EPA-600/2-77-157
August 1977

Environmental Protection Technology Series

WASTE TREATMENT AND DISPOS
SEAFOOD PROCESSING

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WASTE TREATMENT AND DISPOSAL FROM SEAFOOD PROCESSING PLANTS

by

Russel B. Brinsfield
University of Maryland
Center for Environmental and Estuarine Studies
Horn Point Environmental Laboratories
Cambridge, Maryland 21613

and

Douglas G. Phillips
Department of Natural Resources
Maryland Environmental Service
Annapolis, Maryland 21401

Grant No. S803522-01-0

Project Officer

Billy L. DePrater
Industrial Sources Section
Robert S. Kerr Environmental Research Laboratory
Ada, Oklahoma 74820

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OKLAHOMA 74820

DISCLAIMER

FOREWORD

The Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the agency's effort involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs to: (a) investigate the nature, transport, fate and management of pollutants in groundwater; (b) develop and demonstrate methods for treating wastewaters with soil and other natural systems; (c) develop and demonstrate pollution control technologies for irrigation return flows; (d) develop and demonstrate pollution control technologies for animal production wastes; (e) develop and demonstrate technologies to prevent, control or abate pollution from the petroleum refining and petrochemical industries, and (f) develop and demonstrate technologies to manage pollution resulting from combinations of industrial wastewaters or industrial/municipal wastewaters.

This report contributes to the knowledge essential if the EPA is to meet the requirements of environmental laws that it establish and enforce pollution control standards which are reasonable, cost effective and provide adequate protection for the American public.

W. C. Galegar
Director
Robert S. Kerr Environmental
Research Laboratory

ABSTRACT

The objectives of this study were to examine current wastewater and solid waste disposal practices, characterize the wastewater effluent and to recommend economical waste treatment and disposal systems for seafood processing plants in Maryland where municipal treatment facilities are not available. The study also included an examination of current disinfection practices and requirements.

Wastewater samples from randomly selected plants processing blue crabs, oysters, soft-shell clams and fish were analyzed for settleable solids, total suspended solids (TSS), five-day biochemical oxygen demand (BOD_5), oil and grease (O & G), pH, residual chlorine, phosphorus, nitrogen as nitrite and nitrate, nitrogen as ammonia and total Kjeldahl nitrogen, total coliform, and fecal coliform.

All plants sampled were meeting oil and grease as well as pH effluent limitations promulgated by EPA for both 1977 and 1983. Only a few plants were able to meet the TSS limitations using static screens. None of those plants with requirements limiting BOD_5 are currently meeting the criteria for 1983. Several plants sampled were not consistently meeting the State imposed bacterial limitations even though residual chlorine levels in the effluent were relatively high.

This report was submitted in fulfillment of Grant No. S803522-01-0 by University of Maryland, Center for Environmental and Estuarine Studies under sponsorship of Maryland Environmental Service and the U.S. Environmental Protection Agency. This report covers a period from February 15, 1975 to August 15, 1976 and was completed as of August 3, 1976.

CONTENTS

TABLES

ACKNOWLEDGMENTS

The Maryland Department of Economic and Community Development provided C.E.T.A. manpower for wastewater sampling and analysis. Their cooperation is sincerely appreciated.

The University of Maryland Center for Environmental and Estuarine Studies, Horn Point Environmental Laboratories, Cambridge, and Marine Products Laboratory, Crisfield, generously provided manpower and facilities for this study. Their assistance is deeply appreciated.

The continued assistance, cooperation and advice of Mr. Robert Prier of the Chesapeake Bay Seafood Industries Association is gratefully acknowledged.

Funds supporting completion of this document were provided to the author through the Marine Advisory Service division of the University of Maryland Sea Grant Program. Their support is appreciated.

Special thanks to Professor Paul Winn of the University of Maryland Center for Environmental and Estuarine Studies for his continued guidance and support throughout the project.

SECTION 1

INTRODUCTION

There are approximately 80 seafood processing plants in Maryland outside the city of Baltimore and 47 of these are in areas where there are no municipal sewage treatment facilities, thus requiring them to discharge to tidal waters. Of the latter group, 39 are located on the Eastern Shore of the Chesapeake Bay and 8 are on the Western Shore. These 47 processing plants are the ones of principal concern in this study.

These processing plants probably do not fit the pattern of most of the seafood processing plants in other parts of the country because of the low wastewater flow, product mix and unique features of the Chesapeake Bay System. As far as can be determined, very little work has been done to characterize wastewater effluent from Maryland plants and it was assumed that this was an essential first step before considering treatment alternatives.

These problems were brought to the attention of the Maryland Environmental Service, an agency within the Department of Natural Resources, created by the Maryland General Assembly to assist local governments and industry in the elimination of pollution resulting from disposal of liquid and solid wastes. Consequently, this project was initiated through the EPA with costs being shared by both the Federal and State governments.

Seafood harvesting and processing on the Chesapeake Bay are a significant segment of the economy in Maryland. In 1973, the total value of all seafood products processed in Maryland exceeded $80 million (13). Of the total 1973 landings of fish and shellfish in Maryland, about 90% consisted of shellfish, including oysters, clams and blue crabs. The majority of seafood harvesting and processing is done by individuals, partnerships or very small companies. Many processing plants are located in remote areas or very small communities where they are the sole or principal employer, with the result that the economy of these communities depends largely on the seafood industry. The requirements for wastewater treatment called for by E.P.A. and by the State of Maryland become a significant economic factor in the processor's operating costs. This becomes even more significant in light of other requirements placed on processors such as those involving the National Shellfish Sanitation Program (7), which are presently being reviewed and revised prior to re-issue.

If wastewater treatment costs should significantly increase operating costs, a majority of the smaller plants no longer may find it profitable to stay in business. Passing additional costs on to the customers might result in major market losses. Of the 47 seafood processing plants surveyed, none can make the capital investments indicated by the National Commission on Water Quality Report (see Table 1) and remain in business. The wastewater treatment capital costs, in almost all cases, exceed the present capital investment in the processing plant and facilities. It therefore becomes important to find the most economical methods of waste treatment and disposal consistent with meeting water quality standards.

The objectives of the present study were to examine current wastewater and solid waste practices and to determine the most cost-effective methods of treatment and disposal of wastes from seafood processing plants where municipal treatment facilities are not available. It was first necessary to determine the characteristics of the wastewater by means of an extensive wastewater sampling and laboratory testing program. The study also included an examination of disinfection practices, solid waste handling and disposal and wastewater monitoring requirements.

The Special Conditions of the Grant stated that:

"The results of the study will specifically include the following:

1. An evaluation of the possibility of using one centralized treatment facility to handle all seafood processing wastes.
2. An evaluation of the possibility of using more than one centralized treatment facility to handle the same wastes.
3. An evaluation of the possibility of having all seafood processors completely treat their own wastes.

Each of the preceding options will be compared with a recommended scheme(s) for treatment and disposal. The option of pre-treating and discharge to a municipal system will be considered in each case.

The possibilities of waste-product utilization will also be evaluated".

Upon receipt of the Environmental Protection Agency grant, the Maryland Environmental Service entered into an agreement with the University of Maryland Center for Environmental and Estuarine Studies to undertake the major portion of the work.

TABLE 1. SUMMARIZED ESTIMATED WASTEWATER TREATMENT COSTS FOR MODEL CANNED AND PRESERVED SEAFOOD PLANTS

TYPE OF PROCESSING PLANT 1)	CAPITAL AND TREATMENT COST UNDER			
	BPCTA		BATEA 2)	
	CAPITAL COST $	O & M COST $ 3)	CAPITAL COST $	O & M COST $ 3)
Crab-				
States, small	33,000	8,200	58,200	4,700
Finfish-				
States, small	55,000	9,200	37,600	4,400
Shellfish-				
Clam, small	22,500	8,100	58,200	4,600
Oyster, F&F, small	16,100	8,100	37,630	4,200

BPCTA - Best Practical Control Technology Available
BATEA - Best Available Technology Economically Achievable

1) This table has been extracted from Table 51, National Commission on Water Quality Report, Reference (9).
2) Incremental cost after BPCTA is achieved.
3) Does not include taxes, interest or depreciation.

SECTION 2

CONCLUSIONS

1. A survey of the seafood industry in Maryland engaged in processing oysters, blue crabs, soft-shell clams and non-Alaska bottom fish has been made. All of the plants in the survey discharged processing wastewater into the Chesapeake Bay or its tributaries. Wastewater characterization has been established on the basis of sampling a representative number of plants processing one or more of the above species.

2. All processing plants sampled are currently meeting the oil and grease as well as pH limitations required by the BPCTA and BATEA.

3. Using static screens, all soft-shell clam processors sampled are currently meeting both the BPCTA and BATEA Effluent Guidelines for TSS.

4. Six of the 10 oyster processors are currently meeting the TSS limitations for BPCTA and BATEA. Since all the processors use static screening, it is concluded that minor modifications to the existing systems should be adequate to bring the 4 unsatisfactory plants into compliance.

5. The requirement for disinfection of wastewater, imposed by the State of Maryland to protect shellfish harvesting waters, introduces a perplexing problem to the treatment process. The wastewater characterization study revealed that although high levels of residual chlorine were present in the effluent, both total and fecal coliform counts were still significantly higher than the maximum levels allowed by the State of Maryland. This leads to the conclusion that present methods of chlorination are ineffectual in reducing bacterial counts to a level which adequately protects shellfish harvesting waters. Concurrently, high residual chlorine is probably adversely affecting the receiving waters.

   There are several alternatives to the problem of disinfection. One alternative would be to develop an improved method of chlorination which would give a high degree of bacteriological "kill" and would result in a low residual chlorine level before discharge overboard. Another would be to evaluate ultraviolet radiation or other oxidants as means of disinfection through a demonstration project.

6. The blue crab and non-Alaska bottom fish processors cannot presently meet the future effluent limitations utilizing present treatment methods for TSS (BPCTA) or TSS and five-day BOD (BATEA). With regard to the fish processors, the three plants now discharging wastewater overboard are scheduled to have access to public sewerage systems in the near future. Therefore, if present limitations are maintained, only the blue crab processors will require a higher degree of treatment. This situation results from the extremely low limits of TSS and five-day BOD imposed by the Effluent Guidelines on the crab processors.

   If the five-day BOD requirement is eliminated from the effluent limitations for blue crab processing plants and TSS limitations are raised somewhat, then static screens will suffice. It is doubtful that, with very low wastewater flows, the BOD is having any adverse effects on receiving waters especially where the tidal amplitude produces a dilution effect by flushing. This could be demonstrated by measuring D.O. levels at various stations away from the point of the discharge for a typical blue crab processing plant after ascertaining the normal or naturally occuring D.O. levels. If present five-day BOD and TSS limitations are maintained, then a demonstration project for a packaged extended aeration plant would show whether this method was cost effective. Such a plant could be operated either as batch process or on a continuous basis.

7. Central treatment was evaluated as unfeasible for the plants in this study due to the distance between them. Present solid waste disposal methods are considered adequate since none of the practices appear to adversely affect the environment.

8. A wastewater reduction of approximately 20% could be achieved without adversely affecting food product quality. This reduction would simplify the waste water treatment problems, especially in those plants where a higher level of treatment may be required.

9. Present requirements for monitoring wastewater on a monthly basis are not considered to be a problem since at least one qualified commercial laboratory is available to the processors at a reasonable cost.

SECTION 3

RECOMMENDATIONS

1. Effluent limitations on TSS and five-day BOD levels for the blue crab industry should be re-evaluated in view of the additional data available from this report.

2. If the five-day BOD and TSS limits are maintained, then a demonstration project utilizing a package extended aeration plant is essential. The plant could be operated either as a batch or a continuous process and would show whether this method is cost effective.

3. Measure dissolved oxygen (D.O.) levels at various stations away from the point of discharge for a typical blue crab processing plant after ascertaining naturally occurring D.O. levels.

4. Initiate a demonstration project to develop an improved method of chlorination which would maximize bacteriological "kill" and concurrently minimize residual chlorine.

5. Evaluate ultraviolet radiation as a means of disinfection.

6. Determine the source of the Escherichia coliform.

7. Further investigation to determine if the high phosphorus residual shown in this study is adversely effecting the Chesapeake Bay system. If adverse effects are documented then a demonstration project utilizing current technology for phosphorus removal is necessary.

SECTION 4

SEAFOOD PROCESSING AND WASTE DISPOSAL METHODS IN MARYLAND

A total of 47 seafood processing plants in Maryland were considered in this investigation. As previously noted, all are relatively small, employing between two and 40 persons per day, with changes in the number of employees dependent on season, weather, and availability of product. All 47 of the processing plants are currently without access to publicly owned wastewater treatment facilities. Nearby land suitable for disposal of wastewater, such as spray irrigation or overland flow, is either severely limited or non-existent in nearly all cases. The fact that these plants are dispersed widely throughout the State reduces the options for collection and treatment in centralized facilities.

Seafood plants processing oysters, clams and fish use potable water from on-site wells, usually artesian, for washing the raw products. Plants processing blue crabs use low pressure steam in crab cookers. During this process the steam condenses and combines with the crab body fluids so that waste from the crab cooker makes up a significant portion of the waste flow from this type of plant. This flow is considered to be free of bacteria. In all plants, a second source of wastewater is generated during wash down and disinfection of food handling equipment and facilities. The waste flow from these processors range from 2,000 to 4,000 gallons per day. Wastewater from the above sources is discharged to receiving waters categorized as Class II - Shellfish Harvesting - as defined in Appendix A, or tributaries thereof. It is significant that none of the plants investigated permitted human wastes to enter the process wastewater stream, although some plants did have hand-washing sinks connected to the wastewater stream.

The present requirements for treatment which include screening, disinfection, and monitoring, are set forth in the National Pollution Discharge System (NPDES) permit which is issued to each processor, upon application and approval, as a joint Federal-State permit by the Maryland Water Resources Administration, Department of Natural Resources. All permits currently in effect expire July 1, 1977, when new permits will be issued upon application and approval. Maryland has been authorized by E.P.A. to issue joint permits since September, 1974. Permit requirements include the following:

1. Solids removal by 20 mesh screen.
2. Prohibition of floating solids or foam in effluent other than trace amounts.
3. Disinfection of effluent with resultant bacteriological quality not exceeding coliform standards of 70 MPN per 100 ml.
4. pH of effluent in a range of 6.0 to 8.5.

Monitoring requirements provide for flow measurement on a monthly basis and a grab sample analyzed monthly for coliform, with the results being furnished to the Water Resources Administration. Disinfection by the use of chlorine, usually in the form of calcium hypochlorite, is commonly used in the processing plants investigated.

