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ECONOMIC ANALYSIS OF THE POTENTIAL FOR OYSTER AND HARD CLAM DEPURATION IN DIXIE AND LEVY COUNTIES, FLORIDA

by

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Abstract

Illness associated with the consumption of raw molluscan shellfish is one possible factor that has depressed demand for oysters (Crassostrea virginica) in coastal counties of Northeast Florida. Controlled purification (depuration) has been identified as one method of improving public confidence in oysters and increasing sales. This economic analysis determines the anticipated costs of depuration processing in 12 design options with operating capacities from 30 to 498 bushels per week. Based on projected capital and operating costs, the expected premium for depurated product, and the cost of shellstock, depuration is not an economically feasible method of shellfish processing in the area of study.

KEYWORDS: depuration, economics, oysters, shellfish processing

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Executive Summary

In depuration, shellfish are placed in tanks of sterilized, flowing seawater where their natural pumping action purges the animal of gut contents and the pathogens that it can contain. Because depuration has the potential to reduce the number of some illness-causing agents found in mollusks, it has been identified as one way to increase public confidence in shellfish, particularly in oysters. Any resulting increase in sales of shellfish could positively impact the economies of Dixie and Levy counties on the east coast of Florida. Depuration can also increase the size of the oyster resource by opening new areas to harvest.

Shellfish feeding behavior, their location in coastal waters prone to environmental contamination, and the fact that they are often eaten raw or partially cooked makes their consumption riskier than other food products. While depuration has the potential to remove some of the risk of consuming shellfish, it has not been proven to be 100% effective in the elimination of certain pathogens. This decreases the chance that depuration will result in a greater volume of sales or price premium paid for depurated shellfish.

The cost of depuration may be recuperated by a price premium, or it may be covered by purchasing raw shellstock at a lower price than product that will be marketed without depuration. Shellfish in some coastal waters cannot be harvested for direct-to-market sales, but may be sold if depuration processing is used. Oyster harvesters indicate that they would be willing to accept a lower price per bushel if they had access to beds that are in these restricted waters. Based on current oyster purchase prices, the estimated costs of harvesting, and estimates of the catch per trip, $1.80 per bushel is available to cover the costs of depuration. Harvest of hard clams does not provide a similar opportunity, because virtually all hard clams harvested are from aquaculture leases in approved waters.

Based on the estimated size of the oyster resource in restricted waters, an additional 5,800 to 13,600 bushels per year could be made available to harvesters if a depuration facility were available. This is a 22% to 51% increase over average landings in the two counties for the 1990 to 1992 period. At the present time, a 5,800 bushel increase is a more realistic estimate; 13,600 includes resource from the Suwanee Sound which is currently not a viable resource for depuration. The extended time period required for testing for the presence of salmonella in oysters from these waters significantly reduces or eliminates the market shelf life.

Because it is difficult to predict the size of the oyster or hard clam resource available in any given year, the costs of several different size depuration facilities were calculated. Facility capacity ranges from 30 to 480 bushels depurated per week. The size of the oyster resource in restricted waters, size of shellfish processing plants in the area, and length of the operating year were used as a guide for determining the range of capacities.

Depuration facilities are considered shellfish processing facilities and are regulated by the Florida Department of Environmental Protection (DEP). Processing procedures must be

certified by the DEP which conducts monthly inspection of the facility. Certain design elements and operating procedures are regulated by DEP. Other regulatory concerns for a depuration facility are the general permit for effluent discharge, easement for construction on state-owned lands, and wetland resource permit.

Contaminated coastal water combined with the high cost of coastal land makes facility siting one of the most difficult aspects of planning a depuration facility. An optimal location would provide each of the following at the lowest cost: (1) a source of shellfish product, (2) a source of depuration tank waters, (3) a place to discharge effluent, (4) road access for deliveries and personnel, (5) utility access, (6) private ownership, (7) commercial zoning.

Much of the coastal land in the two counties is either state or federally owned, is marshy and thus unsuitable for the facility due to construction and regulatory costs, or is not located near a road. Based on product source, roads, and utility access, three likely locations for a commercial facility are the towns of Cedar Key, Horseshoe Beach, or Suwanee.

The calculated cost per bushel depurated ranges from $42.81 to $9.25. Cost per bushel decreases for larger systems, greater utilization of tanks per cycle, lower mortality, and a longer operating year. Higher mortalities or depuration cycles where tanks are not stocked to their maximum capacity have the greatest potential to increase costs per bushel. Cost per shellfish unit (oyster or clam) changes in response to these factors as well as to the number of units per bushel.

Based on current shellfish prices and production costs, depuration does not appear to be an economically feasible business alternative for the two counties. Retail and wholesale prices for oysters or hard clams in general would have to increase significantly, or a significant price premium would have to be paid for depurated product, for depuration to become a viable business. The cost of depuration appears to be too high to be recuperated by a price premium or a reduction in shellstock cost. Because the number of shellfish units per bushel is greater for hard clams than for oysters, the cost per clam is much lower, and it may be easier to secure the price premium required to cover depuration costs.

