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A Guide to Wastewater Management for Seafood Processors

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A GUIDE TO WASTEWATER MANAGEMENT FOR SEAFOOD PROCESSORS

BY

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The Virginia Sea Grant Program has the capability of assisting people with questions about water quality and wastewater discharge. For additional information and assistance call Dr. Bruce Neilson (804) 642-7204 at the Virginia Institute of Marine Science, or Dr. Gregory Boardman (703) 231-6020 at the Virginia Polytechnic Institute.

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PREFACE

Seafood and seafood processing have been important in the history and the economy of Virginia. Although segments of the seafood industry are in decline, particularly the oyster industry, some segments remain healthy and others are growing. The vitality of the industry depends on many factors, but a healthy seafood industry depends ultimately upon the health of the Chesapeake Bay. Thus it seems appropriate that the seafood industry should be a part of the efforts to restore the Chesapeake Bay. The moneys required for wastewater treatment can be large, however, and meeting all water quality objectives could have severe economic impacts for the seafood industry.

Water pollution control efforts began many years ago, but several major programs were initiated in the early 1970s. Many of the older, seafood processing facilities were grandfathered under the Clean Water Act Amendments of 1972, and the owners were not required to treat wastewaters. State and federal regulators paid particular attention to large municipal wastewater treatment plants and to industrial plants. The level of treatment given to wastewaters at these facilities has increased significantly over time as a result. Relatively little attention, however, has been given to seafood processors. Many seafood processors still provide minimal or no treatment to their wastewaters. Over the past few years, various segments of the seafood industry in Virginia have been scrutinized with regard to the wastewaters they discharge to state waters, leading many to perceive that the state wants this situation to change.

This manual is intended to aid members of the seafood industry as they work to meet the state's demands. In the first part of the manual, the principals of wastewater management are reviewed. These include the reasons why waste management must become a higher priority for seafood processors, the options for treating wastewaters, and the general requirements for disposing wastewaters on the land, to rivers and streams, and to the ocean. The second part of the manual deals with the ways that wastewaters can be treated to reduce both pollutants and water quality impacts. The characteristics of seafood processing wastewaters are reviewed in the third section, using hypothetical blue crab processing plants to illustrate the types of problems encountered and how these problems might be approached.

The citations for books and articles mentioned in the text are given at the back of the manual, along with a list of other reference materials. A glossary of technical terms also is provided. The words or phrases that are included in the glossary are printed in *italics*, at least for the first time that the word is used in a section.

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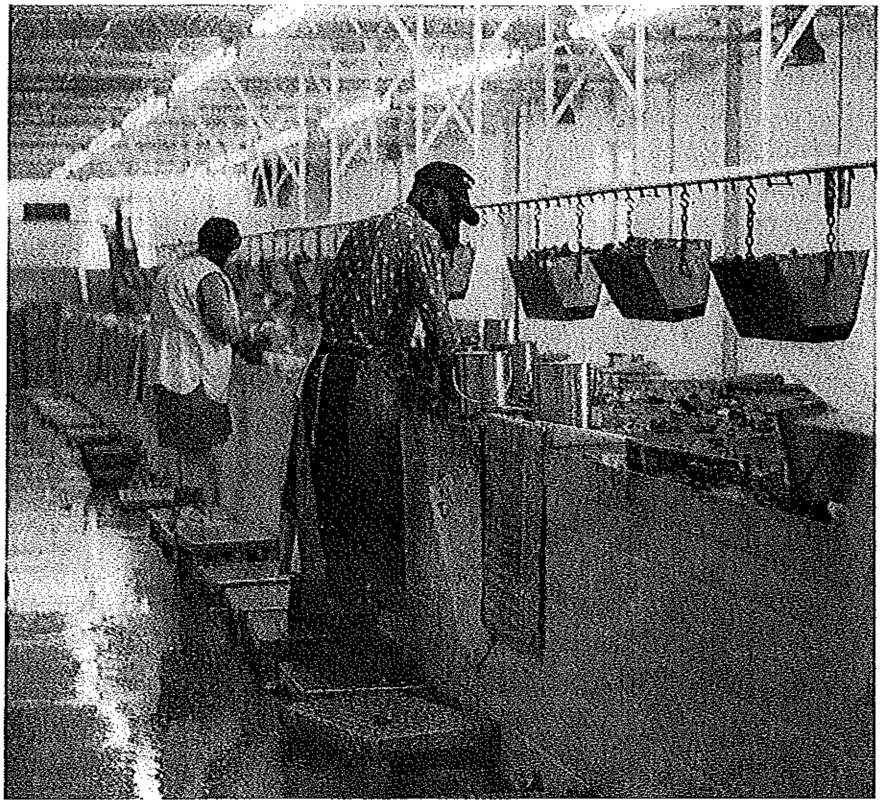


INTRODUCTION

Government agencies at all levels are exerting greater control over the environment. Disposing of seafood processing wastes is becoming very difficult and obtaining and renewing a wastewater discharge permit is complicated, time consuming and frustrating. Some feel that the government is interfering too much, but governmental regulations are not likely to disappear.

WHY ARE REGULATIONS NEEDED?

Polls show that the public desires a clean, safe, and healthy environment. As a consequence, both the U.S. Congress and the Virginia General Assembly have enacted legislation to achieve this goal (for example, see Clements, 1992). As public awareness of and concern for the environment have increased, so have the number and complexity of regulatory programs. Both water quality and air quality standards are becoming stricter and more difficult to meet, and disposal of solid wastes is no longer a simple matter of hauling materials to the local dump. Right or wrong, operating a business in the 1990s means dealing with a host of environmental regulations.

WHY ARE SMALL FACILITIES BEING FORCED TO DO THIS?

Many believe that industries and cities are the real culprits and cause most of the state's water quality problems. Industrial and municipal discharges are large in terms of the volumes of the flows, but the quality of these *effluents* has improved greatly over the last twenty years. In many instances, pollutant loads from industrial plants and municipal sewage treatment plants have decreased, even as production and sewage flows have increased.

Most towns, cities, and industries are responsible members of our community and have spent large sums of money on pollution control projects. These firms and local governments work hard to reduce pollution, if for no other reason than to avoid fines and bad publicity. Federal laws also provide for criminal penalties; a few Virginia residents have been sentenced to jail after having been convicted of consciously and knowingly polluting the environment. For all these reasons and others, the pollutant loads from large facilities have decreased substantially over the past twenty years. The facts show that cities and industries are not gross polluters of the state's water.

Although pollution control efforts have increased, population growth has been relatively rapid. This means that there is more pollution in the runoff from residential and commercial areas. With decreasing "point source" loads and increasing "non-point source" loads, the relative importance of the large facilities has decreased greatly. The emphasis of pollution control efforts consequently is shifting to (1) runoff from the land and (2) the many small wastewater dischargers. None of these has a large impact by itself, although the collective impact is great. If the combined effects are to be reduced, fairness and equity demand that ALL dischargers—not just a select few—be asked to reduce pollutant loads. Boaters, farmers, land developers, small businesses and home owners all are being affected by these new pollution control efforts.

CAN THESE REGULATIONS BE AVOIDED?

Increased regulation appears to be an unavoidable part of doing business in the 1990s. Every indication points to even more regulation in the future. Easy solutions to waste disposal problems are rare, and those which do exist may not be available much longer. These signs suggest that waste management must become a part of the daily routine of virtually all businesses. It should be included in all aspects of planning, because costs can be anticipated and controlled when the changes are planned. After-the-fact additions and modifications to take care of wastes usually are very expensive.

WHY WASTE MANAGEMENT?

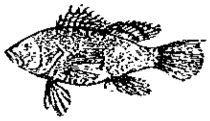
The reader should note there are only three disposal options: air, land, and water. In times past, a discharger could switch from one option to another, but environmental regulations today are stricter and cover all options. It was possible, for example, to truck solid wastes to landfills in order to reduce wastewater loadings, but that option has been limited, and depending on the nature of the wastes, sometimes it has been taken away completely. Seafood processors must consider waste management, not just wastewater management, in this new regulatory environment.

This trend to control all forms of wastes is perhaps best illustrated by the establishment of a Virginia Department of Environmental Quality (DEQ) in the spring of 1993. This agency includes the Department of Air Pollution, the Department of Waste Management, and the State Water Control Board, as well as the Council on the Environment (VA Natural Resources Newsletter, 1992). Note that the three state regulatory agencies included in the new department are responsible for the three disposal categories previously mentioned. Having a single environmental management agency could simplify the process of securing permits, but it also is likely to mean that there will be fewer simple and easy solutions in the future.

WHAT CAN A SEAFOOD PROCESSOR DO TO MEET THESE DEMANDS?

