PROCESSING

PLANT WASTE MANAGEMENT GUIDELINES

-Aquatic Fishery Products -

by

Roy E. Carawan, Ph.D.
Professor (Food Engineering Specialist)
Department of Food Science
North Carolina State University
Box 7624
Raleigh, NC 27695-7624
(919) 515-2956

INTRODUCTION

The quantity and quality of water has received much public attention. As a result, lawmakers are considering, or have already passed, environmentally conscious legislation such as the Clean Water Act (CWA). Seafood processors must address the technological and economic impact of environmental issues on their future.

The public concerns have prompted new economic, regulatory, and political changes that will change the current attitude about water use in the food industry. Water use is extremely important to the aquatic fishery products industry. Clean water is essential for the production of raw products. Processing water use includes washing products, scalding making brines, cooking, cooling, cleaning and sanitation. Water is also an ingredient in some further processed products.

Three areas of water use are of concern. These concerns are (1) the availability of water of sufficient quality for the intended use, (2) the depletion or loss of water associated with use, and (3) the disposal of industrial wastes-both processing residuals and wastewater treatment process residuals. Each area has technological, economic, regulatory, and public image factors. These factors combined, make these areas of concern critical to the location and continued operation of many food plants. The aquatic fisheries production, harvesting, and processing industries will feel the effects of many of these issues.

WATER AND WASTEWATER REGULATIONS

Drinking, Groundwater

The 1986 Safe Drinking Water Act, prior amendments, and the 1974 Safe Drinking Water Act, mandate certain responsibilities and establish the Environmental Protection Agency (EPA) as the regulatory agency. The 1974 Act mandates that all public water supplies must meet EPA safety criteria. The 1986 amendments mandate that EPA set action levels on 83 pollutants by 1989. The Food and Drug Administration (FDA) is responsible for processing water for food plants, and using the Good Manufacturing Practices (GMPs) (21 CFR 110.37(a)). The U.S. Department of Agriculture (USDA) regulates water use and reuse in meat and poultry processing plants. The aquatic products industry is regulated voluntarily by the US Department of the Commerce. The agency with prime responsibility for regulating the aquatic fishery products industry is the U.S. Department of Health and Human Services Food and Drug Administration (FDA). Shellfish is controlled by FDA and the state Public Health officials. However, under these regulations, EPA (40 CFR 141) is responsible for regulating drinking water for employees if more than 24 employees occupy the plant. Lead pipe and lead soldered joints are prohibited under these amendments.

Some states are setting water quality standards more stringent than those of EPA in response to consumer pressure. EPA studies are currently underway to determine the quality of our water supplies and the level of contaminants including agricultural chemicals such as herbicides and pesticides in our groundwater. Further, EPA regulates pesticides and recommends action levels to FDA for enforcement.

Not only are consumer groups demanding action, they are taking actions that will force a future response from our elected officials. Recently, the Center for Response Law and the New York Public Interest Research Group reported that 2,110 contaminants had been found in a study of 3,422 of the U.S. water systems. Some 190 of these contaminants are suspected or known to be harmful to health. A food plant manager may have to justify using water containing a known carcinogen. Such an action would cause legal liability for him and his company. Similarly, are aquatic fisheries managers responsible if they harvest fish with known toxicants?

Waste/Wastewater

Wastewater from food processing plants is regulated by federal (EPA) and state statutes. Plant managers with direct discharges or applications of wastes and wastewater must get the required permits and file the necessary reports. Many food plants discharge to municipalities and are regulated by local, state and federal regulations through the EPA Pretreatment Program. New areas of concern include Proposition 65 in California, stormwater permits, biomonitoring community-right-to-know and underground storage tanks. Key references include those in Table 1.

TABLE 1. Issues and Information

Environmental Issue	Reference/Information
Surface Water Discharge	NPDES Permit 40 CFR 122 and 123 EPA 202 475-8310
Biomonitoring	Journal of WPCF (Jan. 1987)
Stormwater Permits	Federal Register November 16, 1990
Municipal Discharge	40 CFR 403
Nonhazardous Waste to Land (state's control)	40 CFR 257
Sewerage Sludge to Land	40 CFR 257 EPA February 6, 1989 Proposal
Hazardous Substances	40 CFR 117,302,370 40 CFR 372
Community-Right-to-Know	40 CFR 370, 372
Underground Storage Tanks	PL 98-616, 40 CFR 280,281
PCB'S	40 CFR 761
Asbestos	40 CFR 61 EPA 800 368-5888
Employee Drinking Water	40 CFR 141
Accidental Release Reporting	40 CFR 117, 302 NRC 800 424-8802
Municipal Solid Waste	EPA's Agenda for Action EPA 800 424-9346

During the mid-seventies the federal environmental regulatory program expanded to cover virtually all discharges to surface waters. This expansion focused on oxygen demanding pollutants and toxic and hazardous pollutants.

Most of these changes became mandatory with the Clean Water Act amendments of 1977. In 1987, the Act was again extensively amended to include changes that tightened the focus on toxic dischargers. Also, water quality permitting was strengthened to include discharges such as storm water, which were largely unregulated in the past. These amendments also served to strengthen the Act's enforcement mechanisms.

EPA regulatory officials have developed and tested all the regulatory tools, gadgets, and mechanisms for the Clean Water Act Program. EPA, along with the Attorney General's Office, have a long and reasonably distinguished enforcement history. This combination of stricter limits and enforcement is having an ever-increasing impact on actions taken, fines paid, and expenditures.

Section 309 of the CWA makes the Act's enforcement provisions quite formidable. A chief attribute of the CWA enforcement philosophy is the extent to which individual criminal prosecution, or the threat thereof, is relied upon as a deterrent. Under the amendments, purposeful or negligent violation of any of the Act's major requirements is a crime attributable to the corporation, as well as to the individuals responsible. Included are failure to obtain a permit, failure to give notice when required, failure to monitor properly, and failure to report thereon. Inaccurate monitoring through negligence, or the intentional falsification of reports, are actions dealt with severely. The Act's criminal enforcement provisions are supplemented by an increased civil penalty authority, a provision for administrative penalty proceedings, and an expansive provision for citizens' suits.

All the waste and wastewater regulations force state/local actions and responses. The current climate is one of increased litigation and cost. Examples of actions against food processors in the last several years include:

Citizens' Suits

Chesapeake Bay Foundation vs. Gwaltney
$1,300,000 fine proposed against meat processor

Note-This suit was filed to help protect the Chesapeake Bay, one of the nation's prime breading grounds for a variety of aquatic fishery products.

Discharge Violations

Nabisco Plant - Washington State
$300,000 fine
$250,000 reserve trust
$5,000 fine and one year incarceration for plant manager

Ocean Spray - Middleborough, CN
$2,100,000 corporate fines proposed-fines and incarceration for officers considered.

Coca-Cola - Massachusetts
$200,000 fine

WATER USE

Only 6 percent of our rainwater is usable. The rest is lost to evaporation (70 percent) and runoff (24 percent). Of the usable water, industry uses 3 percent, agriculture uses 2.5 percent, and municipalities use 0.5 percent. Industries within municipalities may account for almost 50 percent of the municipal use.

Reports indicate that 25 percent of the nation's groundwater is used faster than it is replaced. Groundwater supplies are threatened by leaking landfills, leaking underground tanks, pesticides and fertilizers.

Water Cost

Water cost for food processors has not been a major concern in the past. Even today most food plants pay less than $3.00 per thousand gallons of water used. Some poultry plants use more than 5,000,000 gallons of water per day. Water and wastewater costs for such a plant could approach $4,000,000 annually. Most aquatic products processing plants use much less water.

