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Seminar on Fish Processing Plant Effluent Treatment and Guidelines

Economic and Technical Review
Report EPS 3-WP-75-1

Water Pollution Control Directorate
February, 1975

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TREATMENT AND GUIDELINES

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NOVEMBER 1974

DEPARTMENT OF THE ENVIRONMENT
GUIDELINES FOR THE CONTROL OF LIQUID EFFLUENTS FROM FISH, SHELLFISH AND FISH MEAL PROCESSING OPERATIONS

Short Title

1. These Guidelines may be cited as the Fish Processing Operations Liquid Effluent Guidelines.

Interpretation

2. In these Guidelines,

"Act" means the Fisheries Act;
"bloodwater" means the liquid phase, consisting mainly of fish blood, associated with the storage of whole fish and offal;
"clean process water" means water used in the fish processing operation or fish meal operation that does not come into contact with the raw fish, processed fish or offal;
"contaminated process water" means all water used by a fish processing operation or fish meal operation that has been in contact with raw fish, processed fish or offal and includes water utilized for the off-loading of fish from fishing vessels to the fish processing operation or fish meal operation;
"discharge" means a discharge or deposit into receiving water;
"domestic sewage" means the liquid effluent originating from toilets or other sanitary facilities;
"fish meal operation" means any facilities used for the processing of whole fish and offal to fish meal;

"fish processing operation" means facilities intended and used primarily for the processing of fish;
"liquid effluent" means any liquid discharge from a fish processing operation or fish meal operation and includes clean process water, contaminated process water, domestic sewage, pressliquor, stickwater, bloodwater, storm water and their associated solids;
"mesh" means the number of openings on a screen per linear inch of surface;
"outfall" means the point at which any liquid effluent from a fish processing operation or fish meal operation enter the receiving water;
"pressliquor" means the liquid phase following the pressing of fish during the production of fish meal;
"receiving water" means water that flows to or is water frequented by fish;
"stickwater" means the liquid phase following the removal of oil from pressliquor;
"storm water" means water run-off that results from precipitation of any kind that falls on a fish processing operation or a fish meal operation and includes water run-off originating from outside the fish processing operation or fish meal operation, that passes over or through the fish processing operation or fish meal operation;

Application

3. These Guidelines apply to every fish processing operation and fish meal operation.

Objectives

4.(1) The objective of these Guidelines is to provide a basis for reviewing plans for liquid effluent control from new fish processing or fish meal operations and plans for alterations to or extensions of existing fish processing or fish meal operations as outlined in section 33.1 of the Act.

(2) These Guidelines shall be used for determining the requirements for existing fish processing or fish meal operations to meet an acceptable level of liquid effluent control.

Sewers and Drainage Systems

5. Sewers and drainage systems of fish processing and fish meal operations should be designed in such a way that contaminated process water, clean process water, storm water and domestic sewage are segregated for treatment as required in these Guidelines.

Treatment of Liquid Effluents from Fish Processing Operations

6.(1) All contaminated process water should be treated for solids removal and the solids removal facilities should produce an effluent similar in quality to that produced by 25 mesh screening of the contaminated process water. A 25 mesh screen has wire openings of 0.71 millimeters (0.0280 inches).

(2) Clean process water may be discharged directly to the receiving water.

(3) Storm water flows may be discharged directly to the receiving water if the storm water does not come into contact with raw fish or offal.

(4) If storm water comes into contact with raw fish or offal it should be handled as contaminated process water as outlined in subsection (1).

(5) Domestic sewage should be treated and disposed of in a manner satisfactory to the relevant regulatory agency.

(6) Plants with reduction facilities should not discharge bloodwater from offal storage areas located in the fish processing plant.

Offal Disposal and Fish Meal Operations

7. Where transportation of offal and whole fish to an off site fish meal or other recovery or disposal operation is necessary, the transportation facilities should be so designed to prevent any leakage of bloodwater and offal.

Liquid Effluent From Fish Meal Operations

8.(1) Stickwater and pressliquor should not be discharged to the receiving water.

(2) Bloodwater should not be discharged to the receiving water.

Sampling and Metering

9.(1) The sewer and drainage systems should be designed to permit sampling of the liquid effluent at each outfall.

(2) A suitable method of metering the flow of contaminated process water should be available.

Outfalls

10.(1) All outfalls should have the approval of the appropriate regulatory agency.

(2) Outfalls should be located in such a manner as to be submerged at low tide.

Advanced Treatment

11. If discharge of treated liquid effluents leads to a deterioration of the receiving water quality then the fish processing operation or fish meal operation concerned may be required to install more advanced liquid effluent treatment than that specified in these Guidelines.

EXPLANATORY NOTES TO THE GUIDELINES FOR THE CONTROL OF LIQUID EFFLUENTS FROM FISH, SHELLFISH OR FISH MEAL PROCESSING OPERATIONS

The following explanatory notes are intended to clarify the meaning and intent of the Guidelines.

Intent

The Guidelines are intended to indicate to the fish processing and fish meal processing industry the level of effluent controls considered necessary to the federal government. The Guidelines will be applied uniformly across Canada as minimum effluent controls. However, a processing facility located in an environmentally sensitive area may be subject to stricter controls. Provincial or local governments may impose even more stringent standards than the federal requirements. In this case the more stringent requirements will prevail.

Purpose

The aim of the Guidelines is to suggest that all fish processing and fish meal processing facilities operating in Canada apply best practicable treatment technology to their liquid effluents. For this purpose, best practicable treatment means a system equivalent to the following:

a) Solids removal from contaminated process water followed by,
b) A well designed outfall discharging below low tide.
c) The recovery of certain high strength wastes associated with fish meal processing.
d) Good housekeeping.

Guidelines and Regulations

A regulation can be considered as a specific law that legally applies to all relevant situations. A government agency does not have the authority to exempt anyone from their legal obligations to obey a regulations. In contrast, a guideline is not a specific law as is a statute or regulation. The Fish Processing Operations Liquid Effluent Guidelines are a statement which indicates what practices Environment Canada considers to be compliance with the intent of the law, in this case the Fisheries Act. It must be remembered that a guideline is not a law and as such a government agency can make exceptions to the general rule in circumstances where it considers exceptions appropriate. A guideline permits flexibility and the exercise of discretion.

Contaminated Process Water

It may not be necessary for plants to fine screen certain contaminated process waters, if such contaminated process waters have low levels of suspended solids, for example, flume water used to move whole groundfish from storage to the processing area. Also it may not be necessary for plants to fine screen certain contaminated process waters which contain high levels of non-contaminating suspended solids, for example water used by equipment unloading groundfish stored in ice on ships. This decision will be based on negotiations between the plant concerned and the appropriate regulatory agency.

Contaminated process water is defined in the Guidelines as all water used by a fish processing or fish meal operation that has been in contact with raw fish, processed fish or offal. However water used for the storage of crustaceans will not be considered contaminated process water.

Bloodwater and Stickwater Recovery

Bloodwater, a high strength effluent associated with the storage of whole fish and offal, should not be discharged from either fish processing or fish meal plants. However, the Guidelines allow for the discharge of bloodwater from fish processing facilities where no practical means of bloodwater recovery is available. In the case of bloodwater discharge from fish processing facilities it is recommended that the bloodwater be added to the contaminated process water prior to fine screening. As stated in item 6.6 of the Guidelines, if a fish processing facility has a reduction plant on-site, bloodwater associated with the storage of offal should be recovered.

In order that items 8.1 and 8.2 of the Guidelines, zero discharge of stickwater, pressliquor and bloodwater, can be adhered to in the case of equipment breakdown, the following provisions are suggested:

Either the provision of sufficient tankage to store a minimum of production of each liquor from one 8 hour shift. (Stickwater and bloodwater storage facilities should include acidification facilities to allow the pH of the contents to be lowered to 4.5 to permit satisfactory storage.)

Or the shut down of the complete fish meal operation until such time as the liquor recovery equipment is operating satisfactorily or other provision is made to handle the stickwater, pressliquor and bloodwater.

In the case of equipment breakdown which might lead to the direct discharge of stickwater, pressliquor or bloodwater, it is suggested that company officials inform the concerned EPS Regional Director of the situation.

Metering

Solids removal facilities (fine screens) are frequently hydraulically designed. Increases in water use to levels above the

design capacity of the treatment facilities can lead to failure of the treatment systems. The metering of contaminated process water will indicate variations in the flow of the treatment facilities. Variations in the flow of contaminated process water could also be monitored by metering the total water flow into the plant. Variations in this total flow could indicate an increase in flow of the treatment facilities.

Increases in the flow of contaminated process water to the treatment facilities should be reported to the appropriate regulatory agency on a regular basis. This reporting procedure will be negotiated for each plant by the appropriate regulatory agency.

Outfalls

In addition to locating outfalls in such a manner as to be submerged at low tide, it is suggested that outfall locations should be such that liquid effluent discharged:

a) will not affect the potential use of the receiving water for water supply or other purposes and,

b) will not cause unsightly conditions arising from floating oil, grease and fish solids.

Special consideration will be given to:

a) plant located in areas where discharge below low water mark is impractical, for example, in areas with a particularly high tidal reach.

b) plants located on wharves where exposed outfall pipes may be subjected to freezing conditions.

It is recommended that plants with a common outfall should each provide facilities to allow their individual plant effluents to be sampled.

Water Usage

The Guidelines specify solids removal as a minimum treatment for contaminated process water. Since solids removal is usually achieved by screening and since screens are frequently designed hydraulically, significant savings in pollution control costs can be achieved by minimizing water usage in the plant. Care, however, must be exercised to ensure that reductions in water usage do not affect the sanitary quality of the product.

Land Availability

Wherever possible, it is suggested that operations should have space or land available to allow for expansion of the waste treatment facilities to include more advanced treatment systems when and where required.

Plant Construction

The construction of new facilities or the alteration of existing operations frequently requires land to be cleared prior to construction. It is suggested that care be exercised to ensure that run-off from the cleared land which carries large volumes of sediment not be allowed to enter nearby water courses or harbours.

Provincial and Local Requirements

It is suggested that operators considering construction of a new facility or the alteration or extension of existing fish processing or fish meal operations contact all relevant local and Provincial regulatory agencies to ensure that their plans meet the environmental requirements of these agencies. It is suggested that such contact be made during the planning stages of any construction.

Federal Requirements

In order to ensure that construction of new facilities or the alteration or extension of existing fish processing or fish meal operations meet with the Fish Processing Operations Liquid Effluent Guidelines, it is suggested that plans and specifications be submitted to the Regional Director, Environmental Protection Service, Canada Department of Environment. The plans and specifications should include the following:

a) A map showing the location of the operation and all outfalls in relation to existing facilities and natural features.
b) A plan of the operation layout showing the location of drains and sewers.
c) The proposed liquid effluent treatment system including its location and size.
d) Proposed operation capacity and anticipated water usage.
e) An indication of the sources of contaminated and clean process water.

Treatment requirements will be negotiated with each new plant. Existing fish processing or fish meal operations will be considered individually. Schedules of compliance with the Guidelines will be negotiated for each existing operation. The level of environmental damage associated with existing effluent discharges and the cost of installing necessary equipment and undertaking plant modifications will be considered during the negotiations with existing plants. Through the negotiation process some existing plants may be exempt from part or all of these Guidelines. Such negotiations will be carried out by the Environmental Protection Service of the Canada Department of the Environment and/or the Provincial regulatory control agency. (The Guidelines provide an indication to industry of the degree of treatment which will be required.)

EFFLUENT CONTROLS AND THE FOOD INDUSTRY

by

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Environmental Protection Service

presented at

Seminar on Fish Processing Plant Effluent
Treatment and Guidelines

Within the past few years there has been a growing awareness of environmental values on the part of Canadians. This public concern has fostered increased demands for new laws and institutions that will preserve and enhance our natural surroundings.

In 1970 and 1971 the federal government put forward a major environmental legislative program - probably the most concentrated that has ever been put before a Canadian parliament in a two year period. A new Act, the Northern Inland Waters Act, which provides for the protection of water north of the 60th parallel, was passed. The Canada Water Act was introduced - providing for the comprehensive planning and management of Canada's waters. Amendments were made to the Canada Shipping Act, permitting the federal government to control the discharge of sewage from ships in Canada's territorial waters. The Arctic Waters Pollution Prevention Act extended Canada's control over Arctic waters. The Clean Air Act was passed to provide for a comprehensive Canadian air management program. A Weather Modification Information Act was introduced and amendments were made to the Fisheries Act - the oldest environmental act in Canada.

Certainly the range and extent of such a legislative program, implemented in such a short time, represented a major response to Canadian society on the part of the federal government.

The focal point of this response was the Government Organization Act which resulted in the organization of a Department of the Environment on June 11, 1971. Under this new Department most federal environmental expertise was drawn together. Built around the old Department of Fisheries and Forestry, it now includes branches dealing with water resource management and research, atmospheric environment, air pollution, public health, Canadian wildlife and land use.

Missing from this aggregation of incoming organizations, however, was the single specific responsibility for environmental protection. To meet this need the Environmental Protection Service was brought into being.

The Service, commonly referred to as EPS, provides a focal point for the environmental concerns of the public, of industry, and of other levels of government. Its prime role is one of problem identification and

solving. Its main concern is with the control and abatement of pollution. It is an objective of EPS to formulate, in cooperation with provincial authorities, a realistic program of pollution control for Canada. We are developing regional operations groups within the Service because we believe that our people should be in the areas where the problems are. These regional groups also act as an interface with provincial government control agencies. Within EPS we have groups specializing in Air and Water Pollution Control and Environmental Emergency Management; and we have an integrated Ecological Protection Branch which is concerned with solid waste management, noise control, ecological impact studies and the disposal of hazardous materials.

Although Canada has an abundance of water, we are not without our water pollution problems. These are due for the most part to our false belief that our lakes and rivers have an unlimited capacity for the assimilation and dispersion of our wastes. Today we are paying the penalty for this way of thinking. However, we in Canada are fortunate. We are at a stage in our development where we are identifying and, indeed, anticipating problems which to a far greater degree other countries already have.

A water pollution control program can be implemented from two different approaches - one being a comprehensive water resources management approach, to tailor controls to achieve decided levels of quality - the other being the application of "best practicable technology" in processes and treatment.

The key principle in a water resource management approach is to maximize the beneficial uses of a water basin. Theoretically this could serve as a means of protecting presently unspoiled waters, upgrading deteriorated ones and perhaps designating some waters primarily for the use of transporting wastes in such a way that health and aesthetic considerations were met. Once the desired use for a specific body of water is determined one would have to arbitrarily assign numerical limits of water quality; that is, set the actual limits of the water to receive and disperse wastes. I say arbitrarily because in many cases our scientific understanding of the environment does not really allow for such rational selection of limits. Although the resource management method

might be an ideal means of environmental protection the difficulty in applying it lies in our lack of knowledge regarding the capacity of our environment to digest wastes.

We feel, in effect, that as of right now, man does not know nearly enough about pollution and the environment -- about the movement and effect of specific contaminants, about how much pollution is too much pollution. Until these gaps in our understanding are filled, our strategy must be to play it safe - to focus not on the receiving waters but on the effluents themselves.

Therefore we have opted for a strategy of containment using the best practicable technology approach; our principle aims being to restrict pollution to within the factory fence - to encourage recycling and reuse within the plant - to participate with industry and municipalities in looking for cheaper, more effective means of pollution control. We feel that this approach reflects our dual concern for both environmental and economic health.

To illustrate what is involved in this best practicable technology approach let's look at the alternatives which are available to us. First we could have drawn up specific blueprints for control measures - to tell industry how to meet the standards. However, by dictating the means as well as the ends, we would have been discouraging innovation and thus blocking progress in the art of pollution control. So one aspect of our best practicable technology approach has been to say to industry - we don't care how you do the job - just that the job is done.

Secondly, we could have left out the word "practicable" basing our guidelines and regulations on what was technically possible - setting standards with no regard to price tags. Instead we decided to set realistic goals which would meet both environmental and economic requirements - standards which could be met by implementing the existing proven technology.

There were also various alternatives available in the matter of compliance schedules. One would have been to name a day and order all plants throughout Canada to comply by that day. This would have been completely inequitable. Older plants would face a much more difficult

and expensive task than newer ones. In many cases it would in effect have been telling many plants to close down. Instead, we have distinguished between the old and the new. For new plants regulations are immediately effective. For older plants individual dates of compliance are negotiated.

This strategy of containment within the factory fence, using the best practicable technology, then had to be translated into a plan of action. It was essential that the provinces be involved since they own the natural resources within their boundaries and are thus responsible for their management. Thus even where federal law does apply to water pollution control we are taking the initiative to see that it is implemented locally, either directly by the province on our behalf or in harmony with provincial water pollution control programs.

Why not let the provinces assume sole control? Because what we most want to avoid is the development of pollution havens; that is industries deserting provinces requiring a high degree of pollution control for those with lower standards. For this reason we require a national policy. The legislative vehicle behind this policy is the amended Fisheries Act. These amendments give the federal government a means of controlling specific industrial effluents by defining certain substances as being deleterious to fish and then regulating their presence in industrial effluents. This means that we do not have to prove that a substance is present in the receiving water in certain specific amounts that are labelled as dangerous. We only have to prove that the substance may be there and that it might cause deterioration of the water quality, for example robbing the water of oxygen, which in turn might be harmful to fish. It means that even though we do not know everything there is to know about the environment or about the movement and effects of pollutants in the environment, we are taking the prudent approach and regulating before the pollutants reach the water and before they reach levels where deterioration is measurable. Generally then it is too late. The federal powers in this area apply only to the effect of pollutants on fish. However, where the water quality is safe for fish it is usually adequate for other uses as well.

Again the fundamental theme behind our control program is containment within the shortest practical time. Our regulations and guidelines are national in scope. They do not depend upon a detailed knowledge of a specific ecosystem. They depend only upon technology - technology applicable in all locations and all provinces nationwide.

To implement regulations we must have a sound legislative base. We must also be convinced that the technological control methods are the best available from both an environmental and economic standpoint. If any doubt exists in either of these regards we will issue guidelines. They are usually an interim measure and form a persuasive rather than an enforcement approach. These guidelines are always set in such a way that if, at some future time, we decide more stringent measures are required, those measures already implemented by the industry can be refined and upgraded rather than completely changed.

Our program to date has produced regulations for the pulp and paper, the chlor-alkali and the petroleum refining industry. Under the Canada Water Act we have also regulated the level of phosphate in detergents.

These national baselines for effluents represent a minimum of control. They are "common decency" standards. Where more stringent controls are necessary, due to specific conditions in the receiving water, special effluent requirements can be tailored to the individual situation based on local or regional requirements.

In the process of developing national guidelines, regualtions or standards every effort is made to ensure the fullest possible participation by both the provinces and the industry. A problem is identified, usually one of national scope. A "state-of-the-art" review is conducted which usually involves a study characterizing the specific industrial wastes and the current technology involved in plant processes and waste treatment. The industry and often the national industry association concerned is then invited to participate in the development of a technical expression of effluent quality reflecting the "best practicable technology". Frequently an economic assessment of the industry in question is also made. A federal/provincial/industrial task force is then organized. It is charged with the responsibility of developing technically practicable effluent

regulations or guidelines. These are then reviewed with all the provincial pollution control agencies and by the national industry association.

Drafts are also sent to the heads of all the principle companies for comment and to all provincial ministers with environmental responsibilities. They are also reviewed with international experts in the field. This broad consultative action does vary from industry to industry and is, of course, very time consuming but it is the only way to obtain a reliable body of facts on a very complex subject while also striving for a general consensus on the soundness of the results.

It then sets the stage for discussing our program as it applies to the food industry.

The importance of Canada's food industry - the largest industry in Canada - has been highlighted this past year to an even greater extent by the spectacular rise in world commodity prices. It is increasingly evident that intelligent planning and distribution of food stuffs throughout the world is more important than ever. As world demand increases Canada's role as a food supplier puts us in an enviable position. The advantages that can be realized will depend largely upon our ability to produce high quality goods while making the most efficient possible use of our resources. To this end, in the development of effluent regulations and guidelines for the food industry, we stress in-plant controls through minimizing water use, water re-use, by product recovery and process modification - maximum utilization of resources and minimization of wastes wherever possible.

The unusually large diversity of products, processes, plant size and distribution throughout the food industry poses a great number of individual problems in regard to pollution control. As a polluter the food industry produces both highly organic wastes and large volumes of solid wastes. Organic wastes in themselves are not usually toxic but produce problems locally. These are usually problems of concentration. Too much organic material concentrated in one location places a heavy demand on the oxygen in the waters as it decomposes. It literally suffocates life in the water body. Solid wastes can frequently be recovered and utilized in a manner which will provide an economic return for

the company. In general solid wastes should be removed from liquid effluents and either utilized by the company or disposed of in sanitary landfill operations. Thus treatment and, wherever possible, utilization of wastes from the food industry, can be beneficial both to the environment and to the industry itself.

Our effluent control strategies have speicial implications for new developments, since they must comply with regulations and guidelines from the day they begin operation. It is essential that environmental considerations be taken into account when plants are being designed. Both we and industry recognize that to rely on end of the pipe treatment systems is both inefficient and costly. The principle of containment within the factory fence is best exemplified in the food industry by process modification, by product recovery and water recycling - all aimed at reducing the waste load. In the development of a new plant this concept applies not only to plant design but also to choice of plant site.

The food processing industries for which effluent guidelines and regulations are being developed are the Fish Processing Industry, Potato Processing Industry and Meat Processing Industries.

A great deal of work has gone into the drafting of the guidelines for the control of effluents from the Fish Processing Industry, as I am sure you are all aware. These guidelines and effluent treatment methods are indeed the focal point of this seminar and they will be dealt with in detail later.

We have collected our initial inventory data regarding the Potato Processing Industry and have funded studies concerned with the utilization of waste potato solids. We are beginning to look at treatment methods. That is we are defining gaps in the present technology that may need plugging before guidelines and regulations can be set. We hope to have these effluent control ready by mid-1974.

With regard to the Meat Industry, we have recently let a contract to a consulting firm to carry out a complete inventory of the industry and to collect data pertaining to the state-of-the-art of effluent treatment. An assessment of the economic impact of effluent controls on the industry is also being made by the consultant. Following the consultant's

report, an industry/government task force will be formed to hammer out the details of guidelines and regulations.

It is anticipated that the guidelines and regulations will be in their final form by the end of 1974.

Studies are currently underway to determine the environmental effects of intensive animal husbandry operations in Canada. Inventory studies are being carried out in Saskatchewan, Alberta and Ontario and are already complete in Manitoba and the Maritime Provinces. It is our feeling that guidelines of good management with respect to animal wastes will be developed in cooperation with the Department of Agriculture. No regulations are anticipated at the present time for this industry.

In the future we will be reviewing other food industries. For example we hope to start studying the Dairy Industry by mid 1974 and the Canned and Frozen Foods Industry sometime in 1975.

So far we have had very good response from the food industry and we anticipate no problems in the development of regulations which the industry can meet from both the technical and economic point of view. However, this is conditional upon receiving the support of the industry during all the various developmental stages of effluent controls.

At this time I want to commend the Fish Processing Industry. In the development of these guidelines we received a high degree of cooperation from the various fisheries associations both national and provincial.

We have done a number of studies which will be covered in the course of this seminar dealing with the characteristics and treatment of fish plant effluents and we anticipate doing further studies on treatment methods.

Obviously the large turnout here today reflects the concern of the fish processing industry with the creation of the environmental controls which it had a hand in developing. You have set an example for others in the food industry to follow and I know we will continue to work closely in the future.

Thank you

EAST COAST FISH PROCESSING

- EFFLUENT CHARACTERIZATION -

by

G.D. LINDSAY

INDUSTRIAL WASTE ENGINEER

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EAST COAST FISH PROCESSING EFFLUENT CHARACTERIZATION

SECTION I

The processes which characterize the fish processing industry in Eastern Canada can be divided into the following four major groups:

Groundfish processing

Herring processing

Shellfish processing

Fishmeal processing

Each group has a unique production process and consequently unique effluent characteristics. Variations in processing procedures are found from plant to plant, but the major features of each type of production are quite consistent and are discussed below.

1.1 Groundfish Processing:

Cod, halibut, ocean perch (redfish), sole and flounder are the species of fish referred to as groundfish. With the exception of halibut the remaining species are processed in somewhat the same manner.

1.1.1 Cod, Redfish, Sole and Flounder

The fish are either stored whole in the ship or are eviserated prior to storage, the viscera and blood being washed overboard. At the wharf, unloading is usually accomplished by pitching the fish into a

basket that has been lowered into the hold. The fish are then weighed, washed and iced in tote boxes. In some larger plants, mechanized unloading methods are used to minimize manual handling.

Most groundfish require no pretreatment prior to filleting, but the scales must be removed from redfish before they can be filleted. The descaling of redfish is accomplished in a revolving cylindrical screen which removes the scales by the abrasive action of the fish rubbing against themselves.

In small plants, the fish are processed by hand. The fillets are cut on a wooden board next to a sink, washed and immediately iced in boxes for distribution.

Most plants processing fillets are mechanized equipment. First, the fish are washed in large wash tanks or by water sprays in large rotating tumblers. Next the fish pass to filleting machines or hand filleting tables. Filleting machines only operate on certain fish sizes and shapes, but considerably reduce labor costs and increase yields, over hand-filleting. The skin is removed from the fillets by hand or machine. The solid wastes from filleting and skinning operations are usually rendered for pet food or animal meal. Figure 1 outlines a typical groundfish filleting operation.

The skinned fillets are transported by conveyor belt through a washing tank and, in some cases, a brining tank. After inspection the

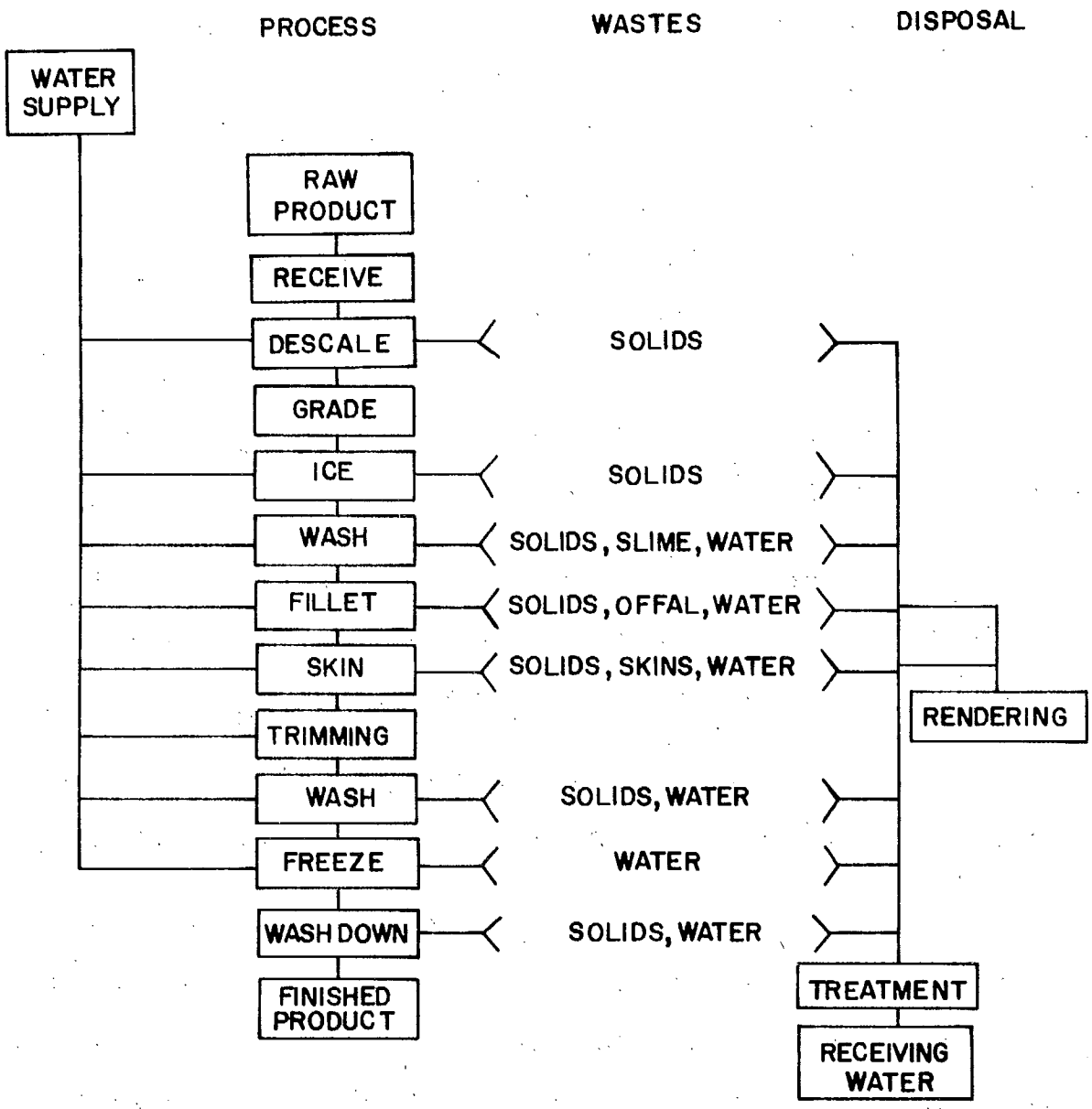


FIGURE I. GROUNDFISH FILLETING

fillets are packed into containers by hand or frozen and then packed. Steaks are produced from the eviscerated fish by cuts made at right angles to the backbone. These steaks are marketed frozen or fresh. Fillets are marketed frozen (fresh or breaded), chilled or fresh.

1.1.2 Halibut:

After being landed on the vessel, the halibut are dressed by removing the viscera and cutting away the gills. The halibut are then packed in ice in the hold. Halibut are ordinarily processed in relatively small plants. The fishermen usually behead the fish before sale to the processor.

If the fish are not processed immediately, they are re-iced in the fish plant. The majority of halibut are filleted and marketed frozen, however, some are frozen whole or sold fresh.

Prior to whole freezing, a continuous belt washer sprays the fish. The fish are frozen with a glaze protection at approximately -20°F.

Halibut are cut in fletches (boneless and skinless pieces produced from fresh fish). This process divides the halibut into four or more trimmed meaty portions weighing from 5 to 20 pounds. The fletches are frozen and either glazed or packaged in moisture proof wrapping. Other forms of fresh or frozen halibut include packaged fillets, steaks, and breaded fillets.

1.2 Pelagic and Estuarial

The most important pelagic and estuarial species are salmon and herring.

1.2.1 Herring Processing:

Herring is processed into a number of products, including fish oil, fish meal, herring fillets, marinated herring, and for the herring roe. This section describes only the operations which process herring for human consumption - herring filleting, marinated herring and herring roe.

1.2.1.1 Herring Filleting:

As with the groundfish processing plants herring are trucked to the plant and stored in holding bins, there being packed in ice. Herring are delivered to the plant round (head, tails, fins and viscera intact) and, in the filleting operation, have the heads, tails, fins and viscera removed by automatic machines. After filleting they are prepared for consumer marketing.

Wastes from herring filleting originate from the fluming of the round herring to the splitting machines, and from the water used in the machines themselves. Offal is removed prior to final discharge of the waste water for further processing in the fish meal operation.

1.2.1.2 Marinated Herring:

In the production of marinated herring, round herring is trucked to the processing plant and stored in iced or refrigerated bins. From the storage bins the herring are either flumed or conveyed to a hand or machine splitting operation where removal of head, tails, fins and viscera takes place. The resulting split fillets are then stored in barrels or vats in a solution of brine and acetic acid for a period of 5 to 9 days. After this period the solution is dumped and the fillets are introduced to a second solution of brine and acetic acid and stored at low temperature for a period of two weeks. While in this stored solution the fillets are called bismarcks. Following this two-week storage period the bismarcks are dumped, skinned, and repacked in barrels ready for distribution. The process is illustrated in Figure 3.

Wastes are produced during the splitting operation, clean-up, and acetic acid brine dumps. The offal is transported to fish meal plants for further processing.

With both the herring filleting and marinated herring processing, the waste is extremely colored, due mainly to the loss of blood during the splitting operation. The coloration does not dissipate readily upon discharge to the receiving waters.

1.3 Shellfish Processing:

1.3.1 Lobster:

Lobster is the major species of shellfish caught and processed in Canada. Lobster are caught in large traps and must be kept alive until processed. Approximately 65 percent of the lobsters are marketed in their shells either alive or cooked. The remaining 35 percent are cooked and shucked.

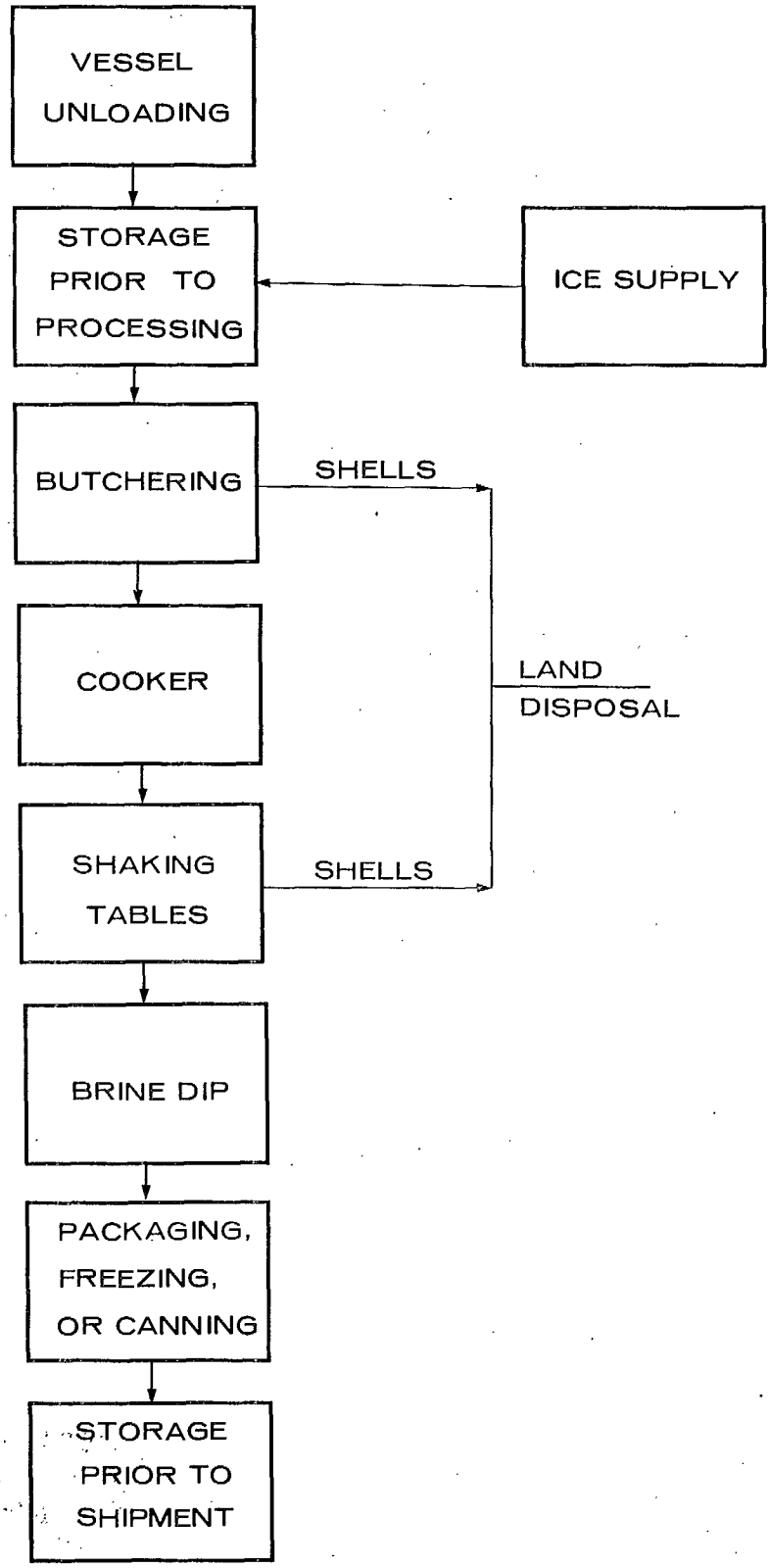
Lobsters are steam cooked in retorts for 20 to 30 minutes and are water cooled after cooking to facilitate handling. If the lobsters are to be butchered their backs are removed and the remaining viscera are washed free. The cooking, cooling and washing waters contain considerable quantities of solids and organic pollutants.

Small numbers of cooked lobsters and meat are frozen for later marketing. Low storage temperatures and quick turnovers are necessary for the maintenance of high quality. Little lobster meat is canned because of the rapid degradation of texture and flavour quality of the canned product.

1.3.2 Crab:

The process flow diagram for crab processing is illustrated in Figure 2.

FIG. 2 PROCESS FLOW DIAGRAM CRAB PROCESSING PLANT



The crab are unloaded live from the holds of the vessels into tubs and then trucked to holding rooms at the processing plant. Once in the holding rooms they are packed in ice or held in refrigerated rooms prior to processing. The first stage of crab processing is butchering which involves removal of the legs and shoulders from the main body of the crab. The main body is flumed to a disposal pit, while the legs and shoulders are flumed to a continuous cooker. After the legs and shoulders of the crab have been cooked, they are flumed to shaking tables where meat and shell are separated. The fluming not only transports the crab, but also serves as cooling water as the crab leaves the cooker. At the shaking tables the meat is removed from the shell by any means possible, usually be persistent pounding. After inspection, the crab meat is dipped in a brine solution in order to preserve and maintain the natural taste of the meat and is then packed for shipment to the consumer market. It is sold in either a frozen or canned state.

Wastes in the crab processing industry originate at the butchering stations, the cooker, the shaking tables, and general clean-up; and are usually flumed to discharge via a system of floor drains. Prior to direct discharge in the receiving water, however, the body of the crab remaining after butchering and the leg shells from the shaking tables are removed and disposed of over land using normal sanitary landfill techniques.

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1.4 Fish Meal Production:

In the processing of most species of fish for food purposes, from 30 to 80 percent of the raw material is waste. Efforts are made by most plants to recover all edible portions, and the recent introduction of deboning machines promises greater utilization in the future. Still, much of the fish poses a disposal problem and one practice has been to produce a protein concentrate for poultry feed. Oil may also be recovered from oily species.

The waste material, termed offal, is normally conveyed wet or dry to the fish meal plant and stored in pits until enough is accumulated to warrant operation. Solids recovered by screening of off-loading and processing water are also sent to the fish meal plant. During storage some liquid is drained or pressed from the offal. This stream called bloodwater, is not large in volume but is very strong in terms of organic content. Some plants attempt to recover this, but most discharge the stream with the plant effluent.

The general flow for fish meal production is shown in Figure 3. The offal is hashed by machine if large pieces are present, and then cooked in direct or indirect continuous steam cookers for up to 10 minutes. Non-oily offal may be added directly to driers, while oily species are pressed to expel most of the water and oil prior to entering the drier.

In the latter case the press liquor undergoes a fine solids separation using vibrating screens or decanting centrifuge followed by oil separation in nozzle centrifuges. The oil is further clarified in polishing centrifuges before sale as either an edible oil or animal oil. The aqueous phase may still contain up to five or six percent organic solids and is termed stickwater. At one time this was discarded, but now many plants employ multiple effect evaporators to concentrate these solids. The resultant product is termed condensed fish solubles and contains from 30 to 50 percent solids. It is marketed as a poultry or animal feed, a specialty fertilizer, or is recycled back to the driers for incorporation in the meal. The condenser water used in the evaporators does pick up volatile solids and gases, the extent depending on the degree of freshness of the offal and the manner of operation of the evaporators.

The fish meal driers are usually rotary kilns, with heat being supplied by direct flame heating of the air, or by indirect heating using steam. The solids are dried to between 5 to 10 percent moisture content, ground to pass 10 mesh screens and solid in either 100 lb. bags or in bulk. The steam and odors generated during the drying of the meal can be very obnoxious and most plants employ some sort of direct water scrubbing to these vapours prior to release. Large volumes of water are employed for this, and the scrubber effluents will contain a significant quantity of organic material.

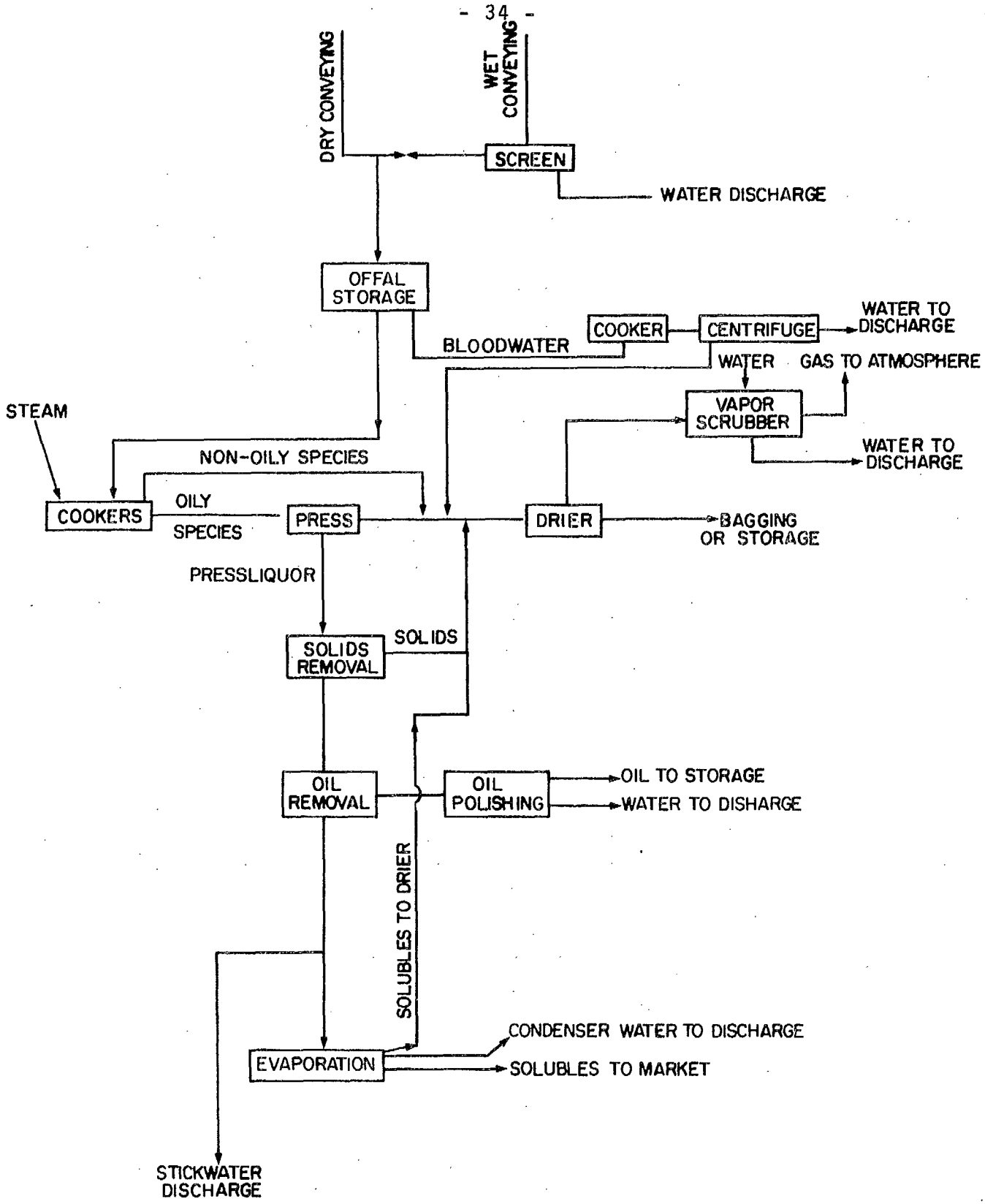

Figure 3. Flow Diagram for Fish Meal Production

Many fish processing plants in Canada combine a number of the above-mentioned operations. For instance, many plants on the West Coast have the capability of processing both groundfish and salmon. These operations might also be linked to a fish meal plant. The resulting wastes from the fish processing plant are usually flumed together and discharged as one effluent, after removal of the offal.

SECTION II

LITERATURE REVIEW

2.1 Characterization Studies:

Fish processing wastes vary considerably in pollutional strength. This variation is due in part to:

1. Species of fish being processed.
2. The age of fish being processed.
3. The processing techniques.
4. Plant size.
5. Water usage.

The characterization of wastes from various types of fish plants has been the subject of a number of studies. It should be noted that the BOD_5 values are all in the same order of magnitude, however, greater fluctuations occur in the suspended and total solids values. There fluctuations are due to those factors listed above.

2.2 ENVIRONMENT CANADA STUDIES

The studies undertaken by Environment Canada for East Coast Fish Processing follows:

LOCATION	TYPE OF EFFLUENT	TYPES OF FISH PROCESSED	PROCESSING TECHNIQUES
(1) Northeast New Brunswick	Characterization	Herring	Marinated & Filleting
(2) Maritime Region	Characterization	Groundfish Fish Meal Prod.	Filleting

DATE OF STUDY

(1) Summer, 1971

(2) Summer, 1972

2.3 Characterization Studies:

2.3.1 Groundfish:

The groundfish operations involve the processing of halibut, cod, redfish, sole and flounder. Two basic types of processing are used:

a) dry line operations which use a system of conveyors to move the raw product and mechanically operating filleting tables. In the majority of cases offal is removed from the filleting area by fluming.

b) wet line operations characterized by the use of water to flume the raw product and the offal.

In general dry line operations are used in the larger operations whereas the smaller plants rely on wet transport of raw product and offal. In the majority of cases fish are washed in tanks or spray conveyors immediately prior to processing.

2.3.1.1 Dry Line Processing:

Table 1 summarizes the total effluent values for the dry line processing of groundfish. The results indicate the range of BOD_5 loadings for this type of groundfish processing varied from 1.3 pounds of BOD_5 to 7.9 pounds of BOD_5 per 1000 pounds of raw product.

Further examination of Table 1 indicates the variablity of suspended solids loading of 0.98 to 2.4 pounds per 1000 pounds of raw product and of 0.13 to 1.0 pounds per 1000 pounds of raw product for ether soluble oil (study #2).

The variability of the effluent in terms of BOD_5, suspended solids and ether soluble oil loadings is considerable due to differences in water usage, age of fish processed, amount of fish processed as well as the processing techniques. The studies also indicate that there is no relationship between effluent loadings and plant size.

TABLE 1 TOTAL EFFLUENT FROM DRY LINE GROUNDFISH PROCESSING

PLANT SIZE (Lbs raw fish/day)		BOD_5		S.S.		ETHER SOLUBLE OIL	
STUDY NUMBER	Conc. (mg/l) Range ($\bar{x}$)	Lbs/1000 lbs raw fish Range ($\bar{x}$)	Conc. (mg/l) Range ($\bar{x}$)	Lbs/1000 lbs raw fish Range ($\bar{x}$)	Conc. (mg/l) Range ($\bar{x}$)	Lbs/1000 lbs raw fish Range ($\bar{x}$)
2						
6,000	96-1775 (451.5)	0.3-39.1 (5.7)	92.1-1006.4 (226.5)	0.2-6.2 (2.4)	2.4-260.6 (56.8)	0.03-5.0 (1.0)
10,000	30-1547 (411.0)	0.22-7.6 (2.7)	6.8-1006 (254)	0.1-5.5 (1.6)	0.4-526.4 (93.3)	0.01-4.1 (0.75)
15,000	27-546 (101.9)	0.4-11.0 (1.3)	14.4-173.8 (64.5)	0.04-3.5 (0.98)	0.33-43.6 (14.6)	0.02-0.4 (0.13)
3						
Unknown Plant Size	100-1140 (455)	-- (5.0)	30-232 (135)	-- (1.0)	0-500 (100)	-- (1.0)
4						
300,000	178-389 (279)	3.80-15.57 (7.9)	140-576 (290)	2.42-23.06 (22.5)		

($\bar{x}$) = mean

2.3.1.2 Wet Line Processing:

Table 2 summarizes the total effluent loadings for the wet line processing of groundfish. The BOD_5 effluent loadings vary from 15.0 to 20.2 pounds per 1000 pounds of raw product whereas the suspended solids loadings vary from a low of 7.0 pounds to a high of 34.0 pounds per 1000 pounds of raw product. As with dry line processing there effluent loadings vary widely.

Comparison between the effluent loadings from dry and wet line processing of groundfish (table 1 and 2) indicates that wet line processing produces an effluent in excess of three times the dry line effluent loadings. These increased loadings are due to:

a) increased BOD_5, suspended solids and oil concentrations in the wet line effluents.

b) water consumption figures (table 3) indicate that wet line processing requires 2 to 3 times the water required for dry line processing.

This variation in the effluent loadings from dry and wet line groundfish processing supports the theory that the longer water is in contact with fish solids the higher the BOD_5, suspended solids and oil concentrations in the effluent. In wet line processing, water is in contact with the fish for considerably longer periods than in dry line processing.

Table 2 Total Effluent from Wet Line Groundfish Processing

PLANT SIZE		BOD_5		S.S.		ETHER SOLUBLE OIL	
		Conc. (mg/l)	Lbs/1000 lbs raw fish	Conc. (mg/l)	Lbs/1000 lbs raw fish	Conc. (mg/l)	Lbs/1000 lbs raw fish
STUDY NUMBER		Range ($\bar{x}$)	Range ($\bar{x}$)	Range ($\bar{x}$)	Range ($\bar{x}$)	Range ($\bar{x}$)	Range ($\bar{x}$)
3	Unknown Plant Size	602-1205 (1136)	-- (15.0)	148-965 (489)	-- (7.0)	200-1500 (900)	-- (13)
4	25,000	146-648 (295)	-- (18.0)	220-1300 (513)	-- (34.0)		
	18,000	270-750 (520)	-- (20.2)	30-470 (160)	-- (7.1)		
	120,000	300-1005 (584)	-- (18.8)	160-1550 (424)	-- (12.0)		

($\bar{x}$) = mean

Table 3 Water Consumption in Groundfish Processing

STUDY NUMBER	PLANT SIZE	PROCESS	WATER CONSUMPTION (FRESH & SALT) GALS./1000 LBS FISH FILLETED
Study #2	6,000 lbs raw fish/day	Groundfish - dry line	2040
	10,000 lbs raw fish/day	Groundfish - dry line	1630
	15,000 lbs raw fish/day	Groundfish - dry line	3780
Study #3	Unknown Plant Size	Groundfish - dry line	1500
		Groundfish - wet line	4600
Study #4	300,000 lbs raw fish/day	Groundfish - dry line	16,700
	270,000 lbs raw fish/day	Groundfish - wet line	32,900
	180,000 lbs raw fish/day	Groundfish - wet line	18,500
	40,000 lbs raw fish/day	Groundfish - wet line	10,000

A major step toward reducing the pollution from groundfish processing plants would be the widescale adoption of dry transporting techniques as opposed to the presently more commonly used fluming methods characteristic of wet line processing.

2.3.2 Pelagic and Estuarial:

2.3.2.1 Herring:

There has recently been a marked increase in the volume of herring being processed for human consumption because of the general decline in the total herring catch and restrictions on the use of herring for fish meal.

The major waste sources associated with the variety of herring processing techniques include pumpout water, brine used in roe recovery processing, acetic acid-brine dumps used in the marinating process, and water used during the filleting processes. The majority of wastes are screened prior to discharge, however, pumpwater used in the unloading process is usually discharged direct to the harbour.

Table 4 gives the effluent characteristics for food herring production as reported from the studies. The total plant effluent from marinated herring does not include the acetic acid-brine dumps. The results shown indicate the high strength of the effluents generated by food herring production.

Table 4 Effluent Characteristics from Food Herring Processing

STUDY NO.	PROCESSING	BOD_5 Conc. (mg/l) Range ($\bar{x}$)	BOD_5 Lbs/1000 lbs raw fish Range ($\bar{x}$)	S.S. Conc. (mg/l) Range ($\bar{x}$)	S.S. Lbs/1000 lbs raw fish Range ($\bar{x}$)	ETHER SOLUBLE OIL Conc. (mg/l) Range ($\bar{x}$)	ETHER SOLUBLE OIL Lbs/1000 lbs raw fish Range ($\bar{x}$)
3	Herring Filleting Total Plant Effluent	3200-5800 (3859)	-- (22)	1150-5310 (3011)	-- (21)	200-3000 (1200)	-- (10)
	Marinated Herring Total Plant Effluent	6900-14,000 (8880)	-- (215)	1508-4600 (3410)	-- (85)	800-5000 (2500)	-- (83)
	Pumpout Water (Herring Pumps)	-- (33,500)	-- (--)	-- (7955)	-- (--)	-- (500)	-- (--)

		COD (mg/l)	TOTAL SOLIDS (mg/l)	SETTLEABLE SOLIDS (mg/l)	SOLUBLE SOLIDS (mg/l)
5	Total Plant Effluent	6258	6986	1476	5530

($\bar{x}$) = mean

The high BOD_5 and suspended solids in the pumpout water indicates clearly the necessity of treating these wastes in the plant's effluent treatment system rather than allowing direct discharge to the harbour.

2.3.3 Shellfish:

2.3.3.1 Lobsters:

Lobsters are processed solely in the Atlantic Region. The main waste source occurs from the butchering operations with its associated wash water. The effluent loadings vary from 20 to 30 pounds of BOD_5 per 1000 pounds of raw product with a suspended solids loading of from 4 to 7 pounds per 1000 pounds of raw product. Water usage averages about 2500 Imp. Gallons per 1000 pounds of raw product.

2.3.3.2 Crab:

Crab are processed in both the Atlantic and Pacific coasts the largest volume being on the Pacific coast. As in lobster processing, the largest waste loads originate in the butchering area. BOD_5 effluent loadings vary from 20 to 60 pounds per 1000 pounds of raw product, with a suspended solids effluent load of between 10 and 20 pounds per 1000 pounds of raw product. Water consumption averaged about 6,500 Imp. gallons per 1000 pounds of raw product.

2.3.4 Fish Meal Production:

The processing of fish meal can lead to the discharge of high strength wastes. A review of table 5 indicates the advisability of limiting the direct discharge of bloodwater and stickwater to receiving waters. Many plants do in fact recover both their bloodwater and stickwater, producing fish meal, condensed solubles and oil from these waste products. Such recovery practices should be encouraged in those plants which presently discharge their waste direct to the receiving water.

Many of the studies reported previously indicate that the results obtained from BOD_5, suspended solids and oil analysis varied widely. This is due to:

1. Inherent sampling and analysis problems.
2. Variable characteristics of the fish such as age, sex, and season of the year.
3. Variations in the catch handling and storage techniques employed by the fisherman as well as the time required to transport the fish to the plant.
4. Variations of off-loading, storage and processing techniques employed by the plants.

Reliable results from fish plant effluents studies can only be obtained from a thorough sampling program. In most cases such a sampling program can only be carried out on the total effluent.

Table 5 Average Effluent Characteristics from Fishmeal Processing

WASTE STREAM	BOD_5 (mg/l)	SS (mg/l)	Ether Soluble Oil (mg/l)
Non-Oily Bloodwater	120,000	--	3,000
Oily Bloodwater	80,000	15,000	--
Deodorizer Water	20	100	--
Condenser Water	10	80	--
Stickwater			
Groundfish	120,000	10,000	300
Herring	70,000	30,000	5,000
Perch and Smelt	160,000	66,000	1,200
Pumpout Water	34,000	8,000	500

The Characteristics of Wastewater from British Columbia Fish Processing Plants

by

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Pollution Abatement Section, Pacific Region
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Environment Canada

1. INTRODUCTION

Fish processing is a major industry in the economy of British Columbia. In 1972 the 70 - odd fish processing plants in the province employed some 3,500 workers. These plants processed more than 337,000,000 lb. of fish with a total landed value of $75,000,000. It is estimated that these plants used in excess of two million gallons of water daily to carry out their processing operations. When an industry uses large volumes of water, wastewater and waste disposal problems are sure to result. In this paper we are attempting to point out the sources of contaminated wastewater within a fish processing plant and also define the wastewater characteristics associated with an effluent from the major fish processing operations carried out in British Columbia.

2. PROCESS DESCRIPTIONS

The processes which characterize the fish processing industry in British Columbia can be divided into the following four major groups:

Groundfish Processing
Salmon Processing
Herring Processing
Fish Meal Production

2.1 Groundfish Processing

Cod, halibut, ocean perch, sole and flounder are the major species of fish referred to as groundfish in British Columbia. With the exception of halibut the remaining species are processed in somewhat the same manner.

2.1.1 Cod, Ocean Perch, Sole and Flounder

The fish are stored whole in the ship. At the wharf, unloading is usually accomplished by pitching the fish into a basket that has been lowered into the hold. The fish are then weighed, washed and iced in tote boxes. In some larger plants, mechanized unloading methods are used to minimize manual handling.

Most groundfish require no pretreatment prior to filleting, but the scales must be removed from ocean perch before they can be filleted. The descaling of ocean perch is accomplished in a revolving cylindrical screen which removes the scales by the abrasive action of the fish rubbing against each other.

In most B.C. plants, regardless of size, the fish are processed by hand. The fillets are cut on a wooden board next to a sink, washed and immediately iced in boxes for distribution. The solid wastes from the filleting and skinning operations are usually rendered for pet food or used directly as animal feed. Figure 1 outlines a typical groundfish filleting operation.

2.1.2 Halibut

After being landed on the vessel the halibut are dressed by removing the viscera and cutting away the gills. The halibut are then packed in ice in the hold. The fishermen usually behead the fish before sale to the processor.

If the fish are not processed immediately, they are re-iced at the fish plant. The majority of halibut are filleted and marketed frozen. However, some are frozen whole or sold fresh.

Prior to freezing whole a continuous belt washer sprays the fish. The fish are frozen with a glaze protection at approximately -20F.

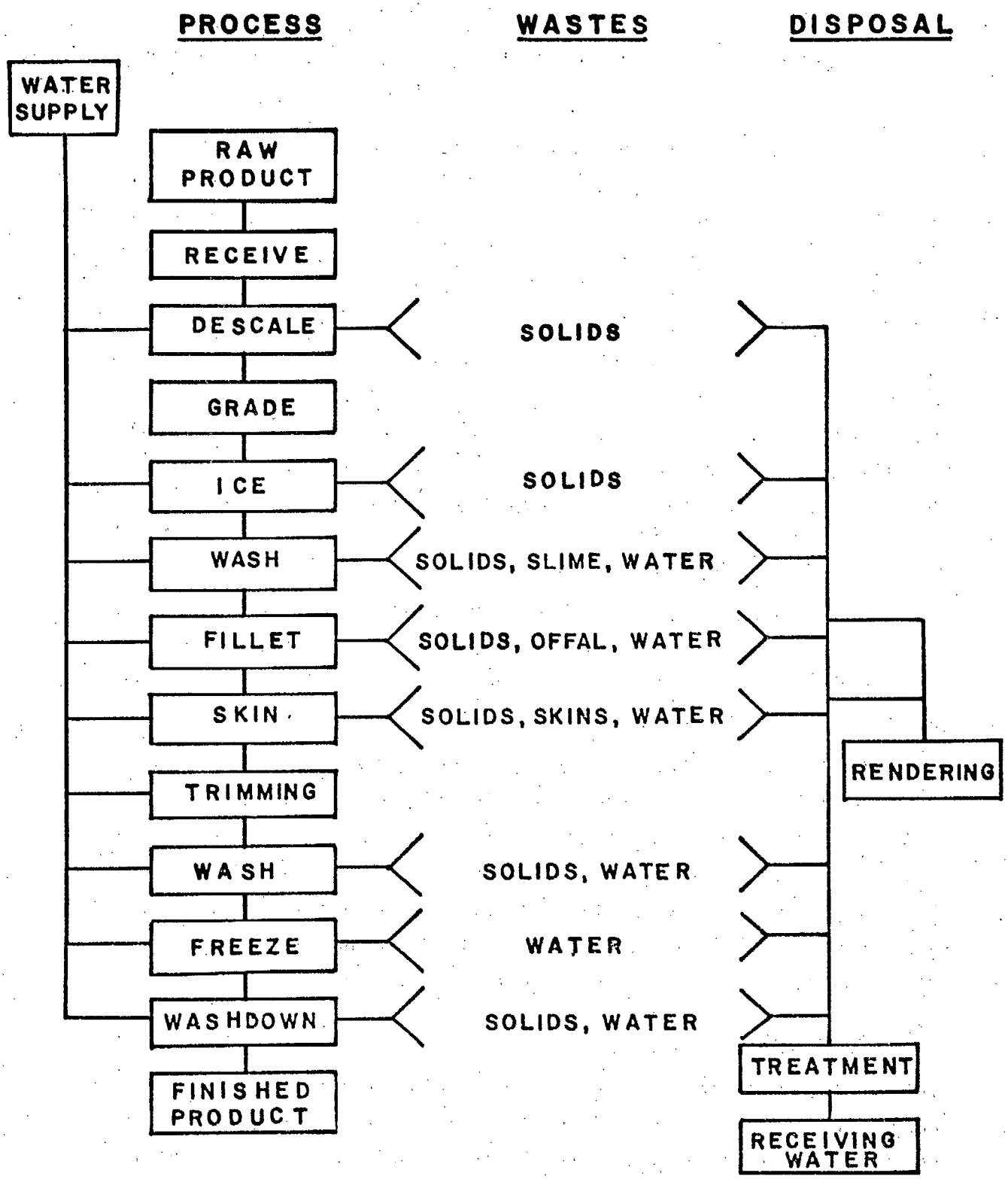
Halibut are cut in fletches (boneless and skinless pieces produced from fresh fish). This process divides the halibut into four or more trimmed meaty portions weighing from 5 to 20 pounds. The fletches are frozen and either glazed or packaged in moisture proof wrapping. Other forms of fresh or frozen halibut include packaged fillets, steaks and breaded fillets.

2.2 Salmon Processing

The five species of slamon are spring, sockeye, coho, pink and chum. The major portion of the catch (approximately 80%) is canned.

Spring, coho, and some sockeye salmon are caught using a trolling technique whereas the remaining species of salmon are netted. Troll-caught salmon

Figure I. GROUNDFISH FILLETING



are often gutted at sea and subsequently stored in ice. Following unloading, a small portion are usually sold fresh while the balance is frozen and glazed for sale in this form or as steaks cut from the frozen fish.

Net caught fish are usually taken close to the canneries and are often held forshort periods in the boats without refrigeration. Canning operations are conducted for the most part employing standard cannery equipment in a conventional manner. The principal exception is the use of the "iron chink". The iron chink performs several functions in one operation by mechanically removing heads, fins and viscera. During all the steps a strong stream of water continuously washes the blood away. The remaining canning operations are somewhat standard and are shown in Figure 2. The fish are washed, inspected and cut into can-length portions and the cans are filled mechanically. Finally, the cans are automatically sealed under vacuum and then retorted.

2.3 Herring Processing

Herring is processed into a number of products, including fish oil, fish meal, herring fillets, marinated herring and herring roe. This section describes only the operations which process herring into herring roe, the major processing operation in this province.

In British Columbia there has been a marked increase in the herring roe industry during the past two years. The herring roe processing industry will undoubtedly continue to grow in the near future. The whole herring are stored in a brine solution for approximately 4 days prior to processing. The roe is then removed, salted, packaged and refrigerated prior to shipment. Following roe removal the remaining herring flesh is sent to a reduction plant for processing into fish meal. (Figure 3)

2.4 Fish Meal Production

In the processing of most species of fish for food purposes, from 30 to 80 percent of the raw material is waste. Efforts are made by most plants to recover all edible portions, and the recent introduction of de-boning machines promises greater utilization in the future. Still, much of the

Figure 2. SALMON CANNING

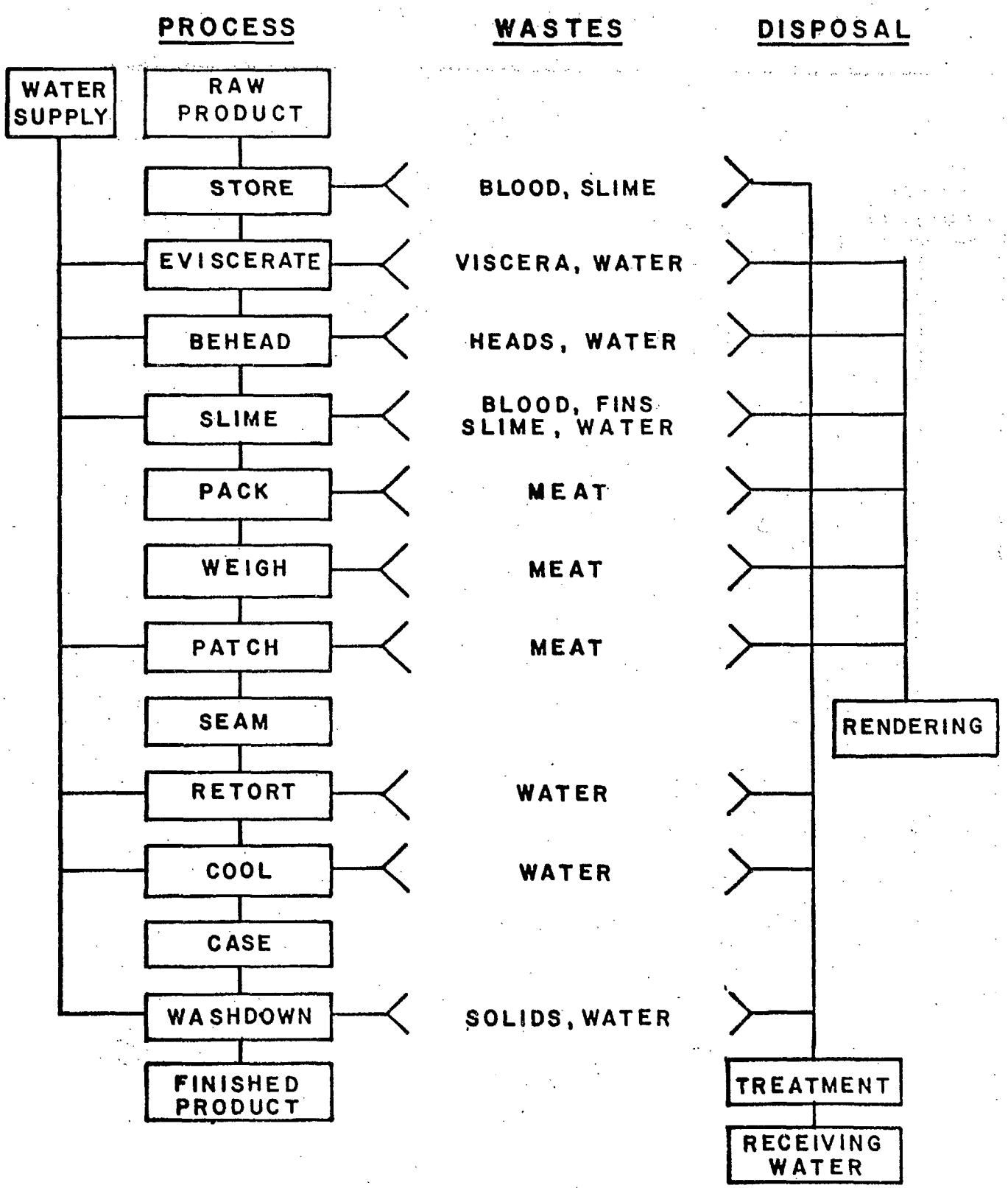
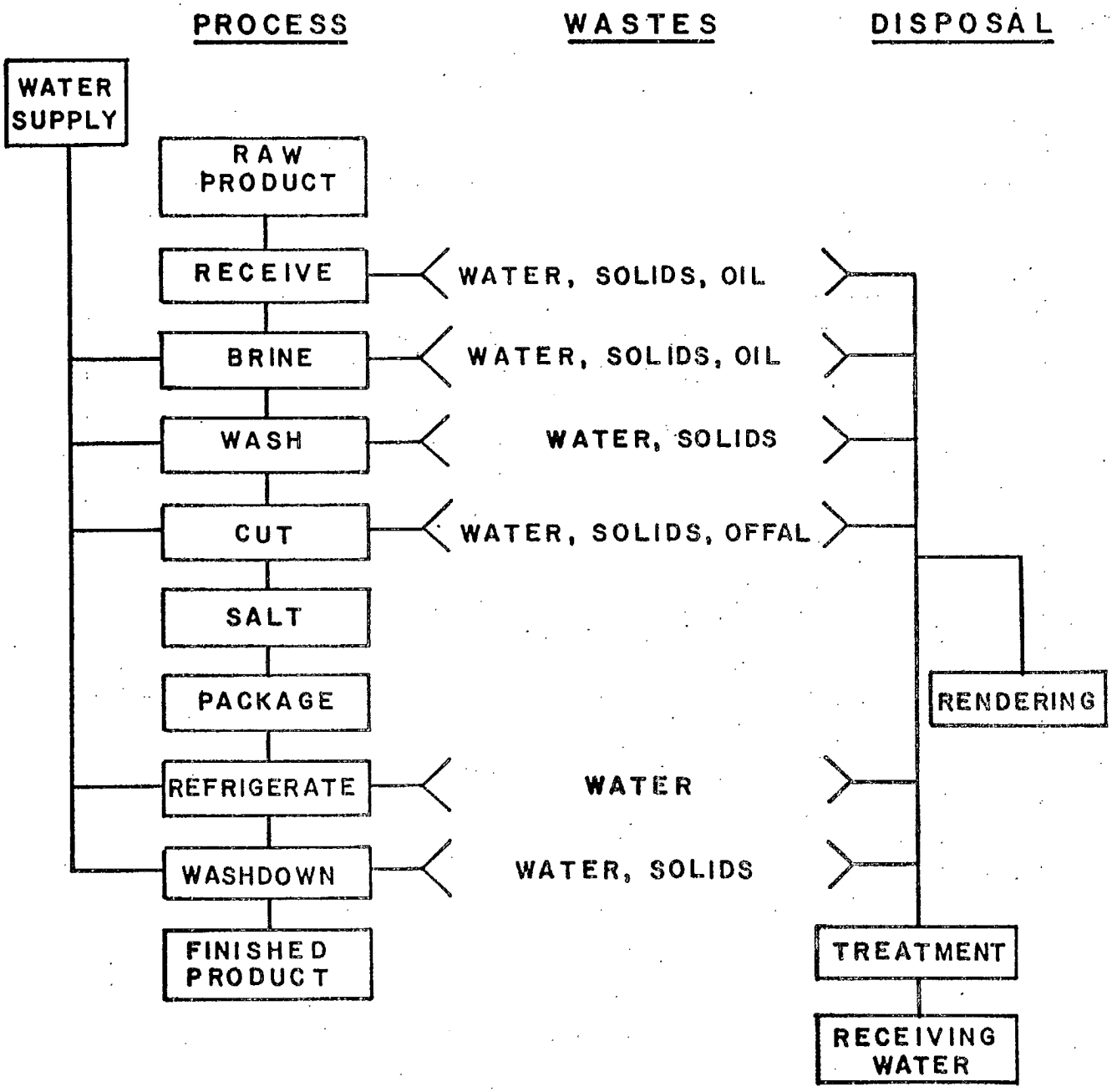


Figure 3. HERRING ROE PROCESSING



fish poses a disposal problem and one practice has been to produce a protein concentrate for poultry feed. Oil may also be recovered from oily species.

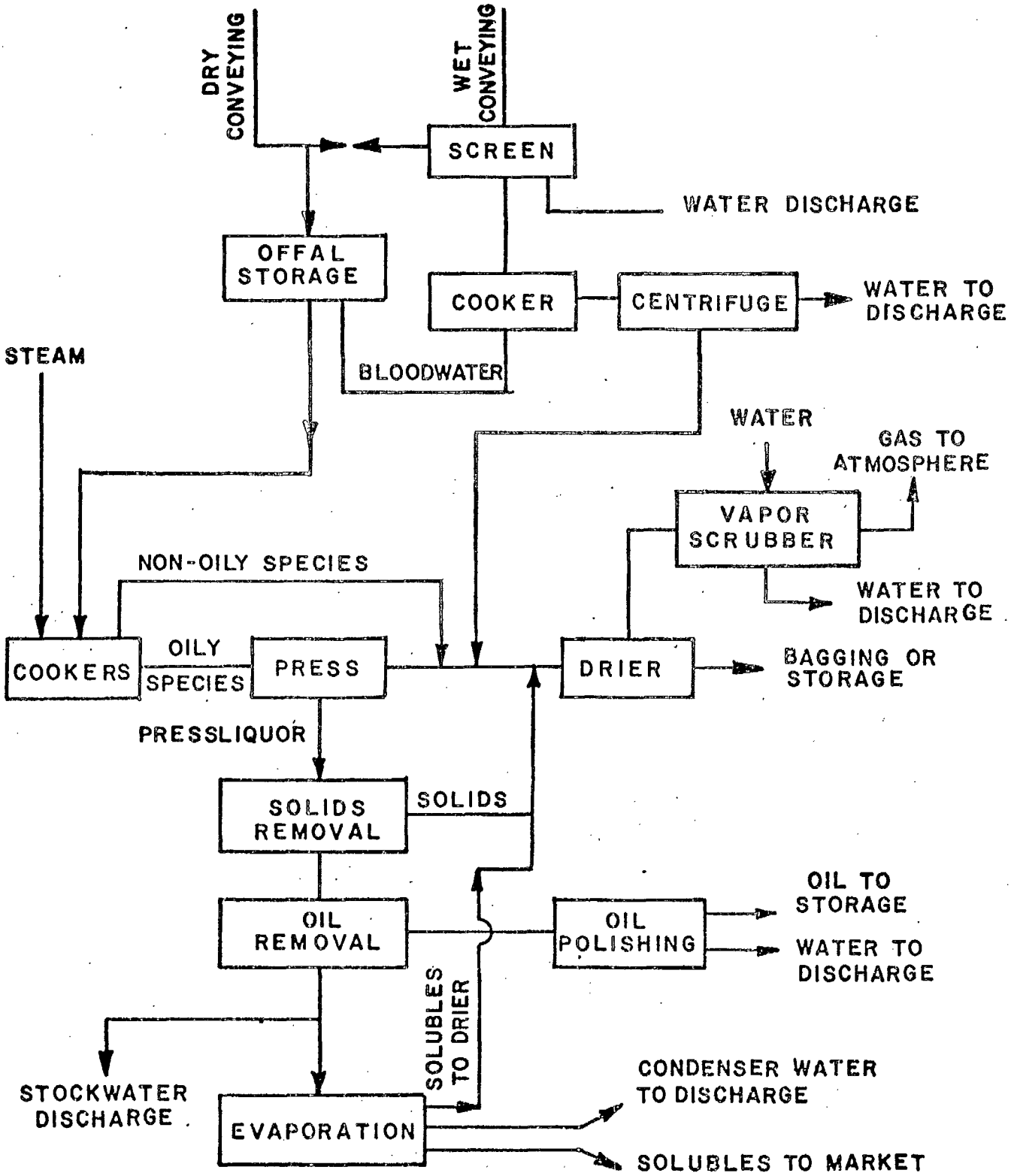
The waste material, termed offal, is normally conveyed wet or dry to the fish meal plant (see Figure 4) and stored in pits until enough is accumulated to warrant operation. Solids recovered by screening of off-loading and processing water are also sent to the fish meal plant. During storage some liquid is drained or pressed from the offal. This stream is called bloodwater. It is not large in volume but is very strong in terms of organic content. Some plants attempt to recover this, but most discharge the stream with the plant effluent.

The general flow for fish meal production is shown in Figure 4. The offal is hashed by machine if large pieces are present, and then cooked in direct or indirect continuous steam cookers for up to 10 minutes. Non-oil offal may be added directly to driers, while oily species are pressed to expel most of the water and oil prior to entering the drier.

In the latter case the press liquor undergoes a fine solids separation using vibrating screens or decanting centrifuge followed by oil separation in nozzle centrifuges. The oil is further clarified in polishing centrifuges before sale as either an edible oil or animal oil. The aqueous phase may still contain up to five or six percent organic solids and is termed stickwater. At one time this was discarded, but now many plants employ multiple effect evaporators to concentrate these solids. The resultant product is termed condensed fish solubles and contains from 30 to 50 percent solids. It is marketed as a poultry or animal feed, a specialty fertilizer, or is recycled back to the driers for incorporation in the meal. The condenser water used in the evaporators does pick up volatile solids and gases, the extent depending on the degree of freshness of the offal and the manner of operation of the evaporators.

The fish meal driers are usually rotary kilns, with heat being supplied by direct flame heating of the air, or by indirect heating using steam. The solids are dried to between 5 and 10 percent moisture content, ground to pass 10 mesh screens and sold in either 100 lb. bags or in bulk. The

Figure 4. FISH MEAL PRODUCTION



steam and odors generated during the drying of the meal can be very obnoxious and most plants employ some sort of direct water scrubbing to these vapours prior to release. Large volumes of water are employed for this, and the scrubber effluents will contain a significant quantity of organic material.

Many fish processing plants in B.C. combine a number of the above-mentioned operations. For instance, many of the plants on the West Coast have the capability of processing both groundfish and salmon. These operations might also be linked to a fish meal plant. The resulting wastes from the fish processing plant are usually flumed together and discharged as one effluent, after removal of the offal.