The recommended approach involves planning and thinking holistically. The latter term may conjure up images of fuzzy New Age thinking, but it is intended to mean thinking about the whole process, rather than focusing on just one segment at a time. For example, when wastewaters are screened, allowed to settle, or treated, there are two waste streams—the treated waters and the solids that have collected on the screen or have settled out. When considering the best option, past practice has been to make the selection based on improvements in the wastewater quality. But the solids also must be disposed somewhere, and the assessment should consider both aspects. One's difficulties have not been eliminated if a water quality problem is solved, but a solid waste disposal problem has been created.

One approach is to study the problem, plan ahead, and remember that all three disposal options—air, land, and water—are now regulated. Two techniques that have not been used widely are waste reduction and by-product recovery. The cheapest waste to treat is one that is avoided. Similarly, if wastes can be used for some beneficial purpose, that reduces the amount to be handled and treated and may even generate revenue.



PRINCIPLES OF WASTEWATER MANAGEMENT

The purpose of this section of the manual is to provide general information regarding wastewater treatment and disposal. First, a philosophy for waste management is proposed and the basic methods for treating wastewaters are described.

Wastewater disposal is covered next. This includes alternatives to discharging wastes to streams and rivers, and what the state looks for when its staff examines requests for permits to discharge wastewaters.

WASTEWATER TREATMENT OPTIONS

Some have defined pollution as being "something in the wrong amount or in the wrong place." By analogy, when the proper amount of fertilizer is applied to a lawn or garden, it stimulates productive growth; when applied in excess, there is plant growth at the expense of the fruits, or plants even may die. Similarly, the organic matter in seafood processing wastes and wastewaters can feed fish and promote plant growth, but if too much is discharged to a stream or river, water quality is degraded and the marine life impacted. The purpose of wastewater treatment is to reduce the amount of organic matter in the wastewaters so that water quality and marine resources are protected.

The most important measure of water quality, and the one which is often used to develop discharge limits, is the dissolved oxygen (DO) concentration. The concern is that decomposition of the organic matter will consume the oxygen in the water and reduce the DO to levels that stress aquatic animals (a condition called *hypoxia*), or in extreme cases all of the DO will be used up (a condition called *anoxia*). Few fish or shellfish can tolerate anoxia, so when it occurs, the river bottom becomes a veritable desert, devoid of life.

In addition, there are concerns that the state's waters will become over-enriched with nutrients. Phosphorus and nitrogen are the nutrients of greatest concern. In response to these concerns, Virginia has adopted a phosphate detergent ban and now limits the concentration of phosphorus in the effluents from large facilities (greater than one million gallons per day).

Ammonia can be toxic to aquatic organisms, so water quality standards have been proposed to limit the concentration of ammonia in streams and rivers. Concentrations of nitrate in drinking waters also are regulated. Treatment processes are selected and treatment plants designed to reduce pollutant loads sufficiently to meet all of these water quality goals.

The first step in protecting the environment is to implement good housekeeping procedures that reduce flows and wastes. Once the quantity and quality of the wastewaters are known, appropriate treatment processes can be selected. Treatment can use physical, biological or chemical methods, sometimes called *primary, secondary* and *tertiary treatment* respectively. All of these processes will be described in general terms in the following sections. Readers wishing to learn more about specific processes should consult one of the reference books listed at the end of the report.

MINIMIZING WASTES AND WASTEWATERS

Good housekeeping procedures can do much to reduce the volume of wastewaters which must be treated. When the volume of wastewaters is reduced, that much less must be treated. Hoses, for example, should be equipped with nozzles that automatically shut off the flow when not in use. Slight modifications in practices can produce important reductions in the wastes and wastewaters generated. Water reuse may be possible in some instances. Waters used in processing food must meet appropriate standards, so opportunities to reuse waters probably will be few.

There also are many ways to minimize the wastes that are produced. For example, in a crab picking plant a good management approach is to keep the picking room floor as dry as possible; when this occurs, both the dry and wet clean-up will be improved. The solids that are swept up can be included with the carcasses and dried, adding to the total weight of product to be made into animal feed. The amount of solids remaining on the floor is reduced, so the solids in the wash-down water, and therefore any water quality impacts also, are reduced.

By-product recovery also is a possibility. The bottled clam juice which can be found in most grocery stores is one example of this. Another example is drying blue crab carcasses to make animal feed. The economics of some of these operations may be marginal when considered alone. When the costs of wastewater treatment and the charges for dumping solid wastes in landfills are factored in, however, there could be benefits for the total operation. In order to capitalize on these possibilities, it may be necessary to modify the plant so that particular waste or wastewater streams are separated out from the others. It also may be necessary for several plants to join forces in order to reduce risks to any single plant owner and to gain economies of scale. *Composting* of fish or shellfish wastes, for example, is likely to be more economical on a large scale.

WASTEWATER TREATMENT PROCESSES

Physical, biological, and chemical processes, or combinations of these, can be used to treat wastewaters. Physical processes include *screening* and settling chambers. Screens, of course, separate pieces of material from the water. These can be fixed screens, which might employ jets of water to continuously remove the accumulated material, or moving screens. Collecting these solids reduces the pollutant loads in the wastewaters, but the solids must be disposed of, say in a landfill or used in animal feeds.

Settling chambers are designed to provide sufficient residence time that particles of a particular size and larger settle out. The residence time of a container is simply the volume divided by the flow rate. With longer residence times, small particles may settle out; with short residence times, only the larger particles will reach the bottom of the tank. *Sedimentation* may be enhanced by the addition of flocculants, chemicals which cause particles to stick together. As the particles clump and become larger, they also tend to settle out faster.

Settling chambers either have sloping bottoms or are equipped with mechanical devices to move the solids to an outlet. The flow of solids from the bottom of a settling chamber often is called sludge. Although the solids content of sludge is relatively high, the mixture is primarily water. Further treatment is needed to reduce the water content; this can be accomplished by spreading the sludge on a sand bed or compressing it in large presses. The relatively dry solids which are produced are more easily handled. They also can be applied to the land or incinerated, especially if the organic content is such that the sludge will continue the burning once combustion has started.

Biological treatment mimics the natural processes that occur in a natural water body, with rates and other aspects enhanced by the system design. Naturally occurring microorganisms consume the organic matter in the wastewaters. These microorganisms may be attached to solid surfaces or they may be floating in the wastewaters. Different organisms thrive in *aerobic* (with oxygen) and *anaerobic* (lacking oxygen) environments; some microorganisms can grow in both environments. The septic systems used in most rural areas get their name from the anaerobic environment created. Most large treatment facilities, however, introduce air into the water to keep it aerobic. Other systems, such as *lagoon* systems, are designed to include both aerobic and anaerobic zones.

When the microorganisms are attached to solid surfaces, these are called "fixed film reactors." *Trickling filters* have been used for more than a century to treat wastewaters. The water is sprinkled over the surface of a thick layer of large stones. After a short period of use, organic films develop on the stones. The plants and animals in this slime use the nutrients in the wastewater to grow, thereby cleansing the water. Trickling filters are simple to operate and are able to provide relatively good effluent even when the pollutant concentrations in the *influent* vary widely. Modern filters use plastic structures instead of stones. These structures have been designed to have a large surface area per unit volume, and therefore have more surface area on which the organisms can grow. Another relatively new system, called rotating biological filters, uses discs, which are like large phonograph records. These discs are suspended above the water so that part of the disc is in the water and part exposed to air; the discs are then rotated.

Many large municipal plants use a version of what is called the *activated sludge* process, where the microorganisms are suspended in aerated wastewaters. After passage through such a unit, the waters then enter a settling chamber. A portion of the solids which settle out must be disposed, while the remainder is returned to the aeration tank to ensure that there will be microorganisms in sufficient numbers to treat the incoming wastewaters.

Examples of *chemical treatment* include breakpoint chlorination to remove nitrogen and the use of chemicals to cause particular compounds to form and preciptate out. For example, many municipal sewage treatment plants use alum or iron salts to preciptate out phosphorus, thereby reducing phosphorus concentrations in the treated effluent. Disposal of the sludge, which in this case will be phosphorus rich, can be difficult.

Over the past century, the history of wastewater treatment has followed the following steps: first, use settling chambers to remove solids (*primary treatment*); next, use biological treatment to reduce oxygen demand (*secondary treatment*); and finally, use *chemical treatment* (*tertiary* or advanced wastewater treatment) to remove other pollutants. In recent years, environmental engineers have reassessed the entire process, rather than simply asking if another step was needed. Some of these new treatment approaches are collectively called biological nutrient removal. None of the treatment steps is new, but the way they are joined together is. Biological nutrient removal processes are able to remove *BOD* comparable to secondary treatment, but they also remove a large portion of the phosphorus and nitrogen. Nitrogen removal is reduced during cooler parts of the year when nitrification is inhibited.

A large, new, 40 million gallon per day facility in Norfolk uses biological nutrient removal to treat the wastewaters. The costs to build and operate this plant appear to be only slightly higher than those for a traditional secondary, or biological, treatment plant. It is likely that the advantages of biological nutrient removal will cause it to be used more often in the future.