Wet-storage and relaying provide two alternatives to depuration which may prove more economically viable than depuration. Wet-storage is similar to depuration but is not considered to be a process to enhance safety. Differences in some operating procedures and regulations make this form of processing less expensive than depuration. Relaying can act as a form of "field depuration," and requires no fixed facility. Relaying in conjunction with private leases provides a potentially less costly alternative to make use of resources in restricted waters.

ECONOMIC ANALYSIS OF THE POTENTIAL FOR OYSTER AND HARD CLAM DEPURATION IN DIXIE AND LEVY COUNTIES, FLORIDA

by R.D. Dunning & C.M. Adams

INTRODUCTION

Oysters and clams are harvested from coastal waters susceptible to environmental pollution. Shellfish feed by filtering their surrounding water and are often consumed raw or partially cooked, making their consumption riskier than that of other meat products. One in 250 servings of raw or partially cooked molluscan shellfish results in illness, compared to 1 serving in 25,000 of cooked chicken, or one in 5 million servings of cooked finfish (U.S. Food and Drug Administration, 1989).

Public concerns with eating raw shellfish is one possible factor that has depressed demand for oysters harvested in the counties of Dixie and Levy in Florida. Shellfish wholesalers in the area estimate that their sales of oysters are 50% or less what they were five years ago (Viele, 1994; Deadrick, 1994). Controlled purification (depuration) can reduce the number of some illness-causing agents found in mollusks, and has thus been identified as one way to increase public confidence in shellfish, particularly in oysters. An increase in consumer confidence may allow for a recovery of lost markets and an overall increase in demand for shellfish products. Any resulting increase in demand could economically benefit oyster harvesters, shellfish packing plants, and other businesses related to the shellfish industry. Greater demand for depurated oysters or hard clams could allow for a premium to be charged on those products. This premium may be sufficient to cover the costs of depuration.

The harvest areas for oysters and clams is regulated by the Food and Drug Administration (FDA) and Interstate Shellfish Sanitation Conference (ISSC) acting in conjunction with state agencies. As a result of this management responsibility, a large volume of oyster resource in Dixie and Levy counties is not open to direct-to-market harvesting. With depuration, however, a portion of the resource in these areas could be utilized. With access to more or richer oyster beds, oysterman would be able to harvest a greater number of bushels per harvest trip, thus lowering their cost per bushel. Shellfish processors could pay a lower price for these oysters, providing another means to cover the costs of depuration.

This paper examines some of the economic benefits and costs related to a hypothetical commercial depuration facility in Dixie or Levy County, Florida. The economic analysis will determine the anticipated costs of production and the sensitivity of production costs to changes in design and operating parameters.

PART ONE: BACKGROUND AND BENEFITS

DEPURATION, WET STORAGE, AND RELAYING

Depuration

In depuration, shellfish are placed in tanks of clean, flowing seawater for a minimum of 48 hours. Since the water contains little food, at the end of the 48 hours the animal is rid of gut contents and the pathogens that these contain (assuming that the animal is actively pumping). Water passing over the mantle and gills can carry away pathogens weakly attached to these tissues. The numbers of pathogens can also be reduced by natural die-off. At the same time, bacteria continue to multiply. The goal of depuration is to generate a net reduction in pathogens to a "safe" level, which is indicated by an ending fecal coliform count of less than 20 cells per 100 grams of shellfish meat. This compares to a fecal coliform standard of not greater than 230 cells per 100 grams meat for all oysters sold at the wholesale level (FACb, 1993).

Regulations specify the source waters for shellfish harvest and waters used in the depuration tanks. The Florida Administrative Code (Code) currently specifies that only shellfish from restricted or conditionally restricted waters (classification of waters is explained below) may be depurated. These waters are not open to harvests for direct-to-market sales.

Few certified commercial depuration facilities exist. One facility in Florida depurates hard clams. A state-owned facility in Massachusetts depurates soft-shell clams, and facilities in Maine and Connecticut depurate oysters and hard clams. Mussels are depurated at a flow-through facility in San Diego.

Wet-Storage

Although the actual design of depuration and wet-storage facilities is very similar, the goal of wet-storage is not to increase the safety of shellfish. Wet storage is primarily used to increase the palatability of shellfish by cleansing sand and grit from the mantle and gills of the shellfish, and adjusting the salt content of the meat by circulating water with a different salinity than that from which the shellfish were originally harvested. Both of these can increase the marketability of shellfish. Shellfish processed by wet-storage can be harvested only from the waters from which oysters for direct-to-market sales are harvested. In comparison to shellfish in the depuration system, meats are not tested for fecal coliform. However, tank waters are tested. There is one oyster wet-storage facility in Florida.

Wet-storage and depuration facilities can also be used to store shellfish for an extended time period (weeks to months), but this appears to require a flow-through system, as opposed to recirculation, to allow a constant supply of natural food. Both wet-storage and depuration have also been touted as ways to increase the shelf life of shellfish; purging shellfish of bacteria in wet-storage and depuration facilities can forestall the multiplication of bacteria that leads to spoilage, thus extending shelf life. Based on conversations with wet-storage and depuration facility operators, however, it is not clear whether either method lengthens shelf life.