Water Use

Water use for food processing is calculated as either the total amount of water used for the product, or the amount of water needed for processing alone. The author categorizes food plants depending on water use per day (Table 2). Most aquatic products processing plants would be classified in the small category although there are a few large plants.

Table 2. Water Use in Food Processing Plants

Category	Water Use Per Day
	(gal)
Small	20,000
Medium	20,000 - 100,000
Large	100,000 - 1,000,000
Very Large	> 1,000,000

Table 3 presents the amount of water used to produce a specific amount of product. Biological processes require large quantities of water. For instance, water needed to produce a bushel of corn may be 6,000 gallons while a bushel of soybeans may require 23,000 gallons. It is estimated that 7,000 gallons of water are necessary to produce one pound of steak. Trout and catfish production require large quantities of water.

Water needed for the food processing industry is not as large as for agricultural production. For example, it requires 6-10 gallons of water to produce one gallon of beer, 8-13 gallons for each fryer, 20-35 gallons for a turkey, and 1 gallon for each pound of hamburger (Table 4). Shrimp peeling cooking and freezing requires about 22 gallons of water for each pound.

Table 3. Water Use Necessary for Agricultural Production

Product	Quantity	Water Use
		(gal)
Bread	Loaf	115
Potatoes	20 lbs.	1,200
Eggs	Dozen	1,440
Steak	1 lb.	7,000
Milk	Gal.	9,500

Table 4. Water Use in Food Processing

Item		Quality Water Used for Processing
		(Gal)
One Fryer		8 - 13
One Turkey		20 - 35
Can #303 (1 lb.)	Sweet Potatoes	1 - 4
Can #303 (1 lb.)	Apples	1 - 2
Can #303 (1 lb.)	Green Beans	1 - 2
1 lb. Hamburger		0.5 - 1
1 lb. Pork Chops		1 - 2
1 gal. Beer		6 - 10
1 gal. Milk		1 - 3
1 lb. Shrimp		22

Water Quality

Water quality is important in processing. For example, food processing plants are concerned about both organic and inorganic impurities, and bacterial content. Potable water is required for all water used in the final preparation of foods intended for human consumption. Some latitude exists in that recirculated or reconditioned water may be used for some purposes.

because of the importance of standardizing water quality in their products, soft drink manufacturers have long subjected their water supplies to rigorous treatment. Soft drink production plants typically take water through coagulation, disinfection, pH adjustment, and carbon filtration steps to remove hydrocarbons and chlorine from water. Other water treatment technologies that food plants could use include ion exchange, membrane filtration, ultra-violet disinfection, air stripping, and biological (bacterial) conversion. In the future, the aquatic products processing industry may need to treat incoming water.

WASTEWATER

Introduction

The volume and characteristics of food processing effluents often exhibit extreme variability. The BOD_5 may be as low as 100 mg/l or as high as 200,000 mg/l. The BOD_5 of seafood processing plant effluents is sometimes as high as 2,000 mg/l. Suspended solids, almost completely absent from some wastes, may be found in concentration as high as 120,000 mg/l. The waste may be highly alkaline (pH 11.0) or highly acidic (pH 3.5). Nutrients such as nitrogen and phosphorous may be absent or they may be present in quantities in excess of those necessary to promote good environmental conditions for biological treatment.

Treatment of wastewater from aquatic products processing plants can be costly and complex. High strength wastewaters and highly variable seasonal loadings make many treatment schemes ineffective and not cost efficient. The locations of new plants is highly dependent on wastewater disposal. As the processing industry for aquatic products expands in the future this limitation may hamper growth.

A majority of the pollutants of concern in the aquatic products processing industry are organic, and compatible with most biological treatment methodologies as well as land disposal. However, the use of chemicals (chlorine for sanitation and cleaning or sodium chloride for pickling operations) causes unique disposal problems.

The enactment and enforcement of sewer use ordinances, pretreatment ordinances, and surcharge ordinances, threaten the economic viability of many suburban and urban food processing plants. As more municipalities require pretreatment, developing improvements in the processes becomes necessary. The best pretreatment schemes involve the utilization of pollution prevention techniques to reduce pollution at the source and using water recycling to minimize potable water needs and wastewater. Existing pretreatment processes for aquatic fisheries processing include screening, clarification or dissolved air flotation (DAF). The disposal of the residue from these processes is expensive and difficult.

Toxins are not often a worry for the managers of most aquatic processing plants. However, as regulations become more restrictive and analysis techniques more sensitive, a number of wastewaters such as those with highly alkaline or acidic wastes, copper, zinc, chrome, laboratory wastes, and sanitizing solutions containing chlorine, will adversely effect the food processing industry-including aquatic products processors.

BOD_5

Biochemical oxygen demand (BOD_5) is the test used for monitoring wastewater from food processing plants. The BOD_5 test is a biological test used to indicate the amount of oxygen necessary to enable the biochemical oxidation of wastewater. The test is widely used because oxygen deficiency is usually the cause of polluted water and fish kills. Oxygen supply is often the greatest expense in wastewater treatment.

BOD_5 from food plants is directly related to food products in the wastewater. In fact, BOD_5 can be estimated in food plant wastewaters by determining the fat, protein, and carbohydrates in a particular wastewater, and using the following factors:

Food Component	lbs BOD_5/lb Food Component
Carbohydrates	0.65
Fats	0.89
Protein	1.03

Any waste parameter such as BOD_5 is usually reported in terms of ppm or mg/l, which are equivalent measures. To determine the amount (waste load) of any given parameter, the following formula is used:

Waste Load	Formula
lbs waste	$= \frac{8.34\ (CONC)\ (FLOW)}{1,000,000}$

where CONC = concentration (mg/l, or ppm)
FLOW = volume of wastewater

Example: We have a food plant that processes 20 days per month with a wastewater discharge of 1,500,000 gal/day with a BOD_5 = 2,750 mg/l. What is the monthly waste load?

For One Month

FLOW = 1,500,000 gal/day x 20 days
= 30,000,000 gal

$$\text{Waste Load} = \frac{8.34\ (CONC)\ (FLOW)}{1,000,000}$$

$$BOD_5\ (lbs/month) = \frac{8.34\ (2,750)\ (30,000,000)}{1,000,000}$$

$$BOD_5 = 688,050\ lbs/month$$

How can we use this information? If the plant discharges to a city that charges $0.20 per pound of BOD_5, what is the monthly bill?

Bill = 688,050 lbs BOD_5/month x $0.20/lb BOD
Bill = $137,610.00 per month

costs

Costs for wastewater include those for pretreatment, for treatment, and for disposal to Publicly Owned Treatment Works (POTWs). In the last 25 years, municipal water and sewer bills, have increased four-to-ten fold. At the same time, restrictions on waste discharge are being imposed with new and/or expanded municipal ordinances.

Disposal to POTWs

In the disposal of wastewater from food processing plants to POTWs, there are three types of costs incurred: the cost of pretreatment, the cost of residual or sludge disposal, and the cost of discharge. Discharge costs include sewer and surcharge costs. Currently sewer costs average about $1.50 per 1,000 gallons but range from $0.20 to about $6.00 per 1,000 gallons. Surcharges are levied for waste loads discharged above the prescribed limit. Surcharges are charged for BOD_5, TSS, FOG, phosphates, TKN, etc. BOD_5 costs range from $0.025 to $2.00 per pound while TSS surcharges range to almost $3.00 per pound of excess suspended solids.