E.P.A. effluent limitations for the canned and preserved seafood processing industry for Best Practicable Control Technology Currently Available (BPCTCA)-1977-and Best Available Technology Economically Achievable (BATEA)-1983-included in References (1) and (2) are summarized in Appendix B. Production limitation exceptions, which are also included in References (1) and (2), are shown in Appendix C. The effluent limitations, plus any additional requirements promulgated by the State, will be the basis for State - NPDES permits issued for discharges in the 1977-1983 period and for discharge permits issued from 1983 on, unless effluent limitations are further modified.

Maryland does not exempt small plants, as defined in Appendix C. If such plants were exempt from discharge permit requirements, some small processors would gain an economic advantage over other processors who had only a slightly higher production level. At present it is considered unlikely, however, that this no-exemption policy will be changed for either the BPCTA (1977) or the BATEA (1983) programs.

None of the processing plants studied deposited solid wastes (shells, offal, etc.) overboard at the plant sites, and only oyster shells, as noted below, are disposed of overboard at other sites. Methods of disposal of solid wastes include the following:

<u>Oyster Shells</u> - Shells are stockpiled at the processing plant for future removal either for use in construction, such as road-building, or for planting under the State cultch-planting program for maintaining productivity of oyster beds.

<u>Clam Shells</u> - Clam shells which usually include the snouts are hauled daily from plant sites to farms for use as hog feed or periodically to landfill sites.

Crab Shells - Crab shells from processing plants in Dorchester County are hauled to a dehydrating plant in Honga, near Hooper Island, where they are processed into ground meal used generally as a poultry food supplement. Crab shells from plants in Somerset County are similarly processed in Marion, near Crisfield. Crab shells from all other crab processing plants are removed and used as hog feed or are landfilled. There is no known work underway in Maryland for the production of chitin and chitosan from crab shells.

Fish Offal - Fish heads, backbones, skin and other offal are collected in cans at the processing sinks and used primarily for bait in lobster traps by fishermen working out of Ocean City, Maryland.

While this investigation was aimed primarily at treatment and disposal of liquid wastes, the handling and disposal of solid wastes as described above was found to cause no problems related to water and air quality.

A number of processing plants were observed to be discharging cooling water overboard from refrigeration and ice making plants. No sampling was made of this flow. It was in each case found to be well water with no chemicals or other additives. Flows were relatively small and temperatures were only slightly elevated over the normal well water temperature. These discharges thus should have no adverse effects on receiving waters.

During this investigation other State and Federal agencies were contacted for information, comments and advice on various aspects of the work. Liaison was maintained with the seafood processing industry, both through the Chesapeake Bay Seafood Industries Association and with individual plant owners or managers during plant visits. Without exception, cooperation was given and it was possible to visit all plants at least once and some on numerous occasions to collect wastewater for laboratory analysis. Comments or questions raised most frequently included:

- Questions regarding the need for disinfection of wastewater from seafood processing plants when similar material in the form of ground clams, for example, was being put overboard in very substantial quantities by sport fishing boats as "chum" to attract fish, without any requirement for disinfecting or screening.

- Disinfection requirements resulting in a total coliform count of 70 MPN per 100 ml in wastewater effluent when the Maryland Department of Health and Mental Hygiene and the Food and Drug Administration permit up to 230 fecal coliform per 100 grams of oyster meat leaving the processing plant for human consumption.

- Concern that additional costs for treatment beyond simple screening would force many smaller processors out of business.

The concern regarding treatment costs was coupled with that resulting from proposed modifications to the National Shellfish Safety Program (7) which included regulations pertaining to product safety, lot segregation and washing of shell stock. However, in regard to the latter, it should be realized that the "Draft-Notice of Proposed Rule Making" which first appeared in the Federal Register, (Volume 40, No. 9, January 4, 1975) has been withdrawn as a result of Congressional action and is under further study and review. The Coastal Zone Management Act Amendments of 1976, passed by the House and Senate and signed by the President July 26, 1976, require a report by April 30, 1977, evaluating the impact on federal water quality laws and proposed regulations on the shellfish industry before any such regulatory may take effect. Thus the environmental impact on water quality and the economic impact on shellfish processors as a result of the modifications will not be known until the new regulations are promulgated.

SECTION 5

WASTEWATER CHARACTERIZATION

Introduction

To determine the most economically feasible method of waste treatment and disposal for each Maryland seafood processing plant that discharges wastewater into the Chesapeake Bay System, base line data on waste generated and character of the waste was necessary for each processing operation.

Because of basic similarities among the processing plants it was decided to select several typical plants at random which processed one or more of the four predominant species, oysters, blue crabs, soft-shell clams or non-Alaska bottom fish.

Specifically, six crab processors, five oyster processors (one of which discharged into a municipal waste treatment facility), two fish processors and five combination oyster and soft-shell clam processors were sampled weekly during their harvest seasons. Spot samples were also collected from three additional processors for comparative purposes. The data from these operations served as a guide for grouping plants with similar problems.

For each plant sampled the following specific tasks were performed:

1. Characterize the wastewater generated in a physical, chemical, and biological sense.

2. Determine the flow rate, volume of product processed, processing time, and specific operation within the plant, e.g. washing down, normal picking, when the samples were taken.

3. Evaluate and recommend management practices which might reduce wastewater.

The samples collected were analyzed for settleable solids, non-filterable residue, five day BOD, oil and grease, residual chlorine, pH, phosphorus, nitrogen as nitrite and nitrate, nitrogen as ammonia, total Kjeldahl nitrogen, coliform and fecal coliform. All tests were performed in accordance with procedures developed by the Environmental Protection Agency and the American Public Health Association (10, 11, 12). The specific procedures for all tests conducted are explained in Appendices G and H.

Sampling Procedures

Field crews collected grab samples from each plant once a week during its operating season. Since the sampling technique was a vital step in estimating the parametric values, every effort was made to obtain a representative sample. Although flow-proportional samples are more accurate than grab samples, the variation in plant configuration and the physical constraints of the effluent discharge points prohibited flow-proportional sampling.

Since the grab samples were used for calculating estimated daily waste loading, the questionnaire in Appendix I was completed for each sample collected. The in-plant operation (an explanation of which appears later in this section), processing interval, volume of raw product processed during the processing interval and flow rate were recorded. Samples were preserved on ice and immediately transported to the laboratory for analysis.

Date Reduction:

Several computer programs were developed for data characterization and reduction.

The first program was developed to convert each data point measured from milligrams per liter to pounds per 1000 pounds of product produced. The program was developed using equation (1):

$$\text{lbs/ton} = \frac{\text{mg/l} \times 8.33 \times \text{mgd}}{\text{tons/day}} \qquad (1)$$

where mg/l = milligrams per liter; the original units used in the laboratory analysis.

mgd = volume of water used per day expressed in terms of millions of gallons (calculated knowing the flow rate and processing interval).

tons/day = calculated knowing the volume of product processed during the processing interval. The following weights were used when converting from bushels to pounds:

1. crabs; 1 bushel = 40 lbs. raw product
2. clams; 1 bushel = 60 lbs. raw product
3. oysters; 1 bushel = 6 lbs. finished product

The next program was a least-squares analysis of variance to detect significant differences between grab samples collected within a plant for different plant operations. The rationale was that samples for a given plant could be analyzed collectively if no significant differences could be detected for the different plant operations (i.e. washdown or normal picking for crab processors[1] or fish processors and washdown, blowdown or normal shucking for oyster and soft shell clam processors). This approach would also add validity to the collecting of grab samples.

To accomplish this analysis, the qualitative variables indicated above for each sample were coded as follows:

a. type of plant (1=crab; 2=oysters; 3=oyster or soft-shell clam

b. plant number (1-6)

c. product processed (1=crab; 2=oyster; 3=clam)

d. in-plant operating (1=blowdown; 2=washdown; 3=normal shucking; 4=normal picking)

It was necessary to differentiate between type of plant and product processed, because five of the plants sampled (coded) B) processed oysters or soft shell clams (but never both) on a given day according to supply and demand.

These variables and the parameters previously noted for each sample were analyzed and the results are shown in Table 2. It compares the calculated F value with the tabular F value. The conclusion indicates that there are no significant ($P > 0.01$) added variance components among samples within a specific plant for different operations.

Based on these results, the data points for a given plant were grouped independent of operation and the means and standard deviations as shown in Appendix K were developed. Specifically, for plants coded A, C, and E, the means and standard deviations were calculated for each plant and for each species. The results are shown in Tables 8 through 14, 27 through 32, and 36 through 38, Appendix K. For the plants coded B the same procedure was followed but since these plants alternated between oysters and soft shell clams the means and

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1 It was found that all of the crab processors sampled regularly had the retort drains from the crab cookers separated from the normal effluent discharge point.

TABLE 2. SUMMARY TABLE FOR ANALYSIS OF VARIANCE COMPARING DIFFERENT OPERATIONS WITHIN A PLANT

PARAMETER	F. CALCULATED	F. TABULAR
Flow Rate	0.84	3.88
Settleable Solids	3.23	3.88
NFR (total)	1.70	3.88
5 Day BOD	1.42	3.88
Oil & Grease	4.08	4.08
Phosphorus (total)	2.34	3.88
Nitrogen (Nitrate-Nitrite)	1.70	3.88
Ammonia (NH_3)	2.83	3.90
Kjeldahl Nitrogen (total)	2.21	3.88
Residual Chlorine	2.40	3.88
pH	1.31	3.94
Coliform	2.19	3.88
Fecal Coliform	1.17	3.88

Conclusion - There are no significant ($P>0.01$) added variance components among samples within a specific plant for different operations.

standard deviations were calculated for each plant and species according to the product processed. Tables 15 through 26 Appendix K show these results.

Results and Discussion:

A. Physical and Chemical Results

Table 3 summarizes the results of sampling for total suspended solids (TSS) oil and grease (O and G) five-day biochemical oxygen demand (BOD_5) and pH from the 18 plants. On the basis of this summary, the following conclusion can be reached regarding the various type of processes:

Blue Crabs (conventional process): based on 74 wastewater samples analyzed from six conventional blue crab plants, both oil and grease and pH limits are being met for both BPCTA and BATEA. However, based on 62 samples analyzed, TSS limits for BPCTA as well as BOD_5 and TSS limits for BATEA are not being met in five or the six plants. With the one plant meeting TSS and BOD_5 limits, the drain from the crab retort did not enter the regular wastewater stream, which gave erroneous results.

Non-Alaska Bottom Fish (conventional process): based on 10 wastewater samples analyzed from two conventional fish processing plants, both oil and grease and pH limits for both BPCTA and BATEA are being met. However, TSS limits for BPCTA and BOD_5 and TSS limits for BATEA are not being met. Both plants are located in areas for which sewage systems are presently in the design stage, and are discussed in Section VI.

Atlantic Oysters (hand shucked): based on 76 wastewater samples from six plants processing oysters, (B-1, B-3, B-4, C-1, C-3, C-4) all of the EPA parameters for both BPCTA and BATEA are now being met. However, based on 40 wastewater samples from four other oyster plants (B-2, B-5, C-2, C-5), the TSS limits for both BPCTA and BATEA are not being met. This leads to the conclusion that if static screening is successful in reducing TSS in some plants, it should be possible to achieve the same results in other plants by minor improvements.

Soft Shell Clams (hand shucked): based on 41 wastewater samples analyzed from five plants processing clams (B-1, B-2, B-3, B-4, B-5) all of the EPA parameters are being met for BPCTA and BATEA.

TABLE 3. MARYLAND SEAFOOD PROCESSORS CURRENT

ABILITY TO MEET E.P.A. BPCTA (1977) and BATEA (1983) EFFLUENT GUIDELINES. 1)

	No. of Plants Sampled	No. of Samples	BPCTA (1977)			BATEA (1983)			
			TSS	O&G	pH	BOD_5	TSS	O&G	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	76	Yes	Yes	Yes	N/A	Yes	Yes	Yes
	4	40	No	Yes	Yes	N/A	No	Yes	Yes
Soft Shell Clams (hand shucked)	5	41	Yes	Yes	Yes	N/A	Yes	Yes	Yes

1) Based on mean values of the indicated parameter from 18 processing plants sampled in 1975-76, Appendix K. "Yes" indicates current ability to meet guideline standards; "No" indicates not meeting guideline standards. N/A - not applicable.

B. Wastewater Flow

Each plant visited had a somewhat different arrangement for collecting, screening, and disinfecting wastewater before discharging it to tidal waters. In all but two plants, the flow was discharged overboard by gravity. In one of these two plants vibrating screens were used but, in all others, static screens were used to meet NPDES requirements. Various arrangements of collecting systems conveyed wastewater to an area where 20 mesh screens were used to remove the larger particles. These screens were shaped like basket strainers, either cylindrical or rectangular boxes or flat rectangular screens. All types could be readily removed for cleaning or replacement.

One of the two plants which did not discharge wastewater by gravity, had a static screen, a collection tank and pump for overboard discharge. In the other plant which is the one with a vibrating screen, waste stream from oyster shucking was pumped to a vibrating screen, through a chlorinator into a holding tank, then overboard by gravity. In this same plant, wastewater from clam processing was pumped to another vibrating screen. The wastewater then flowed by gravity to a settling tank before being pumped intermittently to a spray irrigation field.

The sampling program revealed that mean wastewater flow from all processing plants was slightly less than 3000 gallons per day. The mean flow varied from about 330 gallons/ton for the processing of hand shucked clams to over 6,000 gallons/ton for hand shucked oysters. The flow data are summarized in Table 4. The coefficient of variation (ratio of the standard deviation to the mean) for most plants was found to be quite high. Furthermore, there were found to be substantial variations in wastewater flow among the plants sampled for the same product and processing operation.

C. Bacteria and Disinfection

Table 5 gives the mean values of coliform, fecal coliform and residual chlorine found in the wastewater samples.

The State of Maryland requires that wastewater from seafood processing plants be disinfected before discharge to tidal waters, since receiving waters are Class II - Shellfish Harvesting Waters, (Appendix A).

TABLE 4. MARYLAND SEAFOOD PROCESSORS-FLOW DATA 1)

	No. of Plants Sampled	No. of Samples	GPM 2)		GPT 3)	
			Mean	Range	Mean	Range
Blue Crab (conventional process)	6	74	7.7	3.2-17.2	1512.7	761.7-2675.3
Non-Alaska Bottom Fish (conventional process)	2	10	4.0	N/A	3253.5	N/A
Atlantic Oysters (hand shucked)	5 4)	63	6.8	5.1-12.3	5737.0	3281.6-16476.6
	5 5)	53	9.1	1.9-23.2	6276.2	1076.5-14970.2
Soft Shell Clams (hand shucked)	5 4)	41	4.7	3.4-5.9	328.9	293.7-772.6

1) Based on 18 processing plants sampled in 1975-76, Appendix K.