Relaying

Relaying is sometimes referred to as "field depuration." Shellfish can be harvested and transferred from restricted areas to approved areas for purification. Harvested shellfish could be placed back on the sea floor, or they may be held in containers until re-harvest. Relayed oysters can be re-harvested after a period of 15 days if they pass the fecal coliform test of 230 cells per 100 grams meat. Thus, the bacteriological quality of the shellfish to be harvested after relaying must meet the same quality as that expected from shellfish harvested directly from approved areas.

Relaying has primarily been utilized by the state of Florida to transplant juvenile oysters from areas that may be over-crowded with small oysters, such as intertidal reefs, to depleted oyster beds. In state-sponsored **public relays**, oysters are moved to public bars and become a common property resource. In 1993, 156,000 bushels of oysters were relayed and transplanted by the state of Florida in resource development projects. These relays are conducted primarily during the summer months. Of these, 35,532 bushels were relayed/transplanted in Dixie county and 35,106 bushels in Levy county (Berrigen, 1994). Most of these oysters were transplanted from approved waters to other approved waters.

The state controls the harvest, planting, and re-harvest of oysters during relaying. A state certified monitor must accompany vessels when the oysters are relayed. The approximate cost for a monitor is $100 per day. The monitor must also be present when oyster samples are taken before the oysters are re-harvested. Laboratory analysis of the samples verifies that the fecal coliform count is below 230 cells. The approximate cost of the analysis is $125. Once the oysters have been approved for harvest, oysterman may return and harvest from the bars. In previous public relays, the state has paid the costs of the monitor and lab analysis, and has also paid a price to the oysterman per bushel transplanted. This payment has normally been between $1.00 and $1.25 per bushel (Cooke, 1994).

Since the creation of oyster leases in the Cedar Key area, there has been a somewhat greater interest in **private relaying** from restricted areas to privately-owned leases. In a private relay, the relayer/harvester must obtain a special activity license from the state (free of charge) and, as in a public relay, must be accompanied by a monitor for the initial harvest and transplanting of oysters, and retrieval of the oyster samples for lab analysis. Up to 15 boats may accompany one monitor, and this can help defray the costs of the monitor and lab analysis. Oyster harvesting from a private lease can be more cost effective than harvesting off of public bars because harvesters working their own lease can harvest greater than the 20 bushel daily limit imposed on harvesters of public bars (FACa, 1993). Oystermen can also harvest off of leases during the summer months when public bars are closed (FACa, 1993). A realistic scenario would be that of an oysterman relaying 200 to 250 bushels of oysters in one day during the fall from restricted areas to his own lease, then weeks or months later harvesting 20 or more bushels per day off of the lease.

A state-assisted private relay program was conducted in October of 1993 in Dixie and Levy counties. The state covered the costs of monitoring and sampling, but no per bushel payments were made to oysterman. Approximately 2,500 bushels were moved from the Suwanee Sound to 26 private leases in Dixie and Levy counties.

A disadvantage of relaying is the possibility of heavy mortalities. Those involved in public relays or the October private relay were not able to estimate an average relay mortality because of the number of variables influencing mortality and lack of information from harvesters. Theft of relayed oysters is another disadvantage of private relaying.

Despite disadvantages, relaying used in conjunction with private leases can be profitable (Burrage, et al. 1991) The development of leased areas in conjunction with state support seems to have lead to greater interest in private relays in Dixie and Levy counties.

SHELLFISH SAFETY AND DEPURATION

The majority of seafood related illnesses in the U.S. are associated with the consumption of raw bivalve molluscan shellfish (National Institutes of Health (NIH), 1991). The disproportionate incidence of illness is largely related to the feeding behavior of mollusks and the fact that they are often eaten raw or partially cooked.

Feeding Behavior of Molluscan Shellfish

Oysters and clams feed on plankton by filtering large volumes of seawater. Potential food particles such as phytoplankton, as well as non-food microorganisms like bacteria, viruses, and chemical toxins, are ingested. Some non-food items are immediately rejected as pseudofeces. Remaining particles pass into the stomach. Food particles are digested, and most non-food particles are discharged from the animal. The process from ingestion to discharge can be completed in less than two hours in actively feeding oysters (Cook, 1991). Some ingested particles, however, are neither digested as food nor discharged as feces; they become a part of the shellfish "microflora," joining other microorganisms in the tissues of the animal. These microorganisms neither hurt nor aid the animal. Thus, mollusks have two sources of microbial pathogens: pathogens in the gut that have not yet been discharged through the anus, and pathogens that live sequestered in the tissues of the organism and are not readily discharged.

The majority of the microbial pathogens in mollusks that pose a danger to human health are associated with fecal contamination from land-based sewage treatment plants, septic tanks, or land run-off (NIH, 1991). Oysters live on the ocean bottom or attached to structures in the water column, while clams live buried in sand or mud on the ocean floor. Both are harvested from estuarine and near-coastal areas which are most vulnerable to human and animal waste contamination from sewage treatment plants or land run-off, as well as chemical run-off originating from industry and agriculture. Oyster and clam immobility adds to the likelihood of contamination since they cannot escape degradation of their environment.