There are many treatment options, and information is available to indicate those circumstances where each is most appropriate and effective. The selection of the best treatment technology will depend in large part on the characteristics of the wastewaters and requirements placed on the discharger due to the nature of the receiving waters. The high salt content in some wastewaters and the high concentration of organic matter in other wastewaters could pose special problems. In order to meet permit limits, it might be necessary to separate the wastewaters from particular processing units, or perhaps to temporarily store the waters in order to equalize the flow to the treatment system.

Wastewaters generated by the different segments of the seafood industry vary significantly. Even plants that process the same product can have wastewaters of differing quality and quantity. Consequently, treatment options must be determined on a case by case basis. An engineering firm should be hired to select treatment processes that are appropriate to the operation and will reliably produce an effluent that meets the permit limits. While the expense of hiring an engineering firm may seem high, there could be significant savings over the long run. The costs will be lower and results better if the engineers are familiar with the processing and have designed treatment systems for similar facilities in the past. Hence, processors should consider the option of jointly hiring a firm to design generic treatment units, which then could be tailored to specific installations.

WASTEWATER DISPOSAL

Although it is possible to burn some solid wastes, it is not likely that evaporation of wastewaters will ever be a viable option. That means that land disposal and discharge to streams, rivers, and the ocean are the only practical disposal options for wastewaters.

LAND DISPOSAL (SMALL OPERATIONS)

In most rural areas, domestic wastewaters are treated in *septic tanks* and disposed through subsurface drainfields. This option may be available to seafood plants as well. The size of the drainfield will depend on the flow of water from the plant and the characteristics of the soils. A consulting engineer may be needed to design the system.

Soil tests typically are performed by sanitarians from the local Health Department. If any domestic wastes, say from toilets in the plant, are included with the process waters, Health Department approval is required. If only process waters are treated and disposed, the Health Department may not need to approve the system, but the State Water Control Board must be notified.

The State Water Control Board (SWCB), now the water division of the Department of Environmental Quality (DEQ), has purview over groundwater quality as well as stream water quality. The DEQ will exercise greater or lesser control of land disposal, depending on the perceived threat to groundwater quality. If the volume of wastewaters is small (say roughly equal to or smaller than that from a residence) and if the concentrations of pollutants are not high, then it may be possible to use subsurface drain-fields with little or no monitoring of groundwater. Large operations or those with concentrated wastewaters are likely to be subject to more regulation (see following section).

LAND DISPOSAL (LARGE OPERATIONS)

Many seafood processors are located in rural areas where there is ample land available for the disposal of wastewaters. Even when land adjacent to the plant is taken, it may be possible to pump the wastewaters to a nearby disposal site. If we assume that there are no toxic substances in the wastewaters, then two aspects of the system will be scrutinized—the flow and the waste concentrations (VA SDH/SWCB, 1977).

Virginia's climate is characterized as "humid, sub-tropical," with rainfall distributed relatively evenly throughout the calendar year. Soils can absorb only so much water. During an extended rainy period, it may be necessary to store the wastewaters until soils have dried out. SWCB regulations require that adequate storage facilities be provided to "store all flow during periods when the ground is frozen, during rainy weather, when the ground is covered with snow or when the irrigation field cannot otherwise be operated." The minimum holding period is 10 days to 60 days.

Wastewater characteristics also are important to land application schemes. For seafood processing, salt and high concentrations of organic material are potential problems. The salts could kill some types of vegetation and contaminate the groundwater. The soils will trap sediment particles, but oxidized nitrogen (nitrate-nitrogen) is water soluble, and therefore it will pass through the soil with the groundwater. Drinking water standards limit the nitrate content to 10 mg/l. The phosphorus and BOD content of the wastewaters could pose problems, too. Depending on the quality of the wastewaters, some treatment may be required prior to application to the land.

Land application of wastewaters may be a practical disposal option for some seafood processors. An engineering firm should be consulted to assess the costs and feasibility, and to design the system.

Connection to Sewer Systems

Some seafood processing plants are located in towns and cities with sewers. In this case, wastewaters could be discharged to the sewer system. Once an agreement has been reached with the municipality or sewer authority, the owner of the seafood plant does not need to worry about discharge permits and many other regulations. The agreement, however, may require monitoring of the wastewaters or even *pretreatment*. Pretreatment may not be required, but if the sewer authority has a rate structure that has high charges for wastewaters with elevated concentrations of BOD and other pollutants, the seafood plant owner may opt to install pretreatment for economic reasons.

The operation of seafood processing plants can be erratic. Bad weather, for example, limits seafood harvesting, and therefore the flow of raw product to the processing plant may be reduced or stopped altogether. If there is no raw product, there is no processing. This on-again, off-again nature of seafood processing could cause difficulties for the treatment plant, especially when the seafood plant produces a significant portion of the wastewater flow. *Flow equalization* would reduce this problem. In order to equalize the flow rate, a holding tank would be constructed. Wastewaters would be stored in the tank for up to a few days and pumped to the sewers at a more or less constant rate, thereby providing a fairly uniform loading to the treatment system.

Again, the costs of discharge to a sewer system must be weighed against those for other options. Cost and feasibility analyses, and of course the design of any pretreatment systems, is best done by a consulting engineering firm.

OCEAN DISPOSAL

Federal regulations, 40 CFR Part 220.1(c), allow fish wastes to be dumped in the ocean without an ocean dumping permit provided that the wastes are not disposed into harbors or other enclosed coastal waters or in any other location where the U.S. Environmental Protection Agency (EPA) finds that such dumping may reasonably be anticipated to endanger the marine environment.

The EPA has allowed the dumping of clam wastes off the Eastern Shore of Virginia. For this operation, the following requirements were established:

- the material includes shellfish wastewater and shellfish parts, but no additives or chemicals;
- the material is disposed of fresh daily and not stored for any period of time;
- the transport vessel is adequately outfitted for the open ocean as required by the U.S. Coast Guard and must have an operational Loran C; and
- the dumping occurs within a prescribed area.

In addition, the EPA requested that the disposal area be studied to determine if there were harvestable shellfish in the area, and if bacterial contamination or low dissolved oxygen conditions were occurring. The two concerns were (1) that bacteria in the wastes would contaminate shellfish which might be harvested from the disposal area and (2) that the organic material in the wastes would consume so much oxygen that the marine life in the area would be impacted.

This disposal option requires that the wastes be transported to federally controlled waters, that is, more than three miles offshore.

The natural currents and waves in these offshore areas typically provide for rapid dispersion of the wastes. An engineering firm or an oceanographic institution could estimate how rapidly this occurs. These same groups could conduct the studies of shellfish and water quality conditions that the EPA requires.

It is likely that an offshore disposal operation could be designed to satisfy the EPA. The rate at which the wastes are discharged could be altered, for example, to ensure that initial concentrations were at a level acceptable to the EPA. This option may not be viable, however, due to environmental conditions or costs. If the offshore waters were experiencing poor water quality, it is unlikely that the EPA would allow wastes to be discharged there, since the wastes would be expected to aggravate those water quality problems. The costs to transport the wastes several miles offshore and the liabilities associated with such an operation also could mean that this would not be a viable option.

Discharge to Streams and Rivers

Most seafood processing facilities discharge their wastewaters to adjacent streams and rivers, and have been doing so for many years. A discharge permit is required for these situations. The permit system was established by Congress in 1972 as part of the Clean Water Act Amendments (PL92-500). The stated goal was not just to eliminate obvious water quality problems, but rather to maintain or improve the quality of all of the nation's waters. This was to be achieved by requiring all dischargers to meet minimum standards. The advantages of this approach were that all were treated equally and that improvements would be seen everywhere. A major element in this approach was the National Pollutant Discharge Elimination System (*NPDES*), which required that all dischargers obtain a discharge permit.

This program has been delegated to the states, so now one gets a *VPDES* permit, with the V, of course, standing for Virginia. VPDES permits are issued by the Virginia State Water Control

Board. The NPDES program requires dischargers to not only get a discharge permit, but also to renew it every five years. The process of acquiring or renewing a discharge permit is lengthy and many complicated forms must be completed. In November of 1991, the State Water Control Board held public hearings regarding a "General Permit Regulation for Discharges from Molluscan Shellfish and Crustacea Processing Establishments." Under this regulation, facilities "which produce minimal volumes of wastewaters and whose wastes are not considered to be significant threats to water quality" could apply to be included under the general permit. Staff comments indicate that the application forms would be simple and that the time between permit application and approval would be short (about one month). Draft regulations have not been promulgated, but are expected to be forthcoming in the near future.