Treatment

Costs for treating food plant wastes vary depending on the size and complexity of the operation. Common treatment processes include land disposal, anaerobic ponds, aerobic ponds, activated sludge, clarifiers, trickling filters, and rotating biological contractors (RBCs). The costs for analysis, permits records, and report filing are becoming significant.

Pretreatment/Sewer Use Ordinances /Local Limits /Permits

Pretreatment and sewer use ordinances can impose significant restrictions on food plants. The costs for pretreatment processes are expensive, and technology is not yet available to meet the new restrictive limits imposed by many ordinances

Pretreatment Regulations

The United States Environmental Protection Agency (EPA) in 1978, issued the federal pretreatment regulations. The objectives of the pretreatment regulations are to prevent the pass-through of pollutants that interfere with treatment systems. This assures treatment efficiency, protects treatment system workers, and improves or enhances recycling and reclamation processes. Amendments subsequent to 1978 includes those passed in 1981,1987, and 1988, and those proposed in 1988. Industries located in municipalities that discharge wastewater to the local POTW, were previously only responsible to the local sewer use ordinance. Not only do these new regulations make the acceptance of, and compliance with limitations in a plant specific permit a local matter, now they also subject corporations to state and federal reviews, oversights, and possibly non-compliance actions. Most companies are not likely to have rigorous institutional mechanisms to assure full compliance and to protect the company and its personnel. Plant specific permits are now being rapidly developed throughout the country to replace sewer use ordinance limitations. Most plants have found significant compliance problems with this process. The only way for an industry to guarantee that the pretreatment requirements placed on its discharge are reasonable is to take an active role in the development and implementation of the POTW'S program.

The general pretreatment regulations require all POTWs that are designed to receive flows of five million gallons or more per day to develop and implement a local pretreatment program.

Also, POTWs which are designed for less than five million gallons per day, but, receive significant industrial discharges can be required to develop a local pretreatment program at the discretion of the pretreatment "Approval Authority" (either the state or EPA). POTWs which are required to develop and implement local pretreatment programs must design their local programs around two general types of pretreatment standards, categorical standards and prohibited discharge standards.

Categorical pretreatment standards are developed by EPA for specific classes of industrial users. These limitations are based on the wastewater treatment technologies available to the industry class and the economic ability of the industry class to install the technology. Categorical standards apply to all industrial users (IUs) in the industry class unless local limits, site specific limitations developed by the POTW, are more stringent.

Prohibited discharge standards ban the discharge of certain types of waste to the POTW. Specific bans are placed on pH, temperature, explosive pollutants, and obstructive pollutants. In addition, general prohibitions are placed on any pollutant which can interfere with POTW operations or pass through the POTW into the receiving water. As part of the development of a local pretreatment program, the POTW must develop specific local limitations to implement the general prohibitions.

EPA's decision to delegate pretreatment program responsibility to local POTWs was made for several reasons: most POTWs were already familiar with local industrial users; many POTWs had some existing industrial client relationships through billing/surcharge programs; and, perhaps most compelling, the POTW's NPDES permit served as an ideal vehicle for requiring program development and implementation. There are, however, several problems that occur when POTWs are required to develop and implement a complicated regulatory program. Most of these problems directly effect the industrial user.

The problems with pretreatment program implementation by local POTWs begin with a lack of training and experience in a variety of areas. Development and implementation of an effective pretreatment program requires expert knowledge in environmental law, environmental engineering, environmental chemistry, and industrial engineering. Most POTWs look to the wastewater treatment plant (WWTP) staff to develop and implement their pretreatment program, but it is very rare that the WWTP staff has the required skills. EPA and individual states try to compensate for the POTW's lack of skill by supplying technical support documents such as example ordinances, example permits, and various procedure manuals. Once the POTW has these documents in hand, they often find it easier to adopt the government's generalized guidance word for word rather than develop their own policies using site specific criteria.

Ordinance

The purpose of a sewer use ordinance is to give the POTW the legal authority to carry out the various functions required by the general pretreatment regulations. These functions include issuing industrial user permits, inspections, monitoring and enforcement. EPA's Guidance Manual For POTW Pretreatment Program Development advises POTWs to review the current ordinance and, if modifications are needed, provides a model ordinance. Further, since the model is intended only as a guide, POTWs should modify the model to address local concerns. Unfortunately, most towns tend to adopt the model without significant changes.

As part of industry's role in the pretreatment program, a plant should participate in the local process of sewer use ordinance modification. In many towns this process includes a public notification that the ordinance is being changed, a mailed notice to effected industrial users and one or two readings at the monthly council meetings. The industry should find out the standard notification procedures in its town. If the only opportunity for public comment on ordinance changes is given during two council meetings, the industry should make sure that they receive a copy of the council meeting agenda prior to each months meeting. When sewer use ordinance modifications are on the agenda, the plant should obtain a copy, and complete a thorough review of the draft.

Local Limits

As part of the development of a pretreatment program, each POTW must develop specific local limits in accordance with 40 CPR 403.5(c). In some cases, towns have found it easier to determine their local limits by conducting a poll of other POTWs and adopting the most common limits. As long as these limits are stringent enough to protect the WWTP and the receiving stream, they are approved by the approval authority. If the limits are too stringent, the approval authority usually assumes that the POTW is reserving capacity for future use. Therefore, the first request that an industry should make when reviewing its permit or the sewer use ordinance limits is to see the calculations on which the limits are based.

If the POTW has adopted local limits derived from site specific information, they are said to have technically based local limits. The process for developing technically based local limits involves determining the maximum amount of each pollutant acceptable to the influent (or headworks) of the WWTP, while still protecting the receiving water, the WWTP itself, and the POTW's sludge disposal options. This process is called a headworks analysis. As usual EPA has supplied POTWs with enough guidance via procedures manuals and computer programs to enable a POTW to complete a headworks analysis with a minimum of site specific information. Therefore, when an industry asks about the origin of local limits they may be told that the town has technically based limits and presented with a computer printout of the headworks analysis. Such a response from the POTW should not be the end of the industry's questions on local limits but rather the beginning of a detailed review of the headworks analysis.

The headworks analysis can be divided into three sections: pass through calculations, interference calculations, and sludge calculations. An allowable influent load is calculated for each of the three sections. The three allowable influent loads are then compared and the most restrictive calculation is used as the basis for the final local limits.

Summary

The only way to implement a fully effective pretreatment program is for federal and state regulators, local POTWs, and industrial users, to cooperate toward achieving a mutual goal: the protection of the receiving water and the town's wastewater treatment investment. In order to maintain the best possible cooperation, all parties involved must have a thorough knowledge of the general pretreatment requirements and an understanding of how these requirements helped to develop the POTW's site specific pretreatment program. Industries must take responsibility for understanding the pretreatment program and, in some cases, for educating the POTW in alternative ways to implement its pretreatment program. Industries that do take an active role in the development and implementation of their POTW's pretreatment program, may find that local pretreatment standards and requirements are more stringent than those required by federal regulation, or those needed to protect the WWTP and the receiving water. The aquatic fisheries processing industry needs to ensure that the nation's waters are protected at the same time they need to be sure that they can comply with these regulations.

ATTITUDE

Top management is responsible for a firm's accomplishments in the environmental field. Management's attitude is responsible for water use reductions and waste elimination. The lowest cost control measures usually are those that attack the problem at its source. No change for a food plant can be implemented successfully without management attention.

A thorough understanding of the production process can help to eliminate excessive water use and waste. Many authors have indicated that waste problems in food plants can best be solved by developing byproducts for animal feed. Animal feed byproducts often do not provide economical solutions. Also, the solutions provided often only alleviate or offer temporary solutions until the byproduct market dies.