Shellfish-borne Disease

Most illnesses resulting from the ingestion of raw or under-cooked shellfish arise from bacterial or viral organisms associated with fecal contamination (NIH, 1991). Three of these bacteria are shigella, salmonella, and E. coli. Human ingestion of a significant number of these bacteria result in diarrhea, vomiting, and headaches, which generally subside in 24-48 hours. However, each can be life-threatening depending upon the severity of the symptoms and health of the infected individual (NIH, 1991).

The fecal-associated viruses of main concern that have been linked to shellfish sickness include Hepatitis A, Norwalk virus, and other Norwalk-like viruses. Like the fecal-related bacterial pathogens, sicknesses resulting from ingested viruses generally have mild symptoms which subside within 48 hours. It is suspected that up to 70% of the shellfish-related illnesses reported each year are caused by viral pathogens, specifically Norwalk and Norwalk-like agents (Kilgen and Cole, 1991; NIH, 1991; U.S. FDA, 1989).

Vibrio is a sub-classification of bacterial organisms but, with the exception of *Vibrio cholerae*-01 which is found in waters contaminated by human sewage, vibrio bacteria are of non-fecal origin and naturally occur in most shellfish harvesting areas of the U.S. (Cook, 1991). They are part of the natural flora of a estuarine, marine, or freshwater environment. The vibrio *V. vulnificus* is considered to be the most deadly of these organisms that can infect humans. While *V. vulnificus* accounts for just 1.4% of the total reported incidents of shellfish-related illnesses, the mortality rate for immunocompromised individuals can exceed 50% (NIH, 1991). Individuals at high risk include persons with liver disease, cancer, AIDS, and diabetes. In Florida, during the years 1981 to 1992, an average of six individuals per year were infected by *V. vulnificus* due to oyster consumption. Of these illnesses, about 50% resulted in death (Seanet, 1993).

Naturally occurring and man-made toxins can also be ingested by mollusks and pose a threat to human health, but this discussion will be confined to bacterial and viral disease-causing organisms which cause almost all mollusc-related illnesses.

Processing and Consumption

Improper handling of oysters and clams can cause multiplication of bacteria. Insufficient refrigeration from harvest to consumption increases the likelihood that the number of bacteria will increase (Reily, et al. 1985; Cook and Ruple, 1989.) Viruses, however, do not replicate in seafood products, so time and temperature are not factors (Kilgen and Cole, 1991).

The microbial pathogens that infect human beings could be eliminated through cooking (NIH, 1991). However, oysters and clams are frequently consumed raw and the entire animal is consumed, including the gastrointestinal tract, thus increasing the chance that pathogens will be ingested.

Control of Shellfish-borne Disease: Area Classifications

Acting under the purview of the FDA, the Interstate Shellfish Sanitation Conference (ISSC) agency in each state attempts to control the risk to human health of shellfish-borne pathogens by regulating the waters from which mollusks may be harvested. The Florida Department of Environmental Protection (DEP), Shellfish Environmental Assessment Section, is responsible for classifying and managing Florida shellfish harvesting areas.

Sanitary shellfish harvesting area surveys are designed to identify and evaluate actual and potential sources of pollution that can impact growing areas. "Pollution points" such as sewage treatment systems, areas prone to agricultural run-off, and areas with wild animal populations are identified.

The bacteriological portion of the survey is primarily concerned with environmental contamination resulting from fecal matter discharged into coastal waters. Because it is not feasible to test water for each type of microbial pathogen, authorities measure the presence of one pathogen, fecal coliform. Fecal coliforms are present in large numbers in untreated sewage and thus indicate the presence of human bacterial and viral pathogens that are also found in sewage. Fecal coliform is called the "indicator" bacteria. The following bacteriological standards have been established to aid in the classification of harvest waters:

NSSP 14/43 standard: Median or geometric mean of the fecal coliform indicator not to exceed 14 MPN (mean probable number) per 100 milliliters of water, and MPN not to exceed 43/100 ml of water more than 10% of the time.

NSSP 88/260 standard: Median or geometric mean of the fecal coliform indicator not to exceed 88 MPN (mean probable number) per 100 milliliters of water, and MPN not to exceed 260/100 ml of water more than 10% of the time.

The fecal coliform indicator has been successful in eliminating major outbreaks of gastroenteritis caused by salmonella, and it was originally conceived for this purpose after an outbreak of typhoid in the 1940s (Kator and Rhodes, 1991). However, a major weakness of the fecal coliform indicator is that it does not appear to be an adequate indicator of human health risk from viral pathogens (Regan, et al. 1993), nor health risk from naturally occurring bacterial pathogens such as vibrio (NIH, 1991). The presence of vibrio is independent of fecal contamination, but is generally greater in months with warmer water temperatures (Seanet, 1993).

Based on the findings of the pollution point survey and bacteriological survey, coastal waters are designated as belonging to one of the following six shellfish growing areas (Florida DEP, 1993):

Approved Area (AP): Normally open to shellfish harvesting; may be temporarily closed under extraordinary circumstances such as red tides, hurricanes, and sewage spills. The 14/43 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, or any combination of these).