3. CHARACTERIZATION STUDIES

3.1 Introduction

Characterization studies were undertaken of the effluents from the various types of fish processing operations carried out in the Province. These studies were carried out by:

1) Fisheries Research Board (1968-1973)
2) Stanley and Associates under contract to the Fisheries Association of B.C. (1971)
3) Environment Canada (1971-1973)

Efforts were made to determine the concentrations of various pollution parameters in the plant effluents as well as to determine the waste-loading on a production basis. The following processing operations were studied in B.C.:

Dry-Line Groundfish Filleting
Salmon Canning
Herring Roe Processing
Fish Meal Production

3.2 Dry-Line Groundfish Processing

Tables 1 to 4 have been chosen to illustrate the results obtained in the characterization of the effluent from three dry-line groundfish filleting plants in B.C. Effluent samples were collected from plants processing

TABLE 1

EFFLUENT FROM DRY LINE PROCESSING OF GREY COD-

ENVIRONMENT CANADA

Plant Size (Lb Raw Fish/day)	BOD_5 Conc. (mg/l) Range (x)	BOD_5 Lb/ 1000 lb Raw Fish Range ($\bar{x}$)	SS Conc. (mg/l) Range (x)	SS Lb/ 1000 lb Raw Fish Range (x)	Ether Soluble Oil Conc. (mg/l) Range (x)	Ether Soluble Oil Lb/ 1000 lb Raw Fish Range (x_
SPECIES: GREY COD						
6,000	120-1775 (607)	0.7-39.1 (8.1)	196-694 (259)	0.6-6.0 (2.5)	9.0-227.7 (61.6)	0.04-5.0 (1.7)
10,000	53-1547 (435)	0.3-7.5 (2.2)	75-1006 (293)	0.4-4.8 (1.5)	0.4-55.2 (16.7)	0.01-0.64 (0.2)
15,000	27-117 (74)	0.4-1.5 (0.9)	20.5-90.0 (44.1)	0.3-0.6 (0.5)		

($\bar{x}$) = mean

TABLE 2

EFFLUENT FROM DRY LINE PROCESSING OF LING COD-

ENVIRONMENT CANADA

Plant Size (Lb raw fish/day	BOD_5 Conc. (mg/l) Range (x)	BOD_5 Lb/ 1000 lb Raw Fish Range (x)	SS Conc. (mg/l) Range (x)	SS Lb/ 1000 lb Raw Fish Range (x)	Ether Soluble Oil Conc. (mg/l) Range (x)	Ether Soluble Oil Lb/ 1000 lb Raw Fish Range (x)
SPECIES: LING COD						
6,000	471-1050 (500.1)	2.2-12.7 (6.3)	173.6-517 (248.3)	1.6-5.1 (3.5)	--- (45.7)	--- (0.3)
10,000	30-1102 (468)	0.22-7.4 (4.1)	28-564 (237)	0.21-5.5 (2.2)	--- (320)	--- (0.37)
15,000	54-546 (300)	1.1-11.0 (6.0)	41.6-121.1 (95.5)	8-2.3 (1.8)		

TABLE 3

EFFLUENT FROM DRY LINE PROCESSING OF SOLE-

ENVIRONMENT CANADA

Plant Size (Lb Raw Fish/day)	BOD_5 Conc. (mg/l) Range ($\bar{x}$)	BOD_5 Lb/ 1000 lb Raw Fish Range ($\bar{x}$)	SS Conc. (mg/l) Range ($\bar{x}$)	SS Lb/ 1000 lb. Raw Fish Range ($\bar{x}$)	Ether Soluble Oil Conc. (mg/l) Range ($\bar{x}$)	Ether Soluble Oil Lb/ 1000 lb. Raw Fish Range ($\bar{x}$)
SPECIES: SOLE						
6,000	96-540 (213.8)	0.3-4.8 (1.4)	92.1-296.8 (124.8)	0.2-1.9 (0.8)	37.6-290.6 (109.4)	0.2-2.3 (1.3)
10,000	200-900 (515)	1.5-7.6 (2.7)	118-908 (332)	0.69-3.2 (1.4)	3.0-526.4 (215)	0.01-4.1 (1.6)
15,000	45-130 (81.8)	0.4-1.1 (0.7)	32.6-173.8 (70.5)	0.04-1.5 (0.6)	0.3-43.6 (10.9)	0.02-0.4 (0.1)

($\bar{x}$) = mean

TABLE 4

EFFLUENT FROM DRY LINE PROCESSING OF

HALIBUT AND OCEAN PERCH - ENVIRONMENT CANADA

Plant Size (Lb Raw Fish/day)	BOD_5 Conc. (mg/l) Range ($\bar{x}$)	BOD_5 Lb/ 1000 lbs Raw Fish Range ($\bar{x}$)	SS Conc. (mg/l) Range ($\bar{x}$)	SS Lb/ 1000 lbs Raw Fish Range ($\bar{x}$)	Ether Soluble Oil Conc. (mg/l) Range ($\bar{x}$)	Ether Soluble Oil Lb/ 1000 lbs. Raw Fish Range ($\bar{x}$)
SPECIES: HALIBUT						
10,000	145-420 (282)	1.3-4.0 (2.6)	95-245. (170)	0.8 (1.6)		
15,000	--- (204)	--- (4.0)	--- (352)	--- (7.2)		
Species: Ocean Perch 15,000	40-114 (77)	0.4-1.1 (0.7)	14.4-101.3 (48.9)	0.1-3.5 (1.3)	12.9-35.0 (23.9)	0.12-0.35 (0.2)

($\bar{x}$) = mean

grey cod, ling cod, sole, ocean perch and halibut. BOD_5 and suspended solids analyses were performed on all samples while periodically the ether soluble oil content of a sample was also determined. The results are presented in the tables in both concentrations and loadings per unit of production. Mean values and ranges are also presented.

Table 5 illustrates the wide range of values obtained in determining the wasteloadings resulting from the processing of a certain species of fish at each of the three plants. The resultant range of BOD_5 loadings for dry-line groundfish processing varied from 2.5 lb to 5.3 lb per 1000 lb. of raw fish processed. Further examination of Table 5 indicates the variability in the suspended solids loading of these wastes. Loadings ranged from 1.0 lb to 2.3 lb per 1000 lb of raw fish processed.

3.3 Salmon Canning

The first step in the salmon canning operation in B.C. is usually the hydraulic unloading of the salmon. The water used in the unloading operation is generally recycled until the hold is emptied. At that point the water is discharged to the canning process effluent stream and is either treated or discharged directly to the receiving body of water. The characteristics of the hydraulic unloading water are presented in Table 6.

In addition to the hydraulic unloading wastewater, the overall wastes from a salmon canning include butchering water, wash water, retort water and cooling water. In Table 7 the results of the characterization of the total salmon cannery wastewaters are presented. Water consumption for a salmon cannery is generally in the range of .75 to 3.0 Imp. gallons per pound of raw salmon processed.

3.4 Herring Roe Processing

There has been a marked increase during the past two years in the amount of herring roe being processed in B.C. The major wastewater sources associated with this process are pumpout water (generally the herring are unloaded using a centrifugal pump) and water used in the cutting process for roe removal. The characteristics of wastewater used in the unloading of herring using a centrifugal pump are presented in Table 8. The

TABLE 5

DRY LINE GROUNDFISH PROCESSING

Lb of Raw Product Per Day	Lb B.O.D.$_5$/1000 lb raw fish				Lb Suspended Solids/1000 lb raw fish				Lbs Oil/1000 lb. raw fish			
	Sole	Grey Cod	Ling Cod	Avg	Sole	Grey Cod	Ling Cod	Avg	Sole	Grey Cod	Ling Cod	Avg
6,000	1.4	8.1	6.3	5.3	0.8	2.5	3.5	2.3	1.3	1.7	0.3	1.1
10,000	2.7	2.2	4.1	3.0	1.4	1.5	2.2	1.7	1.6	0.2	0.4	0.7
15,000	0.7	0.9	6.0	2.5	0.6	0.5	1.8	1.0	0.1	-	-	-
Average	1.6	3.7	5.5	3.6	0.9	1.5	2.5	1.6	1.0	0.9	0.4	0.9

TABLE 6

HYDRAULIC UNLOADING EFFLUENT CHARACTERISTICS (SALMON)

FISH UNLOADED (lb.) $\bar{X}$ (Range)	PUMP WATER USAGE (I.G.) $\bar{X}$ (Range)	BIOCHEMICAL OXYGEN DEMAND (mg/ℓ) $\bar{X}$ (Range)	BIOCHEMICAL OXYGEN DEMAND (lb./1000 lb. raw fish) $\bar{X}$ (Range)	SUSPENDED SOLIDS (mg/ℓ) $\bar{X}$ (Range)	SUSPENDED SOLIDS (lb./1000 lb. raw fish) $\bar{X}$ (Range)
41,587 (10,500 - 62,200)	2,240 (1,120 - 2,800)	3,470 (1,420 - 5,100)	1.86 (1.13 - 2.80)	937 (457 - 1,475)	0.51 (0.26 - 0.81)

TABLE 7

EFFLUENT CHARACTERISTICS FOR SALMON CANNING

PROCESSING AND AVERAGE WATER CONSUMPTION	BIOCHEMICAL OXYGEN DEMAND			SUSPENDED SOLIDS			OILS		
	mg/ℓ	lb /1000 lb raw fish	lb. /1000 lb canned	mg/ℓ	lb /1000 lb raw fish	lbs/1000 lb canned	mg/ℓ	lbs/1000 lb raw fish	lb. /1000 lb canned
Hand Processing 3400 I.G./1000 lb canned	1215	29.1	41.3	700	16.8	23.8	159	3.8	5.4
Totally Mechanized Salmon Canning 960 I.G./1000 lb canned	4053	27.3	38.9	3345	22.6	32.1	1084	7.4	10.4

characteristics of the actual process effluent for the herring roe operation have also been studied and appear in Table 8. Also shown in Table 8 are the overall effluent characteristics for herring roe processing. The overall effluent includes the centrifugal pump unloading wastewater as well as the process wastewater.

3.5 Fish Meal Production

The processing of fish and fish carcasses to fish meal can lead to the discharge of high strength wastes. A review of Table 9 indicates the need for eliminating the direct discharge of bloodwater and stickwater to receiving waters. Both of these wastes are noted to have high BOD_5 and suspended solids loadings. Many plants do in fact recover both their bloodwater and stickwater, producing fish meal, condensed solubles and oil from these wastes. Such recovery practices should be adopted by all plants. When stickwater evaporation is practised, the effluent discharge, namely the evaporator condensates, has relatively low BOD_5 and suspended solids loadings.

4. COMMENTS

4.1

It was noted that fish processing wastes vary considerably in pollutional strength. The variation is due in part to:

1. Inherent sampling and analysis problems.
2. Variable characteristics of the fish such as age, sex, and season of the year.
3. Variations in the catch, handling and storage techniques employed by the fishermen, as well as in the time required to transport the fish to the plant.
4. Variations in off-loading, storage and processing techniques employed by plants.

Reliable results for fish plant effluents studies can only be obtained through a thorough sampling program.

TABLE 8

HERRING ROE PROCESSING

OPERATION	BIOCHEMICAL OXYGEN DEMAND lb./1000 lb. raw fish	SUSPENDED SOLIDS lb./1000 lb. raw fish	WATER USAGE I.G./1000 lb. raw fish
Unloading (Centrifugal Pump)	11	7	-
Processing Wastes	3.0 - 15.0	2.0 - 22.0	-
Overall Wastes	14 - 26	9 - 29	300 - 1000

TABLE 9

EFFLUENT CHARACTERISTICS - FISH REDUCTION PLANTS

WASTEWATER	BIOCHEMICAL OXYGEN DEMAND (mg/ℓ)	SUSPENDED SOLIDS (mg/ℓ)	ETHER SOLUBLE OIL (mg/ℓ)
Bloodwater	80,000 - 100,000	15,000 - 20,000	1,000 - 2,500
Stickwater	80,000 - 120,000	15,000 - 20,000	1,500 - 2,500
Evaporator Condensates	100 - 500	50 - 200	0 - 100
Deodorizer Water	100 - 500	50 - 200	0 - 100

4.2

Table 10 has been incorporated in this paper in an effort to define what might be considered a typical effluent for the fish processing operations previously discussed in this paper.

4.3

Table 11 is employed to relate the overall wasteload of a 50,000 lb per day salmon cannery to other effluent discharges. It should be noted that the comparisons are made on BOD_5 and suspended solids basis only.

4.4 Aesthetic Pollution

Numerical criteria cannot be readily used to determine whether an aesthetics problem exists at a fish processing plant. Aesthetics cannot be measured in mg/l or lb/day or for that matter in any other set of units generally employed to define the magnitude of a pollution problem. Yet it is a very real problem. The discharge of an effluent that damages the natural appearance of the environment is not acceptable. The discharge of offal, oily wastes or suspended materials that could create surface scum or some other aesthetic environmental problem must be avoided.

TABLE 10

TYPICAL EFFLUENTS FROM FISH PROCESSING PLANTS

TYPE OF PROCESSING	BIOCHEMICAL OXYGEN DEMAND (mg/ℓ)	SUSPENDED SOLIDS (mg/ℓ)	OILS (mg/ℓ)
DRY LINE GROUNDFISH: Production: 25,000 lb. fillets/day Flow : 60,000 I.G./day	300	160	90
HERRING ROE: Production: 25,000 lb. raw fish/day Flow : 12,500 I.G./day	4,600	3,000	1,200
SALMON CANNING: Production: 25,000 lb. canned fish/day Flow : 25,000 I.G./day	3,800	2,200	540

TABLE 11

COMPARISON OF SALMON CANNERY WASTES TO OTHER WASTES

SALMON CANNERY 50,000 lb canned/day untreated efflent		DOMESTIC SEWAGE Town of 11,000 people untreated effluent		OIL REFINERY 100,000 barrels/day untreated effluent		PULP MILL 500 t.p.d. bleached Kraft Pulp untreated effluent	
BOD_5 (lb)	SS (lb)	BOD_5 (lb)	SS (lb)	BOD_5 (lb)	SS (lb)	BOD_5	SS(lb)
2200	1500	2200	1800	2000	1500	40,000	30,000

THE BIOLOGICAL EFFECTS OF FISH PROCESSING WASTES ON RECEIVING WATERS

by

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April, 1974

This report was prepared solely for the Fish Processing Plant Effluent Treatment and Guidelines Seminar and constitutes only a part of a survey of Newfoundland fish processing plants conducted in 1973. Contents of this report not to be cited without approval of the author.

The aesthetic characteristics associated with fish processing plant effluent, such as stickwater, suspended solids, oily waste and grease is a constant source of complaint in the community and the cause for some concern to the aquatic environment. Consequently, the Environmental Protection Service undertook a survey to examine a number of Newfoundland fish processing plants typifying the industry, to assess the ecological impact of effluent in the receiving waters. Plants in the study ranged in size from small seasonal operations of 3,000,000 lbs. capacity to large, trawler supplied plants of 60,000,000 lbs. annual capacity. At each plant, we examined a number of physical and chemical parameters of the receiving water, chemical characterization of the bottom deposits and the biology. The greater emphasis was placed on the latter two.

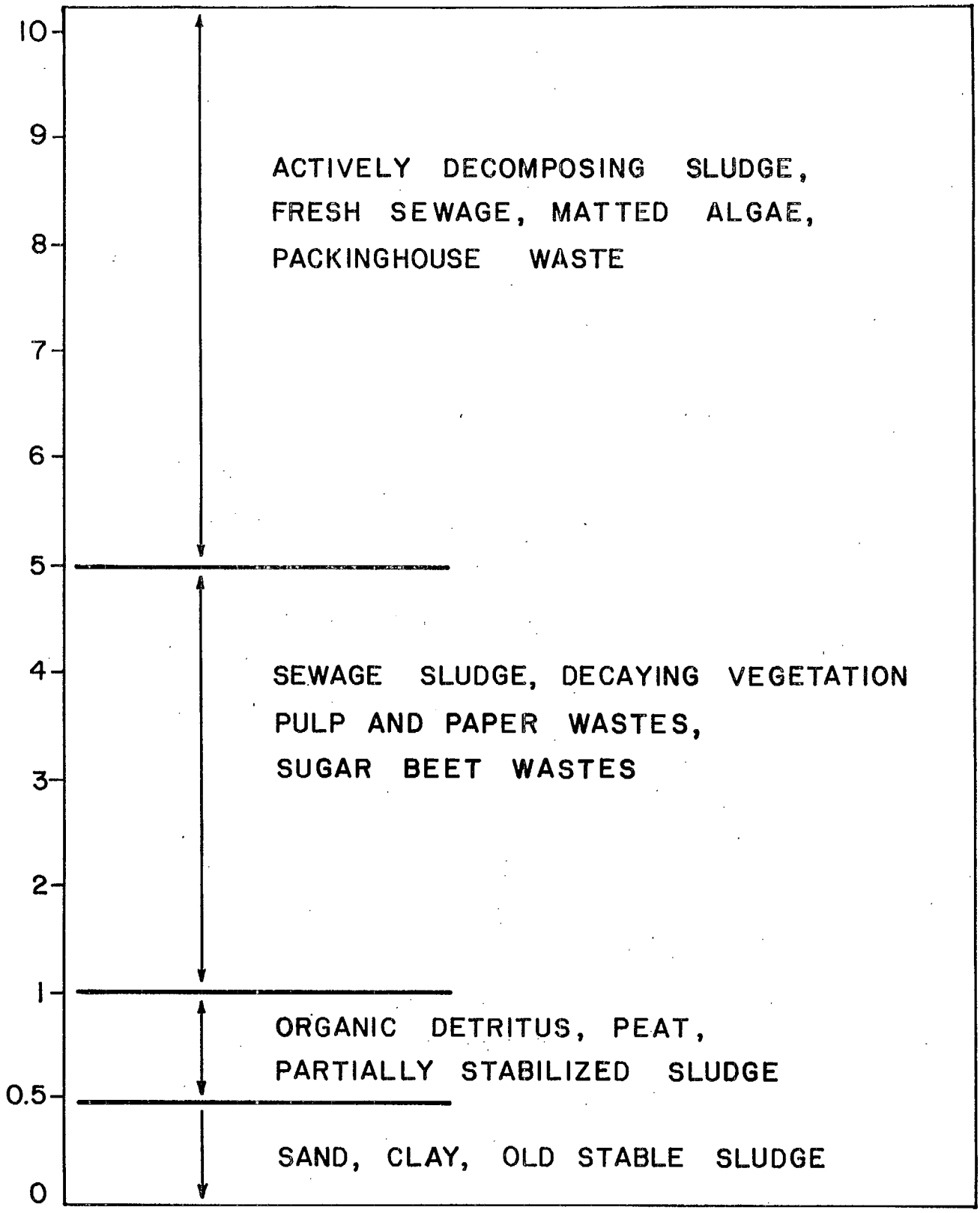
Characterization of the bottom deposits is an important factor in the study of water quality in that it yields valuable information about the source of settleable material, the effect of the sediments on the quality of the overlying water and the biological communities that will predominate. In terms of pollution sources and effects, the most important characteristic of bottom deposits is the organic matter, material derived from living organisms

containing carbon compounds. The rich protein content of fish flesh makes the effluent from a processing plant very high in organic matter and nutrients. Waste characterization studies of plant effluent measure these commodities by using BOD_5 and suspended solids. BOD (Biochemical Oxygen Demand) is a measure of the organic matter and suspended solids, the amount of offal or fish flesh lost from the plant. In the water the heavier particles begin to settle out at varying distances from the plant depending on tides, currents, salinity and physiography of the area. The process of decomposition begins here. Decomposing organic matter exerts an oxygen demand which may restrict the species and numbers of organisms such as fish or invertebrates. Nutrients such as phosphorus and nitrogen may be released during periods of flush out or turn-over to stimulate algal growth. In extreme cases, organic matter settles to form thick anaerobic sludge beds that release hydrogen sulfide and methane to the water. These gases are particularly toxic to fish and are most predominant in small enclosed harbours or bays that have little current or flushing action.

Realizing that organic matter is important in a water quality study, our next step was to measure the breakdown products of decomposition; namely, carbon and nitrogen. We obtained samples of mud from the harbour and analyzed for total carbon and total nitrogen. The values of the percent concentration of these two elements were

multiplied and the resulting product formed the basis for our sediment index. The sediment index was adopted from research work carried out in the U.S.A. (Table 1). It is a useful method of characterizing bottom deposits based on the amount of carbon and nitrogen in the mud and relating it to values for specific types of industries. Index values of 0 to 1 are representative of natural conditions - sand, clay bottoms with depositions of organic detritus such as leaves. As part of our sampling procedure, we chose a control site that is remote from the influence of the fish processing plant and human habitation to obtain data from unaffected areas. Values of our sediment index at control were always less than 1. Values in excess of 1, however, are indicative of man's activities - pulp and paper effluent, domestic sewage or packing house waste. Values obtained from fish processing plants were generally over 5 and one plant was in excess of 12.

Sediment index profiles were prepared for a number of fish plants varying in capacity and production. Figure 1 represents the sediment index profile for two small plants that we sampled. The plants included facilities for processing and freezing groundfish and ranged in size from 3,000,000 lbs. to 12,000,000 lbs. annual capacity. The index value drops rapidly to near normal values as determined from a control or unpolluted representative area. Although these plants are small in production, it is interesting to note



TAB. I ORGANIC SEDIMENT INDEX
FOR TYPICAL BOTTOM DEPOSITS

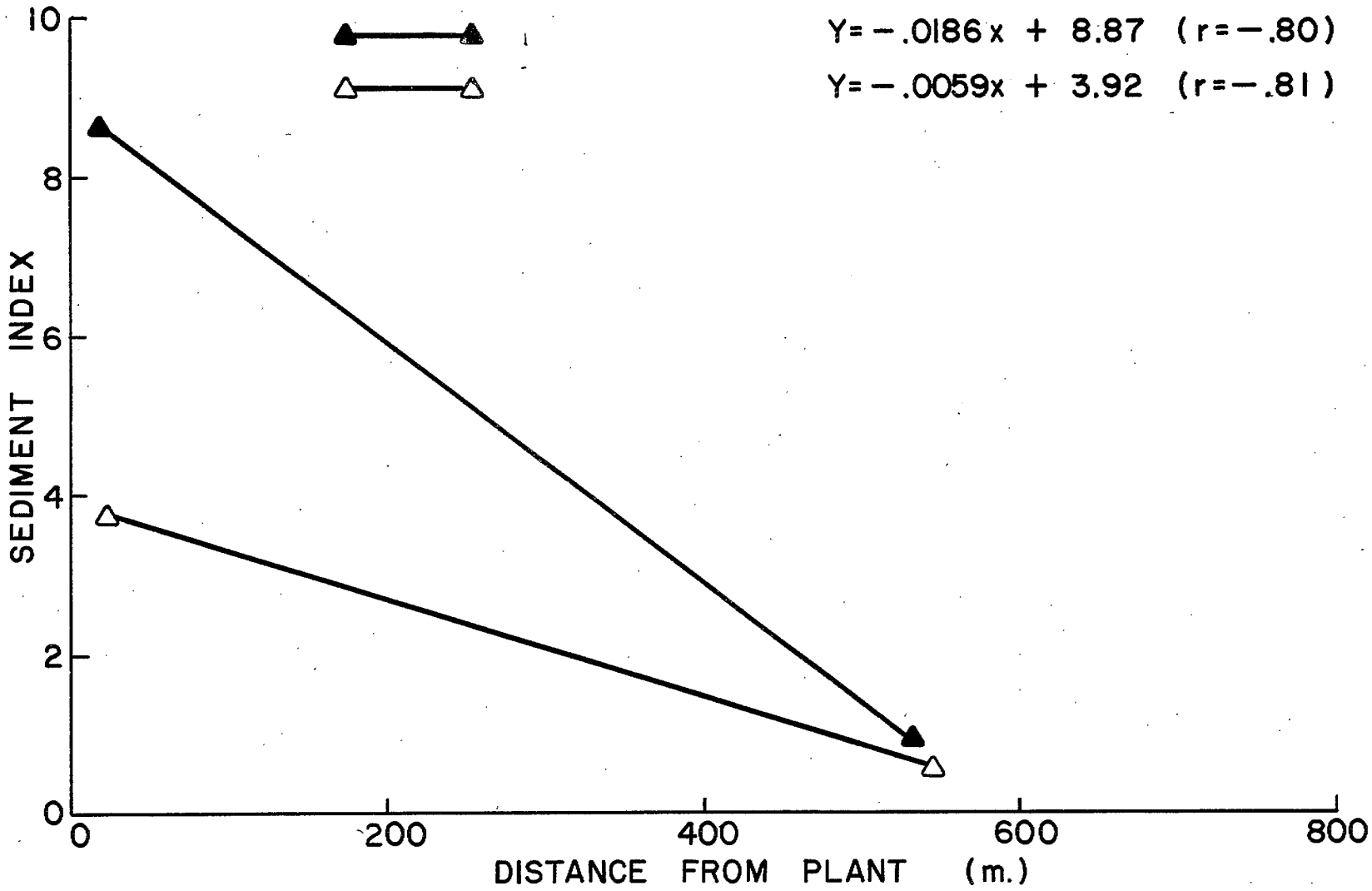


FIG. 1 SEDIMENT INDEX PROFILE

that the effects are evident as far away as 400 meters.

A much larger fresh frozen plant is represented in this sediment index profile (Figure 2). The concomitant increase in distance from the plant (approximately 800-1000 meters) is due to the larger volume of fish processed. The two lines of varying slope represent the sediment index from 400-800 meters upon which we based our biological data. The combined line represents the sediment index determined by using a combination of SCUBA divers and dredge to collect the mud sample. Although the correlation is somewhat less, the line is felt to be more typical of the sediment index values found near the plant as this value was somewhat less than those recorded further out.

We feel that this could be due to the use of fresh-water for fluming and stickwater discharge. The suspended material is carried some distance from the plant before settling out as the fresh and salt water begin to mix.

A typical study area is illustrated in Figure 3 and indicates the method by which we located our sampling stations. Some modifications were made to compensate for depth, shipping lanes, but generally, this procedure was adhered to. The limit of our sampling was 1600 meters, approximately one mile away from the plant. A control station was selected and usually located away from the influence of plants or communities.

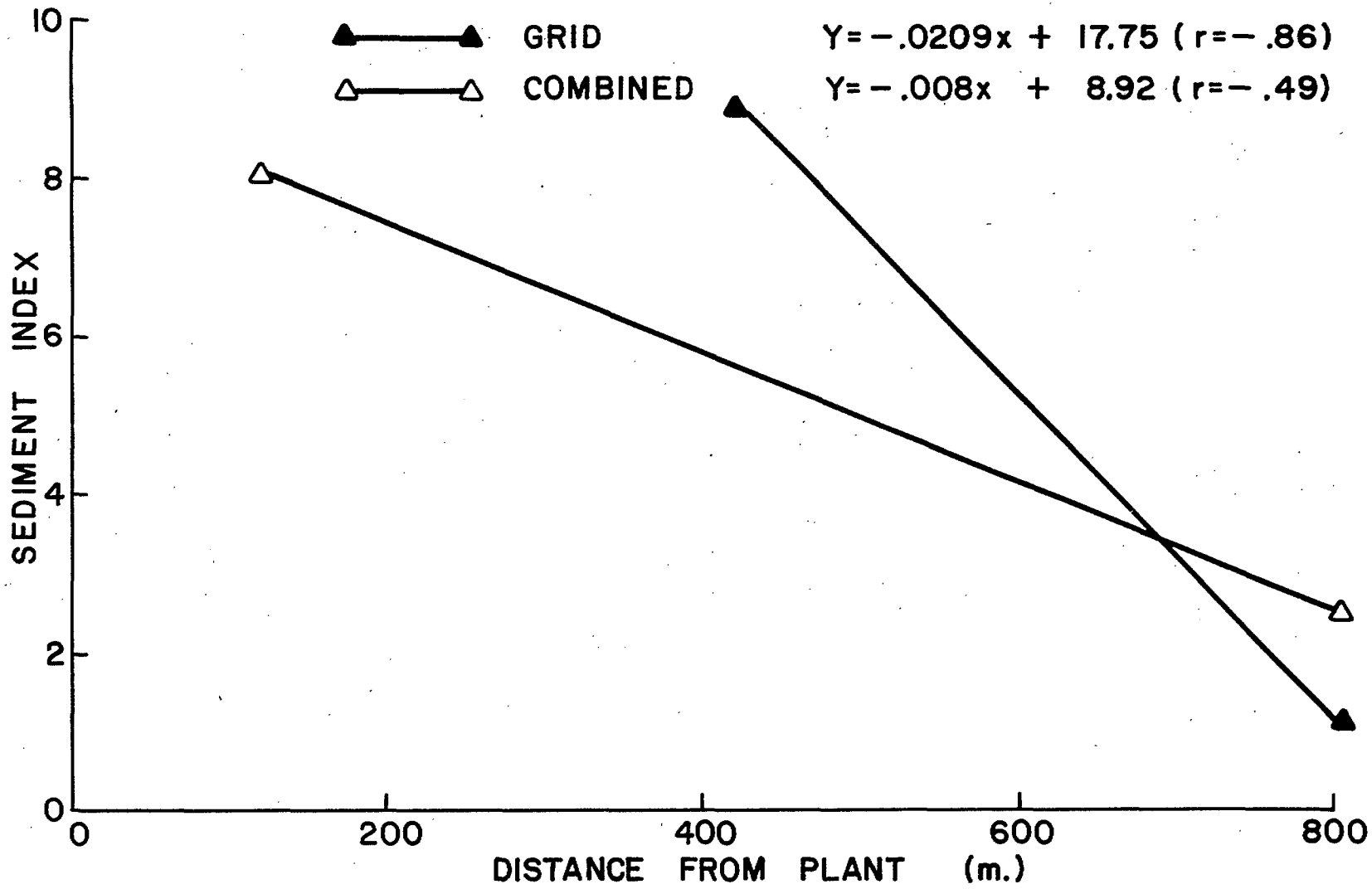


FIG. 2 SEDIMENT INDEX PROFILE

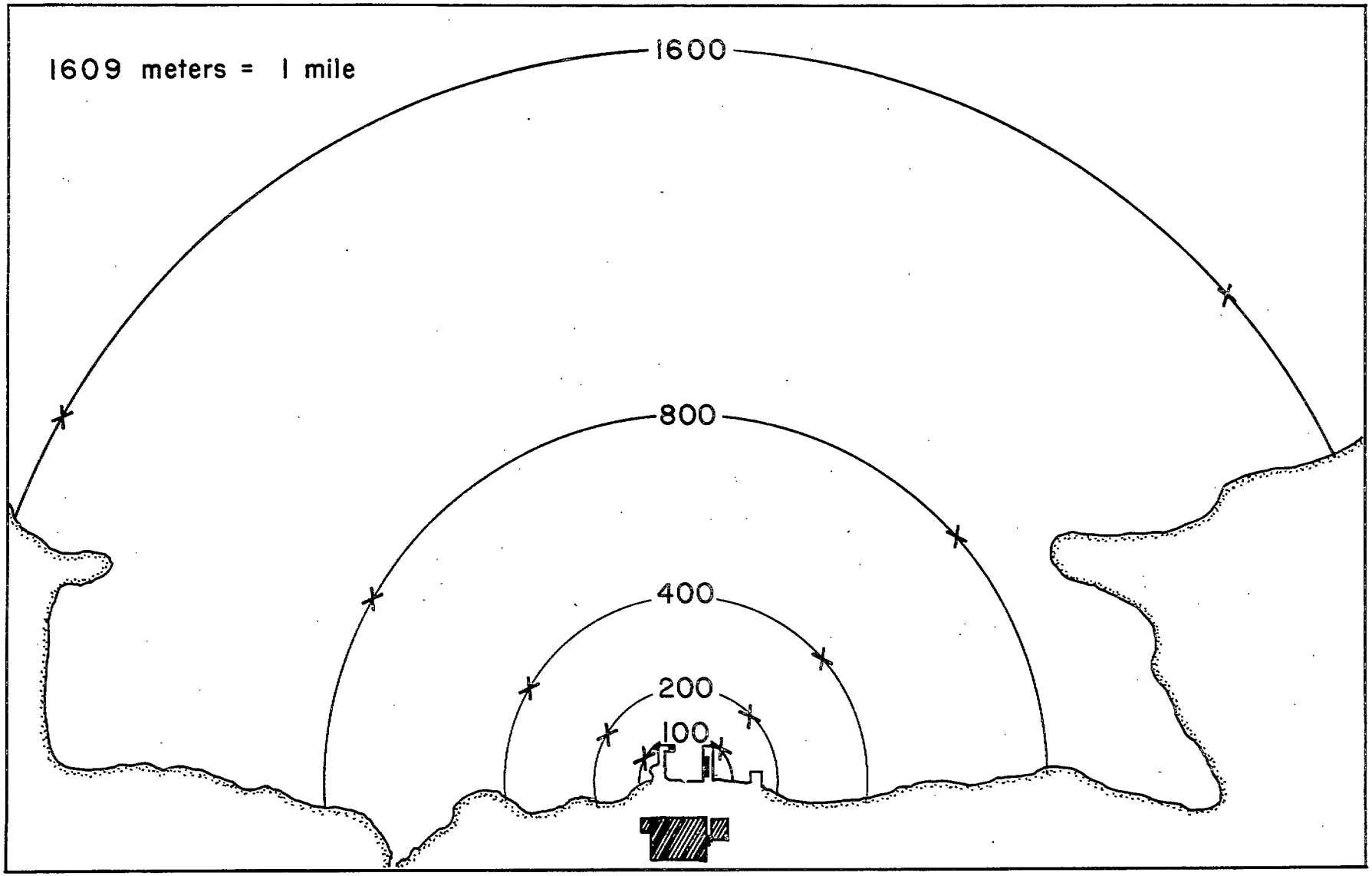


FIG. 3 TYPICAL SAMPLING STATIONS

We'll return to a comparison of our sediment index and biological work, but first we want to outline our biological studies and ecological principles on which the work is based.

At the typical sampling station, our survey crew collected various types of benthic marine organisms. Organisms occurring on the ocean floor such as worms, clams, snails, starfish and sea urchins. We collected these organisms from a known area by SCUBA divers and a small dredge. SCUBA divers were the primary support group as they provided the most reliable data. By collecting the organisms within a specific area and counting and identifying them, we have tried to describe the community structure.

A knowledge of the relative abundance of species, either common or rare is much more useful in evaluating environmental conditions in a stream than is knowledge only of their presence or absence. Community composition is now recognized as being much more reliable than particular indicator organisms for evaluating environmental conditions.

All biological communities are energy-nutrient transfer system, dynamic units consisting of herbivores, carnivous and omnivores, prey and predator. In the aquatic environment, there may be a great variety of communities, each consisting of many different species. With ecological conditions less restrictive, and greater competition for food and space existing between the different organisms that make up the population, no one species is able to increase in

numbers and become represented by the large numbers of individuals characteristic of a polluted stream. Each organism is adapted to its own habitat or ecological niche and offers check reins against too rapid growth or reproduction of the others.

All organisms in natural habitats are subjected to a continuum of variable stresses. They are usually able to survive because they have evolved appropriate genetic information. Pollution might be defined as a form of environmental stress for which the organism of that particular habitat have not accumulated the appropriate genetic information. A natural stress, for example, a seasonal change in water temperature may cause some organisms to go into a period of dormancy or to move off into deeper water. Other organisms capable of enduring the colder water will move in, or multiply and take over the community function of that organism, such as serving as a food supply for fish. When a man-made pollutional stress is introduced, nature may not have a suitable species available to take over the particular function and so the aquatic community is thrown out of balance.

Pollutional stress usually involves two changes in community structure: 1) a reduction in the total number of species present, and 2) an increase in the number of specimens of those species which can survive the stress. This may also be called a reduction in diversity. The rapid loss of diversity in the entire world is a serious general phenomenon.

Maintenance of diversity is important because it enhances stability within the community and any adjustment caused by a new set of conditions is less likely to cause oscillations in a complex system than in a simplified system. Although somewhat theoretical, because we have very little means of assessing function, protecting the community structure is in effect protecting the community function. This has tremendous implications for us both as an industry and as members of the environment. The desirability of diversity in natural ecosystems is in some ways comparable to the reasons which makes diversification worthwhile in the fishing industry. For a single company or plant, diversification ensures that the loss of a single product will not cause undo hardship or bankruptcy if the market goes soft. A company that has only one or two marketable products may be seriously affected under similar conditions. The presence of many species in a natural community or high diversity, insures that the loss of one species does not mean that the functional capacity of the community in some respect is seriously affected. In other words, spreading the risk in natural communities is no different from spreading the risk in industrial operations.

Diversity indices are mathematical expressions which can be used to describe and compare communities of organisms. Community is used here to describe benthic invertebrates in terms of spatially related species, grouping together organisms

that frequently occur together under similar environmental conditions and are a part of each other's biological environment. Natural biotic communities typically are characterized by the presence of a few species with many individuals and many species with a few individuals. A diverse community such as this is highly organized and stable, maintained in this manner by checks and balances that prevent extreme population fluctuations. In contrast, a low diversity system has fewer species, is less organized and unstable. There are simplified food chains and the community is termed fragile.

In this study, we used four of the more common diversity indices to describe organisms found near the plant and varying distances away. As they measure various components of the community, it is desirable to examine a number of indices.

> Margalef's Index - a measure of the variety or richness of the community determined simply from the number of types of organisms present relative to the total number sampled. It is more sensitive to changes in the number of species than in the number of individuals.
>
> Shannon (Shannon-Weaver) Index - a measure of both variety and equitability. The index varies both with changes in the number of species and with changes in the relative abundance of the species.

A decrease in the value of Margalef's and Shannon's index generally means a decrease in the stability of the community measured.

Also used were McIntosh's Index of equitability and Simpson's index of dominance. Dominance is the algebraic complement of equitability, which means the way in which the total number of organisms present is divided up into taxonomic groups. An index of dominance is simply an index of equitability substracted from unity, so that high values means the predominance of only a few taxonomic types in the total sample.

We examined diversity and distance. The change in diversity as we sampled away from the plant is illustrated in Figure 4. It is a composite of all four indices. The three lines sloping upward to the right indicate increasing diversity away from the plant. The fourth line that slopes downward to the right represents an important component of diversity - dominance. Dominance is the reduction in the number of species or for comparative reasons, marketable products in a plant, to one or two organisms that are capable of tolerating certain stresses such as reduced oxygen or limited habitat and proliferate at the expense of other organisms.

To put my work into perspective, a number of inland waters such as parts of Lake Erie, Hamilton Bay and Toronto Harbour have been studied. Researchers have found diversity to approach or even attain zero in local areas of these water bodies. Parts of Hamilton Bay had diversity (Shannon Index) ranging from .89 to 1.80 similar to diversity values obtained near the processing plant. More extreme, Toronto Harbour has a benthic community that is dominated by only two oligochaete worms.

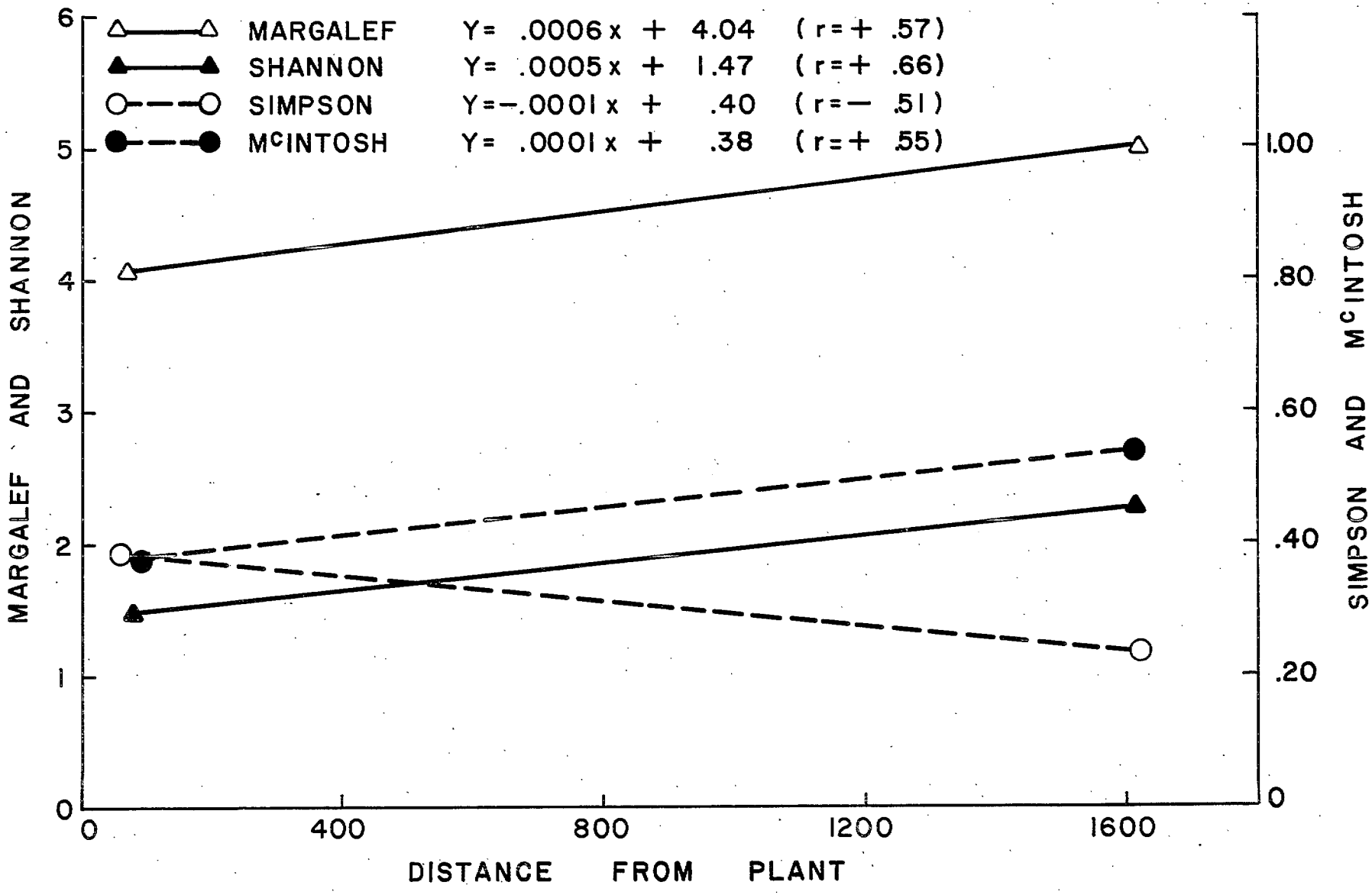


FIG. 4 DIVERSITY AND DISTANCE

We have looked at sediment index and distance, diversity and distance, finally we made a comparison between the sediment index which measures the components of the plant effluent and the diversity indices obtained from the biological studies.

The Shannon and Margalef indices were used because we expected that wastes from the fish plant would result in a reduced number of species and the predominance of a few species capable of tolerating the accumulation of organic matter.

There was a strong correlation between Shannon Index (Figure 5) and the sediment index, which would indicate a reduction in the diversity as the community is exposed to increasing quantities of organic matter.

The Margalef Index (Figure 6) which measures variety or richness is not as strongly correlated, however, the trend in reduced richness as the sediment index increases is definitly in evidence.

The following two indices complement one another. The McIntosh Index (Figure 7) is a measure of the way the organisms are divided up into species as a part of the total. A sharp decrease can be seen in the numbers of organisms capable of inhabiting or tolerating the increasing organic load imposed by the plant.

The complement of McIntosh's Index is Simpson's Index of dominance illustrated in Figure 8. It is again apparent that fewer species are capable of tolerating or proliferating in a

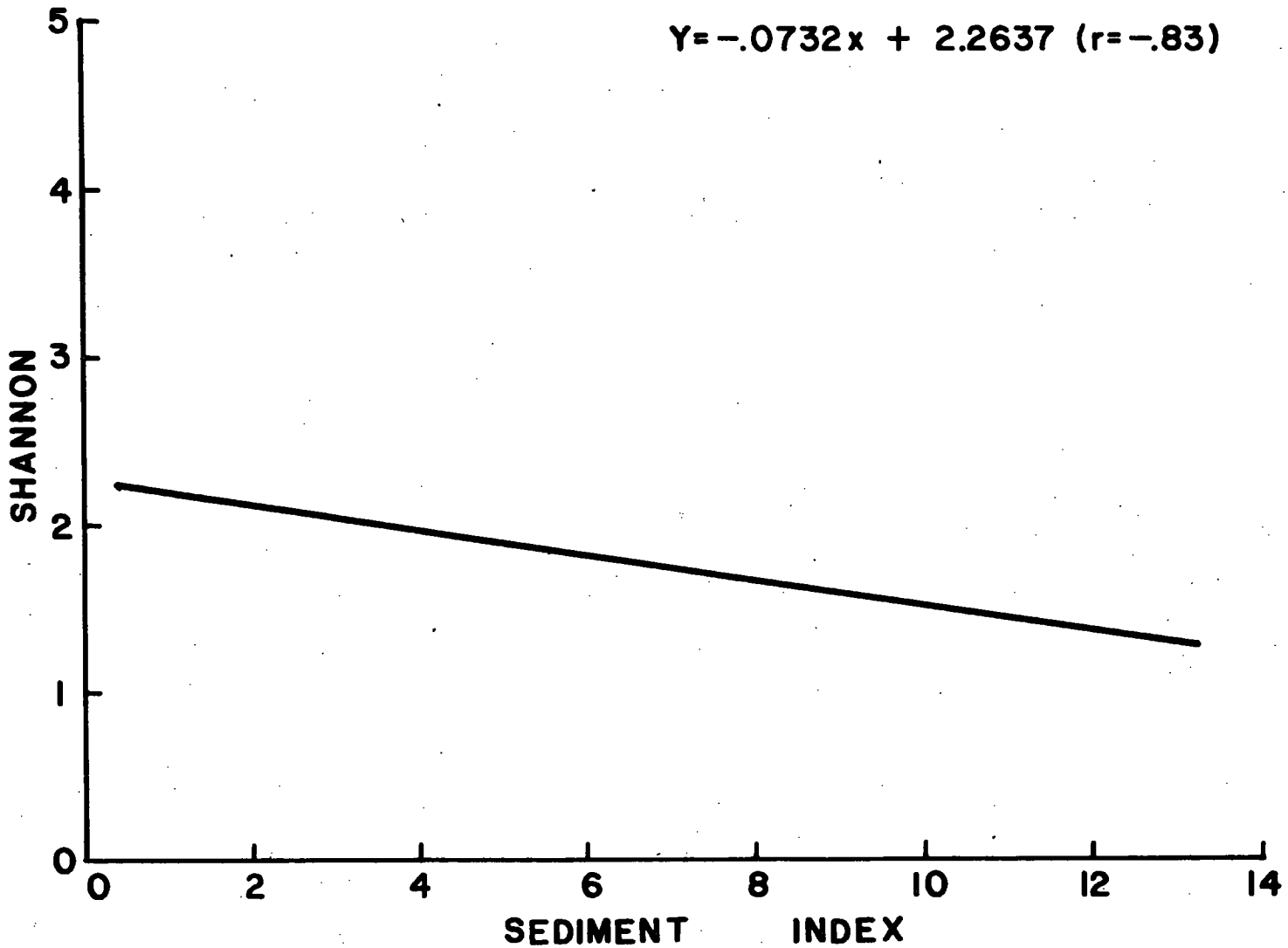


FIG. 5 DIVERSITY

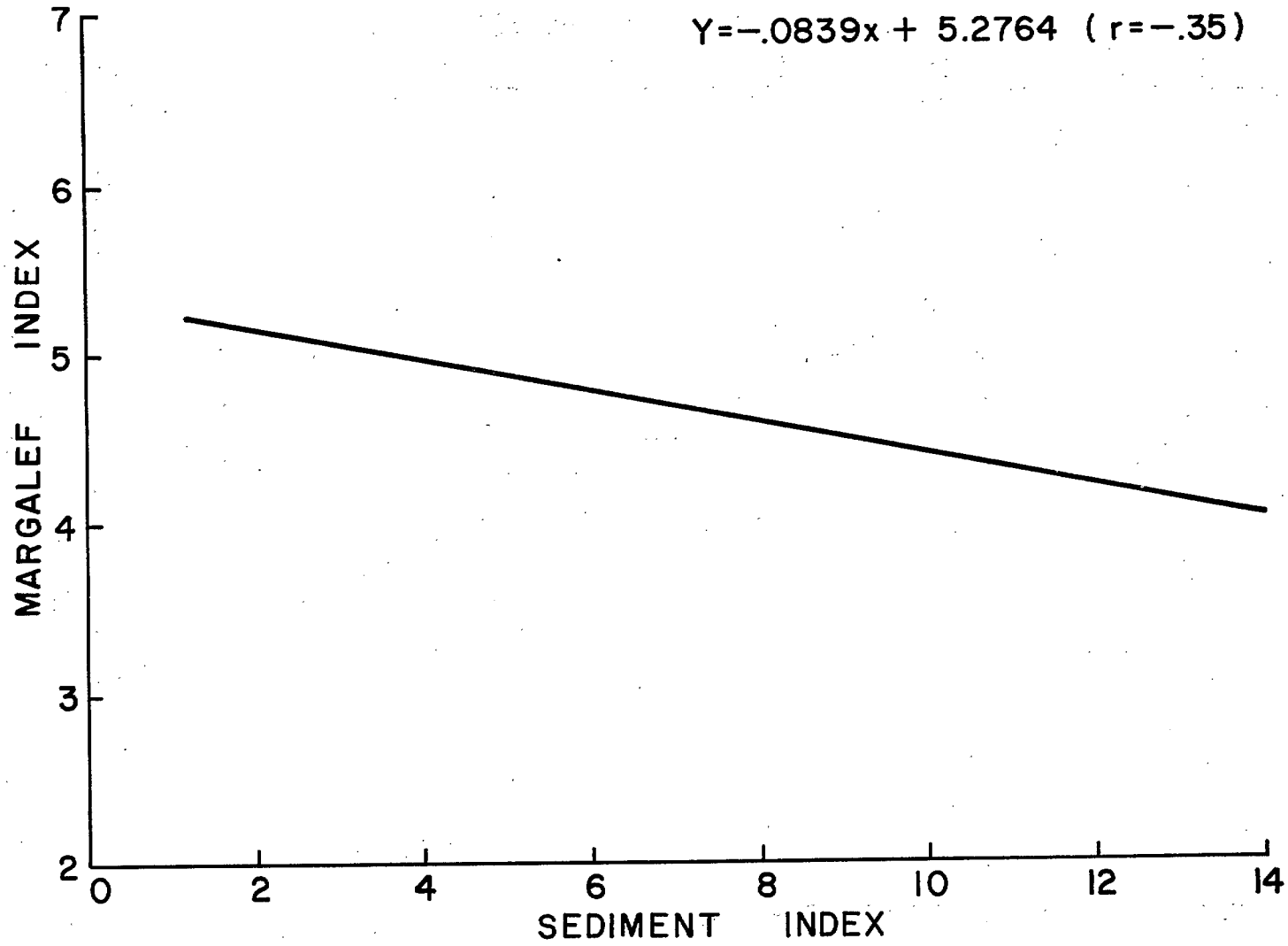


FIG. 6 VARIETY

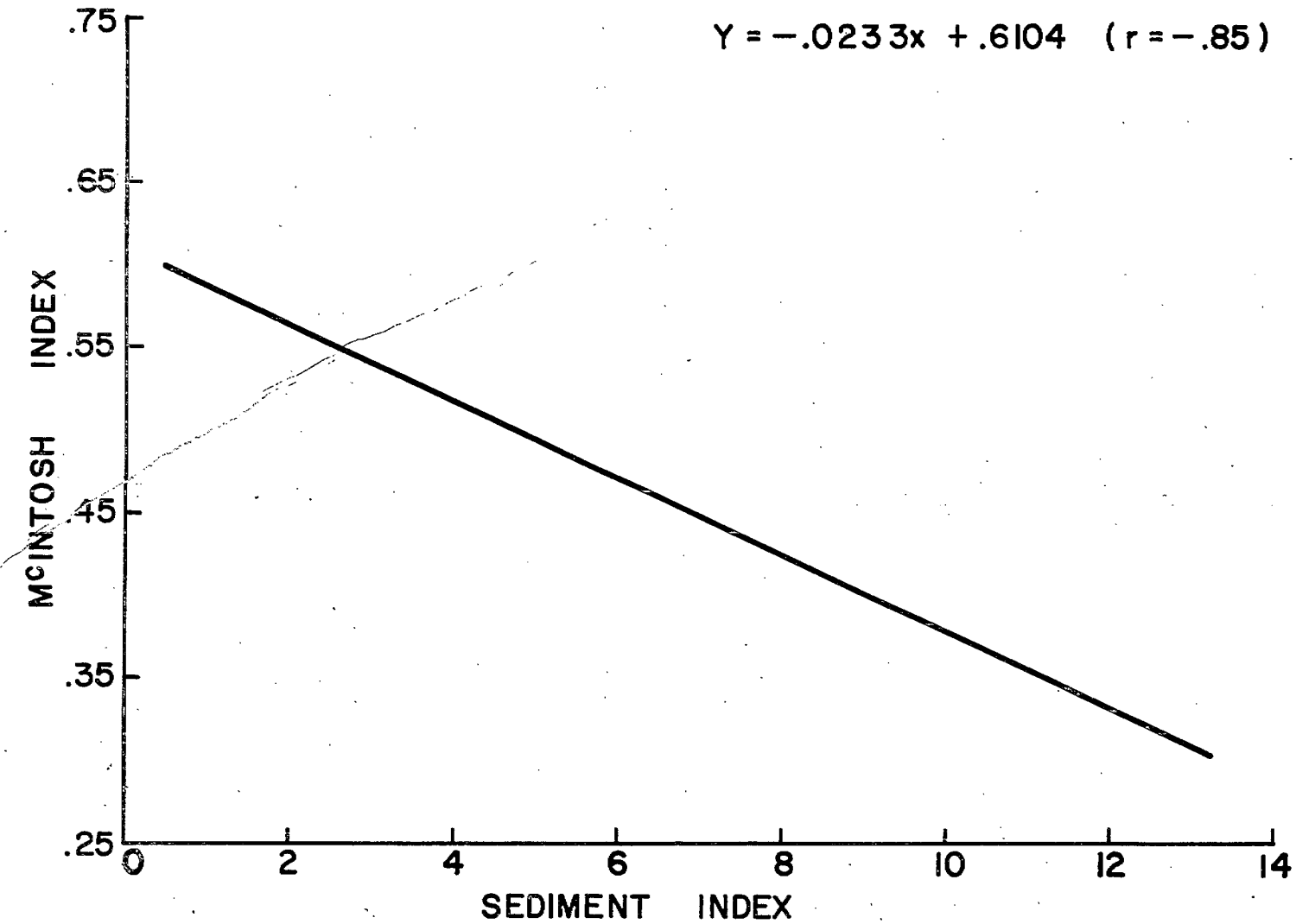


FIG. 7 DIVERSITY

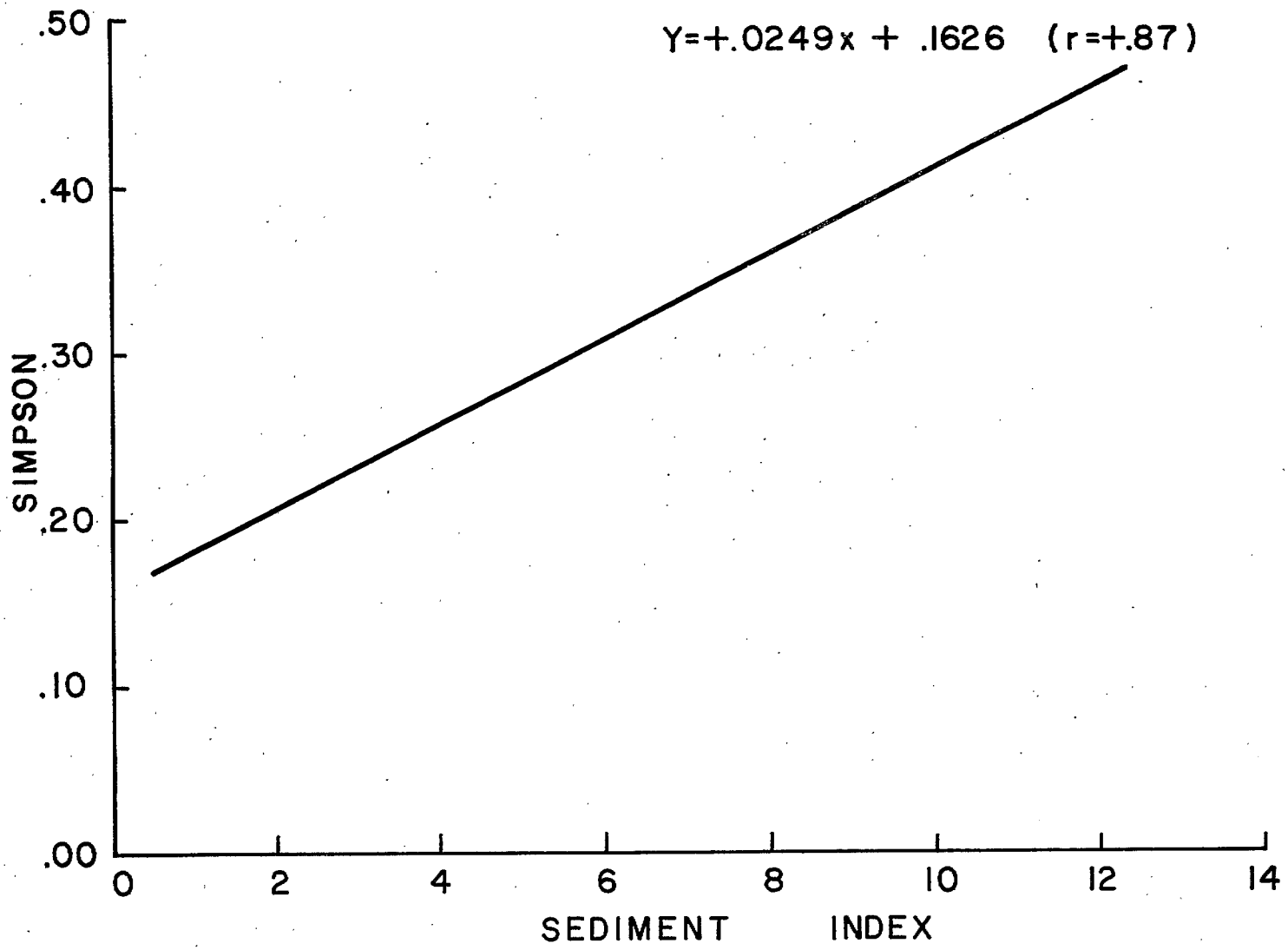


FIG. 8 DOMINANCE

high organic matter environment.

We also looked at the bacteriology, physical and chemical aspects of the water and fish inhabiting the water. These, however, are only instanteous readings and are not meaningful unless large sampling programs are initiated. The biological community on the other hand looks at organisms which have a life cycle of several years or more and gives a long-term look at the effects of fish plants on the receiving water.

Observations made by our SCUBA divers indicated that the fish species most commonly associated with processing plants were flatfish, cunners, tom cods, sculpins and wolfish. The presence of large schools of herring or mackerel feeding in the effluent is not indicative of its non-toxic characteristics. These are pelagic or migratory fish that will make feeding forays and be gone. They do not have to reproduce, live or carry out normal functions in the effluent stream.

The fish processing industry may not be classed as an emitter of highly toxic waste, although there have been documented cases of fish kill in the Atlantic Provinces. The effluent is more sublethal in action tending to reduce the diversity and thereby affecting the stability of the community structure. The zone of influence may vary from approximately 400 meters for a small feeder plant to about 1000 meters for a large fish frozen plant. In small harbours and bays,

400-1000 meters can be tremendously significant. In addition, there are the aesthetic characteristics of processing plants such as stickwater, suspended solids and oily waste. The industry may argue that they are only returning nutrients to the water, however, it is my contention that the manner and the localized area in which it is returned is upsetting the community structure and cannot be assimilated by the environment.

FISH AND SHELLFISH PROCESSING WASTEWATER TREATMENT TECHNOLOGY IN THE UNITED STATES

by

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For presentation at the

SEMINAR ON FISH PROCESSING PLANT

EFFLUENT TREATMENT AND GUIDELINES

Sponsored by

ENVIRONMENTAL PROTECTION SERVICE

ENVIRONMENT CANADA

and

NEW BRUNSWICK FISH PACKERS ASSOCIATION

Hotel Beausejour

Moncton, New Brunswick

April 24 & 25, 1974

PREFACE

This paper was developed by Environmental Associates, Inc. of Corvallis, Oregon to supplement a formal presentation at the Seminar on Fish Processing Plant Effluent Treatment & Guidelines presented by Environment Canada at Moncton, New Brunswick. The paper covers all major subcategories of seafood processed in Eastern Canada. The bulk of the material appearing herein was developed by Environmental Associates, Inc. under separate contract with the U.S. Environmental Protection Agency (Contract Number 68-01-1526).

The wastewater streams and solid wastes generated in the processing of fish and seafood are thoroughly characterized. Then the various wastewater treatment and solid waste disposal alternatives applicable to the subject industries are discussed and the costs of each recommended alternative (capital and operating/maintenance) reviewed for "typical" processing operations. The numbers presented in this report are averages of values developed within a limited time framework; they should not be used as the sole bases for design or cost estimation for specific facilities. The influences of site specificity and other local conditions dictate that each design situation be considered separately. Furthermore, mention of trade names does not constitute endorsement.

1. INTRODUCTION

1.1 Need for Wastewater Treatment

Concern about the discharge of industrial wastewaters into the navigable waters of the United States was expressed in the Federal Water Pollution Control Act Amendments of 1972 (the "Act"). The Act requires the Environmental Protection Agency to establish effluent limitations on point sources of discharge. Many substances are discharged into receiving waters in sufficient quantities to lower the water quality to the point that beneficial uses are impaired. Substances which are potential pollutants include solids (floating, suspended, settleable, and dissolved), organic matter, nutrients, heat, toxic materials, acids and bases.

Floating solids, including foam, grease, scum, and fish viscera, are unsightly and interfere with natural functions such as oxygen transfer and light penetration. Settleable solids adversely affect light penetration, and after settling form anaerobic sludge beds from which emanate methane and hydrogen sulfide.

Organic matter decomposes when present in the marine environment, depleting the amount of oxygen in the water. More desirable species of fish, such as trout and bass, will be replaced by scrap fish, such as carp and others having lower oxygen requirements, when the dissolved oxygen levels fall below 5 mg/l.

Nutrients (particularly phosphorus and nitrogen), when present in the marine environment under the proper conditions, stimulate algae growth. Fish living within the algae bloom will often have off-flavors. When the algae die, their decomposition exerts an oxygen demand which can cause fish kills, unpleasant odors, and unsightliness. Reaeration of oxygen-depleted waters by natural means such as stream turbulence and waves is limited.

Changes in temperature may adversely affect aquatic organisms and the dissolved oxygen content of the water. Many fish have narrow temperature tolerance ranges. If the temperatures vary from the optimum, fish cannot carry out important functions such as reproduction. Water will not hold as much dissolved oxygen at high temperatures as it will at lower temperatures. Increased temperatures also accelerate algae growth, compounding the dissolved oxygen problem.

Toxic chemicals are common in some industrial effluent streams, but are not prevalent in seafood processing wastes. Toxic substances discharged to receiving waters can be harmful to plant, animal, and human life.

Acids and bases present in the effluent can adversely influence biological activity in the receiving waters. Most living organisms can live only near the neutral pH of seven. Even slight deviations from this value can drastically influence the organisms living in the waters. Seafood processing wastes typically have pH's within the six to eight range.

Wastewater treatment of some form may be needed to avoid the impairment of water quality. Treatment, when discharging to a municipal system, usually does not need to be as complete as when the wastewaters flow directly to the receiving waters. Requirements of local, provincial, and federal agencies will dictate the required degree of treatment.

1.2 Industry Categorization

Important factors in the design of a cost effective waste treatment system are: the characteristics of the waste load, the contaminants to be removed, the level of removal required, the scale of the operation, and, very importantly, local factors such as climate, land availability, proximity of solids disposal sites, and availability of by-product recovery facilities. Factors such as local conditions and specifics of the plant site will have to be determined for each case.

Characterization of the waste load is one of the most important factors and can be an expensive and time consuming step in the design procedure. It is expensive because field personnel are required to take measurements and collect wastewater samples for subsequent laboratory analysis. It can be time consuming if the nature of the operation is seasonal or intermittent, requiring long delays before or during an appropriate sampling period.

When one is reviewing an entire industry, one way to maximize efficiency is to categorize the industry such that the waste loads are relatively uniform within each category, and then to conduct a sampling program to characterize the effluent within each group. Once these data are obtained, the designer has background information for most cases and needs only to verify that his plant is typical. The background data will suffice in many cases to determine the most cost effective system.

Several factors should be considered in a categorization study. Some of the more important to the seafood industry are: geographic location, manufacturing processes and subprocesses, form and quality of finished product, species, condition of the raw product, production capabilities, waste loads, number of plants engaged in the activity and ages of facilities and the seasonality of operation.

Recent studies of the wastes from the U.S. seafood industry (Environmental Associates, 1973 and 1974) resulted in the following categorization scheme. The industry was first divided into three main groups: 1) fish reduction; 2) finfish; and 3) shellfish.

The finfish and shellfish groups were further subdivided by commodity and type of preservation method: canning, curing, fresh pack, or freezing. To determine which segments of the industry were most significant from the standpoint of the magnitude of pollution abatement efforts required, a matrix analysis was performed to help focus the study on the more

important areas. Field investigation work was then concentrated in these areas, the data analyzed and the subcategorization scheme shown in Tables 1 and 2 developed. The subcategories are listed in approximate order of importance in terms of the waste loads produced per day from a typical plant.

Table 1. Fish reduction and finfish subcategories.

Fish meal production without solubles plant
Fish meal production with solubles plant
Alaska salmon canning
Northwest salmon canning
Tuna canning
Herring filleting
Herring pickling
Sardine canning
Jack mackerel canning
Mechanized bottom fish, groundfish, or miscellaneous finfish
Conventional bottom fish, groundfish, or miscellaneous finfish
Alaska fresh/frozen salmon
West Coast fresh/frozen salmon
Catfish

Table 2. Shellfish subcategories.

Alaska shrimp West Coast or New England shrimp Gulf shrimp
Alaska crab Mechanized blue crab West Coast crab Mechanically shucked surf clams Conventional shucked surf clams Conventional blue crab
Steamed/canned oysters Hand shucked oysters
Alaska scallops Non-Alaska scallops
Abalone or sea urchin Lobster

1.3. Waste Categorization

Wastes from seafood processing plants typically can be grouped into four categories:

a) "Contaminated fish processing waters" are defined as waters which have been in contact with the raw or finished product, and offal. These waters include flume water, plant wastewater, clean-up water and water used in the machines that do the actual processing. It is these waste streams which contribute the largest part of the waste load.

b) "Uncontaminated fish processing waters" are defined as wastewaters which have not been in contact with the fish. These waters include can cooling water.

c) "Storm water" is water which reaches drains used solely for carrying storm and/or drainage water off the premises.

d) "Sanitary wastes" are waters which originate from toilets and other domestic wastewater facilities within the plant.

1.4. Industry Wastewater Characterization Summary

During the studies conducted by Environmental Associates, Inc. (1973 and 1974), initial evaluations of the industrial segments resulted in sampling programs whose sizes were based on the relative importance of the respective categories. The greater the waste loads from the plants and the larger the industrial category, the greater was the number of samples taken. Because of the large variations in waste loads that occur, large number of samples frequently must be taken to properly define the wastewater.

The parameters of major pollutional significance to the canned and preserved fish and seafood processing industry are: 5-day (20°C) biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, settleable solids, oil and grease, organic nitrogen, ammonia nitrogen, raw product input rate, food/product recovery, and flow. Of these, BOD, suspended solids, grease and oil, flow, and production are considered to be the most significant variables.

All wastewater samples taken should be flow-proportioned composites of the total plant effluent. This method of sampling has been found to reduce variability in the data and produce more representative samples than would be obtained by other sampling methods.

Results from wastewater sample analyses conducted by a laboratory are usually expressed as concentrations, normally milligrams per liter (mg/l). For design pruposes, data are best left in this form. However, for the purpose of characterization, variations in daily flow and daily production need to

be considered by converting mg/l to pounds of waste produced per ton of product (usually raw product) processed. The following formula will convert mg/l to lbs/ton:

$$(mg/l)\ (8.34)\ (MGD) \div (tons/day) = lbs/ton$$

where MGD is an abbreviation for million gallons* per day.

Figures 1 and 2 depict the relative waste loads (based on production) for the finfish and shellfish categories. Figures 3 and 4 depict the relative amounts of waste produced per day for the two major categories. The listings on these four figures are generally in order of decreasing impact on the receiving waters (season lengths as well as waste loads being considered).

In the following sections, the wastewater characteristics of those major subcategories (as defined on Tables 1 and 2) of importance to Eastern Canada are presented. These data were generated (largely) during the recent studies by Environmental Associates (1973 and 1974). Accordingly, for each subcategory there appears a discussion of the sampling program involved and the conclusions reached as a result of data analysis.

1.4.1 Industrial Fish Meal Process

Regardless of the species being rendered, four general types of wastewaters are discharged from a wet reduction process: evaporator drop-leg water, bailwater, washwater, and stickwater. Most large plants employ solubles recovery systems and discharge only evaporator water. Some medium-size plants evaporate the stickwater, but discharge the bailwater, and the smaller, older plants often discharge both stickwater and bailwater. Five of the plants sampled were menhaden reduction plants located on the Atlantic and Gulf Coast and three were anchovy reduction plants located in California.

Figure 5 shows a normalized (to production) summary plot of the wastewater characteristics taken from all the fish

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* U. S. gallons

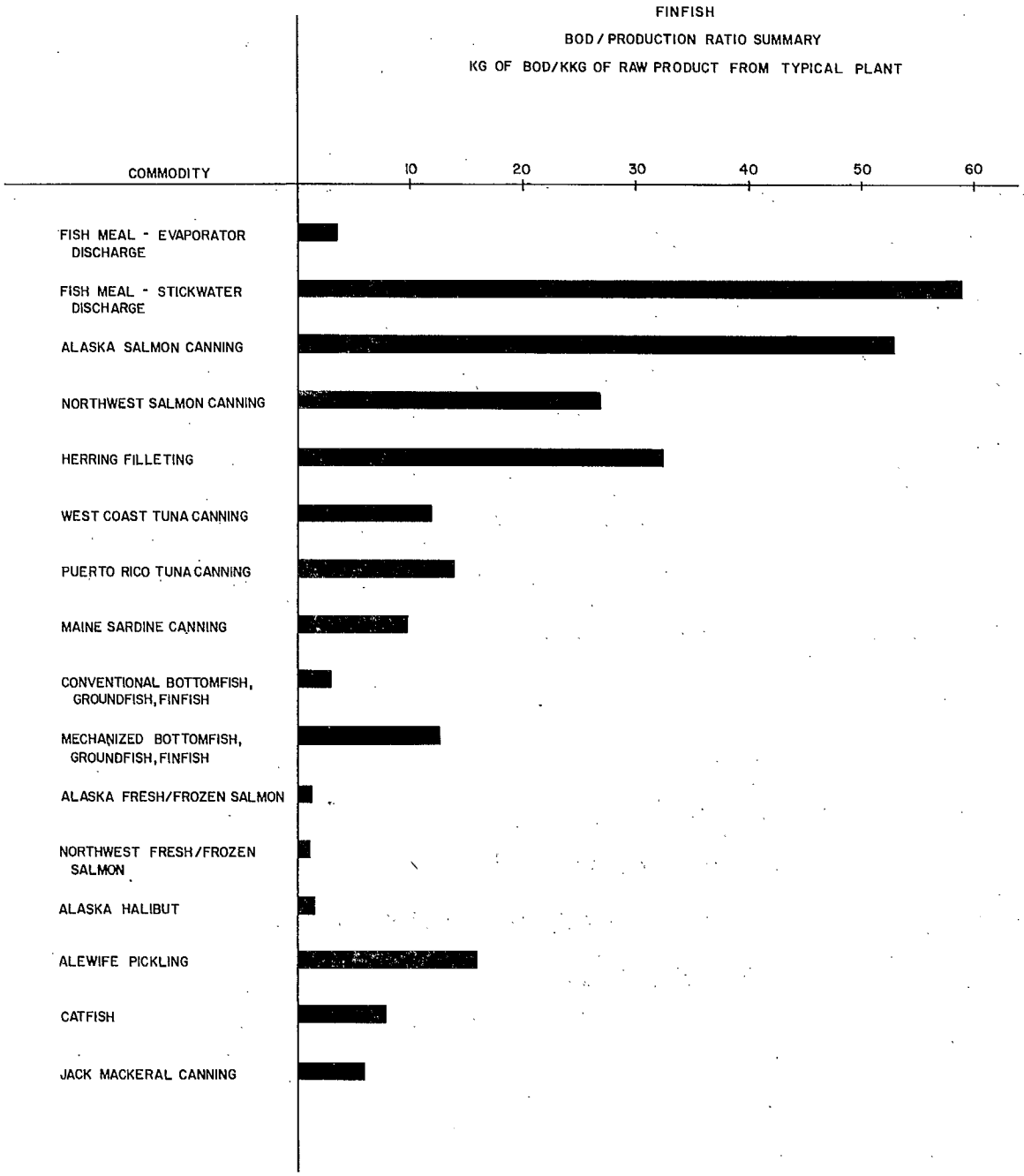


Figure 1. Relative waste loadings for the finfish catagory.

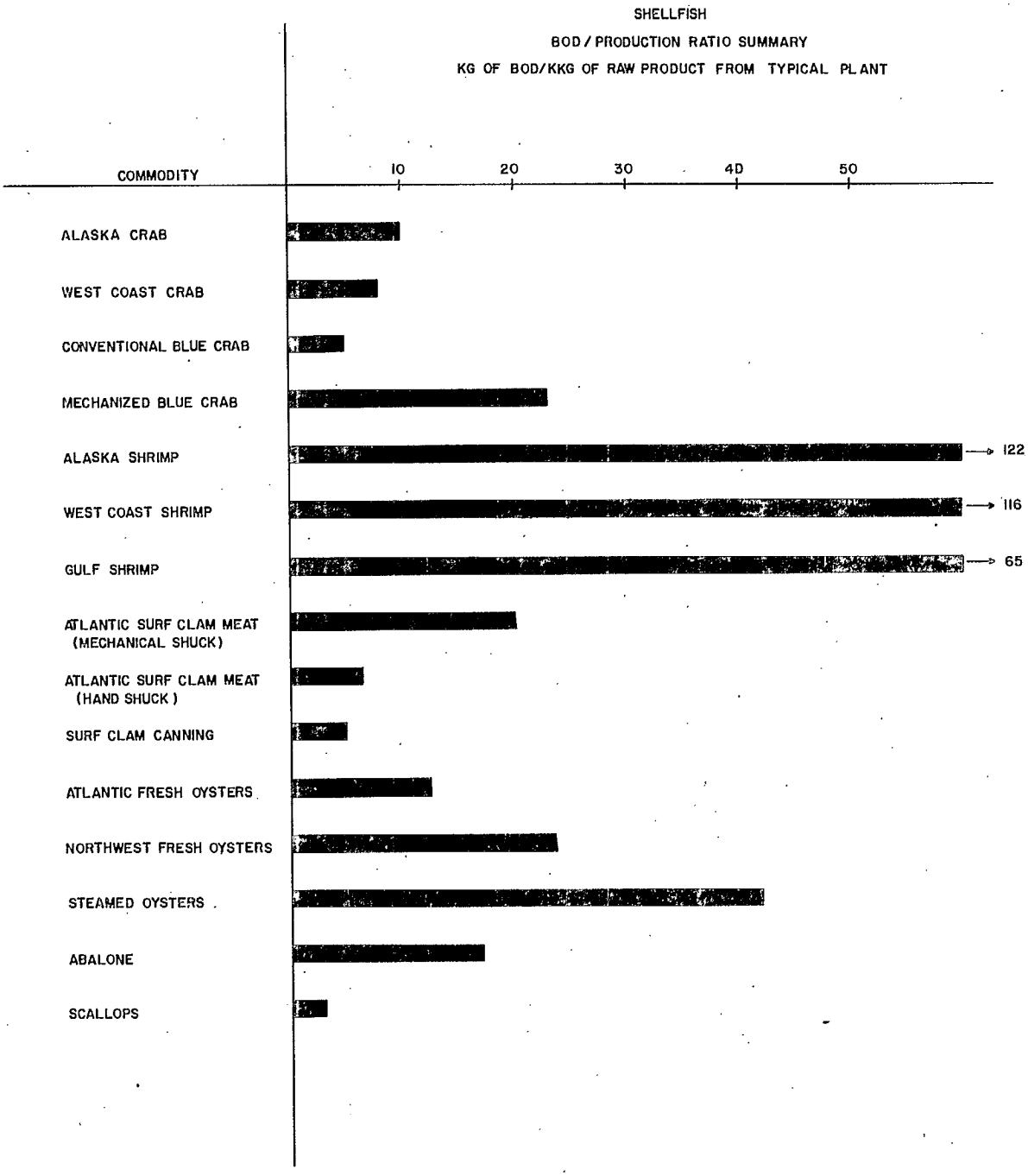


Figure 2. Relative waste loadings for the shellfish catagory.