Joseph T. Ling (3-M Company, VP) noted that we must mandate conservation oriented technology which means utilizing a minimum of resources while creating a minimum of pollution. The authors of a booklet on water and waste management in food processing noted that the traditional sanitary engineering approach of developing treatment processes would not solve the waste control problems of the modem food industry. The authors concluded that a lack of communication between engineers and processors usually was the reason for this lack of success.

Many note the sufficient supply of quality water as an impending national crisis. Drought conditions, together with the increasing demands of an expanding population, and growing industrial needs, underscore the importance of adequate supplies of high quality water. Conservation and industrial water use are inextricably linked with other state and national concerns for environmental quality, energy conservation, agricultural production needs, industrial development, municipal requirements, recreational, and wildlife needs.

MANAGEMENT

Management and Process Changes

The four factors directly related to pollution that would induce a food processing plant manager to incorporate management and process changes designed to reduce waste load, are the following:

Public image	Efficiency
Cost reduction	Regulatory requirements

Public Image

Most food processing plants are very concerned about public image. They do not want to be recognized as a polluter which has a very negative public image. Food plants processing under brand names are probably more concerned by this public perception.

Reducing waste load from a food plant not only can reduce costs, but in plants discharging to a municipality, it also helps the municipality reduce costs. Reduced loads for municipalities should reduce municipal treatment costs, minimize need for expansion of treatment facilities, help to maximize treatment efficiency and allow new citizens and businesses into publicly owned treatment works (POTW's) with peak loading.

Efficient

Food plants that reduce wastes, often find they also increase plant efficiency. As wastes are eliminated, and more byproduct is recovered, there is often more product packaged for sale.

Cost Reduction

Costs for water, sewer, surcharge, and waste disposal are becoming significant expenditures for food processing plants. These costs have risen almost 10 fold over the last several decades, possibly more than any other cost for food processing. A recent survey by Arthur Young, led George Rafetelis to conclude that water costs could increase as much as 500 percent in the next five to ten years.

Regulatory Requirements

External restraints are another factor that can influence a food plant to consider water and waste reduction programs. These restraints can include effluent restrictions on selected wastewater parameters such as BOD_5 chemical oxygen demand (COD), fats, oils and greases (FOG), total kjeldahl nitrogen (TKN), and flow. These restrictions can adversely effect plants.

Aquatic Products Wastewater Characteristics

Introduction

The aquatic products processing industry is made up of the seafood industry with many small processing centers located along the United States coastlines, aquaculture centers such as trout in Idaho and catfish in Mississippi, and a number of larger plants located near industry and population centers. The industry involves the processing of numerous species of seafood including

- mollusks (oysters, clams, scallops)
- crustaceans (crabs and lobsters)
- various species of both salt- and fresh-water fish.

Seafood processors use the following major unit processes: washing eviscerating dressing, processing, and rendering. Rendering of whole fish and fish by-products produces fish meal, oil, and solubles.

Seafood Industries

Bottom Fish

The most economically important bottom fish species which are primarily marketed fresh or frozen as:

- **Haddock**
- **Halibut**
- **Cod**
- **Ocean Perch**
- **Whiting (silver hake)**
- **Flounder**
- **Hake**
- **Pollock**

Industrial Fisheries

Menhaden, herring and alewives are oily fishes which comprise the bulk of the "industrial fisheries" in this country. They are rendered into meal, oils, and solubles. The meal is used primarily as animal feed and fertilizer. The oil becomes an ingredient in paints, varnishes, resins, and similar products. It is also added to animal feed, or used for human consumption abroad. The solubles are either fed directly to animals or are dried and processed into meal.

Anadromous Fishery

The only significant commercial anadromous fishery in the U.S. is the salmon fisher. The five main species harvested in this country are:

- **Chinook (king)**
- **Silver (coho)**
- **Chum**
- **Sockeye (red)**
- **Pink**

The major portion of the salmon catch is canned.

Tuna

Tuna ranks as the number one seafood in the United States. Americans consume over one billion cans of tuna per year. Tuna are large migratory fish which feed on smaller macroscopic sea life.

Shrimp

The shrimp fishery in terms of total value is the most important in the United States. Currently the most important finished products are frozen and breaded shrimp.

Crabs

The blue crab is harvested on the Atlantic Coast, principally in the Chesapeake Bay area. The remaining harvest takes place on the Pacific Coast where Dungeness crab is the leading species followed by Alaskan king crab.

Clams

The surf clam is a relatively recent addition to the Atlantic Coast shellfish processing industry. The major industry growth occurred in the mid 1940's and in 1958, when new offshore beds near Long Island, New York were discovered. Hard clams account for only 12 percent of the landings but about 50 percent of the value. The Chesapeake and Middle Atlantic areas combine for much of the clam landings.

Aquaculture

Catfish is a rapidly expanding industry located primarily in the South. Trout is primarily located in Idaho with North Carolina and California developing segments. The striped bass is being explored.

Seafood Processing

Major types of wastes found in seafood processing wastewater-s are blood, offal products, viscera, fins, fish heads, shells, skins and meat “fines.” These wastes contribute significantly to the suspended solids concentration of the waste stream. However, much of the solids can be removed from the wastewater and collected for animal food.

Water Use

Tuna processing plants were reported to have wastewater discharge as high as 3,600,000 GPD (Table 5). Bottom fish wastewater discharge ranged from 6,000 - 400,000 GPD. Fish meal plants ranged from 10,000 - 92,000 GPD in the survey.

Wastewater Characteristics

Carawan et al (3) reported on an EPA survey with BOD, COD, TSS and oil and grease (FOG) parameters. Bottom fish were found to have a BOD, of 200-1000 mg/l, COD of 400-2000 mg/l, TSS of 100-800 mg/l and FOG of 40-300 mg/l (Table 3). Fish meal plants were reported to have a BOD_5 of 100-24,000 mg/l, COD of 150-42,000 mg/l, TSS of 70-20,000 mg/l, and FOG of 20-5,000 mg/l, COD of 150-42,000 mg/l, TSS of 70-20,000 mg/l, and FOD of 20-5,000 mg/l. The higher numbers were representative of ballwater only. Tuna plants were reported to have a BOD, of 700 mg/l, COD of 1600 mg/l, TSS of 500 mg/l and FOG of 250 mg/l. Seafood processing wastewater was noted to sometimes contain high concentrations of chlorides from processing water and brine solutions, and organic nitrogen (O-300 mg/l) from processing water.

Fish Processing

Tuna. In an EPA report (8), the authors noted that the annual tuna catch averages about 400 million pounds, almost all of which is canned. They concluded that as much as 65 percent of the tune is wasted in the canning process. The degree of wastage depends somewhat on the species being processed so variations will occur. They reported on a study that examined the waste from a tuna canning and by-product rendering plant in detail for a five-day period. The following observations were made:

- The average waste flow was 6,000 gal/t of fish.
- Wastewater varied from 500-1,550 mg/l BOD_5
- The average daily COD ranged from 1,300-3,250 mg/l.
- The total solids averaged 17,000 mg/l of which 40 percent was organic.

Detailed average tuna wastewater characteristics are given in Table 6.