Conditionally Approved Area (CA): Periodically closed to shellfish harvesting based on pollutional events, such as rainfall or increased river flow. The 14/43 standard must be met when the management plan parameter (rainfall, river stage, and or river discharge) is less than the adverse pollution condition during all other adverse pollution conditions.

Restricted Area (RE): Normally open to relaying or controlled purification, allowed only by special permit and supervision. May be temporarily closed under extraordinary circumstances such as red tides, hurricanes, and sewage spills. The 88/260 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, or any combination of these).

Conditionally Restricted Area (CR): Periodically, relay and controlled purification activity is temporarily suspended based on pollutional events, such as rainfall or increased river flow. The 88/260 standard must be met when the management plan parameter (rainfall, river stage, and/or river discharge) is less than the adverse pollution condition during all other adverse pollution conditions.

Prohibited: Shellfish harvesting is not permitted due to actual or potential pollution. This classification is least desirable, and is used only when standards are exceeded for Approved, Conditionally Approved, Restricted, and Conditionally Restricted classification management schemes.

Unclassified: Shellfish harvesting is not permitted pending bacteriological and sanitary surveys.

NSSP area classifications are reevaluated every three years and areas are resurveyed every 12 years.

Harvesting and Depuration in Classified Areas

Based on the classification system, shellfish harvested for direct marketing is permitted from approved (AP) or conditionally approved (CA) areas. Shellfish harvested from restricted (RE) and conditionally restricted (CR) areas must undergo controlled purification, by depuration or relaying, before they may be sold for consumption. Shellfish cannot be harvested from prohibited or unclassified waters.

CA and CR areas may be periodically closed when potential sources of pollution threaten to contaminate waters. Because it is not feasible to carry out daily fecal coliform counts for waters, authorities rely on rainfall and river discharges as indicators that the areas should be closed. Increased rainfall and river discharge implies greater run-off of contaminants from land areas into coastal waters.

CA and CR areas are closed to both direct-to-market harvests and depuration if the conditions of the management plan dictate their temporary closure. Since waters of RE areas have no such management plan, these waters are open to depuration except under extraordinary circumstances. Because the Florida Administrative Code (Code) does not currently include oysters from approved areas as a potential product source for depuration, only oysters from RE or CR areas can be certified as depurated (FACb, 1993). The management plans and number of days of closure in 1993 for each shellfish harvesting area in Levy and Dixie counties is given in Table 1. For most areas, management plans based on rainfall and river discharge were created in mid-1992. Up until that time, most coastal areas in the two counties were managed as AP areas (Harris, 1994). Maps in Appendix A give the current management area classifications for the 5 areas within the two counties. References made in this text to areas in the two counties are referring to the areas associated with each of these maps. (For example, "Suwanee Sound" refers to the area associated with its area classification map).

There are currently no AP or CA areas for direct-to-market harvest in the Suwanee Sound. Sound waters were reclassified in 1989 due to the potential for failing or improperly installed septic systems in the town of Suwanee to contaminate shellfish growing areas. Oysters in CR and RE areas, however, may be harvested in conjunction with depuration and relaying. CR waters may close temporarily as dictated by the management plan.

In Dixie and Levy counties, harvesting in classified areas is allowed only between September 1 and May 31. However, individuals with aquaculture leases may work their leases year-round (FACa, 1993). In March 1994, 137 leaseholders held 548 acres in aquaculture leases in the two counties (Sturmer, 1994).

Depuration and Enhanced Value

The depuration system relies upon the biological processes of the oyster or clam for successful depuration. Any environmental or biological conditions that inhibit the pumping action of the animal can reduce the effectiveness of depuration. Temperature, turbidity, salinity, oxygen levels, handling, tank flow rate and other factors influence the rate of pumping. While relationships are believed to exist between these factors and the success of depuration, no definitive studies (using UV sterilized water) exist which quantify the effect of these factors or time of depuration with its effectiveness as measured by ending pathogen levels.

While laboratory depuration has been used successfully to remove bacterial pathogens from shellfish, it has not been proven to be 100% effective for elimination of viruses and vibrio (Klontz and Rippey, 1991; Richards, 1988; Blake, et al. 1985). Though the animal is rid of gut contents which may contain pathogens, viruses and vibrio may be sequestered in the tissues of shellfish even after depuration. Research indicating that the rate of depuration decreases with time has led to the hypothesis that pathogens weakly attached to tissues are depurated first, while more firmly attached organisms are depleted more slowly or decline due to die-off (Richards, 1988). While ozone used as a water sterilizer is suspected of being more effective in the elimination of some pathogens, like UV it only inactivates pathogens in the water, and not those sequestered in shellfish tissues (Richards, 1991).

Since pathogens may still remain in the shellfish, and because fecal coliform is a poor indicator of the existence of viruses and vibrio in shellfish, it is possible for an oyster or clam to pass the 48-hour fecal coliform test and still cause illness as a result of viruses or vibrio remaining in the meat (Klontz and Rippey, 1991; Richards, 1988). Thus, depuration cannot guarantee 100% eradication of illness-causing pathogens in shellfish.