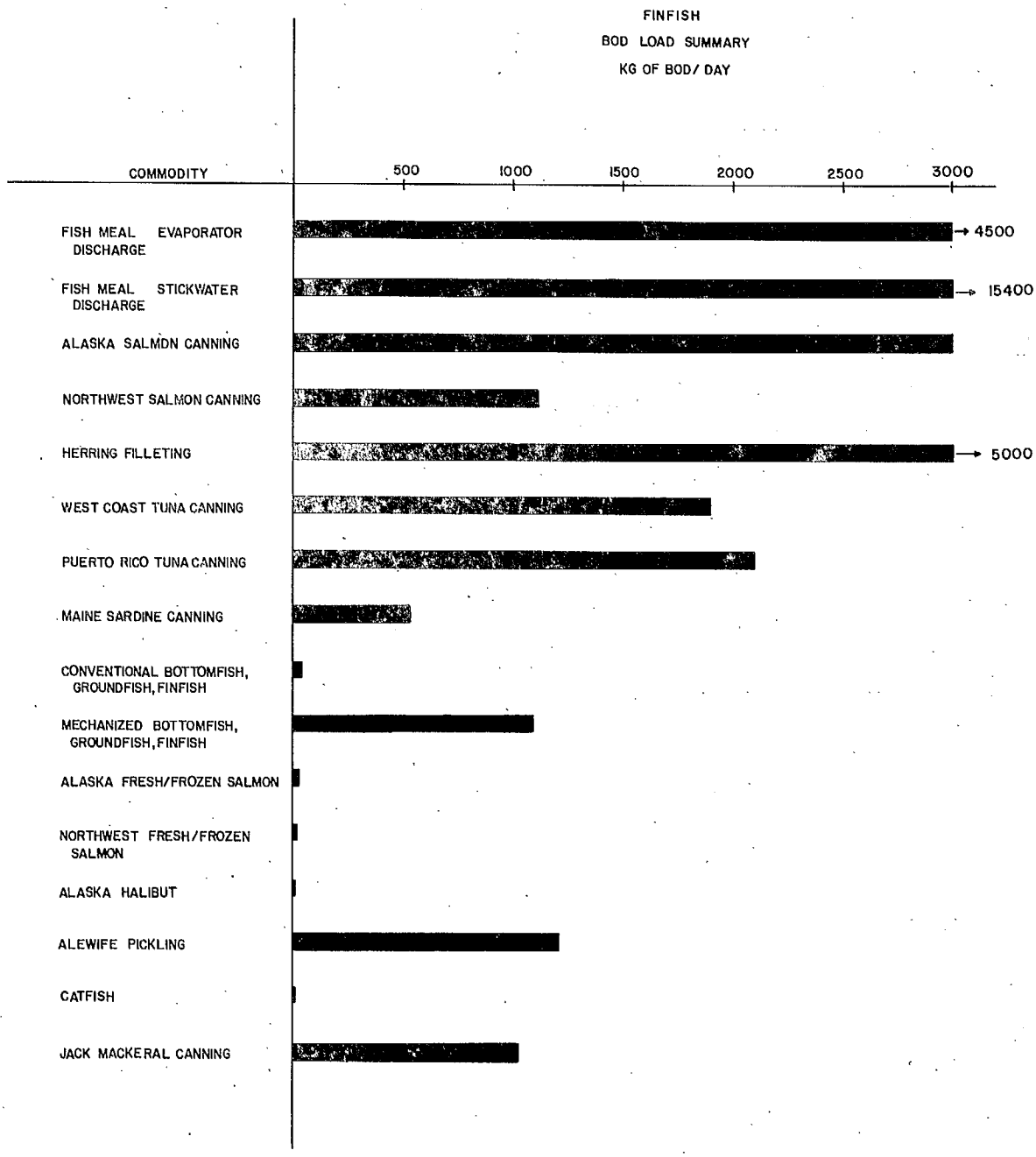


Figure 3. Relative amounts of waste produced per production day for the finfish catagory.

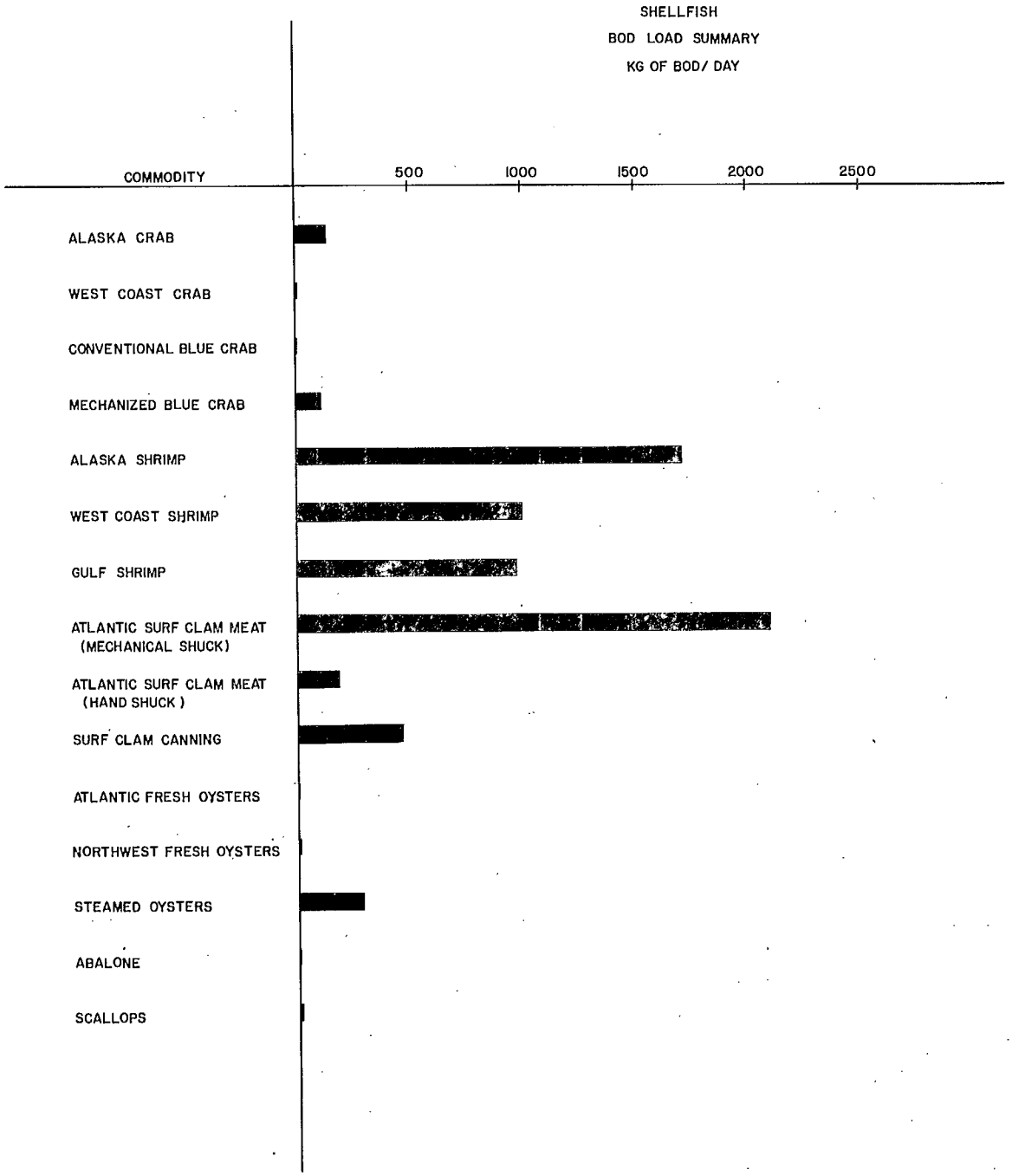
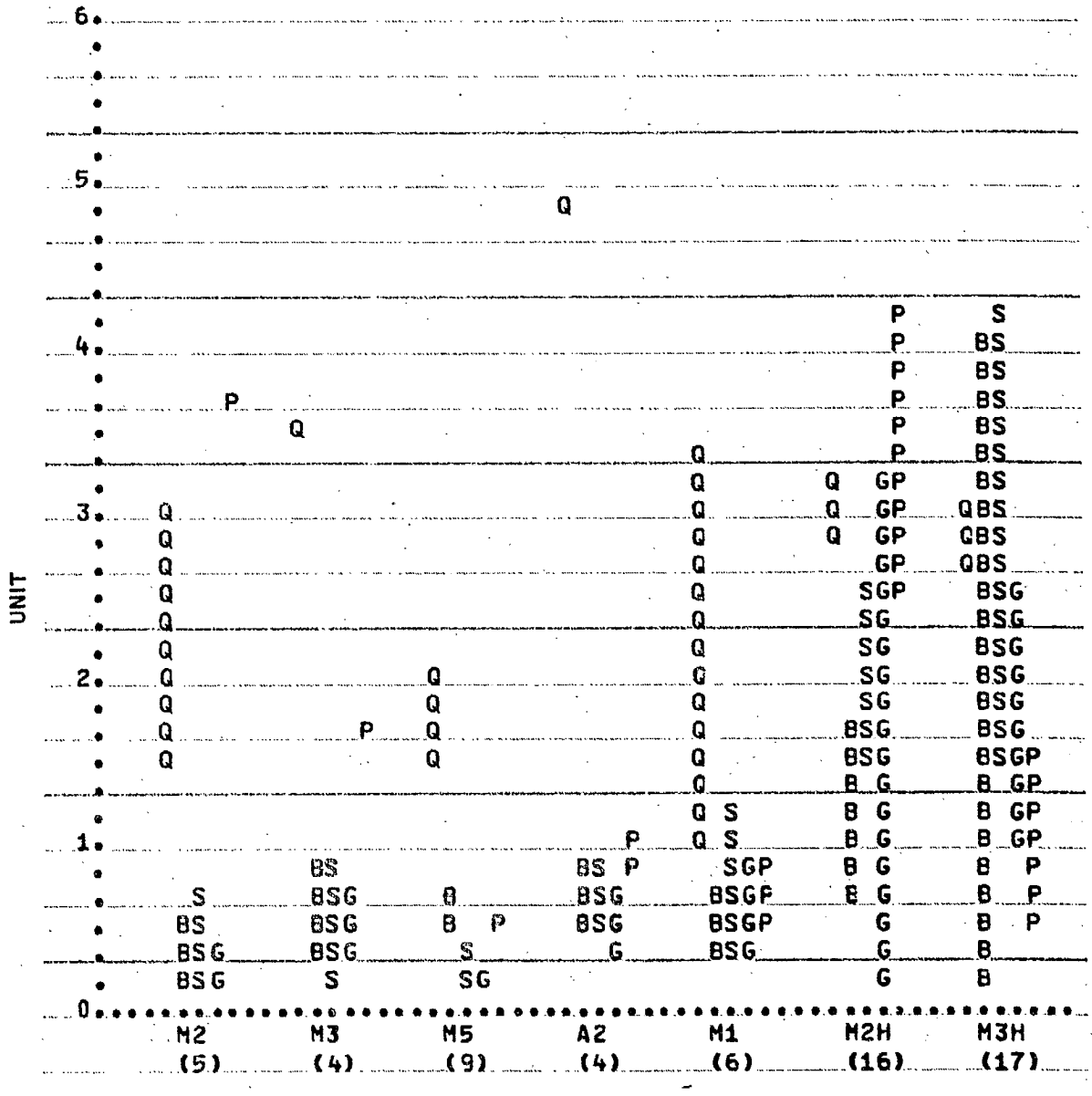


Figure 4. Relative amounts of waste produced per production day for the shellfish catagory.

Figure 5. FISH MEAL PROCESS PLOT (WITH SOLUBLES PLANT).



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 10000 L/KKG
B	5 DAY BOD	1 UNIT = 5 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 2 KG/KKG
G	GREASE & OIL	1 UNIT = 2 KG/KKG
P	PRODUCTION	1 UNIT = 20 TON/HR

meal reduction processes with solubles plants. Five parameters: flow, BOD, suspended solids, grease and oil, and production, are shown for each plant sampled. The vertical scale is in dimensionless units with the scaling factor shown at the bottom of the figure. The average value of the parameter is at the center of the vertical spread with the height of the spread representing one standard deviation above and below the mean. A plant code is shown at the bottom of each group, where "M" stands for menhaden, and "A" stands for anchovy. The number in parentheses under the plant code is the number of samples taken from each plant.

The first four plants (M2, M3, M5, and A2) discharged only evaporator water, while the remaining three plants (M1, M2H, and M3H) discharged bailwater instead of evaporating it. It can be seen that the waste load was generally lower from the plants not discharging bailwater. Plants M2 and M3 provided good examples of the reduction in waste loads that can be achieved by evaporating the bailwater. The codes M2H and M3H represent historical data collected when both plants discharged or barged bailwater, while the codes M2 and M3 represent recent data when both plants were treating and evaporating the bailwater. Table 3 shows the average waste loads both before and after bailwater treatment and evaporation and the percent reductions obtained.

Figure 6 shows a summary of the waste loads from two plants discharging both stickwater and bailwater. The waste loads are about 20 to 40 times greater than those from plants utilizing evaporators.

Table 4 summarizes the average waste loads from plants with three types of discharges: solubles plant only, solubles plant plus bailwater, and stickwater plus bailwater.

The fish meal production industry was segmented into two subcategories: those with a discharge equivalent to that from a solubles plant only, and those without a solubles plant.

Table 3. Waste load reduction using bailwater evaporation.

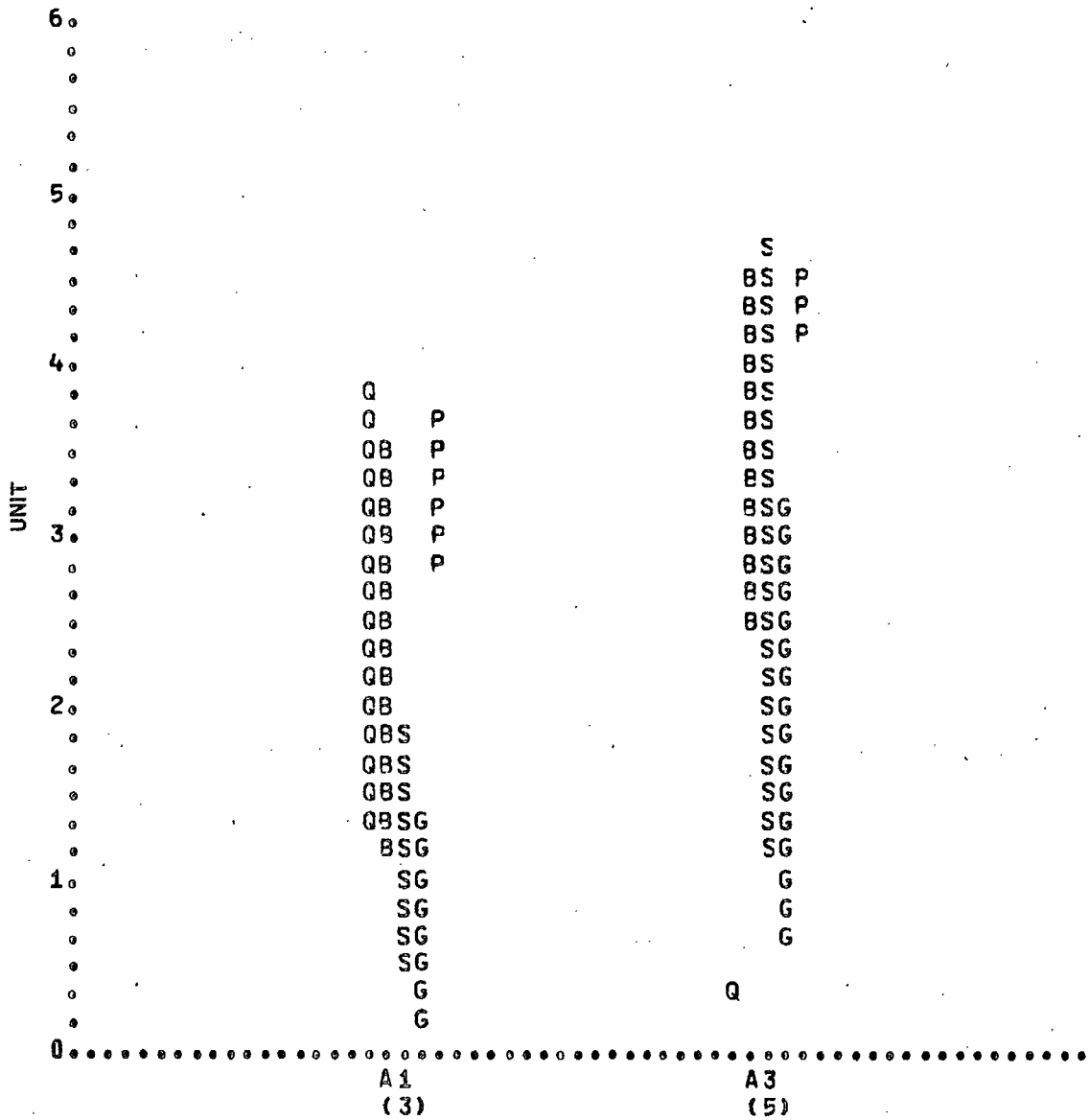
	Parameter (kg/kkg)		
	Suspended solids	BOD	Grease and oil
Plant M2 - Before	4.1	5.9	3.0
- After	0.88	1.7	0.53
- % Reduction	78	71	82
Plant M3 - Before	5.6	10.1	3.5
- After	1.2	3.6	1.0
- % Reduction	78	64	71

Table 4. Summary of average waste loads from fish meal production.

Parameter (kg/kkg)	Solubles plant	Solubles plant and bailwater	Stickwater & bailwater
Suspended solids	1.0	3.8	41
5 day BOD	2.9	6.1	59
Grease and oil	0.7	2.5	25

The exemplary plants treat, recycle, and evaporate the bailwater and washwater. The older, smaller plants typically have no existing solubles plant facilities to expand or modify to

Figure 6. FISH MEAL PROCESS PLOT (WITHOUT SOLUBLES PLANT)



SYMBOL	PARAMETER	SCALING FACTOR			
Q	FLOW	1 UNIT	=	5000	L/KKG
B	5 DAY BOD	1 UNIT	=	20	KG/KKG
S	SUSPENDED SOLIDS	1 UNIT	=	20	KG/KKG
G	GREASE & OIL	1 UNIT	=	20	KG/KKG
P	PRODUCTION	1 UNIT	=	2	TON/HR

treat the stickwater or bailwater; therefore, these were placed into a separate subcategory.

Statistics from plants sampled in these two categories are shown in Tables 5 and 6. The tables show the estimated means, standard deviations, and ranges for each of several parameters.

A basic assumption was that the bailwater, washwater, and stickwater processed by the solubles plant during a given period resulted from the volume of fish processed just previous to the solubles plant operational period which followed, allowing the waste loads to be properly related to the production levels. As a result, the wastewater summary tables show long processing times and relatively low production rates, and it must be remembered that these are in terms of solubles plant operation and not fish pressing and drying time. For cases where bailwater was being discharged, the flow rate was determined by averaging over the period of solubles plant operation so that the two waste loads could be added properly.

Table 7 shows the wastewater balance summary for plants with only evaporator and air scrubber discharges (M3, A2) and Table 8 shows the wastewater balance for plants with evaporator and bailwater discharges (M2H, M3H). It can be seen that the largest flows (by far) were from the evaporator. Bailwater flows are relatively small but contain substantial waste loads. Air scrubbers can contribute relatively large flows containing about the same concentrations of wastes as the evaporator flows.

While most of the total plant BOD load was contributed by the evaporator process, very little suspended solids or grease and oil were added at that point. It was determined that the evaporator (sea water) intake contributed an average of only 8% of the BOD, but 52% of the suspended solids and 78% of the grease and oil (Environmental Associates, 1974).

Table 5. FISH MEAL PROCESS SUMMARY
(DISCHARGE FROM)
(SOLUBLES PLANT ONLY).

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	33.4	28.2	6.04	107
PROCESS TIME HR/DAY	22.1	2.21	19.0	24.0
FLOW L/SEC	243	156	64.6	645
(GAL/MIN)	3840	2470	1020	10200
FLOW RATIO L/KKG	30800	13900	12100	65200
(GAL/TON)	7390	3320	2910	15600
SETT. SOLIDS ML/L	4.61	--	--	--
RATIO L/KKG	142	--	--	--
SCR. SOLIDS MG/L	--	--	--	--
RATIO KG/KKG	--	--	--	--
SUSP. SOLIDS MG/L	28.0	11.4	12.1	55.0
RATIO KG/KKG	0.864	0.351	0.372	1.72
5 DAY BOD MG/L	90.2	23.6	52.7	145
RATIO KG/KKG	2.78	0.728	1.62	4.46
COD MG/L	198	77.5	87.6	386
RATIO KG/KKG	6.09	2.39	2.70	11.0
GREASE & OIL MG/L	22.5	10.1	8.87	47.5
RATIO KG/KKG	0.694	0.311	0.273	1.46
ORGANIC-N MG/L	4.87	3.07	1.33	12.0
RATIO KG/KKG	0.150	0.095	0.041	0.395
AMMONIA-N MG/L	2.76	2.36	0.489	8.96
RATIO KG/KKG	0.085	0.073	0.015	0.276
PH	6.67	1.40	4.33	7.75
TEMP DEG C	35.8	14.8	14.1	47.0

PLANTS M2 , M3 , M5 , A2

Table 6. FISH MEAL PROCESS SUMMARY
(WITHOUT SOLUBLES PLANT).

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	7.60	1.46	5.15	10.3
PROCESS TIME HR/DAY	15.7	11.8	7.33	24.0
FLOW L/SEC	13.1	12.9	1.87	46.3
(GAL/MIN)	208	204	29.6	743
FLOW RATIO L/KKG	7390	7800	931	27700
(GAL/TON)	1770	1870	223	6640
SETT. SOLIDS ML/L	29.4	37.4	2.66	124
RATIO L/KKG	217	276	19.7	918
SCR. SOLIDS MG/L	62.1	--	--	--
RATIO KG/KKG	0.459	--	--	--
SUSP. SOLIDS MG/L	5530	3400	1550	14300
RATIO KG/KKG	40.8	25.1	11.4	106
5 DAY BOD MG/L	7940	2330	4330	13400
RATIO KG/KKG	58.6	17.2	32.0	98.3
COD MG/L	15300	6370	6420	30900
RATIO KG/KKG	113	47.1	47.5	228
GREASE & OIL MG/L	3380	2390	793	9620
RATIO KG/KKG	25.0	17.7	5.86	71.1
ORGANIC-N MG/L	703	8.68	687	721
RATIO KG/KKG	5.20	0.064	5.07	5.32
AMMONIA-N MG/L	30.0	6.76	18.9	45.2
RATIO KG/KKG	0.221	0.050	0.140	0.334
PH	6.80	0.026	6.78	6.32
TEMP DEG C	32.3	15.5	21.3	43.3

PLANTS A1 , A3

Table 7. Fish meal production with solubles plant material balance.

Wastewater Material Balance Summary

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) evaporator	80 - 85%	60 - 85%	60 - 90%
b) air scrubber	15 - 20%	15 - 40%	10 - 40%
Total effluent average M3, A2	51,000 l/kkg	3.7 kg/kkg	1.6 kg/kkg

Product Material Balance Summary

End Products	% of Raw Product
Products	
a) oil	6 - 8%
b) meal	20 - 21%
By-products	
a) solubles	15%
Wastes	
a) water	56 - 59%

Average Production Rate, 540 kkg/day (600 tons/day

Table 8. Fish meal production with bailwater material balance.

Wastewater Material Balance Summary

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) evaporator	>99%	17 - 48%	12 - 36%
b) bailwater	<1%	52 - 83%	64 - 88%
Total effluent average M2H, M3H	29,300 l/kkg	8 kg/kkg	5 kg/kkg

Average Production Rate, 450 kkg/day (495 tons/day)

Table 9 shows the wastewater balance summary for a fish meal plant with no solubles plant discharging stickwater and bailwater. The largest and strongest flow was the stickwater, which is theliquid remaining after the oil is recovered from the press liquor. The waste load from the stickwater is one of the strongest in the entire seafood industry, being very high in BOD, suspended solids, and grease and oil. The bailwater also contributed a relatively high flow and load.

1.4.2 Bottom Fish, Groundfish, and Miscellanious Finfish Processes

Although there are a variety of species and processing operations in the bottom fish, groundfish, and miscellanious finfish processing industry only three factors affected subcategorization: geographic location, size, and degree of mechanization (therefore, water use). The bottom fish, groundfish, and miscellaneous finfish industry was subvategorized into "Alaska" and "Non-Alaska" regions because of the greater costs and more significant treatment problems encountered in Alaska.

With respect to Non-Alaska regions, the bottom fish industry was subcategorized into "conventional" and "mechanized" processes due to the increased water and waste loads associated with the latter.

A conventional process is defined as one where the unit operations are carried out essentially by hand, requiring a relatively low volume of water. A mechanized process is defined as one where many of the unit operations are mechanized and relatively large volumes of water are used. Figure 7 shows a summary plot of the wastewater characteristics for what are considered to be high-water-use mechanized processing operations. With respect to Figure 7, codes FRH1 and FFH1

Table 9. Fish meal production (without solubles plant) material balance.

Wastewater Material Balance Summary

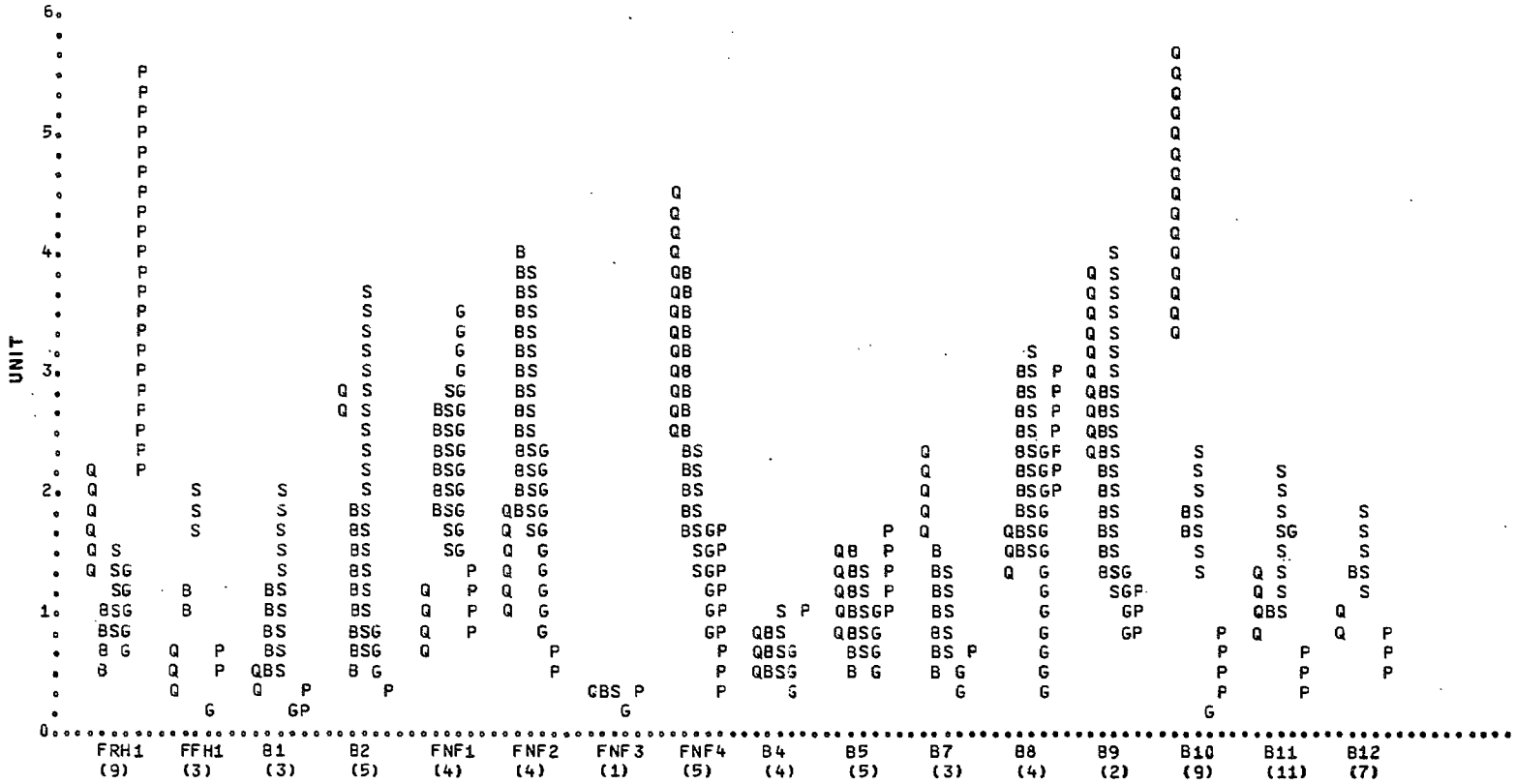
Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) stickwater	45%	93%	94%
b) bailwater	39%	7%	6%
c) washdown	1%	<1%	<1%
d) air scrubber	15%	<1%	<1%
Total effluent average A3	1870 l/kkg	71 kg/kkg	59 kg/kkg

Product Material Balance Summary

End Products	% of Raw Product
Products	
a) meal	28%
b) oil	8%
Wastes	
a) stickwater	35%
b) water vapor	29%

Average Production Rate, 187 kkg/day (207 tons/day)

Figure 7. CONVENTIONAL BOTTOM FISH PROCESS PLOT.



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 5000 L/KKG
B	5 DAY BOD	1 UNIT = 2 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 1 KG/KKG
G	GREASE AND OIL	1 UNIT = 0.5 KG/KKG
P	PRODUCTION	1 UNIT = 2 TON/HR

refer to halibut processing operations in Alaska, codes B1, 2 refer to groundfish plants in New England, codes FNF1, 2, 3, 4, to finfish plants in the Middle Atlantic and Gulf regions, and codes B4, 5, 10, 11, and 12 refer to bottom fish plants in California. With respect to Figure 8, codes W1 and N2 refer to whiting plants in New England, CFC1 to a fish flesh plant in the Gulf, and B6 and B6H to a bottom fish plant in the Northwest. Code B6H represents historical data obtained for plant B6.

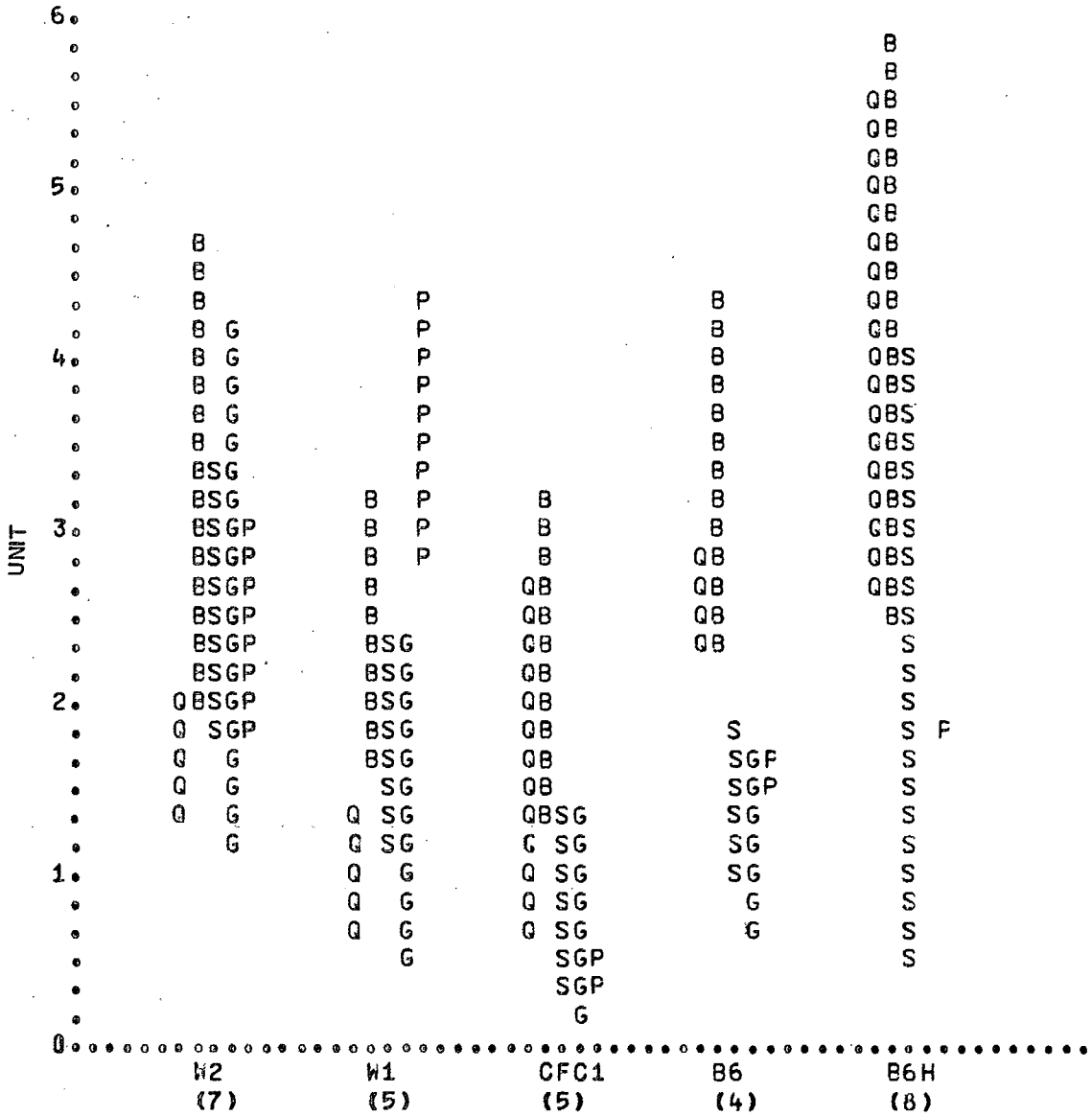
Plant sizes range widely for both the Non-Alaska conventional and mechanized portions of the industry, with the mechanized plants being larger on the average. Information on the annual production of bottom fish is limited. Based on studies conducted in the Northwest and observations made during the recent study, the following divisions were made to break the industry into approximately equal size ranges. The division between large and medium conventional plants was set at 3630 kkg (4000 tons) of raw product per year and the division between medium and small conventional plants was set at 1810 kkg (2000 tons). The division between large and small mechanized plants was set at 3630 kkg (4000 tons).

Table 10 segregates the plants investigated into the selected size ranges.

Table 10. Non-Alaska bottom fish size breakdown.

Size	Conventional	Mechanized
Large	FNF4, B8	W1, W2, B6
Medium	B5, B7, B9, FNF1, FNF2, B10, B11, B12	--
Small	B1, B2, B4, FNF3	CFC1

Figure 8 . MECHANICAL BOTTOM FISH PROCESS PLOT.



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 10000 L/KKG
B	5 DAY BOD	1 UNIT = 5 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 5 KG/KKG
G	GREASE ≤ OIL	1 UNIT = 2 KG/KKG
P	PRODUCTION	1 UNIT = 2 TCN/HR

Although some variability is evident between the plants in the conventional and mechanized subcategories (especially within the flow ratio and production parameters), the following observations can be made. The waste loads, in terms of BOD, suspended solids, and grease and oil, were four to five times greater for the mechanized operations than for the conventional operations. The highly variable flow ratios for the conventional operations were caused mainly by the different methods of washing the fish before processing. For example, the high flow ratio exhibited by plant B10 was attributable to the fact that a high velocity jet spray was used to wash the fish as they were conveyed to the processing lines. The flow ratio for plant FNF4 was also relatively higher and was caused by the use of a fish pump to unload the fish from the boats.

Since the waste loads were relatively low and uniform for all the conventional bottom fish processes, it was reasonable to place them into one subcategory. Table 11 summarizes statistics of the waste parameters for the Non-Alaska conventional bottom fish plants. Plant FNF3 was not included in the average because a small number of fish were being handled in the round on the day the sample was taken and this was not considered typical.

The plants used to represent a mechanized bottom fish process were two New England whiting plants (W1, W2), a fish flesh plant on the Gulf (CFC1), and a bottom fish plant in the Northwest (B6 and B6H). Plant B6 was included in the mechanized subcategory because it used a mechanical scaler with high velocity water jets. Since this was the only scaler of this type observed, and it contributed a high percentage of the waste load, it could not be considered to be typical. Plant CFC1 was also included in the mechanized subcategory, because mechanical beheading and eviscerating machinery was used; however, the fish flesh process is relatively new and is not typical of the rest of the industry. The waste loads from the two

Table 11. CONVENTIONAL BOTTOM FISH
PROCESS SUMMARY.

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	1.77	1.17	0.453	4.30
PROCESS TIME HR/DAY	6.91	0.770	5.50	8.30
FLOW L/SEC	4.07	3.45	0.731	13.1
(GAL/MIN)	64.4	54.7	11.6	208
FLOW RATIO L/KKG	9210	6340	2240	25700
(GAL/TON)	2210	1520	536	6160
SETT. SOLIDS ML/L	10.2	24.0	0.275	58.5
RATIO L/KKG	94.1	221	2.53	539
SCR. SOLIDS MG/L	407	404	57.0	1470
RATIO KG/KKG	3.75	3.72	0.525	13.5
SUSP. SOLIDS MG/L	189	67.8	89.8	352
RATIO KG/KKG	1.74	0.625	0.827	3.24
5 DAY BOD MG/L	354	165	135	765
RATIO KG/KKG	3.26	1.52	1.24	7.05
COD MG/L	646	271	270	1310
RATIO KG/KKG	5.95	2.50	2.49	12.1
GREASE & OIL MG/L	54.7	40.1	12.2	159
RATIO KG/KKG	0.504	0.369	0.113	1.47
ORGANIC-N MG/L	49.6	24.1	18.1	110
RATIO KG/KKG	0.457	0.222	0.166	1.01
AMMONIA-N MG/L	3.20	1.75	1.03	7.65
RATIO KG/KKG	0.029	0.016	0.010	0.070
PH	6.82	0.491	5.82	7.26
TEMP DEG C	16.5	3.64	10.3	24.3

PLANTS B1 , B2 , B4 , B5 , B7 , B8 , B9 , B10 , B11 ,
B12 , FNF1, FNF2, FNF4

whiting plants were considered to be the most representative of the mechanized segment of the industry and are summarized in Table 12.

Several conventional bottom fish processes exist, of which the filleting process is considered to be the most important. There are two main options within the filleting process; the use of skinners and/or scalers. Table 13 shows the wastewater balance for three operations (B2, B4, B8) which used skinners most of the time. Skinners are mechanical and can constitute a large percentage (13 to 64 percent) of the flow and load (6 to 36 percent of BOD), depending on the type used. The flow from the fillet tables is quite variable depending on water conservation practices. It is common practice for a small hose to be continuously running at each filleting position. Fish are sometimes rinsed before filleting or eviscerating and are usually dipped in a wash tank afterward to clean and preserve the flesh. The flows from either of these operations are relatively small; however, the BOD and suspended solids loads can be moderately high.

Table 14 presents the wastewater balance for three operations (B1, B6, B11) which commonly used a descaler. It can be seen that the descaler can contribute a substantial flow and waste load, depending on the type. The scalers which use high pressure water jets in a revolving drum can contribute a very high load. One plant, B6, at times used a scaler which increased the water flow and waste load by a factor of four. This scaler was so significant and contributed such a high waste load that it was not considered to be a conventional operation. On the average, however, the waste loads were about the same whether or not skinners or scalers were used. Flow ratios and waste loads varied significantly between plants, caused partly by different processing methods and partly by different degrees of water conservation; however, the average flows and loads from all the plants were relatively low, compared to other seafood processes.

TABLE 12. MECHANIZED BOTTOM FISH PROCESS SUMMARY

PARAMETER	MEAN	STD. DEV.	5% MIN	95% MAX
PRODUCTION TON/HR	5.91	1.69	3.28	9.83
PROCESS TIME HR/DAY	5.95	3.96	3.15	8.76
FLOW L/SEC	18.3	1.47	15.6	21.3
(GAL/MIN)	290	23.3	247	338
FLOW RATIO L/KKG	13600	4720	6600	24800
(GAL/TON)	3250	1130	1580	5950
SETT. SOLIDS ML/L	6.67	0.081	6.51	6.83
RATIO L/KKG	90.4	1.10	88.3	92.6
SCR. SOLIDS MG/L	820	16.7	788	853
RATIO KG/KKG	11.1	0.226	10.7	11.6
SUSP. SOLIDS MG/L	808	228	453	1340
RATIO KG/KKG	11.0	3.08	6.13	18.1
5 DAY BOD MG/L	1060	268	634	1680
RATIO KG/KKG	14.4	3.63	8.59	22.7
COD MG/L	2110	807	954	4070
RATIO KG/KKG	28.6	10.9	12.9	55.1
GREASE AND OIL MG/L	302	140	115	652
RATIO KG/KKG	4.10	1.90	1.56	8.84
ORGANIC-N MG/L	86.9	17.9	57.0	127
RATIO KG/KKG	1.18	0.243	0.773	1.72
AMMONIA-N MG/L	3.91	1.59	1.69	7.79
RATIO KG/KKG	0.053	0.021	0.023	0.106
PH	7.32	0.550	6.93	7.71
TEMP DEG C	19.6	--	--	19.3

Plants W1, W2

TABLE 13. CONVENTIONAL BOTTOM FISH PROCESS MATERIAL BALANCE (WITH SKINNER)

WASTEWATER MATERIAL BALANCE SUMMARY

UNIT OPERATION	% OF TOTAL FLOW	% OF TOTAL BOD	% OF TOTAL SUSP. SOLIDS
a) SKINNER	13 - 64%	6 - 36%	5 - 39%
b) FILLET TABLE	22 - 83%	43 - 76%	39 - 80%
c) PRE-RINSE OR DIP TANK	1 - 13%	7 - 26%	5 - 34%
d) WASHDOWN	3 - 21%	4 - 20%	7 - 21%
TOTAL EFFLUENT AVERAGE B2, B4, B8	8000 l/kkg	2.8 kg/kkg	1.8 kg/kkg

PRODUCT MATERIAL BALANCE SUMMARY

END PRODUCTS	% OF RAW PRODUCT
FOOD PRODUCTS	20 - 40%
BY-PRODUCTS	
a) Carcass (reduction, Animal Food)	55 - 75%

AVERAGE PRODUCTION RATE, 16.5 kkg/day (18 TONS/DAY)

Table 14. Conventional bottom fish process material balance (with descaler).

Wastewater Material Balance Summary

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) descaler	42 - 66%	56 - 61%	26 - 70%
b) fillet table	21 - 36%	16 - 30%	12 - 19%
c) pre-wash or dip tank	3 - 10%	4 - 8%	4 - 8%
d) washdown	7 - 18%	6 - 19%	7 - 18%
Total effluent average B1, B10, B11	10,000 l/kkg	2.5 kg/kkg	1.6 kg/kkg

The two whiting plants sampled (W1, W2) were considered to be typical mechanized operations where the fish were beheaded, descaled, and partially eviscerated by mechanical methods and relatively large water flows were used. The finfish process in the Gulf (CFC1) was processing croaker for fish flesh and was highly mechanized. The Northwest plant (B6) used conventional processing except for the large scaler, which produced a high waste flow.

Table 15 itemizes the wastewater sources for a typical whiting process. The process water included water from the largest source of wastewater. The largest portion of the process water was attributed to the fluming of fish from the storage bins to the processing line using a high pressure hose and elevator. The replacement of the hose by a dry conveyor system such as used in the sardine plants would reduce the waste flow and load sifnificantly. The visceral flume contributed about 20 percent of the waste load and could be replaced by a dry conveyor system.

1.4.3 Alaska Crab Process

The Alaskan crab industry is reviewed here because it includes the tanner, or snow, crab, which is quite similar to the queen crab of Eastern Canada. It is speculated that characteristics of the wastewaters generated in the processing of tanner crab in Alaska should be similar to those generated in the processing of queen crab in New Brunswick, for instance.

Subcatergorization for the Alaskan crab industry was relatively complicated. In the course of the field work it became evident that, although differences in the processes existed, the variations in wastewater flow and content noted were not significant when compared to the normal plant-to-plant and day-to-day variations within each of the process groups (canning, freezing, and sections).

The king, Dungeness and tanner crab processing industry in Alaska were however, separated from the rest of the United States for several reasons. These reasons were all based on the assumption that a subcategory should be designated whenever differences between plants would seriously affect the development of:

Table 15. Whiting freezing process material balance.

Wastewater Material Balance Summary

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) process water	70 - 75%	74 - 77%	74 - 78%
b) washdown	3 - 8%	2 - 5%	2 - 6%
c) visceral flume	22%	21%	20%
Total effluent average W1, W2	13,500 l/kkg	14 kg/kkg	11 kg/kkg

Product Material Balance Summary

End Products	% of Raw Product
Food Products	50%
By-product a) heads, scales, viscera (to reduction plant)	48%
Waste	≈ 2%

Average Production Rate, 35 kkg/day (38 tons/day)

1. treatment design configurations;
2. designation of expected effluent levels after
3. estimation of costs of treatment.

A very important item in the Alaskan crab processing industry is the plant location. In this region of the country, perhaps more than in any other, site specificity must be an over-riding concern in the development of waste management, treatment, and disposal alternatives. Most, if not all, of the king, tanner and Dungeness crab processing plant in Alaska are located south of Bristol Bay in terrain which can most aptly be described as "vertical." Virtually every plant is built on piling because of the lack of suitable real estate. Although most Alaskan crab processing plants are isolated individual facilities located remotely from population centers, a few concentrations of processing plants in populpus areas exist. The most notable one is in the city of Kodiak, Alaska, where 14 processing plants are located either on pilings, on barges, or in reconditioned (floating or grounded) ships along the Kodiak waterfront.

The fact remains, however, that the general location of the Alaskan processors in an area of limited accessibility and of inflated costs (the Army Corps of Engineers Construction Price Index lists Kodiak, as 2.5, based on a national average of 1.0) justifies the designation of a separate subcategory for these processors.

For the above reasons the Alaskan Dungeness, king and tanner crab processing industries were placed into a single subcategory.

Each of the plants sampled in Kodiak, Alaska used city water for processing and water volumes and flow rates were easily obtained from water meter readings. Plants outside of Kodiak used mostly salt water in processing except for the cooking operation which used local runoff waters.

The average total wastewater flow and the itemization per unit operation are listed in Table 16 for the section process, and in Table 17 for the combined frozen and canned meat processes without use of the grinder. This could be done since

Table 16. Material balance - Alaska tanner and king crab sections process and Alaska Dungeness crab whole cooks (without waste grinding).

Wastewater Material Balance Summary

Average Flow*, 240 cu m/day (0.058 mgd)

Unit Operation	% of Average Flow	Range, %
a) butcher	5	2 - 8
b) precook and cook	15	10 - 20
c) wash and cool	60	50 - 70
d) sort, freeze, pack	10	5 - 15
e) clean-up	10	5 - 15

Product Material Balance Summary

Average Raw Product Input Rate, 13.09 kkg/day (14.40 tons/day)

Output	% of Raw Product	Range, %
Food product	64	57 - 69
By-product	34	20 - 40
Waste	2	1 - 15

* Including clean-up water used during eight hours of processing.

Table 17. Material balance - Alaska tanner crab frozen and canned meat process (without waste grinding).

Wastewater Material Balance Summary

Average Flow*, 352 cu m/day (0.092 mgd)

Unit Opertion	% of Average Flow	Range, %
a) butcher	2	1 - 3
b) precook and cook	5	2 - 7
c) cool	20	15 - 30
d) meat extraction	37	30 - 40
e) sort, pack, freeze	11	8 - 20
f) retort **	15	-- - --
g) clean-up	10	5 - 15

Product Material Balance Summary

Average Raw Product Input Rate, 12.3 kkg/day (13.5 tons/day)

Output	% of Raw Product	Range, %
Food product	14	10 - 20
By- product	84	70 - 89
Waste	2	1 - 15

* Including clean-up water used during 8 hours of processing at the plants using fresh water.
** Canning operation only.

the grinders only operated on an intermittent basis, as the solids in the butcher area accumulated to a certain point.

The water used in the sections process (Table 16) was about 75 percent of that used in the frozen and canned meat process. Most of the water came from the washing and cooling of the sections (60 percent) and contributed a moderate amount of waste. The butcher and cooking operations contributed low flows and low-strength wastes. Most of the water in the frozen and canned meat process (Table 17) came from the meat extraction and cooling operations (57 percent) and contributed a moderate-strength waste. The butcher and cook flows were high-strength but low in volume. The pack, freeze and retort operations contributed a low-strength waste which was about 25 percent of the total volume.

Tables 18 and 19 show the water flow breakdown for the sections and combined frozen and canned meat processed when the grinder was operating to dispose of the carapaces, viscera and gills from the butcher area. It can be seen that the water flow increased about 50 percent for the sections process and 25 percent for the frozen and canned meat processes. A typical grinder used 170-225 l/min (45-60 gal/min). Most plants processing sections used only one grinder while almost all frozen and canned meat operations used two.

Table 20 lists the combined averages obtained for the total Alaska crab industry with grinders. The operation of the grinders required an increase in water use of about 66 percent and the waste loads were increased by a factor of about 5 on a unit product basis. Tables 21 and 22 show the combined section and the combined freezing and canning process respectively; it can be seen that the freezing and canning processes used more water and had higher waste loads than the section processes. The reason for this is that much more solid waste is generated in the freezing and canning process and there is typically one grinder in the butcher area and one grinder

Table 18. Material balance - Alaska tanner and king crab sections process (with waste grinding).

Wastewater Material Balance Summary

Average Flow*, 360 cu m/day (0.086 mgd)

Unit Operation	% of Average Flow	Range %
a) butcher and grinding	26	15 - 40
b) precook and cook	19	15 - 25
c) wash and cool	36	20 - 50
d) sort, pack, freeze	9	5 - 12
e) clean-up	10	15 - 20

Product Material Balance Summary

Average Raw Product Input rate, 13.1 kkg/day (14.4 tons/day)

Output	% of Raw Product	Range, %
Food product	64	57 - 69
By-product	21	15 - 30
Waste	15	10 - 30

* Including clean-up water during eight hours of processing

Table 19. Material balance - Alaska tanner crab frozen and canned meat process (with waste grinding).

Wastewater Material Balance Summary

Average Flow*, 439 cu m/day (0.116 mgd)

Unit Operation	% of Average Flow	Range, %
a) butcher and grinding	30	25 - 45
b) precook and cook	3	1 - 5
c) coll	6	2 - 9
d) meat extraction	34	30 - 40
e) sort, pack, freeze	7	5 - 10
f) retort**	10	5 - 15
g) clean-up	10	8 - 15

Product Material Balance Summary

Average Raw Product Input Rate, 8.4 kkg/day (9.25 tons/day)

Output	% of Raw Product	Range, %
Food product	14	10 - 20
By-product	66	50 - 75
Waste	20	10 - 30

* Including clean-up water during 8 hours of processing.
** Canning operation only.

Table 20. Alaska crab process summary (8 plants) with grinding

Parameter	Mean	Standard Deviation	Coefficient of Variation (% of mean)	Range
Flow Rate, cu m/day[1]	366	103	28	156 - 507
(mgd)	(0.096)	(0.027)	(28)	(0.041 - 0.134)
Flow Ratio, l/kkg[2]	40,340	21,040	52	17,600 - 85,500
(gal/ton)	(9670)	(5060)	(52)	(4220 - 20,500)
Settleable Solids, ml/l	15.6	16.9	103	1.4 - 43.7
Settleable Solids Ratio, l/kkg	412	613	148	46.1 - 1820
Screened Solids, mg/l	16,500	20,770	125	807 - 29,400
Screened Solids Ratio, kg/kkg	580	372	64	28 - 1220
Suspended Solids, mg/l	1030	1140	110	201 - 1630
Suspended Solids Ratio, kg/kkg	38	20	53	20 - 67
5 day BOD, mg/l	1480	1656	112	627 - 2520
5 day BOD Ratio, kg/kkg	51	20	39	22 - 89
20 day BOD, mg/l[3]	2160	1470	68	763 - 4390
20 day BOD Ratio, kg/kkg	101	133	131	31 - 230
COD, mg/l	2440	1225	50	954 - 4540
COD Ratio, kg/kkg	84	32	38	34 - 142
Grease and Oil, mg/l	345	241	70	79 - 754
Grease and Oil Ratio, kg/kkg	13	11	85	4 - 31
Organic Nitrogen, mg/l	217	101	47	92 - 350
Organic Nitrogen Ratio, kg/kkg	7.6	3.4	44	3 - 13
Ammonia-N, mg/l	5.7	2.7	47	2.1 - 8.7
Ammonia-N Ratio, kg/kkg	0.22	0.09	43	0.09 - 0.35
pH[4]	7.5	0.38	5	7.1 - 7.9

1 day = 8 hrs
2 weight of raw product
3 based on seven observations
4 based on five observations

Table 21. Alaska crab section process summary with grinding (4 plants)

Parameter	Mean	Standard Deviation	Coefficient of Variation (% of mean)	Range
Flow Rate, cu m/day[1]	330	124	37	156 - 439
(mgd)	(0.088)	(0.033)	(37)	(0.041 - 0.116)
Flow Ratio, l/kkg[2]	29,000	12,260	42	17,600 - 43,400
(gal/ton)	(6970)	(2940)	(42)	(4220 - 10.400)
Settleable Solids, ml/l	16	17	107	1.4 - 37.7
Settleable Solids Ratio, l/kkg	245	342	139	46 - 754
Screened Solids, mg/l	13,900	12,070	87	807 - 27,000
Screened Solids Ratio, kg/kkg	307	198	65	28 - 474
Suspended Solids, mg/l	904	597	66	201 - 1600
Suspended Solids Ratio, kg/kkg	22	12	55	7 - 32
5 day BOD, mg/l	1525	1930	126	627 - 2520
5 day BOD Ratio, kg/kkg	36	10.5	29	22 - 44
20 day BOD, mg/l[3]	1590	1327	83	781 - 3130
20 day BOD Ratio, kg/kkg	42	19	45	31 - 63
COD, mg/l	2620	1560	60	954 - 4540
COD Ratio, kg/kkg	64	22.3	35	34 - 80
Grease and Oil, mg/l	304	152	50	79 - 400
Grease and Oil Ratio, kg/kkg	8	5.5	69	3 - 15
Organic Nitrogen, mg/l	205	115	56	92 - 350
Organic Nitrogen Ratio, kg/kkg	5	1.6	33	3.3 - 6.0
Ammonia-N, mg/l	5.8	3.1	54	2.5 - 8.7
Ammonia-N Ratio, kg/kkg	0.18	0.19	105	0.09 - 0.30
pH[4]	7.3	--	--	7.1 - 7.5

1 day = 8 hrs
2 weight of raw product
3 based on three observations
4 based on two observations

Table 22. Alaska Crab Frozen & Canned Meat Process Summary without grinding (4 plants)

Parameter	Mean	Standard Deviation	Coefficient of Variation (% of mean)	Range
Flow Rate, cu m/day[1]	400	69.1	17	322 - 507
(mgd)	(0.106)	(0.018)	(17)	(0.085 - 0.134)
Flow Ratio, l/kkg[2]	51,700	56,600	110	32,800 - 85,500
(gal/ton)	(12,400)	(13,580)	(110)	(7870 - 20,500)
Settleable Solids, ml/l	15.3	19.2	125	1.8 - 43.7
Settleable Solids Ratio, l/kkg	580	829	143	78 - 1820
Screened Solids, mg/l	19,180	10,600	56	9000 - 29,400
Screened Solids Ratio, kg/kkg	853	289	34	517 - 1220
Suspended Solids, mg/l	1158	424	37	661 - 1630
Suspended Solids Ratio, kg/kkg	54	11.4	21	45 - 67
5 day BOD, mg/l	1434	630	44	656 - 2160
5 day BOD Ratio, kg/kkg	66	1.7	3	54 - 89
20 day BOD, mg/l[3]	2590	1602	62	1280 - 4390
20 day BOD Ratio, kg/kkg	144	75	52	60 - 230
COD, mg/l	2262	983	43	1140 - 3450
COD Ratio, kg/kkg	104	26.5	25	86 - 142
Grease and Oil, mg/l	387	329	85	86 - 754
Grease and Oil Ratio, kg/kkg	18	13.7	77	4 - 31
Organic Nitrogen, mg/l	230	99	43	97 - 320
Organic Nitrogen Ratio, kg/kkg	10	3.3	33	8 - 13
Ammonia-N, mg/l	5.6	2.8	50	2.1 - 8.7
Ammonia-N Ratio, kg/kkg	0.26	0.08	31	0.2 - 0.35
pH	7.6	0.81	0.11	7.3 - 7.9

1 day = 8 hrs
2 weight of raw product
3 based on three observations

in the meat separation area while in the section process, there is just one grinder in the butcher area.

1.4.4 West Coast Crab Process

The West Coast crab process data are included here because the cost and physical climates on the U.S. West Coast probably more nearly approximate those of Eastern Canada than do those of Alaska. Thus, although the predominant species processed in Washington, Oregon and (to a limited extent) California is the Dungeness crab, the design and cost data presented later in this paper for the West Coast would be more applicable to the Eastern Canadian queen crab industry than those for Alaska.

Subcategorization for the Oregon, Washington, and California tanner and Dungeness crab processing industry was developed following much of reasoning outlined in the discussion of the Alaskan crab industry.

The major differences between the two regions' processing industries were geographical, with one exception: the use of the brine tank in the "lower 48," compared to its general exclusion in Alaska.

The geographical reasons alluded to above, of course, included considerations of climate, topography, relative isolation of the processing plants, land availability, soil conditions, and availability of unlimited water. All of these aspects then, together with significant difference in wastewater characteristics (chloride) between the two regions, prompted designation of different subcategories for the Alaskan industry versus the Oregon, Washington, and California tanner and Dungeness crab processing industry.

Table 23 lists the average waste loads without fluming for all three plants sampled. These values were influenced by both whole cook and meat picking processes; however, the meat picking process was by far the largest operation. The

Table 23. West Coast Dungeness crab process summary without shell fluming (3 plants).

Parameter	Mean	Standard Deviation	Coefficient of Variation (% of mean)	Range
Flow Rate[3], cu m/day[1]	55	--	--	-- - --
(mgd)	(0.014)	(--)	(--)	(-- - --)
Flow Ratio[4], l/kkg[2]	19100	3870	20	15,000 - 21300
(gal/ton)	(4580)	(670)	(15)	(3560 - 5110)
Settleable Solids, ml/l	84	12	14	70 - 92
Settleable Solids Ratio, l/kkg	1604	447	28	1470 - 1960
Screened Solids, mg/l	--	--	--	-- - --
Screened Solids Ratio, kg/kkg	--	--	--	-- - --
Suspended Solids, mg/l	146	26	18	122 - 177
Suspended Solids Ratio, kg/kkg	2.7	0.5	20	2.6 - 2.9
5 day BOD, mg/l	412	143	35	319 - 505
5 day BOD Ratio, kg/kkg	8.0	5.1	2.2	6.6 - 10.6
20 day BOD, mg/l	--	--	--	-- - --
20 day BOD Ratio, kg/kkg	--	--	--	-- - --
COD, mg/l	609	122	20	516 - 740
COD Ratio, kg/kkg	11.3	1.6	14	11.0 - 12.0
Grease and Oil, mg/l	--	--	--	-- - --
Grease and Oil Ratio, kg/kkg	--	--	--	-- - --
Organic Nitrogen, mg/l	86	12	14	68 - 95
Organic Nitrogen Ratio, kg/kkg	1.61	0.35	22	1.41 - 1.99
Ammonia-N, mg/l	5.6	1.9	33	4.0 - 7.0
Ammonia-N Ratio, kg/kkg	0.10	0.04	45	0.075 - 0.14
pH	7.4	0.5	7	7.3 - 7.7

1 day = 8 hrs
2 weight of raw product
3 two values
4 five values

time-averaged waste load characteristics of a typical plant would be similar to that generated by the meat picking process alone.

All of the plants sampled followed the same general processing steps except for two unit operations. The first variation was in the bleed-rinse step. After the crab were butchered the pieces were either conveyed via belt below a water spray or packed into large steel baskets and submerged in circulating rinse water. In either case a continuous wastewater flow resulted. There were no appreciable differences in the characteristics of the waste streams from each method. The second variation in processing was the cooling method employed following cooking. Some plants employed a spray cool and others submerged a steel basket containing the crabs in circulating rinse water. The waste characteristics were unaffected by the cooling method.

Table 24 itemizes the flow from each unit operation as a percentage of the total flow without fluming. The total average flow observed for the three processes was about 120 cu m/day (0.032 mgd). The only water from the butcher area was washdown and contributed a relatively low flow and waste load. The cooking flow was low in volume but high in strength. The flow from the bleeding area was moderate and contributed relatively little waste. The cooling waster contributed a large flow but very little waste. The major source of waste came from the brining operation which produced a high salt load.

The use of fluming to remove solids from the butchering and meat picking area increased the water flow by about 70 percent and produced a moderately high waste load.

1.4.5 West Coast Shrimp

Subcategorization for the shrimp industry was relatively complicated. The wastewater characteristics of the

Table 24. Oregon Dungeness crab whole and fresh-frozen meat process (without fluming wastes).

Wastewater Material Balance Summary

Average Flow*, 120 cu m/day (0.032 mgd)

Unit Operation	% of Average Flow	Range, %
a) butcher (clean-up	8	4 - 11
b) bleed rinse	25	12 - 30
c) cook	3	2 - 4
d) cool	30	26 - 33
e) pick (clean-up)	7	5 - 8
f) brine and rinse	27	18 - 34

Product Material Balance Summary

Average Raw Product Input Rate, 6.3 kkg/day (7.0 tons/day)

Output	% of Raw Product	Range, %
Food product	22	17 - 27
By-product	63	50 - 66
Waste	15	7 - 23

* Including clean-up water

shrimp processed in the Maritimes probably most closely approximate those of the shrimp processed in the New England area. The studies by Environmental Associates (1973), furthermore, indicated that the wastewater characteristics from the processing of New England shrimp were similar to those from the processing of West Coast shrimp. Therefore, the data from this area are included herein.

In the course of the field work it became evident that, although differences in the processes existed, the variations in wastewater flow and content were not significant when compared to the normal plant-to-plant and day-to-day variations within each of the processes. The major difference between the larger Gulf of Mexico and South Atlantic shrimp and the smaller West Coast and New England varieties are due to geography and species diversity.

Manufacturing processes and subprocesses, form and quality of finished product, and nature of operation showed variations between the canning processes and breading processes. Analysis of the sample data indicated that the West Coast canning process, the Gulf Coast canning processes and the breaded shrimp processes were each dissimilar enough so they should be considered separately.

Table 25 itemizes the water use by unit operation for a typical West Coast shrimp process. The two plants studied were located either over water or partially over water, with liquid wastes being discharged directly into adjacent waterways. The average plant flow was 472 cu m/day (0.125 mgd). The largest percentage of this flow (61 percent) was attributed to the mechanical peelers. Water used in these plants for production was all city water. Due to the use of a large number of peelers the flow from Plant #2 (five peelers) was twice as large as that from Plant #1 (two peelers). Plant #2 used PCA peelers, which blanch the shrimp prior to peeling; Plant #1 used the Model A peeler, which may be followed by blanching. Plant #2 recycled approcimately 10 percent

Table 25. Material balance - West Coast shrimp canning process

Wastewater Material Balance Summary

Average Flow*, 472 cu m/day (0.125 mgd)

Unit Operation	% of Average Flow	Range, %
a) de-icing tanks	5.8	3.7 - 7.8
b) peelers (PCA & Model A)	61.5	57.1 - 77.5
c) washer & separator	11.9	10.1 - 12.8
d) blancher	1.6	1.2 - 2.1
e) grading line	1.7	1.5 - 1.8
f) can washer	3.5	0.002 - 6.3
g) retort & colling	5.2	3.6 - 6.8
h) washdown	8.8	4.2 - 9.5

Product Material Balance Summary

Average Raw Product Input Rate, 9.0 kkg/day (9.9 tons/day)

Out put	% of Raw Product	Range, %
Food Product	15	12 - 18
By-product	70	65 - 75
Waste	15	12 - 17

* Including clean-up water

of the total water flow. The water from the separators and washers was used to flume the incoming shrimp to the peelers.

West Coast shrimp (Table 25) are not beheaded at sea; the only preprocessing done is to remove most of the debris and trash fish from the catch. The debris and miscellaneous fish comprise between 3 and 8 percent of the raw weight of the freshly caught shrimp. The average raw product input was about 9.0 kkg/day (10 tons/day) with the average shift length being 9 hours. The percent of raw product utilized for food averaged about 15 percent (Table 25). The shrimp product, when it arrived at the plants, had seldom been held more than three days. The older shrimp were processed first, and from qualitative observations there seemed to be a definite correlation between shrimp age and amount of waste produced. A difference in waste strength was anticipated because of the strong enzymatic action (degradation) of shrimp as a function of time. However, due to the plants processing different ages of shrimp on the same days, the effect of age on wastewater strength could not be determined from the data. The solid wastes which could be utilized for by-product totaled about 70 percent of the input. These were captured either by vibrating screens or trommel screens. In many cases the wastes were transported by truck to a rendering plant, where they were dried and added to fertilizers or used as supplements to various feeds low in calcium.

Table 57 summarizes the wastewater characteristics from the two West Coast processors sampled. The PCA peeler process had a higher flow but lower waste load than the Model A peeler.

1.4.6 Oyster Processes

The only factors which were considered to affect subcategorization within the oyster industry were degree of mechanization and plant size. Figure 9 is a summary plot of the

wastewater statistics for all the oyster processes sampled. Plants represented by codes HS01 and HS06 were East Coast hand-shucked oyster operations; plants represented by codes HS08 through HS11 were West Coast hand-shucked oyster operations; codes S01 and S02 represent steamed oyster processes; code C01 represents a West Coast canned oyster operation; and C02, a West Coast canned oyster stew operation. It should be noted that the production is listed in terms of the oyster meat after shucking. The reason for this is that the measurement of final product in this case is much more accurate, due to variable amounts of loose or empty shells coming into the plant.

It was noted that the waste loads from the steamed and canned oyster processes were higher than those from the hand-shucked operations. Therefore, it was decided that the oyster industry be subcategorized into conventional hand-shucked oyster processes and the more mechanized steamed or canned oyster processes.

Table 26 summarizes statistics from the steamed and canned oyster plants sampled.

It appears that the waste loads from the West Coast hand-shucked oyster processes were a little higher than those from the East Coast processes. It was not considered necessary to further divide the hand-shucked oyster subcategory, however, since the total waste loads per day were quite small. The average Pacific Coast oyster plant only produces about 30 kg of BOD/day, which is very low when compared to other seafood commodities. Table 27 shows summary statistics from the Pacific hand-shucked oyster plants sampled.

Since the size range of the hand-shucked oyster industry is quite large, it was divided into three size groups for the purpose of determining treatment costs of a typical plant. Based on investigations made in the field the large and medium size ranges were divided at 300 tons of finished product per year, and the medium and small ranges at 150

Table 26. STEAMED OR CANNED OYSTER PROCESS SUMMARY.

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	0.679	0.349	0.234	1.56
PROCESS TIME HR/DAY	7.12	1.15	5.50	8.19
FLOW L/SEC	10.7	5.46	3.75	24.5
(GAL/MIN)	170	86.5	59.4	388
FLOW RATIO L/KKG	70200	10300	52200	92400
(GAL/TON)	16800	2460	12500	22100
SETT. SOLIDS ML/L	6.85	3.72	2.22	16.3
RATIO L/KKG	481	261	156	1150
SCR. SOLIDS MG/L	1450	1660	158	5720
RATIO KG/KKG	101	116	11.1	401
SUSP. SOLIDS MG/L	1110	952	198	3610
RATIO KG/KKG	78.1	66.0	13.9	254
5 DAY BOD MG/L	565	170	303	964
RATIO KG/KKG	39.7	12.0	21.3	67.7
COD MG/L	1040	137	799	1330
RATIO KG/KKG	73.1	9.59	56.1	93.5
GREASE & OIL MG/L	27.0	20.6	5.70	81.1
RATIO KG/KKG	1.90	1.45	0.400	5.69
ORGANIC-N MG/L	72.3	17.6	43.9	112
RATIO KG/KKG	5.08	1.23	3.08	7.39
AMMONIA-N MG/L	3.38	1.05	1.79	5.35
RATIO KG/KKG	0.238	0.073	0.126	0.410
PH	6.94	0.150	6.78	7.17
TEMP DEG C	15.0	5.75	10.00	20.1

PLANTS S01 , S02 , C01 , C02

Table 27. HAND SHUCKED OYSTERS
PROCESS SUMMARY.

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	0.178	0.146	0.034	0.561
PROCESS TIME HR/DAY	7.06	1.56	4.75	8.00
FLOW L/SEC	1.70	1.05	0.473	4.40
(GAL/MIN)	26.9	16.6	7.50	69.3
FLOW RATIO L/KKG	40600	11600	22500	67600
(GAL/TON)	9730	2780	5400	16200
SETT. SOLIDS ML/L	2.57	1.35	0.865	5.39
RATIO L/KKG	104	54.9	35.1	243
SCR. SOLIDS MG/L	302	195	79.9	808
RATIO KG/KKG	12.3	7.93	3.25	32.3
SUSP. SOLIDS MG/L	634	315	226	1430
RATIO KG/KKG	25.7	12.8	9.17	57.3
5 DAY BOD MG/L	616	78.2	477	783
RATIO KG/KKG	25.0	3.18	19.4	31.3
COD MG/L	1210	162	921	1550
RATIO KG/KKG	49.0	6.57	37.4	63.1
GREASE & OIL MG/L	36.6	6.96	24.9	52.0
RATIO KG/KKG	1.49	0.283	1.01	2.11
ORGANIC-N MG/L	154	63.2	65.5	309
RATIO KG/KKG	6.24	2.57	2.66	12.5
AMMONIA-N MG/L	2.61	0.565	1.68	3.38
RATIO KG/KKG	0.106	0.023	0.068	0.158
PH	6.82	0.155	6.66	7.00
TEMP DEG C	7.99	4.01	1.97	10.00

PLANTS HS05, HS09, HS10, HS11

tons of finished product per year.

Table 28 shows the wastewater balance for a typical steamed oyster process. It was noted that a large portion of the flow and load is caused by the washdown at these plants. The largest flow comes from the culler and shocker which is used to clean and partially open the shell before steam cooking; however, the BOD load is relatively small.

Table 29 shows the wastewater balance for typical East and West Coast hand-shucked oyster processes. It can be seen that the two sources of water are the blow tanks and the washdowns. The blow tanks, which are used to wash and add water to the product, are the major sources of wastewater and BOD loads. The washdowns can be a major source of suspended solids from the fine pieces of sand which are on or in the oyster shells.

In general, the wastewater loads were higher at the West Coast plants than the East Coast plants. The reason for this appears to be the difference in the type of oysters processed and the flows used. The West Coast plants typically use more water than the East Coast plants in washing the product. One plant on the East Coast (HS05) breaded the oysters after shucking. This operation was found to contribute about 50 percent of the BOD load at that plant; however, the overall load was about average, due to water conservation (see Table 30).

Table 28. Steamed oyster process material balance.

Wastewater Material Balance Summary

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solis
a) belt washer	11%	10%	63%
b) shocker	43%	9%	26%
c) shucker	15%	11%	1%
d) blow tanks	7%	6%	<1%
e) washdown	23%	64%	10%
Total effluent average SO2	66.500 l/kkg	30 kg/kkg	137 kg/kkg

Average Production Rate, 6.8 kkg/day (7.5 tons/day) (production for the oyster processes is measured in terms of final product).

Table 29. Hand shucked oyster process material balance.

Wastewater Material Balance Summary--East Coast

Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) blow tank	71 - 94%	81 - 94%	11 - 58%
b) washdown	6 - 29%	6 - 19%	42 - 89%
Total effluent average	37,000 l/kkg	14 kg/kkg	11 kg/kkg

Wastewater Material Balance Summary--West Coast

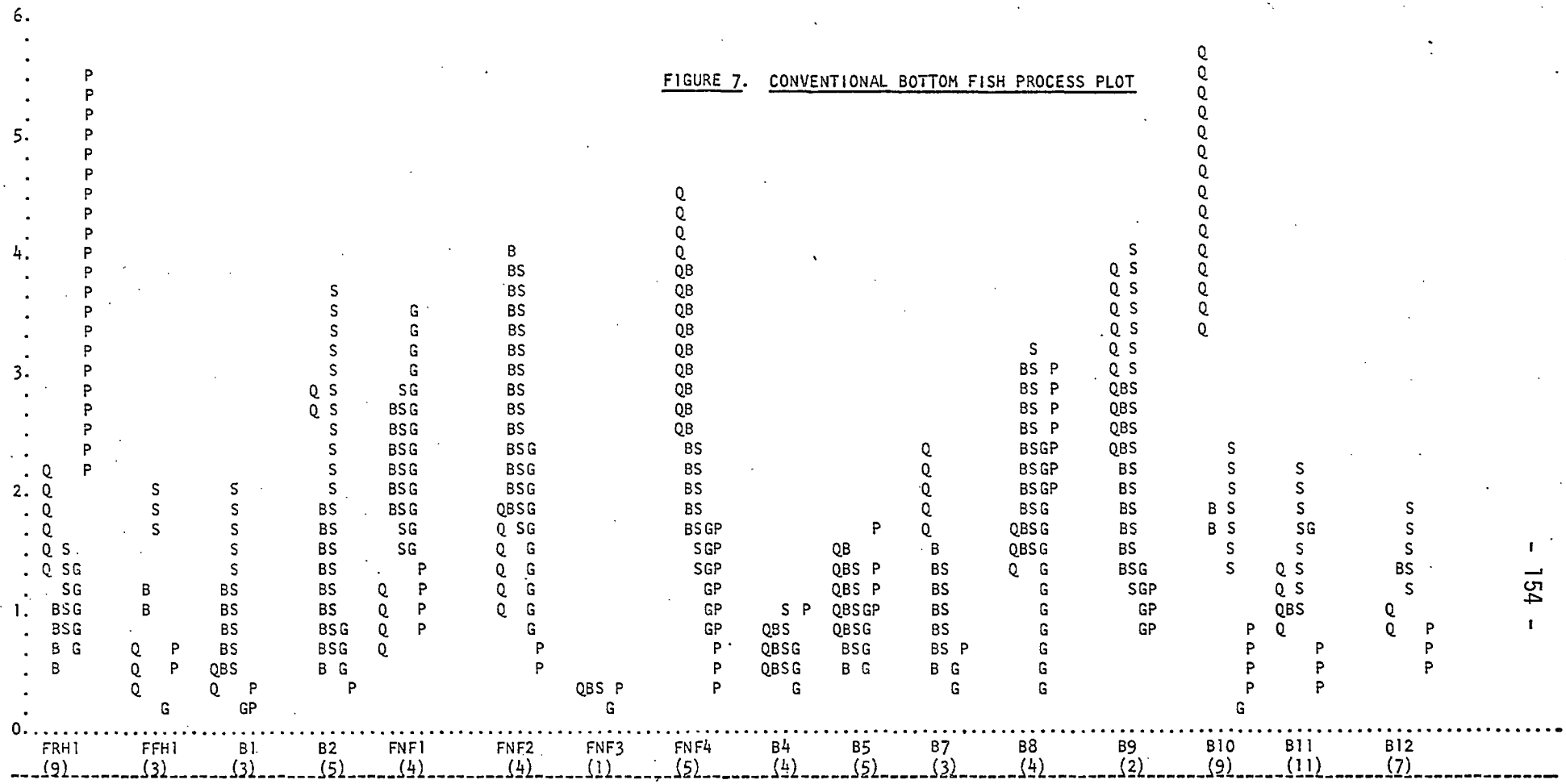
Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) blow tank	45 - 68%	83 - 95%	24 - 75%
b) washdown	32 - 55%	5 - 17%	25 - 76%
Total effluent avrage	41,000 l/kkg	25 kg/kkg	26 kg/kkg

Table 30. Breaded oyster process material balance.

Wastewater Material Balance Summary

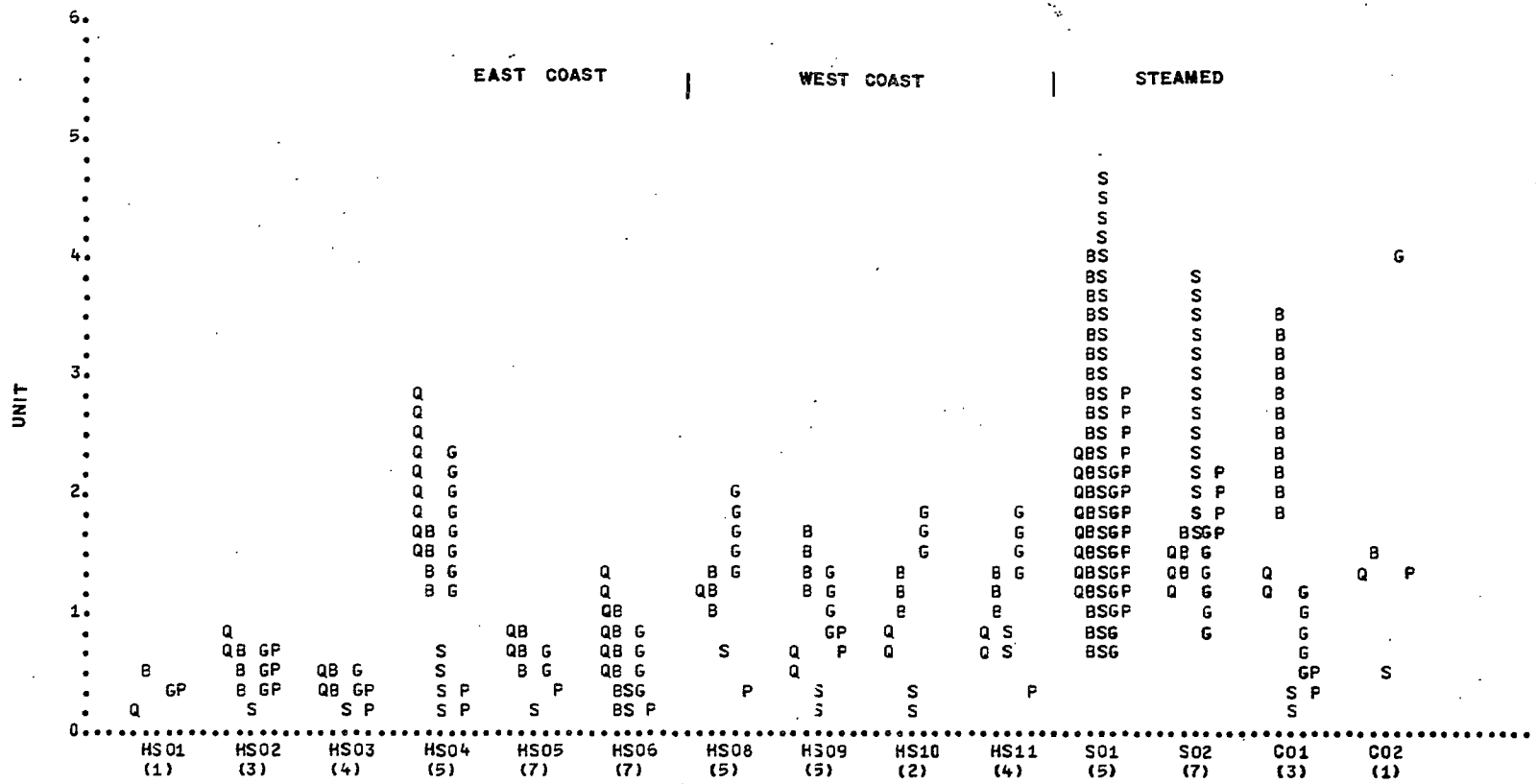
Unit Operation	% of Total Flow	% of Total BOD	% of Total Susp. Solids
a) blow tank	71%	38%	8%
b) breading	9%	50%	8%
c) washdown	20%	12%	84%
Total effluent average HSO5	37,000 l/kkg	14 kg/kkg	11 kg/kkg

FIGURE 7. CONVENTIONAL BOTTOM FISH PROCESS PLOT



SYMBOL	PARAMETER	SCALING FACTOR	
Q	FLOW	1 UNIT	5000 L/KKG
B	5 DAY BOD	1 UNIT	2 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT	1 KG/KKG
G	GREASE AND OIL	1 UNIT	0.5 KG/KKG
P	PRODUCTION	1 UNIT	2 TON/HR

Figure 9. FRESH/FROZEN, STEAMED, OR CANNED OYSTER PROCESS PLOT.