The general permit will become very important to small seafood processors when a program of permit fees is implemented. In December of 1992, the State Water Control Board held public hearings regarding fees that were proposed for permits and certificates. According to hearing documents, "(F)ee revenue will enable the agency to process permit applications in an efficient and expeditious manner by providing the resources needed to hire additional staff to prepare permits required by federal and state law which are growing in both numbers and complexity." The proposed fee for a VPDES General Permit was $200, whereas the proposed fees for a minor industry range between $2,200 and $3,400 for a new permit or reissuance of an existing permit, and from $1,650 to $2,550 for a modification to the discharge permit, which is initiated by the Water Control Board. The economic advantage of a general permit is obvious.

EFFLUENT MONITORING

An important aspect of the VPDES permit program is that the discharger is responsible for characterizing the wastewaters which are discharged and for monitoring the discharge at frequencies stated in the permit. Wastewater characteristics must be specified in the permit application. When a permit is issued, it specifies not only the maximum amounts of pollutants which can be discharged, but also the manner and frequency of effluent monitoring. One might argue that it is unfair to ask a company to monitor its effluent. Given the number of permits in effect, however, it is highly unlikely that the state will take on this burden; self monitoring by dischargers has been and is likely to continue to be part of the VPDES program.

During the 1970s and 1980s, the emphasis of pollution control efforts was on the large dischargers, such as municipal sewage treatment plants (STPs) and industries. Today few, if any, large STPs fail to meet the standards set in PL92-500. Those standards required that the concentrations of biochemical oxygen demand (BOD) and total suspended solids (*TSS*) in the effluent be less than 30 mg/l. Many of the municipalities achieve greater reductions in solids and BOD; for example, the BOD for the Richmond STP effluent is significantly below 10 mg/l.

Once the large pollutant sources had been addressed and their effluents met the standards, attention shifted to smaller dischargers, including seafood processors. The experience of many seafood processors is that inspections are more frequent and the effluent monitoring required by the State Water Control Board has increased. The latter includes both more frequent monitoring and an increase in the number of water quality tests that must be performed. The costs of effluent monitoring can be expected to increase in the future.

ASSESSING DISCHARGE IMPACTS

Although the basic approach in PL92-500 was to have all dischargers achieve the same quality of effluent, there were a few exceptions. First, existing seafood processing facilities were grandfathered and were given discharge limits based on industry norms. Usually these limits varied with the amount of finished product leaving the plant. New facilities, on the other hand, have been required to meet stricter discharge standards, which often have been based on an assessment of potential water quality impacts.

In a similar fashion, it was recognized in PL92-500 that effluent standards would not be sufficient to protect water quality in all instances. When the existing discharges are sufficiently large to cause water quality problems, further reductions in pollutant loadings are demanded.. In recent years the state has even required some large dischargers to gather data and calibrate a water quality model of the receiving waters, which would then be used by the state to set new permit limits. These efforts were required by the conditions of the VPDES permit and were at the dischargers' expense. Fortunately, few seafood processing plants are located in areas where water quality conditions result in the "water quality limiting" designation and the special efforts that this designation requires.

Assessments of potential discharges typically are made using water quality models. Often this occurs in two steps. First, a simple model is used to determine the order of magnitude of the impact. If the impacts are projected to be small and water quality is protected, then a permit may be issued or the project may move forward. If the impacts predicted by the simple model are large or if water quality is compromised, a more elaborate model is required. The costs to acquire field data and to calibrate and verify a sophisticated mathematical model usually are great. Unless these tasks are completed, however, regulators will be reluctant to issue a permit.

Assessments of existing discharges could be based on field monitoring, rather than the predictions of mathematical models. Water samples would be collected at stations at various distances from the discharge and at different times, such as slack before flood or slack before ebb. The sampling program would be designed to show the extent and degree of any impacts, or the lack of any water quality impacts. Showing that no impact occurs is more difficult than showing an impact, because one must document the lack of impact under a variety of conditions, such as wet and dry weather periods, hot, summer conditions as well as cooler periods, and both neap and spring tides. These studies also can be quite expensive.

To summarize, a key element in the VPDES program is self monitoring of the wastewaters discharged. Although sampling requirements for the seafood industry have not been burdensome in the past, it is likely that both more frequent sampling and analysis for more water quality parameters will be required in the future.

The state requires this monitoring to ensure that the discharges are meeting permit limits, and to ensure uniformity within each industry. The alternative to effluent monitoring is to conduct field studies or to apply a water quality model, both of which can be very expensive exercises. Only when a model has been developed for another program is it likely to be a viable option for most seafood processors.

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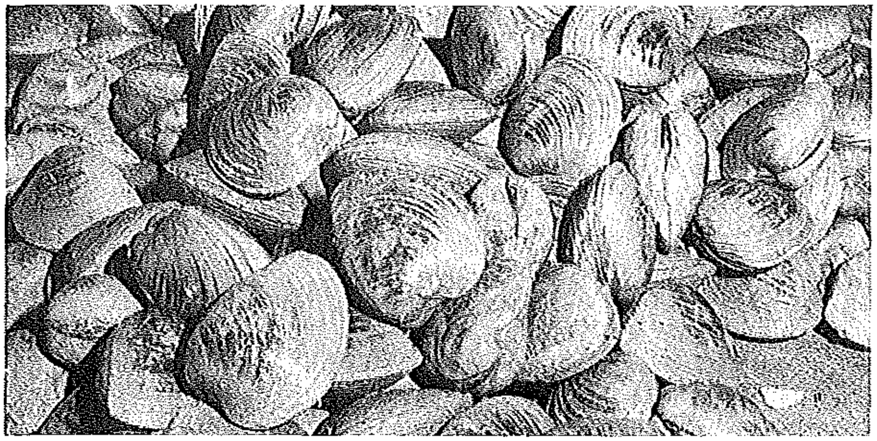


BLUE CRAB PROCESSING CASE STUDIES

INTRODUCTION

In the previous sections, general information on wastewater management has been presented. In this section, the steps a seafood processor might take to address wastewater issues will be illustrated. We will do this by examining hypothetical blue crab operations, plants where crabs are steamed and the meat picked from the carcasses. Blue crab processing has been selected for consideration because it is receiving increased attention and scrutiny from the Virginia Water Control Board. Lessons to be learned from crab processing should apply to other segments of the seafood industry.

Our concern will be crab picking operations. Blue crabs also are sold live to individuals who steam them at home. For this case, the individual disposes of all wastes, and this occurence is not the interest of this exercise. Neither are we concerned with shedding operations. Crabs that are beginning to molt, "*peelers,*" are sold to processors who hold them until they molt. Over the last decade, a large number of land-based operations have been established to produce soft shell crabs; both production and sales have increased dramatically. The growth of this industry has been due in large part to improved technology for treating the waters and dissemination of that knowledge to the industry in a Virginia Sea Grant Program manual (Oesterling, 1988). Shedding operations are considered to be aquaculture activities, which have not been regulated by the State Water Control Board.

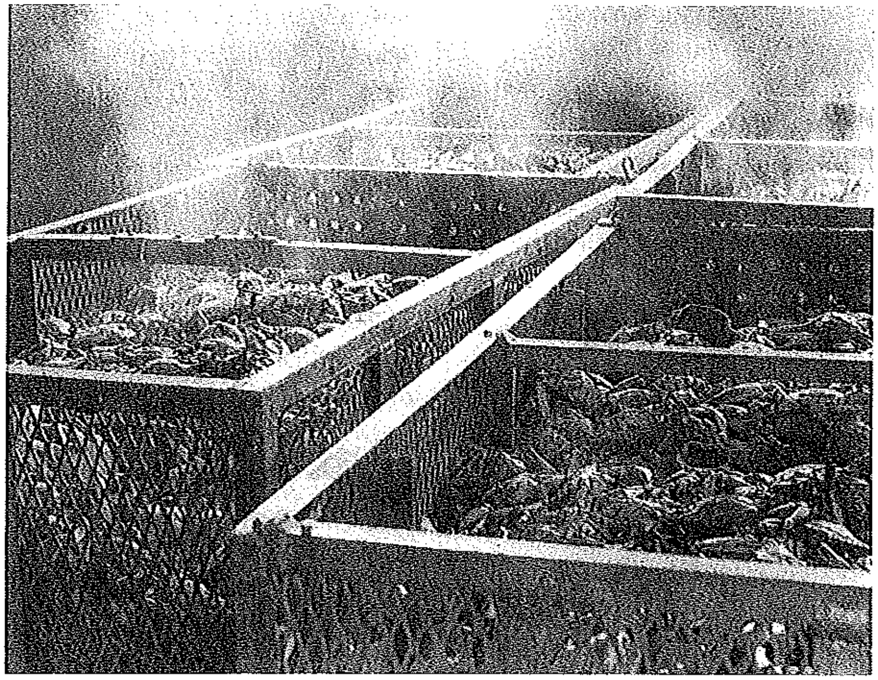
PROCESSING STEPS

Crab picking operations range widely in size, but the basic steps remain much the same. These are receiving, washing, steaming, picking, processing the picked crab meat, and storage, as shown schematically in Figure 1.