2) Flow rate in gallons per minute.

3) Gallons of wastewater per ton of product processed; for blue crabs, fish and soft shell clams, tons are in terms of liveweight; for oysters, tons are in terms of finished product.

4) These five plants alternated between processing oysters and soft shell clams.

5) These five plants processed oysters only.

TABLE 5. TOTAL COLIFORM, FECAL COLIFORM AND RESIDUAL CHLORINE DATA 1)

	No. of Samples	Geometric Mean Coliform MPN/100 ml	Geometric Mean Fecal Coliform MPN/100 ml	Residual Chlorine 4) Mg/1
Conventional Blue Crabs 6 plants sampled	74	1.8×10^3	159	88.6
Conventional Fish 2 plants sampled	10	79.5×10^3	175	0.1
Hand Shucked Clams 2) 5 plants sampled	41	2.4×10^3	106	86.8
Hand Shucked Oysters 2) 5 plants sampled	63	2.6×10^3	60	29.3
Hand Shucked Oysters 3) 5 plants sampled	53	6.7×10^3	232	49.1

1) Based on geometric means of samples from 18 processing plants sampled in 1975-76, Appendix K.

2) These five plants alternate between processing oysters and soft-shell clams.

3) These five plants process oysters only.

4) Maryland policy limits residual chlorine to 0.5 mg/1 for point sources discharging into tidal waters, Appendix D.

The bacteriological standards for these waters limit the coliform organisms to 70 MPN per 100 ml as a median value and not more than 10 percent of the samples may exceed an MPN of 230 per 100 ml for a five-tube decimal dilution test. The State also has an upper limit of 0.5 mg/l residual chlorine level for point source discharging into tidal waters (Appendix D).

In the plants sampled, chlorine was used in the form of dry calcium hypochlorite to satisfy requirements for wastewater disinfection and sterilization of food handling equipment. Residual chlorine levels found in the wastewater were consistently much higher than the 0.5 mg/l required by Maryland. Concurrently very few of the plants sampled met the criterion of 70 MPN per 100 ml coliform. This trend was verified statistically by calculating correlation coefficients for residual chlorine verses log coliform (-.39), and residual chlorine versus log fecal coliform (-.30). In both cases the correlation coefficients indicate that the bacteria kill was ineffectual despite the high level of residual chlorine.

After several bacteriological tests to determine total and fecal coliform levels it became apparent that the samples showed high fecal coliform. These data raised the question, "Could the E.C. tubes used for fecal coliform determination be giving false positive readings?" In order to determine whether the sample contained actual fecal organisms, or another organism which was mimicking the fecal test indicator organism, additional tests were conducted.

Using five wastewater samples in each of two separate laboratories, the API 20E system of Enterobacteriaceae identification, as explained in Appendix H, was used. In all samples tested the presence of Eschericia coli was verified. Concurrent tests indicated that the well water from both plants was free of Eschericia coli or other fecal coliforms.

D. Phosphorus Results

Table 6 compares the mean values for phosphorus in mg/l and lbs/1000 pounds of product with the Maryland State Policy as shown in Appendix D. Although the concentrations are above State limits, the actual weight of phosphorus per 1000 pounds of product is quite low.

TABLE 6. PHOSPHORUS IN WASTEWATER-ACTUAL COMPARED TO MARYLAND POLICY 1)

	Number of Samples	Mean Values lbs. Phorphorus(AS-P) per 1000 lbs. of processed product 2)	Mean Values Phosphorus(AS-P) Mg/1	State Policy Phosphorus(AS-P) Mg/1
Conventional Blue Crab 6 plants sampled	74	.04	7.5	2
Conventional Fish 2 plants sampled	10	1.35	13.6	2
Hand Shucked Clams 3) 5 plants sampled	41	.04	18.2	2
Hand Shucked Oysters 3) 5 plants sampled	63	.28	11.2	2
Hand Shucked Oysters 4) 5 plants sampled	43	.27	9.6	2

1) Based on mean values of 18 processing plants sampled in 1975-76. See Appendix D for Maryland Policy regarding phosphorus.

2) "Product" is liveweight for clams, crabs and fish; for oysters, "product" is finished product.

3) These five plants alternate between processing oysters and processing clams.

4) These five plants process oysters only.

SECTION 6

FLOW REDUCTION, WASTEWATER TREATMENT AND *DISINFECTION ALTERNATIVES*

Wastewater Flow

An analysis of Table 4 indicates a good possibility of reducing wastewater flow by reducing water usage in certain operations. Some obvious steps to reduce water usage are:

1. Turn off hoses and faucets when not in use.
2. Use spring loaded hose nozzles.
3. Use high-pressure, low volume wash-down systems.
4. Encourage plant personnel to minimize water consumption by eliminating other wasteful partices.

It is considered essential that, in implementing water conservation the water used for washing the finished product (oysters, clams, and fish) not be reduced below levels found necessary from experience to produce a quality product meeting acceptable health standards.

It is believed that 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 processors pumping costs as well as wastewater treatment costs, particularly in those plants where treatment facilities other than screening would be required to meet future permit conditions.

Effectiveness of Current Treatment Practices

Static screens are considered to be fairly successful in meeting future treatment requirements. As Table 4 indicates, the hand shucked clam processors are now meeting all of the 1977 and 1983 effluent guidelines. Since 6 of the 10 oyster processing plants are now meeting the 1977 and 1983 guidelines, it is believed that the other plants could meet the same guidelines, simply by improved housekeeping and relatively minor modifications to present screens. Neither fish processor sampled can now meet the 1977 TSS requirements or the 1983 five-day BOD and TSS requirements. However, as Appendix F indicates, all of the fish processors in Maryland will be served by municipal sewerage systems in the near future.

This leaves only the blue crab processors with the problem of TSS reductions to meet 1977 and 1983 effluent limitations as well as five day BOD reductions to meet 1983 limitations. The limits apparently cannot be met with static screening. In this regard, it is interesting to note that the maximum 30 day average for five day BOD is only 0.15 lbs. per 1000 pounds liveweight processed, while steamed/canned oyster processors are allowed 17 lbs. per 1000 pounds of finished product. Even though there is a different basis for comparison, the allowable limits for the oyster processors is substantially higher than for the crab processors. A similar comparison can be made with total suspended solids.

If the effluent limitations for blue crabs were modified to permit TSS levels between 2 to 2.5 lbs. per 1000 pounds liveweight processed and the five day BOD levels between 2.5 and 3 lbs. per 1000 pounds liveweight, then both the 1977 and the 1983 guidelines could be met. If these limitations are not raised or if the small blue crab processors are not exempted from the effluent limitations, then treatment alternatives as discussed later in this section will have to be considered.

Wastewater Disinfection

The fact that high levels of total and fecal coliform were present in the wastewater streams from nearly all processing plants is considered one of the most significant findings of the study (Table 4). The most probable reasons chlorine was ineffective in reducing coliform to required levels are insufficient contract time and relatively large particle size of the suspended solids even after screening. More investigation is needed to further identify the sources of fecal coliform so that action can be taken to reduce their levels.

In addition to the high coliform levels, high residual chlorine levels are also alarming because of potential detrimental effects on the receiving waters. A recent report (12) indicated that very few studies have been made of the effects of chlorine or residual chlorine in sewage effluents on estuarine and marine fishes. There are no reports for chloramines. One study (13) discusses limitations as low as 0.002 mg/l residual chlorine for the protection of most aquatic organisms. Another study (14) reports test results indicating a median tolerance limit (50% survival) for oyster larvae of 0.005 mg/l residual chlorine in 48 hours under certain test conditions. The high residual chlorine levels found present in wastewater effluent (albeit daily flows are relatively low), with the consequent potential hazard to marine organisms having low tolerance, is another important find of this study. Further investigation is needed to find a means of disinfection which will not overchlorinate receiving waters.

Processing Plants Located Where Municipal Sewage Systems are Planned

There are a total of 19 seafood processors located where municipal sewage collection and treatment systems are being planned. A review of the FY 1977 Construction Grants Project list for the State of Maryland was made, and those projects which will include the processing plants presently discharging to tidal waters are listed in Appendix F. These projects will be funded primarily by EPA grants, the remainder of the cost coming from State and local sources. The processors so affected represent about 40% of all of those presently discharging to tidal waters.

Completion of the projects will solve the problem for these processors and static screening is considered adequate in the interim.

Included in the list of projects are those which will serve all fish processors in Maryland that presently discharge to the Chesapeake Bay system. However, only one of the blue crab processors will benefit from the added availability of municipal sewerage service, leaving 19 others faced with the present TSS and five-day BOD limitation.

Centralized Waste Treatment

The Grant requires that the possibility of using centralized treatment facilities be evaluated. It has been shown above that the principal problem regarding wastewater treatment lies with blue crab processing plants since static screening will not achieve the specified BPCTA or BATEA effluent limitations.

There are a total of 20 plants processing blue crabs, one on the Western shore and the remainder on the Eastern shore. Only one plant, located in Queen Anne County, is in an area scheduled to be served by a municipal system; 13 are concentrated to some extent in lower Dorchester County, being located in Fishing Creek, Hoopersville, Toddville, Wingate, Crapo, and Crocheron. The other 5 are in Talbot and Somerset Counties.

In consideration of centralized treatment facilities, three alternatives were evaluated. The first alternative assumed that the existing sewage treatment plant at Cambridge, Maryland, would accept all the wastewater from the 20 crab processors in the State. Wastewater would be transported, by tank truck, to the plant wnere it would be mixed and treated before being discharged overboard. Even though the site is as "central" as possible, hauling over distances up to 124 miles would be involved. Assuming a mean wastewater volume of 3000 gallons per day and a blue crab season extending from mid April through mid

September, it was found that the annual cost to the processors would range from $31,240 to $6,240 for hauling and treatment. Treatment costs were estimated at 80¢/1000 gallons. The computation is shown in Table 7, Alternative I. The second alternative assumed that each crab processor would haul wastewater to the nearest existing sewage treatment plant. In this case the maximum distance was found to be 31 miles. It was found that the annual cost of wastewater hauling and treatment would range from $7,990 for a plant located in Crocheron to $990 for a plant located in Grasonville. These results are tabulated in Table 7, Alternative II.

In both alternatives, the cost of installing holding tanks at each processing plant was not included. It is estimated that this item would cost $2500 to $3000 per plant.

The third alternative considered was the installation of an on-site package sewerage treatment plant. In estimating the cost for this alternative, an extended areation or aerobic digestion system to treat 500 mg/l five day BOD loading (average from all crab plants sampled) would cost approximately $12,000. This price includes foam controls, blowers, sand filters, and installation. In-plant modifications are not included.

It was concluded that for alternatives one and two, hauling costs were disproportionate to treatment cost, particularily when considering the added problems and cost of installing holding tanks. Alternative three appears the least expensive, although in-plant modifications, operation and maintenance and disinfection costs could eliminate this method as a viable treatment system.

Use of Aerated Lagoons and Alternative Treatment Methods

Documents covering blue crabs and bottom fish respectively, (3,4) indicate that in both cases aerated lagoons are the technological basis for the effluent limitations. The National Commission on Water Quality Report (9) noted that:

> "The use of aerated lagoons to achieve five-day biochemical oxygen demand removals in the range of 75 to 97 percent 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,

TABLE 7. EVALUATION OF USING ONE OR MORE CENTRALIZED WASTE TREATMENT FACILITIES

ALTERNATIVE I, CAMBRIDGE, MARYLAND [1)]

Cost:

A. Hauling - Based on approximately 3000 gallons per day per processor and 20¢/ton mile

= (12.5 tons) (20¢/ton mile) = $2.50/mile

B. Cost of treating wastewater at the Cambridge Plant

= 80¢/1000 gallons

= $2.40/day/processor

Hauling Cost

Location	Miles to S.T.P.	Cost/100 gal. [2)]	Total Cost/Day [3)]
Mechanicsville	124	$104.13	$312.40
Deal Island	60	50.80	152.40
Deal Island	57	48.30	144.90
Grasonville	41	34.97	104.90
Sherwood	35	29.97	89.90
Wittman	33	28.30	84.90
Hoopersville (2) [4)]	31	26.63	79.90
Crocheron	31	26.63	79.90

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1) Plant to serve all 20 blue crab processors in Maryland.

2) Includes an 80¢/1000 gallon sewerage charge.

3) Multiply these numbers by 100 to obtain seasonal cost.

4) Indicates number of plants.

TABLE 7. (continued)

Hauling Cost

Location	Miles to S.T.P.	Cost/1000 gal[2)]	Total Cost/Days[3)]
Wingate (3)	28	$ 24.13	$ 72.40
Toddville (2)	28	24.13	72.40
Bellevue	25	21.63	64.90
Crapo	24	20.90	62.40
Fishing Creek (4)	24	20.80	62.40

2) Includes an 80¢/1000 gallon sewerage charge.

3) Multiply these numbers by 100 to obtain seasonal cost.

TABLE 7. (continued)

EACH PROCESSOR DISCHARGES INTO NEAREST S.T.P.

ALTERNATIVE II

Hauling Cost

Location	Nearest Existing S.T.P.	Miles to S.T.P.	Cost 1000 gal.1)	Cost/Day2)
Mechanicsville	Leonardtown	13	$ 11.63	$ 34.90
Grasonville	Queenstown	3	3.30	9.90
Sherwood	Easton	21	18.30	54.90
Wittman	Easton	19	16.63	49.90
Bellevue	Easton	11	9.97	29.90
Crocheron	Cambridge	31	26.63	79.90
Hoopersville (2)3)	Cambridge	31	26.63	79.90
Wingate (3)3)	Cambridge	28	24.13	72.40
Toddville (2)3)	Cambridge	28	24.13	72.40
Deal Island	Salisbury	26	21.30	63.90
Crapo	Cambridge	24	20.80	62.40
Fishing Creek (4)3)	Cambridge	24	20.70	62.40
Deal Island	Salisbury	23	21.36	59.90

1) Includes an 80¢/1000 gallon sewerage charge.

2) Multiply these numbers by 100 to obtain seasonal cost.

3) Indicates number of plants.

located in remote areas. Nevertheless, land availability and use restrictions, as well as economic considerations, severely limit use of aerated lagoons.

There are several alternatives to aerated lagoons. Those suited to the relatively low daily flow rates of the small seafood processors are deserving of consideration.

