40 a.m.	Seafood Processing Wasteload Reduction by Mechanical Filtration Russell Brinsfield, University of Maryland
11:00 a.m.	Closed Loop Process Fluid System Rick Dafler, Blue Channel Corporation
11:20 a.m.	Recovery of By-Products from Seafood Processing Wastes Stanley Barnett, University of Rhode Island
11:40 a.m.	Municipal Discharge - Regulations and Surcharges Roy Carawan, North Carolina State University
12:00 Noon	LUNCH

Wednesday, September 24

Afternoon Session

SEAFOOD WASTE UTILIZATION

Session Chairman: Don Toloday, Singleton's
Shrimp Packing Corp.

- 1:20 p.m. Fishing Harbor Wastes and What Can Be Done
About the Problems
Ersel Lantz, Brownsville, Texas
- 1:40 p.m. Recovery, Utilization and Treatment of Seafood
Processing Wastes
Bob Zall, Cornell University
- 2:00 p.m. Edible Recoverables - Mince Fish, etc.
Bob Baker, Cornell University
- 2:20 p.m. Utilization of Shellfish Meals in Domestic Feeds
Fredric Husby, University of Alaska
- 2:40 p.m. Utilization of Shrimp Processing Wastes in Diets
for Fish and Crustacea
Samuel Meyers, Louisiana State University
- 3:00 p.m. BREAK
- Session Chairman: Russell Miget, Texas A&M University
- 3:20 p.m. Fish and Seafood Waste as Nutrients for Agricultural
Crop Fertilization
Louis Aung, V. P. I. & State University
- 3:40 p.m. Crab Meal Production: Tragic Impact on the Blue Crab
Industry Unless Viable Alternatives Established

Kim Brown, Hampton, Virginia
- 4:00 p.m. Chitin-Chitosan Production for Utilization of
Shellfish Wastes
Ben Averbach, Massachusetts Institute of Technology
- 5:00 p.m. ADJOURN
- 6:30 p.m. Attitude Adjustment
- 7:30 p.m. Informal Banquet

Thursday, September 25

Morning Session

SEAFOOD WASTE REGULATIONS IN THE 1980's

8:30 a.m.	Session Chairman - Louis Burney, Florida Department of Environmental Regulations
8:35 a.m.	EPA's Regulatory Activities Affecting the Seafood Processing Industry Bill Cloward, EPA, Atlanta, Georgia
8:55 a.m.	"Caution" - EPA Contractor at Work David, B. Ertz, Edward C. Jordan Co., Inc., Portland, Maine
9:15 a.m.	Economic Impact Analysis for Proposed Limitations Guidelines for Seafood Processors Arthur Berman, EPA, Washington, DC
9:35 a.m.	BREAK
9:55 a.m.	The Unknowns of Seafood Waste Treatment: Costs, Benefits, and Congressional Intent David Dressel, NMFS, Washington, DC
10:15 a.m.	Industry's Role at the Interface of Regulatory Promulgation and Action Roy Martin, National Fisheries Institute, Washington, DC
10:35 a.m.	Environmental Regulatory Programs Affecting the Seafood Processing Industry Jack Cooper, National Food Processors Association, Washington, DC
11:30 a.m.	Open Discussion
12:00 Noon	ADJOURN CONFERENCE

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Florida Sea Grant College is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number O4-8-M01-76, under provisions of the National Sea Grant College and Programs Act of 1966. This information is published by the Marine Advisory Program which functions as a component of the Florida Cooperative Extension Service, John T. Woeste, dean, in conducting Cooperative Extension Work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914. The Florida Sea Grant College is an Equal Employment Opportunity-Affirmative Action employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.

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