Many crab plants are located on the waterfront and receive live crabs directly from workboats or other vessels. Otherwise crabs are trucked to the plant. During the winter the crabs will be washed down, because they have been dredged from the bottom sediments. Washing live crabs occurs less frequently during other seasons.

The crabs are then steamed in large *retorts*. The steamed crabs are allowed to air cool prior to being moved to a cold room. Usually the crabs are caught and steamed one day, cooled over night, and picked the following day.

Crab picking is done manually at most Virginia plants. The pickers remove the fins, *carapace* and gills, and cut off the top section of the shell. Crab meat is then picked from the carcass. A few plants have mechanical pickers, which are not used routinely, in part because lump crab meat commands a higher price and the mechanical pickers break up the lumps of crab meat. Mechanical



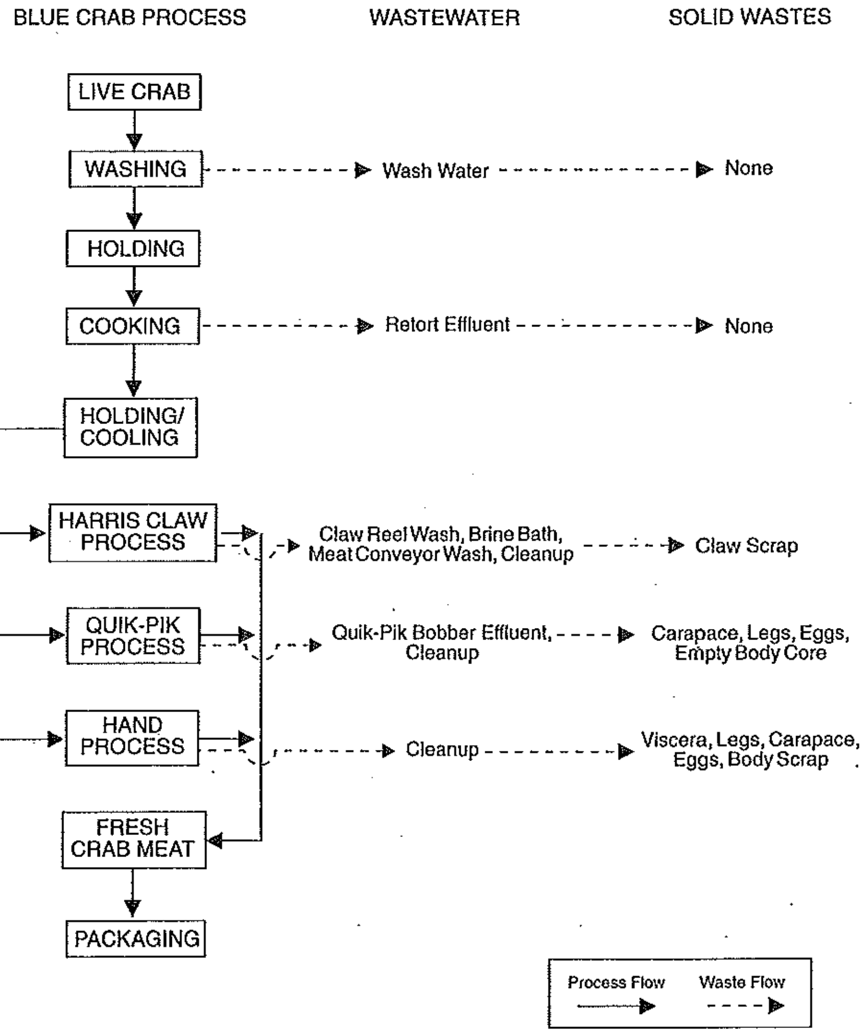


Figure 1. Schematic of blue crab process product and waste flows.
(Adapted from Harrison et al, 1992b)

pickers are used routinely, however, for claw meats. Hammer mills break the claws, the broken shells and pieces of meat fall into a brine solution, and the meat is separated from the shell due to different densities of the two materials.

Crab meat is sorted and checked for shell fragments, and then placed in containers, which are moved to cold storage, or pasteurized and then placed in cold storage.

CHARACTERISTICS OF "TYPICAL" WASTEWATERS

The quantity and quality of the wastewaters from a crab picking operation will vary, due to factors such as the life stage of the crabs, whether the crabs were dredged or caught in crab-pots, the size of the catch, plant design, and the individuals running the operations. The EPA (1974) sampled two crab plants while setting effluent guidelines. Brinsfield and Phillips (1977) surveyed seven Maryland plants, taking 75 effluent samples. The data indicate that effluent characteristics do indeed vary (Table 1) and that BOD concentrations can be high. Data supplied by dischargers to the Virginia State Water Control Board also indicate high BOD concentrations. Geiger et al (1985) suggest that a BOD concentration between 800 and 1,000 mg/l "would be a typical composite value" for effluent from Maryland crab plants.

The characteristics of domestic sewage have been listed in the table for reference purposes. Another set of reference values are those for wastewaters which have been given secondary treatment; TSS and BOD concentrations in treated wastewaters typically are less than 30 mg/l. The wastewaters from a crab plant, then, could have concentrations of TSS and BOD that are ten times higher that effluent from a secondary treatment plant and higher than those for raw sewage. If the wastewaters do have high BOD and solids concentrations, it is not surprising that state regulatory agencies are asking that wastewaters be treated. The next step is to determine where the loads are coming from, so that critical processing steps can be identified.

Table 1. Wastewater Characteristics (in mg/l) for Blue Crab Processing Wastewaters and Domestic Sewage.

		Crab Plants (1)	Crab Plants (2)	Sewage (3)
TSS	mean	620	255	200
	range		20-1,000	100-350
BOD	mean	4,400	423	200
	range		12-850	100-300
Oil & Grease	mean	220	6	100
	range		2-9	50-150
Total Phosphorus	mean		6	10
	range		3-18	6-20
Ammonia-N	mean	50	6	25
	range		2-34	12-50
Total Nitrogen	mean	760	43	40
	range		6-170	20-85

(1) EPA, 1974.
(2) Brinsfield & Phillips, 1977.
(3) Metcalf & Eddy, Inc, 1972.

CHARACTERISTICS OF WASTEWATER STREAMS

The quality and quantity of wastewater that is produced at each processing step will vary from plant to plant, but general characteristics should remain the same. Researchers from Virginia Tech have measured the flows and determined the pollutant concentrations in the wastewaters produced by different crab picking operations (Harrison et al, 1992). The three general types of wastewaters are cooker water, clean-up water, and wastewaters associated with mechanical pickers.

All plants produce some cooker waters or retort waters. During the cooking process, the crabs are subjected to steam under pressure. Some of the steam condenses and collects in the retort, along with body fluids from the crabs. When the cooking cycle is complete and the retort opened, these cooker waters are released. The volume of water is not great, but concentrations of pollutants are very high. BOD concentrations up to 28,500 mg/l have been reported (Harrison et al, 1992a). Concentrations in the range 15,000 to 20,000 mg/l appear to be "typical." The high BODs are due in part to high concentrations of organic nitrogen. The organic nitrogen content is measured by the Total Kjeldahl Nitrogen (TKN) analysis. TKN concentrations in cooker water were well above 2,000 mg/l, with 2,500 mg/l an approximate mean concentration. Only a small portion of the nitrogen is in the form of ammonia-nitrogen, but given the very high nitrogen content, concentrations of ammonia-nitrogen were above 100 mg/l. Concentrations of Total Phosphorus (TP) also were above 100 mg/l. TSS concentrations usually were above 1,000 mg/l.

The weight of cooked crab meat amounts to only about 14% of the weight of the raw crabs. As a consequence, large volumes of solid wastes are produced in the picking operations. Some of the solid waste will contribute to wastewater loads, since scraps fall to the floor and then get incorporated into clean-up waters. Dry clean-up, typically sweeping, is carried out first to remove most of the scraps and other materials. Subsequently, the picking room floor is hosed down. These clean-up waters, not surprisingly, have high concentrations of suspended solids, usually above 1,000 mg/l. Concentrations of other pollutants are much lower than those for cooker waters. BOD is on the order of 1,000 mg/l and TKN is on the order of 200 mg/l.

Process waters associated with mechanical pickers are similar to cooker waters. Concentrations of TKN, ammonia-nitrogen and TP are of comparable magnitude, whereas BOD concentrations tend to be somewhat lower but still above 10,000 mg/l. Suspended solids concentrations, however, often are above 10,000 mg/l. It also must be noted that the volumes are large relative to the volumes of cooker waters and clean-up waters.

Usually there also are some non-process waters, resulting from the operation of steam generators, ice makers and similar equipment, which will be similar to tap water. These non-process waters will not be included in the analysis, since the flows are quite small and the quality of the waters is so good.