In 1973, the Water Resources Administration of the Maryland Department of Natural Resources sponsored a program to evaluate a wastewater treatment system to serve small processing plants. For a typical small seafood processing plant, wastewater from the crab cooker, oyster blow down tank, crab picking and oyster shucking sources were collected in 4 separate sump tanks where they were screened and then pumped to a 900 gallon roughing tank. In this tank, the wastewater was aerated for several hours before flowing by gravity to a second tank of 1250 gallons capacity, where aeration was continued and settling took place. From the second tank, the effluent flowed by gravity to a chlorine contact tank, then overboard to a tidal creek. This system was operated during a period while hand shucked oysters were being processed and for a short period when blue crabs were being processed. Four considerations in the design were:

1. Cost: Total expenditure of about $7,000 covered equipment and installation.
2. Size: The entire treatment unit was housed in a 32 foot trailer.
3. Ease of operation: Daily maintenance consisted primarily of cleaning the basket strainers and checking chlorine tablets.
4. Compatibility: Existing floor drains in the processing plant were not disturbed.

Overall, the system achieved 80 to 90% reduction in five-day BOD.

Another treatment process which should be effective and suitable for small plants is a batch biological treatment. In such a system, wastewater would be screened and collected in a tank sized for the particular plant. The tank would be provided with baffles to separate the aeration section from the settling chambers. Aeration would be provided in the tank as it is filled with wastewater during the working shift. Aeration could continue during the day, evening, and until early the following morning, when blowers would be shut off automatically by a timer switch. After allowing three hours for settling, a pump would be started by a timing switch and decanting would take place. The suction for this pump would be far enough above the tank bottom to allow for settled matter and sludge. These would be removed periodically by a different pump. After decanting the tank would again be ready to receive wastewater at the start of the work shift and aeration would commence as wastewater started to fill the tank.

This operation would continue on a batch basis each working day, aerating while filling, continuing the aeration after filling and decanting after stopping aeration for the settling period. It is believed that such a system would give 85 to 90% five-day BOD reduction and could be built at relatively low cost from available components.

The last treatment system which deserves attention was installed by a blue crab processor during the course of this study. The plant was modified so all wastewater (including retort) is strained through a 20 mesh screen and collected in a 600 gallon sump tank. A float operated sump pump discharged the screened wastewater to a 90 gallon chlorine contact chamber and then overboard. The total cost of the system is estimated to be from $3000 to $3500.

The system was monitored before and after the modifications. Based on a limited number of samples a substantial reduction in both five-day BOD (2.77 vs 0.51 lbs/1000 pounds) and TSS (3.35 vs 0.18 lbs/1000 pounds) was observed. Concurrently there was no reduction in coliform or fecal coliform.

If the five-day BOD loading of wastewater from a seafood processing plant were the same as domestic sewage, there would be reason to believe that a batch system would reduce BOD to acceptable levels. However, due to the higher BOD loadings and their variability in the case of processing plant effluent, demonstration project would be required to determine whether the necessary reductions could be achieved.

DISINFECTION ALTERNATIVES

Ultraviolet Radiation

It has been known for some time that ultraviolet radiation can destroy all types of bacteria. Water sterilizers or purifiers-utilizing mercury vapor lamps which emit a narrow band of radiant energy at 2537 Angstrom units are commercially available. Applications where these have been used include purification of potable water, food processing water, swimming pools and wastewater. The degree of microbial destruction is a function of both exposure time and intensity of radiation. The dosages required for most bacteria are in the order of 20,000 microvolt-seconds per square centimeter. Since transmission may not achieve 100% the design of a system should provide exposure in excess of 30,000 microwatt-seconds per square centimeter.

Turbidity and suspended solids require provision for a filtering unit as part of the system. Filters commercially available for this application include those employing diatomaceous earth. However, in the case of wastewater encountered in seafood processing plants it is believed that filtering the gross suspended solids first and then polishing the effluent with a second filter would be preferable to single-stage filtering in order to reduce the frequency of back-washing the final filter.

During the summer of 1974, limited evaluation of an ultraviolet system for disinfection of wastewater from a seafood processing plant in Maryland was undertaken (16). A filter utilizing fiberglass and charcoal was improvised and used in conjunction with fresh water dilution at a rate of 3 parts fresh water to 1 part effluent. The filter and dilution together reduced turbidity from about 300 Jackson Turbidity Units (JTU) to about 10 JTU. The wastewater then passed through the ultraviolet unit which resulted in reduction of coliform from 43×10^4 MPN/100 ml to less than 3 MPN/100 ml. As would be expected with such a filter, substantial reductions were also found in total suspended solids and five-day BOD. At the time this work was done it was estimated that a permanent commercial installation which would perform as well as the temporary installation and would treat peak flow rates of 3000 gallons per hour would cost approximately $3000. This flow rate exceeds that of any of the plants sampled, so an investigation of availability of smaller units was made. Ultraviolet sterilizers, suitable for salt water, and having a capacity of 480 gallons per hour are available for approximately $600, and with others a capacity of 960 gallons per hour cost approximately $900. However, filters commercially available which would insure a sufficiently clear effluent to obtain adequate microbial "kill" are considerably more expensive than the UV units. The total cost of the UV unit, filter and installation costs would exceed $4000. It is believed, however, that a suitable mixed media or sand filter could be developed from relatively inexpensive, readily, available components and tailored to meet the needs of small seafood processing plants for approximately $500. On this basis, a UV system including filter and installation could possibly be installed for about $1600. A pilot project could easily be designed to demonstrate the feasibility and effectiveness of such a system.

Ozone

Ozone could also be used for disinfection of wastewater. A review of cost data for small capacity ozone generators suitable for this particular application indicates that they would not be cost effective. Furthermore, the problems of operation and maintenance could prove unacceptable.

SECTION 7

Wastewater Monitoring

When the Maryland Environmental Service was first requested to assist seafood processors in finding solutions to their many problems, one concern was the requirements for monitoring wastewater. The NPDES permits for seafood processing plants require monthly samples and reports on coliform and average daily flow. At that time there were too few laboratories to do the bacteriological analysis. Since then, however, at least one commercial laboratory has been performing the required sampling and laboratory work for 16 processing plants located in Queen Anne and Talbot Counties. This represents 34% of the processors included in this study. The laboratory is willing to serve processors in other areas as well.

For a fee of eighteen dollars ($18.00) the laboratory will take wastewater samples and perform laboratory analysis for total coliform, fecal coliform and residual chlorine. This is done monthly and the results are submitted in such a way that the processor can furnish the data to the Water Resources Administration. The laboratory also prepares required quarterly reports for the seafood processors.

In regard to bacteriological analysis, monitoring is no longer considered a problem as long as this commercial service is available. For meeting the flow measurement requirement, it is believed that each processor can measure (or estimate) wastewater flow from his plant in the same manner done for this study. The flow data could then be included in the required reports.

In view of these developments, it is the conclusion of this study that the current monitoring requirements do not place an unreasonable burden on the processor. It is considered that no additional monitoring requirements are needed to adequately maintain surveillance over receiving waters in order to protect water quality.

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APPENDIX A

Department of Natural Resources, Water Resources Administration

Regulation 08.05.04.03

RECEIVING WATER QUALITY STANDARDS

A. GENERAL

The following receiving water quality standards are established to protect the uses indicated. Where the waters of the State are, or may be, affected by discharges from point sources, these standards shall apply outside of a mixing zone designated by the Administration.

B. STANDARDS FOR CLASS I WATERS

Water Contact Recreation and Aquatic Life

(1) Bacteriological Standards

There shall be no sources of pollution which constitute a public health hazard. If the fecal coliform density exceeds a log mean of 200/100 ml, the bacterial water quality shall be considered acceptable only if a detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters.

(2) Dissolved Oxygen Standard

The dissolved oxygen concentration shall not be less than 4.0 mg/liter at any time, with a minimum daily average of not less than 5.0 mg/liter, except where, and to the extent that, lower values occur naturally.

(3) Temperature Standard

a. Thermal effects shall be limited and controlled so as to prevent:

1. Temperature changes that adversely affect aquatic life;

2. Temperature changes that adversely affect spawning success and recruitment; and

3. Thermal Barriers to the passage of fish.

b. Temperature elevations above natural shall be limited to 5°F, and the temperature may not exceed 90°F, outside of designated mixing zones.

c. This limitation of temperature changes in Class I Waters does not preclude the discharge of warmed water. Warming of a portion of a body of water is permissible if it will not produce substantial detriment and if the volume of the new temperature is of such size and duration that the exposure of organisms or life stages thereof, is less than the time associated with deleterious biological effects at that particular temperature.

(4) pH Standard

Normal pH values must not be less than 6.5 nor greater than 8.5, except where--and to the extent that pH values outside this range occur naturally.

(5) Turbidity Standard

a. Turbidity may not exceed levels detrimental to aquatic life.

b. Within limits of Best Practicable Control Technology Currently Available, turbidity may not exceed for extended periods of time those levels normally prevailing during periods of base flow in the surface waters.

c. Turbidity in the receiving water resulting from any discharge may not exceed 50 JTU (Jackson Turbidity Units) as a monthly average, nor exceed 150 JTU at any time.

C. STANDARDS FOR CLASS II WATERS

Shellfish Harvesting

(1) Bacteriological Standards

a. The Most Probable Number (MPN) of coliform organisms may not exceed 70/100 ml, as a median value and not more than 10 per cent of the samples may exceed an MPN of 230/100 ml for a five-tube decimal dilution test (or 330/100 ml, while the three-tube decimal dilution test is used).

b. Compliance also shall be achieved with the sanitary and bacteriological requirements as set forth in the latest edition of "National Shellfish Sanitation Program Manual of Operations".

(2) Dissolved Oxygen Standard

Same as for Class I Waters

(3) Temperature Standard

Temperature elevations above natural shall be limited to 4°F, in September through May, and to 1.5°F, in June through August, outside of designated mixing zones.

(4) pH Standard

Same as for Class I Waters

(5) Turbidity Standard

Same as for Class I Waters

D. STANDARDS FOR CLASS III WATERS

Natural Trout Waters

(1) Bacteriological Standards

Same as for Class I Waters

(2) Dissolved Oxygen Standard

The dissolved oxygen concentration may be not less than 5.0 mg/liter at any time, with a minimum daily average of not less than 6.0 mg/liter, except where, and to the extent that, lower dissolved oxygen values occur naturally.

(3) Temperature Standard

a. No significant thermal changes; and

b. Temperature may not exceed 68°F beyond the distance from any point of discharge specified by the Administration, except where, and to the extent that, higher temperature values occur naturally.

(4) pH and Turbidity Standard

Same as for Class I Waters

E. STANDARDS FOR CLASS IV WATERS

Recreational Trout Waters

(1) Bacteriological and Dissolved Oxygen Standard

Same as for Class I Waters

(2) Temperature Standard

a. Thermal effects shall be limited and controlled so as to prevent:

1. Temperature changes that adversely affect aquatic life;

2. Temperature changes that adversely affect spawning success; and

3. Thermal barriers to the passage of fish.

b. Temperature may not exceed 75°F, beyond the distance from any point of discharge specified by the Administration, except where, and to the extent that, higher temperature values occur naturally.

(3) pH and Turbidity Standard

Same as for Class I Waters

APPENDIX B

Effluent Limitations

Best Practicable Control Technology Currently Available

July 1, 1977

Kg/KKG or lbs/1000 lbs. liveweight processed

Subcategory	Technology Basis	BOD_5		TSS		O & G		pH
		Daily Max.	Max. 30 da. av.	Daily Max.	Max 30 da. av.	Daily Max.	Max. 30 da. av.	Range
Conventional Blue Crabs	S,GT	-	-	2.2	.74	.60	.20	6.0-9.0
Non-Alaska Conventional Bottom Fish	H,S	-	-	2.1	1.6	.55	.40	6.0-9.0
Hand Shucked Clams	H,S	-	-	59	18	.60	.23	6.0-9.0
Atlantic & Gulf Coast Hand Shucked Oysters *	H,S	-	-	19	15	.77	.70	6.0-9.0

* Effluent limitation in terms of finished product

NOTE: The above material has been extracted from References (1) and (2).

S = Screen
H = Housekeeping
GT = Simple grease trap

APPENDIX B (coninuted)

Effluent Limitations

Best Available Technology Economically Achievable and Standards for New Sources

July 1, 1983

Kg/KKG or lbs/1000 lbs. liveweight processed

Subcategory	Technology Basis	BOD_5		TSS		O & G		pH
		Daily Max.	Max. 30 da. av.	Daily Max.	Max. 30 da. av.	Daily Max.	Max. 30 da. av.	Range
Conventional Blue Crabs	S,GT,AL	.30	.15	.90	.45	.13	.065	6.0-9.0
Non-Alaska Conventional Bottom Fish	IP,S,AL	.73	.58	1.5	.73	.04	.03	6.0-9.0
Hand Shucked Clams	IP,S	-	-	55	17	.56	.21	6.0-9.0
Atlantic & Gulf Coast Hand Shucked Oysters *	IP,S	-	-	19	15	.77	.70	6.0-9.0

* Effluent limitation in terms of finished product

NOTE: The above material has been extracted from References (1) and (2).

S = Screen
GT= Simple Grease trap
AL= Aerated Lagoon
IP= In-plant change

APPENDIX C

Production Limitation Exceptions

SECTION 408.20 - CONVENTIONAL BLUE CRAB

"The effluent limitations contained in subpart B are applicable to existing facilities processing more than 1362 KG. (3000 lbs) of raw material per day on any day during a calendar year and all new sources".

SECTION 408.210 - NON-ALASKAN CONVENTIONAL BOTTOM FISH

"These provisions apply to existing facilities processing more than 1816 KG. (4000 lbs) of raw material per day on any day during a calendar year and all new sources".

SECTION 408.230 - HAND SHUCKED CLAMS

"The provisions of this subpart are applicable to discharges resulting from existing hand-shucked clams processing facilities which process more than 1815 KG. (4000 lbs) of raw material per day on any day during a calendar year and all new sources".

SECTION 408.260 - ATLANTIC AND GULF COAST HAND-SHUCKED OYSTERS

"The provisions of this subpart are applicable to discharges resulting from existing hand-shucked oyster processing facilities on the Atlantic and Gulf Coasts which process more than 454 KG. (1000 lbs) of product per day on any day during a calendar year and all new sources".

NOTE: The above material has been extracted from References (1) and (2).