Table 1. Management plan and number of days closed, 1993, Dixie and Levy Counties, Florida[a]			
area	management plan	(occurrences / days closed)[b]	
		open season (Sept-May)	summer (June-Aug)
Cedar Key	(Rainfall based on measurements made at the Cedar Key Forestry Tower)		
Conditionally Approved:			
Zone A	Cumulative four-day rainfall exceeds 5.00"	3 / 25	0 / 0
Zone B	Cumulative four-day rainfall exceeds 0.81"	11 / 70	7 / 64
Conditionally Restricted	Cumulative four-day rainfall exceeds 3.70"	12 / 77	7 / 64
Horseshoe Beach Conditionally Approved and Conditionally Restricted	One-day rainfall measured at the Horseshoe Beach Forestry Tower exceeds 0.83"	13 / 97	7 / 48
Suwanee Sound Conditionally Approved and Conditionally Restricted	One-day rainfall measured at the Sunnyvale, Horseshoe, or Cedar Key forestry towers exceeds 1.45"	all of 1993	
Waccasassa Bay	(Measurements based on Waccasassa River discharge measured near Gulf Hammock three days previous)		
Conditionally Approved	Discharge exceeds 1,223 cubic feet per second	1 / 19	0 / 0
Conditionally Restricted	Discharge exceeds 1,543 cubic feet per second	1 / 19	0 / 0
Withlacoochee Bay	(Measurements based on Withlacoochee River discharge measured at the main gate of the dam at Inglis thrée days previous)		
Conditionally Approved	Discharge exceeds 1,413 cu/feet/second	17 / 1	0 / 0
Conditionally Restricted	Discharge exceeds 2,844 cubic/feet/second	0 / 0	0 / 0

[a]Information from Gainesville, FL, Department of Environmental Protection office. Most areas were not managed by rainfall or river discharge levels until 1992. The next date for reclassification of the above areas is June 1995.
[b]number of closures and days closed to harvesting, depuration, and relaying

Because depuration cannot guarantee a product that can be eaten without fear of illness, any increase in purchases of depurated oysters by consumers would have to rely largely on an improvement in consumer perception of shellfish safety rather than increased demand stemming from a guarantee by the facility or state that the shellfish is pathogen-free. Improved perception could be improved by stating that the shellfish is "state certified" or "laboratory certified." However, without successful elimination of all pathogens, particularly *V. vulnificus*, it is questionable whether depurated oysters would be able to earn a premium sufficient to cover the costs of depuration, or result in any significant increase in the demand for oysters. Market research is on-going which may address this issue (Degner, 1994).

Sellers could make the claim that shellfish are cleaner, if not biologically "pure", because depuration does reduce the number of fecal coliforms in shellfish meat to a level 10 times less than that associated with shellfish harvested for direct-to-market consumption. However, fecal bacteria and other types of bacteria can multiply to predepuration levels and higher if there is mishandling during transport and food preparation. This mishandling could tarnish the reputation of the depurated product.

Depuration produces a visually clean oyster or clam, with little sand or mud, and appearance alone may attract buyers from some markets such as upscale restaurants. However, the market for these restaurants may not be great enough to support a facility of a size that is economically feasible.

DEPURATION AND THE SIZE OF THE OYSTER RESOURCE

Since virtually all clams harvested in the area are from hard-clam (container) aquaculture on leased, conditionally approved waters, the following discussion pertains only to wild-caught oysters.

Depuration allows oysters to be harvested from restricted waters which are closed to direct-to-market harvesting. This effectively increases the size of the oyster resource available for harvest. With a greater resource, oystermen may be able to increase their catch per day, thus lowering the costs per bushel harvested. This difference in cost provides a second means by which the costs of depuration can be covered.

Size of the Existing Resource

It is difficult to precisely estimate the size of the oyster resource in an area. The size of landings in any season depends upon a number of factors including environmental conditions, price per bushel, and profitability of other enterprises. During the mid-1980's, prices rose above $20 per bushel, largely in response to storms and disease which reduced harvests in the beds of Apalachicola Bay (Franklin county), which normally provide about 75% of all oysters harvested in Florida. Record harvests in Apalachicola Bay for the 1993-1994 season put downward pressure on prices, and the average price paid to harvesters in early 1994 was $8 to $12 per bushel.