Wastewaters from rinsing live crabs and from clean-up operations in other parts of the plant were not sampled in the Virginia Tech study. These, too, have been omitted from the analysis. The quality of waters should be relatively good and the volumes relatively small, so this omission should have little effect on the total loads.

HYPOTHETICAL CRAB PROCESSING OPERATIONS

While it is very informative to know the characteristics of the wastewaters from the different processing steps, any water quality impact that a plant may have depends not only on the pollutant concentrations, but also the total amount of pollutant discharged to the stream or river. Loadings are the product of flow and concentration. In order to examine the effect of a crab picking operation, we must use "typical" flow rates. Several hypothetical crab picking operations have been proposed as "typical" operations for the case studies (Table 2). Production is given in terms of live crabs (bushels per day) and processed crab meat (kilograms per day). Flows are given in units of liters per day.

The data from the Virginia Tech study have been used to calculate wastewater concentrations (Table 3) and daily loadings (Table 4) for the hypothetical crab picking operations. These operations will be discussed in the following case studies.

CASE STUDY #1 - A SMALL OPERATION

Small crab picking operations can be found in all parts of tidewater Virginia, especially in the rural areas. The first thing to note about these operations is that flow rates are small, too. The retorts do not produce much water and the volume of the clean-up waters also is limited. Daily flows are only a few hundred gallons, with a likely upper limit of around 500 gallons; a flow rate of 400 gallons per day (1,500 liters per day) was assumed (see Table 2). In other words, these operations have flow rates comparable to a single family residence. Pollutant concentrations, however, are higher than those for domestic sewage (see Table 3). The concentrations calculated using the Virginia Tech results (Harrison et al, 1992) are quite similar to those reported by the EPA (1974).

Table 2. Hypothetical Crab Processing Operations

	Production		Flow
	Raw bu/d	Cooked kg/day	l/d
Small	40	100	1,500
Medium	400	1,000	1,000
Large	3,900	10,000	
All hand pick			26,000
Hand pick + Harris claw mill			190,000
Quik Pik + Harris mill			240,000

Daily loads, the product of concentrations and flows, are small but not insignificant. The impact of such an effluent will depend in large part on the nature of the waters to which they are discharged. If the stream is large and well mixed, a load of this size will have minimal impact. If the stream is small, with little freshwater inflow or tidal exchange, there could be a measurable impact on water quality.

At a minimum, it is recommended that clean-up waters be screened to remove as much of the particulate matter as possible. Virginia's water quality standards include narrative statements that "All State waters shall be free from. . .floating debris, oil, scum, and other floating materials" and "substances that. . .settle to form sludge deposits." Screening is a simple and inexpensive way to achieve these objectives. Septic tanks or other settling tanks should reduce the amount of solids reaching the river or stream and would reduce BOD loads as well.

Table 3. Calculated Effluent Concentrations (in mg/l) for Hypothetical Crab Plants

	BOD	TSS	TP	TKN
SMALL (hand pick)	4,000	530	50	490
MEDIUM (hand pick)	2,680	1,370	137	500
LARGE (hand pick)	19,500	2,600	232	2,375
(hand pick + Harris claw machine)	5,350	4,870	113	1,293
(Quik Pik + Harris claw machine)	8,500	7,100	173	1,440

Good house-keeping procedures also are recommended. Operators should closely monitor the processing, with the intent of having a clean operation. When the floor of the picking room is kept dry, for example, then sweeping and other dry clean-up operations are very effective and remove virtually all of the scraps. If the dry clean-up is thorough, then clean-up waters would carry little solids and they would be much cleaner than those documented in the Virginia Tech study. In some instances, it may be possible to eliminate the wet clean-up altogether.

The Department of Environmental Quality is planning to issue a general permit for small seafood processing operations. It is very likely that small crab picking operations will fall within the guidelines of such a general permit. Certain wastewater controls, such as screening or settling tanks, may be required if a plant is to be covered by the general permit. Ultimately, the determination of minimal versus measurable water quality impact rests with the state. Operators should consult with DEQ staff and seek their guidance.

CASE STUDY #2 - A "NEW" OPERATION

Relatively new operations have been required to meet stricter effluent standards than those plants which existed when the NPDES permit system was implemented. Some of these operations are moderately large, processing hundreds of bushels of live crabs each day, with the production of cooked crab meat on the order of 1,000 kilograms per day. The wastewater flows average about 1,000 liters per day, that is, only a few hundred gallons per day (Table 2). Loads would be less than for a small operation, because the new plants are required to dispose of cooker waters by means other than discharge to rivers and streams (Table 4).

Although these operations are relatively large, the volume of the clean-up waters may not be much greater than for a small operation. The volume does not necessarily increase proportionally with size, nor does the pollutant loading in the clean-up waters necessarily increase significantly. The latter will depend, in large part, on operational procedures. If efforts are made to keep the picking room floor dry, and to do a thorough dry clean-up, then the quality of the wet clean-up waters will be good. Given the nature of those waters, however, screening and settling seem appropriate.

The medium-sized, new operations also may fall within the guidelines of the general permit that the Department of Environmental Quality is planning to issue. It is likely that the monitoring and administrative burdens for a general permit will be less burdensome than those for a standard VPDES permit, but some wastewater treatment may be required. Plant operators should consider whether they want to include their plants within this program, since it could be advantageous to them.

Table 4. Calculated Loads (in kg/day) for Hypothetical Crab Picking Operations

	BOD	TSS	TP	TKN
SMALL (hand pick)	5	0.7	0.6	0.64
MEDIUM (hand pick)	4	1.4	0.14	0.50
LARGE (hand pick)	506	67.5	6.0	61.7
(hand pick + Harris claw machine)	1,017	925	21.5	246
(Quik Pik + Harris claw machine)	2,040	1,703	41.5	346

CASE STUDY #3 - A LARGE HAND-PICK OPERATION

Large operations process thousands of bushels of crabs each day and produce as much as 10,000 kilograms of processed crab meat at times of peak production (Table 2). Hand picking is still the standard practice in Virginia, even at these large operations. Experienced crab pickers can be very efficient, and they can ensure that the large lumps of crab meat are kept separate. Lump crab meat usually commands a higher market price than regular crab meat.

In one sense, a large operation is no different from a small operation, since both include the same processes. The quality of the effluent differs, however, because the relative volumes of cooker waters and clean-up waters vary. The volume of cooker water will increase more or less proportionally with production. The volume of clean-up waters, on the other hand, remains roughly the same, and increases only slightly when production increases. Cooker waters account for nearly 90% of the flow at large plants, versus only 25% of the flow at small plants. Effluent concentrations, therefore, will approach those for cooker water, as indicated in Table 3.

The BOD load from a large operation is numerically equivalent to the treated effluent for a small city with over 40,000 inhabitants. When tidal flushing is strong and the volume of the receiving water is large, the water body may be able to assimilate these loads with minimal impact. When flushing is weak or the water body is small, impacts would be larger and wastewater treatment would be needed. For this case, cooker waters and clean-up waters should be kept separate, so that each wastewater stream could be treated according to its characteristics. Treatment of cooker waters is problematic, given the very high concentrations of nitrogen and BOD.

Clean-up waters pose only a small problem because both the volume and the concentrations are low (at least with respect to cooker waters). Screening of clean-up waters is practiced at most plants today and should be continued. Water quality standards include narrative statements that forbid visible scums, floating solids, and foam. While screening protects the aesthetic qualities of the receiving waters, it removes only a small portion of the solids and little of the BOD. Septic tanks should be considered since the daily flows are comparable to those for a single family residence and septic tanks reduce both BOD and suspended solids loads.

Chemical treatment of the cooker waters is an option. Harrison et al (1992) found that materials in retort water would precipitate out, if the pH were lowered to below 2. If the precipitate could be separated from the remaining liquids, it might be processed with the other solids and increase the nutritive value of the feeds produced, which, in turn, might allow for greater cost recoveries. Much of the BOD, however, is soluble and it is not likely that chemical treatments will be able to reduce the BOD to concentrations typical of secondary treatment. In other words, chemical treatment may have a role to play in treating crab wastewaters, but it will not be sufficient if effluent limits are at all restrictive.

Biological treatment is possible, but both the high concentrations and the intermittent flows (and loads) complicate matters. The volumes of wastewater are not great, so it might be feasible to utilize a system having long residence times. The costs associated with such an operation are likely to be high. First, considerable effort must be given to selection of treatment methods that will work reliably and will produce an effluent that meets the criteria established for the plant. The most certain way to achieve success is to conduct pilot scale studies using effluent from a crab plant. Assuming that a suitable design can be found, a treatment facility then must be constructed and operated. Operation and maintenance of such a plant could be difficult and costs significant.