APPENDIX D

State of Maryland

Water Resources Administration

Tawes State Office Building, Annapolis, Md. 21401

POLICY ON PHOSPHORUS REDUCTION REQUIREMENTS, NITROGEN REDUCTION REQUIREMENTS, TOTAL CHLORINE RESIDUAL LIMITS, AND ALLOCABLE CAPACITY RESERVATION FOR SPECIFIED WATERS OF THE STATE

Purpose of Policy:

Federal and State laws, and the Memorandum of Agreement executed on September 5, 1974, between the State of Maryland and EPA, require that State and NPDES Discharge Permits be issued by July 1, 1975, for all point sources discharging into the Waters of the State. Issued permits are valid for a period not exceeding five years.

The purpose of this policy statement is to establish guidelines for effluent limitations for phosphorus, nitrogen, total chlorine residual, and allocable capacity, prior to the July, 1975, deadline and in the absence of individual water quality management basin plans. As these plans are adopted, discharge permits issued thereafter will reflect requirements established by that plan. Any of the four parameters which is not specifically addressed in an adopted Water Quality Management Basin Plan, will be limited in accordance with this policy, or as it may be revised.

1. Phosphorus Reduction Requirements: For point sources discharging directly to the Maryland portion of the Chesapeake Bay the total phosphorus limit (as P) shall normally be 2 mg/l based upon a monthly average and a required removal efficiency of 80% throughout the year. For point sources discharging into embayments tributary to Chesapeake Bay, the total phosphorus limit may have an additional seasonal control requirement (March 15 through November 15) to reduce the discharge level to an average of 0.3 mg/l as P.

RATIONALE:

a. The Hydroscience study confirms that the Maryland portion of the Chesapeake Bay is phosphorus limited.

b. The State of Pennsylvania requires 80% removal or 2 mg/l of total phosphorus as P for point sources discharging to the Lower Susquehanna River Basin.

c. A reduction of 80% for point sources discharging into the Bay, Baltimore Harbor and the Susquehanna River Basin, should serve to maintain the population of algae at essentially current background levels.

d. More stringent requirements for seasonal control of point source discharges of phosphorus to embayments are based upon available studies documenting the need for additional phosphorus control, e.g. Sod Run - Romney Creek; Elkton - Elk River; Aberdeen-Swan Creek, etc. Specifically, the level of phosphorus is related to algae production and its capability to deplete oxygen levels in the embayments.

e. The early date of March 15 was selected so that the normally sluggish embayments will be flushed before the critical algae production period in the summer.

f. The 0.3 mg/l total P limit is readily attainable from a technical standpoint with the installation of a terminal filter, either sand or multi-media, following the clarifier to capture suspended granular phosphate particles. In fact, with existing technology utilizing chemical control, an average of 1.0 mg/l in the effluent can be achieved without a filter, and an average of 0.1 mg/l with a filter.

2. Nitrogen Reduction Requirements: No nitrogen limits shall be set at this time for point sources discharging into the estuarine waters of the State of Maryland except for the Patuxent River, the Potomac River-Metro Area, and Assawoman Bay.

RATIONALE:

a. For Chesapeake Bay, the Hydroscience study currently being completed for WRA has determined that the Maryland portion of the Bay proper is not nitrogen limited. This will preclude any general nitrogen control requirements for the foreseeable future.

b. In the future, where nitrogen reductions are required, these will be established and implemented on a schedule which takes into account available technology, energy requirements, and financial resources.

c. We recognize the competition for scarce dollars to control much more important water pollution problems in the State.

3. Total Chlorine Residual Limits: The current requirements for continuous total chlorine residual control (i.e. 0.02 mg/l maximum into trout waters, a maximum 0.50 mg/l into other fresh waters, and 0.50 mg/l into tidal waters) shall be maintained.

RATIONALE:

a. The recent chlorine residual workshop held on November 14, 1974, in Baltimore confirmed the need for effective biocide limits and that Maryland's limits were conservative and within the realm of technical control.

b. Effective bacterial control systems are available including chlorine, bromine-chloride, ozone, ultra-violet and long term residence time. Pre-mixing and plug flow contact are essential design operating considerations for all biocides.

c. For small plants (e.g. 0.5 MGD or less) an equlization tank ahead of an activated sludge or trickling filter type plant will simplify control requirements, particularly so, if dechlorination is required.

d. Large plants with a design flow of 1 MGD or greater must have paced control systems to reflect changes in flow and residual demand.

e. The colorometric monitoring instruments, particularly those using the acid OTO test, are not acceptable tools for use in a waste water treatment plant. Careful amperometric residual measurement is required at the minimum.

f. An ad hoc advisory group is being formed to review the requirements and to recommend possible improvements.

4. Allocable Capacity Reserve Clause: The existing WRA Regulation 08.05.04.11 C. (4) is to be revised, following public notice and public hearing, as follows:

> "This allocation is to be established with due consideration for seasonal variations and a margin of safety, whereby such allocations to all point sources will include (a) a reservation up to 50% of the total allocable load at design stream flow for the specific river segment or water region, or (b) the load established by an approved Basin Water Quality Management Plan."

RATIONALE:

a. The existing clause states:

> "This allocation is to be established with due consideration to seasonal variations, a margin of safety, and by allocating to all point sources a maximum load not exceeding (a) 50% of the total available load for the specific river segment or water region, or (b) that load established by an approved Basin Water Quality Management Plan."

b. The existing clause severely restricts load allocations to a maximum figure and as a result does not allow for needed judgement in complex areas or to recognize difficult operating limitations laid on very small facilities.

APPENDIX E

Policy Statement on

Disinfection and Chlorine Residuals[1]

The following are the outlines of the policy to be adopted by the State of Maryland:

1. Both bacterial control and residual chlorine control will be facilitated by upgrading and making improvements in the waste treatment processes and facilities. To this end, the State will make the effort to achieve the necessary upgrading and improvement in systems and in effluent conditions at the earliest possible time.

2. For the protection of public health, the State's ultimate goal of disinfection is to attain adequate destruction of pathogenic bacteria and viruses in treated sewage effluents.

3. For the protection of aquatic life, the State shall work to minimize the discharge of toxic chlorine, if chlorination is used for disinfection.

4. EHA shall review and evaluate the chlorination system of each existing municipal and domestic waste treatment plant and make recommendations to the plant owners on the necessary improvements for meeting the effluent limitations of issued discharge permits. Interim modifications to the existing systems should be specified as well as requirements for long term control. Such consideration should include improvement of the basic treatment system as well as necessary improvement in the disinfection system. The construction grant funds shall also be oriented toward the improvement of the disinfection efficiency by both upgrading the effluent quality and the disinfection systems.

5. EHA shall evaluate each individual municipal and domestic waste treatment plant as to its capability in

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1 Distributed at the Chlorine Residual Advisory Committee, September 8, 1975.

achieving the desired level of disinfection. EHA shall make a determination of coliform limits for each treatment plant and the chlorine residual necessary to achieve those limits during the period of interim modifications and forward this information to the WRA.

6. EHA and WRA shall meet together from time to time, at least once per year, to review the program and make necessary adjustments of the control program and, if necessary, recommend adjustments in the effluent limits and water quality standards.

APPENDIX F

Projects Which, When Completed, Will Provide Sewerage Service

To Certain Seafood Processors

EXTRACTED FROM MARYLAND FY 1977
CONSTRUCTION GRANTS PROJECT LIST (Draft)[1)]

Statewide Priority No.	Step*	County	Area to be Served	Seafood Processors in Area
5	2	Calvert	Solomons Island	J.C. Lore
38	2	Worcester	West Ocean City	Martin Fish Company Davis & Lynch Fish Co.
44	2	Queen Anne	Kent Narrows Stevensville Grasonville	B&S Fisheries Fishermans Seafood W.H. Harris Seafood, Inc. Island Seafood Kent Oyster Company W.A. Thomas & Sons Herman Thompson United Shellfish Co., Inc.
61	1	Calvert	Broomes Island	Warren Denton & Co., Inc.
119	2	Somerset	Crisfield (peripheral area)	Diggs Seafood Company

1) This will be updated when the Project List is finalized and approved by the Governor.

* Step 1 - Facilities Plan; Step 2 - Design of System; Step 3 - Construction

(continued)

APPENDIX F (cotinued)

Projects Which, When Completed, Will Provide Sewerage Service

To Certain Seafood Processors

EXTRACTED FROM MARYLAND FY 1977
CONSTRUCTION GRANTS PROJECT LIST (Draft) 1)

Statewide Priority No.	Step*	County	Area to be Served	Seafood Processors in Area
154	2	Dorchester	Church Creek	Madison Seafood, Inc.
155	3	Dorchester	Church Creek	Madison Seafood, Inc.
194	2	St. Marys	Piney Point	Lumpkin Seafood
198	1	Talbot	Tilghman Island	Harrison Oyster Company
199	2	Talbot	Tilghman Island	Harrison Oyster Company
291	3	Anne Arundel	Includes Galesville	Woodfield Fish & Oyster Co.
343	1	Somerset	Deal Island	Island Seafood Faith Seafood, Inc.
				TOTAL: 19 Seafood Processors

1) This has to be updated when the Project List is finalized and approved by the Governor.

* Step 1 - Facilities Plan; Step 2 - Design of System; Step 3 - Construction

APPENDIX G

All tests except for chlorine were performed in accordance with the Manual of Methods for Analysis of Water and Wastes, 1974, by the U. S. Environmental Protection Agency and the Standard Methods for the Examination of Water and Wastewater, 1971, by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation.

BIOCHEMICAL OXYGEN DEMAND - BOD

Definition:

The EPA Manual of Methods defines the BOD test as "an empirical bioassay-type procedure which measures the dissolved oxygen consumed by microbial life while assimilating and oxidizing the organic matter present".

Sample Collection and Storage:

Samples for BOD were collected in one liter plastic bottles. Samples were transported on ice, then held in a cold room at about 2°C until analysis the next day.

Procedure:

The Wrinkler method described below is used to measure dissolved oxygen (DO) in the sample and in the water used to dilute the sample. Another portion of the sample is appropriately diluted, sealed from the air in special bottles, and incubated at 20°C in the dark. After 5 days, DO is measured in the incubated samples, again by the Winkler method. The DO that was in the bottle before incubation is calculated from the volumes of sample and dilution water that went into the bottle and from their respective DO's, previously determined. DO before incubation minus DO after dilution factor incubation equals BOD.

The saturated point of DO in water is about 9 milligrams per liter at 20°C. The sample can not hold more oxygen than this. Therefore, determination of a BOD value above 9 is not possible unless the sample is diluted. For this reason, most of the bottles for incubation contained diluted samples.

Some samples had been chlorinated. Chlorine inhibits microbial activity, so chlorine was destroyed before samples were incubated. An appropriate quantity of sodium sulfite was added to the chlorinated samples to transform chlorine to innocuous common salt. To insure that micro-organisms were present in the incubated samples, the dilution water was inoculated with a few ml of a culture maintained by periodic addition of seafood processing wastewater.

For determination of DO by the Winkler method, several chemicals are added to the sample to be analyzed. Reactions occur to tie up the DO and release an equivalent quantity of iodine. A dark blue color formed by iodine and starch suddenly disappears when the iodine is consumed by the addition of an exactly equivalent quantity of a standard solution of sodium thiosulfate. The dissolved oxygen is then calculated based on the volume of sodium thiosulfate solution required to react with the iodine.

Accuracy:

Data is reported in units of milligrams of oxygen consumed per liter of sample. According to the EPA Manual of Methods, there is no acceptable procedure for determining the accuracy of the BOD test. Furthermore, precision is poor. Again, according to the EPA Manual of Methods, 86 analysts measured BOD on a sample containing added organic compoinds. The standard deviation was $\pm$ 26 on the sample with an average BOD of 175. The poor precision should be taken into consideration when interpreting BOD data.

Efforts were made to keep accuracy and precision as high as possible. Double distilled dilution water was used. Oxygen depletions of less than 2 ml were rejected they were not used to calculate BOD. Incubated samples with a residual DO of less than 2 mg/l were also rejected. The procedure was routinely checked by determining the BOD of a glucose-glutamic acid standard in accordance with Standard Methods. Results of this check were satisfactory.

TOTAL KJELDAHL NITROGEN

Definition:

Total Kjeldahl nitrogen is defined as the sum of free ammonia and organic nitrogen compounds. In these samples, most organic nitrogen is protein. Kjeldahl nitrogen does not include nitrate and nitrite.

Sample Collection and Storage:

Samples for total Kjeldahl nitrogen were collected in one liter plastic bottles and preserved with the addition of 2 ml of concentrated sulfuric acid. Samples were transported on ice, then frozen at about -23^{o}C until analysis.

Procedure:

A measured volume of sample is boilded with sulfuric acid. This treatment breaks down organic compounds in the sample. Nitrogen in the organic compounds is converted to ammonia. In an acidic solution, ammonia forms a soluable salt, in this case ammonium sulfate. This solution is cooled, then sodium hydroxide is added. The sodium hydroxide neutralizes the sulfuric acid and makes the solution strongly alkaline. The ammonium sulfate converts back to ammonia, which is insoluable in alkaline solution.

The alkaline solution is boiled to distill steam and ammonia gas into a flask containing boric acid. Upon contact with the boric acid, the ammonia again forms a soluable salt, ammonium borate. All of the Kjeldahl nitrogen from the original sample now exists as ammonium borate in the boric acid flask. The ammonia partially neutralizes the boric acid. The final step is the additon of a standard acid of known concentration to the boric acid solution. A measured volume of the standard acid is added to the boric acid solution to restore exactly its pH to what it was before the distillation. The volume of standard acid required is proportional to the ammonia which had been distilled. Since the distilled ammonia represents the Kjeldahl nitrogen, the Kjeldahl nitrogen may be caluculated from the volume of standard acid.

Accuracy:

Data is reported to the nearest tenth of a milligram in units of milligrams of nitrogen per liter of sample. The result of an intra-laboratory study of the accuracy of this procedure is given in the EPA Manual of Methods.

NITROGEN, NITRATE-NITRITE

Sample Collection and Storage:

Samples for nitrate-nitrite were collected in one liter plastic bottles and preserved with the addition of 2 ml of concentrated sulfuric acid. Samples were transported on ice, then frozen at about -23^{o}C until analysis, usually with two weeks.

Procedure:

The sample is filtered, and the pH adjusted. Next, a buffer solution is added to maintain the pH and the sample is passed through a column of cadmium plated with copper. The column converts any nitrate of the sample to nitrite. A color reagent is then added which reacts with the nitrite forming a red dye. The intensity of this color is proportional to the concentration of nitrate plus nitrite which was originally in the sample. The intensity of the red color was measured on a Beckman DB spectrophotometer. Standard solutions containing known amounts of nitrite and nitrate were given the same treatment to calibrate the spectrophotometer readings.