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 50000 L/KKG
B	5 DAY BOD	1 UNIT = 20 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 50 KG/KKG
G	GREASE AND OIL	1 UNIT = 1 KG/KKG
P	PRODUCTION	1 UNIT = 0.5 TON/HR

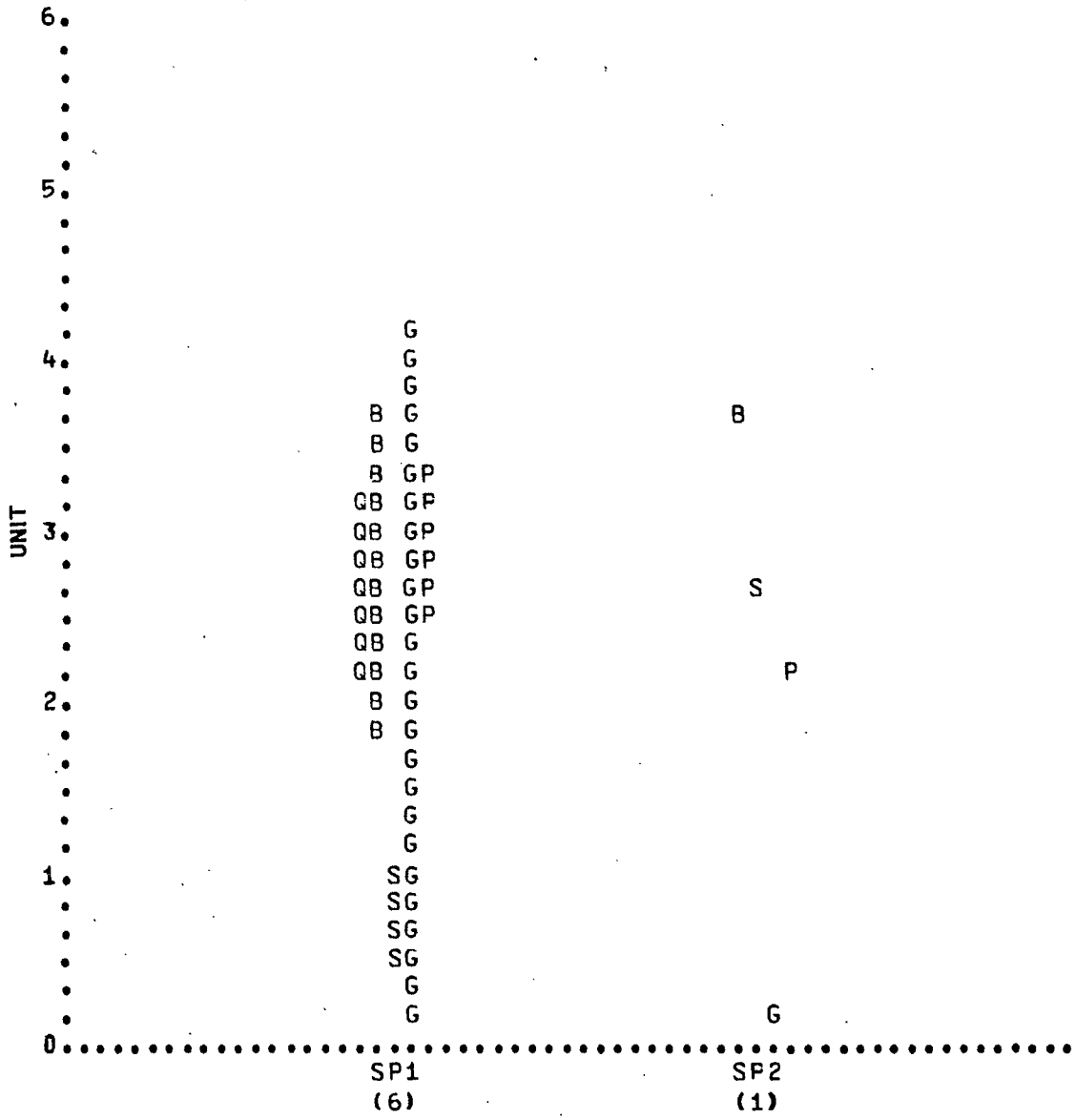
1.4.7 Scallop Process

The only factor which was considered to influence subcategorization of the scallop industry (excluding calico scallops) was geographic location, since the processing operations are essentially the same. It was determined that the processing operations in Alaska should be separated from those outside of Alaska because of greater costs. Figure 10 shows a summary plot of the wastewater characteristics of two scallop processes in Alaska. It was noted that the flows and waste loads were minimal. Table 31 shows the average values of the wastewater parameters for the two plants. There are no data for non-Alaska operations, since the two Alaska plants were the only ones sampled. Other plants were observed in the Middle Atlantic region using essentially the same process; therefore, it should be a good assumption that the waste loads would be similar.

Both plants sampled used chlorinated municipal water supplies, derived from reservoirs and deep wells. The only wastewater produced was in the washing operation; however, each plant sampled had a different method. Plant SP1 used a two-stage continuous flow washing system in which a large volume of fresh water was used. Plant SP2 used a non-flowing brine tank which was dumped approximately every eight hours. The effluent was discharged to the receiving water at one plant and to the municipal sewer system at the other plant.

Production rates for the two plants were similar, averaging about 9 kkg/day (10 tons/day) of finished product. Production rates for the scallops were recorded in terms of finished product since they are shelled and eviscerated at sea. The yield is nearly 100 percent since the only wastes produced are small scallop pieces not suitable for freezing, solid waste removed during the inspection, and small amounts of dissolved organic matter.

Figure 10. **ALASKAN SCALLOP PROCESS PLOT.**



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 5000 L/KKG
B	5 DAY BOD	1 UNIT = 1 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 0.5 KG/KKG
G	GREASE ≤ OIL	1 UNIT = 0.1 KG/KKG
P	PRODUCTION	1 UNIT = 0.5 TON/HR

Table 31. ALASKAN SCALLOP PROCESS SUMMARY.

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	1.27	0.302	0.776	1.35
PROCESS TIME HR/DAY	8.63	4.05	5.77	11.5
FLOW L/SEC	2.55	3.48	0.202	11.3
(GAL/MIN)	40.4	55.2	3.20	178
FLOW RATIO L/KKG	6990	9410	569	30600
(GAL/TON)	1680	2260	136	7330
SETT. SOLIDS ML/L	0.903	0.910	0.123	3.28
RATIO L/KKG	6.31	6.36	0.862	22.9
SCR. SOLIDS MG/L	874	--	--	--
RATIO KG/KKG	6.11	--	--	--
SUSP. SOLIDS MG/L	122	98.8	23.5	381
RATIO KG/KKG	0.851	0.691	0.164	2.66
5 DAY BOD MG/L	453	90.7	301	655
RATIO KG/KKG	3.17	0.635	2.10	4.58
COD MG/L	587	57.2	482	707
RATIO KG/KKG	4.10	0.400	3.37	4.94
GREASE & OIL MG/L	15.5	20.1	1.34	66.2
RATIO KG/KKG	0.108	0.141	0.009	0.463
ORGANIC-N MG/L	97.1	18.7	65.5	139
RATIO KG/KKG	0.679	0.131	0.458	0.970
AMMONIA-N MG/L	4.50	1.09	2.74	6.99
RATIO KG/KKG	0.032	0.008	0.019	0.049
PH	6.58	0.397	6.30	6.86
TEMP DEG C	8.33	3.93	5.56	11.1

PLANTS SP1 , SP2

1.4.8 Lobster Process

The American lobster industry essentially involves holding and shipping operations. The holding operation contributes little or no waste load, as can be seen from Figure 11 which shows the intake and discharge from holding tanks at two plants. Codes L1I and L2I represent the characteristics of the intake water at plants L1 and L2, respectively; while codes L1 and L2 represent the discharge from the holding tanks at these two plants. It can be seen that the discharge was essentially the same as the intake with the exception of the grease and oil levels (plant L1). This indicates that there was little or no contaminant discharge from the holding tanks. It was determined that American lobster plants which boil the product for the fresh market be included with the spiny lobster process as a subcategory.

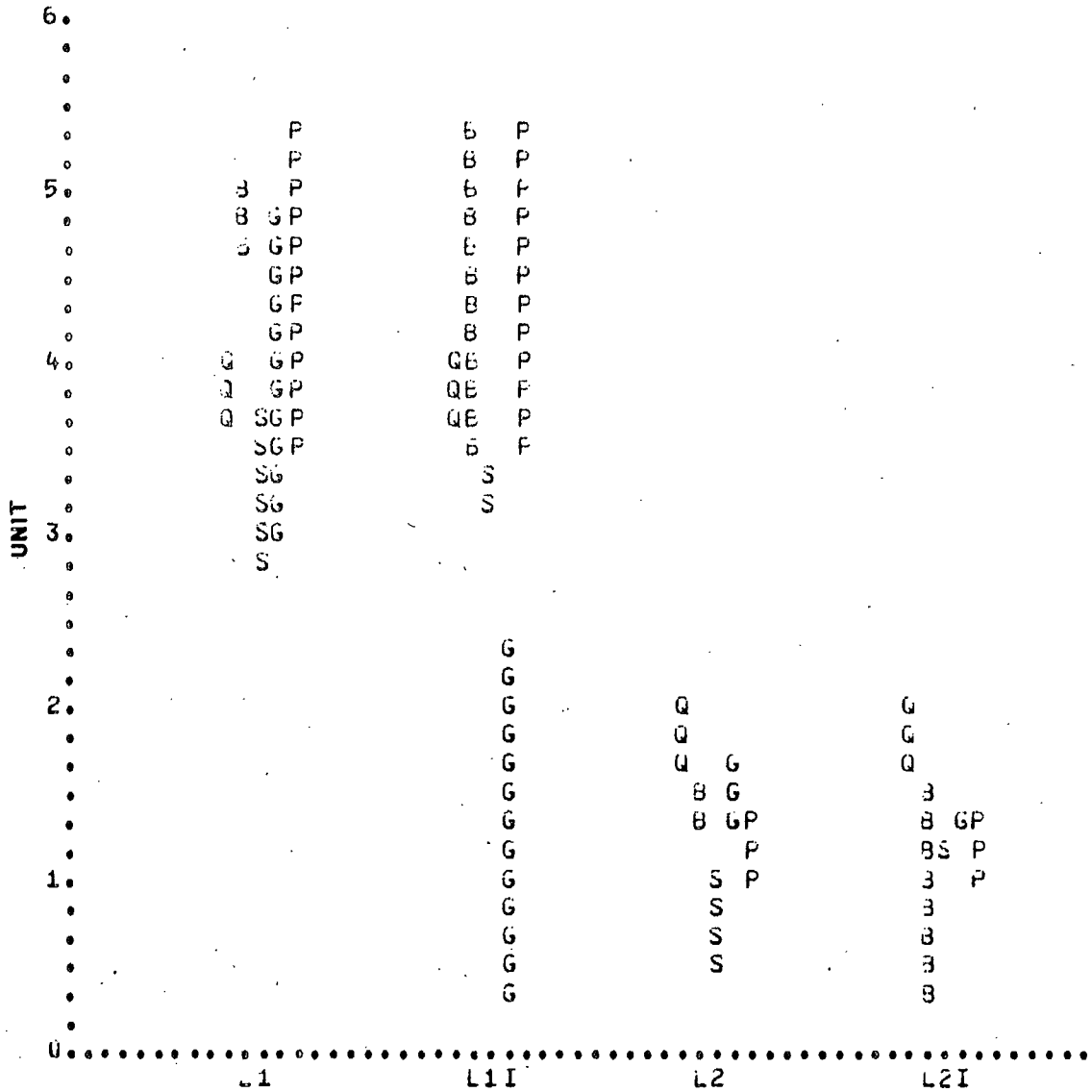
Figure 12 summarizes the characteristics of the wastewaters from two spiny lobster plants sampled in the Southern California area. It was noted that the flow and loads were relatively low per unit of production. Table 32 summarizes the characteristics from the two spiny lobster plants sampled. These values were used as the typical raw waste loads from cooked lobster processes.

The American lobster requires considerable volumes of sea water to sustain life in the holding tanks. These waters are pumped from the local estuary or harbor to live holding tanks which are stacked in tiers such that the overflow from the top tank flows into the next lower tank. When the water leaves the last set of tanks, it is discharged directly back to the receiving water.

The higher COD loadings can be attributed to the saline nature of the process waters. The average discharge BOD loading was 0.6 kg/kkg; however, by comparing the discharge with intake, the BOD loadings added by the holding tanks averaged only 0.1 kg/kkg.

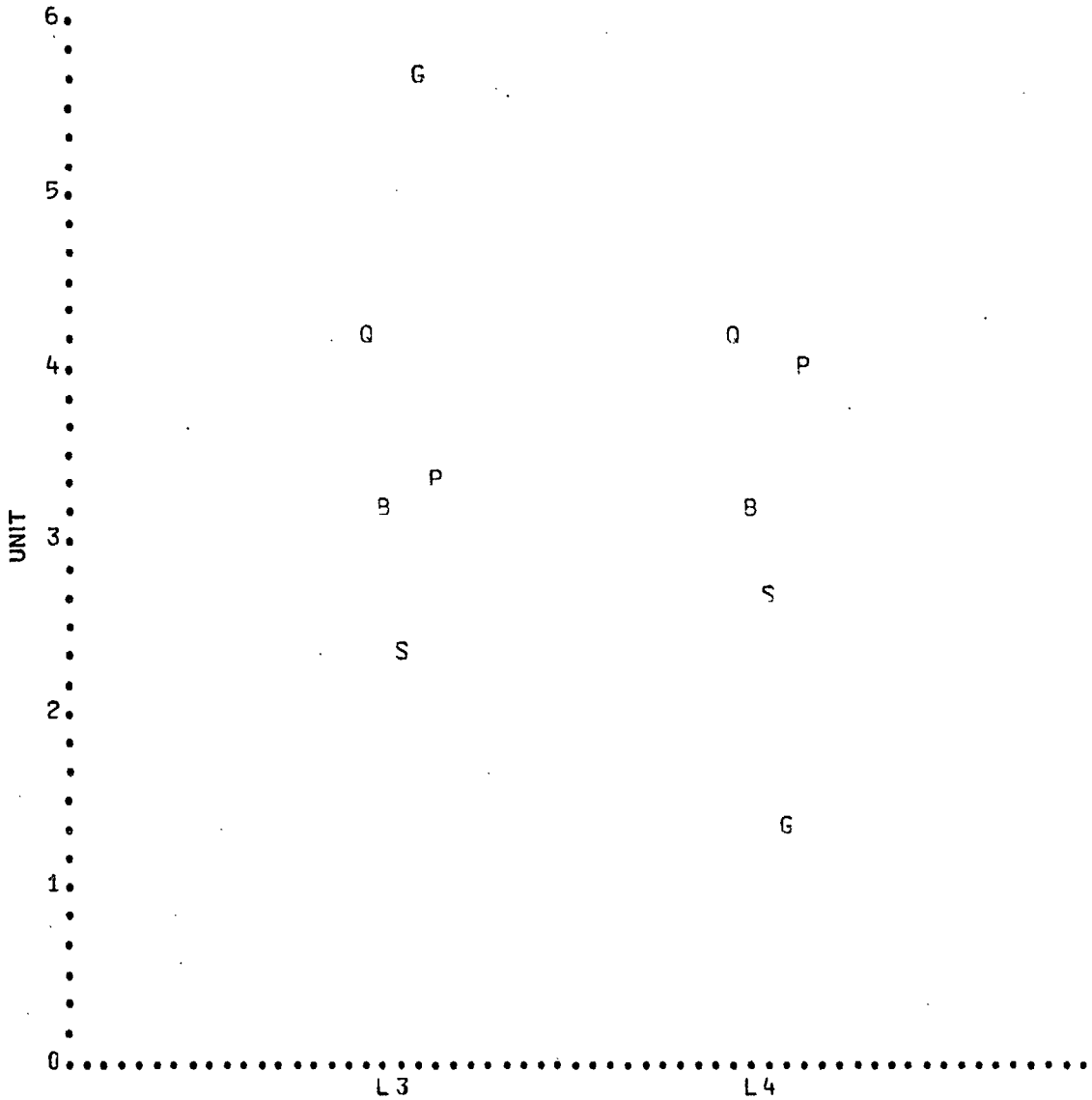
Each of the spiny lobster operations sampled used city water for processing. The main source of wastewater from the spiny lobster process is the cooking water which is high in sodium chloride and dissolved organics.

Figure 11 AMERICAN LOBSTER PROCESS PLOT.



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 50000 L/KKG
B	5 DAY BOD	1 UNIT = 0.2 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 0.5 KG/KKG
G	GREASE & OIL	1 UNIT = 2 KG/KKG
P	PRODUCTION	1 UNIT = 0.1 TON/HR

Figure 12. **SPINY LOBSTER PROCESS PLOT.**



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 UNIT = 500 L/KKG
B	5 DAY BOD	1 UNIT = 1 KG/KKG
S	SUSPENDED SOLIDS	1 UNIT = 0.5 KG/KKG
G	GREASE & OIL	1 UNIT = 0.050 KG/KKG
P	PRODUCTION	1 UNIT = 0.1 TON/HR

Table 32. SPINY LOBSTER PROCESS SUMMARY.

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	0.367	0.047	0.263	0.467
PROCESS TIME HR/DAY	0.400	0.141	0.300	0.500
FLOW L/SEC	0.193	0.025	0.149	0.246
(GAL/MIN)	3.06	0.393	2.36	3.90
FLOW RATIO L/KKG	2090	--	--	--
(GAL/TON)	500	--	--	--
SETT. SOLIDS ML/L	--	--	--	--
RATIO L/KKG	--	--	--	--
SCR. SOLIDS MG/L	--	--	--	--
RATIO KG/KKG	--	--	--	--
SUSP. SOLIDS MG/L	590	56.6	467	706
RATIO KG/KKG	1.23	0.110	1.02	1.46
5 DAY BOD MG/L	1550	--	--	--
RATIO KG/KKG	3.23	--	--	--
COD MG/L	2390	184	2050	2770
RATIO KG/KKG	4.99	0.383	4.20	5.78
GREASE & OIL MG/L	83.0	72.1	14.4	272
RATIO KG/KKG	0.173	0.150	0.030	0.568
ORGANIC-N MG/L	273	22.6	231	320
RATIO KG/KKG	0.569	0.047	0.483	0.668
AMMONIA-N MG/L	6.87	3.32	4.06	16.3
RATIO KG/KKG	0.019	0.007	0.009	0.035
PH	7.10	0.283	6.90	7.30
TEMP DEG C	--	--	--	--

PLANTS L3 , L4

Most parameters corresponded very closely between the two plants except for grease and oil. This was due to sampling problems caused by the high concentrations of grease and oil which rise to the top of the cooking containers, making it difficult to obtain an accurate composite sample. The wastewaters from the two plants sampled were discharged to municipal treatment facilities.

The production rate at the two American lobster plants sampled averaged about 2.0 kkg/day (2.2 tons/day). There is essentially no solid waste produced, since the animals are usually sold alive to restaurants and retail outlets. Some plants feed the lobsters, which increases the waste loads slightly.

The production rates at the two spiny lobster plants sampled averaged only about 135 kg/day (300 lbs/day), which was considered to be lower than normal due to the lack of product during the sampling period. The percent of solid waste depends on whether tails or whole lobsters are being cooked. When only the tails are processed, the cephalothorax, which makes up about 20 percent of the raw product, is removed prior to cooking.

2. WASTE TREATMENT TECHNOLOGY

2.1 Introduction

Little of the technology currently available to the seafood processing industry has been demonstrated at the operational level. Most processors have little if any significant wastewater treatment at the plant. As a result, most technologies which might be found applicable in the future are presently unproven. The methods currently available and thought to be most applicable to the seafood industry are discussed below. The relative cost, efficiency and practicality of each method vary significantly with each subcategory of the industry and location of the plant site. The applicability of waste treatment technology to individual sites is contingent on land availability, operational continuity, plant age, water source and other factors such as climate and product style which determine the most cost-effective technology.

2.2 Physical-Chemical Treatment of Wastewater

Physical methods of wastewater treatment include the technologies to remove coarser wastes such as shell, viscera, carcasses, etc., from the wastewater stream. The most common method used to effect this type of removal is screening. Chemical oxidation is an example of the use of chemicals only to remove pollutants. Air flotation and the various methods of sludge treatment are examples of physical-chemical treatment.

2.2.1 Screening

Screening is practiced in varying degrees throughout the U.S. fish and shellfish industry for both marketable solids recovery and to prevent solids from entering receiving waters or municipal sewers. Nearly all fish processors produce large volumes of solids. Fish and shellfish solids have commercial value as by-products only if they can be collected prior to significant decomposition, economically transported to subsequent processing locations, and marketed. The importance of capturing the solids in dry form to help retard spoilage and minimize handling expense has been recognized by many processors. Solids should be separated from the process water as soon as possible to minimize leaching. A study (Riddle and Shikaze, 1973) of freshwater perch and smelt processing showed that a two-hour contact period between offal and transport water increased the COD concentration by 170 percent, while BOD and suspended solids increased about 50 percent.

Screens may be classified as follows:

a. revolving drums (inclined, horizontal and vertical axes);
b. vibrating, shaking and oscillating screens (linear or circular motion);
c. tangential screens (pressure or gravity fed);
d. inclined troughs;
e. bar screens;

f. drilled plates;
g. gratings;
h. belt screens; and
i. basket screens.

Wire mesh screens are specified in terms of the number of openings per inch ("mesh"). The specification of mesh or mesh equivalents for screens often is ambiguous. At least two standard series are used to define mesh size in terms of openings and wire diameter -- U.S. sieve and Tyler screen scale sieve. The 200 mesh tyler screen has been accepted by the U.S. Bureau of Standards. Table 33 lists the equivalent sizes of U.S. series screens for each Tyler screen. The larger the sieve number, the finer the screen. Ordinary window screen is about (Tyler) #14 mesh (14 openings per inch).

Rectangular holes or slits are correlated to mesh size either by geometry or performance data. Mesh equivalents specified by performance can result in different values for the same screen, depending on the nature of the screen feed. For example, a tangential screen with a 0.076 cm (0.030 in) openings may be said to be equivalent to a 40 mesh screen. This is because the slant of the screen and the nature of the waste may cause the screen to retain particles larger than 0.417 mm diameter.

Revolving drum screens consist of a covered cylindrical frame with open ends. The screening surface covering the frame is either a perforated sheet or woven mesh. Of the three basic revolving drums, the simplest is the trommel screen with the drum axis slightly inclined. Wastewater is fed into the raised end of the rotating drum. The captured solids migrate to the lower end, while the liquid passes through the screening surface. A catch basin is located below the screen.

The horizontal drum screen usually has the invent immersed in the wastewater being held in the catch basins. The solids are retained by ribs on the inside of the drum and conveyed upward until deposited by gravity into a centerline

TABLE 33. Comparison of Tyler and U.S. Sieve Series (Perry, 1950).

TYLER STANDARD SIEVE SERIES				U.S. SERIES APPROXIMATE EQUIVALENT NO.
Opening (in)	Opening (mm)	Tyler Mesh	Diameter of wire (in)	
0.312	7.925	2-1/2	0.088	
0.263	6.680	3	0.070	
0.221	5.613	3-1/2	0.065	
0.085	4.699	4	0.065	4
0.156	3.962	5	0.044	5
0.131	3.327	6	0.036	6
0.110	2.794	7	0.0328	7
0.093	2.362	8	0.032	8
0.073	1.981	9	0.033	10
0.065	1.651	10	0.035	12
0.055	1.397	12	0.028	14
0.046	1.168	14	0.025	16
0.0390	0.991	16	0.0235	18
0.0328	0.833	20	0.0172	20
0.0276	0.701	24	0.141	25
0.0232	0.589	28	0.0125	30
0.0195	0.495	32	0.118	35
0.0164	0.417	35	0.0122	40
0.0138	0.351	42	0.0100	45
0.0116	0.295	48	0.0092	50
0.0097	0.246	60	0.0070	60
0.0082	0.208	65	0.0072	70
0.0069	0.175	80	0.0056	80
0.0058	0.147	100	0.0042	100
0.0049	0.124	115	0.0038	120
0.0041	0.104	150	0.0026	140
0.0035	0.089	170	0.0024	170
0.0029	0.074	200	0.0021	200
0.0024	0.061	250	0.0016	230
0.0021	0.053	270	0.0016	270
0.0017	0.043	325	0.0014	325
0.0015	0.038	400	0.0010	

conveyor. Backwash sprays are generally used to clean the screen. A typical horizontal drum is shown in Figure 13. Claggett and Wong (1969) tested this type of rotary screen on salmon canning wastewater and bailwater from herring boats. The results are listed in Table 34.

TABLE 34. Northern Sewage Screen Test Results (34 mesh)

Waste Stream	Percentage Reduction of total solids
Salmon canning	57%
Herring Bailwater	48%

Inclined and horizontal drum screens have been used successfully in whiting processing operations, herring filleting processes, and fish reduction plants.

At least one commercial screen available employs a drum rapidly rotating (about 200 rpm) about a vertical axis. The wastewater is sprayed through one portion of the cylinder from the inside. A backwash is provided in another portion of the cycle to clear the openings. Woven fabric up to 400-mesh has been used satisfactorily. This unit is called a "concentrator" (see Figure 14) because not all of the impinging wastewater passes through. About 70 to 80 percent of the wastewater is treated effectively, which necessitates further treatment of the concentrate. The efficiencies of this, and other systems, in treating shellfish and seafood wastes have been investigated on a pilot scale in the Washington State salmon industry (1972) and Alaskan crab and shrimp industries (Peterson, 1973b). The results of these studies are shown in Table 35.

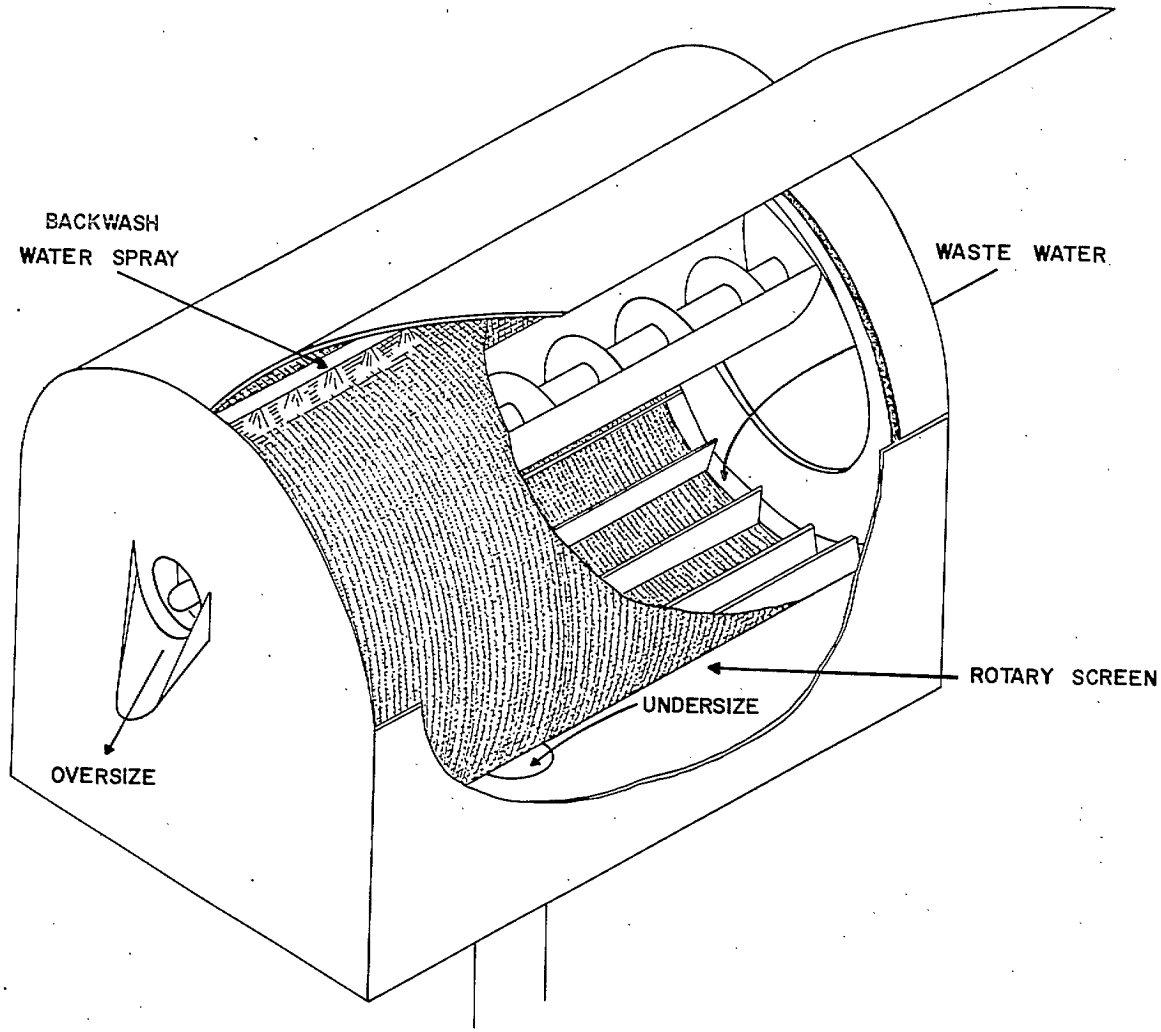


Figure 13. Typical drum rotary screen.

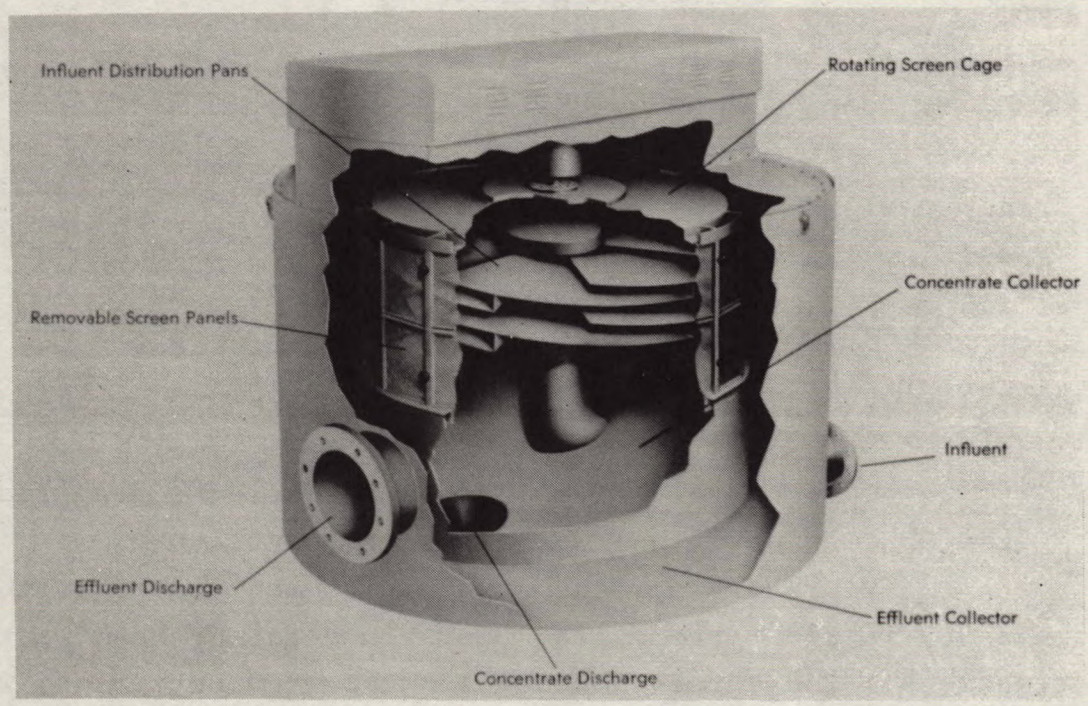


Figure 14. SWECO centrifugal wastewater concentrator

TABLE 35 SWECO Concentrator test results

Waste Stream	Parameter	Percentage Reduction	
		165 mesh	325 mesh
Salmon (_____, 1972)	Setteable Solids	--	100%
	Suspended Solids	53%	34
	COD	36	36
Shrimp peeler (Peterson, 1973b)	Setteable Solids	99	--
	Suspended Solids	73	--
	COD	46	--

Case history five further discusses the application of the SWECO centrifugal wastewater concentrator.

Vibratory screens are more commonly used in the seafood industry in plant processing operations rather than wastewater treatment. The screen housing is supported on springs which are forced to vibrate by an eccentric. Retained solids are driven in a spiral motion on the flat screen surface and discharged at the periphery. Other vibratory-type screens impart a linear motion to retained particles by eccentrics. With vibratory screens, blinding is frequently a problem when seafood wastewaters are being handled. Salmon waste is probably the most difficult to screen because of its fibrous nature and high scale content. Crab butchering waste, also quite stringy, is somewhat less difficult to screen. Table 36 lists the results of the National Canners Association's study on salmon (_____, 1972). The vibrating screen system produced lower solids removals than the tangential screen system or the SWECO concentrator. Also, it was more sensitive to flow variations and the solids content of the wastewater.

TABLE 36 SWECO vibratory screen performance
(_____, 1972)

Species: Salmon
Screen Mesh: 40

Parameter	Percentage Reduction
Setteable Solids	14%
Suspended Solids	31
COD	30

Tangential screens are finding increasing acceptance because of their inherent simplicity, reliability and effectiveness. They consist of a series of parallel, triangular or wedgeshaped bars oriented perpendicularly to the direction of the flow. The screen surface usually is inclined from 45 to 60 degrees. Solids move down the face and fall off the bottom as the liquid passes through the openings ("Coanda effect"). No moving parts or drive mechanisms are required for the operation. The feed to the screen face is via a weir or a pressurized nozzle system impinging the wastewater tangentially on the screen face at the top. The gravity-fed units are limited to about 50 to 60 mesh (equivalent) in treating seafood wastes. Pressure-fed screens can be operated with mesh equivalents of up to 200 mesh. Shrimp waste presents significant blinding problems to tangential screens in a narrow mesh range. Shrimp peeler waste is much more readily handled on tangential screens with equivalent mesh sizes of 35 to 40 than 20 mesh.

Tangential screens have met with considerable acceptance in the fish and shellfish industry. They appear to represent the most advanced waste treatment concept that is currently being voluntarily adopted by broad segments of the industry. One reason for this wide acceptance has been the thorough testing history of the unit. Data are available (although much is proprietary) on the tangential screening of wastewaters emanating

from plants processing a variety of species. A summary of some recent work appears in Table 37.

Coarse pre-screening is often desirable to prevent harmful objects from entering the waste treatment system. Floor drains are normally covered with a coarse grate or drilled plate with holes approximately 0.6 cm (0.25 in) in diameter. A coarse grate and a magnet are desirable to prevent oversize or unwanted objects such as polystyrene cups, beverage cans, rubber gloves, tools, nuts and bolts, or broken machine parts from entering the treatment system. Such objects can cause serious damage to pumps and may foul the screening system.

Some seafood processors utilize a perforated inclined trough to separate large solids from the wastewater. The wastewater is fed into the lower end and conveyed up the trough by a screw conveyor. The liquid escapes through the holes while the solids are discharged to a holding area. Inclined conveyors and mesh belts are commonly used throughout the fish and shellfish industry to transport and separate liquids from solid wastes.

A typical screening arrangement using a tangential screen is shown in Figure 15. Various other screening devices may be substituted in the arrangement. A sump is useful in dampening brief periods of high flow that may overload the screen. It also helps mitigate the wastewater solids loads where batch processes cause fluctuations. Some form of agitator may be required to keep the suspended solids in the sump suspended. Ideally, the sump should contain a one-half hour storage capacity to permit repairs to downstream components. The pump is an important consideration. Centrifugal trash pumps, of the open impeller type, are commonly used. This type of pump tends to pulverize solids as they pass through. During an experiment on shrimp wastes the level of the settleable solids dramatically increased when the wastewater was passed through a centrifugal pump (Peterson, 1973b). Positive displacement or progressing cavity non-clog pumps are recommended.

Table 37. Tangential screen performance.

Waste stream	Parameter	Percentage Reduction				
		30 mesh	40 mesh	40 mesh	100 mesh*	150 mesh*
Sardines (Atwell, *et al.*, 1972)	Suspended solids	26%	--	--	--	--
	BOD	9	--	--	--	--
Salmon (_____, 1972)	Settleable solids	--	--	--	35%	86%
	Suspended solids	--	--	--	15	36
	COD	--	--	--	13	25
Shrimp (Peterson, 1973b)	Settleable solids	88	--	93	83	--
	Suspended solids	46	--	43	58	--
	COD	21	--	18	23	--
Salmon (Peterson, 1973b)	Settleable solids	50	--	--	--	--
	Suspended solids	56	--	--	--	--
	COD	55	--	--	--	--
King crab (Peterson, 1973b)	Settleable solids	83	--	--	--	--
	Suspended solids	62	--	--	--	--
	COD	51	--	--	--	--
Salmon (Claggett, 1971)	Total solids	--	56	--	--	--
Herring (Claggett, 1969)	Total solids	--	48	--	--	--
Shrimp (Environmental Associates, 1974)	Suspended solids	25	--	--	--	--
	COD	16	--	--	--	--

*Pressure fed

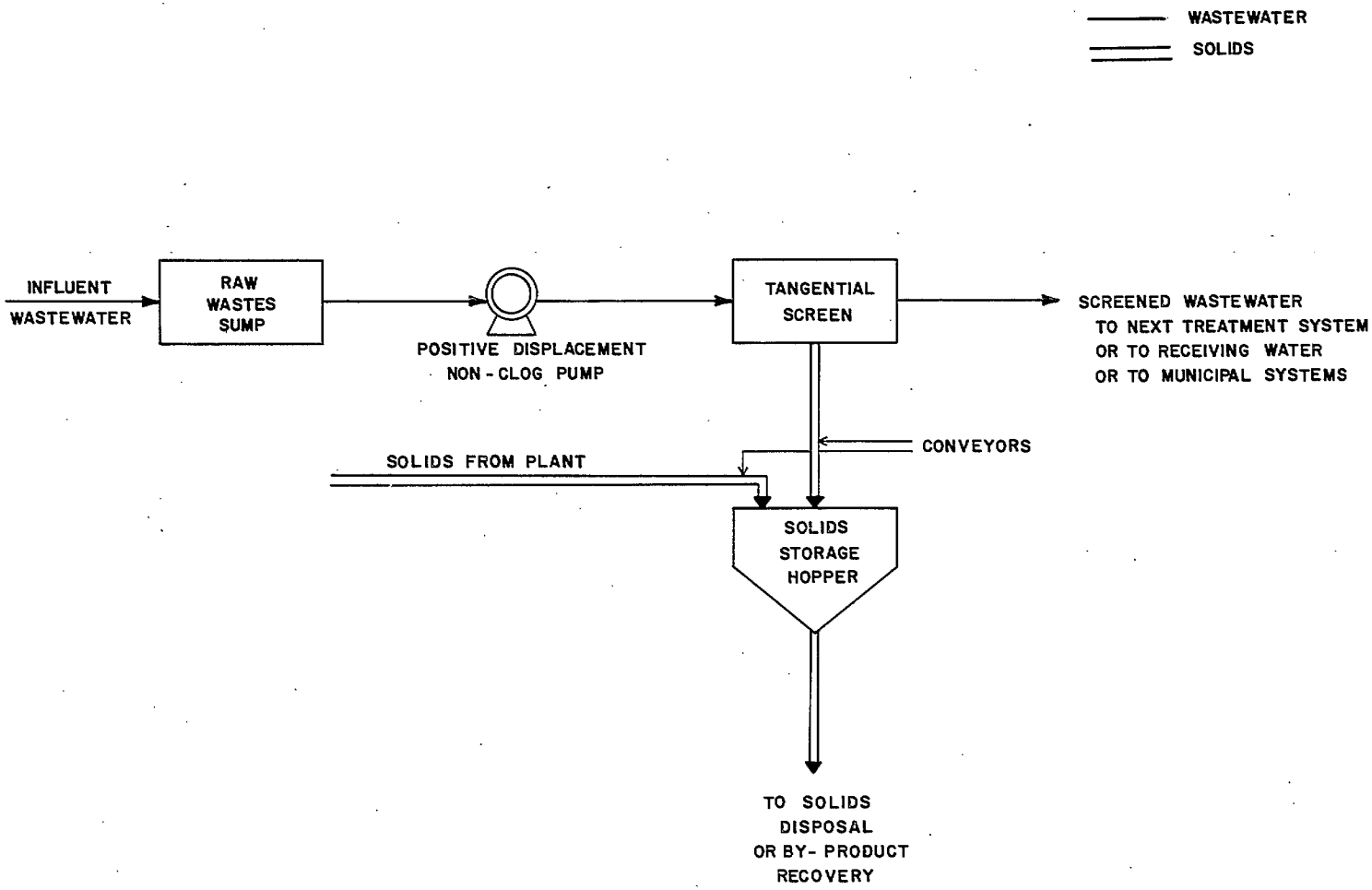


Figure 15. Typical tangential screening system (Environmental Associates, Inc.).

Screens should be installed with the thought that auxiliary screen cleaning devices may be required later. Blinding is a problem that depends, to some extent, on the type of screen employed, but to a greater extent on the nature of the waste stream. Salmon waste is particularly difficult to screen. One processor has installed mechanical brushes over his tangential screen, which reduces plugging by sweeping the face of the screen (see Plate 1).

Many of the screen types mentioned above produce solids containing considerable excess water. In most cases, this water will have to be removed either mechanically or during storage by draining. A convenient place to locate a screen assembly is above the storage hopper so that the solids discharge directly to the hopper. However, hoppers do not permit good drainage of most stored solids. If mechanical dewatering is necessary, it may be easier to locate the screen assembly on the ground and convey dewatered solids to the hopper.

Processing wastewaters from operations in seafoods plants are highly variable with respect to suspended solids concentrations and the sizes of particulates. On-site testing is required for optimum selection in all cases.

Some thought should be given to installing more than one screen to treat different streams within the process plant. Some types of screens are superior for specific wastewaters and there may be economy in using expensive or sophisticated screens only on the hard-to-treat portions of the waste flows. Microscreens (with screen openings as small as 0.010 mm) to effect solids removal from salmon wastewaters in Canada have been tried. They were found to be inferior to tangential screens for that application. Microscreens and microstrainers have not, however, been applied in the United States.

Screens of most types are insensitive to discontinuous operation and flow fluctuations, and require little maintenance. The presence of salt water necessitates the use of stainless steel elements. Oil and grease assumulation can be reduced by spraying the elements with a fluorocarbon coating.

Plate 1. Brush-cleaned screen at salmon cannery (courtesy New England Fish Company).

Screens of proper design are a reliable and highly efficient means of seafood waste treatment, often providing the equivalent of "primary treatment". The cost of additional solids treatment, approaching 95 percent solids removal by means of progressively finer screens in series, must, in final design, be balanced against the cost of treatment by other methods, including chemical coagulation and sedimentation. Screened solids have the advantage of seldom requiring additional dewatering before transport (greater than 10 percent solids) to a reduction plant or other ultimate disposal site.

Figure 16 depicts cost curves for installing screens, together with operation and maintenance costs.

2.2.2 Air Flotation

Air flotation with appropriate chemical addition is a physical-chemical treatment technology capable of removing heavy concentrations of solids, greases, oils, and dissolved organics in the form of a floating sludge. Flotation cells utilize the buoyancy of released air bubbles rising through the wastewater to lift materials in suspension to the surface. These materials include substantial dissolved organics and chemical precipitates, under controlled conditions. Floated, agglomerated sludges are skimmed from the surface, collected and dewatered. Admustment of pH to near the isoelectric point can effect appreciable removals of dissolved protein from fish processing wastewaters (proteins are least soluble at their isoelectric point; for fish proteins these range from pH 4.5 to 5.0). The main differences between flotation cells are the shape of the cell, the manner in which the air is mixed with the water, and the amount of water pressurized.

Because the flotation process brings partially reduced organic and chemical compounds into contact with oxygen in the air bubbles, satisfaction of immediate oxygen demand is a benefit to this process.

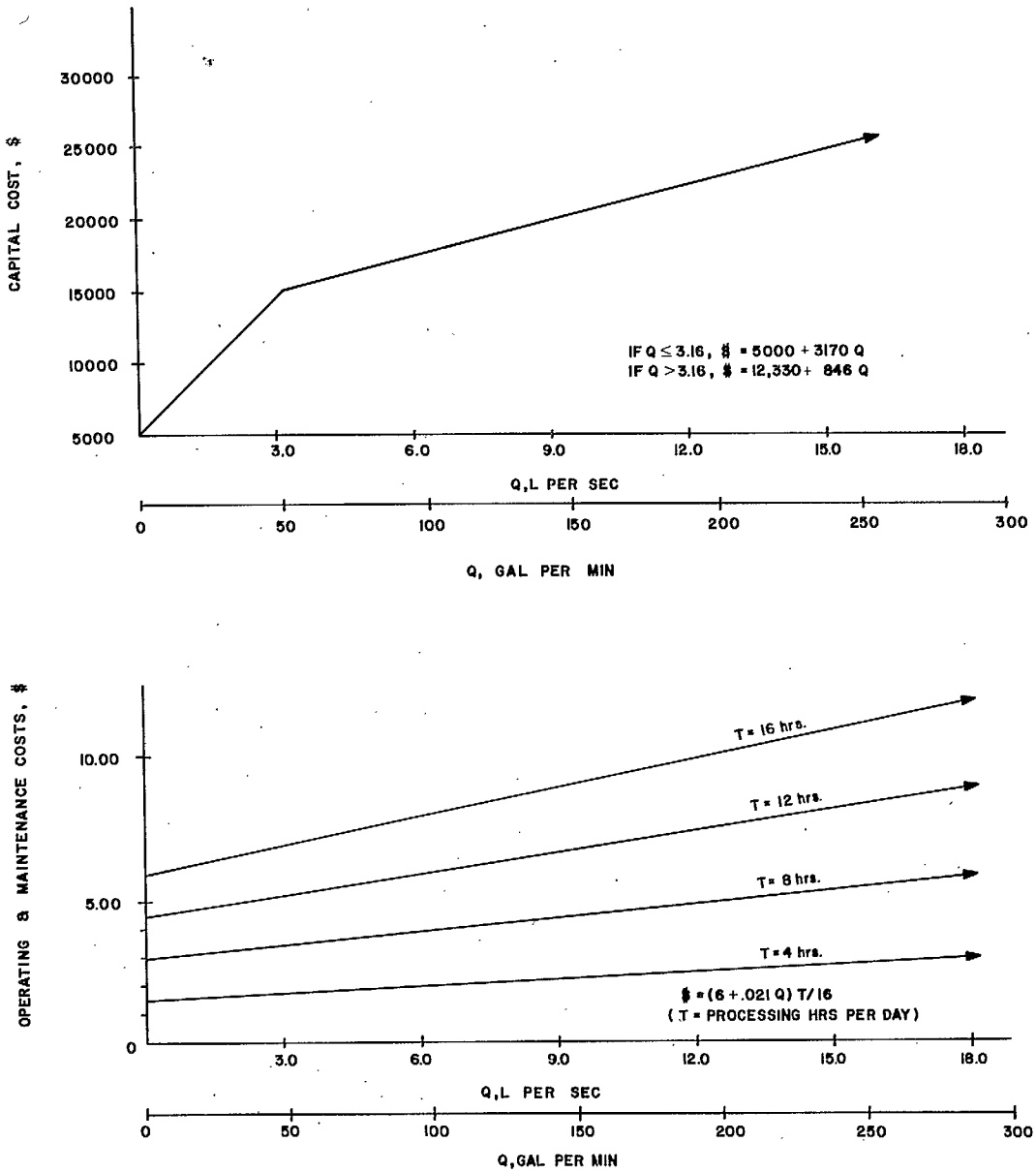


Figure 16. Cost curves for tangential screen installation and maintenance (Environmental Associates, Inc., 1974).

Present flotation equipment consists of three types of systems for wastewater treatment: 1) vacuum flotation, 2) dispersed air flotation, and 3) dissolved air flotation.

2.2.2.1 Vacuum Flotation

In this system, the waste is first aerated, either directly in an aeration tank or by permitting air to enter on the suction side of a pump. Aeration periods are brief, some as short as 30 seconds, and require only about 185 to 370 cc/l (0.025 to 0.05 cu ft per gallon) of air (Nemerow, 1971). A partial vacuum of about 0.6 atm (9 inches of mercury) is applied, which releases some air as minute bubbles. The bubbles and attached solids rise to the surface to form a scum blanket which is removed by a skimming mechanism. A disadvantage is the expensive airtight structure needed to maintain the vacuum. Any leakage from the atmosphere adversely affects performance. No known vacuum flotation units are in use in the seafood industry.

2.2.2.2 Dispersed Air Flotation

Air bubbles are generated in this process by the mechanical shear of propellers, through diffusers, or by homogenization of gas and liquid streams. The provision of aeration tanks in this process, for flotation of grease and other solids, usually is ineffective. Heavy solids that settle to the bottom are collected at a central sludge sump for removal. The floating material is removed to a scum trough from which it is pumped. Some success has been obtained on scum-forming wastes (Metcalf and Eddy, 1972). Figure 17 depicts a typical dispersed air flotation unit.

Table 38 lists removal efficiencies of a dispersed air flotation unit treating tuna wastes. The conclusion of the study was that the unit was ineffective without chemical additions. While removal efficiencies for this process are not as high as those for the dissolved air flotation unit, the price is considerably less. A unit large enough to accommodate a 20.4 l/sec (450 gpm) flow costs approximately $18,000.

The Hydrocleaner Aeration/Flotation Cycle

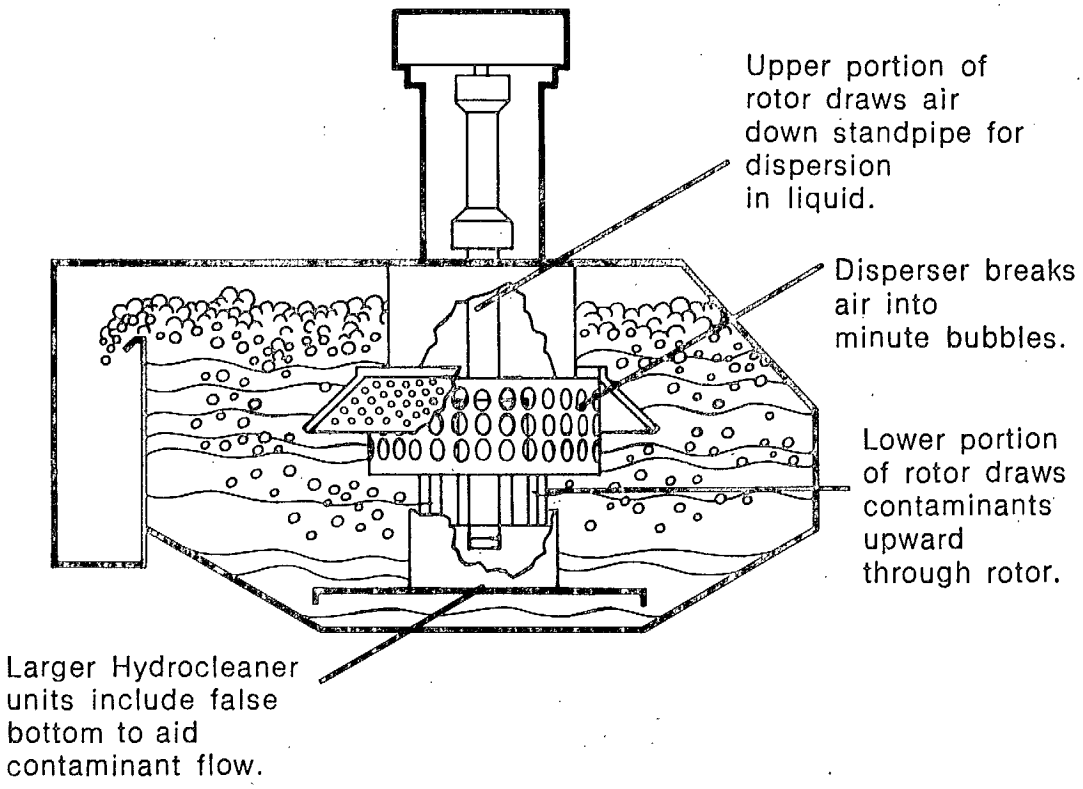


Figure 17 . WEMCO dispersed air flotation unit.

2.2.2.3 Dissolved Air Flotation

In this process, the untreated wastewater or a recycled stream is pressurized to 3.0 to 4.4 atm (30 to 50 psi) in the presence of air and then released into the flotation tank. The recycle stream is held in the pressure unit for about one minute before being mixed with the unpressurized main stream just prior to entering the flotation tank. Figure 18 contains a schematic diagram of a typical dissolved air flotation unit.

TABLE 38 Removal Efficiencies for the Dispersed Air Flotation Unit (_____, 1973).

Agency: Jacobs Engineering Company

Unit: Dispersed Air Flotation -- WEMCO hydrocleaner

Operation: 5-10 minute retention time, pilot study

Species: Tuna

Additive	Parameter	Influent (mg/l)	Reduction (%)
Tretolite chemical 7-16 mg/l	BOD_5	4400	47
	G&O	273	68
	SS	882	30
	(Average of 5 runs)		
Drew 410 3-14 mg/l	BOD_5	211	47
	G&O	54	50
	SS	254	30
	(Average of 8 runs)		

The flotation system of choice depends on the characteristics of the waste and the necessary removal efficiencies. Although Mayo (1966) found recycle pressurization gave best results for industrial waste and required less power, the design of flotation units should proceed from pilot plant studies of the actual wastes involved.

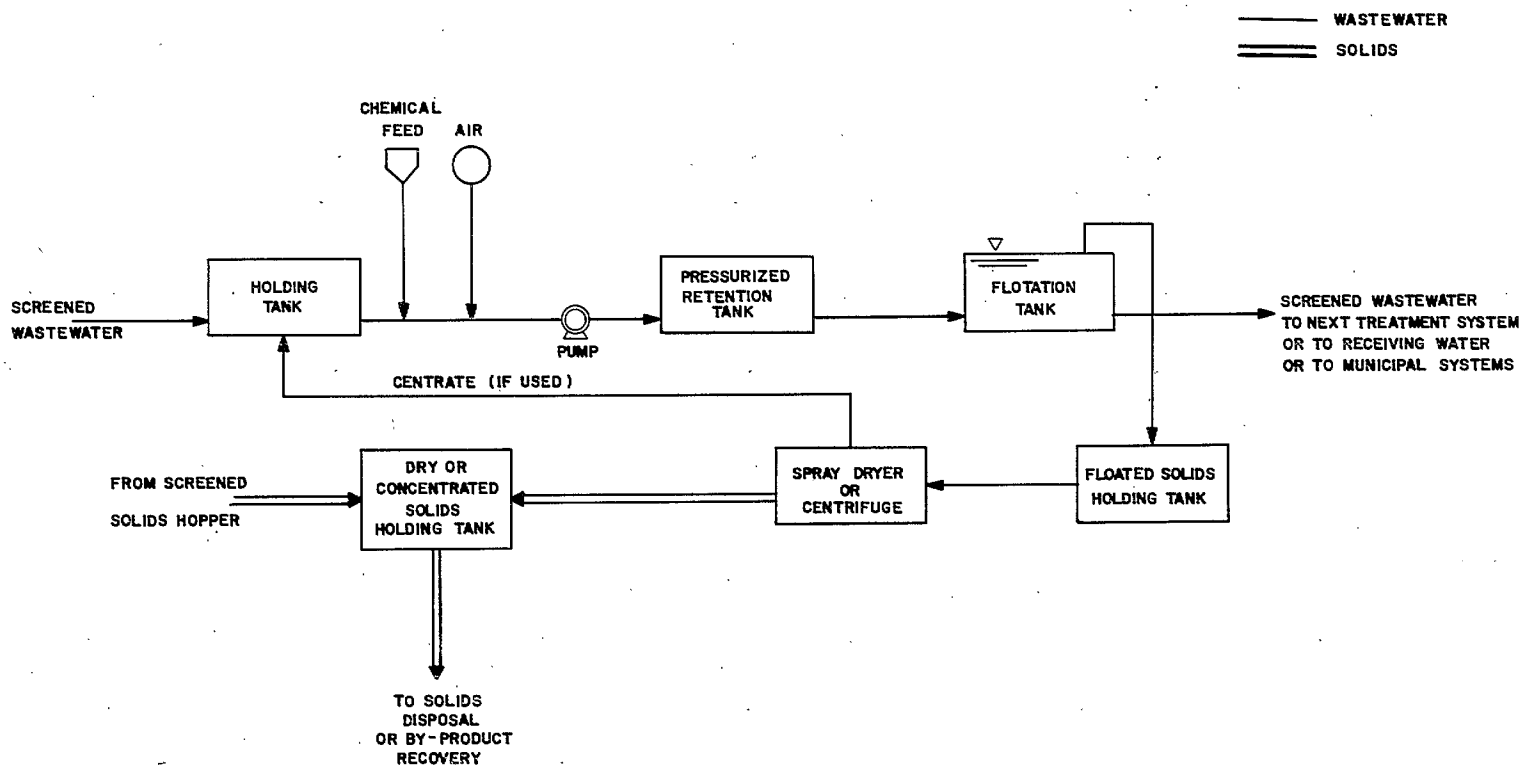


Figure 18. Typical dissolved air flotation system (Environmental Associates, Inc.).

Air bubbles usually are negatively charged. Suspended particles or colloids may have a significant electrical charge providing either attraction or repulsion to the air bubbles. In treating industrial wastes with large quantities of emulsified grease or oil, it is usually beneficial to use alum, or lime, and an anionic polyelectrolyte to provide consistently good removals (Mayo, 1966).

Emulsified grease or oil normally cannot be removed without chemical coagulation (Kohler, 1969). The chemical coagulant should be provided in sufficient quantity to absorb completely the oil present whether free or emulsified. Good flotation properties are characterized by a tendency for the floc to float with no tendency to settle downward. Excessive coagulant additions result in a heavy floc which is only partially removed by air flotation. With oily wastewaters such as those found in the fish processing industry, minimum emulsification of oils should result if a recycle stream only, rather than the entire influent, were passed through the pressurization tank. This would insure that only the stream (having been previously treated) with the lower oil content would be subjected to the turbulence of the pressurization system. The increased removals achieved, of course, would be at the expense of a larger flotation unit than would be needed without recycle.

The water temperature determines the solubility of the air in the water under pressurization. With lower water temperatures, less recycle is necessary to dissolve the same quantity of air. The viscosity of the water, however, increases with a decrease in temperature, so that flotation units must be made larger to compensate for the lower bubble rise velocity at low temperatures. Mayo (1966) recommended that flotation units for industrial applications be sized on a flow basis for

suspended solids concentrations less than 500 mg/l. Surface loadings should not exceed 81 l/sq m/min (2 gal/sq ft/min). The air-to-solids ratio is important, as well. Mayo (1966) recommended 0.02 kg of air per kg of solids to provide a safe margin for design.

Flotation is in extensive use for wastewater treatment among food processors. Mayo (1966) presented data showing high influent BOD and solids concentrations, each in the range of 2000 mg/l. Reductions reached 95 percent BOD removal and 99.7 percent solids removals, although most removals were five percent to 20 percent lower. The higher removals were attainable using appropriate chemical additions and, presumably, skilled operation. Dissolved air flotation was installed in one tuna plant sampled during the recent study conducted by Environmental Associates, Inc. Additional flotation units are planned by other processors. Demonstration-scale units have also been operated on shrimp, salmon, menhaden and crab wastewaters, with variable success (Atwell, et al., 1972;_____. 1971; Mauldin, 1973; Peterson, 1973). Table 39 summarizes the results of these tests.

It appears that flotation in many instances can provide treatment levels comparable to biological treatment (Jordan, 1973). Good operation and correct chemical addition are prerequisites for high treatment efficiency. Air flotation systems can also be operated at lower efficiencies to serve as "primary" treatment steps prior to a physical-chemical or biological polishing step, if that mode proves advantageous from the standpoint of cost-effectiveness.

Figures 20, 21, and 22 show the cost of installation and costs of operation and maintenance both with and without chemical additives for the dissolved air flotation unit.

Table 39. Dissolved air flotation performance--United States.

Waste Stream	Additives	Parameter	Reduction
Sardines (Atwell, et al., 1972)	polymer, 2 mg/l alum, 200 mg/l	Suspended solids	95%
		BOD	64
		Oil & grease	80
Tuna (Jacobs Eng., 1972)	lime, pH 10.0-10.5 polymers: cationic, 0.05 mg/l anionic, 0.10 mg/l	Suspended solids	66
		BOD	65
		Oil & grease	66
Tuna (Jacobs Eng., 1972)	lime, 400 mg/l $FeCl_2$ 45 mg/l	Suspended solids	77
		BOD	22
		Oil & grease	81
Tuna (Environmental Associates, 1973)	$NaAlO_2$ 120 mg/l polymer	COD	37
		Suspended solids	56
	Alum polymer	COD	58
		Suspended solids	65
Shrimp (Peterson, 1973a)	alum, 200 mg/l polymer	Suspended solids	77
		COD	73
		Settleable solids	89
Menhaden bail water (Baker & Carlson, 1972)	acid, pH 5.0-5.3 alum polymer, anionic	Suspended solids*	87
		COD	80
		Oil & grease	100

*Nonstandard method

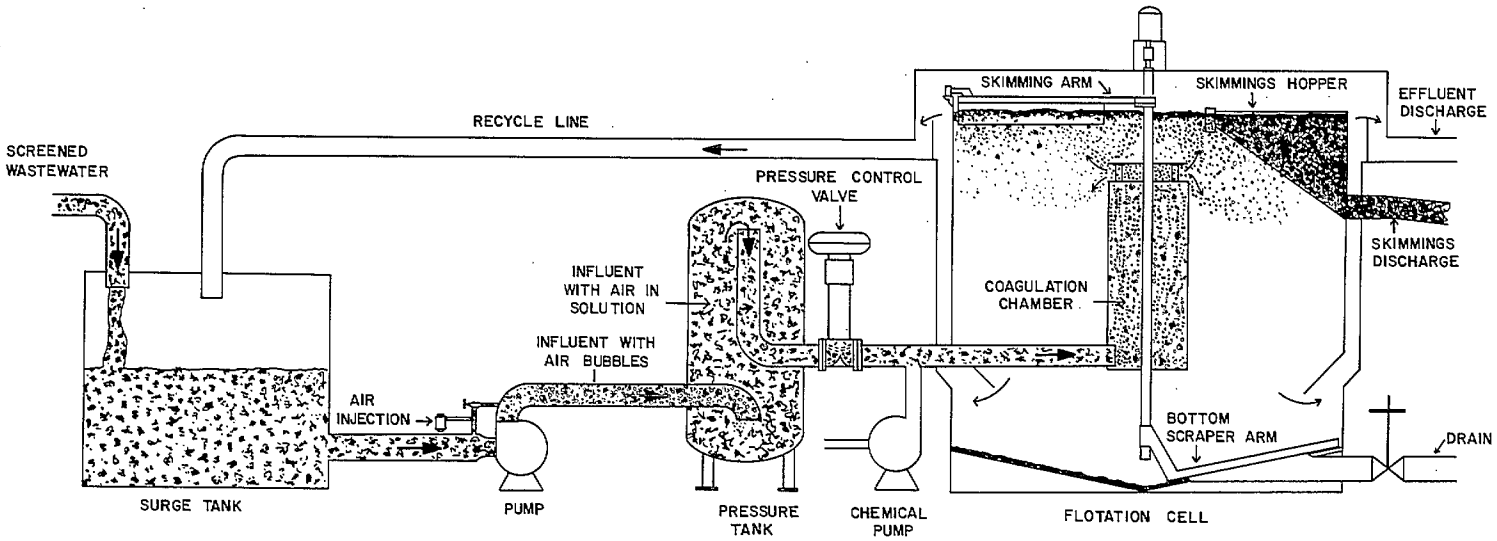


Figure 19. Carborundum Corporation dissolved air flotation system.

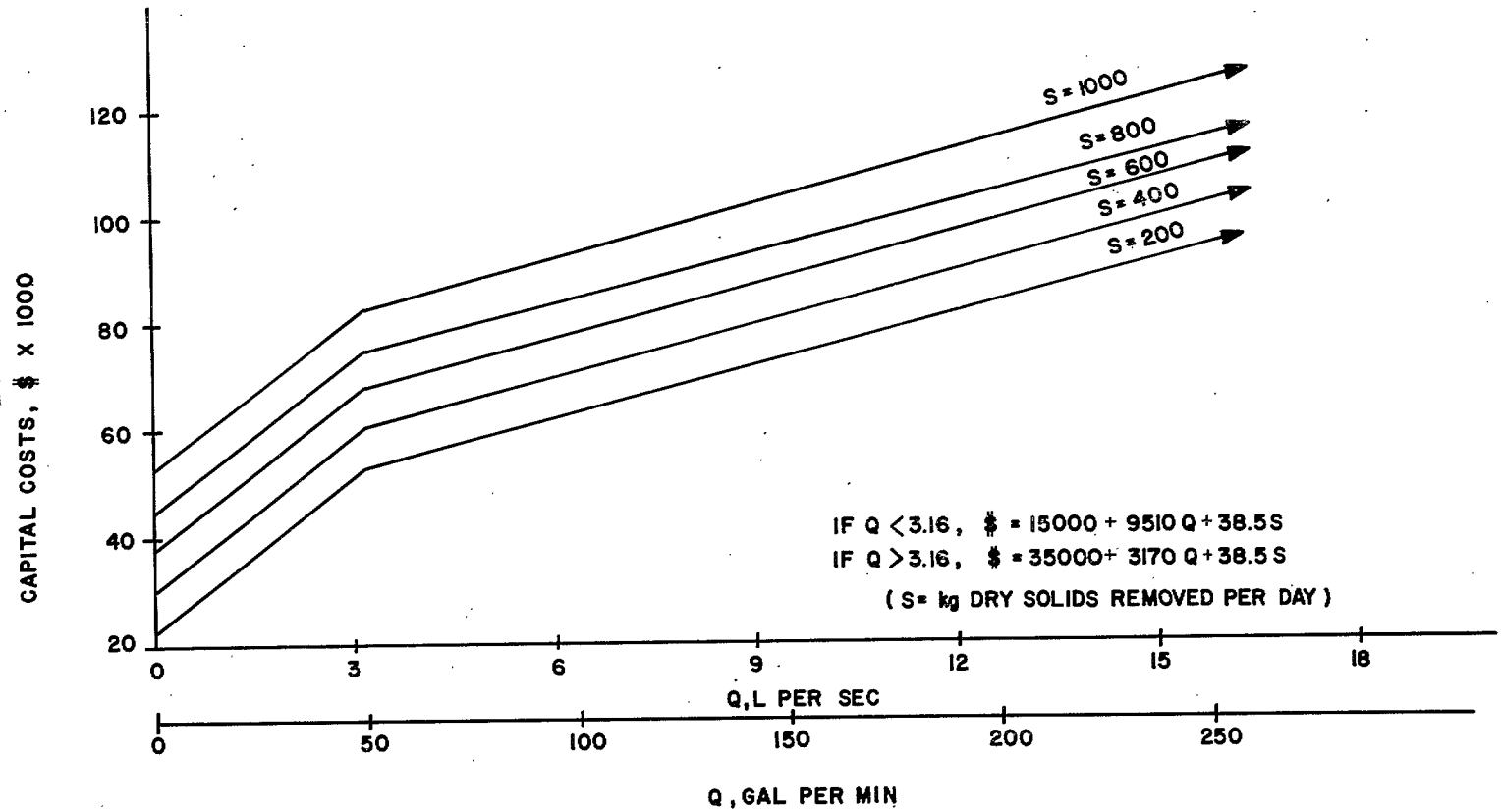


Figure 20. Installation costs of dissolved air flotation units (Environmental Associates, Inc., 1974).

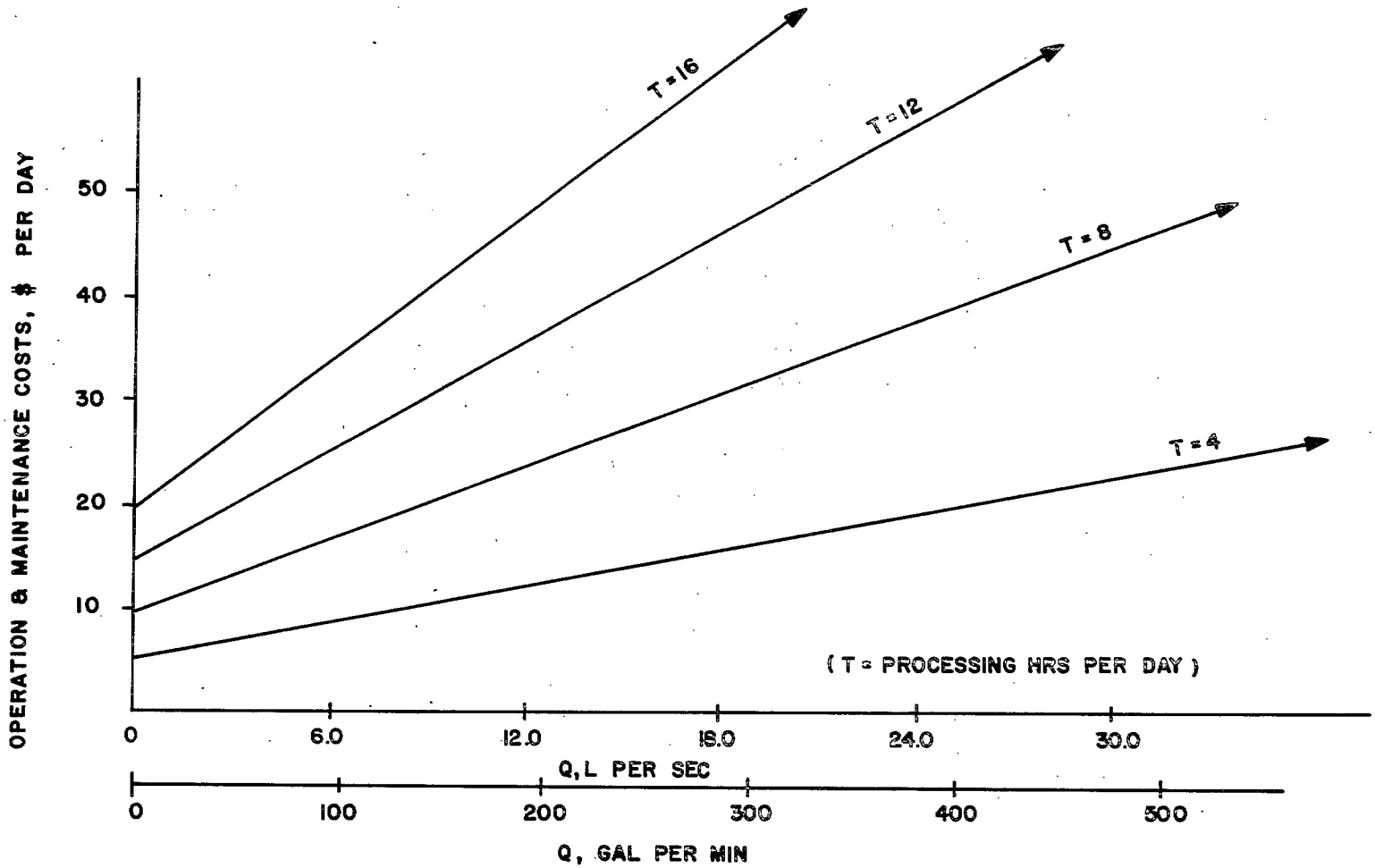


Figure 21. Operating and maintenance costs for dissolved air flotation unit operated with chemicals (Environmental Associates, Inc., 1974).

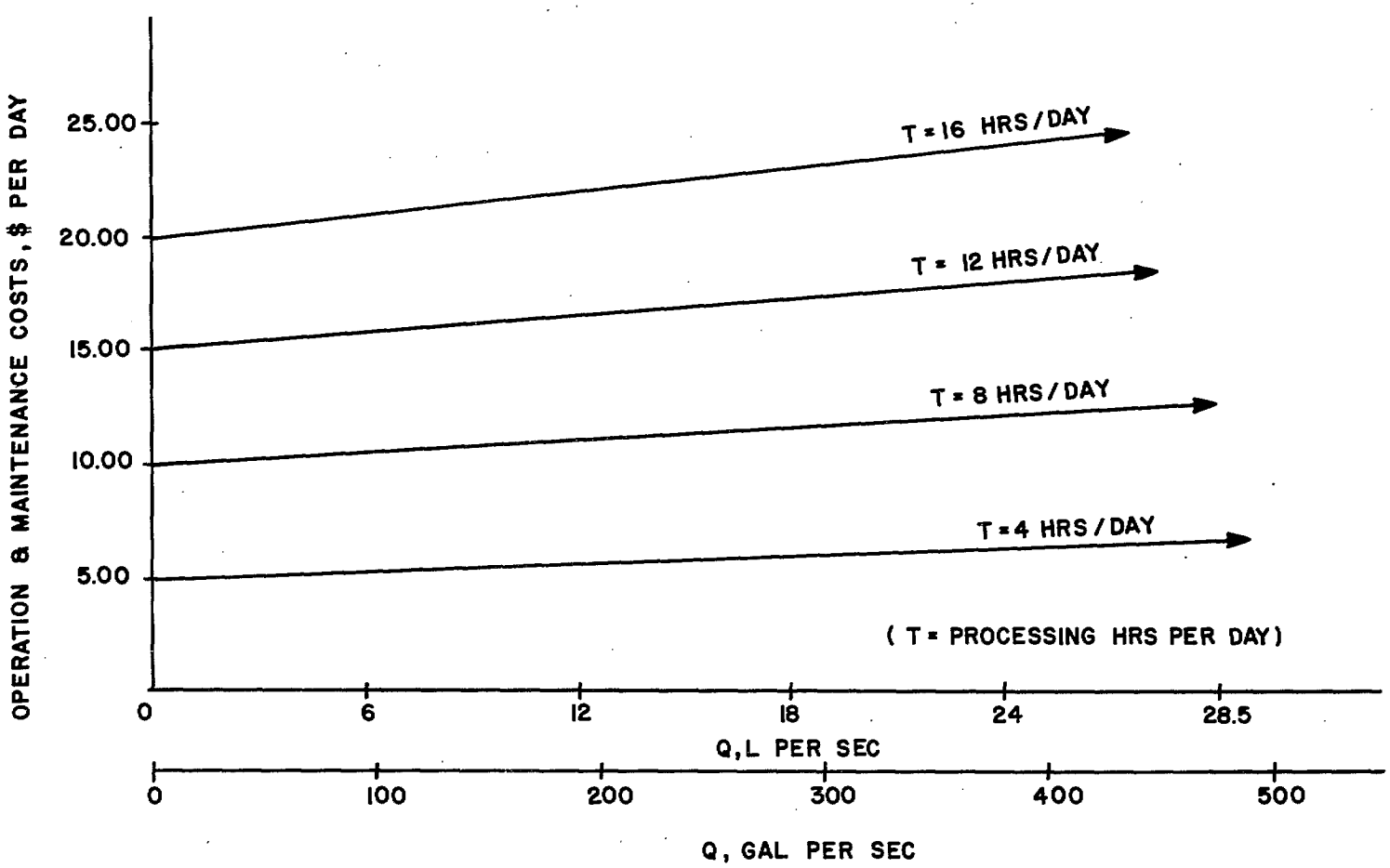


Figure 22. Operating and maintenance costs for a dissolved air flotation unit operated without chemicals (Environmental Associates, Inc., 1974).

2.2.3 Sedimentation and Clarification

Sedimentation is the separation of solids from a liquid by means of gravity. Ancillary functions of sedimentation units are grease flotation, flow equalization and (occasionally) BOD reduction. Often the first step in a multiple sedimentation process is the grit chamber which is a pretreatment basin for collecting heavy particles. The clarifier commonly incorporates the use of chemicals to convert a large amount of the remaining particles into setteable solids, which are then removed.

The design of each unit is based primarily on 1) the vertical settling velocity of discrete particles to be removed, and 2) the horizontal flow velocity of the liquid stream. Detention times required in the settling basins range from a few minutes for heavy shell fragments to hours for low-density suspensions. The current absence of settling basins or clarifiers in the fish industries indicates the need for simple on-site settling rate studies to determine appropriate design parameters for liquid streams undergoing such treatment.

Removal of settled solids from sedimentation units is accomplished by drainoff, scraping, and/or suction-assisted scraping. Frequent removal is necessary to avoid putrefaction. Seafood processors using brines and seawater must consider the corrosive effect of salts on mechanism operation. Maintaining reliability in such cases may require parallel units even in small installations.

Sedimentation processes can be upset by such "shock loadings" as fluctuations in flow volume, concentration and, occasionally, temperature. Aerated equalization tanks may provide needed capacity for equalizing and mixing wastewater flows. However, deposition of solids and waste degradation in the equalization tank may negate its usefulness.