An alternative to treatment is use of the cooker waters for other purposes. It has been proposed that cooker waters be used to prepare flavorings that could enhance artificial crab products made with surimi. The high nitrogen content means that the cooker waters have value as a fertilizer, although the salt content or some other factor might complicate this. Alternative uses and alternative disposal are likely to become more important in the future. The high BOD and nitrogen content of cooker water means that it will be difficult to treat these wastewaters and achieve effluent concentrations of the same magnitude as secondary effluents. Both technical and economic considerations dictate that alternative disposal mechanisms be investigated.

It should be noted that the calculated concentrations are much higher than those monitored by Brinsfield & Phillips. They noted (page 13) that "(I)t was found that all of the crab processors sampled regularly had the retort drains from the crab cookers separated from the normal effluent discharge point." The report does not make it clear whether cooker waters were sampled. Several of the plants were large (production on the order of 2,500 kg/day) but had low pollutant concentrations, suggesting that only clean-up waters were sampled.

CASE STUDY #4 -A LARGE OPERATION WITH HARRIS CLAW MACHINE

Although hand picking is standard practice for removing meat from the crab carcasses, so-called Harris claw machines are sometimes used to remove the meats from the claws. These machines are often used when production is high and the staff is not sufficient to hand-pick both the carcasses and the claws.

The first thing to note is that the mechanical operations use large volumes of water. The total flow for a large plant jumps from about 26,000 l/d to 190,000 l/d when the Harris claw machine is used. This increased flow reduces the concentrations for all parameters but suspended solids (see Table 3). Daily loads, however, increase by about 2 to 4 times, except for TSS which increases by more than a factor of 10 (see Table 4). The calculated BOD and TSS loads are the equivalent to that in the treated effluent of a city of more than 80,000 persons. The state is likely to require some treatment of these wastewaters, given the size of the loadings and the concentrations.

Cooker waters and waters from the mechanical picking operations will be difficult to treat for several reasons. First, the concentrations are high. Second, flows vary appreciably. Variations in flows and loads are difficult to accomodate, no matter whether physical, biological or chemical processes are used. Treatment processes are negatively affected by large variations in flows. And last, but not least, salts in the wastewaters could affect both treatment and disposal.

The Harris machine involves several steps. First, the claws pass through and are broken by a hammer mill. The pieces of shell and claw meat fall into a concentrated brine bath. The shell fragments settle to the bottom of the brine tank and are removed by a conveyor. Some of the brine is carried with the shell fragments; Harrison et al. (1992) referred to this flow as "shell liquid." The shell liquid is nothing more than slightly diluted brine. The brine tank is replenished throughout the day, and at the end of the work day, the contents of the brine tank are dumped. Both the brine and the shell liquid have high chloride content.

The salt content of the shell liquid and the brine could greatly complicate wastewater treatment. An alternative approach is to keep these wastewaters separate and discharge them to the estuary, where the salt content will not pose a problem. Although these two waste streams account for only 10% of the total flow, they include about 30% of the BOD and 60% of the TSS. The solids are mostly small bits of crab meat, which should cause little or no environmental harm. The crab meat is a food source for small fish, plus its density is close to that of water, so it will settle out very slowly. In other words, it is not likely that a sludge deposit will develop around the outfall. Approval for such an arrangement rests ultimately with the regulatory agency. If that is not given, then either another disposal method is needed or an alternative to the brine solution must be found. To be viable, the new solution should have roughly the same density as brine, so that the shell fragments and the meats can be sorted, but it should not interfere with land disposal or wastewater treatment.

If we ignore the salty, process waters, the remaining process waters will have a BOD concentration on the order of 5,000 mg/l and TSS concentration on the order of 2,500 mg/l. The daily flow will be around 170,000 liters. It should be possible to develop a treatment scheme that will handle these waters. A combination of trickling filters and some version of the activated sludge process might be suitable and provide the level of treatment desired.

Trickling filters should be evaluated, since they are noted for providing good treatment despite variations in wastewater flows and concentrations. The Hampton Roads Sanitation District uses trickling filters to pre-treat wastewaters with high organic loads resulting from brewery discharges. No biological treatment system, however, can accomodate drastic changes in flows and loads. If flows are nil over the weekends, and around 20,000 l/d on workdays, but jump to 200,000 l/d on other days when the Harris machine is used, then it will be virtually impossible to find a system that can handle these different flows, provide suitable treatment and have acceptable costs. Some method to equalize flows will be needed. This could be achieved by having a relatively uniform production every day of the week, or by storing wastewaters in a pond.

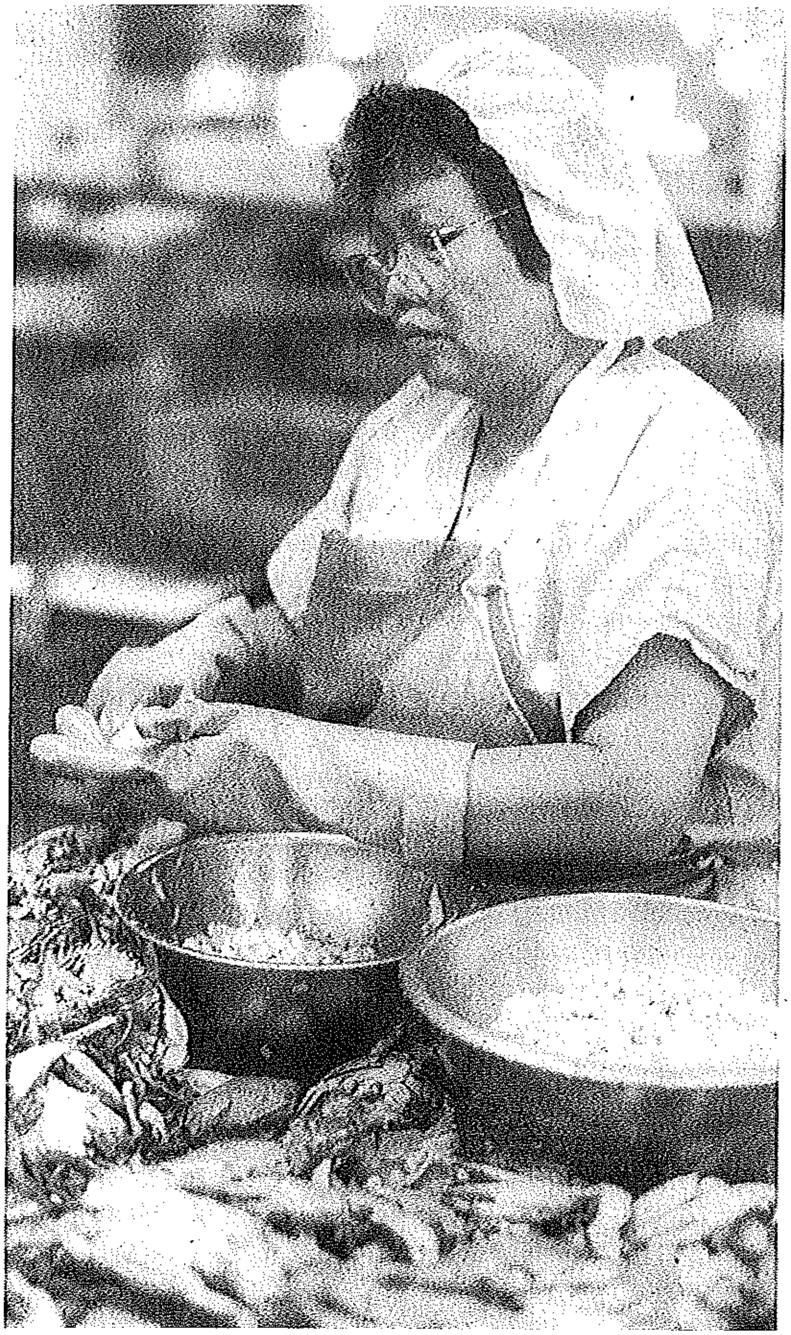
It may not be possible to achieve the same effluent quality as achieved by large municipal facilities, but it should be possible to greatly reduce BOD loads. Geiger et al. (1985) conducted bench scale tests to treat crab processing wastewaters using aerobic biological reactors. They achieved removal rates on the order of 90% with influent BOD concentrations in the range of 500 to 1,000 mg/l. Anaerobic digestion and other treatment approaches may be advantageous as well. Since some of the plants are located in rural areas, there may be space to accomodate lagoons, which, like trickling filters, are able to handle varying loads relatively well.

If the decision is made to treat crab processing wastewaters, a cost effective approach would be for several large processors to jointly hire a consultant to develop a method for treating these waters. Differences among the crab processors are anticipated to be small relative to the differences in wastewater characteristics among different food processors (e.g. poultry processors versus crab processors). The consultant will need to become familiar with the industry and the particulars of the wastewaters, and these costs could be shared. Similarly, the costs to develop and test a treatment approach could be shared. The design of treatment systems for each facility, however, would be the burden of the individual plant owner.