Accuracy:

Data is reported to the nearest hundredth of a milligram in units of milligrams of nitrogen per liter of sample. This nitrogen was in the form of nitrite and/or nitrate in the original sample. The results of a study by one laboratory on the accuracy of this procedure are given in the EPA Manual of Methods.

OIL AND GREASE

Sample Collection and Storage:

Samples for oil and grease were collected in one liter glass bottles and preserved with the addition of 2 ml of concentrated sulfuric acid. Samples were transported on ice, then held in a cold room at about 2°C until analysis, often the next day, and usually within a week.

Procedure:

Oil and grease is defined by the analytical procedure used. The one liter sample is poured into a two liter separatory funnel. Thirty ml of Freon 113 is added to the sample collection bottle to rinse it, then the Freon is added to the separatory funnel. The Freon is shaken with the sample, causing any oil and grease of the sample to dissolve in the Freon.

Freon is insoluable in water and more dense than water, so it sinks to the bottom of the separatory funnel. The valve at the bottom of the separatory funnel is opened to allow the Freon with its dissolved oil and grease to drain into a previously weighed flask. When the Freon is drained, the valve is closed, retaining the sample in the separatory funnel. This is repeated with two additional 30 ml portions of fresh Freon. The sample is discarded, then the separatory funnel is rinsed with 10 ml of Freon. These four portions of Freon are combined in the weighed flask. The flask is heated, evaporating the Freon. The flask is again weighed and the increase is attributed to oil and grease from the sample.

Data is reported to the nearest milligram in units of milligrams of oil and grease per liter of sample. The accuracy of the oil and grease procedure cannot be evaluated since the definition of oil and grease is based on the procedure used.

RESIDUE, TOTAL NON-FILTERABLE

Sample Collection and Storage:

Samples for residue, total non-filterable were collected in 100 ml glass bottles. Samples were transported on ice, then held in a cold room at about 2°C until analysis, either the same day or the day after sample collection.

Procedure:

Residue, total non-filterable is defined by the procedure used. The sample is shaken and an appropriate measured volume is filtered through a dry, weighed, standard glass fiber filter. The filter, with the residue, is then dried to a constant weight in a forced air oven at 103-105°C. This constant weight minus the weight of the filter equals the weight of the residue.

Accuracy:

Data is reported in units of milligrams of residue per liter of sample. According to Standard Methods, there is no satisfactory procedure for obtaining the accuracy of the method on wastewater samples, since the true concentration of suspended matter is unknown.

SETTLEABLE MATTER

Sample Collection and Storage:

Samples for settleable matter were collected in one liter glass bottles. Samples were transported on ice, then held in a cold room at about 2°C until analysis, either the same day or the day after sample collection.

Procedure:

Settleable matter is defined by the procedure used. The sample is shaken and poured into an Imhoff cone. This is a glass cone with volumetric graduations near the bottom. The sample is allowed to settle for 45 minutes, then the cone is spun to dislodge settleable matter stuck to the sides of the cone, and allowed to settle for an additional 15 minutes. The volume of settleable matter is then read from the graduations near the bottom of the cone.

Accuracy:

Data is reported to the nearest tenth of a milliliter in units of milliliters of settleable matter per liter of sample. EPA has not established standards for accuracy.

pH

Definition:

The pH scale tells whether water is acidic, neutral, or alkaline. The pH of neutral water is 7. The pH of acidic water is below 7, with smaller numbers indicating more acidity. The pH of alkaline water is above 7, with larger numbers indicating more alkalinity.

Sample Collection and Storage:

Samples were collected in glass bottles. Samples were transported on ice, then held in a cold room at about 2°C until analysis, either the same day or the day after sample collection.

Procedure:

The pH was measured with glass electrodes on a Corning Model 12 Research pH meter. The meter was calibrated with two standard solutions of known pH before measuring the pH of the sample.

Accuracy:

Data is reported in pH units to one decimal place. According to Standard Methods, ±0.1 pH units represents the limit of accuracy under normal conditions.

TOTAL PHOSPHOROUS

Definition:

This test measures the total of all forms of phosphorous in the sample.

Sample Collection and Storage:

Samples for phosphorous were collected in one liter plastic bottles and preserved with the addition of 2 ml of concentrated sulfuric acid. Samples were transported on ice, then frozen at about -23°C until analysis, usually within two weeks.

Procedure:

A small volume of sample, usually one ml, was heated for 20 minutes at 121°C in an autoclave with sulfuric acid and ammonium persulfate. The step converted all forms of phosphorous in the sample to the orthophosphate form. The pH of the samples was adjusted, then ammonium molydate and antimony potassium tartrate were added to form an antimony-phospho-molyb-date complex with the phosphate of the sample. Ascorbic acid was added to reduce this mixture to a blue colored complex. The intensity of the blue color is proportional to the amount of phosphorous in the sample. The intensity was measured on a Beckman DB spectrophotometer. Standard solutions containing known amounts of phosphorous were given the same treatment to calibrate the spectrophotometer readings.

Accuracy:

Data is reported to the nearest tenth of a milligram in units of milligrams of phosphorous per liter of sample. The results of an intra-laboratory study of the accuracy of this procedure is given in the EPA Manual of Methods.

AMMONIA

Sample Collection and Storage:

Samples for ammonia determination were collected in one liter plastic bottles. All samples were preserved with the addition of 2 ml of concentrated sulfuric acid. Samples were transported to the laboratory on ice. Analysis for ammonia began on March 23, 1976. Samples collected before then were stored at about -23°C. Samples collected on and after March 23, were held in a cold room at about 2°C until the analysis was performed - within 24 hours.

Procedure:

Ammonia is measured with an Orion ammonia electrode. With the electrode immersed in the sample solution, an excess of sodium hydroxide is added to make the solution strongly alkaline. In an alkaline solution ammonia is in the form of a dissolved gas. The ammonia gas diffuses through the membrane of the electrode, causing an electric potential to develop across the terminals of the electrode. The potential is proportional to the concentration of ammonia in the sample. The potential is measured on a voltmeter, which is calibrated with standard ammonia solutions.

Accuracy:

Data is reported to the nearest tenth of a milligram in units of milligrams of nitrogen per liter of sample.

CHLORINE

Procedure:

Chlorine is not stable in solution. Samples cannot be stored. Chlorine analysis was done as samples were collected, at the site. Hach Co. portable chlorine test kits were used. Model CN-46-A was used for concentrations of chlorine below 3 mg/l and Model CN-21-P was used for Concentrations of chlorine above 3 mg/l.

The Low range test kit, Model CN-46-A, works by the development of a yellow color from the reaction between the chlorine and orthotolidine, which is added to the sample. Chlorine concentration is then determined by comparison of the intensity of the yellow color in the sample to standard yellow colors in plastic supplied by Hach. The high range test kit, Model CN-21-P, works by adding chemicals which release a quantity of iodine in the sample equivalent to the quantity of chlorine in the sample. The iodine is then measured by a procedure very similar to the one for iodine measurement described with the Winkler method in the BOD section.

Accuracy:

Data is reported in units of milligrams of chlorine per liter of sample. Hach provides no information on accuracy of these kits. The data should probably be interpreted as rough estimates of chlorine concentrations.

APPENDIX H

Determination of Coliform and Fecal Coliform Concentration

The waste water samples for bacteriological examination were collected in sterile 250 ml, screw-capped bottles. Clean dry bottles, with caps loosened, were covered with a double layer of aluminum foil and autoclaved for 15 minutes at 121°C. Two tenths (0.2) ml of a sterile 10% sodium thiosulfate solution was added to each bottle as a dechlorinating agent. This amount of sodium thiosulfate will neutralize up to 30 mg residual chlorine per liter of water and prevent a continuation of bactericidal action of the chlorine until the water is analyzed. At the time of sampling, the screw caps and aluminum covers were removed together. The bottle was filled without rinsing directly from the waste water discharge stream and the cap with aluminum cover replaced. Throughout the sample collection, care was taken to avoid touching or otherwise externally contaminating the mouth or neck of the bottle. The cap was tightened and the filled bottle was placed in an ice chest for transit to the laboratory. The samples were analyzed immediately upon receipt in the laboratory, or, if time did not permit analysis the same day, were stored overnight in the cold room for processing early the next morning. All samples were analyzed within 24 hours of the time of collection.

The procedures of analysis followed those outlined in "Standard Methods of Examination of Water and Waste Water", 1971. The water was examined by the multiple-tube fermentation technique for members of the coliform group including fecal coliforms. The coliform group comprises all aerobic and faculative anaerobic gram-negative, non-sporeforming bacteria which ferment lactose with production of gas within 48 hours at 35°C. Fecal coliforms (of fecal origin, principally Eschericia coli) are defined as those coliforms which will ferment lactose with production of gas at 44.5°C within 24 hours.

The bacteriological analysis is performed in two steps, a presumptive test and a confirmation test. Lauryl sulfate Tryptose broth (LST), used for the presumptive test, serves as an enrichment medium for the selection of coliform bacteria, including fecal coliforms. In the confirmation test, Brilliant Green Bile broth (BGB) at 35°C confirms the coliforms and EC broth at 44.5°C confirms fecal coliforms.

The water sample was vigorously shaken to evenly distribute the bacteria and disperse clumps and 10 ml was added to each of 3 tubes containing 10 ml double strength LST. One ml sample was added to each of 3 tubes containing single strength LST. The sample water was diluted 1:10, 1:100 and 1:1000 in phosphate buffered dilution water at pH 7.2, and for each dilution, one ml was added to each of 3 tubes LST. The inoculated LST tubes were incubated at $35^{o} \pm 0.5^{o}C$. The tubes were examined at 24 hours and 48 hours for growth (cloudiness) and gas production as evidenced by a bubble in the inverted fermentation tube or by a persistence of bubbles rising through the liquid upon gentle shaking. The tubes showing growth and gas are recorded as presumptive positive and are used to inoculate tubes of BGB and EC. Transfer of culture from LST to BGB and EC was accomplished by transferring a 3mm loopful of fluid from positive LST tubes to tubes of BGB and EC. BGB was incubated at $35^{o}C$ and examined at 24 hours and 48 hours for growth and gas to confirm coliforms. EC was incubated at $44.5^{o}C \pm 0.2^{o}C$ in a covered circulating water bath. Those tubes showing growth with gas formation after 24 hours were considered confirmed positive for fecal coliforms.

The results of the multiple-tube fermentation technique are expressed as the Most Probable Number (MPN) usually per 100 ml of sample. The MPN is an estimation and not a precise enumeration of the actual numbers of bacteria of any given type per volume of sample. For the 3 tube multiple-fermentation tests used in this study, the approximate lower and upper 95% confidence limits may be estimated as 21% of the reported MPN for the lower and 395% for the upper.

The results for both coliforms and fecal coliforms were reported as the MPN/100 ml. The MPN was determined by selecting the highest sample dilution where all 3 tubes were positive and the numbers of positives in the next two successive dilutions to give a series of three numbers. Using this series of three numbers, the MPN/100 ml was found from MPN tables in "Standard Methods for Examination of Water and Waste Water", 1971.

APPENDIX H (continued)

Identification of Bacteria with API 20E System

The routine coliform bacteriological examination was now taken one step further. The API 20E system of *Enterobacteriaceae* identification was used. This is a miniaturized version of conventional laboratory procedures (as per *Standard Methods for the Examination of Water and Waste Water*) for the identification of *Enterobacteriaceae* and certain allied bacteria. The intent of this "completed diagnostic test for coliforms" is to enable laboratory personnel to identify members of the family *Enterobacteriaceae* accurately and easily.

The test kit consits of microtubes containing dehydrated media. These media are reconstituted by adding bacterial suspension, incubated at 35-37^{o}C and reactions read after 18-24 hours. The organism reacts with the media and either changes color of an indicator or shows distinct characteristics upon the addition of indicator substances. Results were matched with a chart of organism reactions and identification was then made.

This test was conducted after the multiple-tube fermentation technique for estimation of fecal coliform levels. The last positive E.C. tube (i.e., the highest dilution that was positive) became the source of bacteria used in the API test procedure. This culture tube was streaked onto Eosion Methylene Blue (EMB) agar plates. After 24 hours incubation at 35-37^{o}C the plates were examined for growth. Four distinct colonies, showing a metalic green sheen were selected from this plant, each being transferred to a separate MEB plate and streaked to "purify" the culture and confirm the colony type. The procedure was carefully done so as to transfer only one separate colony onto each plate. These plates were incubated for 24-48 hours at 35-37^{o}C. At the end of this period a colony of the organism was transferred to 5 ml of sterile water and mixed. With a Pasteur pipette the bacterial suspension was introduced into the test capsule and the media reconstituted. The test capsules are then incubated for 18-24 hours at 35-37^{o}C. At the end of this period the results are recorded and compared to the API organism reaction chart for identification.

APPENDIX I

SAMPLER NAME ____________________ DATE ________________________

PLANT SAMPLED ___________________ TIME ________________________

Questions to be Answered at the Plant

1. Product (s) being processed

2. Volume of product processed (in bushels)

3. Number of employees working

4. List of treatments prior to discharge

   a. Clorination yes ___ no ___ If yes, what

   b. Screening yes ___ no ___ concentration?