Table 5. Raw Wastewater Characteristics - Canned and Preserved Seafood Processing Industries					
Subcategory	Flow	BOD	COD	TSS	FOG
	(GPD)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Farm-Raised Catfish	21M-45M	340	700	400	200
Conventional Blue Crab	700	4400	6300	620	220
Mechanized Blue Crab	20M-73M	600	1000	330	150
West Coast Shrimp	90M-160M	2000	3300	900	700
Southern Non-Breaded Shrimp	180M-240M	1000	2300	800	250
Breaded Shrimp	150M-200M	720	1200	800	---
Tuna Processing	65M-3.6M	700	1600	500	250
Fish Meal	92M-lOM[a]	lOO-24M[a]	150-42M[a]	70-20M[a]	20-5M[a]
All Salmon	58M-500M	253-2600	300-5500	120-1400	20-550
Bottom & Finfish (all)	6M-400M	200-l000	400-2000	100-800	40-300
All Herring	29M	1200-6000	3000-l0000	600-5000	600-800
Hand Shucked Clams	86M-170M	800-2500	1000-4000	600-6000	16-50
Mechanical Clams	300M-3MM	500-1200	700-1500	200-400	20-25
All Oysters	14M-320M	250-800	500-2000	200-2000	10-30
All Scallops	lM-115M	200-l0000	300-l1000	27-4000	15-25

- Higher range is for bailwater only
M - 1,000
MM - 1,000,000

Reference 3

Table 6. TUNA WASTE CHARACTERISTICS

Parameters	Concentration	Local
	(mg/1	lbs/fish 1,000 lb
COD	2,273	64.5
BOD_5	895	24.0
TS	17,900	475.0
TSS	1,081	29.0
FOG	287	7.5

Reference 8

Finfish Handling and Processing

Carawan and Thomas (12) surveyed the North Carolina seafood industry. They examined finfish handling practices in North Carolina related to wastewater. Finfish primarily include flounder, croaker, trout, spot and bluefish. Unloading, washing and separating ice, sorting grading and re-icing before shipping all constitute finfish handling. Most of the wastes were generated from the debris and ice removal in the washing tank.

Results of the survey (Table 7) found that total solids averaged 2.4 ash 1.11, organic solids 1.30 and BOD_5 0.23 lb/1000 lb while water use was 110 gal/l000 lb of fish handled. Table 8 illustrates the species differences found during handling of fish.

Scales may drop off during unloading, contributing large amounts of settleable solids to the waste load. Slime, blood and sand were also found to be part of the wastewater. Fish were strenuously washed, and removed materials were measured to gain an idea of maximum waste load.

Average BOD_5 of rinse tank wastewaters was 251 mg/l. Scales seemed to constitute the bulk of the solids in the effluent from the wash tanks surveyed. The scales and other solids were removed during screening with a 20 mesh screen. Results of screening tests are tabulated in Table 9. Some 74-90 percent of the settleable solids were removed with the screen.

North Carolina finfish processors use hand labor in processing flounder, trout and croaker. Carawan and Thomas (1981) examined three finfish processing plants. These three plants were processing 715-1000 lb/hr of flounder, trout and croakers in the round or fillet. Raw effluent from these plants had the average characteristics as listed in Table 10. The average water use was 1.34 gal/lb and the wastewater BOD_5 was 190 mg/l.

Plant review confirmed that controlling waste solids greatly influenced the wastewater characteristics. Of 29 plants surveyed by Carawan and Thomas, 9 sent their solids for dehydration, 12 used their solids for bait and 8 plants disposed of all the material overboard.

One processor cooperated in an experiment where raw fish frame composting was tried as a disposal method. Grass cuttings, pine straw, horse manure and soil were mixed and composted for six weeks. Raw fish frames were added and completely decomposed within 4 weeks.

Table 7. Water Use and Wastewater in Finfish Handling

Parameter	Waste Load	
	(lb/1000 lb)	
	Average	Range
Total Solids	2.40	.87-4.60
Ash	1.11	.53-2.15
Organic Solids	1.30	.34-2.44
BOD_5	.23	.01-1.00
	(gal/1000 lb)	
Wastewater	110	60-180

Table 8. Waste From Fish Handling

	Trout	Croaker	Flounder
	(lbs/1000 lbs)		
Total Solids	6.56	4.08	3.20
Organic Solids	4.06	1.98	1.36
Ash	2.50	2.10	1.34

Table 9. Effect on Screening on Fish Handling Wastewater

	Settleable solids			
	Plant 1	Plant 2	Plant 3	Average
	(mg/l)			
Effluent				
Raw	3.8	20.0	100	41
Screened	1.0	2.0	14	5.7
Removal (%)	74	90	86	86

Table 10. Water & Wastewater for NC Finfish Processors					
	Rinse Tank	Mechanical Scaling	Fillet & Scaling	Cleanup	Total
(lb/1000 lb raw fish)					
TS	2.08	4.74	3.44	0.27	10.53
Ash	0.37	2.03	1.37	0.12	3.89
OS	1.71	2.60	2.08	0.15	6.54
TSS	0.38	2.59	0.86	0.09	1.96
DS	0.71	1.85	2.96	0.13	5.65
BOD	0.59	0.56	0.86	0.10	2.11
FOG	0.10	0.30	0.71	0.03	1.14
(gal/1000 lb)					
Flow	544	318	457	16	1335

Table 11. Sources of Waste in a Frozen Fish Factory

Description of Source	
1.	Fish Handling on Board: Manner in which fish are conveyed from nets to hold can reduce quality and yield from cut fish
2.	Unloading Fishing Vessels: Use of water to convey fish to wash tank for rinsing
3.	Fish Handling Operations on Land: Conveyors from waste tank to processing rooms
4.	Cleanup Operations in Processing Room: Wash down of processing equipment
5.	Compressors/Cooling Tower Water
6.	Solid Waste Through Mishandling of Whole Fish

Reference 4

Table 12. Bottom Fish Processing Wastewater Characteristics

Reference	BOD_5 (mg/l)	TSS (mg/l)	Flow (GPM)
A	640	300	105
B	192-640		320-410
C	1,726		132
D		750	450

Reference 8

Bottom Fish

Sources of waste in a bottom fish factory are identified in Table 11. Bottom fish processing wastewater characteristics are presented in Table 12. The average waste load for Reference B was 31 lb. BOD_5/1,OOO lb. raw fish.

Salmon

Large salmon plants use less water for production than do small salmon plants (Table 13). Large salmon plants have less waste load than do small salmon plants.

Table 13. Salmon Wastewater Characteristics		
Parameters	Large Salmon Processing Average	Small Salmon Processing Average
Flow- (gal/l,000 lb)	374	1186
BOD- (lb/l,000 lb)	1.13	5.2
SS- (lb/l,000 lb)	1.3	2.2
Grease/Oil- (lb/l,000 lb)	0.8	2.2

Reference 10

Gulf Shrimp Canning

Peelers use as much as 58.1% of the average water use in gulf shrimp canning plants (11). The BOD_5 from these plants is 1,081 mg/l (11).

Table 14. Gulf Shrimp Canning, Water Use and Wastewater	
Unit Operation	Percent of Average Flow
Peelers	58.1
Washers	8.8
Separators	6.9
Blancher	1.6
De-Icinq	4.2
Cooling/Retort	12.1
Washdown	8.3

Reference - pg. 15,ll

Table 15. Gulf Shrimp Canning		
Parameter	Average Concentration	Load
	(mg/l)	(lbs/1,000 lbs)
BOD_5	1,081	46
COD	2,296	109
FOG	258	11
TKN	196	7.6
N-NH,	802	37.7

Reference - pg 16, 11

Blue Crabs Conventional (as contrasted with mechanical) blue crab processing has a flow of about 756 gal per 1,000 pounds of crabs processed. The BOD_5 load is 2.67 lbs per 1,000 pounds of crabs while the TSS load is 1.92lbs.