Table 2. Commercial oyster landings, (bushels), in Dixie Co., Levy Co., Franklin Co., and the State of Florida, 1985-1993				
	Dixie County	Levy County	Franklin County	Florida
1993 (Jan-Oct)	595	3,963	139,545	191,223
1992	4,076	8,147	165,682	256,803
1991	15,228	4,468	155,092	236,129
1990	33,498	13,230	190,091	285,450
1989	72,355	20,227	104,491	236,080
1988	53,409	10,491	164,040	281,549
1987	52,501	10,584	353,035	481,423
1986	107,205	29,626	60,072	279,503
1985	2,674	15,809	484,592	559,316

source: Florida Department of Natural Resources, Marine Fisheries Information System, Annual Landings Summary
Bushels will not sum across columns because not all counties are represented.
Meat weight converted to bushels by dividing by 0.13125 to equal meat with shell and by 60 for number of 60 pound (standard) bushels

Oyster landings in Dixie and Levy counties have declined considerably in recent years. This has been due to a combination of factors. Shellfish wholesalers indicate that media attention to the danger of eating raw oysters has significantly reduced demand for oysters. The profitability of alternative enterprises, most notably aquaculture of hard clams on privately-owned leases, has provided a profitable alternative to harvest of wild oysters. The low expected catch rate, averaging eight bushels per day (estimate based on National Marine Fisheries Service (NMFS) landings/trip data and information from harvesters in Cedar Key), translates into a higher cost per bushel for the harvester. Oystermen often blame fewer bushels per trip and per season on harvest area management which closes some waters permanently and other waters temporarily.

Table 2 gives oyster landings in Dixie, Levy, and Franklin counties and the state of Florida since 1985. The average landings for the 1990 - 1992 period was 17,600 bushels in Dixie county and 8,615 bushels in Levy county. These figures cannot be used as a definitive estimates of the size of the resource in the two counties, because the number of oysters harvested in any area depends on many factors. Nevertheless, landings do give a sense of the quantity of oyster resource in AP and CA waters that was "worth harvesting:" oystermen harvested oysters until it was unprofitable to do so or until another alternative became relatively more profitable.

The Resource Available for Depuration

DEP's Shellfish Environmental Assessment Section carries out the sanitary and bacteriological surveys that are used to define the water classifications for different harvest areas. DEP also carries out sampling to determine the general size and condition of the oyster resource in some areas. Based on this resource assessment, it is possible to make general estimates of the size of the resource available in some CA and CR waters that could be utilized in a depuration process. Because the resource assessment is in large part carried out to identify potential sources of oysters for the purpose of relaying, resource assessments for the two counties have concentrated in the areas that are considered to be the most productive for oystering.

Based on these surveys, it is estimated that an additional 12,000 bushels of oysters per growing season (1 to 1.5 years) are available in Dixie county in the CR waters of Horseshoe Beach (all resource estimates from Gunter, 1994). In the Suwanee Sound, an additional 19,500 bushels of oysters per season could be harvested in RE areas. Approximately 2,500 additional bushels would be available in the CR waters of Cedar Key in Levy county. Thorough resource assessments have not been made in the areas south of Cedar Key because these areas are not considered to be extremely productive for oystering. Thus, it is not possible to estimate the size of the resource in CR waters of Waccasassa and Withlacoochee Bays.

The total increase in the size of the resource using depuration is estimated to be approximately 34,000 total bushels per growing season, or approximately 27,200 bushels per year for the two counties. Assuming a catch rate of 50%, this equals a potential increase in landings per year of 13,600 bushels.

However, current restrictions to harvesting in the Suwanee Sound effectively keeps the resource in this area from being considered for depuration. Unlike oysters from CR or RE waters in other areas, lab analysis must confirm that oysters from the Suwanee Sound have no detectable levels of salmonella. Salmonella analysis adds approximately $180 to the laboratory analysis costs per depuration cycle. Oysters cannot be sold until all lab results have been received, and the lab analysis requires seven days. Considering that oysters have a shelf life of five to 15 days (shelf life depends on many factors such as season and temperature), the time period required to do the lab analysis and receive results significantly reduces or eliminates the market shelf life.

An associated risk is the possibility that oysters at the close of the depuration cycle would not be proven free of salmonella. While depuration has been shown effective in reducing salmonella to undetectable levels in oysters that have been infected in the laboratory, the effectiveness in reducing salmonella in oysters that have naturally acquired the bacteria has not been confirmed (Rodrick, 1994). If lab analysis indicates that salmonella is still present in the meats, the oysters must be re-depurated or disposed of. This risk combined with the effective reduction in shelf life discounts the use of Suwanee Sound oysters in conjunction with depuration.

Without the resource from the Suwanee Sound, the potential annual resource for oyster depuration (using a 50% catch rate of the total estimated resource) is equal to 4,800 in the Horseshoe Beach area (Dixie county), and 1,000 in Cedar Key (Levy county). Compared to the average number of bushels landed in the 1990 - 1992 period in the two counties (26,215 bu), the depuration facility has the potential to increase the number of oysters harvested annually for the two counties by about 22%. If the Suwanee Sound resource were included, the total increase in the available resource would be approximately 13,600 bushels per season, an increase of 52% over the average for the 1990-1992 period.

Oyster Harvesting Costs

An increase in the number of oysters available for harvest should increase the average number of bushels harvested per oysterman per year, given that the number of oystermen does not increase dramatically. More bushels harvested per trip means that many of the oysterman's costs are spread out over more bushels, resulting in a decline in the costs per bushel harvested. The difference in costs between a bushel harvested in AP or CA waters and RE or CR waters may cover the costs of depurating that product. At the same time, it may create a greater net income for the oysterman.

To determine the approximate decrease in costs per bushel that could accompany harvests for depuration, an estimate was made of the cost of commercial oystering in Dixie and Levy counties. Costs are presented in Tables 3 and 4. These estimated costs are approximate and are based on a limited sample of oystermen.