Major disadvantages of sedimentation basins include areal requirements and structural costs as well as solids disposal problems. In addition, the settled solids normally require dewatering prior to ultimate disposal.

Chemical coagulants, such as alum and ferrous chloride, can be added to sedimentation processes to induce removal of suspended colloids. Properly designed and operated sedimentation units incorporating chemical coagulation can remove practically all particulate matter. Dissolved contaminants, however, will require further processing to achieve the necessary removals. The use of some coagulants in large quantities may render the resulting sludge unusable as a by-product because of contamination. Also, some flocculation agents are quite expensive.

Sedimentation tests run on a combined effluent from a fresh water perch and smelt plant produced an average of approximately 20 percent BOD and nine percent suspended solids removals after 60 minute detention (Riddle, et al., 1972). The nature of most fish and shellfish wastewaters requires that chemical coagulants be added to sedimentation processes to induce removal of suspended colloids.

A partially successful gravity clarification system was developed using large quantities of a commercial coagulant called F-FLOK. In a test on salmon wastewater, reported by Robbins (1973), the floc formed slowly, but sedimentation rates of four feet (1.2 meters) per hour were achieved. Table 40 summarizes the results of the test.

TABLE 40. Gravity Clarification Using F-FLOK Coagulant

Coagulant Concentration (mg/l)	Total Solids Recovery (%)	Protein Recovery (%)
5020	68	92
4710	60	80
2390	47	69

It is important to note that the gravity clarifiers described above, when operated with normal detention times, may release strong odors from rapid microbial action. This could also produce floating sludge.

2.2.4 Chemical Oxidation

This method uses chemicals to oxidize the organic matter present in the wastewater, thereby reducing the BOD load. Chlorine and ozone are the most common oxidants, although chlorine dioxide, potassium permanganate, and others are capable of oxidizing organic matter found in the process wastewater. This technology is not widely used because it lacks economic feasibility.

Chlorine could be generated electrolytically from saltwaters adjoining most processors of marine species, and utilized to oxidize the organic material and ammonia present (Metcalf and Eddy, 1972). Ozone could be generated on-site and pumped into deaerated wastewater. Deaeration is required to reduce the build-up of nitrogen and carbon dioxide in the recycle gas stream. The higher the COD, the higher the unit ozone reaction efficiency. Both oxidation systems offer the advantages of compact size. The operability of the technology with saline wastewaters, and the practicality of small units, have not been evaluated in the seafood processing industry (McNabney and Wynne, 1971).

The removal efficiency of chemical oxidation using chlorine on domestic wastes is 10 to 35 percent (_____, 1969). No known treatment facilities of this type have been used in the seafood industry.

2.2.5 Sludge Treatment

Sludges, floats, skimmings, and other slurries vary widely in dewaterability. Waste activated sludges and floated solids are particularly difficult to dewater. It is probable that most sludges produced in treating fish processing wastes

would require conditioning before dewatering. Such conditioning may be accomplished by means of chemicals or heat treatment. Because of toxicity problems, anaerobic digestion to stabilize sludges before dewatering is not feasible at plants employing salt waters or brines. Aerobic digestion will produce a stabilized sludge, but not one which is easy to dewater. The amount and type of chemical treatment must be determined in light of the ultimate fate of the solid fraction. For example, lime may be deposited on the walls of solubles plant condensers. Alum has been shown to be toxic to chickens at 0.12 percent concentrations, and should be used with care in sludges intended for feed by-product recovery (_____, 1970).

A large variety of equipment is available for sludge dewatering and concentration, each unit with its particular advantages. These include vacuum filters, filter presses, gravity-belt dewaterers, spray dryers, incinerators, centrifuges, cyclone classifiers, dual-cell gravity concentrators, multi-roll presses, spiral gravity concentrators, and screw presses. Such equipment can concentrate sludges from 0.5 percent solids (5000 mg/l) to a semi-dry cake of 12 percent solids (120,000 mg/l) with final pressing to a dry cake of over 30 percent solids (300,000 mg/l). Units are generally sized to treat sludge flows no smaller than 38 l/min (10 gpm). Because maintenance requirements range from moderate to high, the provision of dual units is required for continuity and reliability.

Except in meal plants, solids dewatering and concentrating equipment is not presently employed in the fish industries. The wide variety now available implies that workable equipment exists which is suitable for moderately-sized installations [over 757 cu m/day (200,000 gpd)]. Sludge and float flows from smaller installations could probably not be utilized in dewatering equipment economically. This condition effectively favors the larger processors.

2.3 Biological Treatment of Wastewater

The term "biological treatment" encompasses the applications of living organisms to the reduction and/or removal of organic constituents and nutrients from wastewater. In practice, this is accomplished by the assimilation of dissolved and colloidal organic materials from the wastewater by the metabolic processes of microorganisms.

By far the largest and most important group of microorganisms utilized in biological treatment are the bacteria. To a lesser extent, molds, yeasts, protozoa, and rotifers are important in certain phases of the treatment processes. One additional group or organisms not generally considered with the microorganisms, but important nonetheless in wastewater treatment, are the algae, uni- and multicellular plants useful in some types of treatment systems. As with most living systems, microorganisms are very susceptible to environmental changes, especially abrupt, "shock" changes, so careful control must be maintained in biological treatment systems to assure the proper environment for effective microbial activity.

Microorganisms are classified by their specific environmental requirements. One division is based on the type of carbon source required by the organism. Those able to utilize inorganic carbon sources, specifically carbon dioxide, are termed autotrophic; those needing organic sources of carbon are termed heterotrophic.

Another classification is determined by the oxygen requirements of the organisms for growth. Those organisms which require the presence of free oxygen are called strict aerobes. Organisms requiring a complete absence of free oxygen are labeled strict anaerobes. Some organisms are capable of growth either with or without free oxygen, and these organisms are termed facultative.

The temperature range for growth is yet another factor by which organisms are classified. Psychrophiles grow best at low temperatures, but these organisms are of minimal importance in wastewater treatment. Mesophiles grow in the wide range of temperatures intermediate to the other groups. Thermophilic organisms grow at rather high temperatures not usually found in waste treatment systems, but some of the anaerobic bacteria useful in sludge digestion are of this type.

Other environmental parameters are bases for classifying the microorganisms; these include salt tolerance, sugar tolerance, osmotic pressure, etc. These categorizations are of limited importance, however, in the discussion of biological wastewater treatment.

In the actual treatment systems, many microorganisms are present, and the influent wastewater provides the nutrients and environment necessary for their growth. The organisms utilize the dissolved and colloidal organic materials, the levels of which are measured by the BOD test, for growth and reproduction, thereby creating new cells. These cellular organisms often clump together to form a slime or a mass, often called cultures, colonies, and biomass. The metabolic processes are efficient in removing constituents from the wastewater, and the organisms are usually fairly easy to remove from the water by sedimentation. Since the rate of BOD uptake from the water by the organisms depends mainly on the number of organisms, it is desirable to maintain a fairly large number of organisms in contact with the raw waste to optimize the rate of BOD removal. This is done in many systems by recycling the settled organisms in the "sludge", thus, the origin of the term, "activated sludge". Treatment efficiency also depends heavily on the maintenance of the proper environment for microbial growth.

In biological treatment, the major considerations for BOD removal efficiency are the availability of oxygen to the organisms and residence time in the system. Aerobic organisms are much more versatile and resistant to slight environmental changes than anaerobic organisms, and are much faster in metabolizing waste. They produce low-energy, relatively-inert end products (CO_2 and water), and are thus the most desirable organisms to utilize in treating wastewater. Anaerobic organisms are slower, are usually thermophilic, or upper mesophilic, and often produce reduced chemical compounds, many of which are highly-malodorous and undesirable. However, they do play a role in certain phases of wastewater treatment. The vast majority of biological treatment is carried out by aerobic organisms in bio-oxidative metabolic processes, which has led to the use of the term "biological oxidation" to describe aerobic microbial treatment.

One additional consideration in biological treatment, affecting mainly the treatment rate, is temperature. The metabolic processes of the microorganisms are affected directly by temperature. Generally, as temperature increases, the metabolic rate (and thus BOD removal rate) increases, and as temperature decreases, the metabolic rate decreases. Usually an upper limit temperature exists, above which the metabolic functions break down, but this temperature is rarely, if ever, reached in typical treatment systems. Low temperatures are quite a problem in some areas of the U.S., and near the freezing point of water, microbial metabolism drops off nearly to zero. This is a very important consideration in areas which experience cold weather during the year, and provisions must usually be made to combat this problem.

At the present, biological treatment is not practiced extensively in the U.S. seafoods industry. Sufficient nutrients are available in most seafood wastewaters, however, to indicate that such wastewaters are amenable to aerobic biological treatment. The salt found in nearly all wastewaters discourages the consideration of anaerobic processes. Salt is toxic to

anaerobic bacteria and, although a certain tolerance to higher salt levels can be developed and carefully controlled (constant input systems), fluctuating loads continue to be inhibitory or toxic to these relatively unstable systems. Aerobic biological systems, although inhibited by "shock loadings" of salt, have been demonstrated feasible at full scale for the treatment of saline wastes of reasonably constant chloride levels. The effectiveness of many forms of biological oxidation however, remains to be demonstrated under the extreme variations common in the fish processing industry.

2.3.1 Activated Sludge

The activated sludge process, an aerobic system, is employed commonly in municipal wastewater treatment. It involves suspending a concentrated microbial mass in the wastewater in the presence of oxygen. Aeration (oxygenation) is accomplished by diffusion or mechanical agitation. Growth occurs naturally in the aerated organic wastes. The organism floc or group together in highly active masses of living bacteria, food and higher life forms. Organic carbonaceous material is converted to carbon dioxide and water. Nitrogenous matter is concurrently oxidized to nitrate. The dissolved colloidal and suspended materials in the wastewater are converted by biological action to cell matter and then transported to the clarifier. A sludge pump removes the sediment and transports it to a sludge tank. The treated supernatant from the clarifier discharged as effluent, while the sludge is partially recirculated to maintain the high population of microorganisms in the aeration tank. This is schematically depicted in Figure 23.

By controlling the contact period and/or the concentration of recycled sludge, varying degrees of organic removal can be obtained. If a large organic load is present in the wastewater, higher sludge recycling rates, more air, and a longer contact time may be necessary to obtain adequate BOD removals.

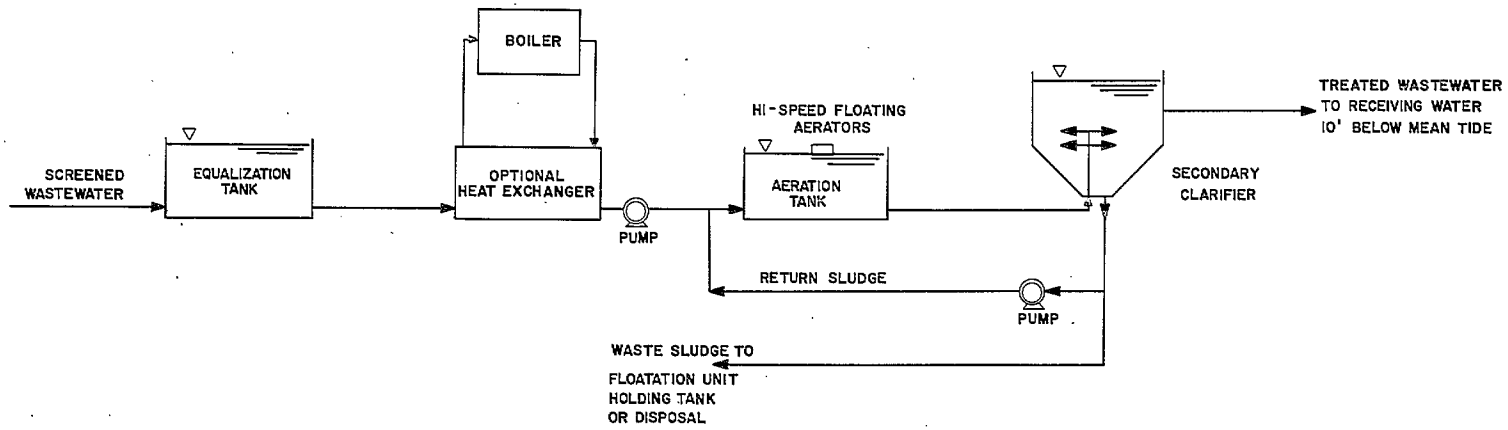


Figure 23. Typical activated sludge treatment system (Environmental Associates, Inc., 1973).

Maintenance of proper balance between these three critical criteria is necessary to obtain optimum efficiency from the system.

The conventional activated sludge process is capable of high levels of treatment when properly designed and skillfully operated. Flow equalization, by means of an aerated tank, can minimize shock loadings and flow variations which are highly detrimental to treatment efficiency. Oily materials can have an adverse effect. A recent study (Environmental Associates, 1973) concluded that influent oil levels MLSS (petroleum based) should be limited to 0.10 kg/day/kg. Toxic metal, organic nondegradable matter, lack of nutrients required for biological oxidation, high temperatures, and high or low pH can also upset the activated sludge process.

The nature of the waste stream, complexity of the system, and the difficulties associated with dewatering waste activated sludge, indicate that the more application, the best activated sludge system for the seafood industry would be the "extended aeration" modification. The extended aeration process is similar to the conventional activated sludge process, except that residence time in the aeration chamber is longer. The common detention time for extended aeration is one to three days, in contrast to the conventional six hours. This prolonged contact between the sludge and raw wastes provides ample time for the organic matter to be assimilated by the sludge and also for the organisms to metabolize the organics, allows for substantial removals of organic matter. In addition, the organisms undergo considerable endogenous respiration, which oxidizes much of the cellular biomass. During this phase of the growth curve (see Figure 24), metabolism plays a much more significant role than during the "logarithmic growth" phase, when cellular reproduction is dominant. Maintenance of significant endogenous respiration assures minimum accumulation

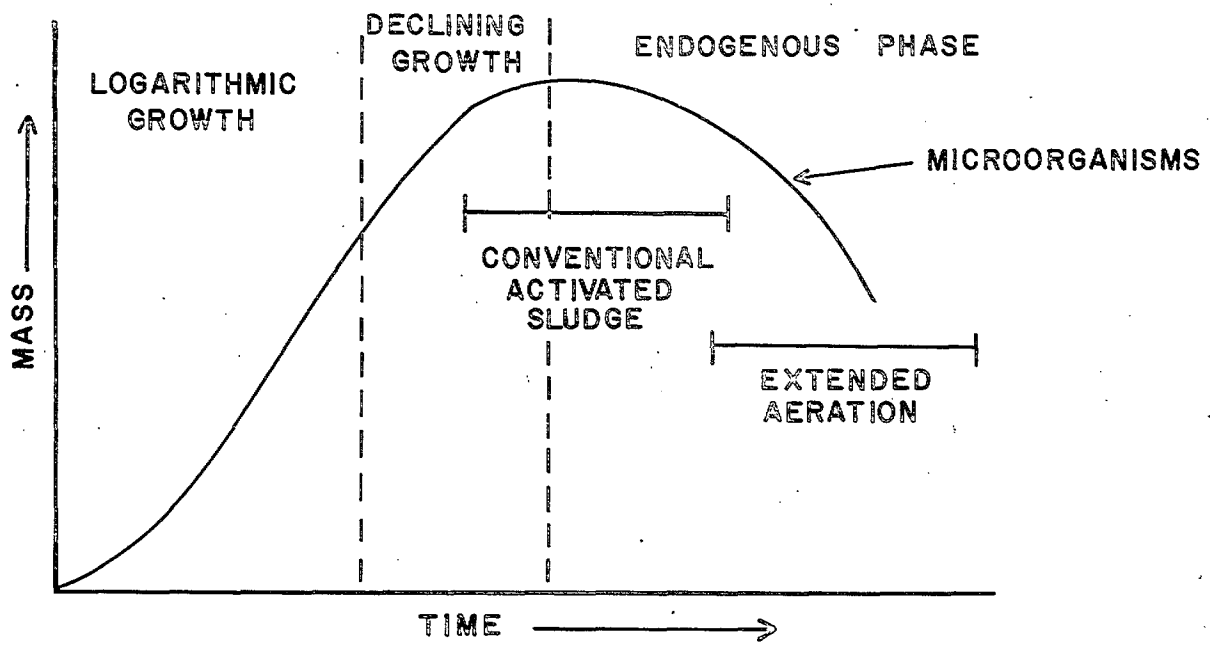


Figure 24. Phases of biological growth.

of excess biomass. As a result, less sludge is produced and little is discharged from the system as waste activated sludge.

In extended aeration, as in the conventional activated sludge process, it is necessary to have a final sedimentation tank. The solids resulting from extended aeration are finely dispersed and settle slowly, requiring a long period of settling (hence larger sedimentation tanks). The system is relatively resistent to shock loadings, provided the clarifier has sufficient storage to prevent the loss of biomass during flow surges. Clarifiers can be built with additional storage area and adjustable overflow wiers to absorb flow surges. Extended aeration, like other activated sludge systems, requires a continuous flow of wastewater to nurture the microbial mass. The re-establishment of an active biomass in the aeration tank requires from several days to a few weeks if the unit is shut down or the processing plant ceases to operate for significant periods of time.

Both treatment units are available in all size ranges. It is unlikely that activated sludge will prove to be the most cost effective treatment where 1) processing is intermittent, or 2) plant flows are so large that alternative systems of suitable scale are available. The wide variation in quality of the small package extended aeration systems now available dictates careful selection of the equipment if the process is to approach the removals now achieved by well-operated municipal systems.

Figure 25 contains cost curves for initial capital costs of extended aeration systems. The curve was generated on the basis of flow (gpm) and daily processing time. Figure 25 also shows the operation and maintenance costs of extended aeration systems for various operating day lengths.

Depending on the efficiency of operation, extended aeration systems can typically achieve 80 to 90 percent reductions in BOD.

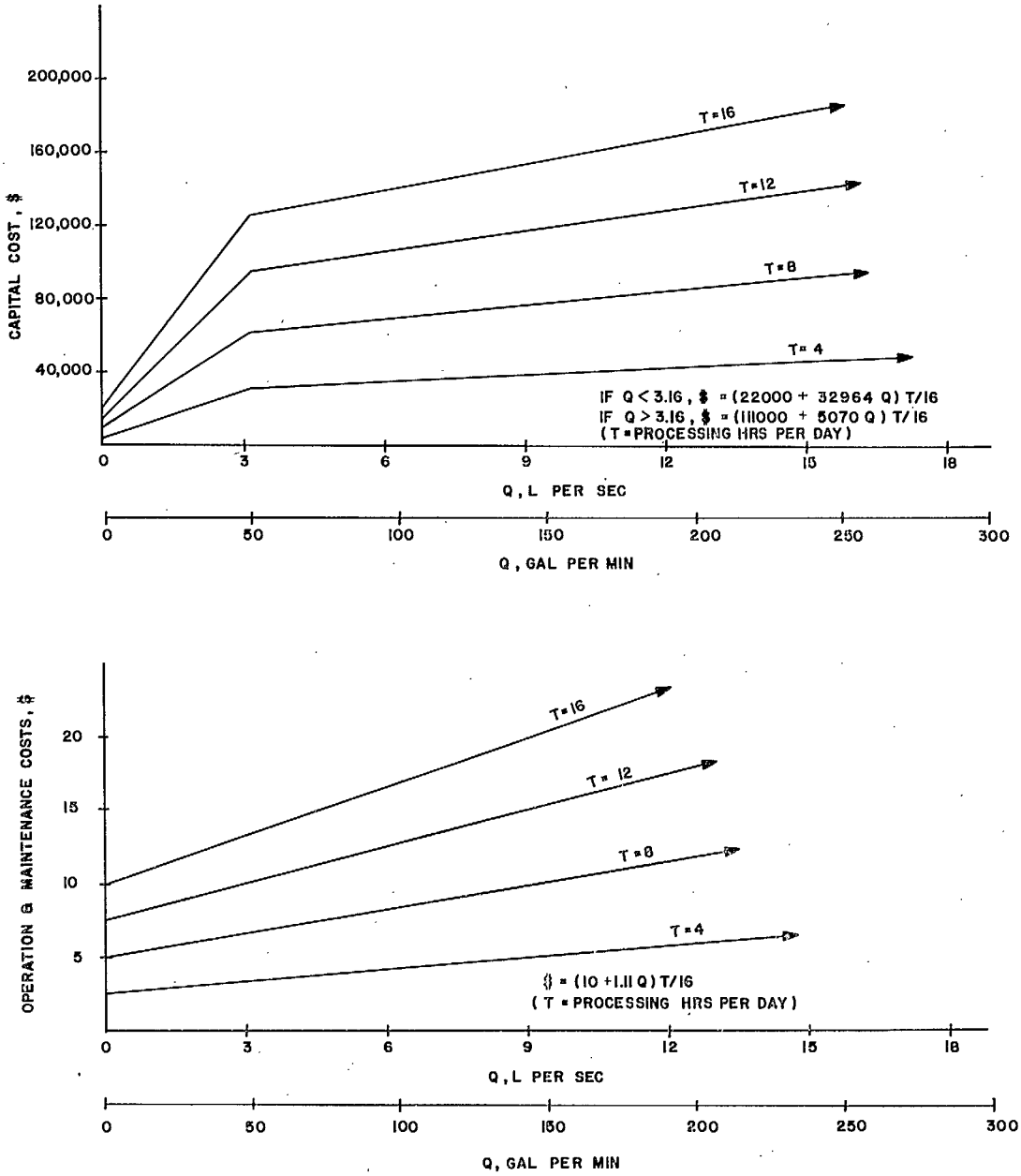


Figure 25. Capital and operating/maintenance costs for typical extended aeration activated sludge systems (Environmental Associates, Inc., 1974).

2.3.2 Rotating Biological Discs

The next biological treatment system to be discussed is the Rotating Biological Contactor (RBC), or Biodisc unit. This consists of light-weight plastic discs approximately 1.3 cm (0.5 in) thick and spaced 2.5 to 3.8 cm (1 to 1.5 in) on centers. The discs, to 3.4 m (11 ft) in diameter, are mounted on a horizontal shaft and partially submerged in a semicircular tank through which the wastewater flows. Clearance between the discs and tank wall is 1.3 to 1.9 cm (0.5 to 0.75 in). The discs rotate slowly, in the range of 5 to 10 rpm, passing the disc surface through the incoming wastewater. Liquid depth in the tank is kept below the center shaft of the discs. Reaeration is limited by the solubility of the air in the wastewater and rate of shaft rotation.

Shortly after start-up, organisms begin to grow in attached colonies on the disc surfaces, and a typical growth layer is usually established within a week. Oxygen is supplied to the organisms during the period when the disc is rotating through the atmosphere above the flowing waste stream. Dense biological growth on the discs provide a high concentration of active organisms resistent to shock loads. Periodic sloughing produces a floc which settles rapidly; the shear-forces developed by rotation prevents disc media clogging and keeps solids in suspension until they are transferred out of the disc tank and into the final clarifier. Normally, sludge recycling shows no significant effect on treatment efficiency because the suspended solids in the mixed liquor represent a small fraction of the total culture when compared to the attached growth on the disc.

Removal efficiency can be increased by providing several stages of discs in series. European experience on multi-stage disc systems indicates that a four-stage disc plant can be loaded at a 30 percent higher rate than a two-

stage plant for the same degree of treatment. Because the BOD removal kinetics approach those of a first order reaction (see figure 26) the first stage should not be loaded higher than 120 g BOD/day/sq m disc surface. If removal efficiencies greater than 90 percent are required, three or four stages, depending on the flow, waste load, and disc surface area, should be installed. Mixtures of domestic and food processing wastes in high BOD concentrations can be treated efficiently by the RBC-type system.

Because 95 percent of the solids are attached to the disc system, the RBC unit is less sensitive to shock loads than activated sludge units, and for the most part is not upset by variations in hydraulic loading. Waste loads high enough to deplete the dissolved oxygen in the water can stress aerobic organisms; anaerobic conditions can result with production of malodorous gases. This can be avoided by pre-aerating the wastewater. Secondary benefits of the pre-aeration tank would include the dampening of pH, temperature, and organic peaks. During low flow periods the RBC unit yields effluents of higher quality than at design flow. During periods of no flow, effluents can be recycled for a limited time to maintain biological activity.

Both the Rotating Biological Contactor and the trickling filter process (discussed below) utilize an attached culture. However, with the rotating disc the biomass is passed through the wastewater rather than wastewater over the biomass. Continuous wetting of the entire biomass surface also prevents fly growth, often associated with conventional trickling filter operations.

The RBC process requires housing to protect the biomass from exposure during freezing weather and from damage due to heavy winds and precipitation. F.G. Claggett (1973) reported COD removals greater than 50 percent with a RBC unit treating salmon cannery wastewater.

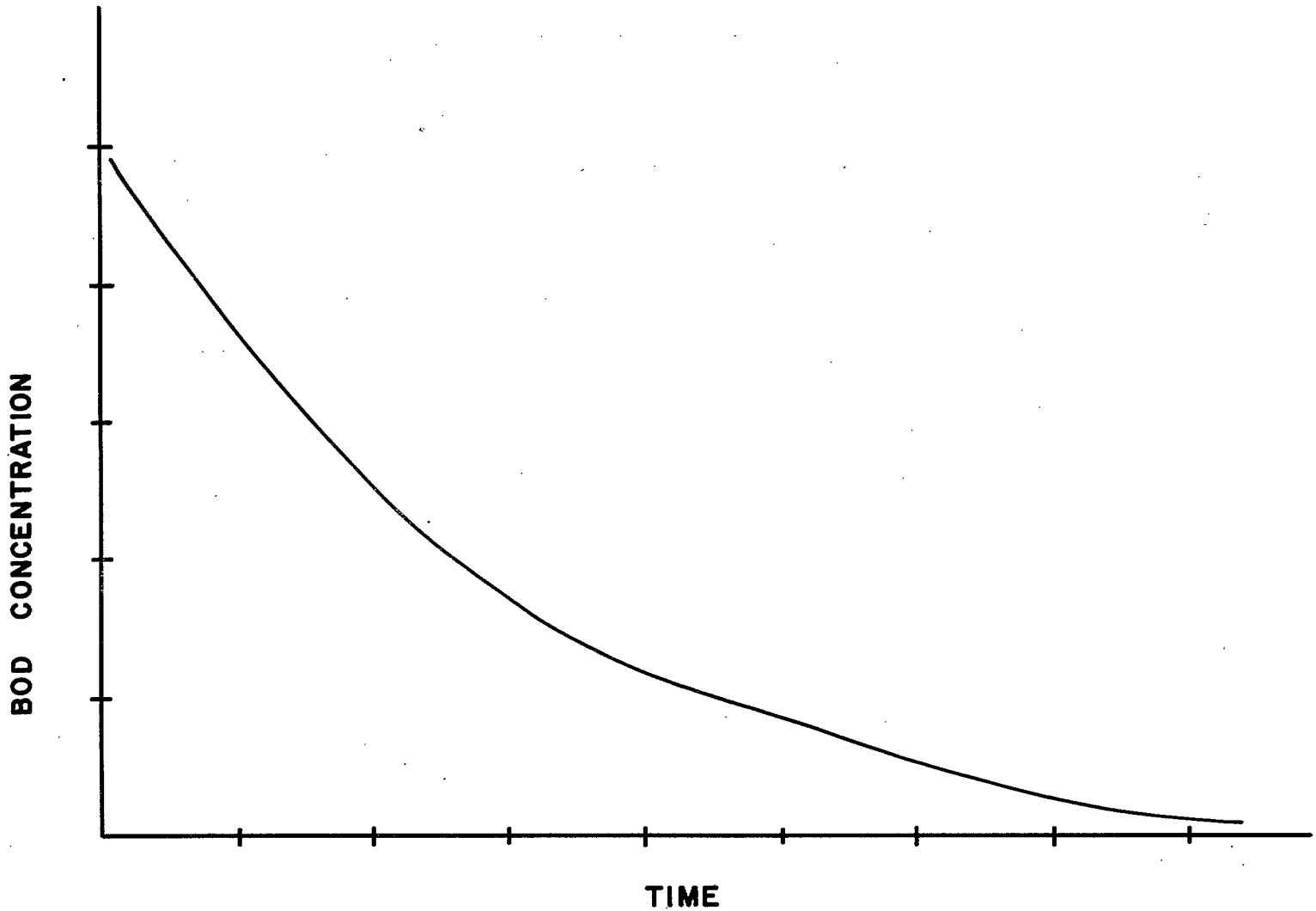


Figure 26. BOD removal curve for hypothetical biological treatment system.

2.3.3 High Rate Trickling Filter

Trickling filter consists of a vented structure containing a packed bed of media, which can be either rock, Fiberglas, plastic, or redwood material on which a growth of microorganisms develops (see Plate 2). Microbial growth is in the form of a slime. As wastewater flows downward over the structure the microbial mass assimilates and metabolizes the organic matter. The biomass continuously sluffs and is readily separated from the liquid stream by sedimentation. The resulting sludge requires further treatment and disposal, as described previously.

Artificial media promotes air circulation, and reduces clogging. As a result, artificial media beds can be over twice as deep as rock media beds and have correspondingly longer contact times. Longer contact times and recirculation of liquid flow enhance treatment efficiencies. The recirculation of settled sludge with the liquid stream is also claimed to improve treatment.

Typical systems, pictured in Plates 3 and 4 are simple to operate, the sole operational variable being recycle rate. The treatment efficiency of a well-designed deep-bed trickling filter tower of 14 feet or more with high recycle can be superior to that of a carelessly-operated activated sludge system. The system is not particularly sensitive to shock loadings, but is severely impaired by wastewater temperatures below 7°C (45°F). Below 2°C (35°F), treatment efficiency is minimal. The effect of grease and oil in trickling filter influent has not been evaluated; this would likely be detrimental. High-rate trickling filters can provide up to 85 percent reduction of BOD and influent wastewater. At this time, no cost data are available for high-rate trickling filters for the seafood industry.

2.3.4 Ponds and Lagoons

Aerated lagoons and basins of significant depth, 6 to 12 feet, in which oxygenation is accomplished by

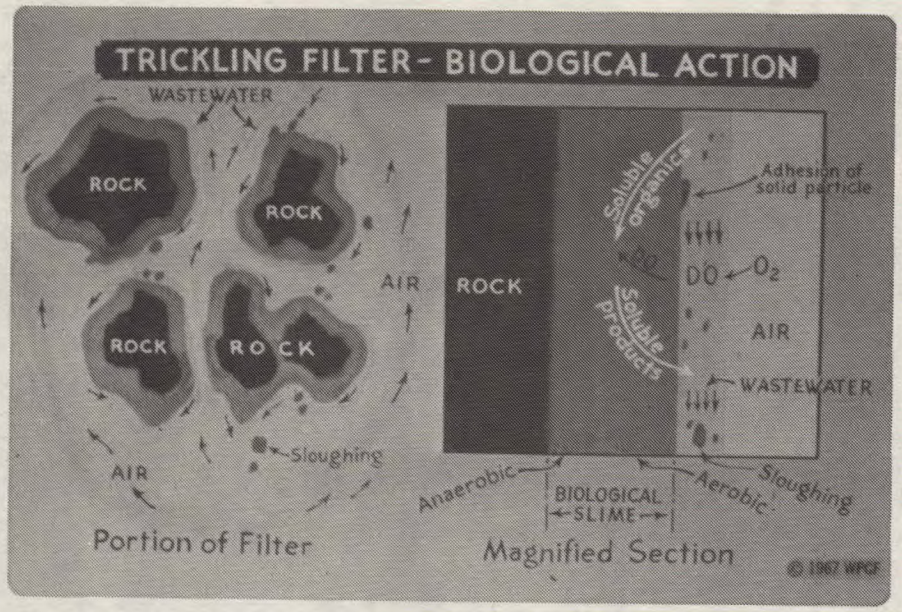


Plate 2. Trickling filter - biological action.

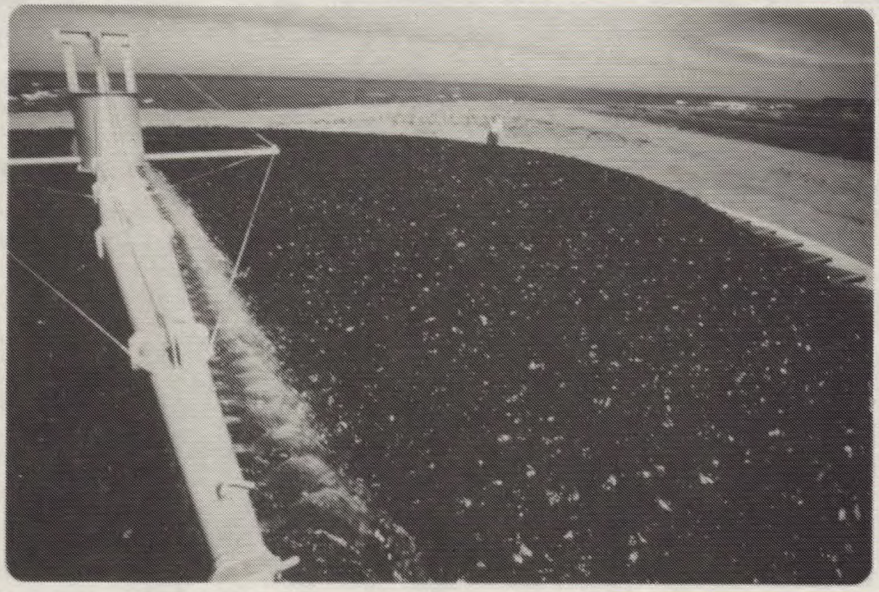


Plate 3. Surface view of a typical trickling filter with rock media.

Plate 4. Trickling filter with synthetic media.
(courtesy of Surfpac).

mechanical (Plate 5) or diffused aeration units. Oxidation ponds and facultative lagoons utilize natural aeration. The land requirements for ponds and lagoons limit the locations at which these facilities are practicable. Where conditions permit, they can provide reasonable treatment alternatives.

Two types are in common use: 1) the completely mixed aerobic basin, where the solids are maintained in suspension; 2) the non-agitated aerobic-anaerobic (facultative) basin where the upper portion of the basin is aerobic, while the lower depths are anaerobic. Naturally aerated lagoons, which are of the aerobic-anaerobic type are termed oxidation ponds. Such ponds are 0.9 to 1.2 m (3 to 4 feet deep), with oxidation taking place chiefly in the upper 0.45 meters (18 inches). Mechanically-aerated lagoons are mixed ponds over 1.8 m (6 feet) and up to 6.1 m (20 feet) deep, with oxygen supplied either by a floating aerator or a compressed air diffuser system. Artificial aeration has the secondary advantage of keeping the contents mixed, thus providing maximum contact between the organic matter and the active biological mass.

The design of lagoons requires particular attention to local insolation, temperatures, wind velocities, etc., for critical periods. There variables affect the selection of design criteria. Loading rates vary from 22 to 112 kg BOD/day/ha (20 to 100 lb/day/acre), and detention time, from 3 to 50 days.

Although not frequently used in the fish processing industry, lagoons are in common use in other food processing industries. Serious upsets can occur. The oxidation pond may produce great quantities of algae and the aerated lagoon may turn septic in zones of minimal mixing. Recovery from such upsets may take weeks. The major disadvantage of lagoons is the large land requirement. In regions where land is available and soil conditions make excavation feasible, the aerobic lagoon should find application in treating fish wastes.

Plate 5. Aerated lagoon (courtesy Eimco Co.).

If the plant discharge does not contain salt water, anaerobic and/or anaerobic-aerobic systems may also be utilized. Aerated lagoons are reported to produce an effluent suspended solids concentration of 260 to 300 mg/l (mostly algae) while anaerobic ponds produce an effluent with 80 to 160 mg/l suspended solids (Metcalf and Eddy, 1972). Figure 27 shows the costs versus flow relationship for aerated lagoons.

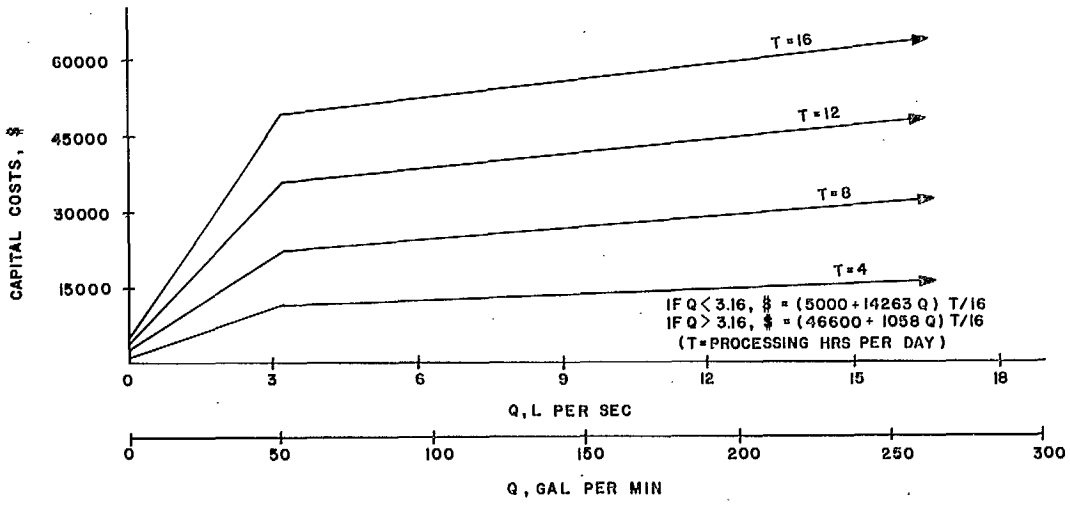
2.4 Land Disposal of Wastewater

"Zero-discharge" technology is practicable where land is available upon which the processing wastewaters may be applied without jeopardizing groundwater quality. The site, surrounded by a retaining dike should sustain a cover crop of grass or other vegetation.

Wastes are discharged in spray or flood irrigation systems by 1) distribution through piping and spray nozzles over relatively flat terrain or terraced hillsides of moderate slope; or 2) pumping and disposal through ridge-and-furrow irrigation systems which allow a certain level of flooding on a given plot of land. Pretreatment for removal of solids is advisable to prevent plugging of the spray nozzles, or deposition in the furrows of a ridge-and-furrow system, which may cause odor problems or plug the soil.

In a flood irrigation system the waste loading in the effluent would be limited by the waste loading tolerance of the particular crop being grown on the land. It may also be limited by the soil conditions or potential for vector or odor problems.

Wastewater distributed in either manner percolates through the soil where the organic matter in the waste undergoes biological degradation. The liquid in the waste stream is either stored in the soil or passed into the groundwater. A variable percentage of the waste flow is also lost by evapotranspiration (the loss due to evaporation to the atmosphere through the leaves of plants). The following factors affect



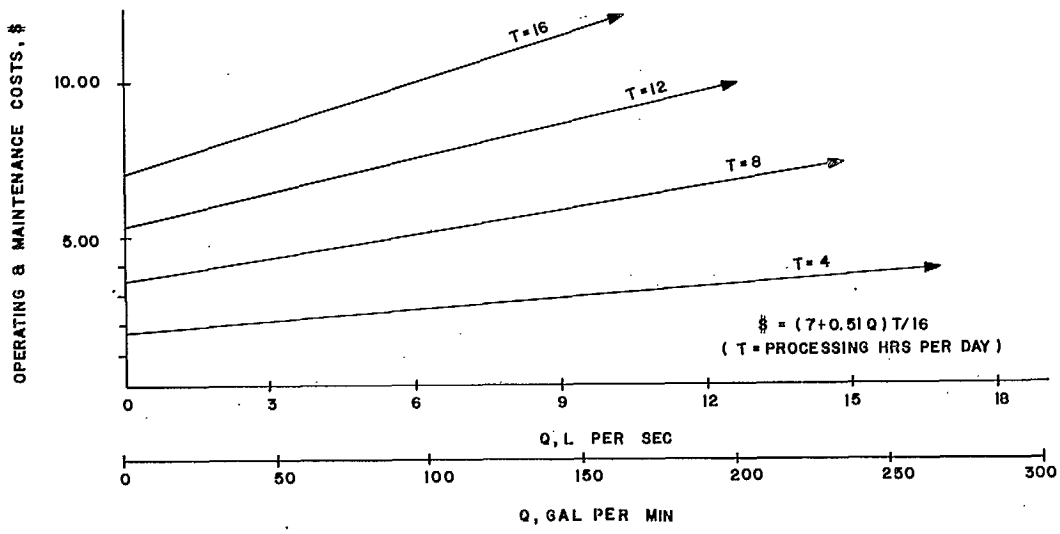


Figure 27. Capital and operating/maintenance costs for typical aerated lagoon systems (Environmental Associates, Inc., 1974).

the ability of a particular land area to absorb wastewater: 1) character of the soil, 2) stratification of the soil profile, 3) depth of groundwater, 4) initial moisture content, 5) terrain and groundcover, 6) precipitation, 7) temperature, and 8) wastewater characteristics.

The greatest concern in the use of irrigation as a disposal system is the total dissolved solids content and especially the sodium content of the wastewater. Salt-water waste flows are incompatible with land application technology at most sites. Limiting values for total dissolved solids (TDS) which may be exceeded for short periods but not over an entire growing season were estimated (conservatively) (Talsma and Phillip, 1971) to be 450 to 1000 mg/l. Where land application is feasible it must be recognized that soils vary widely in their percolation properties. Experimental irrigation of a test plot is recommended in untried areas. Cold climate systems may be subjected to additional constraints, including storage needs.

The long-term reliability of spray or flood irrigation systems depends on the sustained ability of the soil to accept the wastewater. Problems in maintenance include 1) controlling salinity levels in the wastewater; 2) compensating for climatic limitations; and 3) sustaining pumping without failure. Many soils are improved by spray irrigation. Certain nutrient accumulations in the soil complex can be eliminated by physically removing or harvesting crops.

Removal efficiencies for this type of treatment are difficult to measure, but are assumed to be 100 percent by definition. Associated costs include pumps, piping, and spray nozzles. Maintenance and operating costs are at a minimum with this system.

2.5 Solids Disposal Methods

Disposing of the solid waste, generated by screens, biological systems, or one of the air flotation methods, is often a problem. Where reduction or other solid fish waste processing plants are not close by, other methods of solid waste disposal must be considered. The methods thought to be most practical for the seafood industry are sanitary landfill, land disposal, deep sea disposal, and incineration.

2.5.1 Sanitary Landfill and Land Disposal

Land disposal has in one form or another (often simply the open dump) been used as the mainstay of solid waste disposal since solid wastes become a problem. The only acceptable form of land disposal, however, is the sanitary landfill. Few land disposal operations across the U.S. today meet the criteria of a sanitary landfill, although they may carry the name. Moreover, many sites cannot meet the criteria without substantial design modifications.

The use of land disposal for such highly putrescible wastes as those from seafood processing requires sanitary landfills with daily cover and treatment of leachates. Without these conditions, found in well-operated and designed sanitary landfills, land disposal has substantial negative impacts on surrounding lands through attraction of rodents and insects, emission of odors, and pollution of surface and subsurface waters. Land disposal can be an economical option if careful site selection is practiced and the site is properly engineered to take into account resulting environmental effects (Dehn, 1974).

2.5.2 Deep Sea Disposal

In addition to placement in or on the land, another ultimate disposal alternative is dispersion in the waters. Ocean disposal itself has come under considerable scrutiny over the past year. New federal legislation provides for closer supervision of ocean disposal by the federal government.

Whether through an outfall directly from the cannery or via barging to deep sea sites, arguments in favor of this option center around the fact that it returns nutrients to the sea for the further support of marine life. Deep sea disposal is costly in terms of equipment, particularly if large quantities of waste are involved and the cannery is distant from acceptable disposal areas. Grinding and out-fall discharge to deep water is more economical and can achieve adequate dispersion of solids to avoid substantial impacts on dissolved oxygen levels in receiving waters. No further solids disposal is needed with either of these methods.

Grinding and disposing of wastes in shallow, quiescent bays has been practiced in the past, but will undoubtedly be discontinued. Disposal depths of less than 13 m (7 fathoms), particularly in the absence of vigorous tidal flushing, may be expected to have detrimental effects on the marine environment and the local fishery, whereas (generally) a deep disposal site would not.

The identification of suitable sites for this practice undoubtedly demands good judgement and detailed knowledge of local conditions. Used in the right manner, however, deep sea disposal is an efficient and cost-effective technique second only to direct solids recovery and by-product manufacture.

2.5.3 Incineration

No known incineration of seafood solid wastes is currently being practiced. Incineration by means of multiple hearth furnaces has been effective with municipal wastes and sludges, when operated on a continuous basis. Intermittent start-up and shut-down is inefficient and shortens the useful life of the equipment. A technique for incinerating solid wastes in a molten salt bath is under development, with one unit in operation. The by-products are CO_2, water vapor, and a char residue which is skimmed from the combustion chamber.

This device may prove to be viable in reasonably small units (Lessing, 1973). Pit incinerators have been used for many solid and semi-solid wastes and may be useful in disposing of seafood wastes. The incinerators are brick lined and have air supplies to aid particulate retention and ensure complete combustion. This disposal method is simple to operate and especially adaptable to situations requiring batch incineration (Nemerow, 1971).

Processing in incineration is popular for many types of waste materials and can be economical if wastes are relatively dry and contain substantial fuel value. Neither of these conditions is met by wastes from seafood processing, and additional costs might be incurred in waste processing and use of supplemental fuel. More stringent air pollution regulations may require costly additions to an incineration process for seafood wastes to eliminate odors from waste stack gases. Incombustible residues must still be landfilled or disposed of at sea.

2.6 Waste Treatment Case Studies

Information on full-scale and pilot plant installations of waste treatment systems in the seafood industry is not plentiful. The main reasons for this are two fold: 1) many firms regard their waste treatment systems performance and cost data proprietary; and 2) only a small percentage of firms processing fish and shellfish in the U.S. practice wastewater treatment to a significant extent.

A few selected case studies are described below.

2.6.1 Case Study Number 1: Tangential Screening of Shrimp Processing Wastewater (Peterson, 1973b)

The National Marine Fisheries Service conducted a test in mid-1972 to analyze the performance of gravity-fed tangential screens in removal of solids from shrimp processing wastewaters at a plant in Kodiak, Alaska. A plant was selected which incorporated typical processing operations so that representative results could be obtained. The equipment selected consisted

of Bauer Hydrasieves with equivalent openings of 30 mesh (0.040 inch). One 6 ft wide and one 18 inch wide screen was used. Effluent was pumped or flumed from discharge sumps or troughs.

The test was conducted at East Point Seafoods Company on July 14, 1972. This plant used Laitram Model A peelers in its shrimp canning operation (depicted in Figure 28). Plant flows averaged 900 gpm of which all intake water was fresh water. The 6 foot wide screen was used, and the wastewater was added at the top of the feed hopper (as opposed to the normal design of pumping it in at the bottom). The reductions obtained are tabulated in Table 41.

TABLE 41. Screening Study Results - Shrimp Processing Wastewaters (Peterson, 1973b)

	Before Screening	After Screening	% Reduction
Total COD	2734 mg/l	2360 mg/l	14
Total Solids	2680 mg/l	1900 mg/l	29
Total Susp. Solids	1160 mg/l	720 mg/l	38
Setteable Solids	50-55 ml/l	6 ml/l	85
Turbidity	200-230 jtu	180-207	10

2.6.2 Case Study Number 2: Dissolved Air Flotation Treatment of Sardine Processing Wastes

In 1971 the Maine Sardine Council retained the Edward C. Jordan Company (Atwell, *et al.*, 1972) to study sardine processing wastewater and evaluate treatment systems applicable to such waste. Various systems were set up at the Stinson Canning Company in Prospect Harbor, Maine to test its performance on sardine packing wastewaters.

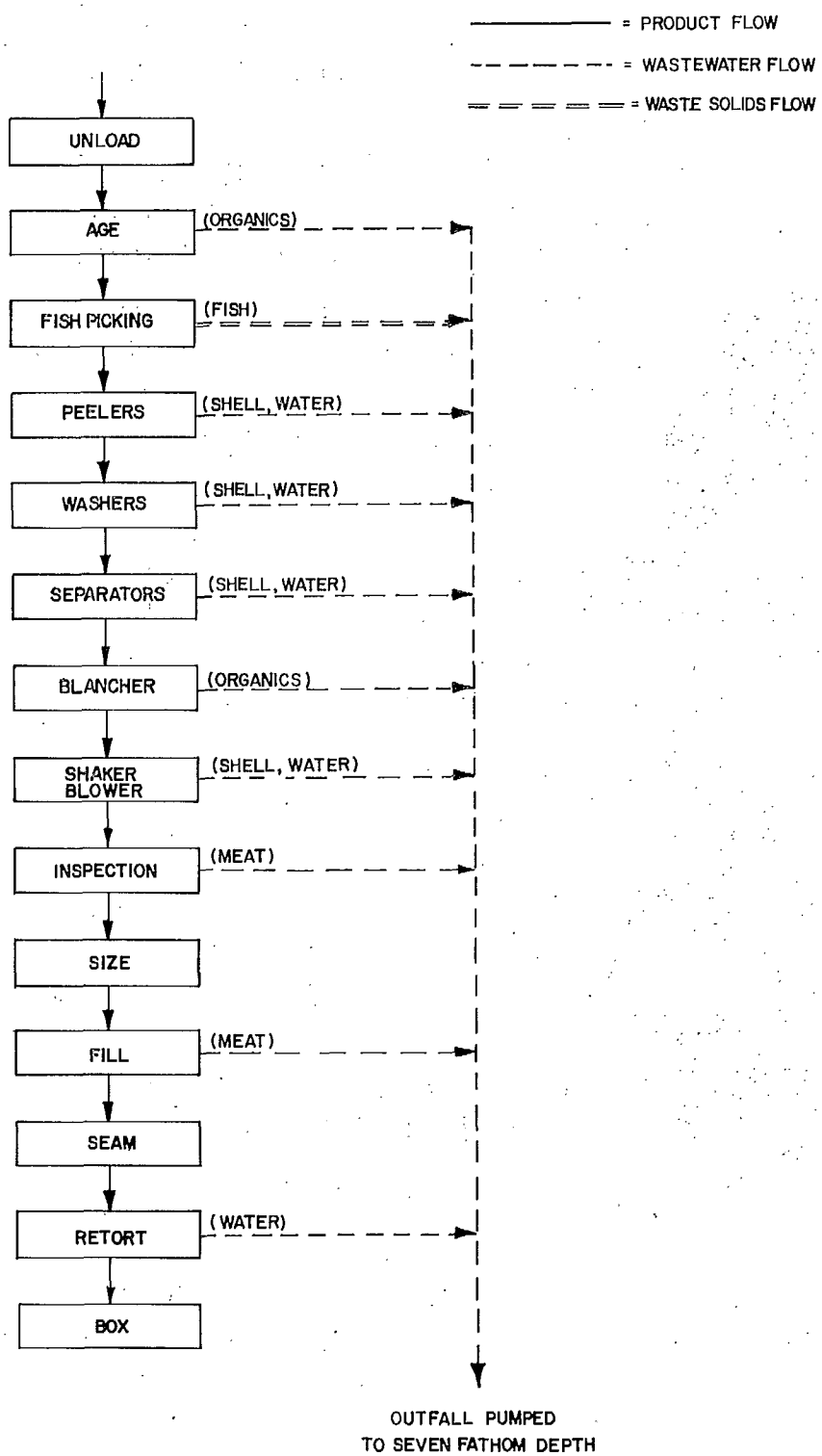


Figure 28. Alaska and west coast shrimp canning process (Environmental Associates, Inc., 1973).

The plant selected utilized the typical sardine process. The wastewater was characteristically high in grease and oil, the principal source of which was the pre-cook operation. The total composition of the plant's effluent is tabulated in Table 42.

TABLE 42. Sardine Processing Wastewater, Industry Average (mg/l)

BOD_5	COD	Total Solids	Susp. Solids	Oil and Grease
750	1850	32,500	600	400

Wastewater quantities depend on in-plant conservation practices from plant to plant. However, a working average is from 135,000 to 155,000 gallons per day.

The initial investigation of the wastewater treatability determined the presence of large quantities of large solid particles which could be easily screened from the flow. Preliminary testing of several screen designs indicated that tangential screen with 0.040 inch openings gave the most satisfactory results. Removals of 16-37 percent of the suspended solids and 14 percent of the BOD were achieved with this screen. Thus, a Bauer Hydrasieve tangential screen was incorporated in the test plant to pre-treat the effluent before subsequent treatment.

In attempting to find the most effective subsequent treatment system, the consultants had to deal with several factors affecting the sardine industry. Sardines are very seasonal and during the short season landings are erratic. Thus, waste flows are highly variable from day to day. In addition, the processes use large volumes of seawater, which severely affects biological treatment. It was decided, therefore, that a non-biological system must be found which

could handle the wide fluctuations in waste flow. Based on these criteria, dissolved air flotation was determined to be the system of choice.

Two models of equipment were erected at the sardine plant, one designed by Pollution Control Engineering and one by CE NATCO. During the testing, the PCE unit performed as expected. The CE NATCO unit had mechanical difficulties and was not as effective. Little work was done on optimization of chemicals for most efficient removal. Alum was added at 200 ppm and a polymer was used at 2 ppm during the tests. Table 43 indicates the approximate removal efficiencies during the tests.

TABLE 43. Dissolved Air Flotation and Removal Efficiencies on Sardine Processing Wastewater

BOD	Suspended Solids	Oil and Grease
57-71%	91-98%	80%

In summary, it was found that air flotation equipment was the most practicable method of treatment of sardine wastewater. Its ability to treat a wide range of waste flows and loadings, its relative insensitivity to saline wastes and "shock" loads, its relatively low cost and minimal land requirements make it the system of choice in the Maine sardine industry.

2.6.3 Case Study Number 3: Dissolved Air Flotation Treatment of Tuna Processing Wastes

A study was conducted to evaluate various wastewater treatment systems in treating tuna cannery waste. Treated effluent was to be brought to a level commensurate with government

standards imposed on the plant. A short testing period was necessary to get the plant operating as soon as possible within the imposed limits, so the usefulness of the data is somewhat attenuated by its brevity.

The plant processed tuna through a fairly typical operation, as depicted in Figure 29. Wastewater was generated by the operations depicted in the diagram. Several in-plant process changes were considered to decrease water usage. These changes were thought to change the total plant effluent character, so for the purposes of these tests, butcher sump water was used.

In evaluating the treatment systems and equipment for this project, several criteria were of primary importance. First, space requirements had to be minimized due to a lack of sufficient low-value land on which to construct a facility. Secondly, cost had to be minimized while still retaining a high removal efficiency. Since the treatment system was non-profitable to the plant, a large expenditure could not be justified. Finally, the unit selected must be flexible to handle changing waste loads resulting from future plant modification.

After preliminary investigation, the choice was narrowed to either dissolved air flotation or dispersed air flotation. Pilot scale equipment of each design was obtained and installed at the plant to treat the effluent from the butcher sump. The dispersed air flotation unit was a Depurator unit made by the Wemco Division of Envirotech. The dissolved air flotation system was a Flotator unit manufactured by the Eimco Division of Envirotech. In these systems, various chemicals were added to promote flocculation of suspended solids in the waste. For this study, several combinations of chemicals, consisting of alum, lime, ferric chloride and polymer products were tested in each system by conducting several extended polit runs, each time using a different chemical combination. The effluents from the equipment were compared with the influent waste.

Based on three important wastewater parameters, (suspended solids, BOD, and oil and grease) the dissolved air

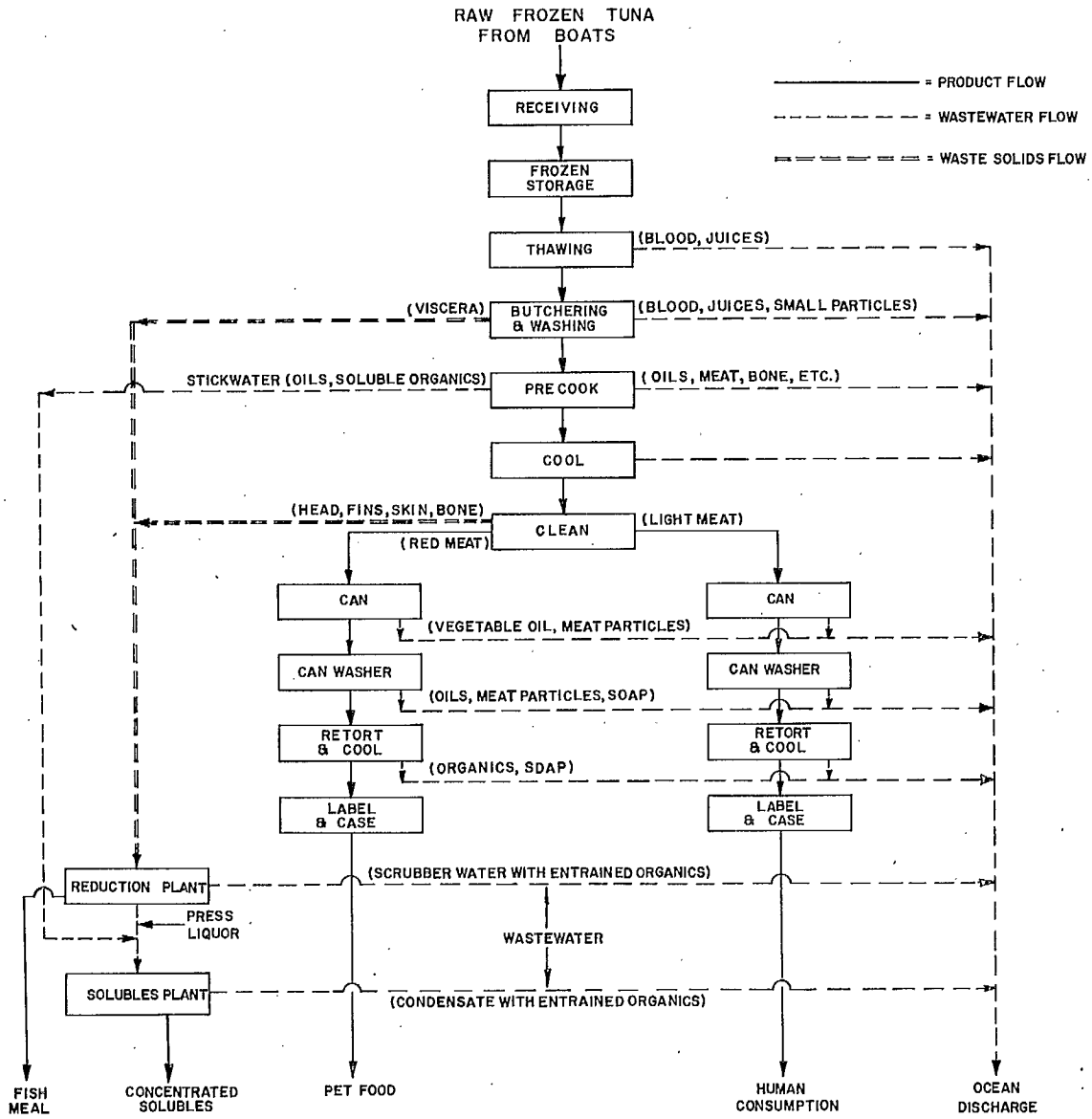


Figure 29. Tuna process (Environmental Associates, Inc., 1973).

flotation unit proved to be superior in terms of removal efficiency. It yielded average total removals of 60-66 percent, depending on the chemicals used. The dispersed air flotation unit did not produce similar results. Both systems produced highly variable and unsatisfactory results when operated without chemical additions.

In conclusion, it was found that dissolved air flotation would be the system of choice in this case due to its combination of low space requirement, flexibility of operation, relatively low cost, production of a more concentrated (and thus less voluminous) sludge, and production of an oxygen saturated effluent.

2.6.4 Case Study Number 4: Biological Treatment of Oyster Processing Wastes

The Ray J. Jones Seafood Company of Wittman, Maryland, in conjunction with the Maryland Water Resources Administration, conducted an on-line commercial test of a biological treatment system beginning in March of 1973. The plant processes hand-shucked oysters, blue crab, and some clams, and the treatment system was to be tested on the wastewater effluents from all three processes during 1973. Preliminary results are available for the oyster process and they indicate the system performs well.

The hand-shucked operation at the R.J. Jones plant is fairly typical of small oyster processors. The blowdown tanks and the shucking and washdown operations produce practically all the wastewater, which, on a typical day of processing, amounts to approximately 2000 gal. This small waste flow makes most wastewater treatment systems difficult to operate and prohibitively costly to purchase.

For small processors such as this, treatment systems must be found which can meet several important criteria:

1) low cost - large expenditures required for waste treatment would simply put these processors out of business.
2) ease of operation - constant monitoring and maintenance of a waste treatment system cannot be economically justified by small processors, and
3) small size - many processors have limited land on which to construct treatment systems.

Preliminary analysis of the wastewater from the plant indicated that it was amenable to biological treatment. A review of available equipment and system designs indicated that an extended aeration system would probably be the design most capable of meeting the requirements.

A small package plant mounted in a 32 foot van was manufactured by the Cromoglass Corporation for use in this test. It consisted of a 900 gallon aerated "roughing" tank, a 1250 gallon settling tank, and a small chlorine contact chamber. Chlorination was supplied by solid tablets (sodium hypochlorite) added to the tank. Influent from the plant was screened through rough basket screens and pumped into the system. The capital cost of the system was $7000. Daily maintenance was minimal, requiring only screen cleaning and chlorine tablet addition. The whole unit was contained within the van.

Preliminary results indicate effective reduction of waste loadings using this system. The prime waste consists of dissolved and suspended organic matter, measured as BOD. Untreated effluent BOD levels of 400 to 1200 mg/l (ppm) were common. After treatment, BOD levels averaged approximately 160 mg/l. Overall BOD reductions averaged 80-90 percent.

This method of treatment fits the needs of small processors fairly well. It might be used to treat economically a wide variety of seafood wastes if conditions warrant its use.

2.6.5 Case Study Number 5: Centrifugal Wastewater Concentrator Treatment of Shrimp Wastes

Environmental Associates, Inc., and the National Marine Fisheries Service conducted a study using the SWECO centrifugal wastewater concentrator at East Point Seafood's South Bend Washington plant. The plant employs two Model A and two Model PCA Laitram peelers.

A positive displacement pump was used to pump the wastestream to the 0.020 inch Bauer Hydrasieve. Alum (220 ppm) and lime (250 ppm) were added to the screened effluent in the contact chamber. The slurry was then pumped through the SWECO concentrator (400 mesh) and into a skimming trough. Approximately 20 percent of the flow used to backwash the screen was discharged with the solids. In the skimming trough, the highly aerated wastewater was allowed sufficient retention time for the bubbles to float the solids to the surface. These solids were removed by a skimming mechanism.

The results of this study are shown in Table 44.

TABLE 44. Removal Efficiencies of the Screen, SWECO Wastewater Concentrator and Skimming Tank With and Without Chemical Addition

Parameter	Influent-mg/l (includes shell)	Removal Efficiencies (%) After Sieve	After Skimming Trough Without Chem.	After Skimming Trough With Chem.
Susp. Solids	1020	35	52	95
BOD	1320	18	24	81
COD	2160	13	28	75
Oil and Grease	80	--	--	85
Set. Solids (ml/l)	45	84	99	--

3. TREATMENT SYSTEM COSTS

3.1 Assumptions

Certain assumptions were necessary prior to development of the cost analyses for the treatment systems. These assumptions, the length of the processing day and processing season, the production and water use rate, and the water used per unit of product, are listed at the top of each table. Any deviations from these assumptions would vary the costs correspondingly. Theoretical effluent (BOD, suspended solids, and grease and oil) levels after application of each treatment system are also listed in each table. Plant locations, plant and equipment age, variations in unit processes and waste treatment systems presently in use are also pertinent to the costs and are enumerated briefly for each process/product subcategory.

With respect to the tables, the costs of the treatment systems 1,2,3,4 are cumulative. That is, the costs listed under number 2 are actually the costs of system 1 plus system 2. All cost data were based on the most recent Environmental Associates' study (1974) of the seafood industry.

3.2 Industrial Fishes and Finfish

3.2.1 Fish Meal Processes

Fish meal plants are found with and without solubles plants. The large plants (those processing around 170,000 tons/year) usually have a solubles plant that evaporates the stickwater, bailwater and washwater. These plants use available surface water to draw a vacuum on barometric condenser. Presently, condenser water usually is used for one pass only before discharge to the source. If a cooling system is installed, the water can

be recirculated through the system. A recirculation system with trickling filter was priced for a typical plant at about $325,000 capital costs with annual O and M costs of $16,500. Table 45 estimates the costs to install and operate either an extended aeration or aerated lagoon system at a fish meal with solubles plant.

Some of the smaller fish meal plants evaporate the stickwater but discharge the bailwater. Either the solubles plant can be enlarged to facilitate the bailwater or the bailwater can be treated separately. Table 46 shows the costs associated with treating bailwater from a typical plant.

The small fish meal plants usually do not have a solubles plant, these plants typically discharge both stickwater and bailwater. Barging is a disposal option that costs 0.010425 per gallon based on a 50-mile round trip. If the stickwater is barged, then only the bailwater requires treatment consideration. If the stickwater is not barged, it too must be treated.

The strength of stickwater without pretreatment makes the amenability of it to standard treatment very questionable. The University of Wisconsin (Quigley, 1972) performed a laboratory study on treatment of stickwater from the alewife reduction industry. They found coagulation with chemicals followed by filtration to be a plausible system. They estimated the equipment costs for a plant processing 7 ton/hour to be about $30,000 (excluding drying). Chemical costs of $0.023/1000 lbs stickwater for HCl and $1.25/1000 lbs stickwater for glutenaldehyde were considered recoverable by solids value. They estimated the costs of anaerobic-aerobic lagoon system to handle the pretreated process water (1400 gpm) at $12,000 per year annual costs based on seven percent capital costs and ten percent depreciation.

TABLE 45 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : FISH MEAL WITH SOLUBLES PLANT

OPERATING DAY	22.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	38.6	TON/HR
	35.0	KKG/HR
PROCESS FLOW	1500.0	GPM
	94.7	L/SEC
HYDRAULIC LOAD	2333.8	GAL/TON
	9.7	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	892.	202.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	71.	16.
DEPRECIATION @ 10%	89.	20.
DAILY COSTS($)		
O&M	158.	76.
POWER	1.	1.
TOTAL ANNUAL COSTS($1000)	192.	52.

PARAMETER	RESULTING EFFLUENT LEVELS	
BOD-MG/L	60.	80.
-KG/KKG	0.58	0.78
TSS-MG/L	29.	34.
-KG/KKG	0.28	0.33
G&O-MG/L	38.	38.
-KG/KKG	0.37	0.37

TREATMENT SYSTEMS

1 EXTENDED AERATION

OR

2 AERATED LAGOON

Table 46. Water effluent treatment costs
canned and preserved fish and seafood

Subcategory: Fish meal without solubles plant

Operating day	22.0	hours
Season	200.0	days
Production	8.2	ton/hr
	7.4	kkg/hr
Process flow	100.0	gpm
	6.3	l/sec
Hydraulic load	30.3	gal/ton
	0.1	cu m/kkg

Treatment system	1	2
Initial investment ($1000)	564.	105.
Annual costs ($1000)		
Capital costs @ 8%	45.	10.
Depreciation @ 10%	56.	12.
Daily costs ($)		
O & M	48.	145.
Power	1.	5.
Total annual costs ($1000)	111.	51.

Parameter	Resulting effluent levels	
BOD - mg/l	11396.	90.
kg/kkg	1.42	2.90
TSS - mg/l	2933.	28.
kg/kkg	0.37	1.10
G&O - mg/l	793.	22.
kg/kkg	0.10	0.69

Treatment systems (cumulative)

1. Flotation
2. Evaporator only

NOTE: Treatment 1 for bailwater only; treatment 2 for bailwater and stickwater.

We estimate that a double effect stickwater evaporator for a plant processing eight to ten tons/hour would cost $200,000 to $250,000.

Any cost estimate should consider the following:

1) location - the larger plants are located on pilings with a good deal of the plant extending onto the land. The medium plants are mostly inland, while the small plants are located on land near docking facilities. Plants on the East Coast run from Massachusetts to Florida, while on the West Coast they are located along the Northwest and Southern California coastline.
2) Plant age - the physical age of plants sampled runs between 20 to 60 years while the processing equipment varied from 20 years to new.
3) Plant production - the large plants produce nearly 170,000 tons per year, while small plants may produce 32,000 tons per year.
4) Processing hours - most fish meal plants operate almost continuously while fish are available. Some downtime for evaporator cleaning is needed.
5) Season - the processing season varies with location, usually running somewhere between May and December.
6) Unit operations - the methods used to achieve the saleable product are similar except that larger plants recover a larger percentage of the raw product with a solubles plant.

3.2.2 Conventional Bottom Fish Processes

Tables 47 through 53 list the treatment alternatives and associated costs for plants in the "lower 48". Bottom fish plants are scattered along much of the coastline of the lower 48 states. Plants in the "lower 48" process a wide variety of bottom fish species and use a variety of processing methods.

Large plants are those with a throughput of more than 4000 tons of raw product annually. Medium plants process

TABLE 47 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN CONV. BOTTOM FISH - LARGE

OPERATING DAY	10.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	4.3	TON/HR
	3.9	KKG/HR
PROCESS FLOW	100.0	GPM
	6.3	L/SEC
HYDRAULIC LOAD	1396.3	GAL/TON
	5.8	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	19.	77.	166.	110.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	2.	6.	13.	9.
DEPRECIATION @ 10%	2.	8.	17.	11.
DAILY COSTS($)				
O&M	5.	27.	37.	33.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	5.	20.	38.	27.

	RESULTING EFFLUENT LEVELS			
PARAMETER				
BOD-MG/L	601.	301.	60.	80.
-KG/KKG	3.50	1.75	0.35	0.47
TSS-MG/L	309.	31.	60.	200.
-KG/KKG	1.80	0.18	0.35	1.16
G&O-MG/L	69.	7.	5.	5.
-KG/KKG	0.40	0.04	0.03	0.03

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 48 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN CONV. BOTTOM FISH - LARGE

OPERATING DAY	10.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	4.3	TON/HR
	3.9	KKG/HR
PROCESS FLOW	100.0	GPM
	6.3	L/SEC
HYDRAULIC LOAD	1396.3	GAL/TON
	5.8	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	19.	53.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	2.	4.
DEPRECIATION @ 10%	2.	5.
DAILY COSTS($)		
O&M	5.	11.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	5.	12.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	601.	120.
-KG/KKG	3.50	0.70
TSS-MG/L	412.	200.
-KG/KKG	2.40	1.16
G&O-MG/L	69.	34.
-KG/KKG	0.40	0.20

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING

2 AERATED LAGOON

TABLE 49 .WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN CONV. BOTTOM FISH -MEDIUM

OPERATING DAY	9.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	2.5	TON/HR
	2.3	KKG/HR
PROCESS FLOW	60.0	GPM
	3.8	L/SEC
HYDRAULIC LOAD	1420.6	GAL/TON
	5.9	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	17.	65.	138.	94.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	1.	5.	11.	8.
DEPRECIATION @ 10%	2.	7.	14.	9.
DAILY COSTS($)				
O&M	4.	20.	28.	25.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	4.	16.	31.	23.

	RESULTING EFFLUENT LEVELS			
PARAMETER				
BOD-MG/L	591.	295.	60.	80.
-KG/KKG	3.50	1.75	0.36	0.47
TSS-MG/L	304.	30.	60.	200.
-KG/KKG	1.80	0.18	0.36	1.18
G&O-MG/L	68.	7.	5.	5.
-KG/KKG	0.40	0.04	0.03	0.03

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 50. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY: NONALASKAN CONV. BOTTOM FISH - MEDIUM

OPERATING DAY	9.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	2.5	TON/HR
	2.3	KKG/HR
PROCESS FLOW	60.0	GPM
	3.8	L/SEC
HYDRAULIC LOAD	1420.6	GAL/TON
	5.9	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	17.	46.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	1.	4.
DEPRECIATION @ 10%	2.	5.
DAILY COSTS($)		
O&M	4.	9.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	4.	10.

PARAMETER	RESULTING EFFLUENT LEVELS	
BOD-MG/L	591.	118.
-KG/KKG	3.50	0.70
TSS-MG/L	405.	200.
-KG/KKG	2.40	1.18
G&O-MG/L	68.	34.
-KG/KKG	0.40	0.20

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING

2 AERATED LAGOON

TABLE 51. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN CONV. BOTTOM FISH - SMALL

OPERATING DAY	8.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	1.3	TON/HR
	1.2	KKG/HR
PROCESS FLOW	30.0	GPM
	1.9	L/SEC
HYDRAULIC LOAD	1361.4	GAL/TON
	5.7	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	12.	46.	88.	62.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	0.	4.	7.	5.
DEPRECIATION @ 10%	1.	5.	9.	6.
DAILY COSTS($)				
O&M	3.	15.	22.	19.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	3.	12.	21.	16.

PARAMETER	RESULTING EFFLUENT LEVELS			
BOD-MG/L	617.	308.	60.	80.
-KG/KKG	3.50	1.75	0.34	0.45
TSS-MG/L	317.	32.	60.	200.
-KG/KKG	1.80	0.18	0.34	1.14
G&O-MG/L	70.	7.	5.	5.
-KG/KKG	0.40	0.04	0.03	0.03

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 52 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY: NONALASKAN CONV. BOTTOM FISH - SMALL

OPERATING DAY	8.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	1.3	TON/HR
	1.2	KKG/HR
PROCESS FLOW	30.0	GPM
	1.9	L/SEC
HYDRAULIC LOAD	1361.4	GAL/TON
	5.7	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	12.	28.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	0.	2.
DEPRECIATION @ 10%	1.	3.
DAILY COSTS($)		
O&M	3.	7.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	3.	7.

PARAMETER	RESULTING EFFLUENT LEVELS	
BOD-MG/L	617.	123.
-KG/KKG	3.50	0.70
TSS-MG/L	423.	200.
-KG/KKG	2.40	1.14
G&O-MG/L	70.	35.
-KG/KKG	0.40	0.20

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING

2 AERATED LAGOON

TABLE 53 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY: NONALASKAN CONV. BOTTOM FISH - SMALL

OPERATING DAY	8.0	HOURS
SEASON	180.0	DAYS
PRODUCTION	1.0	TON/HR
	0.9	KKG/HR
PROCESS FLOW	50.0	GPM
	3.2	L/SEC
HYDRAULIC LOAD	3025.3	GAL/TON
	12.6	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	16.	64.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	1.	5.
DEPRECIATION @ 10%	2.	6.
DAILY COSTS($)		
O&M	4.	14.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	4.	14.

RESULTING EFFLUENT LEVELS

PARAMETER		
BOD-MG/L	793.	475
-KG/KKG	10.00	6.00
TSS-MG/L	650.	146
-KG/KKG	8.20	1.85
G&O-MG/L	166.	17.
-KG/KKG	2.10	0.21

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITHOUT CHEMICALS

between 2000 and 4000 tons of raw product annually. Small plants process less than 2000 tons of raw product annually.

Many bottom fish plants run a standard shift of eight hours per day, if raw product is available, while others lengthen the work day as the availability of the raw product increases. During the sampling period the observed average shift length was seven hours for plants outside Alaska.

Most bottom fish plants process throughout the year; however, weather often hampers fishing operations during certain parts of the year.

3.2.3 Mechanized Bottom Fish Processes

Most mechanized plants are located on the Atlantic and Gulf Coasts. These plants are typically larger than the conventional plants because of the high amount of mechanization results in a faster raw product flow through. Many of the unit operations that are done by hand in a conventional plant are done by machine in a mechanized operation. Large plants process over 7000 tons of raw product per year, whereas the smaller plants process less than 2000 tons annually. Plant ages vary; however, the equipment is usually periodically updated. The processing seasons are generally shorter since few species of fish are utilized.

Coarse screening and solids recovery systems are common. Some plants employ primary clarifiers before discharging wastewater. Solids are used in rendering plants or sold for bait. The costs associated with treatment are listed in Tables 54 through Table 56.

3.3 Shellfish

There are many operating conditions that apply to all of the subcategories in this group. Plant age cannot be

TABLE 54. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN MECH. BOTTOM FISH - LARGE

OPERATING DAY	8.0	HOURS
SEASON	180.0	DAYS
PRODUCTION	6.1	TON/HR
	5.5	KKG/HR
PROCESS FLOW	180.0	GPM
	11.4	L/SEC
HYDRAULIC LOAD	1782.2	GAL/TON
	7.4	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	24.	104.	188.	134.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	2.	8.	15.	11.
DEPRECIATION @ 10%	2.	10.	19.	13.
DAILY COSTS($)				
O&M	5.	28.	39.	34.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	5.	24.	41.	31.

PARAMETER	RESULTING EFFLUENT LEVELS			
BOD-MG/L	1346.	336.	60.	80.
-KG/KKG	10.00	2.50	0.45	0.59
TSS-MG/L	807.	81.	60.	200.
-KG/KKG	6.00	0.60	0.45	1.49
G&O-MG/L	283.	28.	14.	14.
-KG/KKG	2.10	0.21	0.11	0.11

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 55. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN MECH BOTTOM LARGE

OPERATING DAY	8.0	HOURS
SEASON	180.0	DAYS
PRODUCTION	6.1	TON/HR
	5.5	KKG/HR
PROCESS FLOW	180.0	GPM
	11.4	L/SEC
HYDRAULIC LOAD	1782.2	GAL/TON
	7.4	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	24.	104.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	2.	8.
DEPRECIATION @ 10%	2.	10.
DAILY COSTS($)		
O&M	5.	16.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	5.	20.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	1346.	806.
-KG/KKG	10.00	6.00
TSS-MG/L	1103.	248.
-KG/KKG	8.20	1.85
G&O-MG/L	283.	28.
-KG/KKG	2.10	0.21

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITHOUT CHEMICALS

TABLE. 56. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NONALASKAN MECH. BOTTOM FISH -SMALL

OPERATING DAY	8.0	HOURS
SEASON	180.0	DAYS
PRODUCTION	1.0	TON/HR
	0.9	KKG/HR
PROCESS FLOW	50.0	GPM
	3.1	L/SEC
HYDRAULIC LOAD	3025.3	GAL/TON
	12.6	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	16.	63.	126.	88.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	1.	5.	10.	7.
DEPRECIATION @ 10%	2.	6.	13.	9.
DAILY COSTS($)				
O&M	4.	17.	24.	21.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	4.	15.	28.	20.