Soft-Shell Clams Clam shucking has a wastewater discharge of about 164 gal per 1,000 pounds of clams processed. The BOD_5 and TSS loads are 2.49 and 0.74 lbs per 1,000 pounds of clams, respectively.

Atlantic Oysters Hard shucked (Atlantic oysters) processing requires about 2,868 gal per 1,000 pounds of oysters. The BOD_5 load is 25.24 while the TSS load is 8.73 lbs per 1,000 pounds of oysters.

Table 16. Blue Crabs (Conventional Process)		
Parameter	Unit	Mean
Flow Ratio	(Gal/l,000 lb)	756
Settleable Solids	(mg/l)	2.79
TSS	(lbs/l,OOO lb)	1.92
BOD_5	(lbs/l,OOO lb)	2.67
FOG	(lbs/l,OOO lb)	0.04
Phosphorus (Total)	(lbs/l,OOO lb)	0.04
N-NH,	(lbs/l,OOO lb)	0.04
TkN	(lbs/l,OOO lb)	0.27
PH		7.63

Reference 1

Table 17. Soft-Shell Clams (Hand-Shucked)		
Parameter	Unit	Mean
Flow Ratio	(gal/l,000 lb)	164
Settleable Solids	(mg/l)	1.40
TSS	(lbs/l,OOO lb)	0.74
BOD_5	(lbs/l,OOO lb)	2.49
FOG	(lbs/l,OOO lb)	0.01
Phosphorus (total)	(lbs/l,OOO lb)	0.04
N-NH,	(lbs/l,OOO lb)	0.01
TkN	(lbs/l,OOO lb)	0.20
PH		7.11

Reference 1

Table 18. Atlantic Oysters (Hand-Shucked)

Parameter	Unit	Mean
Flow Ratio	(gal/l,000 lb)	2,868
Settleable Solids	(mg/l)	1.66
TSS	(lbs/l,OOO lb)	8.73
BOD_5	(lbs/l,OOO lb)	25.24
FOG	(lbs/l,OOO lb)	0.11
Phosphorus (total)	(lbs/l,OOO lb)	0.28
N-NH,	(lbs/l,OOO lb)	0.08
TkN	(lbs/l,OOO lb)	3.12
PH		7.15

Reference 1

JAPANESE FOOD FISH FACTORIES

The Japanese have an extensive background in processing fish into various food products. Japanese fish factories have calculated water use at 1800 gal / 1000 lb to 6,000 gal / 1000 lb for the various types of plants. If the highest waste load and lowest volume are used for calculations of wastewater strength, the BOD_5 could exceed 7,000 mg/l for surimi processing. However, average values calculated from Japanese Fish factories indicated BOD's of 750 mg/l for tuna, 240 mg/l for frozen fish, 205 mg/l for kamaboko and 3,625 mg/l for surimi. The wastewater parameters reported in Table 19 are also for Japanese fish products factories. Surimi plants would have a BOD_5 of 8,204 mg/l. Kamaboko plants would have a BOD_5 of 6,776 mg/l while fish meal plants would have a BOD_5 of 18,400 mg/l. Another Japanese scientist reported that water use in surimi processing was twenty-five times the throughput. Thus, water use is 3,000 gal/l000 lb fish or 27,300 gal/l000 lb surimi. This can be contrasted with the reported volume of 4,800 gal/l000 lb fish.

The Industrial Fisheries

In a properly managed menhaden rendering plant, wastewater quantities are small. The only inherently troublesome wastewater source is the fish pumping water. The other wastes result from spills and leakages, both of which can be minimized.

The menhaden is a small, oily fish of the herring family. This fishery, largest in the United States, is located mainly in the Middle Atlantic and Gulf states including North Carolina. Menhaden have been used primarily for the manufacture of fish meal, fish solubles and oil. The manufacturing process is (in most cases) highly mechanized.

The fish are caught in purse seines and pumped into the fish holds for transport to the plants. Then the fish are pumped from the holds, washed, automatically weighed and conveyed into the plant. Continuous steam cooking is normally employed. The cooked fish are the pressed to remove the oil and most of the water. This press water is screened to remove solids and centrifuged to separate the oil. The remaining water, called stickwater, is descharged or evaporated to produce condensed fish solubles. The solid residual from which the water and oil have been pressed is known as "pressed cake." The pressed cake is dried to about 10 percent moisture and then ground for fish meal.

The wastewaters from the production of fish meal, solubles, and oil from herring, menhaden, and alewives can be divided into two categories: high-volume, low-strength wastes and low-volume, high-strength wastes. The high-volume, low-strength wastes consist of the water used for unloading, fuming, transporting, and handling the fish plus the washdown water. The fuming flow has been estimated to be 200 gal/t of fish with suspended solids of 5,000 mg/l. The solids consist of blood, flesh, oil and fat. The above figures vary widely. Other estimates listed herring pump water flows of 250 gpm with total solids concentrations of 30,000 mg/l and oil concentrations of 4,000 mg/l. The boat's bilge water has been estimated to be 400 gal/t of fish with a suspended solids level of 10,000 mg/l.

The stickwaters comprise the strongest wastewater flows. The average BOD_5 value for stickwater ranges from 56,000-112,000 mg/l, with average solids concentrations, mainly proteinaceous, ranging up to 6 percent. The fish processing industry has found the recovery of fish solubles from stick-water to be at least marginally profitable. In most instances, stickwater is now evaporated to produce condensed fish solubles. Volumes have been estimated to be about 120 gal/t of fish processed.

Dried scrap and meal are the most highly valued products from menhaden, although oil production was the initial reason for processing. Most of the scrap and meal is used as an animal feed supplement.

Summary

Wastewater from fish processing and industrial fisheries is very diverse and varies with management and process practices. Each plant is unique so generalizations about water use and wastewater characteristics are difficult. However, average numbers for water use and waste load appear to have value for each industrial category.

Table 19. Wastewater Parameters in Japanese Product Factories

Parameter	Factory Type Surimi	 Fish Meal	 Kamaboko
	Wastewater Concentration		
	(mg/l)		
BOD_5	8,204	18,400	6,776
COD	1,210	5,032	606
SS	757	1,683	578
Fat	541	1,743	149
NH_3-N	15	86	5
TkN	305	912	199

Table 20. Measures to Control Water Use, Product Loss and Waste Load

Number	Measure
1.	Management understanding, interest and support
2.	Installation of modern equipment and piping to reduce loss of product and maximize recovery of byproducts
3.	Appointment of water-waste supervisor
4.	Employee training
5.	Accurate records of water use and waste
6.	Scheduling to reduce water use and waste
7.	Proper cleaning procedures
8.	Wastewater monitoring
9.	Planned maintenance program to reduce losses and waste
10.	Planned quality control program to reduce losses and waste
11.	Planning systems for wasted product and byproducts
12.	Development of alternatives for wasted product recovery

Methods of Reduction

There are three proven ways to reduce water use, wastewater discharge, waste loads, and product loss. One method is to operate the plant more efficiently. The second method is to institute process changes proven to reduce water use, product waste, and waste loads. The third method is to install conventional pretreatment technologies such as clarifiers, separators and / or dissolved air flotation (DAF) units to remove settleable (floatable) solids. Measures to control water use, product loss and waste load are given in Table 20.

Pollution Prevention Pays Concept

Although many scientists and technical people have practiced pollution prevention, Dr. Joseph T. Ling of the 3M Company can be credited with first using the 3M Pollution Prevention Pays (3P) program.