5. Approximate flow rate at discharge point

6. Number of hours plant operates at the above flow-rate

7. Number of hours plant will operate that day

8. What operation is taking place at sampling time?

APPENDIX J

MARYLAND SEAFOOD PROCESSORS
LISTED ALPHABETICALLY BY COUNTY
(current as of June 1976)

	Mailing Address	Product(s) Processed
ANNE ARUNDEL		
Woodfield Fish & Oyster Co.	Galesville	Oysters, Fish
CALVERT		
Denton, Warren & Co., Inc.	Broomes Island	Oysters
Lore, J.C. & Sons, Inc.	Solomons	Oysters
DORCHESTER		
Cannon, I.F. & Son	Crapo	Crabs
Dorchester Crab Co.	Wingate	Oysters, Crabs
Goose Creek Seafood	Toddville	Crabs
Hall, Russell	Fishing Creek	Crabs
Madison Seafood	Madison	Oyster
Meredith & Meredith	Toddville	Oysters, Crabs
Parks, Charles H.	Fishing Creek	Crabs
Phillips, A.E. & Son, Inc.	Fishing Creek	Crabs
Powley, Inc.	Wingate	Oysters, Crabs
Rippons Brothers	Hoopersville	Crabs
Ruark & Ashton	Hoopersville	Crabs
Ruark, W.T.	Fishing Creek	Crabs
Todd, Bradye P. & Son, Inc.	Crocheron	Crabs
Toddville Seafood, Inc.	Wingate	Crabs
QUEEN ANNE		
B. & S. Fisheries	Grasonville	Oysters, Clams
Calvert Shellfish Co.	Dominion	Clams
Crouch's Seafood	Dominion	Oysters
Eastern Bay Seafood	Dominion	Oysters, Clams
Fisherman's Seafood Market	Grasonville	Oysters, Crabs
Harris, Wm. H., Seafood	Grasonville	Oysters
Islander Seafood, Inc.	Grasonville	Oysters, Clams
Kent Oyster Co.	Grasonville	Oysters, Clams
Thomas, W. A. & Son	Grasonville	Oysters, Clams

APPENDIX J (continued)

	Mailing Address	Product(s) Processed
Thompson, H.S., Inc.	Grasonville	Oysters
United Shellfish Co.	Grasonville	Oysters, Clams
SOMERSET		
Bivalve Seafood Packers	Mt. Vernon	Oysters
Diggs Seafood Co.	Crisfield	Oysters
Faith Seafood, Inc.	Wenona	Crabs
Island Seafood	Deal Island	Crabs
Mt. Vernon Packing Co.	Mt. Vernon	Oysters
ST. MARYS		
Copsey, Leonard W.	Mechanicsville	Oysters, Crabs
Lumpkin Seafood	Piney Point	Oysters
Milburn Creek Seafood	St. Marys City	Oysters
Sheehan, J. C.	Drayden	Oysters
Trossbach Bros.	Ridge	Oysters
TALBOT		
Bellevue Seafood Co.	Bellevue	Oysters, Clams
Chesapeake Shellfish Co.	Sherwood	Oysters, Crabs Clams
Harrison Oyster Co.	Tilghman	Oysters
Jones, Ray J. Seafood Co.	Wittman	Oysters, Crabs Clams
Tidewater Clam Co.	McDaniel	Oysters, Clams
Turner, W. A. & Son, Inc.	Bellevue	Crabs
WICOMICO		
Kennerly, H. B. & Son, Inc.	Nanticoke	Oysters, Clams
WORCESTER		
Davis & Lynch Fish Co.	West Ocean City	Fish
Martin Fish Co.	West Ocean City	Fish

APPENDIX K

TABLE 8. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNITS	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.71	0.49
PROCESS TIME	(HRS/DAY)	6.94	0.95
FLOW RATE	(GAL/MIN)	4.96	2.73
FLOW RATIO	(GAL/TON)	761.70	315.00
SETTLEABLE SOLIDS	(ML/L)	4.53	3.59
TSS	(LBS/1000 LB)	3.01	2.30
5 DAY BOD	(LBS/1000 LB)	0.47	0.59
OIL & GREASE	(LBS/1000 LB)	0.03	0.04
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.01	0.01
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.01	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.02	0.02
RESIDUAL CHLORINE	(LBS/1000 LB)	1.91	2.36
pH		7.8	0.74
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.00	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.00	

PLANT A1
9 SAMPLES

TABLE 9. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	1.13	0.33
PROCESS TIME	(HRS/DAY)	8.21	0.80
FLOW RATE	(GAL/MIN)	3.16	2.77
FLOW RATIO	(GAL/TON)	1380.21	404.71
SETTLEABLE SOLIDS	(ML/L)	0.64	0.72
TSS	(LBS/1000 LB)	1.03	1.45
5 DAY BOD	(LBS/1000 LB)	1.74	2.20
OIL & GREASE	(LBS/1000 LB)	0.05	0.07
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.04	0.06
NITROGEN (NITRITE-NITRATE	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.19	0.28
RESIDUAL CHLORINE	(LBS/1000 LB)	0.04	0.08
pH		7.80	0.38
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	5.31×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	114.00	

PLANT A2
14 SAMPLES

TABLE 10. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.45	0.26
PROCESS TIME	(HRS/DAY)	7.33	0.48
FLOW RATE	(GAL/MIN)	11.41	8.78
FLOW RATION	(GAL/TON)	2048.87	961.48
SETTLEABLE SOLIDS	(ML/L)	0.11	0.03
TSS	(LBS/1000 LB)	0.17	0.16
5 DAY BOD	(LBS/1000 LB)	0.10	0.18
OIL & GREASE	(LSB/1000 LB)	0.02	0.01
PHOSPHORUS (TOTAL)	(LSB/1000 LB)	0.04	0.09
NITROGEN (NITRITE-NITRATE)	(LSB/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LSB/1000 LB)	0.04	0.04
KJELDAHL NITROGEN (TOTAL)	(LSB/1000 LB)	0.06	0.06
RESIDUAL CHLORINE	(LSB/1000 LB)	0.00	0.00
pH		7.25	0.32
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	72.85×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	1812.00	

PLANT A3
12 SAMPLES

TABLE 11. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.67	0.41
PROCESS TIME	(HRS/DAY)	6.91	0.30
FLOW RATE	(GAL/MIN)	17.24	15.64
FLOW RATIO	(GAL/TON)	2675.27	691.30
SETTLEABLE SOLIDS	(ML/L)	2.38	2.90
TSS	(LBS/1000 LB)	2.72	4.24
5 DAY BOD	(LBS/1000 LB)	3.68	5.79
OIL & GREASE	(LBS/1000 LB)	0.07	0.13
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.06	0.13
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.02	0.03
KJELDAHL NITROGEN	(LBS/1000 LB)	0.45	0.93
RESIDUAL CHLORINE	(LBS/1000 LB)	0.09	0.19
pH		7.8	0.68
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	18.88×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	565.00	

PLANT A4
12 SAMPLES

TABLE 12. BLUE CRABS

(CONVENTIONAL)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.79	0.42
PROCESS TIME	(HRS/DAY)	6.43	0.90
FLOW RATE	(GAL/MIN)	5.68	6.02
FLOW RATIO	(GAL/TON)	785.30	766.78
SETTLEABLE SOLIDS	(ML/L)	4.74	5.69
TSS	(LBS/1000 LB)	3.35	8.41
5 DAY BOD	(LBS/1000 LB)	2.78	3.62
OIL & GREASE	(LBS/1000 LB)	0.02	0.03
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.06	0.07
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.11	0.03
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.57	1.09
RESIDUAL CHLORINE	(LBS/1000 LB)	0.01	0.01
pH		7.39	0.05
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.67×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	472.00	

PLANT A5
14 SAMPLES

TABLE 13. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	1.21	0.70
PROCESS TIME	(HRS/DAY)	7.19	1.03
FLOW RATE	(GAL/MIN)	4.28	2.04
FLOW RATIO	(GAL/TON)	1530.91	180.04
SETTLEABLE SOLIDS	(ML/L)	4.65	9.08
TSS	(LBS/1000 LB)	1.63	1.33
5 DAY BOD	(LBS/1000 LB)	1.11	1.33
OIL & GREASE	(LBS/1000 LB)	0.03	0.02
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.03	0.03
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.02	0.03
KJELDAHL NITROGEN	(LBS/1000 LB)	0.15	0.18
RESIDUAL CHLORINE	(LBS/1000 LB)	0.18	0.36
pH		7.78	0.35
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	83.00×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)		

PLANT A6
13 SAMPLES

TABLE 14. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.20	0.78
PROCESS TIME	(HRS/DAY)	7.24	0.89
FLOW RATE	(GAL/MIN)	7.67	9.10
FLOW RATIO	(GAL/TON)	1512.86	624.43
SETTLEABLE SOLIDS	(ML/L)	2.79	5.13
TSS	(LBS/1000 LB)	1.92	4.26
5 DAY BOD	(LBS/1000 LB)	2.67	7.81
OIL & GREASE	(LBS/1000 LB)	0.04	0.07
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.04	0.08
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.04	0.13
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.27	0.66
RESIDUAL CHLORINE	(LBS/1000 LB)	0.29	1.00
pH		7.63	0.54
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	1.8×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	200.00	

PLANTS A1 thru A6
74 SAMPLES

TABLE 15. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.57	0.13
PROCESS TIME	(HRS/DAY)	7.94	2.16
FLOW RATE	(GAL/MIN)	6.12	3.90
FLOW RATIO	(GAL/TON)	5111.99	3791.50
SETTLEABLE SOLIDS	(ML/L)	1.90	3.02
TSS	(LBS/1000 LB)	3.37	3.46
5 DAY BOD	(LBS/1000 LB)	19.30	19.68
OIL & GREASE	(LBS/1000 LB)	0.07	0.05
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.24	0.24
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.04	0.03
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	1.97	1.81
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		7.10	0.34
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	26.90×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	272.00	

PLANT B1
15 SAMPLES

TABLE 16. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.31	0.13
PROCESS TIME	(HRS/DAY)	6.85	1.54
FLOW RATE	(GAL/MIN)	12.34	6.47
FLOW RATIO	(GAL/TON)	16476.66	4750.68
SETTLEABLE SOLIDS	(ML/L)	1.90	2.24
TSS	(LBS/1000 LB)	16.01	18.50
5 DAY BOD	(LBS/1000 LB)	26.42	25.71
OIL & GREASE	(LBS/1000 LB)	0.24	0.34
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.33	0.41
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.02	0.02
AMMONIA-NH_3	(LBS/1000 LB)	0.11	0.12
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	3.26	4.79
RESIDUAL CHLORINE	(LBS/1000 LB)	0.12	0.34
pH		7.46	0.86
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	6.32×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	81.00	

PLANT B2
9 SAMPLES

TABLE 17. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.65	0.21
PROCESS TIME	(HRS/DAY)	6.92	1.29
FLOW RATE	(GAL/MIN)	5.11	2.71
FLOW RATIO	(GAL/TON)	3281.58	1005.61
SETTLEABLE SOLIDS	(ML/L)	1.12	2.48
TSS	(LBS/1000 LB)	2.07	2.56
5 DAY BOD	(LBS/1000 LB)	8.13	16.76
OIL & GREASE	(LBS/1000 LB)	0.04	0.05
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.16	0.14
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.76	0.55
RESIDUAL CHLORINE	(LBS/1000 LB)	1.21	1.41
pH		6.92	0.28
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	0.04×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	7.00	

PLANT B3
20 SAMPLES

TABLE 18. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.39	0.13
PROCESS TIME	(HRS/DAY)	5.35	1.77
FLOW RATE	(GAL/MIN)	6.04	1.02
FLOW RATIO	(GAL/TON)	4971.39	827.65
SETTLEABLE SOLIDS	(ML/L)	3.18	3.20
TSS	(LBS/1000 LB)	14.97	20.51
5 DAY BOD	(LBS/1000 LB)	27.88	18.26
OIL & GREASE	(LBS/1000 LB)	0.10	0.07
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.37	0.30
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.06	0.03
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	4.43	3.53
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.01
pH		7.03	0.32
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	6.58×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	50.00	

PLANT B4
10 SAMPLES

TABLE 19. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.29	0.17
PROCESS TIME	(HRS/DAY)	7.57	0.79
FLOW RATE	(GAL/MIN)	6.67	3.36
FLOW RATIO	(GAL/TON)	10563.52	961.57
SETTLEABLE SOLIDS	(ML/L)	1.33	2.11
TSS	(LBS/1000 LB)	21.21	25.63
5 DAY BOD	(LBS/1000 LB)	91.31	72.26
OIL & GREASE	(LBS/1000 LB)	0.07	0.06
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.50	0.27
NITROGEN (NITRITE-NITRATE	(LBS/1000 LB)	0.01	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.29	0.28
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	11.29	9.02
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		7.25	0.45
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	14.80×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	159.00	

PLANT B5
9 SAMPLES

TABLE 20. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.50	0.21
PROCESS TIME	(HRS/DAY)	7.02	1.82
FLOW RATE	(GAL/MIN)	6.75	4.30
FLOW RATIO	(GAL/TON)	5737.02	2218.37
SETTLEABLE SOLIDS	(ML/L)	1.66	2.72
TSS	(LBS/1000 LB)	8.73	15.17
5 DAY BOD	(LBS/1000 LB)	25.24	35.99
OIL & GREASE	(LBS/1000 LB)	0.11	0.19
PHOSPHORUS(TOTAL)	(LBS/1000 LB)	0.28	0.28
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.01	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.08	0.13
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	3.12	4.66
RESIDUAL CHLORINE	(LBS/1000 LB)	0.38	0.94
pH		7.15	0.53
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	2.60×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	60.48	

PLANTS B1 thru B5
63 SAMPLES

TABLE 21. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	3.92	0.61
PROCESS TIME	(HRS/DAY)	6.75	1.67
FLOW RATE	(GAL/MIN)	4.46	4.02
FLOW RATIO	(GAL/TON)	461.06	662.71
SETTLEABLE SOLIDS	(ML/L)	3.07	5.72
TSS	(LBS/1000 LB)	0.58	0.70
5 DAY BOD	(LBS/1000 LB)	3.22	2.91
OIL & GREASE	(LBS/1000 LB)	0.01	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.02	0.21
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.00	0.00
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.19	0.18
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		7.23	0.46
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	88.80×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	1784.00	

PLANT B1
8 SAMPLES

TABLE 22. SOFT-SHELL CLAMS (HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.18	1.44
PROCESS TIME	(HRS/DAY)	5.14	0.95
FLOW RATE	(GAL/MIN)	5.24	4.47
FLOW RATIO	(GAL/TON)	742.42	176.96
SETTLEABLE SOLIDS	(ML/L)	0.58	0.58
TSS	(LBS/1000 LB)	0.63	0.35
5 DAY BOD	(LBS/1000 LB)	1.19	0.91
OIL & GREASE	(LBS/1000 LB)	-	-
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.02	0.01
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.00
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.09	0.05
RESIDUAL CHLORINE	(LBS/1000 LB)	0.06	0.10
pH		-	-
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	2.70×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	108.00	

PLANT B2
8 SAMPLES

TABLE 23. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	4.29	1.96
PROCESS TIME	(HRS/DAY)	6.22	2.06
FLOW RATE	(GAL/MIN)	3.38	1.35
FLOW RATIO	(GAL/TON)	293.68	85.49
SETTLEABLE SOLIDS	(ML/L)	0.93	0.90
TSS	(LBS/1000 LB)	0.31	0.29
5 DAY BOD	(LBS/1000 LB)	1.32	1.22
OIL & GREASE	(LBS/1000 LB)	0.01	0.01
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.07	0.10
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.00	0.00
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.12	0.13
RESIDUAL CHLORINE	(LBS/1000 LB)	0.59	1.16
pH		6.64	0.26
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	0.14×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	30.00	