	RESULTING EFFLUENT LEVELS			
PARAMETER				
BOD-MG/L	793.	198.	60.	80.
-KG/KKG	10.00	2.50	0.76	1.01
TSS-MG/L	476.	48.	60.	200.
-KG/KKG	6.00	0.60	0.76	2.52
G&C-MG/L	166.	17.	8.	8.
-KG/KKG	2.10	0.21	0.11	0.11

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

considered a factor influencing the waste strength especially in hand-shucked operations where there is very little mechanization. Age influence on mechanized operations is partially nullified by periodic equipment modifications. Plant age can affect treatment costs somewhat by the potential plumbing costs that exist at some of the older plants. Most plants attempt to process eight hours per day but it usually varies with raw product availability and therefore averages somewhat less than eight hours.

Clam, oyster and abalone plants salvage the shell. In those mechanized subcategories where the shell is broken during the meat removal operation, some plants have installed settling basins to facilitate shell fragment removal. Other plants use coarse screening for this purpose.

3.3.1 West Coast Crab Processes

Table 57 shows the recommended treatment systems and their related removal efficiencies for Dungeness and tanner (queen) crab processors. Most crab processors are located in small coastal towns.

The West Coast plants process both tanner and Dungeness crab either as hand-picked meat or whole. Solid wastes are generally screened and taken to a rendering plant. Little variations in processes exist between plants.

3.3.2 Northwest Shrimp Processes

Table 57 shows the treatment system costs for an average Northwest Coast shrimp plant. Northwest plants are typically located in small coastal towns.

The only variations in the processes are in the number and type of peelers used and whether the peeled shrimp is canned or frozen. Most of the processors in metropolitan areas screen their wastewater. The solids are typically disposed of by further processing for animal feed.

TABLE 57. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : WEST COAST DUNGENESS CRAB

OPERATING DAY	10.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	0.9	TON/HR
	0.8	KKG/HR
PROCESS FLOW	67.0	GPM
	287.8	L/SEC
HYDRAULIC LOAD	4560.6	GAL/TON
	19.0	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	17.	67.	149.	99.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	1.	5.	12.	8.
DEPRECIATION @ 10%	2.	7.	15.	10.
DAILY COSTS($)				
O&M	5.	23.	32.	29.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	4.	17.	34.	24.

	RESULTING EFFLUENT LEVELS			
PARAMETER				
BOD-MG/L	421.	210.	60.	80.
-KG/KKG	8.00	4.00	1.14	1.52
TSS-MG/L	142.	14.	60.	200.
-KG/KKG	2.70	0.27	1.14	3.80
G&O-MG/L	5.	5.	5.	5.
-KG/KKG	0.10	0.10	0.10	0.10

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 58..WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : NORTHWEST SHRIMP

OPERATING DAY	12.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	1.2	TON/HR
	1.1	KKG/HR
PROCESS FLOW	258.0	GPM
	805.9	L/SEC
HYDRAULIC LOAD	12772.1	GAL/TON
	53.3	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	29.	135.	279.	182.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	2.	11.	22.	15.
DEPRECIATION @ 10%	3.	13.	28.	18.
DAILY COSTS($)				
O&M	9.	26.	47.	37.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	7.	30.	60.	41.

RESULTING EFFLUENT LEVELS

PARAMETER				
BOD-MG/L	2178.	1525.	229.	305.
-KG/KKG	116.00	81.20	12.18	16.24
TSS-MG/L	1014.	304.	60.	200.
-KG/KKG	54.00	16.20	3.20	10.65
G&O-MG/L	789.	118.	18.	59.
-KG/KKG	42.00	6.30	0.94	3.15

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

3.3.3 Steamed and Canned Oyster Processes

Steamed oyster plants are located along the coastline of Chesapeake Bay. Canned oyster plants are known to be located along the Gulf Coast and Washington State coast. The season runs through the fall to an early spring with approximately 160 days per year of processing. Table 59 shows treatment costs for a typical plant.

3.3.4 Hand-Shucked Oyster Processes

Plants are usually found in small towns along the Pacific, Eastern and Gulf Coasts. Processing methods are very similar in each area. Treatment systems have been costed out for typical operations in Tables 60 through 66.

3.3.5 Scallops Processes

Scallops are caught and processed the year around in Alaska. The costs for Alaskan and non-Alaskan plants are shown in Table 67.

3.3.6 Lobster Processes

Spiny lobster water effluent treatment costs are shown in Table 68. Spiny lobster plants are located along the Southern California and Florida coastlines. The Southern California spiny lobster season is closed from April to October. No treatment was considered necessary for the American lobster plants since no processing is practised.

TABLE 59. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : STEAMED OR CANNED OYSTERS

OPERATING DAY	8.0	HOURS
SEASON	110.0	DAYS
PRODUCTION	0.9	TON/HR
	0.8	KKG/HR
PROCESS FLOW	220.0	GPM
	13.9	L/SEC
HYDRAULIC LOAD	14975.1	GAL/TON
	62.5	CU M/KKG

TREATMENT SYSTEM	1	2	3	4
INITIAL INVESTMENT($1000)	26.	123.	213.	153.
ANNUAL COSTS($1000)				
CAPITAL COSTS @ 8%	2.	10.	17.	12.
DEPRECIATION @ 10%	3.	12.	21.	15.
DAILY COSTS($)				
O&M	5.	31.	44.	38.
POWER	1.	2.	3.	3.
TOTAL ANNUAL COSTS($1000)	5.	26.	44.	32.

PARAMETER	RESULTING EFFLUENT LEVELS			
BOD-MG/L	641.	160.	60.	80.
-KG/KKG	40.00	10.00	3.75	5.00
TSS-MG/L	1249.	125.	60.	200.
-KG/KKG	78.00	7.80	3.75	12.49
G&O-MG/L	30.	5.	5.	5.
-KG/KKG	1.90	0.31	0.31	0.31

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITH CHEMICALS
3 EXTENDED AERATION
OR
4 AERATED LAGOON

TABLE 60 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : EASTERN HAND SHUCKED OYSTERS - LARGE

OPERATING DAY	8.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	0.4	TON/HR
	0.4	KKG/HR
PROCESS FLOW	60.0	GPM
	3.8	L/SEC
HYDRAULIC LOAD	9335.1	GAL/TON
	39.0	CU M/KKG

TREATMENT SYSTEM	1	2	3
INITIAL INVESTMENT($1000)	17.	65.	130.
ANNUAL COSTS($1000)			
CAPITAL COSTS @ 8%	1.	5.	10.
DEPRECIATION @ 10%	2.	6.	13.
DAILY COSTS($)			
O&M	4.	14.	21.
POWER	1.	2.	3.
TOTAL ANNUAL COSTS($1000)	4.	15.	28.

	RESULTING EFFLUENT LEVELS		
PARAMETER			
BOD-MG/L	360.	252.	60.
-KG/KKG	14.00	9.80	2.34
TSS-MG/L	283.	85.	60.
-KG/KKG	11.00	3.30	2.34
G&O-MG/L	18.	5.	5.
-KG/KKG	0.70	0.19	0.19

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITH CHEMICALS
3 EXTENDED AERATION

TABLE 61 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY EASTERN HAND SHUCKED OYSTERS - MEDIUM

OPERATING DAY	8.0	HOURS
SEASON	200.0	DAYS
PRODUCTION	0.2	TON/HR
	0.2	KKG/HR
PROCESS FLOW	25.0	GPM
	1.6	L/SEC
HYDRAULIC LOAD	8508.6	GAL/TON
	35.5	CU M/KKG

TREATMENT SYSTEM	1	2	3
INITIAL INVESTMENT($1000)	11.	41.	78.
ANNUAL COSTS($1000)			
CAPITAL COSTS @ 8%	1.	3.	6.
DERRECIATION @ 10%	1.	4.	8.
DAILY COSTS($)			
O&M	3.	13.	19.
POWER	1.	2.	3.
TOTAL ANNUAL COSTS($1000)	3.	11.	19.

	RESULTING EFFLUENT LEVELS		
PARAMETER			
BOD-MG/L	395.	276.	60.
-KG/KKG	14.00	9.80	2.13
TSS-MG/L	310.	93.	60.
-KG/KKG	11.00	3.30	2.13
G&O-MG/L	20.	5.	5.
-KG/KKG	0.70	0.18	0.18

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION - WITH CHEMICALS
3 EXTENDED AERATION

TABLE 62 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : PACIFIC HAND SHUCKED OYSTER - LARGE

OPERATING DAY	8.0	HOURS
SEASON	110.0	DAYS
PRODUCTION	0.4	TON/HR
	0.4	KKG/HR
PROCESS FLOW	115.0	GPM
	7.3	L/SEC
HYDRAULIC LOAD	15655.8	GAL/TON
	65.3	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	20.	94.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	2.	7.
DEPRECIATION @ 10%	2.	9.
DAILY COSTS($)		
O&M	4.	13.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	4.	19.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	429.	64.
-KG/KKG	28.00	4.20
TSS-MG/L	199.	60.
-KG/KKG	13.00	3.92
G&O-MG/L	28.	14.
-KG/KKG	1.80	0.90

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 EXTENDED AERATION

TABLE '63 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : PACIFIC HAND SHUCKED OYSTER - MEDIUM

OPERATING DAY	8.0	HOURS
SEASON	110.0	DAYS
PRODUCTION	0.2	TON/HR
	0.2	KKG/HR
PROCESS FLOW	50.0	GPM
	3.2	L/SEC
HYDRAULIC LOAD	13613.7	GAL/TON
	56.8	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	16.	79.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	1.	6.
DEPRECIATION @ 10%	2.	8.
DAILY COSTS($)		
O&M	4.	10.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	3.	16.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	493.	74.
-KG/KKG	28.00	4.20
TSS-MG/L	229.	60.
-KG/KKG	13.00	3.41
G&O-MG/L	32.	16.
-KG/KKG	1.80	0.90

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 EXTENDED AERATION

TABLE 64. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : PACIFIC HAND SHUCKED OYSTERS -MEDIUM

OPERATING DAY	8.0	HOURS
SEASON	110.0	DAYS
PRODUCTION	0.2	TON/HR
	0.2	KKG/HR
PROCESS FLOW	50.0	GPM
	3.2	L/SEC
HYDRAULIC LOAD	17017.1	GAL/TON
	71.0	CU M/KKG

TREATMENT SYSTEM	1	2	3
INITIAL INVESTMENT($1000)	16.	63.	79.
ANNUAL COSTS($1000)			
CAPITAL COSTS @ 8%	1.	5.	6.
DEPRECIATION @ 10%	2.	6.	9.
DAILY COSTS($)			
O&M	4.	14.	11.
POWER	1.	2.	2.
TOTAL ANNUAL COSTS($1000)	3.	13.	15.

PARAMETER	RESULTING EFFLUENT LEVELS		
BOD-MG/L	395.	237.	60.
-KG/KKG	28.00	16.80	4.26
TSS-MG/L	606.	182.	152.
-KG/KKG	43.00	12.90	10.70
G&O-MG/L	25.	5.	12.
-KG/KKG	1.80	0.35	0.90

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITHOUT CHEMICALS
3 OR EXTENDED AERATION

TABLE 65. WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : PACIFIC HAND SHUCKED OYSTER - SMALL

OPERATING DAY	8.0	HOURS
SEASON	90.0	DAYS
PRODUCTION	0.0	TON/HR
	0.0	KKG/HR
PROCESS FLOW	13.0	GPM
	0.8	L/SEC
HYDRAULIC LOAD	17697.8	GAL/TON
	73.9	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	8.	33.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	0.	3.
DEPRECIATION @ 10%	0.	3.
DAILY COSTS($)		
O&M	3.	9.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	2.	7.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	379.	60.
-KG/KKG	28.00	4.43
TSS-MG/L	176.	60.
-KG/KKG	13.00	4.43
G&O-MG/L	24.	12.
-KG/KKG	1.80	0.90

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 EXTENDED AERATION

TABLE 66 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : PACIFIC HAND SHUCKED OYSTER - SMALL

OPERATING DAY	8.0	HOURS
SEASON	90.0	DAYS
PRODUCTION	<0.1	TON/HR
	<0.1	KKG/HR
PROCESS FLOW	13.0	GPM
	0.8	L/SEC
HYDRAULIC LOAD	17697.8	GAL/TON
	73.9	CU M/KKG

TREATMENT SYSTEM	1	2
INITIAL INVESTMENT($1000)	8.	32.
ANNUAL COSTS($1000)		
CAPITAL COSTS @ 8%	0.	3.
DEPRECIATION @ 10%	0.	3.
DAILY COSTS($)		
O&M	3.	13.
POWER	1.	2.
TOTAL ANNUAL COSTS($1000)	2.	7.

	RESULTING EFFLUENT LEVELS	
PARAMETER		
BOD-MG/L	379.	228.
-KG/KKG	28.00	16.80
TSS-MG/L	583.	175.
-KG/KKG	43.00	12.90
G&O-MG/L	24.	5.
-KG/KKG	1.80	0.37

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITHOUT CHEMICALS

TABLE 67 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : ALASKAN SCALLOPS
(NON-ALASKAN SCALLOP COSTS IN PARENTHESIS)

OPERATING DAY	12.0	HOURS
SEASON	60.0	DAYS
PRODUCTION	1.7	TON/HR
	1.5	KKG/HR
PROCESS FLOW	55.0	GPM
	3.5	L/SEC
HYDRAULIC LOAD	1996.7	GAL/TON
	8.3	CU M/KKG

TREATMENT SYSTEM	1	2	3
INITIAL INVESTMENT($1000)	42.(17)	158.(63)	281.(113)
ANNUAL COSTS($1000)			
CAPITAL COSTS @ 8%	3.(1)	13.(5)	22.(9)
DEPRECIATION @ 10%	4.(2)	16.(6)	28.(12)
DAILY COSTS($)			
O&M	5.	21.	31.
POWER	1.	2.	3.
TOTAL ANNUAL COSTS($1000)	8.(4)	30.(12)	52.(23)

	RESULTING EFFLUENT LEVELS		
PARAMETER			
BOD-MG/L	384.	269.	60.
-KG/KKG	3.20	2.24	0.50
TSS-MG/L	108.	32.	60.
-KG/KKG	0.90	0.27	0.50
G&O-MG/L	12.	5.	5.
-KG/KKG	0.10	0.04	0.04

TREATMENT SYSTEMS
(CUMULATIVE)

1 SCREENING
2 FLOTATION WITHOUT CHEMICALS
3 SCREENING AND EXTENDED AERATION

TABLE 68 . WATER EFFLUENT TREATMENT COSTS

CANNED AND PRESERVED FISH AND SEAFOOD

SUBCATEGORY : SPINY LOBSTER

OPERATING DAY	8.0	HOURS
SEASON	120.0	DAYS
PRODUCTION	0.4	TON/HR
	0.3	KKG/HR
PROCESS FLOW	3.0	GPM
	31.2	L/SEC
HYDRAULIC LOAD	495.0	GAL/TON
	2.1	CU M/KKG

TREATMENT SYSTEM	1
INITIAL INVESTMENT($1000)	19.
ANNUAL COSTS($1000)	
CAPITAL COSTS @ 8%	1.
DEPRECIATION @ 10%	2.
DAILY COSTS($)	
O&M	10.
POWER	1.
TOTAL ANNUAL COSTS($1000)	5.

PARAMETER	RESULTING EFFLUENT LEVELS
BOD-MG/L	1085.
-KG/KKG	2.24
TSS-MG/L	174.
-KG/KKG	0.36
G&O-MG/L	19.
-KG/KKG	0.04

TREATMENT SYSTEMS
(CUMULATIVE)

1 FLOTATION- WITH CHEMICALS

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TERMS APPLICABLE TO WASTE TREATMENT AND THE SEAFOOD INDUSTRY

Activated Sludge Process: Removes organic matter from wastewater by saturating it with air and biologically active sludge.

Aeration Tank: A chamber for injecting air or oxygen into water.

Aerobic Organism: An organism that thrives in the presence of oxygen.

Algae (Alga): Simple plants, many microscopic, containing chlorophyll. Most algae are aquatic and may produce a nuisance when conditions are suitable for prolific growth.

Algorithm: Any mechanical or repetitive computational procedure.

Ammonia Stripping: Ammonia removal from a liquid, usually by intimate contact with an ammonia-free gas, such as air.

Anadromous: Type of fish that ascend rivers from the sea to spawn.

Anaerobic: Living or active in the absence of free oxygen.

Aquaculture: The cultivation and harvesting of aquatic plants and animals.

Bacteria: The smallest living organisms which comprise, along with fungi, the decomposer category of the food chain.

Bailwater: Water used to facilitate unloading of fish from fishing vessel holds.

Barometric Leg: Use of moving streams of water to draw a vacuum; aspirator.

Batch Cooker: Product remains stationary in cooker (water is periodically changed).

Benthic Region: The bottom of a body of water. This region supports the benthos, a type of life that not only lives upon but contributes to the character of the bottom.

Benthos: Aquatic bottom-dwelling organisms. These include (1) sessile animals, such as the sponges, barnacles, mussels, oysters, some of the worms, and many attached algae: (2) creeping forms, such as insects, snails and certain clams;and (3) burrowing forms, which include most clams and worms.

Bight: An indentation or recess in the shore of a sea; a bay.

Biological Oxidation: The process whereby, through the activity of living organisms in an aerobic environment, organic matter is converted to more biologically stable matter.

Biological Stabilization: Reduction in the net energy level or organic matter as a result of the metabolic activity of organisms, so that further biodegradation is very slow.

Biological Treatment: Organic waste treatment in which bacteria and/or biochemical action are intensified under controlled conditions.

Blow Tank: Water-filled tank used to wash oysters or clam meats by agitating with air injected at the bottom.

BOD (Biological Oxygen Demand): Amount of oxygen necessary in the water for bacteria to consume the organic sewage. It is used as a measure in telling how well a sewage treatment plant is working.

BOD-5: A measure of the oxygen consumption by aerobic organisms over a 5-day test period at 20°C. It is an indirect measure of the concentration of biologically degradable material present in organic wastes contained in a waste stream.

Botulinus Organisms: Those that cause acute food poisoning.

Breading: A finely ground mixture containing cereal products, flavorings and other ingredients, that is applied to a product that has been moistened, usually with batter.

Brine: Concentrated salt solution which is used to cool or freeze fish.

BTU: British thermal unit, the quantity of heat required to raise one pound of water 1°F.

Building Drain: Lowest horizontal part of a building drainage system.

Building Drainage System: Piping provided for carrying waste-water or other drainage from a building to the street sewer.

Bulking Sludge: Activated sludge that settles poorly because of low-density floc.

Canned Fishery Product: Fish, shellfish, or other aquatic animals packed singly or in combination with other items in hermetically sealed, heat sterilized cans, jars, or other suitable containers. Most, but not all, canned fishery products can be stored at room temperature for an indefinite period of time without spoiling.

Carbon Adsorption: The separation of small waste particles and molecular species, including color and odor contaminants, by attachment to the surface and open pore structure of carbon granules or powder. The carbon is "activated", or made more adsorbent by treatment and processing.

Case: "Standard" packaging in corrugated fiberboard containers.

Centrifugal Decanter: A device which subjects material in a steady stream to a centrifugal force and continuously discharges the separated components.

COD (Chemical Oxygen Demand): A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water.

Chemical Precipitation: A waste treatment process whereby substances dissolved in the wastewater stream are rendered insoluble and form a solid phase that settles out or can be removed by flotation techniques.

Clarification: Process of removing undissolved materials from a liquid. Specifically, removal of solids either by settling or filtration.

Clarifier: A settling basin for separating settleable solids from wastewater.

Coagulant: A material, which, when added to liquid wastes or water, creates a reaction which forms insoluble floc particles that adsorb and precipitate colloidal and suspended solids. The floc particles can be removed by sedimentation. Among the most common chemical coagulants used in sewage treatment are ferric chloride, alum and lime.

Coagulation: The clumping together of solids to make them settle out of the sewage faster. Coagulation of solids is brought about with the use of certain chemicals such as lime, alum or poly-electrolytes.

Coefficient of Variation: A measure used in describing the amount of variation in a population. An estimate of this value is $S/\overline{X}$ where "S" equals the standard deviation and $\overline{X}$ equals the sample mean.

Coelom: The body cavity of a specific group of animals in which the viscera is located.

Coliform: Relating to, resembling, or being the colon bacillus.

Comminutor: A device for the catching and shredding of heavy solid matter in the primary stage of waste treatment.

Concentration: The total mass (usually in micrograms) of the suspended particles contained in a unit volume (usually one cubic meter) at a given temperature and pressure; sometimes, the concentration may be expressed in terms of total number of particles in a unit volume (e.g., parts per million); concentration may also be called the "loading" or the "level" of a substance; concentration may also pertain to the strength of a solution.

Condensate: Liquid residue resulting from the cooling of a gaseous vapor.

Contamination: A general term signifying the introduction into water of microorganisms, chemical, organic, or inorganic wastes, or sewage, which renders the water unfit for its intended use.

Correlation Coefficient: A measure of the degree of closeness of the linear relationship between two variables. It is a pure number without units or dimensions, and always lies between -1 and +1.

Crustacea: Mostly aquatic animals with rigid outer coverings, jointed appendages, and gills. Examples are crayfish, crabs, barnacles, water fleas, and sow bugs.

Cultural Eutrophication: Acceleration by man of the natural aging process of bodies of water.

Cyclone: A device used to separate dust or mist from gas stream by centrifugal force.

Decomposition: Reduciton of the net energy level and change in chemical composition or organic matter because of actions or aerobic or anaerobic microorganisms.

Denitrification: The process involving the facultative conversion of anaerobic bacteria of nitrates into nitrogen and nitrogen oxides.

Deviation, Standard Normal: A measure of dispersion of values about a mean value; the square root of the average of the squares of the individual deviations from the mean.

Digestion: Though "aerobic" digestion is used, the term digestion commonly refers to the anaerobic breakdown of organic matter in water solution or suspension into simpler or more biologically stable compounds or both. Organic matter may be decomposed to soluble organic acids or alcohols, and subsequently converted to such gases as methane and carbon dioxide. Complete destruction of organic solid materials by bacterial action alone is never accomplished.

Dissolved Air Flotation: A process involving the compression of air and liquid, mixing to super-saturation, and releasing the pressure to generate large numbers of minute air bubbles. As the bubbles rise to the surface of the water, they carry with them small particles that they contact.

Dissolved Oxygen (D.O.): Due to the diurnal fluctuations of dissolved oxygen in streams, the minimum dissolved oxygen value shall apply at or near the time of the average concentration in the stream, taking into account the diurnal fluctuations.

Echinodermata: The phylum of marine animals characterized by an unsegmented body and secondary radial symmetry, e.g., sea stars, sea urchins, sea cucumbers, sea lilies.

Ecology: The science of the interrelationship between living organisms and their environment.

Effluent: Something that flows out, such as a liquid discharged as a waste; for example, the liquid that comes out of a treatment plant after completion of the treatment process.

Electrodialysis: A process by which electricity attracts or draws the mineral salts from sewage.

Enrichment: The addition of nitrogen, phosphorus, carbon compounds and other nutrients into a waterway that increases the growth potential for algae and other aquatic plants. Most frequently, enrichment results from the inflow sewage effluent or from agricultural runoff.

Environment: The physical environment of the world consisting of the atmosphere, hydrosphere, and the lithosphere. The biosphere is that part of the environment supporting life and which is important to man.

Estuary: Commonly an arm of the sea at the lower end of a river. Estuaries are often enclosed by land except at channel entrance points.

Eutrophication: The normally slow aging process of a body of water as it evolves eventually into a terrestrial state as effected by the enrichment of the water.

Eutrophic Waters: Waters with a good supply of nutrients. These waters may support rich organic productions, such as algal blooms.

Extrapolate: To project data into an area not known or experienced, and arrive at knowledge based on inferences of continuity of the data.

Facultative Aerobe: An organism that although fundamentally an anerobe can grow in the presence of free oxygen.

Facultative Anaerobe: An organism that although fundamentally an aerobe can grow in the absence of free oxygen.

Facultative Decomposition: Decomposition of organic matter by facultative microorganisms.

Fish Fillets: The sides of fish that are either skinned or have the skin on, cut lengthwise from the backbone. Most types of fillets are boneless or virtually boneless, some may be specified as "boneless fillets."

Fish Meal: A ground, dried product made from fish or shellfish or parts thereof, generally produced by cooking raw fish or shellfish with steam and pressing the material to obtain the solids which are then dried.

Fish Oil: An oil processed from the body (body oil) or liver (liver oil) of fish. Most fish oils are a by-product of the production of fish meal.

Fish Solubles: A product extracted from the residual press liquor (called "stickwater") after the solids are removed for drying (fish meal) and the oil extracted by centrifuging. This residue is generally condensed to 50 percent solids and marketed as "condensed fish solubles".

Filtration: The process of passing a liquid through a porous medium for the removal of suspended materials by a physical straining action.

Floc: Something occurring in indefinite masses or aggregates. A clump of solids formed in sewage when certain chemicals are added.

Flocculation: The process by which certain chemicals form clumps of solids in sewage.

Floc Skimming: The flocculent mass formed on a quiescent liquid surface and removed for use, treatment, or disposal.

Flume: An artificial channel for conveyance of a stream of water.

Grab Sample: A sample taken at a random place in space and time.

Groundwater: The supply of freshwater under the earth's surface in an aquifer or soil that forms the natural reservoir for man's use.

Heterotrophic Organism: Organisms that are dependent on organic matter for food.

Identify: To determine the exact chemical nature of a hazardous polluting substance.

Impact: (1) An impact is a single collision of one mass in motion with a second mass which may be either in motion or at rest. (2) Impact is a work used to express the extent or severity of an environmental problem; e.g., the number of persons exposed to a given noise environment.

Incineration: Burning the sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash. The ash can then be disposed of safely on land, in some waters, or into caves or other underground locations.

Influent: A liquid which flows into a containing space or process unit.

Ion Exchange: A reversible chemical reaction between a solid and a liquid by means of which ions may be interchanged between the two. It is in common use in water softening and water deionizing.

Iron Chink: A machine used in the salmon processing industry to butcher salmon.

Kg: Kilogram or 1000 grams, metric unit of weight.

Kjeldahl Nitrogen: A measure of the total amount of nitrogen in the ammonia and organic forms.

KWH: Kilowatt-hours, a measure of total electrical energy consumption.

Lagoons: Scientifically constructed ponds in which sunlight, algae, and oxygen interact to restore water to a quality equal to effluent from a secondary treatment plant.

Landings, Commercial: Quantities of fish, shellfish, and other aquatic plants and animals brought ashore and sold. Landings of fish may be in terms of round (live) weight or dressed weight. Landings of crustaceans are generally on a live weight basis except for shrimp which may be on a heads-on or heads-off basis. Mollusks are generally landed with the shell on but in some cases only the meats are landed (such as scallops).

Live Tank: Metal, wood or plastic tank with circulating seawater for the purpose of keeping a fish or shellfish alive until processed.

M: Meter, metric unit of length.

Mm: Millimeter = 0.001 meter.

Mg/l: Milligrams per liter; approximately equal parts per million; a term used to indicate concentration of materials in water.

MGD: Million gals per day.

Mesenteries: The tissue lining the body cavities and from which the organs are suspended.

Microstrainer/microscreen: A mechanical filter consisting of a cylindrical surface of metal filter fabric with openings of 20-60 micrometers in size.

Milt: Reproductive organ (testes) of male fish.

Mixed Liquor: The name given the effluent that comes from the aeration tank after the sewage has been mixed with activated sludge and air.

Municipal Treatment: A city or community-owned waste treatment plant for municipal and, possibly, industrial waste treatment.

Nitrate, Nitrite: Chemical compounds that include the NO_3- (nitrate) and NO_2- (nitrite) ions. They are composed of nitrogen and oxygen, are nutrients for growth of algae and other plant life, and contribute to eutrophication.

Nitrification: The process of oxidizing ammonia by bacteria into nitrites and nitrates.

Organic Content: Synonymous with volatile solids except for small traces of some inorganic materials such as calcium carbonate which will lose weight at temperatures used in determining volatile solids.

Organic Detritus: The particulate remains of disintegrated plants and animals.

Organic Matter: The waste from homes or industry of plant or animal origin.

Oxidation Pond: A man-made lake or body of water in which wastes are consumed by bacteria. It is used most frequently with other waste treatment processes. An oxidation pond is basically the same as a sewage lagoon.

Pelagic Region: The open water environment of the ocean consisting of water both over and beyond the continental shelf and which is inhabited by the free swimming fishes.

Per Capita Consumption: Consumption of edible fishery products in the United States, divided by the total civilian population.

pH: The pH value indicates the relative intensity of acidity or alkalinity of water, with the neutral point at 7.0. Values lower than 7.0 indicate the presence of acids; above 7.0 the presence of alkalies.

Phylum: A main category of taxonomic classification into which the plant and animal kingdoms are divided.

Plankton (Plankter): Organisms of relatively small size, mostly microscopic, that have either relatively small powers of locomotion or that drift in the water with waves, currents, and other water motion.

Polishing: Final treatment stage before discharge of effluent to a water course, carried out in shallow, aerobic lagoon or pond, mainly to remove fine suspended solids that settle very slowly. Some aerobic microbiological activity also occurs.

Ponding: A waste treatment technique involving the actual holdup of all wastewaters in a confined space with evaporation and percolation the primary mechanisms operating to dispose of the water.

Pound net: A net laid perpendicularly out from the shoreline with a circular impoundment at the seaward end.

Ppm: Parts per million, also referred to as milligrams per liter (mg/l). This is a unit for expressing the concentration of any substance by weight, usually as grams of substance per million grams of solution. Since a liter of water weighs one kilogram at a specific gravity of 1.0, one part per million is equivalent to one milligram per liter.

Press Cake: In the wet reduction process for industrial fishes, the solid fraction which results when cooked fish (and fish wastes) are passed through the screw presses.

Press Liquor: Stickwater resulting from the pressing of fish solids.

Primary Treatment: Removes the material that floats or will settle in sewage. It is accomplished by using screens to catch the floating objects and tanks for the heavy matter to settle in.

Process Water: All water that comes into direct contact with the raw materials, intermediate products, final products, by-products, or contaminated waters and air.

Processed Fishery Products: Fish, shellfish and other aquatic plants and animals, and products thereof, preserved by canning, freezing, cooking, dehydrating, drying, fermenting, pasteurizing, adding salt or other chemical substances, and other commercial processes. Also, changing the form of fish, shellfish or other aquatic plants and animals from their original state into a form in which they are not readily identifiable, such as fillets, steaks, or shrimp logs.

Purse Seiner: Fishing vessel utilizing a seine (net) that is drawn together at the bottom, forming a trap or purse.

Receiving Waters: Rivers, lakes, oceans, or other water courses that receive treated or untreated wastewaters.

Recycle: The return of a quantity of effluent from a specific unit or process to the feed stream of that same unit. This would also apply to return of treated plant wastewater for several plant uses.

Regression: A trend or shift toward a mean. A regression curve or line is thus one that best fits a particular set of data according to some principle.

Retort: Sterilization of a food product at greater than 284°F with steam under pressure.

Re-use: Water re-use, the subsequent use of water following an earlier use without restoring it to the original quality.

Reverse Osmosis: The physical separation of substances from a water stream by reversal of the normal osmotic process, i.e. high pressure, forcing water through a semi-permeable membrane to the pure water side leaving behind more concentrated waste streams.

Rotating Biological Contactor: A waste treatment device involving closely spaced light-weight discs which are rotated through the wastewater allowing aerobic microflora to accumulate at each disc and thereby achieving a reduction in the waste content.

Rotary Screen: A revolving cylindrical screen for the separation of solids from a waste stream.

Round (Live) Weight: The weight of fish, shellfish or other aquatic plants and animals as taken from the water; the complete or full weight as caught.

Sample, Composite: A sample taken at a fixed location by adding together small samples taken frequently during a given period of time.

Sand Filter: Removes the organic wastes from sewage. The wastewater is trickled over a bed of sand. Air and bacteria decompose the wastes filtering through the sand. The clean water flows out through drains in the bottom of the bed. The sludge accumulating at the surface must be removed from the bed periodically.

Sand Trap: Basin in sewage line for collection of high density solids, specifically sand.

Sanitary Sewers: In a separate system, are pipes in a city that carry only domestic wastewater. The storm water runoff is teken care of by a separate system of pipes.

Sanitary Landfill: A site for solid waste disposal using techniques which prevent vector breeching, and control air pollution nuisances, fire hazards and surface or groundwater pollution.

Scatter Diagram: A two dimensional plot used to visually demonstrate the relationship between two sets of data.

Secondary Treatment: The second step in most waste treatment systems in which bacteria consume the organic parts of the wastes. It is accomplished by bringing the sewage and bacteria together in trickling filters or in the activated sludge process.

Sedimentation Tanks: Help remove solids from sewage. The wastewater is pumped to the tanks where the solids settle to the bottom or float on top as scum. The scum is skimmed off the top, and solids on the bottom are pumped out to sludge digestion tanks.

Seine: Any of a number of various nets used to capture fish.

Separator: Separates the loosened shell from the shrimp meat.

Setteable Matter (Solids): Determined in the Imhoff cone test and will show the quantitative settling characteristics of the waste sample.

Settling Tank: Synonymous with "Sedimentation Tank."

Sewers: A system of pipes that collect and deliver wastewater to treatment plants or receiving streams.

Shaker Blower: Dries and sucks the shell off with a vacuum, leaving the shrimp meat.

Skimmer Table: A perforated stainless steel table used to dewater clams and oysters after washing.

Shock Load: A quantity of wastewater or pollutant that greatly exceeds the normal discharged into a treatment system, usually occurring over a limited period of time.

Sludge: The solid matter that settles to the bottom of sedimentation tanks and must be disposed of by digestion or other methods to complete waste treatment.

Slurry: A solids-water mixture, with sufficient water content to impart fluid handling characteristics to the mixture.

Sliming Table: Fish processing vernacular referring to the area in which fish are butchered and/or checked for completeness of butcher.

Spatial Average: The mean value of a set of observations distributed as a function of position.

Species (Both Singular and Plural): A natural population or group of populations that transmit specific characteristics from parent to offspring. They are reproductively isolated from other populations with which they might breed. Populations usually exhibit a loss of fertility when hybridizing.

Standard Deviation: A statistical measure of the spread or variation of individual measurements.

Steam Box: A form of cooker which precooks the product with the use of steam in order to remove oils and water from fish.

Stickwater: Water and entrained organics that originate from the draining or pressing of steam cooked fish products.

Stoichiometric Amount: The amount of a substance involved in a specific chemical reaction, either as a reactant or as a reaction product.

Stop Seine: A net placed across a stream or bay to catch or retain fish.

Stratification: A partition of the universe which is useful when the properties of sub-populations are of interest and used for increasing the precision of the total population estimation when statum means are sufficiently different and the within stratum variances are appreciably smaller than the total population variance.

Sump: A depression or tank that serves as a drain or receptacle for liquids for salvage or disposal.

Suspended Solids: The wastes that will not sink or settle in sewage.

Surface Water: The waters of the United States including the territorial seas.

Synergism: A situation in which the combined action of two or more agents acting together is greater than the sum of the action of these agents separately.

Temporal Average: The mean value of a set of observations distributed as a function of time.

Tertiary Waste Treatment: Waste treatment systems used to treat secondary treatment effluent and typically using physical-chemical technologies to effect waste reduction. Synonymous with "Advanced Waste Treatment".

Troll Dressed: Refers to salmon which have been eviscerated at sea.

Total Dissolved Solids (TDS): The solids content of wastewater that is soluble and is measured as total solids content minus the suspended solids.

Trickling Filter: A bed of rocks or stones. The sewage is trickled over the bed so the bacteria can breakdown the organic wastes. The bacteria collect on the stones through repeated use of the filter.

Viscera: The internal organs of the body, especially those of the abdominal and thoracic cavities.

Viscus (pl. Viscera): Any internal organ within a body cavity.

Water Quality Criteria: The levels of pollutants that affect the suitability of water for a given use. Generally, water use classification includes: public water supply; recreation; propagation of fish and other aquatic life, agricultural use and industrial use.

Weir: A fence, net, or waffle placed across a stream or bay to catch or retain fish. In engineering use it is a dam over which, or through a notch in which, the liquid carried by a horizontal open channel is constrained to flow.

Zero Discharge: The discharge of no pollutants in the wastewater stream of a plant that is discharging into a receiving body of water.

APPENDIX A

List of Equipment Manufacturers

AUTOMATIC ANALYZERS

Hach Chemical Company, P.O. Box 907, Ames, Iowa 50010

Combustion Equipment Association, Inc., 555 Madison Avenue New York, N.Y. 10022

Martek Instruments, Inc., 879 West 16th Street, Newport Beach, California 92660

Eberbach Corporation, 505 South Maple Road, Ann Arbor, Michigan 48106

Tritech, Inc., Box 124 Chapel Hill, North Carolina 27514

Preiser Scientific, 900 MacCorkle Avenue, S.W., Charleston, West Virginia 25322

Wilks Scientific Corporation, South Norwalk, Connecticut 06856

Technicon Instruments Corporation, Tarrytown, New York 10591

Bauer - Bauer Brothers Company, Subsidiary Combustion Engineering, Inc., P.O. Box 968, Springfield, Ohio 45501

CENTRIFUGES

Beloit-Passavant Corporation, P.O. Box 997, Jonesville, Wisconsin 53545

Bird Machine Company, South Walpole, Massachusetts 02071

DeLaval Separator Company, Poughkeepsie, New York 12600

FLOW METERING EQUIPMENT

Envirotech Corporation, Municipal Equipment Division, 100 Valley Drive, Brisbane, California 95005

LABORATORY EQUIPMENT AND SUPPLIES

Hach Chemical Company, P.O. Box 907, Ames, Iowa 50010

Eberbach Corporation, 505 South Maple Road, Ann Arbor, Michigan 48106

National Scientific Company, 25200 Miles Avenue, Cleveland, Ohio 44146

Preiser Scientific, 900 MacCorkle Avenue, S.W., Charleston, West Virginia 25322

Precision Scientific Company, 3737 Cortland Street, Chicago, Illinois 60647

Horizon Ecology Company, 7435 North Oak Park Avenue, Chicago, Illinois 60648

Markson Science, Inc., Box NPR, Del Mar, California 92014

Cole-Parmer Instrument Company, 7425 North Oak Park Avenue, Chicago, Illinois 60648

VWR Scientific, P.O. Box 3200, San Francisco, California 94119

SAMPLING EQUIPMENT

Preiser Scientific, 900 MacCorkle Avenue, S.W., Charleston, West Virginia 25322

Horizon Ecology Company, 7435 North Oak Park Avenue, Chicago, Illinois 60648

Sigmamotor, Inc., 14 Elizabeth Street, Middleport, New York 1410 5

Protech, Inc., Roberts Lane, Malvern, Pennsylvania 19355

Quality Control Equipment, Inc., 2505 McKinley Avenue, Des Moines, Iowa 50315

Instrumentation Specialties Company, P.O. Box 5347, Lincoln, Nebraska 68505

N-Con Systems Company, Inc., 410 Boston Post Road, Larchmont, New York 10538

SCREENING EQUIPMENT

SWECO, Inc., 6033 E. Bandine Blvd., Los Angeles, California 90054

Bauer-Bauer Brothers Company, Subsidiary Combustion Engineering Inc., P.O. Box 968, Springfield, Ohio 45501

Hydrocyclonics Corporation, 968 North Shore Drive, Lake Bluff, Illinois 60044

Jeffrey Manufacturing Company, 961 N. 4th Street, Columbus, Ohio 43216

Dorr-Oliver, Inc., Havemeyer Lane, Stanford, Connecticut 06904

Hendricks Manufacturing Company, Carbondale, Pennsylvania 18407

Peobody Welles, Roscoe, Illinois 61073

Clawson, F.J. and Associates, 6956 Highway 100, Nashville, Tennessee 37205

Allis-Chalmers Manufacturing Company, 1126 S. 70th Street, Milwaukee, Wisconsin 53214

DeLaval Separator Company, Poughkeepsie, New York 12600

Envirex, Inc., 1901 S. Prairie, Waukesha, Wisconsin 53186

Liak Belt Environmental Equipment, FMC Corporation, Prudential Plaze, Chicago, Illinois 60612

Productive Equipment Corporation, 2924 W. Lake Street, Chicago Illinois 60612

Simplicity Engineering Company, Durand, Michigan 48429

WASTEWATER TREATMENT SYSTEMS

Cromaglass Corporation, Williamsport, Pennsylvania 17701

ONPS, 4576 S.W. 103rd Avenue, Beaverton, Oregon 97225

Tempo, Inc., P.O. Box 1087, Bellevue, Washington 98009

Zurn Industries, Inc., 1422 East Avenue, Erie, Pennsylvania 16503

General Environmental Equipment, Inc., 5020 Stepp Avenue, Jacksonville, Florida 32216

Envirotech Corporation, Municipal Equipment Division, 100 Valley Drive, Brisbane, California 95005

Jeffrey Manufacturing Company, 961 N. 4th Street, Columbus Ohio 43216

Carborundum Corporation, P.O. Box 87, Knoxville, Tennessee 37901

Graver, Division of Ecodyne Corporation, U.S. Highway 22, Union, New Jersey 07083

Beloit-Passavant Corporation, P.O. Box 997, Janesville, Wisconsin 53545

Black-Clawson Company, Middletown, Ohio 54042

Envirex, Inc., 1901 S. Prairie, Waukesha, Wisconsin 53186

Environmental Systems, Division of Litton Industries, Inc., 354 Dawson Drive, Camarillo, California 93010

Infilco Division, Westinghouse Electric Company, 901 S. Campbell Street, Tuscon, Arizona 85719

Keene Corporation, Fluid Handling Division, Cookeville, Tennessee 38501

Komline-Sanderson Engineering Corporation, Peapack, New Jersey 07977

Permutit Company, Division of Sybron Corporation, E. 49 Midland Avenue, Paramus, New Jersey 07652

Conversion Table

Conversion Table

MULTIPLY (ENGLISH UNITS)		by		TO OBTAIN (METRIC UNITS)
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig+1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	t	0.907	kkg	metric tons (1000 kilograms)
yard	y	0.9144	m	meters

* Actual conversion, not a multiplier

Treatment Technology in Canada

- Physical Treatment (Screening)

by

F. Claggett
Technical Advisor,
Technical Service and Abatement Section
Pacific Region
Environmental Protection Service,
ENVIRONMENT CANADA

1 SCREENING

Water is widely used in the fish processing industry, and consequently various methods have evolved for separation of the coarse fish solids prior to discharge. Studies have shown that the longer the solids are in contact with water, the more highly contaminated the water will become due to leaching of blood, oil and soluble protein. Plant design should include methods of dry handling and rapid separation of coarse solids wherever feasible. For achievement of the latter, a knowledge of the types of coarse and fine screens applicable to the fish processing operation is required.

2 SCREENING SIZES

In discussing screen sizes, the term "mesh" is frequently used to designate the screen size. Where mesh is referred to as a number, the reference is to the number of openings per linear inch. The mesh is determined by starting from the centre of one wire and counting the number of openings in a specified length. If applicable, a fraction may be included.

The actual opening between the wires is "space", and is a much better way of specifying the ability of fine screens to remove suspended material. Thus, 0.25 inch space, 0.135 wire will adequately define a screen. For fine screen, the space is often given in thousandths (e.g. 0.030) or in millimeters (e.g. 0.71 mm.).

2.1 COARSE SCREENS

Up to the present time, most screening devices are only used to remove coarse solids, hence the space is seldom less than 0.25 inch. Attempts at using conventional screens in finer sizes have failed due to the ability of raw protein and fish oil to blind fine screens. The raw protein is easily forced into screen openings, preventing passage of further solids and water. Where solids are large enough to pull free of the screen during inversion, no problems develop. Since the protein is quite "sticky", fine particles do present a special problem, and are required to be removed by sprays or brushes.

Oil adds a further dimension to the problem. Droplets will spread over a fine screen opening, and the surface tension of the drop will prevent passage of water or solids. Proper choice

of flow patterns across the screen surface will greatly reduce this tendency.

One of the simplest dewatering devices used is the screw drain. Here a rotating screw carries the solids and water through a perforated or slotted pipe. The close fit between the screw and sleeve is supposed to ensure that the perforations are kept clean. This system works best where large volumes of water must be removed from relatively few coarse pieces (i.e. crab shells, etc.).

The most widely used coarse screening device is the rotary trommel screen. Water and solids are discharged into a perforated cylinder which rotates at speeds of up to 15 RPM. The trommel surface is usually a stainless steel mesh wrapped on a frame. The screen sizes are typically of 4 to 10 mesh. The water passes through the screen and is collected in troughs while the solids are carried to the end of the cylinder by gravity or by flights. Water sprays are often mounted to keep the screen surfaces clean.

In some plants coarse solids are also separated from water by the use of wire mesh belts. The water easily passes through the belt, while the larger solids collect and are carried to a discharge chute where the belt passes around a roller which inverts the screen surface.

2.2 FINE SCREENS

The type of fine screen most familiar to the industry is the vibrating screen, such as is supplied by SWECO or CAISSON. These are typically of 60 to 100 mesh or finer. This type has proven of value where the solids have been heat-denatured (such as in press liquor treatment) or in screening waste from shrimp and crab operations. Although satisfactory for the latter treatment, maintenance costs are generally high. Many thousands of dollars have been spent in numerous attempts to separate raw fish waste from water, with little or no success reported.

The SWECO (Southwest Engineering Company) has recently introduced a centrifugal concentrator, which has been tested on several types of fish processing effluent. In general it has proven capable of concentrating solids present in the effluent into a flow of about one quarter of the original volume. It is slightly more successful on shrimp waste. It does not, however, appear to be as applicable as the other types detailed.

3 STATIC OR SIDE-HILL SCREENS

During the past several years, a substantial number of "static" screens have been installed in many processing operations to recover suspended matter from liquid flows. Highly successful applications have been made in meat packing, tanning, canning, textile and paper products, as well as in domestic sewage treatment.

The primary function of a static screen is to remove "free" or transporting liquid. Several types have developed, which have proven themselves in numerous applications.

3.1 DSM Screen

A concavely curved screen developed and patented in the 1950's for mineral classification by Dutch States Mines Corporation has been applied by Dorr-Oliver for use in the process industries. This design employs bar interference to the slurry, which knives off thin layers of the flow as it cascades over the curved surface

By far the most data for screening of fish processing plant effluent are available for this type of screen, since it was the type chosen for use in the demonstration waste treatment plant at Steveston, B.C. A similar screen has been in use for some time at a New England Fishing Company plant in Washington state.

Two 6-foot Dorr-Oliver 45° DSM screens were chosen for the demonstration plant. The screened surfaces have 0.7 and 1.0 mm. apertures (corresponding roughly to 18 and 25 mesh) in 304 stainless steel. The box was of mild steel. The initial installation also had installed a battery of cone-jet nozzles for cleaning purposes.

A 1500-gallon equalization tank stabilizes the feed to the screens at about 600 IGPM. From the tank a 4-inch centrifugal pump transports the water to a manifold feeding the two screens. The flow pattern to each is controlled by positioning of butterfly valves. A manually-adjusted by-pass valve connects the pump discharge to the tank. Cracking of this valve ensures that the pump impeller is kept wet at all times.

The screened liquid flows by gravity to a wet well from where it is pumped either to the treatment plant or to the river outfall. The oversize solids are carried by screw conveyor for transfer to the reduction plant.

Shortly after startup of this plant, some blinding problems developed, and modifications were made to the spray system to enable the maintenance of an automated spray flushing of the screen surface, consisting of a 30-second burst every three minutes. Results obtained over a two-year operating period are shown in Table I.

Table I - Treatment of Fish Processing Effluent by DSM Screens

Wastewater	Optimum Flow (IGPM/ft.)	Oversize Flow (IGPM)	Dry Solids Recovery (lb./hour)	Suspended Solids Reduction (%)
Salmon	50	3	200	40
Groundfish	75	1	15	35
Herring Roe	40	8	1,000	75

Experimentation continues with the screens, and two late developments appear interesting. On one screen the pattern spray has been replaced by an ordinary garden oscillating sprinkler, and appears to be working well. On the other screen a brush has been installed, and is doing an adequate job without increasing the wastewater flow. In both cases the solids coming off the screens are so dry that water is being added to them to enable them to be pumped.

3.2 The Hysrasieve

Beginning in 1969, U.S. and foreign patents were allowed on a three-slope static screen made of specially coined curved wire. This concept used the Coanda or wall attachment phenomena to withdraw the liquid from the underlayers of a slurry stratified by controlled velocity over the screen. Construction of the screen is detailed in Figure 4.

This screen has been tested on shrimp and crab plant effluents in Alaska and Louisiana, and successful installations have been made at the Omstead Plant, Wheatley, Ontario, and the Freshwater Fish Marketing Board plant in Winnipeg. A similar installation operating on effluents from a Maine sardine plant has had steam jets installed to assist in preventing blinding.

3.3 The Hydrocyclonics Hydrascreen

This screen is basically a combination of the previous two. Bar interference is used on three separate sloping surfaces. Tests have been performed on effluents from a salmon hand-butchering operation with very encouraging results.

In general, any of these screens appear useful for fish processing effluent screening. It might be advisable to purchase the screen chosen without either sprays or brush, and add these as needed, unless it has been shown in a very similar installation that either a brush or spray system will be needed.

4 THE HYDROCYCLONICS ROTOSTRAINER

A recent entry into the field of fine screens appears to offer promise to the screening of fish processing plant effluents. The rotostrainer comprises relatively few moving parts: a fractional horsepower motor, variable speed gear reducer, and a cylindrical screen. All parts are made of stainless steel. The head box is designed to minimize influent turbulence and to ensure a steady flow over the weir.

The water to be screened passes over the weir and through the slowly rotating screen. The solids which cannot pass through the screen spaces ride over the top of the screen and are removed by a wiper system. The wiper blade is designed to channel the dewatered solids away from the screen into the collection and removal system.

The influent, meantime, passes through the top of the screen, falling through its interior, and exits through the mesh at the bottom. In doing so it effectively backwashes the screen, thereby providing a reliable self-cleaning action.

Rotation of the screen is variable between 1 and 10 RPM with increasing rotational velocity allowing greater throughput at the expense of water carryover in the solids.

Tests have been performed on the 24-inch model using .030 inch screens at B.C. Packers Imperial Plant, Steveston, B.C. and at the Bumblebee Seafoods Plant in Bellingham, Washington. In the latter case, the test was concluded to be highly satisfactory, while in the former, modifications to the location of the wiper blade were felt to be necessary to ensure that the solids which are removed from the screen are immediately carried away so as to not interfere with subsequent wiper operation. Flows as high as 150 USGPM per foot of screen appear quite possible, with removal efficiencies similar to those reported for the static screens.

5 SCREEN SOURCES

Local outlets for these screens are:

1. Dorr-Oliver Long Ltd.,
   525 Seymour Street,
   Vancouver, B.C.
   684-1161 — 45° DSM Screen

2. John Block Ltd.,
   2182 West 12th Avenue,
   Vancouver, B.C.

   or

   Bauer Bros. Company (Canada) Ltd.,
   Box 910,
   Brantford, Ontario.
   (519) 753-8635

3. Frank E. Hindson & Company,
   1885 Barclay Street,
   Vancouver 5, B.C.
   - Hydrocyclonics sidehill
   - Rotostrainer

Treatment Technology in Canada

- Chemical Treatment and Air Flotation

by

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CHEMICAL TREATMENT AND AIR FLOTATION

Background

Fine screening is able to achieve considerable reduction in settlable solids, but does little to reduce the levels of suspended and soluble solids. Various chemicals may be used to flocculate emulsified and colloidally dispersed solids, and pH adjustment can lower the solubility of proteins. Gravity separation may then be used (Pavia and Tyagi, 19th) to separate the solids. Since the effluents from many fish processing operations have fat associated with the proteins, a three-phase separation is necessary. Separation of the phases under these conditions is slow, and anaerobic conditions, due to bacterial action, may develop, leading to odour problems. Proper selection of the chemicals, combined with dissolved air flotation, was shown by us to allow a rapid separation of the solids and fat fractions as a single phase.

Chemical Treatment

Various chemicals and combinations thereof have been used to flocculate suspended organic materials (Kato and Ishikawa, 1969; Touseth and Berridge, 1969; Schultz, 1956). Among those tested by us in the laboratory and pilot plant were ferric chloride, sodium aluminate, aluminum sulphate, each of the above with various polyelectrolytes, and pH adjustment using acids.

We also investigated the use of lignosulphonic acid (LSA) to separate soluble proteins, as reported by Touseth and Berridge. Under laboratory conditions exceptional results could be obtained with this system. The system was discontinued after pilot plant tests due to the following conclusions:

1. The reaction requires a fairly definite LSA:protein ratio, which requires either an extensively buffered system, or development of a system capable of monitoring protein levels.

2. The floc resulting from the protein:LSA interaction is very fragile, forcing the use of recycle pressurization, and hence oversized flotation equipment.

3. The system operates at a pH of 4, requiring the use of corrosion-resistant materials.

Best results in our studies were obtained using aluminum sulphate, either with added alkalinity, or anionic polyelectrolytes. The mode of action of the aluminum sulphate (alum) can be postulated as follows:

> As alum is added to the wastewater, the cations are attracted to the charged particles, thus coating them and forming microflocs. If alkalinity is present, the excess alum reacts to form a voluminous hydroxide floc. The microfloc, which has a positive charge in the acid range, agglomerates to this floc, or may be physically enmeshed along with other colloids or particles. Surface adsorption is also active. The high molecular weight anionic polyelectrolytes of the polyacrylamide type are also effective in agglomerating microflocs. The floc of either type is easily separated by air flotation, resulting in a good, dense sludge blanket.

Our pilot plant studies were conducted using alum and sodium hydroxide (Claggett and Wong, 1969), as was the first year of operation of a demonstration unit (Claggett, 1971). We were able to show (Table I) that not only could a good clarification be achieved, but that the sludge solids could be recovered for safe use in poultry feeds.

Dissolved Air Flotation

This unit operation utilizes the buoyant effect of air bubbles to float suspended solids and oil. Some or all of the wastewater is mixed with air and pressurized to force an air-water solution. When the pressure is released, the air comes out of solution as pin-point bubbles, gathering on any available interface. A further study of air flotation principles may be found in the work by Vnablik (1937).

The equipment normally used for total flow pressurization is shown in Figure I. Water from the collection tank is pressurized by a centrifugal pump and control valve to about three atmospheres. Air is metered into the pump suction at about 2 per cent by volume, using either an aspirator or a compressor. A retention tank with a residence time of about one minute allows intimate air-water contact, ensuring a maximum solution of the air. The control valve provides a rapid pressure drop which decreases the air solubility. It also causes extreme turbulence, so floc formation should take place downstream of this point. The air bubbles coming out of solution attach themselves to the solids present, and as the mixture enters the flotation cell, carries the solids to the tank surface. Here a paddle arrangement carries away the solids. Clarified water is removed from the bottom of the cell by standpipes.

TABLE I OPERATING DATA ON FLOTATION CELL, 1971, USING CAUSTIC ALUM ON SALMON CANNING EFFLUENT

STREAM	SUSPENDED SOLIDS (mg/ℓ)	SOLUBLE SOLIDS (mg/ℓ)	COD (mg/ℓ)	OIL (mg/ℓ)	TURBIDITY (JCU)
Influent	956 ± 360	1590 ± 2498	5635 ± 2498	360	>2500
Effluent	61 ± 28	1075 ± 155	815 ± 125	>20	<200
Removal	92 ± 5	28 ± 16	84 ± 6		

Sludge volume flow was 2 to 3% of cell flow

Sludge average solids content was 7.2%

Alum was 235 mg/ℓ

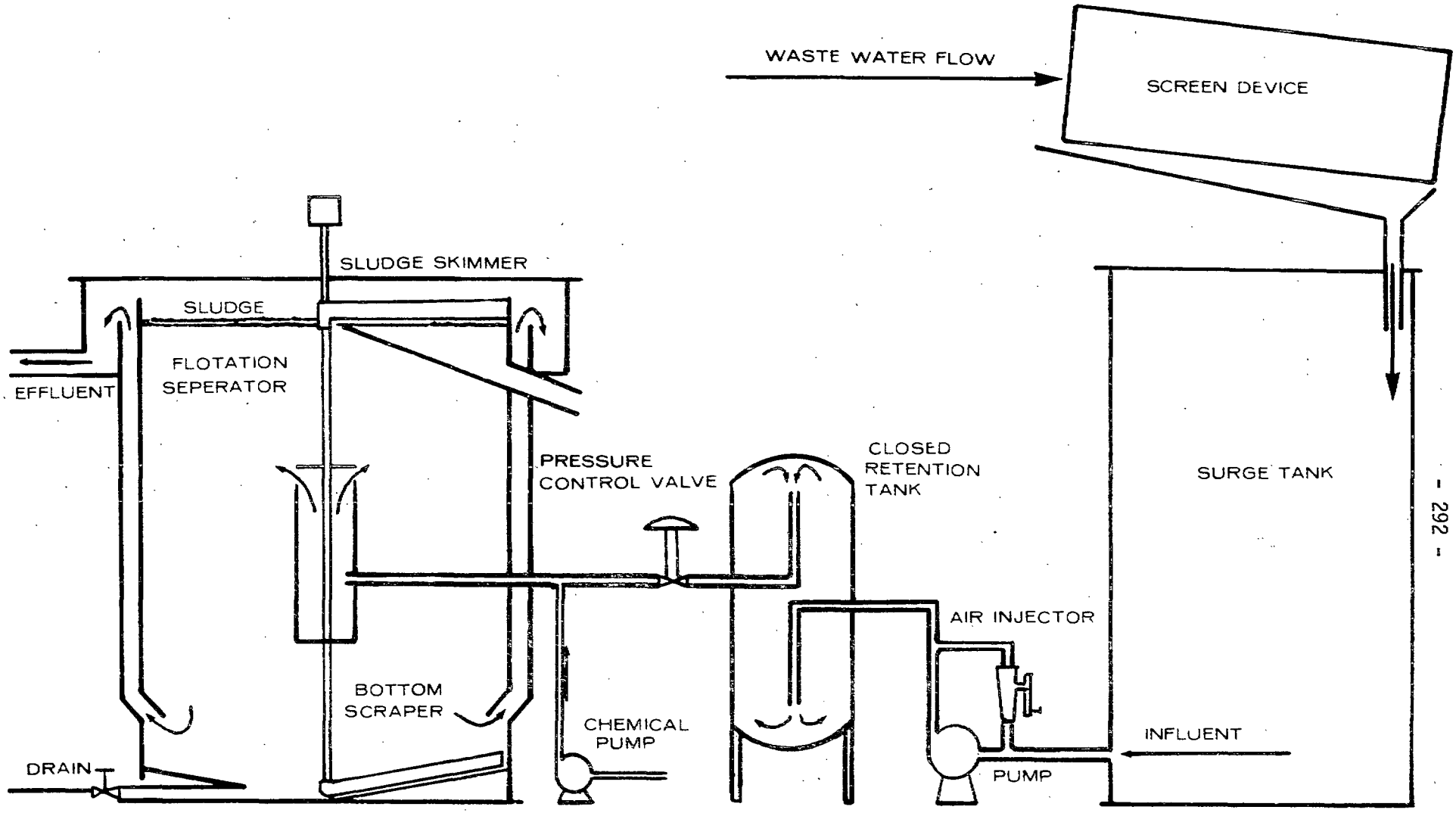

FIGURE 1 - Total flow pressurization

The flotation cell may be circular or rectangular. Both types were tested on a pilot plant scale with similar results. Based on these results, it was decided to install a full-scale demonstration unit.

THE AIR FLOTATION DEMONSTRATION UNIT

Plant Design

In a cooperative effort between the Fisheries Association of British Columbia and Environment Canada (Fisheries Research Board, and the Industrial Development Branch of Fisheries Service), a demonstration wastewater treatment plant was designed and erected, based on the results of our pilot plant studies. The system was sized to handle an estimated flow of 750 Imperial GPM originating from either the salmon cannery or groundfish operation of B.C. Packers Imperial Plant. The flotation cell was designed at an overflow rate of 2 g/sq. ft./min. Other design criteria may be found in our Technical Report Number 14 (Claggett, 1970).

Although much existing plant equipment was utilized in the construction in order to minimize the capital investment, the plant was designed to allow calculation of capital and operating costs as well as to solve problems expected to be encountered in operating a demonstration unit.

A flow diagram of the plant is shown in Figure 2. The chemical addition system included a 1000 gal. Koroseal-lined caustic tank, a 6000 gal. Fibreglas alum tank, and two 200 gal. polyelectrolyte tanks. A Milton-Roy diaphragm duplex pump rated at 80 U.S. gal. per min. was used for the 30 per cent alum and an 18 gal. per min. single head pump for the 50 per cent sodium hydroxide. The polyelectrolyte addition was made from a 0.5 per cent solution by a rotary vane pump rated at 5 gal. per min. of water.

The Beckman pH monitoring system is shown schematically in Figure 3. It included two Series III flow chambers containing a standard glass and a Lazaran reference electrode connected through a manual electrode switch to a Model 940 Beckman pH analyser. This system allowed the checking of either the caustic addition or the pH of the incoming water as well as the amount of pH depression obtained from the addition of the alum. Most of the chemical and water lines in this system were of 1/2 or 3/4 inch polyethylene tubing with stainless steel fittings. Subsequent testing indicated that the alum addition could be automated by pH control, with alum added through signal from the pH analyser

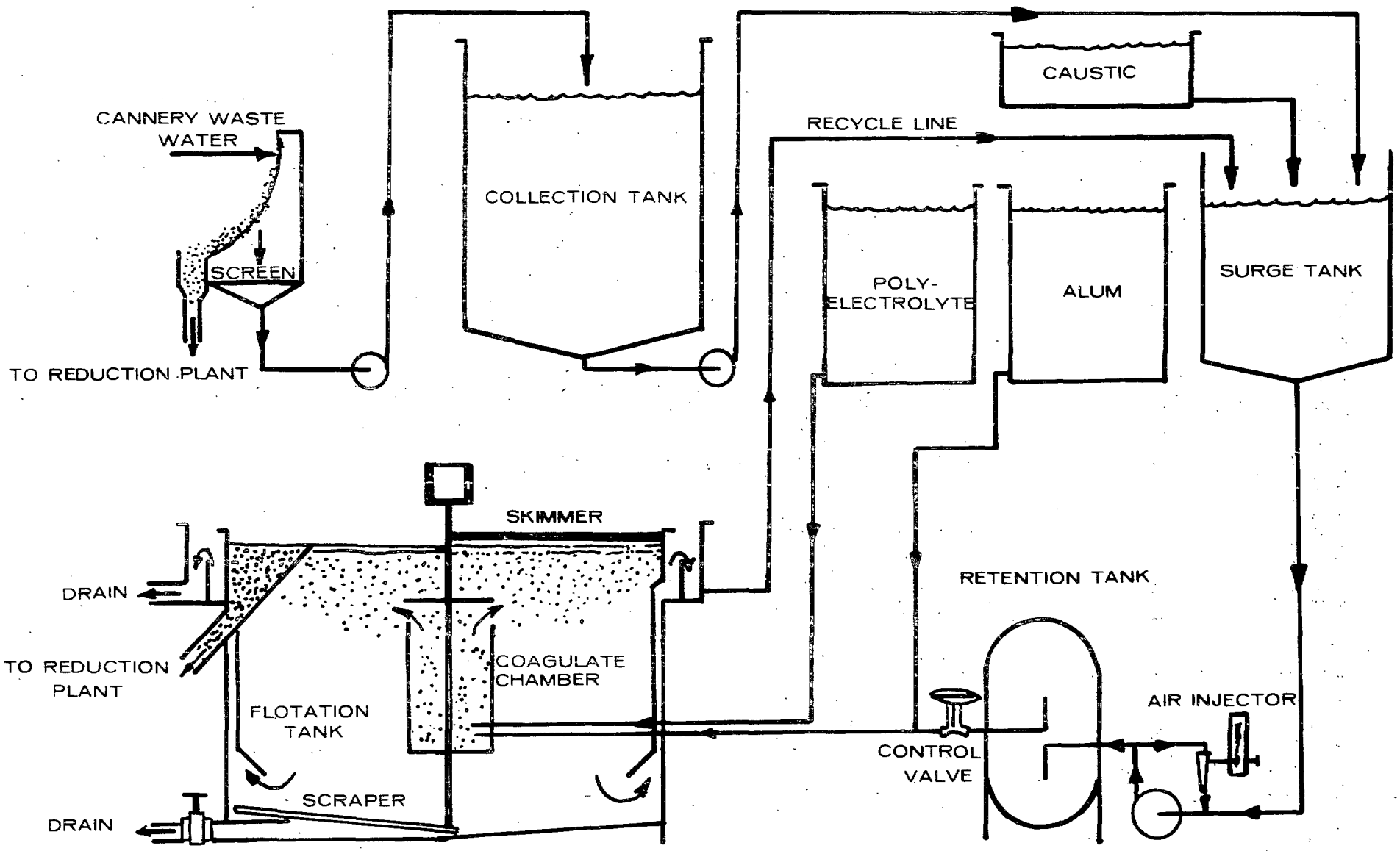

FIGURE 2 - Flow diagram of demonstration plant

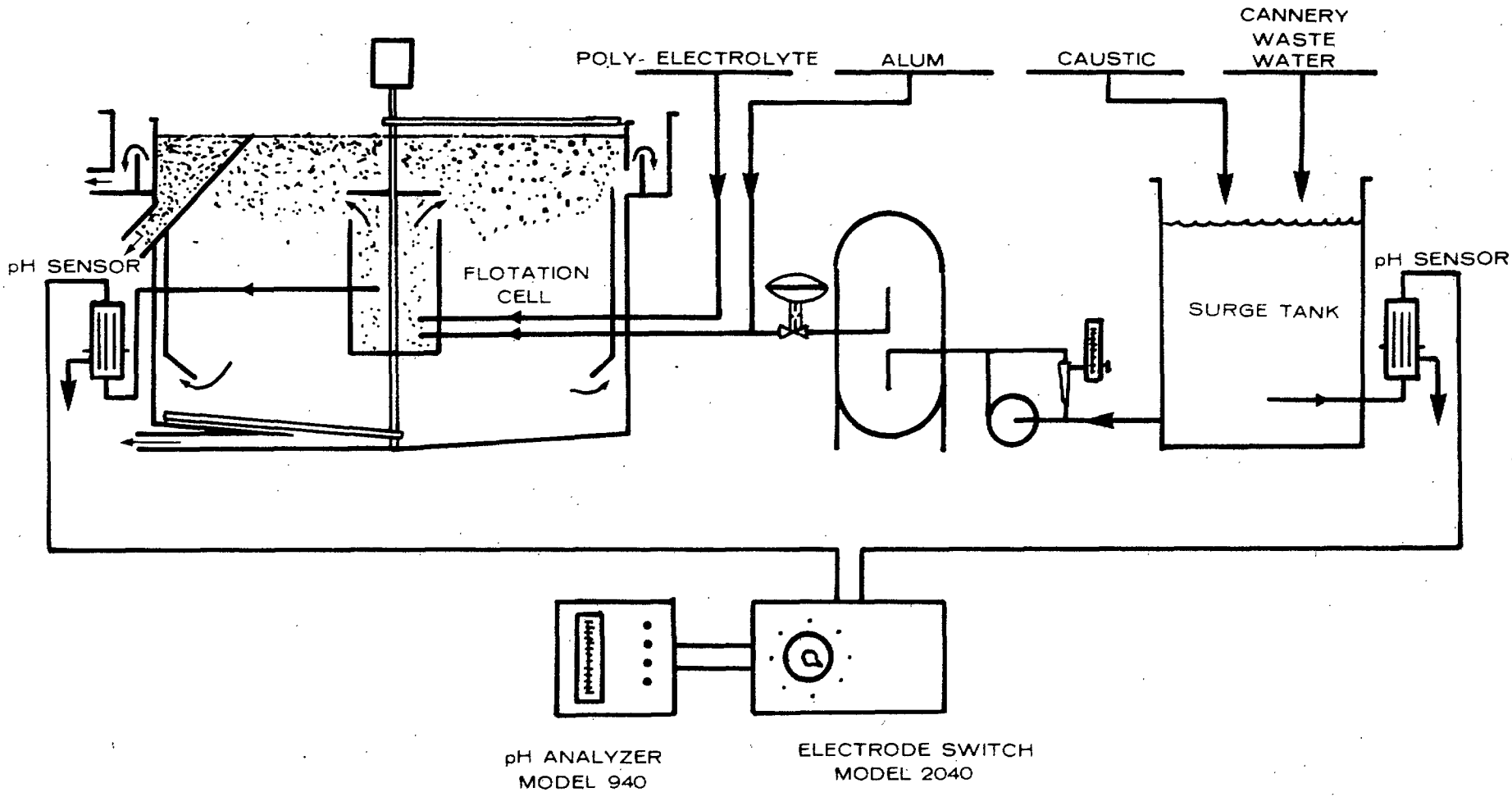

FIGURE 3 pH Monitoring System

to position the plunger on a Minton-Roy control diaphragm pump. The desired pH appears to be about 5.4 for most wastewaters.

The flotation cell was equipped with two sludge scrapers to handle the heavy volume of sludge encountered in various wastewaters. Sludge was discharged through a hopper into a 3-inch line leading to a 3-inch Viking gear pump equipped with a 5 HP motor. The solids were pumped about 100 yards through a 3-inch line to the reduction plant for sludge recovery.

Problems encountered with air-locking in the Viking gear pump indicates that a diaphragm pump such as supplied by Marlow would be a better choice.

The results obtained in the first year of testing with the caustic-alum combination are detailed in Table II. Although the sludge could be recovered as a 15 per cent solids cake in a basket centrifuge after heat treatment, the recovery is difficult. When the alum is flocculated with an anionic polyelectrolyte, the solids content of the cake can be increased to 20 per cent, with a recovery of about 90 per cent. Preliminary tests indicate that a decanter (horizontal bowl) centrifuge might be applicable and a small Super D-Canter will be tested in the spring of 1974.

Using the alum-polyelectrolyte combination, the data obtained are detailed for effluents from groundfish, salmon canning and herring roe operations in Tables II, III and IV.

Applicable Polyelectrolytes

The only polyelectrolytes found to be effective in our tests are the anionic polyacrylamide copolymers with molecular weights of 5 to 15 million. Table V shows the ones found to be satisfactory, their suppliers, and approximate price. Similar materials are available from other polyelectrolyte polymers.

Although the dosages are in the 1 to 5 mg/ℓ range, the polyelectrolyte is concentrated in the sludge with a potential level of 500 mg/ℓ being possible. A supplier of the material states that toxicity studies on rats have proven negative, and that materials with this high a molecular weight would not be absorbed by the stomach of animals. Approval of the recovered sludge solids has been approved by the Canadian Department of Agriculture, based on feeding trials performed on poultry at the University of British Columbia.

TABLE II OPERATING DATA ON FLOTATION CELL, 1972, USING ALUM-ANIONIC POLYELECTROLYTE ON SALMON CANNING EFFLUENT

STREAM	SUSPENDED SOLIDS (mg/ℓ)	SOLUBLE SOLIDS (mg/ℓ)	COD (mg/ℓ)	OIL (mg/ℓ)	TURBIDITY (JCU)
Influent	1450 ± 520	1850 ± 360	6120 ± 1880	440	2500
Effluent	200 ± 40	1280 ± 170	960 ± 300	30	350
Removal	86 ± 6	30 ± 20	84 ± 8		

Sludge volume flow as 3 to 4 percent of cell flow

Sludge average solids was 4.9 percent.

TABLE III OPERATING DATA ON FLOTATION CELL, 1972, USING ALUM-POLYELECTROLYTE ON GROUNDFISH FILLETING EFFLUENT

STREAM	SUSPENDED SOLIDS (mg/ℓ)	SOLUBLE SOLIDS (mg/ℓ)	COD (mg/ℓ)	BOD (mg/ℓ)
Influent	265	448	1295	500
Effluent	55	312	550	245
Removal	95%	34%	58%	51%

Sludge volume flow was about 1 percent of cell flow

Alum usage averaged 20 mg/ℓ

Polyelectrolyte usage averaged .5 mg/ℓ

TABLE 1V OPERATING DATA ON FLOTATION CELL, 1973, USING ALUM-POLYELECTROLYTE ON HERRING ROE RECOVERY EFFLUENT

STREAM	SUSPENDED SOLIDS (mg/ℓ)	SOLUBLE SOLIDS (mg/ℓ)	COD (mg/ℓ1)
Influent	1240	6337	5087
Effluent	344	4823	1774
Removal	74%	24%	66%

Sludge flow is 6 to 7 percent of cell flow

Alum usage is 180 mg/ℓ

Polyelectrolyte usage is 4 mg/ℓ

TABLE V: Polyelectrolyte Sources and Costs

Polyelectrolyte Trade Name	Supplier	Price per lb.
Polyfloc 1200	Betz Laboratories	$1.80
Magnafloc 835A	Cyanamid	1.95
Magnafloc A-100	Cyanamid	1.25

Treatment Technology in Canada
- Outfalls.

by

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Outfalls to Marine Environments

The success of an outfall depends mainly on the ability of the receiving water to assimilate or disperse the waste discharge. This, in turn, is dependent on such factors as tide, wind, wave and current action. The ability to predict adverse effects of an outfall also requires a knowledge of the uses to which the receiving water may be put, such as recreation, bathing, shellfish growing and the like.

Tidal currents are the water movements which accompany the tide changes. These are periodic in nature, and vary widely with the geography of each area.

Since floating material from an outfall will move faster than the effluent discharged at an outfall due to wave and wind action, a knowledge of these is important.

Coastal currents are major sustained movements of water, often parallel to the coast. Their effect near shore is usually minimal, but occasionally an eddy or counter current may be induced which can greatly assist in proper effluent discharge.

Density, salinity and temperature of the receiving water can markedly effect the dispersion of wastes. A density gradient at the outfall can prevent the effluent mixture from reaching the surface.

Submarine outfalls which discharge relatively untreated wastes will have some effect on the marine environment, at least near the outfall. Proper design of an outfall, using knowledge of the previously mentioned factors, can greatly minimize deleterious physical, chemical and biological effects.

The physical effects depend mostly on the location of the outfall and the degree of treatment. Deposition of significant amounts of solids in the discharge area is common for fish processing plants at present. Fine screen will significantly reduce this effect. Temperature changes due to the discharge will be of little consequence due to the large dilution available.

Submarine outfall disposal of naturally occurring organic wastes will have little effect on the chemical characteristcs of the receiving water. The change in salinity is only marked in the close proximity to the outfall. Oxygen deficiency resulting from the biochemical utilization of the wastes may occur where dilution is restricted for any reason. This is not normally of significance for properly located outfalls.

The suitability of a particular ocean outfall may be governed by its proximity to marine shellfish beds. Because certain shellfish concentrate bacteria, restrictions are required on either the location of outfalls in proximity to the beds, or in the harvesting of such shellfish.

Since the effluent from fish processing operations is not either as noxious or as liable to contain pathogens, outfalls should be designed more for aesthetics than from public health consideration. Consequently, the restrictions on outfalls listed by the Pollution Control Branch, B.C. Government in the October, 1971 policy statement for municipal discharges may be too restrictive. If these were applied, however, plants discharging over 10,000 gpd would require an outfall located 50 feet below low-water, and at least 100 feet from shore.

In Plant Design and Changes for Minimizing Water Use

by

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Inplant Design and Changes for Minimizing Water Use

In connection with characterization studies by Soderquist, Stanley and Associates, and some of our in-house surveys, it has been pointed out that water usage in the fish processing industry varies widely, depending more often on the availability of water than on the needs of the particular processing step. For example, figures for water usage in the salmon canning operations were reported by Stanley and Associates to vary between 1 and 7 gallons per pound of material processed.

That these wide variations were found to exist is really not surprising, since outside of a few isolated locations in British Columbia good quality water is available in abundance and is inexpensive. Since the major regulatory influence on fish processing operations has been the Fish Inspection Branch of Fisheries Operations, and since their chief concerns are plant cleanliness and sanitation, companies have tended to use a maximum of water wherever possible. It is not uncommon to find many plants with floors flooded at all times of processing.

Coupled with this is the general lack of controls to vary the amount of water used with the amount of fish processed. One often finds that two or three valves control the major portion of the water used in the plant, and these are opened and closed at the start and end of processing operations.

For those designing new plants, or contemplating changes to control water usage, the following guidelines are offered. No exact figures on recommended usages can be given due to differences in processing lines, sizes of operations, the general cost and availability of water, and the waste treatment requirements

Processing Operation	Recommended Range (Gals/1000 lb fish/processed)
Salmon canning	1 - 2
washing, glazing, freezing	1 - 1½
filleting	3/4 - 1
herring roe	¼ - ½
herring canning	½ - 3/4
shrimp processing	6 - 8
crab	5 - 6

The following points are worthy of consideration during design of new plants or changes to existing facilities.

Unloading Devices

Wherever possible the utilization of unloading devices such as pumps, which use water as the conveying medium should be avoided unless provision can be made for maximum recycle of the water. The centrifugal herring pump, such as supplied by Yeoman's, Marco and others is a major source of pollution, and should not be used.

Vacuum systems such as the Marco and Temco pumps are becoming quite popular. Although power costs are high, they use little water, and hence are a great advantage over the hydraulic type. Systems such as the air-lift and hydraulic syphon, while utilizing water do lend themselves to a simple recycle system.

Ice Separation

The use of water for either melting ice or flotation separation of ice from unloaded fish should be examined closely for alternatives. Physical separation of ice using continuous circulations of water may be feasible after belt screening of ice. Since the ice already contains blood water, slime and pieces of flesh, mixing with water can only lead to its contamination. Physical separation of the ice, followed by disposal by melting is a preferable method.