Dr. Ling concluded that government, industry, and the public are beginning to become aware of the shortcomings of conventional pollution controls, not to mention their cost. "Pollution Prevention Pays" utilizes the concept that the conservation approach should be used to eliminate the causes of pollution before spending money and resources for clean up afterward. Dr. Ling defines the conservation approach as the practical application of knowledge, methods, and means to provide the most rational use of resources to improve the environment.

Dr. Ling believes that the pollution prevention approach is hindered or precluded by many rigid environmental laws and regulations. One current example is municipal pretreatment ordinances with specific limits on the concentration of pollutants in wastewater discharge. For food processing plants, maximum concentration limits on compatible pollutants, such as BOD_5, often preclude water reuse and recycling. Studies indicate that plants with the least amount of water use per unit of product processed have the least amount of pollutants per unit of product processed. Thus, such ordinances may discourage water conservation and waste reduction practices.

Dr. Ling noted that pollution controls solve no problem; they only alter the problem. He notes there is a significant opportunity if realistic and effective solutions are sought for pollution problems.

Pretreatment of food plant wastewater does not really solve a pollution problem. Instead, pretreatment generates secondary nutrients (sludge) that must be disposed of properly to prevent moving the pollution to another location. As pretreatment or treatment requirements increase, resources are consumed, and residues are produced-the costs incurred rise exponentially. Dr. Ling defined this environmental paradox as follows: "It takes resources to remove pollution: pollution removal generates residue; it takes more resources to dispose of this residue and disposal of this residue also produces pollution."

Michael G. Royston recognized pollutants as material residues from industrial, domestic or agricultural processes which are discharged into the environment. He concluded that such materials could either be reused or they should not have been produced in the first place. Royston noted that pollution acts as an indication of inefficient processes. He concluded that as inefficiencies are reduced, so is pollution reduced.

The aquatic products processing industry has an opportunity to increase plant efficiency, reduce pollution, conserve water (one of our most vital resources), and increase profitability. Knowledge, management commitment, thorough understanding of the processes, and employee education, are the key components of a successful program.

The Time To Act Is Now

Many changes are taking place in waste regulations. Water and waste costs are creeping steadily upward, and the increases promise to continue. It's important for aquatic fishery products processors to take action now to be prepared for limitations on water use and waste loads that are likely to occur in the not-sodistance future. Reduce your plant's waste load before it has a chance to become a costly burden. Follow the waste reduction hints suggested in Table 21.

Table 21. Waste Reduction Hints

Reduce water use; most water used in processing becomes wastewater.
Use screens and efficient systems for recovering solids.
Install dry systems for solid waste collection.
Collect solids from the floor and equipment by sweeping and shoveling the material into containers before actual cleanup begins. Do not use water hoses as brooms.
Adopt the attitude that waste load reduction is one of the best business decisions a manager can make.
Train employees in the concepts of pollution prevention, and show them how to perform their jobs in a way that will cut waste loads in your plant.

EXAMPLES

Groundfish. A Canadian study (13) compared extensive wastewater analysis for dry and wet line processing of groundfish. The wet line data indicates that wet line processing produces an effluent in excess of three times the dry effluent loadings. The authors concluded that the excess was due to the following:

A) Increased BOD_5 suspended solids, and oil concentrations in the wet line effluents supporting the theory that the longer water is in contact with fish solids, the higher the wastewater parameters will be.

B) Water consumption for wet processing was two to three times that required for dry processing.

They concluded that the widespread adoption of dry transporting techniques as opposed to fuming would save water and reduce wastes.

Table 22. Comparison of Wet and Dry Line Groundfish Processing

Plant	Mean Wet Processing Load			Mean Dry Processing Load		
	BOD_5	TSS	FOG	BOD_5	TSS	FOG
	-------(lb/1000 lb fish)			----------------------		
1				5.7	2.4	1.0
2				2.7	1.6	0.75
3				1.3	0.98	0.13
4				5.0	1.0	1.0
5				7.9	22.5	--
6	15.0	7.0	13.0			
7	18.0	34.0				
8	20.2	7.1				
9	18.8	12.0				
AVG.	18.0	15.0	13.0	4.5	5.6	0.72

Frozen Fish. A research team (4) predicted that five process changes could prevent 250,000 lb BOD_5 per year and eliminate the need for 15 million gallons of potable water annually. Initial costs to implement the changes would be $300,000. Annual costs would be about $300,000 per year with annual net savings approaching $9OO,OOO.

Shrimp Processing. The wastewater from most breaded seafood shrimp plants exceeds 2,000 mg/l of BOD_5. It often contains large amounts of organic matter, small particles of shrimp flesh, breading, soluble proteins, and carbohydrates. Georgia researchers studies how to reduce the pollutants and this was summarized (2).

Screening reduced the BOD_5 load from processing operations by 38 percent, from 117 pounds to 72 pounds per thousand pounds of green headless shrimp processed. The BOD_s load resulting from cleanup operations was decreased 53 percent, from 104 pounds to 49 pounds. The total BOD_s load was reduced from 221 to 121 pounds per day. Thus screening decreased the total raw waste load at this plant by 45 percent.

Cleaning up production areas by dry methods before flushing them with water is another way to keep pollutants out of drains. Although screening had reduced waste loads greatly, plant managers and scientists wanted to see whether dry cleanup methods could cut the BOD_s load even further.

The answer was yes! The waste load resulting from cleanup operations was reduced further from 49 pounds of BOD_s per thousand pounds of shrimp processed to only 21 pounds, as the table shows. This decrease of 57 percent in cleanup load meant a further 13 percent decrease in overall BOD_s load. Dry cleanup tips are presented in Table 24.
Before screening the total $B0D_5$ load was high: 221 pounds per thousand pounds of shrimp

processed. After the change to screening and dry cleanup, the total BOD_5 load dropped to only 92 pounds per thousand pounds, a decrease of almost 60 percent.

Another study (15) of a shrimp canning plant found that an effective water and wastewater management program could result in a 60.1 percent reduction in BOD_5 load. Further, the cost of such a program was estimated at $0.013 per pound BOD_5 as contracted with $0.65 for screening and $0.83 to $7.18 for DAF removal.

Table 23. Effect of Screening and Dry Cleanup on BOD_5 Loads in a Shrimp Plant

Operation	Before	With Screening	With Dry Cleanup and Screening
($lb\ BOD_5$/l,OOO lb shrimp)			
Processing	117	72	71
Cleanup	104	49	21
Total	221	121	92

Table 24. TIPS FOR EFFECTIVE DRY CLEANUP

Collect any dripping batter by placing pans under breading tables.

Squeegee spilled batter into a pan from the floor so batter will not enter the drain during wet cleanup.

Empty batter tanks into barrels instead of pumping their contents into the drain.

Place trays under conveyor belts to catch particles of breading-- a concentrated source of soluble and suspended BOD_5.

Place trays under machines to help keep breading off the floor.

Remove leftover breading from machines such as sifters by hand, not hosed or air-gunned, so that it will not enter the drain.

Dry cleanup utensils should be cleaned and stored separately from regular wet cleanup gear.

Use a stiff broom to sweep breading from the floor. Scraping and then brushing is the only effective way to recover breading from under equipment.

Place salvaged breading in barrels so it can be given or sold for animal feeding; it is a good source of carbohydrates and energy.

Remove shrimp hulls by dry cleanup whenever possible. When left in contact with water, enzyme action turns them into a major source of pollution.

Install a hydro-sieve to remove any shrimp hulls and particles that enter the floor drains during wet cleanup. Collect material in a dumpster and dispose of it in an approved manner.

Look for opportunities to make use of waste materials. Sieved wastes containing shrimp hulls, breading, and other particulate wastes can be rendered into meal for animal food if enough can be collected.