PLANT B3
6 SAMPLES

TABLE 24. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	1.76	0.49
PROCESS TIME	(HRS/DAY)	5.00	1.83
FLOW RATE	(GAL/MIN)	4.54	2.33
FLOW RATIO	(GAL/TON)	772.62	523.50
SETTLEABLE SOLIDS	(ML/L)	1.09	1.02
TSS	(LBS/1000 LB)	1.14	1.20
5 DAY BOD	(LBS/1000 LB)	2.93	2.55
OIL & GREASE	(LBS/1000 LB)	0.01	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.06	0.05
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.45	0.46
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		7.13	0.43
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	97.11×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	362.00	

PLANT B4
7 SAMPLES

TABLE 25. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.02	1.01
PROCESS TIME	(HRS/DAY)	3.90	2.03
FLOW RATE	(GAL/MIN)	5.90	3.36
FLOW RATIO	(GAL/TON)	682.79	406.29
SETTLEABLE SOLIDS	(ML/L)	1.63	2.49
TSS	(LBS/1000 LB)	0.99	0.60
5 DAY BOD	(LBS/1000 LB)	3.68	6.11
OIL & GREASE	(LBS/1000 LB)	0.00	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.05	0.04
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.29	0.37
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.29	0.37
RESIDUAL CHLORINE	(LBS/1000 LB)	0.54	1.20
pH		7.26	0.34
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.69×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	19.00	

PLANT B5
12 SAMPLES

TABLE 26. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	2.81	1.57
PROCESS TIME	(HRS/DAY)	5.34	1.93
FLOW RATE	(GAL/MIN)	4.73	3.26
FLOW RATIO	(GAL/TON)	328.92	240.91
SETTLEABLE SOLIDS	(ML/L)	1.40	2.69
TSS	(LBS/1000 LB)	0.74	0.73
5 DAY BOD	(LBS/1000 LB)	2.49	3.70
OIL & GREASE	(LBS/1000 LB)	0.01	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.04	0.05
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.20	0.25
RESIDUAL CHLORINE	(LBS/1000 LB)	0.27	0.81
pH		7.11	0.41
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	2.40×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	106.00	

PLANTS B1 thru B5
41 SAMPLES

TABLE 27. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.53	0.11
PROCESS TIME	(HRS/DAY)	7.39	1.04
FLOW RATE	(GAL/MIN)	1.87	1.04
FLOW RATIO	(GAL/TON)	1565.06	579.42
SETTLEABLE SOLIDS	(ML/L)	9.33	12.83
TSS	(LBS/1000 LB)	3.88	4.10
5 DAY BOD	(LBS/1000 LB)	4.00	4.41
OIL & GREASE	(LBS/1000 LB)	0.11	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.05	0.08
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.63	0.70
RESIDUAL CHLORINE	(LBS/1000 LB)	0.99	1.67
pH		7.34	0.52
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	2.00×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	141.00	

PLANT C1
13 SAMPLES

TABLE 28. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.66	0.09
PROCESS TIME	(HRS/DAY)	8.00	0.00
FLOW RATE	(GAL/MIN)	1.95	1.12
FLOW RATIO	(GAL/TON)	1411.77	0.00
SETTLEABLE SOLIDS	(ML/L)	5.70	3.18
TSS	(LBS/1000 LB)	17.91	16.04
5 DAY BOD	(LBS/1000 LB)	4.61	3.30
OIL & GREASE	(LBS/1000 LB)	0.01	0.01
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.04	0.03
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.02	0.02
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.60	0.50
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		7.44	0.50
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	228.62×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	670.00	

PLANT C2
4 SAMPLES

TABLE 29. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.42	0.11
PROCESS TIME	(HRS/DAY)	7.80	0.45
FLOW RATE	(GAL/MIN)	2.31	1.30
FLOW RATIO	(GAL/TON)	2557.96	315.99
SETTLEABLE SOLIDS	(ML/L)	4.28	5.62
TSS	(LBS/1000 LB)	5.99	7.16
5 DAY BOD	(LBS/1000 LB)	25.05	24.16
OIL & GREASE	(LBS/1000 LB)	-	-
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.20	0.18
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.04	0.02
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	2.71	2.42
RESIDUAL CHLORINE	(LBS/1000 LB)	0.01	0.02
pH		7.02	0.58
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	0.62×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	69.00	

PLANT C3
4 SAMPLES

TABLE 30. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.62	0.11
PROCESS TIME	(HRS/DAY)	5.57	1.44
FLOW RATE	(GAL/MIN)	2.01	1.44
FLOW RATIO	(GAL/TON)	1076.52	1185.73
SETTLEABLE SOLIDS	(ML/L)	1.14	0.62
TSS	(LBS/1000 LB)	1.24	1.06
5 DAY BOD	(LBS/1000 LB)	5.40	4.32
OIL & GREASE	(LBS/1000 LB)	-	-
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.06	0.07
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.01	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.76	0.52
RESIDUAL CHLORINE	(LBS/1000 LB)	0.04	0.01
pH		7.32	0.24
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	7.09×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	236.00	

PLANT C4
14 SAMPLES

TABLE 31. ATLANTIC OYSTERS
(HAND SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.69	0.34
PROCESS TIME	(HRS/DAY)	7.44	1.10
FLOW RATE	(GAL/MIN)	23.19	8.74
FLOW RATIO	(GAL/TON)	14970.19	1701.39
SETTLEABLE SOLIDS	(ML/L)	6.52	8.00
TSS	(LBS/1000 LB)	99.77	121.67
5 DAY BOD	(LBS/1000 LB)	45.36	55.10
OIL & GREASE	(LBS/1000 LB)	-	-
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.67	0.69
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.01	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.41	0.28
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	5.95	9.34
RESIDUAL CHLORINE	(LBS/1000 LB)	0.15	0.27
pH		7.32	0.57
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	2.63 x 10	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	96.00	

PLANT C 5
18 SAMPLES

TABLE 32. ATLANTIC OYSTERS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.61	0.23
PROCESS TIME	(HRS/DAY)	7.02	1.39
FLOW RATE	(GAL/MIN)	9.06	11.28
FLOW RATIO	(GAL/MIN)	6276.23	4165.24
SETTLEABLE SOLIDS	(ML/L)	5.46	8.24
TSS	(LBS/1000 LB)	36.39	82.66
5 DAY BOD	(LBS/1000 LB)	19.40	36.43
OIL & GREASE	(LBS/1000 LB)	0.02	0.03
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.27	0.49
NITROGEN (NITRITE-NITRATE	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	0.17	0.27
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	2.64	5.99
RESIDUAL CHLORINE	(LBS/1000 LB)	0.29	0.90
pH		7.29	0.47
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	6.70×10^3	
FECAL COLIFORM (GEMOETRIC MEAN)	(MPN/100 ML)	232.00	

PLANTS C1 thru C5
53 SAMPLES

TABLE 33. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	1.46	0.23
PROCESS TIME	(HRS/DAY)	5.00	1.41
FLOW RATE	(GAL/MIN)	7.00	0.00
FLOW RATIO	(GAL/TON)	1435.41	-
SETTLEABLE SOLIDS	(ML/L)	0.70	0.14
TSS	(LBS/1000 LB)	2.38	1.88
5 DAY BOD	(LBS/1000 LB)	5.53	5.14
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.10	0.10
NITROGEN (NITRITE-NITRATE	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.08	0.01
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.87	1.07
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	-	-
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	-	-

PLANT D1
2 SAMPLES

TABLE 34. SOFT-SHELL CLAMS
(HAND-SHUCKED)

PARAMETER	UNIT	
PRODUCTION	(TONS/DAY)	8.13
PROCESS TIME	(HRS/DAY)	8.00
FLOW RATE	(GAL/MIN)	2.40
FLOW RATIO	(GAL/TON)	14.18
SETTLEABLE SOLIDS	(ML/L)	0.10
TSS	(LBS/1000 LB)	0.26
5 DAY BOD	(LBS/1000 LB)	1.65
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.01
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.00
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.09
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00
COLIFORM GEOMETRIC MEAN)	(MPN/100 ML)	24.0×10^3
FECAL COLIFORM GEOMETRIC MEAN)	(MPN/100 ML)	215.00

PLANT D2
1 SAMPLE

TABLE 35. BLUE CRABS
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	
PRODUCTION	(TONS/DAY)	0.80
PROCESS TIME	(HRS/DAY)	6.00
FLOW RATE	(GAL/MIN)	0.50
FLOW RATIO	(GAL/TON)	225.00
SETTLEABLE SOLIDS	(ML/L)	1.20
TSS	(LBS/1000 LB)	0.18
5 DAY BOD	(LBS/1000 LB)	0.15
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.01
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.00
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	0.02
RESIDUAL CHLORINE	(LBS/1000 LB)	0.23
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.00
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	3.00

PLANT D3
1 SAMPLE

TABLE 36. NON-ALASKA BOTTOM FISH
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.74	1.08
PROCESS TIME	(HRS/DAY)	7.10	1.03
FLOW RATE	(GAL/MIN)	4.80	4.28
FLOW RATIO	(GAL/TON)	2076.70	243.33
SETTLEABLE SOLIDS	(ML/L)	2.16	3.43
TSS	(LBS/1000 LB)	11.63	8.90
5 DAY BOD	(LBS/1000 LB)	244.89	348.27
OIL & GREASE	(LBS/1000 LB)	0.00	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	2.26	3.95
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.01	0.01
AMMONIA-NH_3	(LBS/1000 LB)	1.89	3.63
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	15.17	18.35
RESIDUAL CHLORINE	(LBS/1000 LB)	0.03	0.05
pH		6.95	1.03
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	162.48×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	220.00	

PLANT E1
5 SAMPLES

TABLE 37. NON-ALASKA BOTTOM FISH
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.24	0.24
PROCESS TIME	(HRS/DAY)	6.20	2.49
FLOW RATE	(GAL/MIN)	3.23	2.37
FLOW RATIO	(GAL/TON)	4947.75	1493.37
SETTLEABLE SOLIDS	(ML/1)	2.42	1.88
TSS	(LBS/1000 LB)	7.11	9.69
5 DAY BOD	(LBS/1000 LB)	29.49	31.76
OIL & GREASE	(LBS/1000 LB)	0.00	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	0.44	0.42
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.00
AMMONIA-NH_3	(LBS/1000 LB)	0.26	0.22
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	3.96	4.03
RESIDUAL CHLORINE	(LBS/1000 LB)	0.00	0.00
pH		6.82	0.16
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	38.95×10^3	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	138.00	

PLANT E2
5 SAMPLES

TABLE 38. NON-ALASKA BOTTOM FISH
(CONVENTIONAL PROCESS)

PARAMETER	UNIT	MEAN	STD DEV
PRODUCTION	(TONS/DAY)	0.49	0.78
PROCESS TIME	(HRS/DAY)	6.65	1.86
FLOW RATE	(GAL/MIN)	4.02	3.37
FLOW RATIO	(GAL/TON)	3253.51	478.23
SETTLEABLE SOLIDS	(ML/L)	2.29	2.61
TSS	(LBS/1000 LB)	9.36	9.05
5 DAY BOD	(LBS/1000 LB)	137.19	259.32
OIL & GREASE	(LBS/1000 LB)	0.00	0.00
PHOSPHORUS (TOTAL)	(LBS/1000 LB)	1.35	2.81
NITROGEN (NITRITE-NITRATE)	(LBS/1000 LB)	0.00	0.01
AMMONIA-NH_3	(LBS/1000 LB)	1.27	2.88
KJELDAHL NITROGEN (TOTAL)	(LBS/1000 LB)	10.95	15.31
RESIDUAL CHLORINE	(LBS/1000 LB)	0.02	0.03
pH		6.89	0.69
COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	79.50 x 10	
FECAL COLIFORM (GEOMETRIC MEAN)	(MPN/100 ML)	175.00	

PLANTS E1 and E2
10 SAMPLES

SECTION IX

GLOSSARY

BATEA - Best Available Technology Economically Achievable.

BPCTA - Best Practicable Control Technology Available.

FILTERABLE SOLIDS - Filterable solids are defined as those solids capable of passing through a standard glass fiber filter and dried to constant weight at 180°C. Filterable solids are also referred to as filterable residue.

NON-FILTERABLE SOLIDS - Non-filterable solids are defined as those solids which are retained by a standard glass fiber filter and dried to a constant weight at 103-105°C. Non-filterable solids are also referred to as non-filterable residue (NFR) or (TSS).

SETTLEABLE MATTER (SOLIDS) - Settleable matter is defined as bits of debris and fine matter heavy enough to settle out of water within a standardized time interval, usually one hour. Settleable matter is measured volumetrically with an Imhoff cone.

TOTAL RESIDUE (SOLIDS) - Total residue is defined as the sum of the homogeneous suspended and dissolved materials.

TOTAL SUSPENDED SOLIDS (TSS) - Suspended solids plus settleable solids, measured by standardized filter.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-77-157	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE WASTE TREATMENT AND DISPOSAL FROM SEAFOOD PROCESSING PLANTS		5. REPORT DATE August 1977 issuing date 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) R. B. Brinsfield and D. G. Phillips		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Maryland Cambridge, Maryland 21613		10. PROGRAM ELEMENT NO. 1BB610 11. CONTRACT/GRANT NO. S803522-01-0
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratory-Ada, OK Office of Research and Development U.S. Environmental Protection Agency Ada, Oklahoma 74820		13. TYPE OF REPORT AND PERIOD COVERED Final Draft 2/75 to 8/76 14. SPONSORING AGENCY CODE EPA/600/15
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Examinations of current wastewater and solid waste disposal practices and characterization of the wastewater effluent for seafood processing were carried out in a project within the state of Maryland in order to recommend economical waste treatment and disposal systems for the industries. Chemical and bacteriological examination of the present plants in light of promulgated EPA Guidelines for the industry for 1977 and 1983 revealed all plants meeting oil and grease as well as pH effluent limitations. Other chemical parameters were only partially or were entirely beyond limitations while bacteriological data showed large numbers of organisms surviving even in heavily chlorinated effluents. Several of the types of treatment evaluated were satisfactory. Plants located close to municipal treatment can use those facilities. An extended aeration package plant would cost $12,000 to treat the average 500 mg/1 five-day BOD of the wastes. Centralized treatment proved too costly.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Shellfish Crustacea Mollusca Fishing Canneries Waste Water Waste Treatment Industrial Plants	Seafood wastes Seafood Industries Seafood processing wastes Aerated lagoons Static screens Commercial Shellfish	08 A 13 B 06 H

18. DISTRIBUTION STATEMENT Release to public	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES 106
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (9-73)

☆ U. S. GOVERNMENT PRINTING OFFICE 1977-757-056/6510 Region No. 5-11