Conveying

The use of conveyor belts, tote bins, front-end loaders and pneumatic conveying are preferable for moving of fish, and especially for offal. Studies on the east coast by Environment Canada showed that not only can water usage, but the major pollution parameters of BOD_5 and suspended solids can be reduced by at least fifty percent through the adoption of dry handling techniques in the groundfish processing plants.

Thawing

One of the major uses of water in a filletting plant is the thawing of frozen fish. If the fish have been washed properly prior to freezing, the initial thawing stage absorbs few contaminants. In the latter stages of thawing some blood, slime and oil contaminants begin to leach from the fish. The recirculation of thawing water using external heat is one solution, which also has the advantage of control of the rate of thawing. Other possible alternatives are the use of air or declectric thawing methods, or vacuum thawing in retorts.

Process Modifications

The one major change is in valving, to allow only those portions of the plant actually in use to receive water. On areas such as processing tables, the use of sprays rather than flowing hoses should be adopted. Fish, fillets and offal should be conveyed rather than flumed. Floors should be periodically cleaned by shovel, then washed using spring-loaded nozzles on hoses, rather than using continuous flushing. The settings for water use in filletting, skinning and gutting machines should be inspected regularly to determine that optimum water use is maintained.

Summary

When one examines the copious use of water in the fish processing industry, and realizes that one may be paying from 16 to 30 cents per thousand gallons for water, and roughly the same or more for cleanup prior to discharge, it becomes necessary to consider the need for such a large usage. It is possible to curtail some use, while still maintaining a good work flow and sanitary requirements. Each plant should begin a water audit as soon as possible, so that data will be available when it becomes necessary to make the changes required to meet coming pollution standards.

A DISCUSSION ON ECONOMICS OF FISH WASTE TREATMENT AND ON THE EFFECT OF THE "GUIDELINES" FOR IN-PLANT CHANGES AND MODIFICATIONS

Prepared by:
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April, 1974

CHAPTER I

INTRODUCTION

A discussion on the economics of fish waste treatment and on what effect the prescribed "guidelines" can have on the fishing industry or on any given plant must, for the very reason that the scope is enormous, be very limited.

- There are no pat answers applicable to all plants.
- Each plant must be looked at specifically to see how they may compare to the guidelines.
- The technology used, the system, the equipment, the machines, and also the location of any given plant will, both now and in the future, determine the extent to which waste recovery economy can be achieved within the framework of the prescribed guidelines.

For this reason it would be wrong to generalize and to seek general answers to solve the pollution problems of the fishing industry as one, as it is felt that any such general solutions may tend to become "so-called proven methods" which, in themselves, could restrict the continued search for new and better effluent and waste disposal methods.

By the same token, a discussion on the subject -- treating the fishing industry as one -- would not bear any relevance to the need in any given plant, other than in a roundabout way.

That is to say, a discussion of this sort may be of use to some plant owners or plant operators who may recognize certain aspects of these discussions as being of relevance to their own concern and their own plant.

It is important to take note of this because:

- guidelines tend to become rules;
- rules tend to eliminate flexibility - and
- rigidity prevents innovate solutions to complex problems.

It is urged that in the implementation of any guidelines there be room for flexibility and that the object - to prevent pollution - be kept in the front rather than calling a strict adherence to something which at this time are considered to be sensible guidelines.

CHAPTER II

CONCLUSION

Fish waste may be treated to give economic returns to many types of fish plants. The overall return on investment will at best be marginal.

A new technology is evolving which, hopefully, will help to facilitate:

- the capturing of existing and new economic benefits, and
- the implementation of the guidelines for in-plant changes and modification.

An early implementation of the "guidelines" requires an intensification of mission oriented research, equipment prototype design and prototype testing.

Simultaneous product research, product development and product test marketing must take place hand in hand with future projections into the technological changes that can be identified at any given time.

The capital requirements of fish plants, generally, are such that most plants will be hard pressed to find the capital needed to implement the prescribed guideline changes.

It is therefore imperative that research and studies be conducted to explore the possibilities of constructing systems, machines and equipment that can reduce the capital cost of the effluent systems.

Studies of this sort ought to take into account in-plant modifications of all the processing and the materials handling equipment in the plant.

It is not enough to seek solutions that will connect new effluent systems to existing, old and/or possibly outdated production equipment.

In many instances it may be found more practical and economical to tear down old plants and build new ones. But then the capital requirement may become a problem.

"Economy of scale" concepts do not apply generally to all types of fish processing plants. There are optimum sizes for plants, depending on the location, the processes, the people and the products produced. Medium sized plants often yield higher returns on capital requirements than mammoth sized plants.

CHAPTER III

RECOMMENDATIONS

An orderly and economic implementation of the guidelines for fish waste treatment and in-plant modifications and changes can be achieved over a period of 4 to 5 years, providing the appropriate governmental agencies can become tuned to the economic needs of individual fish plants.

To get quick results, it is recommended that;

- Overall, mission oriented, but flexible policies be established to facilitate the implementation of the objectives inherent in the "guidelines", by methods that will allow problems to be solved according to a general master plan, but from there in specifics.

- The general master plan be designed and developed so that it could utilize existing and new talent resources within the fishing industry itself, and also within research establishments, universities, governmental agencies and the engineering industry at large.

- The funding of the implementation of the master plan, and the search for solutions in specifics be made available from the public purse.

- As time goes by, consideration be given to the creation of a capital source which can be made available to fish companies looking for means to implement the guidelines.

CHAPTER IV

ECONOMICS OF FISH PROCESSING PLANTS

Fish processing plants are generally divided into three categories:

Category A - Fish Filleting and Freezing Plants
B - Fish Meal Plants
C - Fish Canning Plants

There are only a few fish canning plants on the East Coast. The economics of each of these plants are vastly different, and therefore no attempt has been made to generalize their economics.

The economics of each of these plants can only be looked at individually and in specifics to be meaningful.

The same can also be said for the other categories of plants, that is the fish filleting plants and the fish meal plants.

As the plant capacity and the plant layout vary, so does the economy of the different plants.

However, due to the similarity of both supply and products, there are certain "hand rules" of economics that apply to both fish meal plants and fish filleting plants.

These rules may be described as follows:

(A) ECONOMICS OF FILLETING AND FREEZING PLANTS

The processing cost per pound of frozen fillets varies from about 16¢ a pound to 18¢ a pound for most types of ground fish.

Thus, a species which may cost 10 cents a pound delivered to the plant round and on ice, will cost about 46¢ or 48¢ a pound, f.o.b. plant - assuming a 33% yield.

This calculation makes no allowance for the contributions which a plant may receive from the guts, the bones, the roe, the liver; that is, offal or other by-products.

The offal which is generally about 2/3 the volume of fish delivered to the plants can, if carefully considered and utilized, make a significant contribution to the economy of any given plant.

The easy way, and the most frequently used method, is to utilize all the offal for fish meal and oil. The economy of the fish meal plant is described in more detail later.

Most fish filleting plants need to have their own fish meal plant operation, simply as a means to get rid of their offal, which cannot be used for anything but meal and oil.

Filleting plants not having a fish meal plant will have to truck their offal to nearby fish meal plants, but these plants can selcom consider the possibility of obtaining any return from the sale of offal.

The cost of trucking generally absorbs the price of offal.

Even though there will always be offal that can only be used for meal, all filleting plants may stand to benefit from a more selective utilization of offal, blood water and pumping water. Some plants are doing something in this field already.

Among the many opportunities for the selective utilization of offal, the following products may be listed:

- frozel offal in bulk - for mink food
- deboned and frozen fish mash - extracted from offal for human consumption
- cod roe - canned
- cod liver - canned
- cod liver - oil
- fish soup concentrates
- Herring spawn - frozen or canned
- fish - skin glue
- salted fish skins
- soil nutrients products (fertilizers)
- fish scales - pearl essence
- mashed and frozen offal - for dog food products.

These are just some examples of different kinds of products that can be extracted from the offal.

Nearly all of these can be shown to have economic potential, considering that the conversions can take on a wide variety of forms.

The utilization of fish offal to produce by-products such as these requires, more than anything else, innovate skills, market and consumer know-how, connections, technical sophistication and more than ordinary management capabilities.

The skills and capabilities required are of a higher degree than what is needed to manage and run a conventional fish filleting and freezing plant.

It is doubtful that there is any fish company in Canada that would have the required in-house capability to pursue these opportunities fully.

The opportunities to be identified have their roots, not so much in the fishing industry, as in the markets, which are often altogether different industries, such as:

- the drug industry
- the poultry industry
- the pet food industry
- the soup industry - and
- the catering industry.

It is the needs of these other industries that are the opportunities for the fishing industry.

The ability of any given fish company to seek out these needs, and then to organize themselves to supply the right kind of products in order to satisfy these needs, will, in the end, determine the extent and the speed by which in-plant changes can be made to any such purpose.

The ramification of this is - the "guidelines" - designed to prevent pollution may serve a dual purpose.

This could happen if the implementation of these could be organized to go hand in hand with the research and the exploration of the commercial utilization of the offal produced in any given plant.

(B) ECONOMICS OF FISH MEAL PLANTS

The processing cost of fish meal plants varies with the size of the plant. Basically, it is the cost of the plant, the yield and the yearly production volume that makes the difference.

The performance curves for modern fish meal plants may be approximated fairly accurately. Such curves have been worked out (see graph I attached). These curves related to plants which are 6 to 7 years old.

Recent price increases in the area of fuel, labour, electricity, packing material and equipment have shifted these curves upwards, so the unit production costs are now somewhat higher than what is shown on the graph.

The graph applies to both white fish and fat fish meal plants, even though the yields are different.

These differences can be accounted for in the so-called business potential per ton of raw material.

Thus, for example, to calculate the profitability of fish reduction, the following method may be used to get a quick idea of the economy of a given operation:

Assuming for example that two kinds of raw material are to be used -

- round herring, and
- offal from a filleting plant.

At any given time the market price is quoted in so many dollars per protein unit in the meal. Assuming that it is $7.00 per unit at a given time - whole herring meal may contain up to 73% protein, so the herring meal will sell at $510 per ton of meal.

A modern plant working on herring will have a yield of 20%, so the meal price per ton of raw material works out to $102.00 per ton of raw fish.

If the raw herring is delivered at the plant at $60.00 per ton, then the business potential is $42.00 per ton of raw material. This does not take into account the oil which is an additional contribution.

Meal from offal may contain 66% protein, so it will sell for about $460 per ton of meal. The yield from an offal production is lower - about 18% on an average, so this price works out to about $83.00 per ton of raw material.

Offal may be bought from other fish filleting plants at a cost of about $20 per ton of raw material, and that leaves $63.00 per ton business potential in the fish meal production.

Fish filleting plants which have their own fish meal plant may consider the $83.00 per ton as a total contribution to their operation, inasmuch as they normally calculate the cost of the offal raw material into the fish price for frozen products.

It depends on the plant and what they choose to do, of course.

From these figures, and comparing them with the performance curves shown on Graph I, one may thus approximate the profit that may be obtained from a given fish meal plant operation.

It is important to note that certain minimum volumes are required to break even, depending on the size of the fish meal plant installation, and also on the size of the filleting operation where the offal is produced.

The capital cost of the equipment is the all important aspect. The fixed cost charges per ton of raw material produced increases drastically as the volume of the offal produced, in a given year, is reduced.

This signifies the possible need to have subsidies or grants given to the smaller plants where the volume is so low they cannot afford to buy any fish meal plants at all.

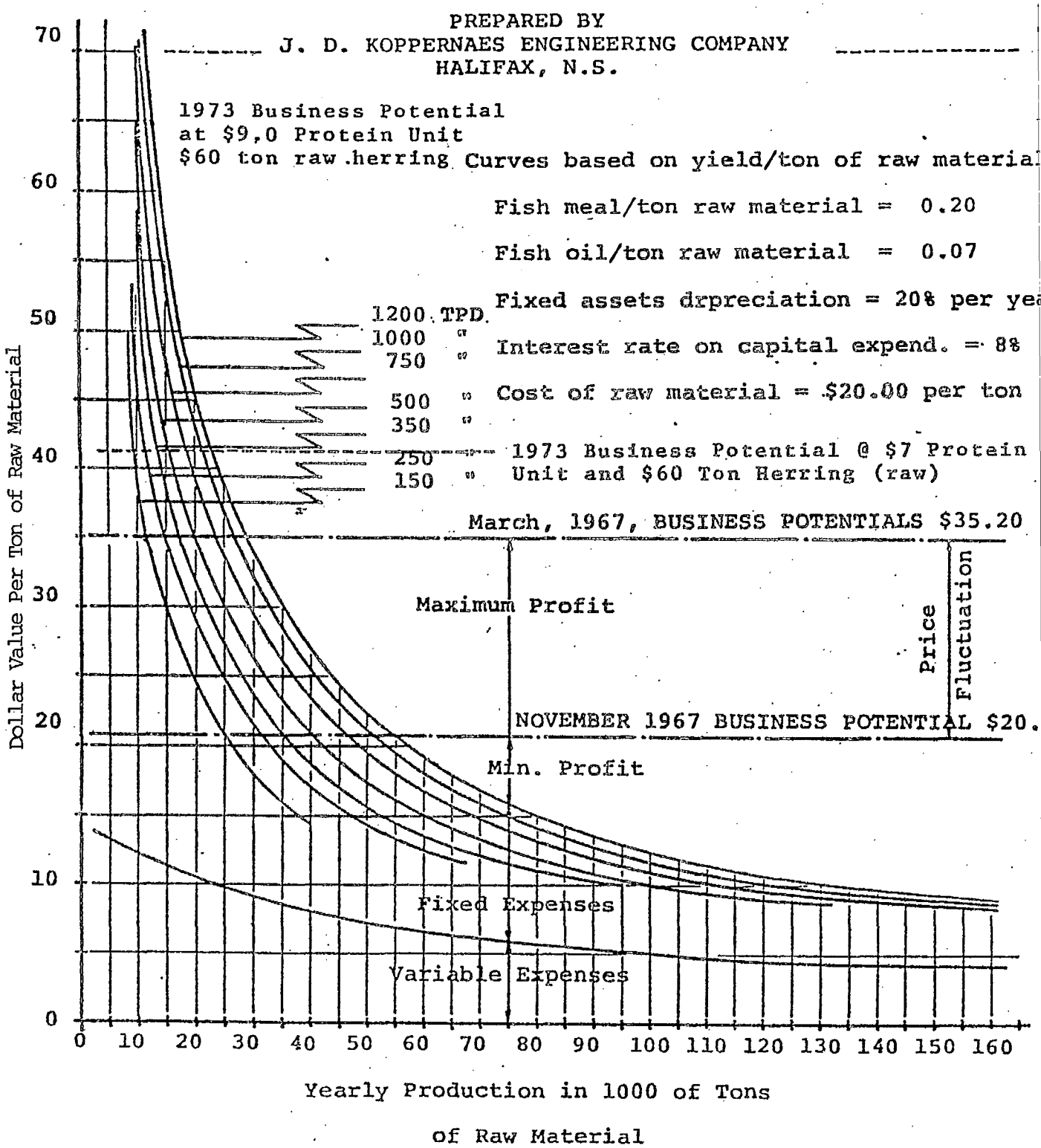
Thus, it may be observed that there may be many smaller plants which, due to size and location, will find that they cannot afford to comply with the "guidelines" both now and in the future.

A solution to this predicament may be found, if not by subsidy, then possibly with the design of simple and less costly plants, or with the implementation of select offal reduction plants built at strategic locations.

There are many variables to consider.

GRAPH I

FINANCIAL PERFORMANCE CURVES FOR VARIOUS HERRING REDUCTION PLANTS



CHAPTER V

A BRIEF DISCUSSION ON THE ALTERNATIVES FOR IN-PLANT MODIFICATIONS

Graph II shows a general flow diagram for fish processing plants.

This diagram basically shows how fish may be handled in series and in parallel as it passes through the plant.

It would be difficult to find a plant having all the production facilities as shown on this diagram. However, the diagram may serve to identify the points at which there may be in-plant modifications and changes designed to facilitate the more extensive use of the fish, the offal and other by-product raw materials.

A rational approach to seek alternative solutions for in-plant modifications and changes will require that a series of flow diagrams representing the various waste and effluent treatment systems be superimposed on basic flow diagrams as shown.

To prepare such waste and effluent flow diagrams, which will be in line with the proposed "guidelines", will require time, effort in research, design, model building and prototype testing. It will be an expensive affair requiring the organization of skills and facilities, presently in existence in organizations, such as:

- the research facilities at the universities
- the established research organizations
- the engineering consulting firms, and
- the equipment manufacturing companies.

A mission oriented approach, properly divided into stages subsequent to the design and adaptation of a master plan, should create the beginnings of the much desired results.

The desires of the fishing industry and of the environmental protection agencies thus need not be in conflict.

The approach on how one goes about finding the solutions that are of optimum benefit to both parties concerned, the fishing industry and the environmental protection agencies, is the key to the most rapid implementation of the guidelines. Thus, by extending the examination from the general to the specific, it is felt that many beneficial solutions and alternatives can be found.

In the area of specifics, there are a number of systems and alternatives that will require in-depth study and design.

All the alternatives and systems examined must, however, eventually be tied together to make one or many approved waste disposal systems applicable to the different plants.

Because of the many systems to be considered, and because there is limited knowledge and experiences about the different systems and alternatives, how they are to be proposed suggests that it would be unwise at this time to make attempts describing in detail, alternative solutions which may or may not work in practice.

Many different alternatives, solutions and systems have been partially tried in the past.

Environmental pollution starts at the point of ship unloading.

Ships are unloaded by systems such as:

- bucket and hoist unloader
- bucket elevators
- vacuum unloader
- pallets and boxes
- pitchfork - and
- fish pumping system.

Each of these systems introduces different pollution problems, and hence each requires special solutions.

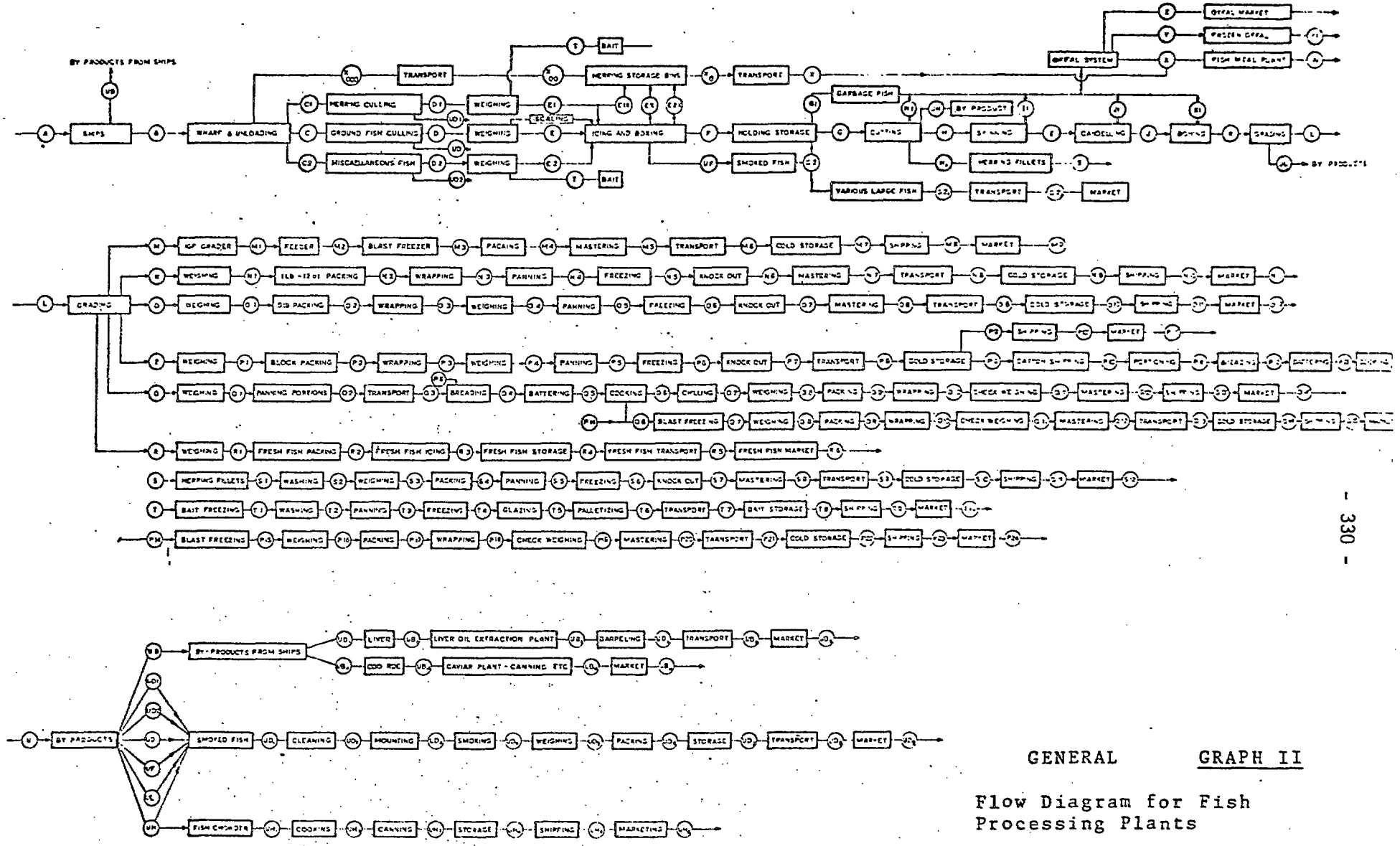
Common to all plants, and regardless of the unloading system, is the problem created when the ships are washed down and holds are cleaned.

Then there is also the problem of sanitary discharge from the ships while tied to the wharves.

There are not systems available yet, specially designed, to solve these problems.

It may be that different systems can be created which will look after these problems (i.e., the mess associated with both the washing down of the ship and the washing down of the plant, the unloading equipment and so on).

Such a system may also be designed to treat the vacuum unloader water of the fish pump water.



GENERAL GRAPH II

Flow Diagram for Fish Processing Plants

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A number of systems designed to screen, re-circulate and re-use the water again and again have been tried. All trials have failed so far. However, from the failures in the past, there are experiences which can be of significant value when considering the design of new systems. These experiences need to be recorded and documented.

Within the plants there is one pollution problem common to all; namely, the contamination of process fluming water and plant wash down water. Basically, this is a problem which stems from having bits and pieces of fish, bones, skin, spawn, roe, etc. mixed with the water.

The guidelines spell out clearly how this water should be treated and screened. There are numerous ways to consider. All systems, however, are limited by the fact that most fish plants are located 6' to 7' above high water tide. The drains and the flumes must have 1/ 8" or 1/4" slope, which means that screens or the fluming-water-pick-up systems will be below high water tide.

To pump the fluming water by conventional methods does not work. All trials have failed. The fish skins will plug any pump on the market.

Great savings in costs can be realized, however, if methods can be found to elevate the fluming water to sufficient levels, so that there will be room for a series of free fall screening systems. There are a number of possibilities. We have proposed two solutions:

- to install blow down tanks, or
- to install an archimedes screw

There are no such systems on the market. We can design such systems, but then there has to be someone willing to try them and to pay for the cost of the design and the construction of the system.

This suggests that there is a major problem of just finding out where the money can be found to design new systems, new machines and to make prototype tests on equipment specifically needed to solve the problem of implementing the proposed "guidelines".

To find the best solution for in-plant changes, it is not enough to consider what is already there, and then search for solutions, but to consider the whole aspect of fish processing.

One must look at the equipment used, what improvements can be made in these, so as to eliminate pollution problems at the source, and then follow through and look at what can best be done to solve the effluent problems at the end.

It is suggested that considerations of this sort may be of economic benefit to any given fish plant, but the question remains, who shall do the work and who will pay for the work that is needed.

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FISHING INDUSTRY IN BRITISH COLUMBIA

by

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FISHING INDUSTRY IN BRITISH COLUMBIA

This presentation discusses plant production figures for all fish processing establishments in operation and registered under the Fish Inspection Act in 1973 in British Columbia. In 1973 there were 120 fish processing operations registered under Fish Inspection Regulations in the Pacific Region. These plants were concentrated in four (4) main locations: 66 plants in Vancouver Lower Mainland; 5 plants in Powell River area; 37 plants on Vancouver Island and; 12 plants in Northern British Columbia with 9 plants centralized in Prince Rupert.

The plants can be divided into five main categories based on type of operation:

1) Canneries - Used mainly for salmon, but some also canning tuna, herring, clams, crabs and shrimp.

2) Salt Fish Establishments - Smoking, pickling or curing groundfish or salmon. Also included are salmon roe and herring roe operations.

3) Fresh and Frozen Fish Establishments - Processing groundfish into fillets, washing, dressing and freezing salmon and halibut, halibut fletching and other processing such as abalone, clams, and oyster shucking, shrimp, crab and sea urchin operations.

4) Frozen Fish Storage - Freezing and holding fisheries products either for further processing or for sale on frozen market.

5) Reduction Plants - Processing fish frames and offal from fish processing plants into fish meal and fish oil.

Historically the two main fisheries on the Pacific Coast are salmon and halibut, but the processing of other groundfish species, herring, shrimp, tuna and shellfish is increasing. The canning of salmon began in 1864 when the firm of Hapgood and Hume produced about 2,000 cases of canned salmon which sold for around $20.00 per case in England. Until this time all salmon had been salted in barrels for shipment to England or for local consumption. The canning industry expanded and numerous canneries were constructed on rivers and estuaries close to the major salmon runs. A total of 137 salmon canneries have been located at one time or another on the Nass River, Skeena River, Rivers Inlet, Smith Inlet, Vancouver area and Fraser River. A period of consolidation began after 1918 and there are now 16 canneries: 7 on the Vancouver Lower Mainland; 6 in Prince Rupert and the area surrounding and; 3 on Vancouver Island, as well as 5 sports canneries which specialize in canning sports caught salmon. These canneries have a maximum capacity of 38,380 48 pound cases per 8 hour shift although the maximum capacity is rarely, if ever, utilized.

In discussing the fish production figures it is necessary to consider the types of fishing vessels and gear used to catch the various fish species since plant production is affected by catch rates and the quality of fish.

Salmon are harvested by gillnetters, seiners, and trollers. The seiners and gillnetters fish in the inside waters, as the salmon return to their rivers and streams of origin. The salmon caught by these vessels is usually sold in the "round" as cannery fish. The trollers fish mostly chinook and coho salmon as they feed on the banks off the West Coast of Vancouver Island, and elsewhere on the Coast. The troll caught fish are dressed, and usually end up on the fresh and frozen markets.

The salmon catch varies from year to year, since the abundance of salmon depends on many natural environmental factors such as survival from spawning grounds and ocean survival as well as rate of exploitation for the five species of Pacific salmon - sockeye, chinook, coho, chum and pink.

Since 1955 the catch has ranged from a low of 75.1 million pounds in 1960 to 181.3 million pounds in 1958. No discernible trend in catch volume can be observed during the 1955-72 period.

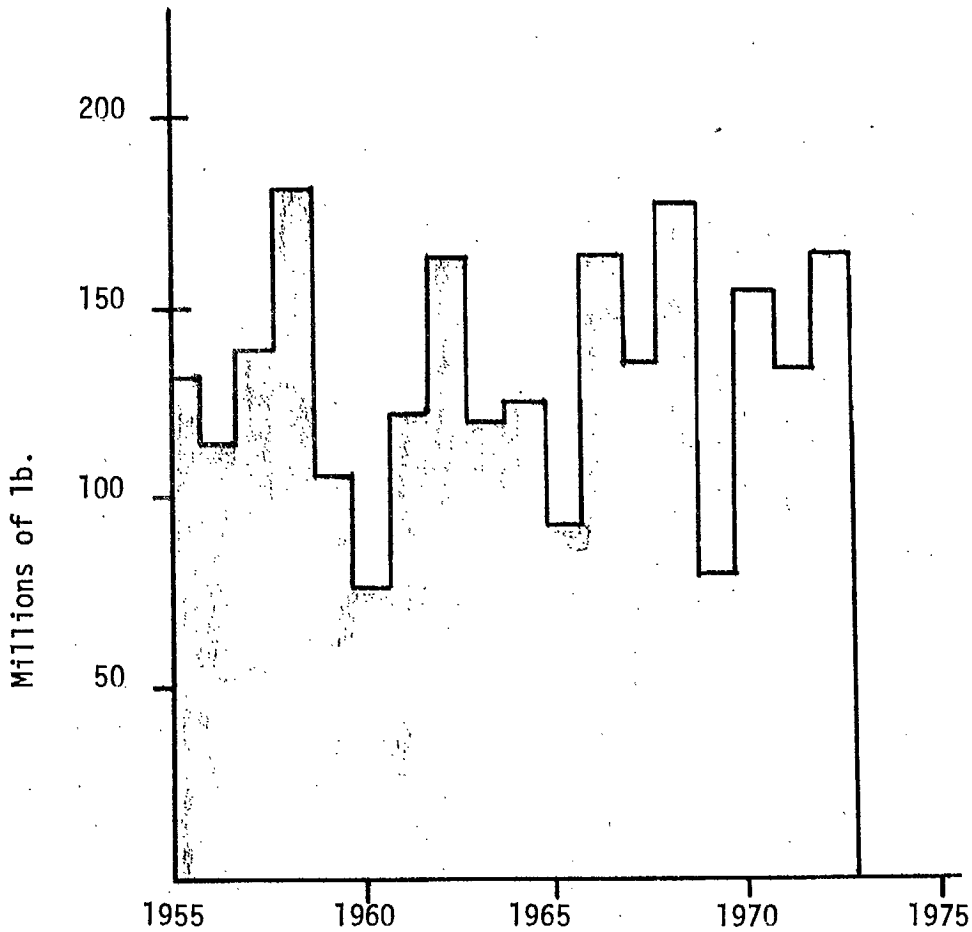

FIGURE 1. TOTAL SALMON LANDED.

Area	Number Canneries		Capacity Cases/8 hr.
Vancouver Area	7		24,700
Vancouver Island	3		1,280
Prince Rupert & area	6		12,400
		Total	38,380

TABLE 1. CAPACITY OF CANNERIES

The production capacity between canneries in the Fraser area, the South Coast and the North Coast do not indicate any definite trend but production figures illustrate that all plants in the North have produced a high of 1,076,956 cases of salmon in 1966 and all plants in the Fraser area and South Coast also produced a high of 1,012,150 cases in 1971. Due to the variations in salmon runs, a high production in the Northern area usually corresponds to a low production in the South.

	#Canneries	Fraser Area & South Coast	North Coast	Total
1972	14	674,323	498,429½	1,172,752½
1971	13	1,012,150	391,855½	1,404,005½
1970	16	666,009	757,873½	1,423,882½
1969	14	444,492½	179,660½	624,153
1968	19	811,974½	935,014	1,746,988½
1967	22	983,030½	482,678	1,465,708½
1966	-	742,259	1,076,956	1,819,215
1965	-	508,655	405,301½	913,956½
1964	-	549,713	705,595½	1,255,308½
1963	-	838,036½	365,235	1,203,271

TABLE 2. B.C. SALMON PACK (48 lb cases).*

*from Fisheries Statistics of B.C.

There are eight main processing steps in the salmon canning procedure:

1) The salmon is first fed into the automatic gutting machine, commonly called the "iron chink" since this machine has replaced the hundreds of Chinese workers which originally carried out this operation. Large volumes of water are used to clean the belly cavity of the fish.
2) The salmon are further cleaned (mainly the kidney) at the sliming table by plant workers.
3) The salmon is fed into the cutting machine which has revolving blades set apart according to the size of can being produced - ¼ lb., ½ lb., 1 lb.
4) From the cutting machine the salmon is inserted into the individual cans in the filling machine. Both the cutting and filling machines produce a volume of minced salmon flesh which is now being recovered by centrifuges and frozen in poly-bags for further processing.
5) The canned salmon is automatically weighed, salt added and a lid placed on the can.
6) There are two seaming machines; the first makes the first roll on the seam then the can passes into the vacuum sealer where the final roll finishes the seam.
7) The salmon can is washed as it comes out of the vacuum sealer.
8) The final processing step and possibly the most important is the retorting or heat sterilising procedure which kills any bacteria inside the can and produces a safe product for the consumer. The retorting procedure uses large volumes of water during can cooling. Usually the cans are cooled either in the retort by water spray headers or by placing the carts of cans in a cooling channel. Some canneries use an air cooling system where the baskets of cans are left, usually overnight, to cool naturally.

The production and utilization of salmon in the Pacific Region indicates that canned salmon, mildcured, fresh and smoked salmon production has remained relatively uniform, whereas the frozen salmon production has increased four times in the 10 year period from 11,639,400 pounds in 1961 to 49,278,000 in 1972. This trend to increased production of frozen salmon in comparison to the total volume of landed salmon will continue as salmon enhancement programs and conservation measures produce more salmon.

The production of salmon roe has assumed a greater importance in recent years. Whereas the roe was once considered suitable only for reduction with the offal, over 4 million pounds of salmon roe worth over $9.5 million was produced in 1972. This is a salted product which is destined for the Japanese market.

There are presently twenty-seven (27) cold storage establishments in the Pacific Region which are registered to process or store frozen fishery products. These establishments can be large single storey storages, multistorey storages or middle size structures capable of storing from one to one-and-a-half million pounds of frozen fishery products.

The total cold storage capacity for the Pacific Region is presently 162,150,000 lb. with 2,178,000 lb per day freezing capacity.

	Southern Inspection District	Northern Insp. District	Total
Cold Storage Capacity(lbs)	134,822,000	27,328,000	162,150,000
Freezing Capacity (lbs per day)*	1,349,000	829,200	2,178,200

TABLE 3. SUMMARY CAPACITIES OF COLD STORAGE FACILITIES, PACIFIC REGION.

*The freezing capacity per day is based on loading the freezers during and 8 hour working day and freezing overnight.

Halibut is fished by the longline method from large vessels in waters from Queen Charlotte Sound to the Bering Sea. The Canadian halibut landings have declined from 37.3 million pounds in 1963 to 22.1 million pounds in 1972 and around 14 million pounds in 1973. The halibut is landed mainly in Prince Rupert with Vancouver second. Most of the product is frozen and further processed into steaks, or fish sticks; all produce is destined for fresh and frozen markets.

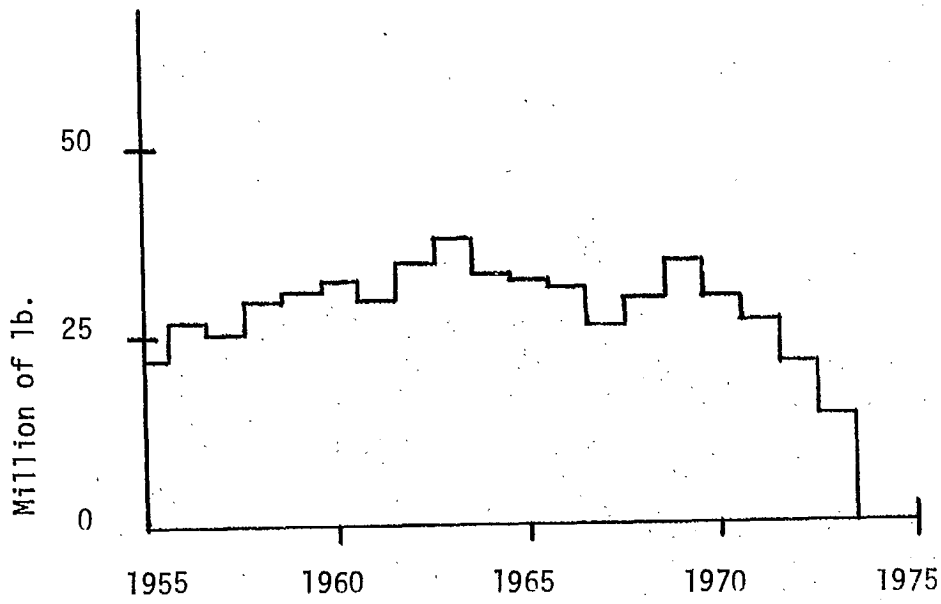

FIGURE 2. CANADIAN HALIBUT LANDINGS, 1955-1973*.

*Source: International Pacific Halibut Commission Annual Reports.

A fleet of groundfish trawlers (25-100 net tons) fish the narrow continental shelf on the West Coast of Vancouver Island, and in Queen Charlotte Sound and Hecate Strait. The West Coast fishery is mainly an inshore or near shore fishery, with processing plants located in close proximity to the fishing grounds. This is a distinct advantage whcih Canadian West Coast fishermen enjoy over foreign fishermen and the main reason for smaller fishing vessels being used for our fisheries.

Groundfish landings from these trawlers have increased from 16 million pounds in 1955 to 32 million pounds in 1972 with the fish mainly being filleted and frozen either as individual quick frozen (I.Q.F.) fillets or into blocks for further processing into fish sticks, portions, etc.

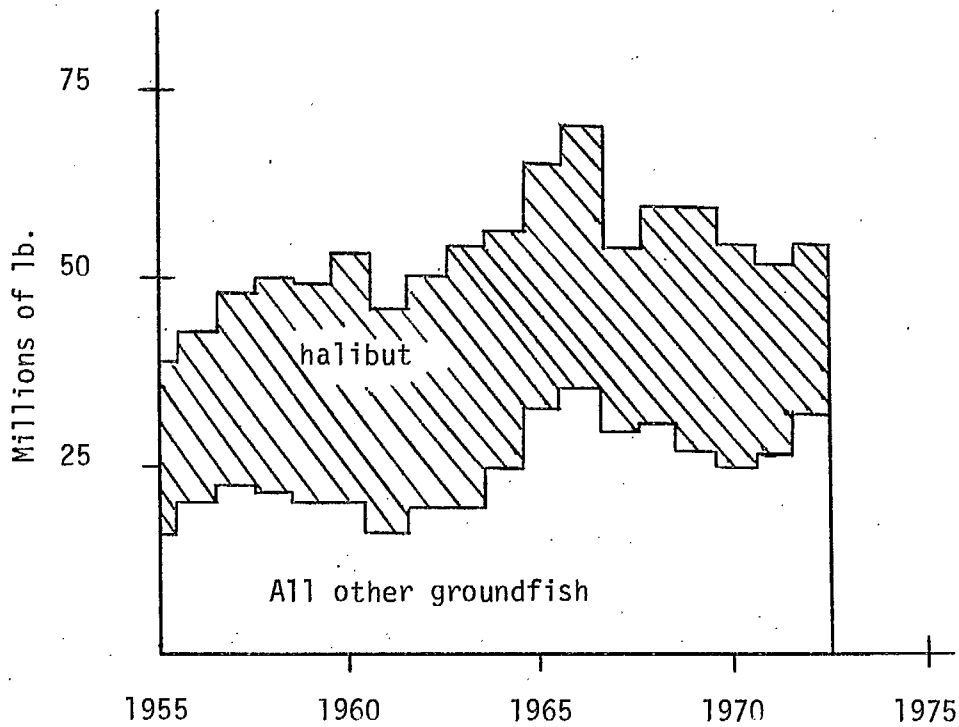

FIGURE 3 TOTAL LANDED WEIGHT GROUNDFISH INCLUDING HALIBUT

The production capacity of the fillet lines must be matched with the freezing capacity of the associated freezer and cold storage.

Up until 1967 herring was fished mainly for reduction. Between 1967 and 1971 herring stocks were rebuilding from a serious decline, and no fishing at an economically significant level was permitted. The herring fishery has developed to its present volume in just two years as a result of extracting the roe for sale as food on the Japanese market.

Landings of 43,013 tons in 1972 resulted in a market value of $12.6 million. Roe and herring frozen for the roe market valued at $10.2 million accounted for 81% of the total market value.

A study completed by the Inspection Branch of Environment Canada after the 1973 herring season estimated that all plants in the Southern District had a combined production capacity of 2983 tons landed weight of herring per day. All plants in Northern District had a combined production capacity of 1115 tons landed weight per day. During the 1973 herring season all plants in the Pacific Region should have been able to handle 4100 tons per day (round weight) and meet Fish Inspection Regulations. Production at all plants was not 4100 tons per day because the catch rate was not maintained at a constant level. Instead, landings fluctuated, flooding the plants with sometimes twice their capacity of herring. Most of the herring was channeled for extraction of herring roe from the females by one of the following methods:

1) Whole herring is brined in a 100% brine solution for two or three days depending on the condition of the fish. Once the roe has hardened the roe is "popped" by plant workers breaking the herring to extract the roe. A good worker can "pop" about one ton of whole herring in a 10 hour shift.
2) Whole herring can be frozen and held for roe extraction once the short three week roe fishery is completed. Once the herring is thawed, the roe is "popped" in similar procedure as brined herring although the recovery of first quality roe is higher using this extraction process.

After removal the herring roe is further processed by salting and grading, and finally boxing. The herring carcasses are reduced into herring meal and herring oil.

Area	Number of Reduction Plants	Capacity tons/day
Southern District	3	2100
Northern District	3	1725
		3825

TABLE 4. CAPACITY REDUCTION PLANTS 1973.

In 1968 a survey of all reduction plants was completed by the Inspection Branch. This survey showed that there were twelve reduction plants in the Pacific Region. In 1973 there were 6 reduction plants operated by fish companies, and 6 privately operated reduction plants, both in Canada and United States, processing the herring for meal and oil. The combined capacity of the reduction plants operated by the fish companies was 3825 tons of raw product perday.

Other species are processed by various plants in the Pacific Region. Shrimp and crab are processed by 17 plants producing either a canned or fresh frozen product. A total of 1,976,000 pounds of crab was processed in 1972 either as a fresh, frozen or canned product. Shrimp and prawn landings resulted in 794,000 pounds of produce, either fresh or frozen in the shell, or as fresh or frozen meat in 1972.

Shellfish are processed by 35 plants in the Pacific Region; 20 plants are registered to shuck and pack oysters. These plants are centralized on Vancouver Island with major concentrations of 6 plants in Fanny Bay area, 3 plants in the Ladysmith area and 2 plants in the Victoria-Sooke area. These plants marketed a total of 8,251,000 lb. of oysters worth $798,000.00 in 1972.

Clams, abalone, sea urchins, sea cucumbers, octopus, and skate are some of the other species which are being processed by our fishing industry in British Columbia.

THE FISH PROCESSING INDUSTRY

OF NEWFOUNDLAND

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THE FISH PROCESSING INDUSTRY OF NEWFOUNDLAND

The purpose of this paper is to give a picture of the relative and absolute importance of the fish processing industry in Newfoundland. An appreciation of the absolute importance of this activity can be gained from examining the available data on total output and value. A relative picture can be gotten from data on value added in goods producing industries in the province. An inter-provincial comparision would also be useful but is hindered by duplication that exists when some products are produced or reprocessed from the final output of another province.

Let us first look at the importance of fish processing to the province of Newfoundland itself. The first table shows data on value added by fisheries and all commodity-producing industries in Newfoundland and the Atlantic Provinces. Because these data show value added only, they differ from others to be presented later on the gross value of fish processing. Value added is calculated by deducting the cost of materials and supplies, fuel and electricity consumed from the gross value of shipments of fishery products. The fact that the calculations are based on shipments will also vary these data from our own production statistics to be used later.

Leaving aside the various complications arising from

TABLE I

Contribution of Fisheries to Value in Commodity-producing Industries, Newfoundland and Atlantic Provinces, Selected Years.

1956-1971
($ millions)

VALUE ADDED IN	NEWFOUNDLAND	ATLANTIC COAST	NEWFOUNDLAND AS PERCENT OF ATLANTIC COAST
1956			
Fishing	15.1	56.6	26.7
Fish Processing	8.0	30.9	25.9
Subtotal	23.1	87.5	26.4
Fisheries as Percent of All commodity producing Industries	10.9	1.6	----
Fish Processing as Percent	3.8	0.6	----
1966			
Fishing	26.6	101.3	26.3
Fish Processing	18.5	64.9	28.5
Subtotal	45.1	166.2	27.1
Fisheries as Percent of All commodity producing Industries	10.7	1.9	----
Fish Processing as Percent	4.4	0.8	----
1969			
Fishing	30.8	121.4	25.4
Fish Processing	35.7	95.5	37.5
Subtotal	66.5	216.9	30.7
Fisheries as Percent of All commodity producing Industries	12.8	2.1	----
Fish Processing as Percent	6.8	0.9	----
1971			
Fishing	36.8	133.9	27.5
Fish Processing	40.8	109.3	37.3
Subtotal	77.6	243.2	31.9
Fisheries as Percent of All commodity producing Industries	11.1	2.1	----
Fish Processing as Percent	5.8	1.0	----

Sources: Statistics Canada — Survey of Production (Annual)
Statistics Canada — Fish Products Industry (Annual)

changes in methods of calculating these figures several facts are evident from Table I:

1. In the period since 1956 which, in particular, save development of a strong mining industry, fish processing increased its share of total value added for the province.

2. The Newfoundland industry's share of Atlantic Coast value added in fish processing increased rather substantially over the period, in contrast with value added in fishing (catching) which only marginally improved its share.

3. Fish processing contributes a much higher proportion of total value added in Newfoundland than it does on the whole Atlantic Coast.

Fish processing should also be examined in terms of employment provided. However, several problems arise in drawing conclusions from the published data:

1. Data on fishermen are in terms of the number of people engaged.

2. Data on total employment are on the basis of those meeting the labour force definition in the given period.

3. Data on employment in fish processing present two difficulties:

   (a) Published data are in terms of manyears and not people.

   (b) All fish processing activity is not included in operations covered.

Consequently, we get a rather significant difference in data on fish processing employment compared to those for fishing and total employment.

Table 2 gives the available data for selected years from 1956-1971

TABLE II

Employment in Fishing and Fish Processing, and Total Employment, Newfoundland, 1956-1970
(thousands)

YEAR	FISHING	FISH PROCESSING	TOTAL EMPLOYMENT
1956	15	3	100
1960	18	3	91
1964	23	3	112
1968	19	5	130
1971	16	6	141

Source: Environment Canada, Annual Statistical Review of Canadian Fisheries, Vol. 5, 1973

The Overall effect is an understatement in the numbers of persons employed in fish processing operations. The actual number of individuals engaged at the peak of operations is more in the order of 10,000. In effect fish processing accounts for almost 10 percent of total employment in Newfoundland. Equally important is that the widespread nature of fish processing operations throughout the province spreads the employment over a large portion of the population.

Let us now turn to some features of the fish processing operations in Newfoundland. The type and quantity of raw material utilized is a

basic consideration. Table 3 gives data on the amount of landings by species group for selected years from 1956 to 1973.

TABLE III

Commercial Seafish Landings, Newfoundland, Quantity by Species Groups, Selected Years, 1956-1973
('000 lbs)

YEAR	GROUNDFISH	PELAGIC	SHELLFISH	TOTAL
1956	507,788	62,873	21,989	592,650
1960	497,441	32,907	15,703	546,051
1964	497,678	34,580	27,631	559,889
1969	611,327	381,449	5,217	981,388
1973	514,880	147,665	11,647	674,192

Source: Economics and Intelligence Branch, Fisheries & Marine Service, St. John's Newfoundland

Groundfish has been, and continues to be, the major source of raw material for fish processing. Plagic species, the bulk of which is herring, have increased in importance but have undergone a severe decline in availability in the last few years. However, with a switch to food herring production, this has provided the second major processing input after many years of relying only on groundfish. Apart from the perennial lobster, shellfish have taken on a fair relative importance in the last years especially with the advent of snow crab processing.

After this brief summary of what is used, a look at the types of final product is equally important. In Newfoundland, fish products are produced in five main forms.

A. Frozen

B. Pickled

C. Salted

D. Meal and Oil

E. Fresh

While there are various types of output under each form there is no real necessity to describe them here. Table 4 gives quantity data for the various forms of output for selected years since 1961.

TABLE IV

Quantity of Seafish Products, by Main Types, Selected Years, Newfoundland, 1961-1972

Year	Fresh (000 lbs)	Frozen (000 lbs)	Salted (000 lbs)	Pickled (bbls.)	Meal (tons)	Oil (000 lbs)
1961	13,561	65,082	72,752	24,393	10,962	6,973
1964	16,165	84,757	70,522	75,244	12,939	5,800
1967	12,632	104,103	50,065	27,355	29,455	21,417
1970	15,662	148,102	24,490	120,913	50,565	28,641
1972	13,643	128,843	14,642	158,092	25,028	8,736

Source: See Table III

Several important points are contained in this table:

1. The output of fresh products has not changed significantly mainly because of the small local market and the distance to major continental fresh fish markets.

2. Frozen output has experienced a tremendous rise since 1961 because of an increase in the numbers of plants and in offshore groundfish catches, and a switch away from salting by fishermen.
3. Pickled production has also risen significantly over the same period, even when landings have declined as raw material was diverted from meal production.
4. Meal and oil production increased greatly with rising herring landings but then fell off in the last few years as catches declined and a higher proportion went into food products.

A brief look at product value adds a dimension to this perspective of the industry. Total gross value of sea fish products for various years has been as follows:

1961 - $32.6 million

1964 - $45.6 million

1967 - $53.2 million

1970 - $81.6 million

1972 - $98.4 million

In effect, gross value of output has more than doubled in ten years. This has been due especially in the last few years, to higher prices generally as well as a higher unit value mix in output. This has been exemplified by increasing filet pack production, food herring products instead of meal, and higher value new species such as snow crab.

The relative shares of product value also indicates or reinforces the predominant position of frozen products in the industry. As shown in Table 5, this position has, in fact been strengthening in recent years mainly at the expense of salt fish output.

TABLE V

Percentage Distribution of Product Value by Main Types
Newfoundland Selected Years 1961-72

Year	Fresh	Frozen	Salted	Pickled	Meal	Oil
1961	13.5	46.2	30.2	2.2	3.1	0.8
1964	13.9	46.1	27.7	4.9	3.4	0.8
1967	12.0	49.8	23.3	1.9	8.0	2.8
1970	12.6	57.5	14.1	1.7	11.5	2.5
1972	10.5	66.4	6.1	7.6	4.3	0.7

No other type of output even approaches the position that frozen products hold in the industry. Even at its highest point meal production was worth only one-fifth of frozen output. Salted products have gradually shifted from a position of near equality to one where it holds fourth place behind frozen, fresh and pickled output. Fresh output seems to be undergoing an overall decline in terms of share of total value.

We can conclude with a brief examination of the location of fish processing around the province. Operations of one sort or another can be found in all areas with sections of greater or lesser concentration. The most prevalent type of operation is freezing establishments around the province, ranging from the large offshore supplied plants of the Burin Peninsula to a small government operated pelagic freezing plant in Northern Labrador.

As an adjunct to the freezing operations some 27 feeder stations are located around the province with concentration parrelling that of freezing operations especially on the Avalon and North east Coast.

There are 13 registered salted fish drying plants, the majority of which are located in the Trinity-Conception Bay area. There are also a fair number (61 in 1973) of salted fish producing operations all around the province where fish is put under salt by a commercial operator. Not to be forgotten are the many communities where fishermen salt fish in their own premises.

Registered pickled fish plants number 33 and are found all around the province. Size of operation varies considerably and some are actually part of other types of operations, (freezing, salting or meal production). In this case, there is an increasing involvement by fishermen in pickled fish production which spreads the processing activity all over the coastline.

There are 24 fish meal plants located around the province. Most of these are auxiliary to freezing operations although about 3 were designed solely for herring reduction. The highest concentration is on the ice-free South Coast.

Canneries are relatively few in number (7), and in all but three cases are part of a deversified operation. All but one are located on the East Coast.

There are other activities that are not processing operations but are involved in acquiring raw material for production plants. These include collection depots where fish is bought and held for transport to a processing point. There are at least 150 of these operations all over the province with concentration tending to follow that of freezing plants to which they are mainly connected. Over and above all these are the many locations where fish is simply purchased from fishermen and trucked away to be processed. This is occurring in almost every community where there is a road and in many where there is not. A conservative estimate is that this pure buying operation takes place at some time or other in at least 250 other locations.

In total, the Newfoundland fish processing industry consists of operations ranging from small one species seasonal collection or buying operations to multi-species multi-product year around plants. The industry exists in one form or another all around the Island. For this reason alone it can be considered an important economic force in the provincial economy.

AN OVERVIEW OF THE FISH PROCESSING INDUSTRY OF THE MARITIME PROVINCES

by

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HALIFAX

I. INTRODUCTION

I have been requested by the Environmental Protection Service to present an overview of the fish processing industry of the Maritime Provinces and to discuss the industry's prospects in terms of quotas, landings, development policies, new product development, marketing, etc. This is a difficult task to accomplish in the 15 minutes alloted. Nevertheless, I shall attempt to present a description of the existing fish processing industry and its prospects as seen by a Fisheries and Marine Service economist.

II. ANALYSIS OF EXISTING INDUSTRY

For the purpose of this paper, a fish processing plant will be defined as a building in which capital, labour and management combine to produce a product from fish which is different from its common landed form. Not included in this definition are lobster pounds, oyster packing plants, buyers and wholesalers.

As of December, 1973, there were 232 fish processing companies in the Maritime Provinces. They operated a total of 277 processing plants. The number of employees per plant ranged from 1 to over 500 and averaged approximately 30. Many of these processing plants produce a single product such as marinated herring, boneless salt cod, dried Irish moss, or bloaters while some produce hundreds of different products utilizing a large number of species.

In 1972, the value of products of fish processing plants in the Maritimes was approximately $190 million and in 1973 was probably well over $200 million.[1]

The fish processing industry, like other industries in the Maritimes, has been facing rising costs. Costs have increased substantially the past three or four years as a result of inflation affecting the prices of most goods companies purchase, demands by labour for higher wages to keep pace with inflation, and shortages of supply, particularly, fish.

Fish landings in the Maritime Provinces increased steadily to 1968 when they reached a level of 1,378 million pounds. Since 1968, however, landings have declined. In 1973, they amounted to 1,055 million pounds, a decrease of 23% since 1968. However, if landings of herring, redfish and Irish moss, which account for approximately 60% of the quantity of landings but only 17% of the value, are removed from the total, landings over the past 20 years show a remarkable constancy, ranging from 360 million to 525 million and averaging 445 million pounds. Landings of species other than herring, redfish and Irish moss, in 1973, were 12 million pounds above the 20 year average. The trend is all too clear to most processors and fishermen -- increasing amounts of fishing effort are not producing an increased amount of fish.

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1. These figures do not include unprocessed fishery species such as live lobsters, round fish, etc.

Although landings have declined, the price of round fish has continued to increase. A large increase in the price of fish began in 1969. From 1964 to 1969, the only major species to increase more than 50% in price over the total five year period were lobsters and alewives. From 1969 to 1974, however, of the top 20 species in terms of value, 17 increased by over 50% and three species (herring, haddock, and snow crabs) increased by over 100%. It is unlikely that the price of round fish will continue to increase at the rate it has been over the past four or five years, although prices will probably still continue to advance. The largest price increases will probably occur in previously underexploited species as these become increasingly substituted for the more traditional species and the products become acceptable to consumers.

As with the price of fish, wage rates appear to have increased more since 1969 than they did in the five years prior to 1969. However, they have not increased as much as the price of fish. Whereas the price of more fish has more than doubled, with some species tripling in price over the past ten years, wages are approximately twice as high in 1973 as they were in 1964. One of the most significant developments over the past few years has been the introduction of the individual incentive system in some of the major processing plants. Many workers, under such a system, are able to earn higher wages than if they were paid on an hourly rate as their own individual productivity becomes the most important

factor in determining their pay. Another important development has been the joining of unions by workers at some plants in the Maritimes. In general, wage rates will probably continue to increase at about the same rate, or higher, as they have over the past four or five years, especially if inflation continues to increase at or above its present rate. One of the most important factors affecting wage rates may be the amount of unionization that occurs among plant workers.

Unfortunately, recent data are not available on the costs of other inputs but one suspects that they have increased at about the same rate as the price of fish, particularly the price of fuel and packing supplies. As these items become in increasingly short supply, an increasing demand will continue to drive their prices up.

Although costs of production have risen substantially, particularly over the past four or five years, so also have the prices of products. I think it is probably fair to state that 1973 was one of the most profitable years ever for fish processing companies. Between 1968 and 1972, the prices of most fish products nearly doubled. Prices for groundfish products, on the average, increased more than prices for products from other species, excepting a few shellfish products such as scallops. Average F.O.B. prices for 1973 are not yet available but the price of most fish products increased well above their 1972 level. It would not be surprising if the increase of some products was in the order of

50%. However, in the period 1963-1968, when costs of production were increasing, there was very little change in the price of products. Some products, such as fresh flounder fillets, frozen redfish fillets, salt hake, and groundfish meal actually decreased in price. In general, the period 1963 to 1968 was a depressed one for the fish processing industry, in particular for the groundfish sector. Only one major product, scallops, doubled in price during this period.

Over the whole period 1963-72, product prices seem to have about kept pace with costs although as mentioned previously, in 1973, it appears they increased more than costs. The very rapid increase in product prices over the past few years is unlikely to continue, although some increase in prices can be expected. The overall level of fish product prices is determined by the interaction of supply and demand. Demand is determined largely by the level of disposable income, the size of population or extent of the market, and the price of substitutes. None of these, excepting perhaps the price of substitutes, have been increasing as rapidly as the price of fish products so the overall level of fish product prices can be expected to level off somewhat. A sharp reduction in supply could possibly lead to large price increases but that is unlikely to occur. What is more likely is for there to be a more or less constant supply entering the market.

Already, in 1973, the price of some products have declined. The price of blocks is being affected by the large supply of minced pollock blocks and the price of scallops by supplies from other areas. Meal prices are also down from 1973. Although a reduction in prices is by no means general, some product lines will be less profitable this year than they were last year. Nevertheless, the market outlook for most fish products is fair.

III. RECENT DEVELOPMENTS

There have been some fairly significant developments recently in the fish processing industry. One noticeable development has been a switch from labour intensive operations to much more capital intensive operations. Even small plants which traditionally carried out almost all operations by hand are purchasing equipment such as automatic filleting machines and vacuum unloaders. The obvious reason for this is the recent increase in the price of labour which has made capital intensive operations more efficient and profitable. As the price of labour continues to increase, capital will probably be increasingly substituted for labour and the total number of plant workers may decline. Individual worker productivity, however will increase. From 1961 to 1969, the number of persons employed in fish processing plants in the Maritime increased from 6,627 to 8,993. Since 1969, however, the number has declined at least until 1971, the last year for which data are available, when there were 7,949 persons employed, a decrease

of nearly 1,000 in two years. Value added per employee, however, increased from $3,512 in 1961 to $5,242 in 1969 to $6,301 in 1971.

Another significant development has been the greater utilization of all fish landed and a switch to products with a higher value added. The recent introduction of mechanical separators for producing comminuted fish has increased utilization. Protein that was previously going to meal is now being turned into feed for human consumption. Although the number of plants producing comminuted fish is not that great an increasing number of processing companies are going into this line of production and mechanical separators are being used for producing a great many more products than when they were first introduced into the Maritime Provinces a few years ago.

The very long-term trend away from cured fish into fresh and frozen has continued although the trend over the past decade has not been very great, excepting perhaps in salt fish, where there has been a definite trend away from dried salted cod and pollock in favour of frozen fillets. The production of boneless salt cod has remained at about the same level it was 10 years ago. It would not be surprising, however, if there were a switch back to cured fish again as the market for these products moves away from low-income regions where they were considered staples to high-income regions where they are becoming gourmet items.

A few processing plants in the Maritime Provinces produce what is normally considered gourmet fish products. The number of plants and amount of output is not very great, however. This would appear to be one field of production where significant gains could be made in terms of value added.

A great deal of progress has been made over the past decade in improving plant standards. With the recently introduced regulations regarding pickled and marinated plants, all major types of processing are now subject to at least minimum standards regarding plant construction and equipment. There seems to be little doubt that these standards have forced the fish processing industry into improving production conditions much more quickly than if the industry had been left to upgrade its standards without regulations. Certainly, the future will not see a relaxing of standards and the most likely occurence is a continuous upgrading. Combined with such programs as the current one for ice making equipment, the overall quality of fish products should continue to improve.

IV. QUOTAS

I have been asked to say something about the effects of quotas on the processing industry, a subject about which I know very little. International quotas are an attempt to manage fisheries so that individual stocks are harvested at or near their maximum sustainable

yield. Quotas are supported mainly on biological grounds. They can, however, have some very undesirable economic effects. Normally, if no limits are put on fishing effort, the amount of effort increases and the quotas are taken in a progressively shorter time each year. The major effect on the processing industry is to create idle capacity and thus increase processing costs over what they would be if the supply of fish was fairly evenly distributed over the year. Seasonality is a particular problem in the fish processing industry to which there appears to be no easy solution. The effect of quotas when effort is not limited is to compound somewhat the normal seasonality problem. The herring fishery is a good example. In 1971, when there were no quotas, 523 million pounds of herring were landed in the Maritimes. Monthly landings ranged from 8 to 97 million pounds and averaged 44 million. The monthly deviation from the average was 16 million pounds. In 1973 under quotas landings totalled 348 million pounds. Monthly landings ranged from 1 to 105 million pounds and averaged 28 million. The monthly deviation from the average was 20 million pounds. Both the monthly range and deviation were greater under quotas than when there were no quotas.

Quotas will probably continue as this method of fishery management appears to be the most accepted one internationally. The number of species and areas under quota increased in 1973 and

1974 and will probably increase again in 1975. In traditional fishing areas the east coast fishing industry has met or exceeded its allowable catch. In more remote areas, Canadian vessels in 1973 took only a fraction of the allowable catch. The obvious reason is an economic one. It simply does not pay to harvest fish from these remote areas. As fishing in traditional areas becomes more costly because of increased effort, the more remote areas will become relatively less costly and fishing effort in areas where we are not taking our quota will probably increase.

V. DEVELOPMENT PROGRAMS

I shall conclude with some observations on development programs as they apply to the fishing industry. The Department of Environment does not itself provide funds for what may be termed development projects. Most of the funds available to private industry are provided by the provinces and the Department of Regional Economic Expansion, although some funds are available through other departments, such as Industry, Trade and Commerce. The number of government agencies promoting development is very large and I suspect that the amount of co-ordination is not as great as it could be.

Each province has its own development aspirations. Both Nova Scotia and New Brunswick are currently developing fishery programs under the General Development Agreements of the Department of Regional Economic Expansion. In Prince Edward Island, the Comprehensive Development Plan which includes a fisheries sector has been operating since 1969 and is currently being reviewed for the second phase which begins in 1975. It remains to be seen what direction these programs will take, but I suspect more funds will become available to private industry for fisheries development programs. It is hoped that the various programs will be co-ordinated so that there will not be a wasteful duplication of effort and funds.

Other than subsidies on vessels for companies which own them, the most important source of funds to processing plants are those available under the Regional Development Incentive Act administered by the Department of Regional Economic Expansion. From 1969 to 1973, grants totalling approximately $9.9 million were made to fish processing companies in the Maritime Provinces. These grants were expected to create approximately 2,800 new jobs. The R.D.I.A. program is designed basically to expand processing activity although it can also be used for plant modernization. All provinces have received at least $1.0 million of grants and they have been distributed more or less equally among companies of different sizes.

As you are probably aware, the Regional Development Incentive Act is being modified to reduce eligible capital costs from $60,000 for expansion and $30,000 for modernization to $25,000 for both. New plants which create a minimum of 5 new jobs will also be eligible. The number of applications for assistance is expected to increase under the revised regulations.

VI. CONCLUSION

I have rambled long enough and shall conclude by thanking the Environmental Protection Service for having extended me an invitation to speak. My only regret is that I did not have sufficient time to prepare the type of detailed analysis on various aspects of the industry which I think should have been prepared.

APPENDIX I

AVERAGE LANDED VALUE, MAJOR SPECIES, 1964-1973, MARITIMES

GROUNDFISH	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964
Cod	10.0	7.2	6.4	5.4	5.1	5.0	4.8	5.0	4.5	4.2
Haddock	19.5	14.6	11.4	11.1	8.6	7.6	6.6	7.2	6.7	6.1
Redfish	5.1	4.0	3.5	3.3	2.9	2.7	2.7	3.1	2.9	2.9
Halibut	89.3	70.4	55.9	55.5	5.1	47.5	45.4	42.3	37.9	35.8
Flatfish	7.1	5.7	5.2	5.1	4.3	3.8	3.7	3.7	3.5	3.5
Pollock	5.8	4.9	4.5	3.9	3.3	3.4	3.9	4.0	3.6	3.2
Hake	6.7	5.5	4.6	3.6	3.7	3.3	3.5	3.3	2.9	3.1
Cusk	7.1	5.6	5.9	4.5	4.1	4.0	4.2	4.1	4.0	3.7
Catfish	6.1	4.9	3.9	3.7	3.5	3.9	3.4	3.6	3.5	3.3
Other	4.0	2.3	1.6	1.9	1.2	0.9	1.4	1.8	1.6	1.8
PELAGIC & ESTUARIAL										
Herring	2.4	1.9	1.5	1.3	1.1	1.1	1.1	1.1	1.1	1.0
Mackerel	5.1	4.2	3.2	3.6	3.8	4.0	3.8	3.5	3.4	3.8
Tuna	26.88	26.1	21.5	21.3	15.3	11.2	8.1	8.3	8.0	7.8
Alewives	2.6	2.4	1.9	2.1	2.3	1.8	1.6	1.7	1.6	1.5
Eels	29.2	27.9	23.9	17.8	11.9	11.8	12.1	11.6	10.7	11.2
Salmon	25.0	121.0	92.7	87.8	73.7	65.2	60.8	58.8	56.1	61.8
Smelts	17.3	13.4	12.4	10.7	8.7	10.2	8.6	7.5	6.6	6.8
SHELLFISH										
Clams	12.5	12.1	8.6	7.7	7.7	7.4	7.1	6.7	6.5	5.9
Oysters	19.1	18.1	20.2	19.9	18.3	19.5	17.0	15.9	15.3	12.1
Scallops	146.0	162.0	116.0	109.0	88.9	85.8	58.3	40.7	54.9	43.6
Lobsters	115.0	111.0	88.4	82.4	75.0	66.4	67.9	59.5	67.3	60.1
Queen Crab	18.8	14.5	8.1	9.8	9.1	9.0	* Other shellfish			
Shrimp	19.0	17.5	18.0	19.0	23.3	12.8	12.9*			
OTHER										
Irish Moss	2.6	2.3	2.2	2.7	2.8	2.6	2.9	1.9	1.5	1.6

* included with other shellfish

APPENDIX II

WAGE RATES, SELECTED POSITIONS, EASTERN CANADA AVERAGE, 1964-1973

	Cleaner & Cutter (Male)	Processer Machine Feeder	Freezer Man	Labourer	Packer (Male)	Packer (Female)	Tallyman
1964	1.01	---	1.06	1.09	.85	.76	1.07
1965	1.07	---	1.13	1.13	1.00	.83	1.16
1966	1.21	---	1.18	1.16	1.12	.89	1.23
1967	1.29	---	1.29	1.25	1.20	.99	1.35
1968	1.38	---	1.36	1.38	1.24	1.10	1.49
1969	1.46	---	1.44	1.46	1.25	1.15	1.47
1970	1.55	---	1.51	1.55	1.39	1.25	1.69
1971	1.71	---	1.62	1.63	1.61	1.41	1.78
1972	1.90	---	1.75	1.82	1.73	1.60	1.85
1973	2.12	2.07	2.07	1.91	1.86	1.87	2.18

Source: Canada, Department of Labour. Wage Rates, Salaries and Hours of Labour. Ottawa: Information Canada, various issues.

APPENDIX III

AVERAGE MARITIME PROVINCES, F.O.B. PLANT PRICES FOR SELECTED FISHERY PRODUCTS, 1963-1972

	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
FROZEN FILLETS										
Cod	.51	.43	.28	.29	.25	.27	.29	.28	.25	.23
Haddock	.71	.57	.56	.54	.38	.35	.36	.35	.33	.31
Pollock	.34	.30	.27	.24	.19	.19	--	.20	--	--
Redfish	.44	.32	.32	.28	.24	.22	.26	.27	.25	.25
Flounder	.65	.48	.51	.48	.35	.32	.34	.33	.33	.31
FROZEN BLOCKS AND SLABS										
Cod	.44	.42	.31	.23	.21	.23	.24	.27	.23	.21
Pollock	.29	.30	.24	.20	.19	.19	--	.19	--	--
Flounder	.65	.45	.43	.40	.28	.24	.27	.27	.26	.23
Haddock	.53	.45	.39	.38	.30	.29	.33	.32	.29	.26
FROZEN SHELLFISH										
Snow crabmeat	2.27	1.41	1.37	1.42	1.43	1.38	--	--	--	--
Lobster meat	4.61	4.08	3.70	3.72	3.33	3.28	2.98	3.03	3.07	2.05
Unbreaded Scallops	2.08	1.53	1.37	1.27	1.09	.93	.60	.65	.69	.51
FRESH FISH - DRESSED										
Haddock	.29	.23	.23	.16	.12	.16	.15	.12	.11	.12
Halibut	.91	.73	.70	.59	.55	.57	.55	.47	.48	.49
FRESH FILLETS										
Cod	.56	.45	.40	.33	.28	.30	.30	.29	.27	.24
Haddock	.82	.66	.62	.51	.40	.37	.40	.39	.37	.35
Redfish	.45	.37	.36	.29	.24	.25	.28	.25	.20	.23
Flounders	.71	.52	.52	.50	.36	.43	.40	.40	.36	.39

APPENDIX III (cont'd)

	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
LIVE LOBSTERS	1.44	1.18	1.11	.98	.88	.90	.85	.87	.71	.62
SALT FISH										
Heavy Salted Cod	.40	.34	.30	.26	.25	.25	.26	.24	.30	.21
Pollock	.33	.34	.28	.23	.22	.24	.26	.24	.24	.20
Hake	.34	.31	.28	.20	.18	.21	.27	.25	.23	.21
Boneless Cod	.75	.61	.55	.44	.38	.43	.40	.38	.37	.37
Marinated Herring Fillets (per barrel)	44.95	36.04	34.28	29.02	25.41	27.49	26.70	28.16	22.30	25.70
CANNED										
(per case of 96-5 oz. tins)										
Crab	76.60	58.00	58.75	63.00	60.20	62.80	---	---	---	---
Lobster	171.05	154.50	154.25	149.43	115.40	114.95	105.60	113.90	108.12	83.26
MEAL										
Groundfish	239	142	150	150	126	126	150	155	134	128
Herring	254	167	176	174	142	135	155	165	140	124

CHARACTERIZATION OF FISH PROCESSING EFFLUENTS IN THE UNITED STATES

by

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Treatment and Guidelines

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Preface

To restore and maintain the chemical, physical, and biological integrity of the nations waters is the objective of the Federal Water Pollution Control Act Amendments of 1972. The goal of the Act is to eliminate the discharge of pollutants into navigable waters by 1985. To help achieve this goal, the E.P.A. was directed to promulgate effluent limitations guidelines for a minimum of 27 categories of wastewater sources, including the canned and preserved seafood processing industry.

The first and essential step, to develop realistic limitations and guidelines, is to characterize the effluent from each segment of the industry. The approach used and commodities characterized by Environmental Associates, Inc., the E.P.A. contractor to assist in guidelines development for the seafood industry, are reviewed in this paper.

The results of the characterization for Phase I of the program covering the catfish, crab, shrimp, and tuna fish commodities were published July, 1973. The results of the characterization for Phase II of the program covering the remainder of the industry will not be published until March, 1974. Either of these reports will be available through the contractor for the cost of printing and handling.

Introduction

Characterization of effluents from the U.S. Seafood Processing Industries was conducted in two phases due to seasonal variability. Phase I covered a period from February to July, 1973, and Phase II, from July to December, 1973.

The characterization, subcategorization and effluent guideline recommendations for the Phase I commodities, which included catfish, crab, shrimp, and tuna, were published by the contractor July, 1973 (Environmental Associates, Inc., 1973). Phase II of the program, which includes the remainder of the industry, will be completed by the contractor by February 1974.

A summary of the total number of individual seafood processes characterized and the number of end-of-pipe (total effluent) and unit operation daily composite samples obtained during the Phase I and Phase II programs is given in Table 1. Information for ten of the 115 processes was obtained from previous studies. The different kinds of finfish and shellfish commodities characterized, the number of plants sampled and the number of end-of-pipe and unit operation samples obtained for each commodity are shown in Tables 2 and 3 respectively. The commodities sampled during Phase I are marked with an asterisk.

Table 1. Seafood Characterization Summary

Group	Number of Processes Sampled	End of Pipe Samples	Unit Operation Samples
Fish reduction	8	56	135
Finfish	54	306	530
Shellfish	51	320	530
Total	115	684	1195

Table 2. Summary of Commodities Sampled

Finfish

No.	Commodity	Plants	End of Pipe	Unit Operation
1	Menhaden reduction	5	44	104
2	Anchovy reduction	3	12	31
3	Alaska salmon canning	4	26	13
4	Northwest salmon canning	4	21	39
5	* West Coast tuna canning	5	31	210
6	* Puerto Rico tuna canning	4	31	67
7	Maine sardine canning	5	18	68
8	New England ground fish	4	21	36
9	West Coast bottom fish	9	47	44
10	Atlantic & Gulf finfish	4	18	8
11	Alaska fresh/frozen salmon	3	38	20
12	Northwest fresh/frozen salmon	2	8	0
13	Alaska halibut	3	14	19
14	New England herring filleting	1	3	4
15	* Catfish	5	27	0
16	Jack mackeral canning	1	3	2

* Phase I commodities.

Table 3. Summary of Commodities Sampled

Shellfish

No.	Commodity	Plants	End of Pipe	Unit Operation
1	* Alaska crab	7	76	15
2	* West Coast crab	3	16	93
3	* Blue crab	3	25	61
4	* Alaska shrimp	5	47	4
5	* West Coast shrimp	2	21	216
6	* Gulf shrimp	5	31	52
7	* East Coast shrimp	1	7	18
8	Atlantic surf clam	6	18	20
9	Atlantic fresh oysters	7	27	0
10	Northwest fresh oysters	4	13	11
11	Steamed oysters	3	17	30
12	Abalone	3	9	10
13	Alaska scallops	2	13	0
14	American lobster	2	4	4
15	Spiny lobster	2	2	0

* Phase I commodities.

Approach

Very little knowledge of the character and volume of canned and preserved fish and seafood processing wastewaters was available before the start of the E.P.A. study (Soderquist, et al., 1970). Field characterization was, therefore, a major effort in both Phase I and Phase II of the study.

Segmentation

A preliminary segmentation of the industry was developed through review of all significant literature, consultation with industry contact groups, related governmental representatives, and recognized experts in the areas of fish processing and waste control and treatment. Some of the more important of the several factors considered were manufacturing processes and subprocesses, form and quality of finished product, species being processed, production capacities, waste load, number of plants, and variability of the operation.

Relative Importance Matrix

A matrix analysis, based on existing knowledge, was then conducted to indicate the relative importance of each segment of the industry from a pollution impact viewpoint. The relative importance matrix for the industrial fish and finfish of Phase II of the study is shown in Table 4, as an example. A level was assigned to each of four parameters to determine the impact score. The estimated load (BOD per day), the flow (volume per day), and the number of plant parameters were quantized to four

Table 4. Relative Importance Matrix

Industrial Fish and Finfish

Commodity/ Process	Load (BOD/ day)	Flow (volume/ day)	Industry Size (Number of Plants)	Seasonality	Score
Range	3	3	3	1	10 Total
Menhaden reduction	3	3	1	0	7
Anchovy reduction	3	3	1	0	7
Salmon canning	3	2	2	1	8
Sardine canning	2	2	1	1	6
Bottom/ground fish (conventional)	1	1	3	0	5
Bottom/ground fish (machine)	2	2	1	0	5
Whiting freezing	2	2	0	0	4
F/F finfish	1	1	3	0	5
F/F salmon (round)	1	1	3	1	6
F/F salmon (predressed)	1	1	2	1	5
Halibut freezing	1	0	2	1	4
Herring filleting	3	3	0	1	7
Alewife pickling	3	2	0	1	6
Jack mackeral	2	3	0	0	5
Fish flesh	1	1	0	0	2

levels (0, 1, 2, 3). The seasonality, or variability parameter was quantized to two levels (0, 1). The pollution impact was computed by adding the score for each parameter. The maximum possible impact is indicated by a score of 10 and a minimum impact by a score of zero.

Sample Allocation

Using the philosophy that industry segments with the higher impact scores should be characterized more accurately, the results of the matrix analysis was used to allocate the samples budgeted for the program. The industry segments were therefore assigned to large, medium, and small impact groups. Assuming that about 50% of the samples would be of unit operations, to estimate material balances and to indicate areas where process changes could reduce the waste load, the segments in the large group were allocated 20 to 30 space-time samples of the total effluent and about 20 to 25 samples of the unit operations. Medium impact segments were allocated 15 to 20 space-time samples of the total effluent and about 15 to 20 samples of the unit operations. The small impact segments were allocated about 12 samples each. This totaled about 1000 samples for the Phase II part of the study.

Important Parameters

Based on previous experience in examining wastewater from the seafood processing industry, the parameters considered to be most important from the standpoint of waste control and treatment and which could be obtained within the alloted time

and economic constraints were: production rate, processing time, flow rate, settleable solids, screened solids, suspended solids, 5 day BOD, COD, grease and oil, organic nitrogen, ammonia, pH, temperature, food product recovery, and by-product recovery.

Field Organization

Much of the plant information was more readily available on a regional, rather than on a commodity basis; therefore, the country was divided into seven regions for planning purposes: Alaska, Northwest, Great Lakes, New England, Middle Atlantic, South Atlantic and Gulf, and California.

Typical and exemplary plants in each industry segment were identified and contacted, usually through an industrial contact such as a trade organization or the general management of the parent company. If this was not possible, contact was made through members of government agencies, or universities. Assuming that an average of about five daily composite samples should be taken of each plant in the large or medium impact groups, a sufficient number of plants were selected for personal contact.