***REMEMBER: Keep breading off the floor and out of drains!

What Can You Do?

If you're the manager of a firm ,you may have an opportunity to reduce wastes and save money. Reducing water use and waste load now could save you that much money next year. If water and sewer costs increase tenfold over the next decade, you may be able to save many dollars annually by 1998. Here are some suggestions to help you conserve:

- Ensure that plant managers measure water use daily or at each shift change.
- Emphasize to personnel at all levels that conserving water and reducing waste load are sound business practices.
- Appoint someone in each plant to be responsible for water conservation and waste reduction practices and for monitoring their effectiveness.
- Provide a training program for your managers and employees.
- Show your interest and example that you take water conservation and waste reduction seriously. Helping your personnel develop the proper attitude is 90 percent of the battle. It starts at the top.

DIRECT DISCHARGE

After you have implemented effective controls, direct discharge has been suggested as possible by some researchers and not possible by others. In fact, such determinations probably must be made on a site-specific basis. Current EEA requirements mandate screening although various states and EPA offices seem to reach different conclusions in regard to specific requirements for seafood processors.

Researchers (17) studying the discharge from the tuna processors on Terminal Island, CA, noted that the processor's discharges enhanced the food chain. The researchers concluded that energy-rich effluents should be utilized by developing alternative methods for waste management and new regulatory concepts, rather than imposing traditional secondary treatment.

Environment Canada researchers (13) concluded that all major effluents associated with fish processing are of sufficient strength to require some type of treatment. In the majority of cases the removal of solids is adequate treatment to protect the receiving environment as this will prevent a build up of sludge around the effluent out fall with its consequent effect on dissolved oxygen. Following screening the effluent should be discharged through an out fall which allows sufficient tidal flushing action to dilute the remaining effluent and thus minimize pollution problems.

Georgia researchers (18) studied the flushing of shrimp heads from the coastal waters surrounding Brunswick Harbor. They concluded that shrimp heads were flushed away from the areas where they were deposited within two to four days.

CONCLUSION

Aquatic products processing environmental issues will be prominent in the 1990's. Management must plan now to comply with new environmental regulations, as well as minimizing costs and insuring the delivery of safe, nutritious fishery products to the consumer.

REFERENCES

1. Brinsfield, Russel B. and Douglas G. Phillips. 1977. "Waste Treatment and Disposal From Seafood Processing Plants." U.S. Environmental Protection Agency, ADA, OK 74820

2. Carawan, Roy E., 1988. Preventing Pollution in Shrimp Processing. CD-25. The North Carolina Agricultural Extension Service, North Carolina State University, Raleigh, NC 27695. 4 pp.

3. Carawan, Roy E, James V. Chambers, Robert R. Zall, and Roger H. Wilkowske. 1979. "Spinoff on Seafood Water and Wastewater Management." Extension Special Report No. AM-18F. North Carolina State University, Cornell University, Purdue University, and Science and Education Administration-Extension USDA-Washington, D.C.

4. Carawan, Roy E., David P. Green, Frank B. Thomas, and Sam D. Thomas. 1986. Reduction in Waste Load From a Seafood Processing Plant. The North Carolina Agricultural Extension Service. North Carolina State University, Raleigh, NC 27695. 89 pp.

5. EPA. January 1974. Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Catfish, Crab, Shrimp, and Tuna Segment of the Canned and Preserved Seafood Processing Point Source Category. U.S. EPA, Washington, D.C.

6. EPA. January 1975. Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Fish Meal, Salmon, Bottom Fish, Sardine, Herring, Clam, Oyster, Scallop, and Abalone Segment of the Canned and Preserved Seafood Processing Point Source Category. U.S. EPA, Washington, D.C.

7. Goldhor, Susan H. and Joe M. Regenstein. 1991. Improving the Profitability of Finfish Processing Waste: Options for Fish Processors with an Emphasis on Mechanical Deboning (Mincing), Hydrolysis (Liquid Fertilizer Production), and Composting. New York Sea Grant Institute.

8. Jones, Harold R. Pollution Control in Meat, Poultry, and Seafood Processing. Noyes Data Corporation, Park Ridge, N.J. 1974.

9. Laughlin, W. M., P. F. Martin, and G. R. Smith. 1973. Processed Crab Waste: Liming and Fertilizer Value on Two Alaskan Soils. Research Report 73-l. University of Alaska Institute of Agricultural Sciences and Agricultural Research Service, U.S. Department of Agriculture.

10. Lin, S. S., and Paul B. Liao. 1979. Evaluation of an Extended Aeration Process for Skokomish Salmon Processing Wastewater Treatment. Industrial Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, Ohio 45268

11. Mauldin, A. Frank, and A. J. Szabo. 1974. Shrimp Canning Waste Treatment St. Project S 800904. Office of Research and Development, U. S. EPA, Washington, D.C. 20460

12. Otwell, W. Steven, ed. Seafood Waste Management in the 1980's: Conference Proceedings, Orlando, FL 1980. Report Number 40, Florida Sea Grant College, February, 1981.

13. Riddle, M. J. and K. Shikaze. 1973. Characterization and Treatment of Fish Processing Plant Effluents in Canada. Report No. EPS3-WP-741. Food and Allied Industries Division, Water Pollution Control Directorate, Environmental Protection Service.

14. Scott, Paul M., Marc D. Wright, and Wayne A. Bough. 1978. Characterization of Waste loading From a Shrimp Packing House and Evaluation of Different Screen Sizes for Removal of Heads. Georgia Sea Grant Program, Athens, GA 30602.

15. Szabo, A. J., larry F. LaFleur, and Felon R. Wilson. 1979. Dissolved Air Flotation Treatment of Gulf Shrimp Cannery Wastewater. industrial Environmental Research Laboratory, Office of Research and Development, U.S. EPA Cincinnati, Ohio 45268.

16. Wheaton, F. W., R B. Brinsfield, K. M. Lomax, and E. L. Geiger. "Blue crab processing plant effluent treatment." Journal WPCF, Vol. 56, 5:482

17. Soule, Dorothy F., M. Oguri, and John D. Soule. "Urban and Fish-Processing Wastes in the Marine Environment: Bioenhancement Studies at Terminal Island, California." Bulletin of the California Water Pollution Control Association, 15(1)58-63, July 1978.

18. Perkins, Brian E., Paul M. Scott, Wayne A. Bough, James M. Higgins, and Thomas D. Shierling. "Flushing of Shrimp Heads From Coastal Waters." Proceedings of the Third Annual Tropical and Subtropical Fisheries Technological Conference of the Americas, April 23-26, 1978; New Orleans, Louisiana, pp. 180-204, Compiled by R. Nickelson II (September 1978), TAMU-SG-79-101.

1 OCTOBER 1991-

Appendix A. Environment Canada Data

Environment Canada (13) have provided the fish processing industry with characterization and treatability data on their effluents. Although there is a good deal of variation in the effluent loadings determined for each type of effluent, characterization results are summarized in Table 25.

Table 25. Summary of Environment Canada Characterization Data (Averages)

Fish Processed	BOD_5 (lbs/1000 lbs raw product)	Suspended Solids (lbs/1000 lbs raw product)
Groundfish Filleting		
a) Dry Line	4.5	1.5
b) Wet Line	18.0	15.0
Salmon Processing	28.2	19.7
Herring		
a) Filleting	22.0	21.0
b) Marinated	215.0	85.0
Shellfish		
a) Lobster	25.0	5.5
b) Crab	40.0	20.0
Freshwater Fish		
a) Combined Perch and Smelt	4.5	2.3

Reference 13