If a commitment is made to treat the wastewaters, then operational changes may be needed. As mentioned above, some means to reduce flow differences will be needed. This could mean a 7-day-per-week operation, or use of ponds or tanks to store wastewaters. It is likely that greater attention to water usage will be required, to minimize impacts on the treatment processes. If production stops during the winter, then it will be necessary to resume production in such a way that the treatment system can adjust. In other words, many aspects of the operation of a crab processing facility will be altered if wastewater treatment is added.

CASE STUDY #5 -LARGE MECHANIZED OPERATION

No Virginia crab procesors use mechanical pickers routinely, as far as we are aware. Theoretically, a plant operator could decide to minimize staff and use mechanical pickers all of the time. Loads have been calculated for an operation using both a "Quik-Pik" machine to get meat from the carcasses and a Harris machine to get meat from claws (see Table 4). The calculated loads for an operation producing 10,000 kg of crab meat per day would be more than four times as large as those for a hand pick operation, and more than twice as large as those for an operation that uses hand-picking and a Harris Claw machine. BOD and TSS loads would be equivalent to those in the treated effluent of a city of some 150,000 persons.



Use of mechanical pickers presents a dilemna. If used all of the time, the product of the plant would be different from what the market values. There would be no lump meat, for example. If the mechanical pickers were used on some days only, this would negatively impact the wastewater treatment efforts. Treatment systems are designed to handle wastewaters having particular characteristics. When those characteristics change, so will the ability of the system to treat the wastewaters. If BOD concentrations were to vary between 5,000 mg/l (hand pick plus Harris claw), 8,500 mg/l (Quik-Pik and Harris claw) and 19,000 mg/l (all hand pick), then one might expect effluent quality to vary as much, if not more. Either permit limits might not be met, or the treatment facility would be designed to handle the higher concentrations, and thus would be over-designed (and more expensive) for times when loads were smaller.

The concentrations and loads from the hypothetical, totally mechanized plant are such that state regulators are likely to require wastewater treatment. When that occurs, plant operators may be forced to decide whether mechanical pickers will be used all of the time (for either a portion or all of the production) or none of the time. Otherwise, design and operation of a treatment facility will be greatly complicated.

As noted in the previous case study, the decision to treat wastewaters could have many ramifications for the plant operations. These could include seven-day-a-week operations, more regular use of mechanical pickers, changes in standard operating procedures, and construction of a pond to temporarily store wastewaters until treatment.

Treatment processes have been designed, for the most part, for wastewaters similar to domestic sewage. Treatment of wastewaters with high organic content requires attention and study to ensure that the unit selected reliably and adequatedly produces high quality effluent. Few engineering firms have experience with seafood processors. Plant owners should consider pooling their resources so that at least one engineering firm is familiar with the industry, the wastewaters produced, and how they can best be treated. The same group of processors might fund bench scale—and even pilot scale—studies to determine the best treatment methods and how they can be "tuned" to perform best. Costs for the design of treatment facilities at any given plant, however, would be covered by the plant owner.

Use of mechanical pickers greatly increases pollutant loads and flows. If the state requires wastewater treatment, mechanical pickers might so complicate matters, and provide small enough economic benefit, that use would be discontinued. These decisions must be made after effluent limits have been set by the state, since these are needed for the selection and design of the treatment system.

SUMMARY

Several case studies from the crab processing industry have been examined to illustrate how decisions about wastewater treatment are made. The owner of another kind of seafood processing facility would go about matters in much the same way. The general steps are

1. Examine Available Information and Assess Options

Any processor who has a VPDES permit has taken wastewater samples and had them analyzed. Data also is available from studies conducted by Sea Grant institutions and others. The available information should be used to determine if there is a problem and what that problem is. Once the problem is defined, the various options can be reviewed and assessed for practicality, cost, and other factors.

Note that a plant owner may not perceive that there is a problem, but if neighbors of the plant regularly complain to state regulators, he still has a problem. If the regulatory agency staff believes that there is a problem, then the plant owner has a problem. Both problem definition and selection of a solution must include the other players in this game.

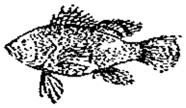
2. Get Help, if Necessary

If there is a wastewater problem, a seafood processor should get help. A consulting engineer would be of great value. It is likely that efforts will be needed to gather additional information. One might, for example, collect wastewaters from each processing step, in order to determine steps where pollutant loads originate and steps that produce minimal pollution. The consulting engineer should be a prime actor in this work, since he or she will be using the data to select appropriate strategies for relieving the water quality problem.

3. Assess Options

Once the problem has been defined in greater detail, solutions should be developed and assessed. Disposal on land, discharge to a sewer system, and alternative use of waste products all must be considered in addition to wastewater treatment. These options could apply to a single wastewater stream (e.g. the cooker water at a crab picking plant) or wastewaters from several processing steps. Reliability and costs are likely to be the determining factors when selecting an approach to solve the problem.

All food processing plants are similar, but each is unique. The problems encountered by one segment of an industry are likely to be similar. If little is known about the nature of the wastewaters produced by that industry, and how those wastewaters might be treated, then plant owners should consider pooling resources to get the basic problems defined and possible treatment technologies tested.



GLOSSARY

Activated sludge—A type of biological treatment where the microorganisms are kept suspended in the water by aeration. Following this stage, the wastewaters are allowed to settle. A portion of the sludge is returned to the aeration tank to ensure that there is a large population of microorganisms to consume the organic matter in the sewage.

Aerobic—Oxygen is present.

Anaerobic—Oxygen is not present. In practice, when dissolved oxygen concentrations go below 1 mg/l, anaerobic conditions probably exist locally.

Biological treatment—Treating wastewaters using microorganisms, which use up the nitrogen, carbon and phosphorus in the wastewaters as they grow. The organisms can be attached to solid materials (trickling filters) or suspended in the water (activated sludge).

Biochemical Oxygen Demand (BOD)—A measure of the amount of oyxgen that will be consumed as the organic matter in wastewaters is decomposed by bacteria and other microorganisms.

By-product recovery—Capturing a by-product of a process and using it for beneficial purposes. A good example is the collection and drying of blue crab carcasses for use in animal feeds.

Carapace—The shell of a blue crab.

Chemical treatment—Treating wastewaters using chemical processes. The addition of iron salts or other substances to cause phosphate compounds to form and settle out is one example.

Composting—Combining organic matter, such as sludge from settling tanks, with wood chips or other bulking materials and allowing the organic matter to decompose. When the bacteria break down the organics, they release heat, causing compost piles to be very warm. This also kills pathogenic bacteria.

Effluent—The water that flows out of a processing plant or out of a wastewater treatment facility.

Flow equalization—Providing mechanisms to smooth out variations in flow rates.

Influent—The water flowing into a treatment plant.

Lagoon—A small pond, often in an oval, race-track shape, used to treat wastewaters.

Molting—When a blue crab sheds its shell and then develops a newer, larger shell.

Nonpoint source pollution—Pollution arising in a diffuse and dispersed manner, such as materials deposited from the air or coming off the land in runoff.

National Pollutant Discharge Elimination System (NPDES)—The program established by the U.S. Environmental Protection Agency that requires all dischargers to obtain a discharge permit which includes monitoring requirements and limits on the amount of pollutants that can be discharged.

Peelers—A name for blue crabs that are about to molt.

pH—A measure of the acidity of water.

Point source pollution—Pollution from industries or cities arising at one or more points, such as pipes that discharge to a river.

Pretreatment—Treating waste waters prior to discharge to a municipal sewer system. Pretreatment is used to remove toxic substances and to reduce pollutant concentrations and therefore also sewage fees.

Primary treatment—The first step in wastewater treatment, typically physical treatment, which uses gravity to separate solids and floating matter from the water.

Retort—A vessel in which blue crabs are cooked using steam.

Screening—Use of screens in floor drains or elsewhere to capture solid materials in the waste waters.

Sedimentation—Allowing solids to settle out of the water, typically by reducing the flow rate.

Septic tank—A sytem for on-site treatment of wastes, especially domestic wastewaters. Solids settle to the bottom and are decomposed by anaerobic bacteria. Grease and oils float to the surface. Both solids and floating materials must be removed from the tank periodically, if the system is to continue to provide treatment.

Tertiary treatment—The third step in wastewater treatment, usually chemical treatment.

Trickling filter—One form of biological treatment. Rocks or plastic devices specially designed for this purpose are placed in tanks; wastewaters are then sprinkled over the surface of the rocks. Slimes and microorganisms, which grow on the surfaces, remove materials from the waters, thereby reducing nutrient and BOD concentrations.

Total Suspended Solids (TSS)—The amount of solid material suspended in the water. This is measured by running a known volume of water through a filter, and then drying and weighing the filter.

Virginia Pollutant Discharge Elimination System (VPDES)—The U.S. Environmental Protection Agency has delegated authority for the NPDES permitting system to qualifying states, including Virginia. Discharge permits therefore are issued by the Virginia Department of Environmental Quality.

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