Based on the results of the initial contacts, the plants were visited by the project engineer. The purpose of this initial visit was to identify plants which were suitable for sampling, determine sampling locations in the plant, estimate daily and long-term variations, and determine the unit operations which appeared to contribute the greatest loads. Field crews were then sent to areas where there were concentrations of suitable plants

for sampling. Once the processing routines of the plants were determined, they would usually be able to sample several plants in the area each day.

Sampling Procedures

The field crews were instructed to increase the sampling frequency at point sources where the estimated variation of the waste load appeared to be greater. Estimates of the daily fluctuations in the process were used to determine the duration of the sampling program at the plant. An attempt was made to increase the duration at plants which showed higher variability from day to day, to obtain estimates with similar confidence intervals.

At plants where the effluent was being discharged at more than one point, each point was sampled and flow proportion to obtain a sample which was considered to be representative of the combined total effluent.

Each grab sample was passed through a standard 20 mesh Tyler screen prior to adding it to the composite. This practice removes the larger solid particles and greatly reduces the resultant variability of the data. The 20 mesh screen size was used since this was considered to be comparable to a full scale screen installation, which was considered to be a minimum requirement for virtually all segments of the industry.

The flow, temperature, pH, and settleable solids parameters were measured in the field. Flows were obtained by various methods such as meters, open channel measurements, weirs, Parshall

flumes, trajectories, and container and stop watch. The pH of each sample was measured using a portable pH unit prior to compositing.

Samples were prepared for shipment to the laboratory in the following manner. Solids for the screened samples were shaken off the screen and rolled into a plastic bag. Sufficient liquid was composited to fill four plastic liter containers. One was acidified with sulfuric acid cooled to 4°C. and used to analyze for grease and oil, COD, and suspended solids. The second was frozen and used to analyze for BOD. The third was preserved with mecuric chloride, cooled, and used to analyze for nitrogen. The fourth container was acidified, frozen and stored locally to be used in case of a lost shipment.

Data Reduction

Several computer programs, which proved to be very efficient and precise tools for analyzing and presenting characterization data, were developed by the contractor.

The first program accepts a series of daily data from a single seafood process and provides a table consisting of estimates of the time average, the standard deviation, and the minimum and maximum of both concentrations (mg/l) and load per unit production (kg/kkg of raw product) for each parameter. If multiple outfalls could not be readily composited in the field, the program mathematically flow proportions the load from each outfall and provides an estimate of the end-of-pipe waste load. A typical output from this program is shown in Table 5.

Table 5. Typical Single Plant Characterization

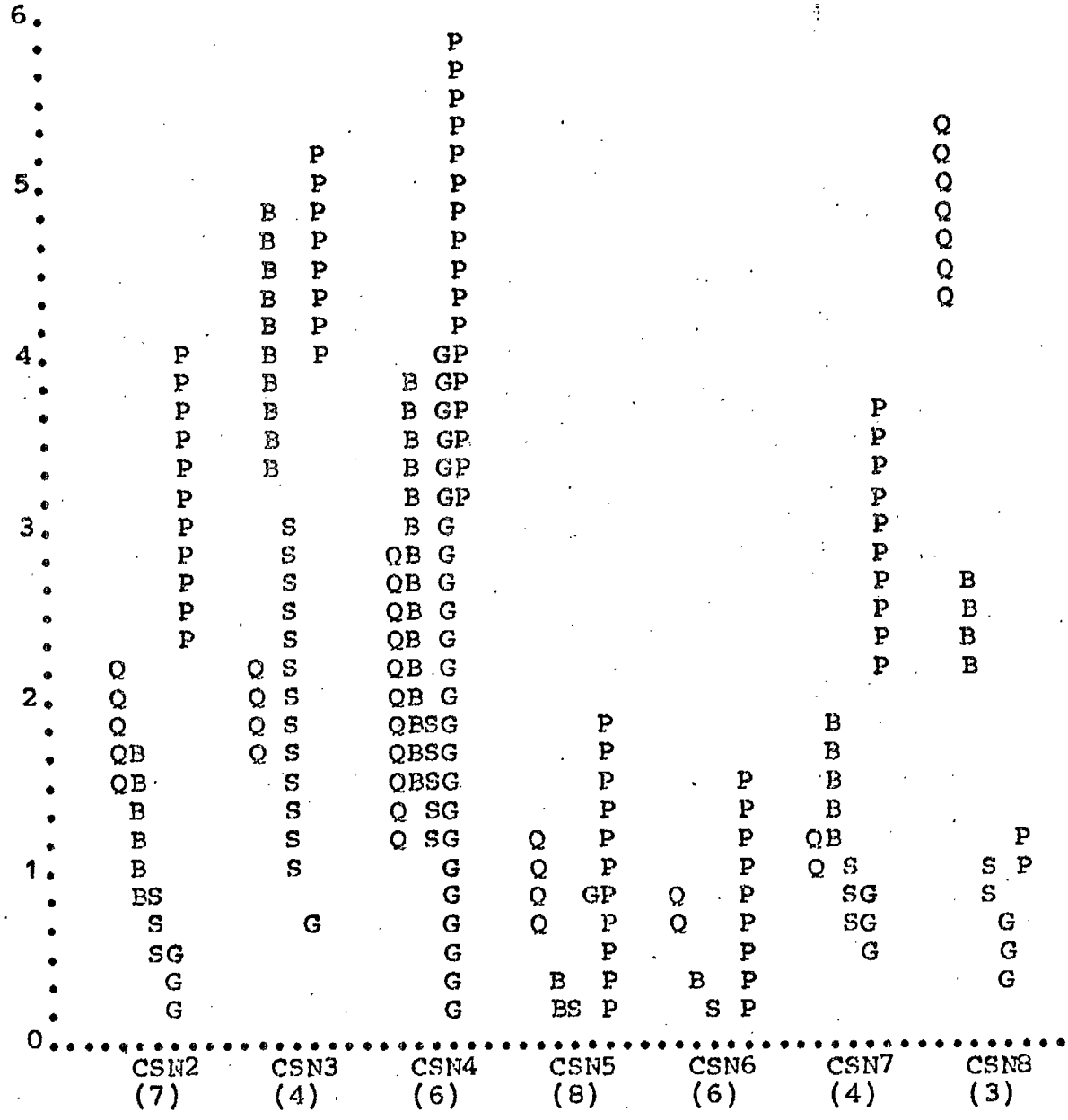
PARAMETER	MEAN	STD DEV	MINIMUM	MAXIMUM
PRODUCTION TON/HR	2.90	0.782	2.04	3.79
PROCESS TIME HR/DAY	7.38	--	7.00	8.00
FLOW L/SEC	7.70	1.56	5.96	9.55
(GAL/MIN)	122	24.8	94.6	152
FLOW RATIO L/KKG	10600	1040	9300	11800
(GAL/TON)	2550	250	2230	2840
SETT. SOLIDS ML/L	15.6	10.4	9.02	27.5
RATIO L/KKG	166	111	96.0	293
SCR. SOLIDS MG/L	451	143	265	603
RATIO KG/KKG	4.80	1.52	2.82	6.42
SUSP. SOLIDS MG/L	1340	163	1150	1540
RATIO KG/KKG	14.2	1.73	12.2	16.4
5 DAY BOD MG/L	2430	440	2080	3030
RATIO KG/KKG	25.9	4.68	22.2	32.3
COD MG/L	5060	600	4320	5760
RATIO KG/KKG	53.9	6.39	45.9	61.3
GREASE & OIL MG/L	537	83.4	472	657
RATIO KG/KKG	5.71	0.887	5.02	6.99
ORGANIC-N MG/L	270	67.6	183	348
RATIO KG/KKG	2.87	0.719	1.95	3.70
AMMONIA-N MG/L	4.91	0.810	3.99	5.50
RATIO KG/KKG	0.052	0.009	0.042	0.059
PH	6.59	0.178	6.43	6.93
TEMP DEG C	14.3	--	--	--

PLANT CSN7
4 SAMPLES

A plant code (CSN7 for this example), which designates the type of process and the name of the plant, and the number of daily composite samples taken, is shown in the lower right corner. The ratio of the load of each parameter to the unit of production can be converted from kg/kkg to lbs/ton by multiplying the former by a factor of two. The consistent use of three significant figures for all the data does not imply that this accuracy is achievable for all of the parameters.

A second program plots the mean plus and minus the standard deviation for five selected parameters for each of several processes. This allows the data from several processes to be visually integrated to help determine if they are similar enough to include in one subcategory. Figure 1 shows an example of the output from this program. The codes for each of the plants represented and the number of samples taken at each one are shown on the horizontal axis below their respective characterization data. The five parameters shown are the flow, BOD, suspended solids and grease and oil ratios and the production rate. The vertical scale is in inches with the scaling factor given at the bottom for each parameter. This plot allows the relative values of the plant parameters to be easily compared. For example, the flow ratios (liters/kkg of raw product) represented by Q are similar for each of the plants except for plant CSN8, which is over twice the value of the other plants. The wider the vertical spread of a parameter, the greater the standard deviation. The mean of each parameter is at the center of the vertical spread.

Figure 1. Typical Multiple Plant Characterization



SYMBOL	PARAMETER	SCALING FACTOR
Q	FLOW	1 INCH = 10000 L/KKG
B	5 DAY BOD	1 INCH = 20 KG/KKG
S	SUSPENDED SOLIDS	1 INCH = 20 KG/KKG
G	GREASE & OIL	1 INCH = 10 KG/KKG
P	PRODUCTION	1 INCH = 1 TON/HR

It is also easy to see that two plants on the left (CSN3 and CSN4) have greater waste loads, especially in terms of BOD and suspended solids. This is very helpful for determining how the industry should be subcategorized.

Once a decision has been made on subcategorization, the data from selected processes is used by another program to determine estimates of spatial averages (average of the plant means), standard deviations, and minimum and maximums for each parameter. Table 6 shows an example of the output from this program.

The plants used to determine the spatial average are indicated by the code list at the bottom. The table is similar in form to the one used to present the temporal averages for the individual plants. One difference is that 5% minimums and 95% maximums are presented instead of the observed minimum and maximum. Because the width of the observed range tends to increase as the number of samples taken increases, the probability that the observed minimum and maximum is exceeded could be quite different between groups of different numbers of plants. This problem was obviated by assuming that the probability distributions of each parameter value for several plants can be approximated adequately by a log-normal model. The minimum and maximum value of each parameter which would be exceeded by 5% of the plants are then computed using the observed spatial variance.

TABLE 6 TYPICAL MULTIPLE PLANT SUMMARY TABLE

PARAMETER	MEAN	STD DEV	5% MIN	95% MAX
PRODUCTION TON/HR	1.43	0.986	0.349	4.00
PROCESS TIME HR/DAY	6.22	0.892	5.20	7.38
FLOW L/SEC	7.90	4.16	2.66	18.4
(GAL/MIN)	125	66.0	42.0	292
FLOW RATIO L/KKG	21900	19700	3600	73500
(GAL/TON)	5240	2760	1760	12200
SETT. SOLIDS ML/L	9.07	12.1	0.745	39.6
RATIO L/KKG	198	266	16.3	865
SCR. SOLIDS MG/L	1100	1100	153	3990
RATIO KG/KKG	24.1	24.1	3.34	87.2
SUSP. SOLIDS MG/L	471	375	93.3	1460
RATIO KG/KKG	10.3	8.20	2.04	31.8
5 DAY BOD MG/L	1020	971	155	3570
RATIO KG/KKG	22.4	21.2	3.39	78.1
COD MG/L	2030	1850	327	6890
RATIO KG/KKG	44.4	40.5	7.15	151
GREASE & OIL MG/L	299	179	86.5	760
RATIO KG/KKG	6.54	3.92	1.89	16.6
ORGANIC-N MG/L	146	138	22.0	509
RATIO KG/KKG	3.19	3.03	0.480	11.1
AMMONIA-N MG/L	3.11	3.33	0.383	11.8
RATIO KG/KKG	0.068	0.073	0.008	0.258
PH	6.74	0.229	6.51	6.98
TEMP DEG C	14.7	0.912	13.7	15.6

PLANTS CSN5, CSN6, CSN7, CSN8

Summary

Significant progress has been made during the last year toward characterizing wastewater effluents from the U.S. seafood processing industry. Almost 1900 samples from 115 individual processing operations representing all significant segments of the seafood industry were taken and analyzed. About one-third of this information has been published and used to develop guidelines for that part of the industry, and the remainder will be published shortly.

Although this study required a relatively large expenditure of time and money, it can be justified by the fact that more realistic and equitable guidelines will be promulgated.

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Guidelines for Control of Effluents from Fish Processing Plants - a detailed discussion

by

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GUIDELINES FOR CONTROL OF EFFLUENTS FROM FISH PROCESSING PLANTS

The purpose of these effluent control guidelines is to provide the basis for reviewing and approving plans for effluent control from new fish processing plants, or alteration or extension of existing fish processing plants as outlined under Section 33.1 of the Fisheries Act. In addition, they also provide a basis for determining the requirements of existing fish processing plants to meet a desired level of effluent control.

1. Plant Effluents

For the purpose of these guidelines four types of effluents are considered:

(a) Contaminated process water is defined as all water which has been in contact with the raw fish, processed fish, or offal, or which is listed as contaminated process water in Appendix A. Contaminated process water includes, but is not limited to, flume water, plant wastewater, pumpout water, and water used in canning processes (retort and can washing).

(b) Clean process water is defined as water which has not been in contact with fish or which is not included in the list in Appendix A. Clean process water includes, but is not limited to, cooling water and boiler blowdown.

(c) Storm water is the flow from drains used solely for the purpose of carrying storm and/or drainage water.

(d) Domestic sewage is the wastewater which originates from toilets and other sanitary facilities.

2. Treatment of Plant Effluents

Plant sewer and drainage systems should be designed in such a way that contaminated and clean process water, storm water and domestic sewage are segregated for treatment as required in these guidelines.

(a) Contaminated Process Water

All contaminated process water must be treated for solids removal. The solids removal facilities should produce an effluent similar in quality to that produced by 25 mesh screening of contaminated wastewater. A 25 mesh screen has openings of 0.71mm (0.0280 inches).

Solids removal from the effluent should be taken to a fish meal plant, if available, or disposed of in a manner approved by the relevant regulatory agency.

Approval for new plants, alterations or extensions of existing facilities will not be given unless solids removal facilities, as specified above, are included in the plant design for installation when the plant is constructed.

(b) Clean process water may be discharged directly to the receiving water after it has been certified as clean process water by the relevant regulatory agency.

(c) Storm water flows may be discharged directly to the receiving water. The relevant regulatory agency must approve the storm water handling system.

(d) Domestic Sewage should be treated and disposed of in a manner satisfactory to the relevant regulatory agency.

3. Sampling and Metering

The sewer and drainage system should be designed to permit sampling of the effluent at each outfall. Where a single outfall discharges effluent from more than one of the major fish processing operations given in Appendix A, facilities should be available to allow for the sampling of waste streams from individual operations.

Water flows into or wastewater flows from the plant should be metered continuously.

4. Outfalls

All outfall locations should have the approval of the appropriate regulatory agencies. Outfalls should be located in such a manner as to be submerged at low tide and so as not to affect water supplies and inshore waters.

5. Offal Disposal and Fish Meal Plants

Plants should either have on-site reduction facilities for offal, whole fish and screenings or arrange for reduction at an off-site meal plant. In the case of off-site reduction, the storage and transportation facilities should be of adequate size to contain all bloodwater. As an alternative to reduction, the disposal of offal and screenings for use as pet or mink food is acceptable.

The discharge of stickwater and bloodwater to the receiving water is not permissible. Where stickwater and bloodwater are recovered, sufficient tankage (up to a minimum of 1 days production) should be provided to store these liquors in the event of equipment breakdown or shutdown. If shutdown time of the recovery equipment exceeds the storage capacity, resulting in a possible discharge of stickwater and bloodwater to the receiving water, it will be necessary to shutdown the complete reduction plant until such time as the recovery equipment is operating satisfactorily or other provision is made to handle the stickwater and bloodwater. In addition, stickwater and bloodwater storage facilities shall include acidification facilities to allow the pH of the contents to be lowered to 4.5 to permit satisfactory storage.

Condenser and scrubber water are the only effluents from a fish meal plant suitable for direct discharge to the receiving water.

6. General Requirements

(a) Consequent to the satisfactory sanitary quality of the product, the plant should be designed to minimize water usage.

(b) Plants should have space or land available to allow for expansion of the waste treatment facilities to include more advanced treatment systems when and where required.

(c) If discharge of treated wastewaters leads to a deterioration of the receiving water quality affecting other water uses then the fish plant concerned may be required to install more advanced treatment than that specified above.

All new fish processing plants are required to submit plans for effluent control measures to be installed to comply with these guidelines. Existing plants shall submit plans for their complete effluent control systems where alterations or extensions are planned in their processing facilities. These plans should be submitted to the Regional Director, Environmental Protection Service, Canada Department of Environment (see Appendix B for addresses and telephone numbers of each Regional Office). These plans should include the following:

1. A map showing the location of the plant and all outfalls in relation to existing facilities and natural features.

2. Layout of the plant showing the location of drains and sewers.
3. Proposed effluent treatment system including its location and size.
4. Proposed plant capacity and anticipated water usage.
5. Sources of contaminated and clean process water.

These plans will be carefully reviewed, and if necessary, additional appropriate measures taken to ensure that proposed new plants, alterations or expansions of existing facilities, will not cause environmental damage. Individual schedules of compliance will be negotiated for each existing fish processing plant by the Environmental Protection Service and/or the provincial regulatory control agency.

APPENDIX A

The principal contaminated wastewater flows associated with the major fish processing techniques are listed below:

A. GROUNDFISH FILLETING

1. Water from unloading, receiving and storage facilities.
2. Transportation of raw product to processing area.
3. Descaler wastes (usually for red fish processing only).
4. Fish wash water.
5. Water used during the filleting, skinning, trimming and candling processes.
6. Offal flume water.
7. Clean-up and washdown water.

B. FRESH WATER FISH FILLETING OPERATIONS

The wastewater flows associated with fresh water fish filleting operations are similar to those produced during groundfish filleting.

C. HERRING PROCESSING

a. Filleting

The wastewater flows associated with herring filleting operations are similar to those outlined for groundfish filleting.

b. Roe Recovery

1. Water utilized in the unloading and storage processes.
2. Sodium chloride solution utilized during storage.

3. Raw product fluming water (a mixture of brine and fresh water).
4. Water used during the processing of the herring.
5. Water used to wash and convey the roe.
6. Offal flume water.
7. Clean up and wash down waste.

c. Marinating and Pickling

1. Water from unloading, receiving and storage facilities.
2. Raw product flume water.
3. Water used during the processing (evisceration).
4. Offal flume water.
5. Brine and acetic acid.
6. Water used during skinning process.
7. Clean up and wash down water.

D. SARDINE CANNING

1. Water used in unloading, receiving and storage (the juvenile herring are usually stored in brine).
2. Raw product flume water (mixture of brine and freshwater).
3. Water used during processing.
4. Oily wastes associated with pre-cooking.
5. Wash water associated with saucing and sealing the cans.
6. Cooling water associated with can sterilization.
7. Caustic wastes associated with can cleaning.
8. Can rinse water.

9. Clean up and wash down water.
10. Offal flume water.

E. SALMON CANNING

1. Water used in unloading, receiving and storage.
2. Raw product flume water.
3. Water used during the evisceration and beheading process.
4. Fish wash waste.
5. Offal flume water.
6. Retort waste water and can cooling water.
7. Clean up and wash down water.

F. LOBSTER PROCESSING

1. Water used in storage.
2. Water used in butchering.
3. Shell flume water.
4. Process flume water (before and after cooking).
5. Brine solution.
6. Wastes from the cooker.
7. Clean up and wash down water.

G. FISH MEAL OPERATION

1. Water used in unloading, receiving and storage.
2. Offal or whole fish flume water.
3. Press liquor.

4. Stickliquor.
5. Bloodwater.
6. Clean up and wash down water.

APPENDIX B

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ECONOMIC CONSIDERATIONS IN THE DESIGN OF POLLUTION ABATEMENT REGULATIONS FOR THE FISH PROCESSING INDUSTRY

by C. NEWTON
CHIEF ECONOMIST
PACIFIC REGION
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ENVIRONMENT CANADA
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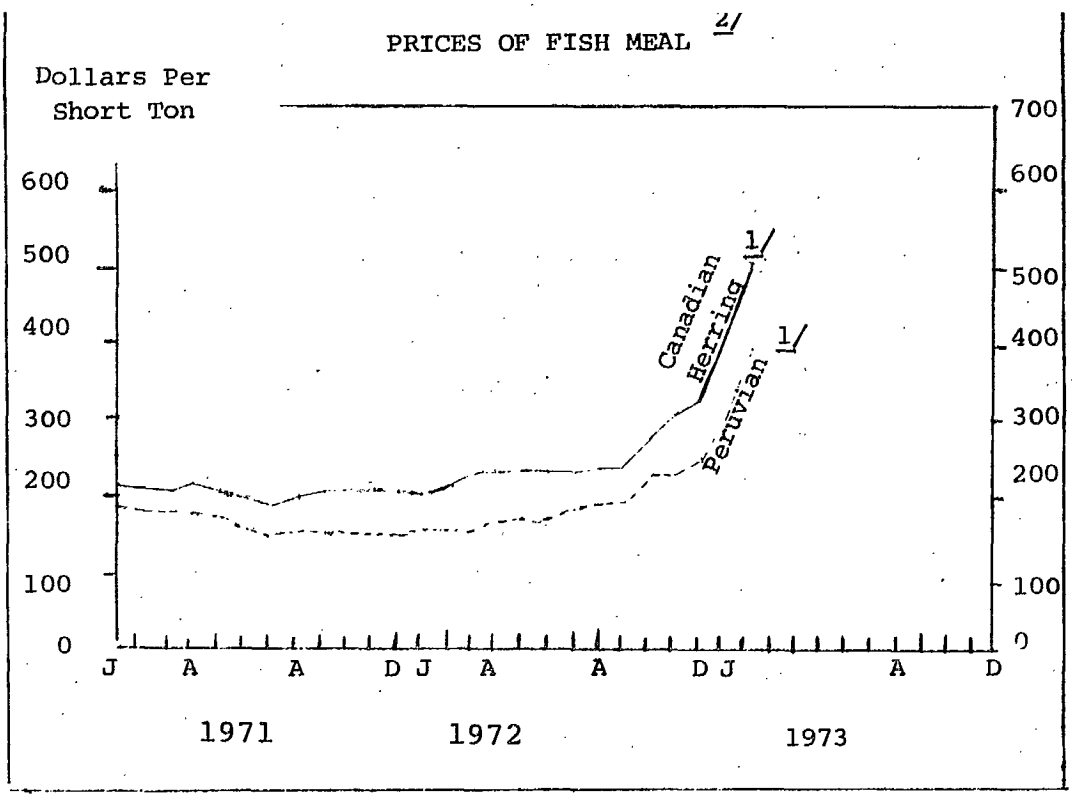
The national objective for the initial phase of imposing pollution abatement regulations on industries is the adoption of the principle of "best practical technology." In many industries this objective requires the implementation of a collection system for the waste products of an industrial process to an area where a treatment can be applied. Present and expected future technology is understood to be directed toward treatment, rather than changes in processes. Treatment techniques are directed to the recovery of wastes from the dilution medium, and on possible methods of converting the waste product into a marketable commodity in order to offset the full or partial cost of the pollution abatement equipment. But, if regulations are effective, the final adjustment by firms in an industry will be to find the optimum between the use of the diluting medium against the cost of recovery, an adjustment that will inevitably involve changes in the industrial process.

For the fish processing industry, the imposition of 'best practical technology', will require: (a) the diversion of wastes to a treatment area, (b) the application of 'best treatment technology' to recover the wastes, and (c) provide the incentive for converting these wastes to a profitable commodity. In most instances, recovered fish wastes will be directed to the fish reduction process for the manufacture of fish meal.

Reduction equipment, however, is an expensive capital item and is usually found only in large production fish processing companies. For these plants, the increment in cost for processing fish wastes into fish meal is marginal and the returns, with today's prices, are healthy. The current high price of meal is the result of the decline in the Peruvian anchovy fishery and to some degree the decline in Canadian herring stocks. Unless the demand for fish meal is satisfied by a substitute product, the return of the Peruvian anchovy should cause fish meal prices to fall. In this interim period, high meal prices have resulted in the construction of some reduction plants in British Columbia, based on the processing of waste products alone.



1/ Exports banned by both Governments.

2/ Prices of fish meal - Seattle

The profitability of reduction, however, is dependent on the cost of the reduction process, the cost of collecting wastes and prices for fish meal.

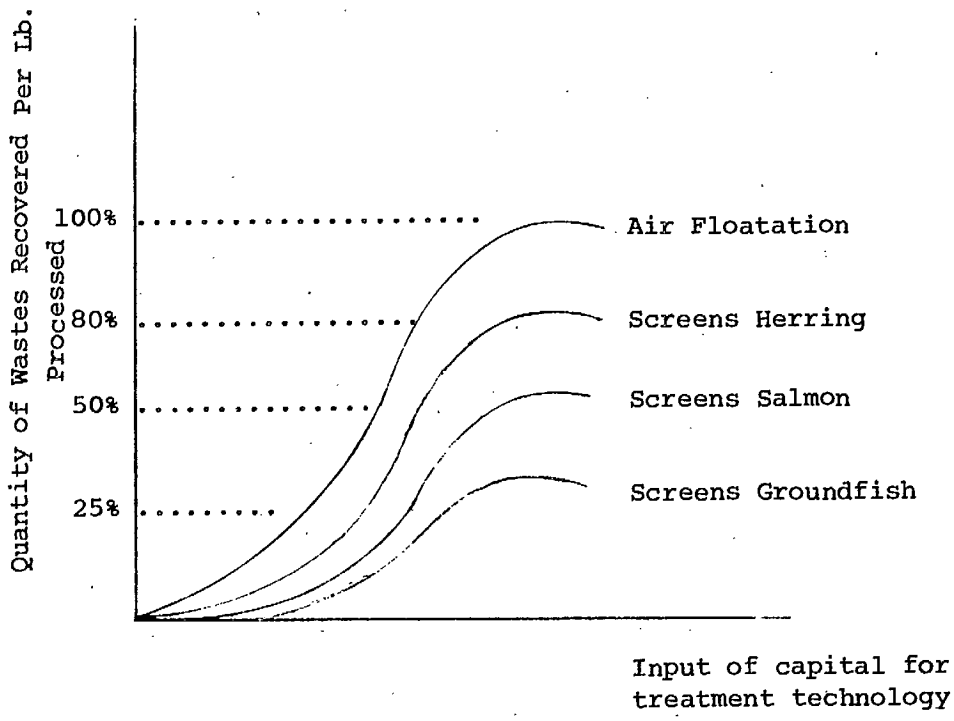
At issue, in terms of pollution abatement regulations, is the cost of collecting wastes. The initial cost imposed on firms in the fish processing industry will be the diversion of wastes to a collection area for treatment. Treatment costs for separating wastes from the diluting medium, for the most part water in this industry, should be perfectly divisible in order to be equitable to all firms in the industry. Perfectly divisible treatment costs mean that costs are directly related to the volume of wastes produced. At this time, it appears that only screening technology is perfectly divisible, and equitable to all firms in the industry, in that costs are proportionate to volume. If all firms in the fish processing industry are required to install fine screening for separating wastes, the only disparity that remains in terms of equity, is the return to the firm from processing the recovered wastes.

Firms have the choice of processing wastes through reduction and earning a return, or disposing of wastes at a cost to themselves. For some firms, the small processors in terms of volume, the reduction option is not feasible since the volume of wastes generated is too small. The burden of pollution abatement regulations that would require screening, would therefore fall on small processors. To some extent, small fish processors that are not situated in

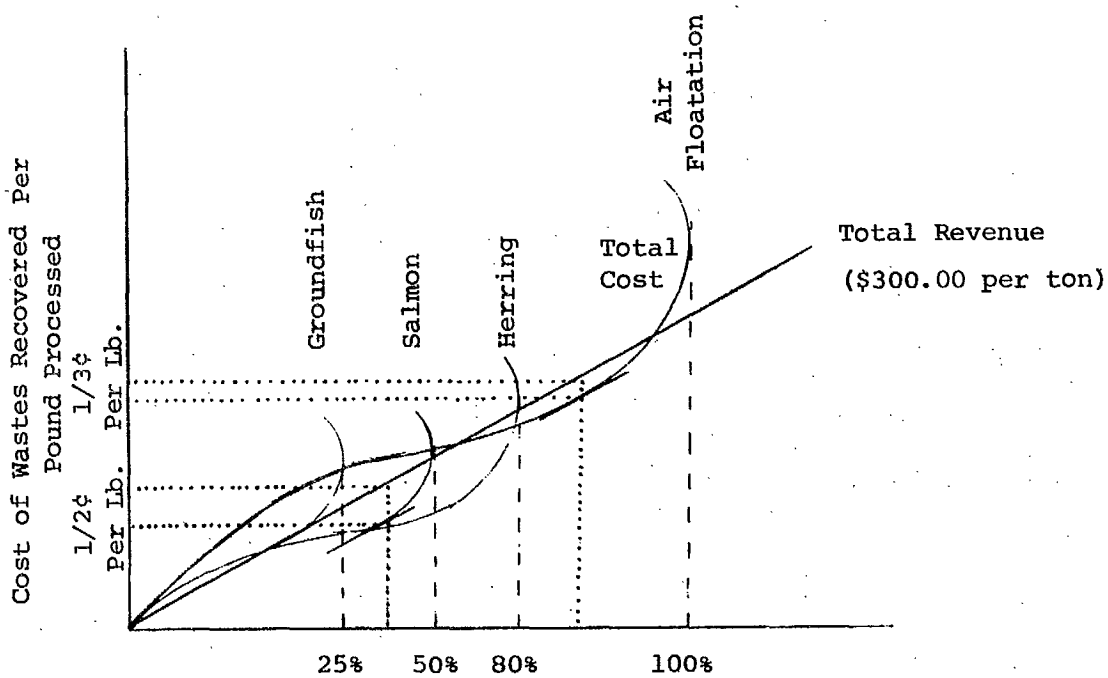
isolated areas could collectively generate enough fish wastes to rationalize a co-operative reduction plant. The burden then would rest on small processors in isolated areas.

Alternatively, in order to prevent changes in the status quo in the industry as a result of pollution abatement regulations, the burden on small processors from screening requirements may be offset by imposing more stringent regulations on those firms earning the highest revenue from their recovered wastes. Large volume processors would therefore require a more stringent regulation than the fine screening requirement, the increased costs resulting from further regulations would diminish the returns from processing fish meal from wastes.

Air floatation cells, a technique for improving water quality beyond the quality achieved from screens, recovers wastes that have passed through screens.



In the diagram above, the production function for recovered wastes is given for screening and air floatation cells and the effectiveness of screening, by species processed, is demonstrated in relation to air floatation. Converting the function into a cost/quantity relationship gives:



Source: F. G. Claggett and J. Wong - Treatment of Fish Processing Plant Wastewater. Fisheries Research Board of Canada, Ottawa 1973, Pages 44, 45.

Since screening ranges from 25 percent to 80 percent effectiveness in the removal of suspended solids depending on species processed, returns to wastes processed for fish meal will be maximized where the slopes of the total revenue curve are equal. In the diagram above, returns to screening are

maximized at 1/2 cents per pound for salmon; and for screening combined with floatation at 1/3 cents per pound. These figures are based on a production level of 10 million pounds of salmon and 10,000 tons of herring per year, at a price for fish meal at $300.00 per ton. 1/

It is therefore hypothesised that fish processing plants, can, with present prices of fish meal, earn a return from waste recovery if reduction processing equipment is part of the plant. Those plants that can generate enough wastes will also be able to earn a return if they are prepared to invest in reduction equipment. Plants without the production levels necessary to justify reduction, will have to consider their recovery as full costs.

C.H.B. Newton

January 15, 1974.

1/ F.G. Claggett and J. Wong - Treatment of Fish Processing Plant Wastewater - Fisheries Research Board of Canada, Ottawa 1973.

FISH MEAL PRICES

1971	Canadian Herring	Peruvian Anchovy
	$ Per Ton	$ Per Ton
January	214	184.10
February	211	178.90
March	211	177.30
April	218	177.00
May	211	169.40
June	200	156.80
July	192	154.50
August	207	160.10
September	203	159.00
October	207	157.80
November	---	157.50
December	211	158.40
1972		
January	210	163.30
February	218	163.60
March	229	164.00
April	232	171.50
May	236	180.60
June	236	176.10
July	236	180.90
August	242	192.00
September	242	194.90
October	283	210.80
November	308	231.00
December	315	241.00

FISH MEAL PRICES (CONTINUED)

1973	Canadian Herring	Peruvian Anchovy
	$ Per Ton	$ Per Ton (1)
January	384	347.25
February	507	406.25
March		411.90
April		405.00
May		480.00
June		
July		
August		
September		
October		
November		800.00*
December		

(1) Nominal Price.

* Recent newspaper quote November 13, 1973.

BRITISH COLUMBIA VIEW OF E.P.S. GUIDELINES

by

G.F. BOOTHBY

RESEARCH MANAGER
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INDUSTRY VIEW OF THE E.P.S. GUIDELINES

The industry shares the Government's concern about river, stream and marine pollution and is on record to this effect. Our association as an important segment of the fishing industry is concerned about three areas:

1. Discharge of toxic substances entering our waters.
2. Discharge of substances which will lower the dissolved oxygen level below the recognized safe level.
3. Discharge of waste water which will significantly affect the aesthetic quality or general characteristics of the receiving waters.

Fish processing operations in British Columbia of any significant size have, for many years now, utilized the non-edible portions of the fish and converted them into by-products, either through reduction plants, producing fish meal and oil, or other by-products for pet foods, fur bearing animals and fish feeds. This action has substantially reduced the incidence of solid wastes entering the waters. In addition, evaporator plants have been installed in connection with some of these reduction operations to further utilize the suspended and dissolved solids in the process waters known as stickwater. Stickwater is the process

water resulting from centrifuging the press water obtained from the cooking and pressing operations. However, there is a body of scientific thinking which questions whether these solids are in fact adversely affecting the environment or rather whether they are not serving as nutrients for marine life. I will refer to this again later.

In 1967 we entered into a joint study with the Fisheries Research Board, Technological Station, in Vancouver to undertake a characterization and treatment study of cannery and fresh fish process wastes.

This programme began on a pilot plant scale to learn, in general, more about the characteristics of this process water but more specifically to study the effects of various chemical treatments and equipment on the suspended solids and Biological Oxygen Demand (BOD_5). It assessed the effectiveness of different types of fine screens for solids removal followed by the evaluation of different types of flotation cells. This programme was then expanded from these pilot plant studies to the operation of a full scale 650 imperial gallon per minute treatment facility consisting of fine screens and a flotation cell. Another study of biological treatment was undertaken to learn something of its potential.

Studies undertaken on some of these latter pieces of equipment, namely the flotation cell and biodisc biological treatment were undertaken to determine the capability of current equipment and technology rather than to determine biologically whether these treatments were necessary for the protection of marine life in our waters.

Now to speak more specifically of the guidelines of EPS as presently formulated. We are inclined to agree that there may be justification for the installation of fine screens to remove suspended solids using a 25-mesh screen, for certain processing operations in order to ensure that the dissolved oxygen (DO) in the receiving waters is not significantly lowered. We say this although only in one instance in our studies were we able to detect even the slightest depression of the dissolved oxygen level in the receiving waters adjacent to our plants. Even in this situation the residual dissolved oxygen level vastly exceeded the recognized safe level of DO established for marine life.

We in the industry have agreed to install proven screening equipment where it is deemed desirable for the removal of suspended solids so as not to depress the DO significantly. We furthermore have agreed that this effluent should be discharged by a submerged pipe to prevent so far as possible any adverse aesthetic effect on the surface of the water.

However, we are very much opposed to undertaking further treatments just for the reason that there is equipment and the technology available, until it has been demonstrated that these treatments are necessary for the protection of marine life in our waters or that the general characteristics of the receiving waters are being significantly altered. We say this for a number of reasons:

1. It may be quite possible that by removing solids still further from the process effluent that we in fact may be harming the aquatic ecology by reducing the availability of these nutrients for marine life. In this regard I will refer you to "A Study of the Waste Characteristics of Fish Processing Plants" by Dr. K.T. Brodersen for the Water Pollution Control Directorate, Environmental Protection Service, in which he states, and I quote:
"However, the use of the waste characteristics determined by this study as a sole criteria on which to base the effects of fish processing wastes on the receiving waters may be the wrong approach to the problem, in that additional field data may have to be considered. The value of additional data is exemplified by the field observation that, at almost every discharge of fish processing plant effluent, the receiving waters abound with fish. Fish of various

species can be seen teeming around the effluent discharges seemingly thriving on the waste being discharged.

Consequently, the discharge of these wastes may be contributing to the productivity of the fish species."

At the time of this study Dr. Brodersen was a member of the Department of Civil Engineering, University of Ottawa. Another research biologist, Dr. R.E. Nakatani, of the Fisheries Research Institute, University of Washington, made a study entitled, "The Effects of Salmon Cannery Waste on Water Quality and Marine Organisms at Petersburg, Alaska 1971". He states in his report and again I quote, "The preliminary investigation indicated no serious or significant detrimental effect on the ecology of aquatic organisms but the wastes caused some small depressions of dissolved oxygen at the surface and bottom in highly localized small areas near the point of discharge." I might add for clarification in this Alaskan study that the total non-edible portion of the fish was being discharged -- which is vastly different from our situation.

Let us look at another situation. We are all aware of the relatively new field of fish farming or aquaculture. Here marine areas or bays are equipped with net enclosures in which commercially desirable fish, including salmon, are grown. They are

fed by spreading pellets of compounded fish meal and other ingredients onto the water. The irony of this is that processing plants are being required to install expensive equipment to remove fish solids from the water effluent then further process these same solids only to take them a few miles away to spread them on the water again to feed fish farming programmes. Does this make any sense - least of all any economic sense?

Let us look at still another situation. One may well ask who assumes the responsibility for the tons of fish solids deposited in our spawning streams and lakes each year when salmon return to spawn and die. Such solids are an essential part of the natural cycle of the great salmon runs of the world.

However, having expressed these views, we want to make it abundantly clear that we are prepared to employ procedures and equipment that have been demonstrated necessary for the protection of the ecology of our waters.

Fine screens, where they have been deemed desirable and submerged outfalls will have been installed in most of our fish processing plants by mid-1974. It is therefore our firm view that no further treatment equipment should be required until studies have been undertaken by EPS to determine factually whether fish in our waters are or are not being affected by the natural dispersement of these nutrient containing effluents or that these discharges are significantly affecting the aesthetic or general characteristics

of the receiving waters. I am confident that EPS would find our industry cooperative in such studies.

We cannot escape the reality that all costs for these treatments must be reflected in higher costs to the consumer for our products. Therefore, further capital expenditures for process water treatment beyond that of fine screening must be able to be justified on the basis that it is necessary to protect our marine life or prevent significantly altering the receiving waters. To do otherwise would be wasteful and irresponsible.

PRESENTED AT THE EPS SEMINAR
January 15, 1974 on behalf of the
members of the Fisheries Association of British Columbia

INDUSTRY VIEW OF GUIDELINES

by

BEN SMITH

CHIEF ENGINEER

HIGH LINER DIVISION

NATIONAL SEA PRODUCTS

As a Director of the Fisheries Association of Newfoundland and Labrador, I have been assigned to comment on the set of Guidelines relating to liquid effluents from fish, shell fish and meal processing plants. The comments which I make to you are based on the consensus opinions of all the processors in the Province. They represent what we feel is a valid, sane assessment of these Guidelines arrived at after months of study and mutual consultation.

I can assure you the industry in Newfoundland are not taking a negative approach to these Guidelines. The Association has had several meetings in which we have convinced all members that a positive approach is essential. You will undoubtedly become aware from the comments we make that we are awake to the fact that the spirit in which the Guidelines were drawn up is most important, as well as the essentiallity that the Guidelines be written and interpreted as a means to an end - and not an end to themselves.

As Newfoundlanders, living in Newfoundland in most instances; in the environment which exists immediately adjacent to our processing plants; and raising our children in this environment; we feel that while the concern of the Environmental Protection Service is sincere - yet it is professional. With us, it is a personal concern and we will make every effort to cooperate with the effective implementation of those Guidelines which will effectively assist in controlling, preserving and protecting the environment.

We were informed that the Guidelines as presented to us on April 4, 1974 are final Guidelines. We find this particularly embarrassing and unfortunate; as in many instances they do not seem to take into consideration practical situations now in existance in Newfoundland. Certainly they do not in many instances reflect the viewpoint or suggestions made by industry in the past.

I submit to you that on February 22, 1972 a letter bearing the signature of Mr. K.C. Lucas, was sent to Mr. Gordon O'Brien and circulorized by him to the fish trade with a request for action, comments and cooperation.

Let me quote from Mr. Lucas' letter:

Paragraph 2: "a set of interim guidelines which are being used by our Regional Offices to determine the necessary pollution control equipment to be installed in new plants"

Paragraph 3: "It is our intention to actively consult with the industry and provincial water pollution control agencies prior to finalizing our guidelines".

On April 25, 1972 a letter containing eight (8) paragraphs, over two typewritten pages in length commenting and suggesting recommendations on the broad outline of water effluent control; as well as thirteen (13) paragraphs dealing item by item with guidelines was sent to Mr. Lucas.

What has happened since the exchange of these letter in 1972, which indicated that for once Newfoundlanders were to have some input into the rules and regulations and which they were to live and operate - and the arbitrary - 'fait accompli' - presentation of final guidelines on April 4th, 1974.

It is necessary at this time to inform you that the Guidelines as presented as final are unacceptable both as to their practicality and also in the sociological sense, in the manner of their presentation. The days of arbitrary, take it or leave it, regulations whether of industrial or sociological nature are no longer acceptable by any Newfoundlander and this need for common sense examination is general and not confined to members of the fish processing industry alone. We want to protect our environment, but we want to do it with guidelines set up in partnership between ourselves and the various regulatory bodies. This type of serious discussion is the only possible way to arrive at practical guidelines which will achieve the results we all desire.

Further, it may be appropriate while speaking in general terms terms to express to you our fears, however unpalatable to you these fears may be about possible pressure methods of implementation of Guidelines.

We are all aware of the inter-relationship between DREE funds and the Environmental Protection Service. No portion of DREE

funds allocated to the fishing industry in Newfoundland can be forthcoming until a letter signed by the Regional Director of Environmental Protection Service indicates all pollution requirements have been met. This may be a valid requirement when confined to the particular project for which the DREE GRANT is made. However, as the regulation is written it would not be possible to build a new ice plant, a new crab plant, or modernize a portion of existing facilities without subjecting the entire operation old, new or modernized to the requirements of the Guidelines. Unless clarification of this point is made and a policy set up as to where and how Guidelines must be met it may be necessary for existing processors to allow their premises to deteriorate and not enter into contracts with DREE unless totally new and separate facilities are contemplated.

Would it not be fairer and more practical to set up a clear cut division of the application of the Guidelines in such cases; with policy and directives issued to the personnel of the Department which would prevent the too enthusiastic overlapping of application of Guidelines. This clarification is a must if sensible, economic upgrading of the majority of present plants is to be achieved.

Guidelines, <u>for new plants only</u>, were originally submitted to industry for comment with the statement that both industry and the

provincial authorities would be actively consulted before finalizing these Guidelines. However, the comments made by industry concerning the original Guidelines appear to have either not reached their author or appear to have been disregarded. Also, additional Guidelines and definitions, which are of major consequence, have been added to the preliminary Guidelines and these change the assumed meaning of the original Guidelines and would change the comments from industry. For example, a definition of what flows would have to be screened, which would be completely unacceptable to industry, has been added; and definition and treatment of bloodwater which do not appear practical have been added; and the Guidelines are now defined as a basis for determining the requirements for existing fish processing plants, as well as new plants with no clear concept of how the regulations would apply to the expansion of existing plants. It is regrettable that federal thinking on this subject has developed so far without continuous inputs from the industry. However, this seminar may do much to offset previous deficiencies and hopefully provide the first substantial dialogue between the interested parties.

At this time, we would like to acknowledge that there are serious pollution problems throughout our entire country and some of these problems directly affect our fisheries. In particular, the contamination of rivers, streams and enclosed harbours and in certain cases the pollution of the ocean itself has had an adverse effect on

fisheries. Therefore, the fishing industry has an interest in seeing that the pollution of our water resources does not increase and in the long term we look for the reduction or elimination of certain undesirable pollutants which flow into the rivers, lakes and oceans of the world.

We feel that Governments, being the regulatory agencies, have to take the responsibility of seeing that a logical priority is established in tackling pollution problems so that the serious pollutants and the areas where the environment is affected the most are tackled first. It does not make sense to us to force the spending of relatively large sums of capital to eliminate non-harmful waste just because a government body has a lot of power in a certain instance, while allowing harmful pollutants to continue to be released in another instance because it is not politically expedient to correct the situation. Also, it does not make sense to us to see a set of Guidelines drawn up which treat some effluents as contaminants when obviously they would not be so listed if considered as individual items. In other words, where the effluent being discharged is non-harmful, and realizing the amount of money that can be spent on pollution control in Canada each year is limited, we do not agree that companies should be forced to spend large amounts of money to achieve little in the way of practical improvements, for an uneconomic return. This point should be borne in mind then examining any proposed Guidelines and their period of implementation.

When we look at the fishing industry, we look at an industry which cannot be classed as one generating harmful or serious effluents such as the pulp and paper industry, the steel industry, the chemical industry, etc. The effluent from a fish processing plant does contain particles of fish and liquids from the fish but these substances are natural to the environment and only cause problems if the volume is too great for the receiving waters. Much of the material is consumed by other living matter within a short distance from the plant. In very many cases if one were say 50 yards from an outfall and could not see the fish plant there would be no way of knowing that one existed nearly, and these are plants without all the sophisticated equipment mentioned in the Guidelines.

Also, we must realize that the problems caused by effluent from fish plants is in general a diminishing problem due to influence of other than Government regulations. For one thing, more of the fish being caught comes from offshore boats than it did say 25 years ago.

Also, the per cent of offal being used for fish meal or mink food is increasing due to its higher value. Less and less is allowed to go directly to the harbour or to a nearby field although if Guidelines such as those proposed or other regulations force small fish meal operations out of business there might be no alternative but to put the offal into the sea. Furthermore, the newer plants incorporate better equipment to handle offal and better fish meal

equipment for economic reasons as well as effluent control reasons.

We feel that Guidelines, such as those proposed, have to give serious consideration to where the effluent is going and provision has to be made to judge each case on its own merits. We, in the fishing industry, know only too well that some people, put in a position to administer similar regulations, will treat the written work as a bible, apply their own interpretation and forget about common sense. If these Guidelines are implemented, industry could be forced to spend huge sums of money in some places with no practical results whatsoever. Treatment which might be necessary for a plant on the side of a lake or small river may be quite unnecessary for a tidal estuary and likewise what may be necessary in an estuary may be unnecessary where the outfall is to a sea of ocean. The Guidelines allow for more advanced treatment where required. It is our opinion that the standard requirements or Guidelines should be very carefully written to cover only those flows which are a necessity to treat in all new plants and then if there are instances where the discharge of wastewaters leads to a deterioration of the receiving water quality affecting other water uses then the fish plant concerned may be required to install more treatment equipment.

Lastly, we would like to point out that the fishing industry is not highly sophisticated like, for instance, the oil refining business. Also, the solutions, proposed in the Guidelines, for some of the problems are quite complicated and would be extremely difficult to successfully operate with the people and money available at some of the present plant locations. Also, these solutions are not validly proven to be necessary or the right solution; and in some cases are not proven to be a solution at all. We would hope that the seafood industry is not singled out as a guinea pig so that the Federal Department of the Environment can try out their ideas and regulations.

We can now comment specifically on the proposed Guidelines for the control of fish plant effluents:

1. Probably the area of most disagreement with the present Guidelines is the definition of contaminated process water and the treatment required. The Department of the Environment has taken the laboratory definition of contamination; as all water which has been in contact with raw fish, processed fish or offal or which is included in a list of some 65 water uses broken down according to the type of processing in Appendix A. But surely the contamination that should be of concern and the flows that should be worked on are only those that cause adverse effects on the environment. For instance, why should the water used in a lobster tank house for storage of lobsters be considered contaminated and required to be treated for

solids removal? Will the water in the many small fishing ports where lobsters are stored in floating crates or pounds in the harbour have to be treated for solids removal?

Is there any point in taking the water used as a water seal in air unloaders for groundfish and passing this water through screens in order to remove the tons of ice which come with every trip of fish. Eventually, the ice will only melt and run away so why force fish plants to save it in the first place. It is technically true that the ice contaminates the water (and it will have a little blood in it) but has it ever caused an environmental problem? No, it is not and has not been a problem. Similarly, there is no practical justification for screening many of the water flows listed in Appendix A of the proposed Guidelines.

The Guidelines must be rewritten to pick out the flaws which can cause environmental problems and modify the definition of contamination of these flows if the Guidelines are to be workable at all. It should be remembered that these Guidelines are being proposed at a time when the majority of coastal communities are not even giving primary treatment to sewage.

2. The requirement that all so-called contaminated process water must be treated for solids removal so that it produces an effluent similar in quality to that produced by 25 mesh screening of contaminated wastewater appears to us to be an arbitrary requirement with no consideration to the following circumstances:

a) is the flow contaminated to such an extent that it justifies making the changes in the building and equipment to capture and screen the water. We feel this is a place where common sense must prevail, for instance, the matter of lobster storage water or groundfish unloading and raw material transporting.

b) does the yearly volume of fish processed in certain circumstances justify the changes in building, and equipment to enable the water to be captured and screened. For instance some plants handle a few baskets of herring or mackerel per day from inshore boats for a short summer season and these fish often are flumed into the plant with no environmental damage. The cost of the effluent treatment equipment could never be repaid by the small volume of product and the net result could be the end of this section of the industry.

c) it appears to us that most of the testing being done now or proposed by the Department of Environment is designed to prove that 25 mesh screening is possible and not whether or not it is necessary. We feel that any screening requirement would vary greatly according to the product being produced (a salmon canning operation would require finer mesh screening than a groundfish filleting plant). We know that many fish plants, especially the older ones, do not have screening facilities for their offal flume water, nor by the nature of their location do they need them. Dr. Frankenstein was a respected scientist until he created

the monster which bears his name. Now his name is anathema and used as a term of ridicule for injudicious application of basic scientific principles.

It is possible for dedicated men, with total committment, and unlimited resources to make a case for any particular piece of equipment in a limited test area. However, the same equipment when subjected to the voluminous demands and the multitude of different demands made by a modern multipurpose plant can well turn out to be a Frankenstein monster to the financial embarassment of the processor; and the scientific and common sense embarrassment of those who insisted on its installation without proper, long range testing.

We pose this question - if a 100% perfect method of screening every drop of water used in a processing plant were available and installed - what would we do with the volume of sludge removed? How would it be transported, and to where? Economical methods of processing this sludge are not now available. Those which are available and could only handle a portion would merely transform the problem to one of noxious gases which would pollute the atmosphere.

Also technology is not available for mixing, 'so called blood water', and excessive stickwater back into meal, in quantities greater than in normal operation. Dictating saving or storing excess liquids during breakdowns etc., can only create tanks of gaseous nuisances as the ability to absorb them is not now proven.

3. Guideline 3 - Sampling and metering.

We agree continuous metering of 'so called contaminated water' would be scientifically desirable, but also both from a scientific and practical point of view would the metering of the following:

a) Water temperatures - a vast amount of useful information regarding keeping quantities of fish, build up of residual heat in fish and fillets being processed, proper utilization of compressor and condensor facilities as well as many other disciplines could ensure which could help to control costs and improve quality.

b) Cold storage temperatures and air flows - the effect on shelf life of products - the ideal temperature for various products - the results of fluctuations on products.

c) Blast freezer temperatures and air flows - the proper combinations on various products where and when dehydration build up could be anticipated. Savings in power by eliminating over utilization.

d) Fillet residual moisture contents in trap fish with a view to upgrading the end product.

e) Fish meal moisture content metered on a continuous basis to produce a stable uniform product.

I could go on almost indefinitely but will mention in passing, steam flows, solids in solubles, amonia pressures, etc.

In general all of these and more are immediately desirable, but in general industry cannot afford to install or maintain all of

them. We feel strongly we should be able to set our own priorities as to where we spend money for information gathering equipment.

4. Sampling pits for selected flows from the fish processing plants, (such as offal flume water) make some sense but sampling pits for the multitude of so-called contaminated wastewater flows associated with fish processing mentioned in the Guidelines appear to be designed to turn each fish plant into a research laboratory instead of a production facility.

5. We agree that outfalls should be located in such a way that water supplies will not be affected.

However, we must remember that most existing fish plants are built on wharves and there is no practical way to pick up, for example, the water used in washing the floors and lead it to an outfall below low tide. Any attempt to do this would lead to massive freeze-ups in winter time and normally plants and wharves are not designed to have extra floors put on top of the existing ones. If this Guideline alone were implemented and existing plants were forced to come into compliance, a majority of fish processing operations would be forced to close.

6. We agree that on-site facilities for offal are required and transportation facilities should be tight. However, the whole

question of bloodwater is one which requires more thorough examination. The bloodwater squeezed out of a tank of herring for reduction purposes is much more of a problem than the so-called bloodwater which comes from a hopper of cod fish frames which were gutted at sea. The latter is made up mostly of flume water which has clung to the frames after dewatering and, as such, we feel that it should be drained off the offal and washed to the sea instead of trying to carry it around the countryside to an off-site reduction plant. It has never proved to be a problem in the past so why should it be taken to another place where it probably will be a problem to handle, contain and process.

At on-site reduction facilities it is a fact that the flume water which stays with the offal after dewatering and which mixes with bloodwater can be of such a volume that it will cause processing problems. We do not know of any practical way to dry this offal and remove the flume water so it is not a problem except for the method now used of releasing it to the receiving water. However, it is a situation on which more work can be done.

To write a Guideline that says this so-called bloodwater cannot be discharged without knowing if there is anything else that can economically be done with it, is, in our opinion, just not satisfactory. Anyone that is familiar with the operation of the common type of continuous fish meal plant containing cooker, press, dryer, separators and evaporator knows that there is often a great

problem for the operators to add back to the meal, all the solubles produced in the evaporator due to such things as mixing of the press cake and solubles, oiliness or glueiness of the end product, drying capacity, etc. In our opinion, it is not possible to say that for any given plant it would be possible at all times to add the evaporated bloodwater to the evaporated stickwater and still be able to absorb the resulting liquid in the press cake and make a suitable product. It appears that in this instance the Guidelines might create and impose an impossible condition for plants to meet, at least with present day technology, market possibilities for the product and financial limitations.

Similarly the requirement for tankage to hold a minimum of one day's production of stickwater and bloodwater in order to store these liquids in the event of equipment breakdown or shutdown, is not practical. We agree that where it is economically feasible to do so, which would be the case with practically all fish meal plants with a continuous year around supply of offal, or where its release would cause real aesthetic or environmental problems, that stickwater should be recovered as part of whole meal. However, we must realize that the fish meal plant is the last operation in a long chain of operations. If the fish meal plant is shut down. the filleting plants that it serves will have to shut down if there is no other alternative to dispose of their offal; if the filleting plants shut down the fishermen will have to stop bringing fish in unless there is an alternate place to land it, and this could mean dumping the fish

which has already been caught at sea.

Even the best run and most modern fish meal plant can experience problems of a few hours or a few days duration during which time the evaporator cannot be operated. We have seen this happen when repairs have had to be made to the evaporator or separator ahead of it, when the steam supply has failed or when cleaning has been required, etc. In general these problems are not frequent, may be once every couple of years, but rather than shut down a whole industry and disrupt the entire economy of a region, we would suggest making provision for this by allowing the discharge of stickwater during these emergency conditions. It has been done in the past without adverse affect to the environment, provided the outfall is well located, and it could be regulated by having the plant report all such occurrences when they are to happen and the expected duration to the Department of Environment. If the breakdowns occurred too frequently then steps would have to be taken to make the plant more reliable.

The tankage requirement does not make sense also for the same reason as the capture of bloodwater does not make sense. We do not know that a fish meal plant will be able to catch up on a day's supply of stickwater even if it has been stored and acidified for odour control. The stickwater might prove to be something which has to be stored for months before it can be disposed of. The Guidelines to us appear to be ridiculous and appear to have been proposed without

thought being given to the implications.

One other point that should be considered is that there are some meal plants where the stickwater is not evaporated but is fed back to a dryer at the same rate it is produced for direct drying with the press cake. These plants have no use at all for stickwater storage, since if the stickwater can't be processed it means that the dryer or auxiliary equipment is not operating and therefore the fish meal plant has to be shut down in any case. In this type of plant the Guideline does not make sense.

7. We do not know the industry can conform to an open ended clause such as the one requiring space or land available to allow for expansion of the waste treatment facilities to include more advanced treatment systems when and where required. In particular it would be impossible to bring some existing plants into compliance with this Guideline. Also, there is no way of knowing just what would be considered acceptable for a new plant. We presume that there are many other reasons for having space of land available around a new plant and this statement should be changed to read in a more positive way that land must be made available for waste treatment facilities and possible some percentage area can be named in relation to the size of the plant itself.

In summary, we would again like to confirm the fishing industry's interest in existing in a clean environment and in being part of a productive and forward looking community in which the fish

processing plant is a highly respected part. The Newfoundland industry would again like to emphasize its interest in working with both the Federal Department of Environment and the Provincial Air, Water and Soil Authority with a hope that:

a) the end result is a workable set of Guidelines.

b) the Guidelines will suit both the Federal and Provincial Authorities so that we proceed under substantially the same rules; which would serve to eliminate duplication of effort and expenditure.

We fear that if the Guidelines are given to people to administer and rigidly enforce their present format, the result will be the closing down of most of the present fish plants and the replacement of the jobs lost with an army of people checking, administering and controlling the few remaining plants.

As my final thought I leave with you the following proposition:

1. Danger to the environment caused by a man lighting a match in the middle of a powder room is such that the public insist on stringent regulations and safeguards to prevent such an occurrence. However, the same stringent regulations and safeguards would not be deemed necessary in the public interest to deal with a situation where a man lit a match in the depths of hell.

The analogy here, possibly far fetched and stated in colloquial language is that the same Guidelines cannot be written for over fifty processing plants, existing in the many different environments which are part of the Newfoundland scent.

I leave you with two final thoughts:

1. While we normally consider the generation of man to be 20-25 years, experience has taught us that because of any number of factors the generation of federal inspectors and administrators is about 5 years.

We feel that if established Guidelines are not supplemented by interpretation and implementation policies by this generation of administrators and inspectors - the next generation which will be upon us within five years may well mistake them for supplements passed down on Mount Sinai immediately after the ten commandments and endeavor to administer them word by word as written with no consideration of the intentions of those who are now promulgating the regulations.

2. We make our last request that you remove the word <u>final</u> from all consideration and publication regarding Guidelines for liquid effluents. Sit down with us, allow us to assist you to prepare practical, sensible Guidelines which will achieve the end we all so devoutly desire - the improvement and preservation of the environment of the Province of Newfoundland.

AN INDUSTRY COMMENT ON FISH PROCESSING PLANT EFFLUENT TREATMENT AND GUIDELINES

by

R.D. Moores

May 14, 1974 St. John's, Nfld.

We have heard an excellent paper from Mr. Bob Cove which gives the opinion of our industry in Newfoundland on the material as presented today by Environment Canada. It would be difficult for me to add much to the observations made by Mr. Cove on the specific details of these guidelines. Rather, I would like to express my overall view and then remark briefly on other factors which must be considered when such a program is to be implemented in an industry.

I believe that all responsible people involved in the fish processing industry would not like to consider themselves parties to an enterprise, activities of which could be considered hazardous to our environment and society. We are in the food production business as a link in a natural course of events. We do not want to be included with those industries whose operations, if not properly controlled, can have a long-term determental impact upon our ecology. With this in mind, we realize that some form of operation regulations for effluent control are required; however, the present draft proposal include details which are impractical and if implemented would not produce any worthwhile results.

The persons responsible for the preparation of this material have investigated all the operations that require water in a fish processing plant and have produced a document, the substance of which can be reduced to one sentence.

All the water that passes through a fish plant which comes in contact with man or beast is polluted and must be treated in some form. Having a concept established, a set of guidelines were conceived that are required to be national in scope to allow for every possible situation which may occur across the country. These rules may not indicate the true needs of the local environmental situation. I would suggest that a better approach could have been employed. Namely a more general national guide be provided, and that local representatives of all three levels of government Federal, Provincial and Municipal, together with the individual company concerned, seek and agree upon a workage solution to any pollution problem which is present.

For exmaple, the requirement that all water which is classified as contaminated be treated for solid removal by 25 mesh screens or equal may not actually be warrented according to local conditions. A processing plant located in an area of strong tidal and wave activity could get adequate solid waste control from simplier and cheaper equipment than that suggested by the guidelines. If natural forces are available to help eliminate effluent material, then they should be considered when planning the control system. All the decisions should be made locally with first hand knowledge of the problem to produce a fair and functional solution.

Recently the Provincial Government published regulations which provide for the quality of effluents being discharged from any manufacturing or processing facility in this province. Now the Federal Government has tendered these guidelines for the fish processing industry. Undoubtably, the agencies in both governments responsible consulted one another to eliminate any conflict and to consider the impact upon the fishing industry. I would also suggest that since pollution control effects the whole of our society that both governments seriously consider a program which would provide financial assistance to any company that requires capital to purchase pollution control equipment.

Many fish processing plants in the Province are seasonal in operation with a work period generally extending from May to October. In Conception and Trinity Bays from Brigus to Dildo, there are nineteen fish plants alone. These are dependent upon inshore fish as a source of raw material for their operations. Can all these plants and many more like them around the coast be expected to abide with the guidelines as presented here today? I don't think they can afford to.

Any extra funds which these operations would have available for investing in their businesses would undoubtably go towards ways and means of extending the work periods at their plants or for buying equipment that would upgrade their

products. The purchase of any large amount of pollution control machinery would be a luxury few could afford.

At present, the Federal Fisheries Service is encouraging fish processing firms in certain areas of the province to increase their ice making and storage facilities by providing grants covering one-half of the allowed capital cost of the project up to a maximum of 25,000 dollars. A similar program for pollution control machinery could be implemented by the Federal Government. This could be coupled to a provincial system involving grants or loan accommodation. The Industry would be generally willing to co-operate to overcome any problem caused by its activities, however, government which represents the people who are demanding a clean environment should assist those firms which require financial support.

It is our industries hope that we are not being singled out as a test case for Environment Canada's implementation policies. It would hardly be fair if a fish processing company is required to completely eliminate solid waste from its plant when possibly 100 yards from the plant outfall, fishermen could be dumping their unwanted fish extracts and other materials directly into the harbour. Also, the domestic sewage in many of the coastal towns in Newfoundland is not treated in any way but is discharged directly into the sea.

Processing firms operating in the same towns could be required to install the necessary treatment facilities. I mention these two cases not to suggest that two wrongs can make a right, but to point out the fact that when pollution control is being considered for the fishing industry, then there are other places which require as much and as immediate attention.

To reconfirm then, the points which I would like:

Firstly, such strict guidelines are generally not required in Newfoundland at this time. Any regulations should be discussed and implemented keeping the local situation and condition in mind at all times. We should take advantage of the natural forces of the sea around us and use a reasonable approach to the problem of solid removal.

Secondly, the majority of seasonal plant operations in this province are not in a financial position to afford the necessary equipment required to conform to these proposed guidelines. With a short work period these plants do not pose a serious pollution threat to the environment.

A clean surrounding will be expensive to provide and if the taxpayer is making such a demand on the fishing industry then he must expect to provide assistance to those companies which are financially incapable to meet such guidelines which are presented here today.

INDUSTRY VIEW ON GUIDELINES

by

R.J. COVE
NATIONAL SEA PRODUCTS LIMITED
ST. JOHN'S, NEWFOUNDLAND

As a representative of the fish processing industry, we have been given the task of commenting on a set of guidelines relating to liquid effluents from fish, shellfish and meal processing plants. Although (at the present time of this address being prepared), nobody has come right out and written or stated the fact, we get the impression that these guidelines are being presented as final guidelines and we find this particularly embarrassing and unfortunate since the guidelines, as written, do not appear to consider the practical situation as it exists and do not reflect the view point or suggestions made by industry in the past.

Guidelines, for new plants only, were iriginally submitted to industry for comment with the statement that both industry and the provincial authorities would be actively consulted before finalizing these guidelines. However, the comments made by industry concerning the original guidelines appear to have either not reached their author or appear to have been disregarded. Also, additional guidelines and definitions, which are of major consequence have been added to the preliminary guidelines and these change the assumed meaning of the original guidelines and would change the comments from industry; for example, the list of so-called contaminated flows which would have to be screened has been added to the guidelines and this list would be completely unacceptable to industry; a definition and

treatment of bloodwater which do not appear practical have been added; and the guidelines are now defined as a basis for determining the requirements for existing fish processing plants, as well as new plants with no clear concept of how the regulations would apply to the expansion of existing plants. It is regretable that Federal thinking on this subject has developed so far without continuous inputs from the industry. However, this seminar may do much to offset previous deficiencies and hopefully provide the first substantial dialogue between the interested parties.

At this time, we would like to acknowledge that there are serious pollution problems throughout our entire country and some of these problems directly affect our fisheries. In particular, the contamination of rivers, streams, and enclosed harbours and in certain cases the pollution of the ocean itself has had an adverse effect on fisheries. Therefore, the fishing industry has an interest in seeing that the pollution of our water resources does not increase and in the long term we look for the reduction or elimination of certain undesirable pollutants which flow into the rivers, lakes and oceans of the world.

We feel that Government, being the regulatory agencies, have to take the responsibility of seeing that a logical priority is established in tackling pollution problems so that the serious pollutants and the areas where the environment is affected the most are tackled first. It does not make sense to us to force the

spending of relatively large sums of capital to eliminate non-harmful waste just because a government body has a lot of power in a certain instance, while allowing harmful pollutants to continue to be released in another instance because it is not politically expedient to correct the situation. Also, it does not make sense to us to see a set of guidelines drawn up which treat some effluents as contaminants when obviously they would not be so listed if considered as individual items. In other words, where the effluent being discharged is non-harmful, and realizing the amount of money that can be spent on pollution control in Canada each year is limited, we do not agree that Companies should be forced to spend large amounts of money to achieve little in the way of practical improvements, for an uneconomic return. This point should be borne in mind when examining any proposed guidelines and their period of implementation.

When we look at the fishing industry, we look at an industry which cannot be classed as one generating harmful or serious effluents such as the pulp and paper industry, the steel industry, the chemical industry, etc. The effluent from a fish processing plant does contain particles of fish and liquids from the fish but these substances are natural to the environment and only cause problems if the volume is too great for the receiving waters. Much of the material is consumed by other living matter within a short distance from the plant. In very many cases if one were say 50 yards from an outfall and could not see the fish plant there would be no way of knowing that one existed nearby, and these are plants without all the sophisticated equipment mentioned in the guidelines.

Also we must realize that the problems caused by effluents from fish plants is in general a diminishing problem due to influence other than government regulations. For one thing, more of the fish being caught comes from offshore boats than it did say 25 years ago. Today there is very little cleaning of fish at wharves and in waters close to fish plants and the throwing of the guts into the water.

Also, the per cent of offal being used for fish meal or mink food is increasing due to its higher value. Less and less is allowed to go directly to the harbour or to a nearby field although if guidelines such as those proposed or other regulations force small fish meal operations out of business there might be no alternative but to put the offal into the sea. Furthermore, the newer plants incorporate better equipment to handle offal and better fish meal equipment for economic reasons as well as effluent control reasons.

In the case of most fish plants, the people who operate and work in the plant are residents of the nearby area. As these people live in the neighborhood, they are directly affected if there are environmental problems caused by the plant. It is not the same as a case where the problem affects people 50 miles downstream or only affects people in another industry. In general, the people who live in towns with a fishing industry do not find their environment deteriorated because of the liquid effluents from the fish plant.

We feel that guidelines, such as those proposed, have to give huge consideration to where the effluent is going and provision has to be made to judge each case on its own merits. We, in the fishing industry, know only too well that some people, put in a position to administer similar regulations, will treat the written word as bible, apply their own interpretation and forget about common sense. If these guidelines are implemented, industry could be forced to spend huge sums of somey in some places with no practical results whatsoever. Treatment which might be necessary for a plant on the side of a lake or small river may be quite unnecessary in a tidal estuary and likewise what may be necessary in an estuary may be unnecessary where the outfall is to a sea or ocean.

The guidelines allow for more advanced treatment where required. It is our opinion that the standard requirements or guidelines should be very carefully written to cover only those flows which are a necessity to treat in all new plants and then if there are instances where the discharge of wastewaters leads to a deterioration of the receiving water quality affecting other water uses, then the fish plant concerned may be required to install more treatment equipment.

Lastly, we would like to point out that the fishing industry is not highly sophisticated like, for instance, the oil refining business. Also, the solutions, proposed in the guidelines, for some of the problems are quite complicated and would be extremely difficult to successfully operate with the people and money available at some of

the present plant locations. Also, these solutions are not highly proven to be necessary, or the right solution, or in some cases are not proven to be a solution at all. We would hope that the seafood industry is not singled out as a guinea pig so that the Federal Department of the Environment can try out their ideas and regulations.

We can now comment specifically on the proposed guidelines for the control of fish plant effluents.

1. Probably the area of most disagreement with the present guidelines is the definition of contaminated process water and the treatment required. The Department of the Environment has taken the laboratory definition of contaminated as all water which has been in contact with raw fish, processed fish or offal or which is included in a list of some 65 water uses broken down according to the type of processing in Appendix A. But surely the contamination that should be of concern and the flows that should be worked on are those that cause adverse effects on the environment. For instance, why should the water used in a lobster tank house for storage of lobsters be considered contaminated and required to be treated for solids removal? Will the water in the many small fishing ports where lobsters are stored in floating crates or pounds in the harbour have to be treated for solids removal?

Is there any point in taking the water used as a water seal in air unloaders for groundfish and passing this water through screens in order to remove the tons of ice which come with every trip of fish. Eventually, the ice will only melt and run away so why force fish plants to save it in the first place. It is technically true that the

ice contaminates the water (and it will have a little blood in it) but has it ever caused an environmental problem? No, it is not and has not been a problem. Similarly, there is no practical justification for screening many of the water flows listed in Appendix A of the proposed guidelines.

The guidelines must be rewritten to pick out the flows which can cause environmental problems and modify the definition of contamination of these flows if the guidelines are to be workable at all. It should be remembered that these guidelines are being proposed at a time when the majority of coastal communities are not even giving primary treatment to sewage.

2. The requirement that all so-called contaminated process water must be treated for solids removal so that it produces an effluent similar in quality to that produced by 25 mesh, screening of contaminated wastewater appears to us to be an arbitrary requirement with no consideration of the following circumstances:

(a) is the flow contaminated to such an extent that it justifies making the changes in the building and equipment to capture and screen the water. We feel this is a place where common sense must prevail, for instance, the matter of lobster storage water or groundfish unloading and raw material transporting.

(b) does the yearly volume of fish processed in certain circumstances justify the changes in building, and equipment to enable the water to be captured and screened. For instance some plants handle a few baskets of herring

or mackerel per day from inshore boats for a short summer season and these fish often are flumed into the plant with no environmental damage. The cost of the effluent treatment equipment could never be repaid by the small volume of product and the net result could be the end of this section of the industry.

(c) it appears to us that most of the testing being done now or proposed by the Department of Environment is designed to prove that 25 mesh screening is possible and not whether or not it is necessary. We feel that the screening requirement would vary greatly according to the product being produced (a salmon canning operation would require finer mesh screening than a groundfish filleting plant). We know that many fish processing plants, especially the older ones, do not have good screening facilities for their offal flume water. By reason of their inefficiency much more solid particles than are necessary escape to the receiving waters. We suggest that before implementing an expensive and relatively complicated 25 mesh screening requirement, that the installation of rotating screens with holes of 1/4 or 3/8 inch, or the equivalent, be implemented. We feel that this would pretty well eliminate any areas where there are problems now due to inefficient screening of offal flume water.

2. Metering water flows out of a plant is just not practical.

Metering all flows into a plant is also unreasonable as salt water used in condensers, scrubbers and barometric condensers, which is used in relatively massive quantities, just makes this a ridiculous request. The net result of this guideline will be to make the meter selling and servicing industry rich and to provide employment to a bunch of people recording useless information.

Sampling pits for selected flows from the fish processing plants, (such as offal flume water) make some sense but sampling pits for the multitude of so-called contaminated wastewater flows associated with fish processing mentioned in the guidelines appears to be designed to turn each fish plant into a research laboratory instead of a production facility.

3. We agree that outfalls should be located in such a way that water supplies will not be affected.

However, we must remember that most existing fish plants are built on wharves and there is no practical way to pick up, for example, the water used in washing the floors and lead it to an outfall below low tide. Any attempt to do this would lead to massive freeze-ups in winter time and normally plants and wharves are not designed to have extra floors put on top of the existing ones. If this guideline alone were implemented and existing plants were forced to come into compliance, a majority of fish processing operations would be forced to close.

4. We agree that on-site and off-site facilities for offal are required and transportation facilities should be tight. However, the whole question of blood water is one which requires more

thorough examination. The blood water squeezed out of a tank of herring for reduction purposes is much more of a problem than the so-called blood water which comes from a hopper of cod fish frames which were gutted at sea. The latter is made up mostly of flume water which has clung to the frame after dewatering and, as such, we feel that it should be drained off the offal and washed to the sea instead of trying to carry it around the countryside to an off-site reduction plant. It has never proved to be a problem in the past so why should it be taken to another place where it probably will be a problem to handle, contain and process.

At on site reduction facilities it is a fact that the flume water which stays with the offal after dewatering and which mixes with bloodwater can be of such a volume that it will cause processing problems. We do not know of any practical way to dry this offal and remove the flume water so it is not a problem except for the method now used of releasing it to the receiving water. However, it is a situation on which more work can be done.

To write a guideline that says this so-called bloodwater cannot be discharged without knowing if there is anything else that can economically be done with it, is, in our opinion. just not satisfactory. Anyone that is familiar with the operation of the common type of continuous fish meal plant containing cooker, press, dryer, separators and evaporator knows that there is often a great problem for the operators to add back to the meal, all the solubles produced in the evaporator due to such things as mixing of the press cake and solubles, oiliness or glueiness to the end product, drying

capacity, etc. In our opinion, it is not possible to say that for any given plant it would be possible at all times to add the evaporated bloodwater to the evaporated stickwater and still be able to absorb the resulting liquid in the press cake and make a suitable product. It appears that in this instance the guidelines might create and impose an impossible condition for plants to meet, at least with present day technology, market possibilities for the product and financial limitations.

Similarly, the requirement for tankage to hold a minimum of one day's production of stickwater and bloodwater in order to store these liquids in the event of equipment breakdown or shutdown, is not practical. We agree that where it is economically feasible to do so, which would be the case with practically all fish meal plants with a continuous year around supply of offal, or where its release would cause real aesthetic or environmental problems, that stickwater should be recovered as part of whole meal. However, we must realize that the fish meal plant is the last operation in a long chain of operations. If the fish meal plant is shut down, the filleting plants that it serves will have to shut down if there is no other alternative to dispose of their offal; if the filleting plants shut down; the fishermen will have to stop bringing fish in unless there is an alternate place to land it; and this could mean dumping the fish which has already been caught at sea.

Even the best run and most modern fish meal plant can experience problems of a few hours or a few days duration during

which time the evaporator cannot be operated. We have seen this happen when repairs have had to be made to the evaporator or separator ahead of it, when the steam supply has failed or when cleaning has been required, etc. In general these problems are not frequent, may be once every couple of years, but rather than shut down a whole industry or disrupt the entire economy of a region, we would suggest making provision for this by allowing the discharge of stick water during these emergency conditions. It has been done in the past without adverse affect to the environment, provided the outfall is well located, and it could be regulated by having the plant report all such occurrences when they are to happen and the expected duration to the Department of Environment. If the breakdowns occurred too frequently then steps would have to be taken to make the plant more reliable.

The tankage requirement does not make sense also for the same reason as the capture of bloodwater does not make sense. We do not know that a fish meal plant will be able to catch up on a day's supply of stickwater even if it has been stored and acidified for odour control. The stickwater might prove to be something which has to be stored for months before it can be disposed of. This guideline to us appears to be ridiculous and appears to have been proposed without enough thought being given to the implications.

One other point that should be considered is that there are some meal plants where the stickwater is not evaporated but is fed back to a dryer at the same rate it is produced for direct drying with the press cake.

These plants have no use at all for stickwater storage, since if the stickwater can't be processed it means that the dryer or auxiliary equipment is not operating and therefore the fish meal plant has to be shut down in any case. In this type of plant this guideline does not make sense.

We do not know how the industry can conform to an open-ended clause such as the one requiring space or land available to allow for expansion of the waste treatment facilities to include more advanced treatment systems when and where required. In particular it would be impossible to bring some existing plants into compliance with this guideline. Also, there is no way of knowing just what would be considered acceptable for a new plant. We presume that there are many reasons for having space or land available around a new plant and this statement should be changed to read in a more positive way that land must be made available for waste treatment facilities and possibly some percentage area can be named in relation to the size of the plant itself.

In summary, we would again like to confirm the fishing industry's industry's interest in existing in a clean environment and in being part of a productive and forward looking community in which the fish processing plant is a highly respected part. The Plant where my office is located has had over 10,000 visitors a year for the past 10 years and we are sure that neither these visitors nor our neighbours found our surroundings have been deteriorated by the presence of the industry. Also we would again like to emphasize our interest in working with both the Federal Department of the Environment and the five Atlantic Provincial water pollution control agencies with the hope

that (a) the end result is a working set of guidelines and (b) the guidelines will suit both Federal and Provincial Departments so that we operate under substantially the same rules in each province.

We fear that, if the guidelines are given to people to administer and rigidly enforce in their present format, the result will be the closing down of most of the present fish plants and the replacement of the jobs lost with an army of people checking, administering and controlling the few remaining plants.

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