Cost estimates were made based on inflation-adjusted costs in a 1983 study made of oyster harvesting in Franklin county (Prochaska and Keithly, 1986), and recent discussions with oystermen and managers of shellfish processing facilities in Cedar Key. Table 3 gives the inflation adjusted figures of the study (adjusted by the consumer price index), and the final estimates calculated for the Florida counties.

The costs per trip and bushel are for an "average" oysterman who harvests four days a week throughout the nine month oyster season. These costs may not be applicable to a part-time oysterman. Costs do not include operator's labor. The oysterman travels approximately 16 miles per trip, and harvests 8 bushels per trip. The costs per bushel would vary widely based on a number of factors such as the age of the boat, the expertise of the fisherman, and the number of oysters harvested. Using average costs and average bushels harvested, the cost per bushel is $4.21.

Table 4 illustrates the effect on the cost per bushel and cost per oyster with more bushels harvested per trip. Varying the number of trips and number of bushels harvested per trip has a great effect on the cost per bushel. Applying the greater number of trips and bushels per trip of the 1983 study to Dixie and Levy county costs results in a cost per bushel of $2.33. Using the estimated 153 trips per year with the 20-bushel daily limit, the cost falls to $1.97 per bushel.

While it is difficult to estimate the exact increase in the number of bushels harvested per trip if CR and RE areas were made available for harvesting to supply a depuration facility, oysterman indicate that their harvests would be closer to 20 bushels per day than the eight bushels that they harvest currently. If the oysters in the closed Suwanee Sound were available, they indicate that the 20 bushel per day limit would be easily achievable.

In addition to capital and operating costs of harvesting, the costs of hiring a monitor to accompany the oyster boat(s) must be included. The monitor can accompany up to 15 boats, and the approximate daily charge is $100. Assuming that every boat reaches its daily 20 bushel limit, the cost per bushel ranges from $0.33 to $5.00 depending upon the number of boats ($100 / (20 bushels per boat * 15 boats) = $0.33/bushel; $100 / (20 bushels per boat * 1 boat) = $5.00/bushel).

Table 3. Estimates of annual costs of oyster harvesting in Dixie and Levy counties, Florida, 1994

	1983 study[a]		
	original estimates	inflation adjusted[b]	Dixie & Levy Co.[c]
Variable costs:			
engine repair	$225.96	$324.03	$350
boat repairs	$282.24	$404.73	$450
gloves & boots	$370.92	$531.89	$600
tongs	$162.20	$232.60	$250
fuel & oil	$1161.69	$1665.86	$2000
Total Variable Costs	**$2203.01**	**$3159.11**	**$3650**
Fixed Costs:			
boat depreciation	$138.80	$198.48	$250
engine depreciation	$663.64	$951.66	$1200
license & permits	$19.28	$27.65	$50
Total Fixed Costs	**$821.72**	**$1177.79**	**$1500**
Total Costs	**$3024.73**	**$4337.46**	**$5150**
trips/year	186	186	153
bushels/trip	**11.9**	**11.9**	**8**
cost/trip	$16.26	$23.32	$33.66
cost/bushel	**$1.37**	**$1.96**	**$4.21**

[a]Prochaska and Keithly, 1986
[b]adjusted by the consumer price index
[c]estimates confirmed by oystermen in Cedar Key, Florida, 1994

Table 4. Illustration of the decrease in estimated cost per bushel of oysters harvested based on number of bushels harvested per trip, Dixie and Levy Counties, Fl, 1994

bushels harvested per trip	cost per trip	cost per bushel
8	$33.66	$4.21
10	$34.61	$3.46
15	$37.00	$2.24
20	$39.39	$1.97

An increase of 2% in variable costs per extra bushel of oysters harvested is assumed. Variable cost increase is minimal because the same approximate overall distance is assumed regardless of the number of bushels harvested.

DEPURATION AND AQUACULTURED HARD CLAMS AND OYSTERS

Hard Clams

In the mid-1980's, as many as six clam depuration facilities operated on the east coast of Florida (Rhodes and Kasweck, 1991). Depuration facilities were used to cleanse wild clams of sand and mud, and to make saleable wild clams harvested from restricted waters. All but one of the facilities closed in response to decreasing clam prices and a declining supply of clams.

Training and clam seed provided by Harbor Branch Oceanographic Institution's Project OCEAN has led to the establishment of a hard clam aquaculture industry in Dixie and Levy counties. Aquacultured clams are grown on private leases in AP or CA waters. Although hard clams are native to area waters, they do not grow in sufficient numbers to support a viable fishery. Therefore, costs of depuration could not be covered by purchasing cheaper wild clams harvested from restricted waters.

As with oysters, depurated clams may be able to command a price premium based on consumer perceptions of improved safety, or due to a better appearance or taste. Since clams grow buried in sand and mud, depuration or wet-storage can be used for cleansing. Hard clams also reportedly respond more positively to depuration, in the sense that they pump more readily than oysters under the same conditions.

While it appears that wet-storage would be a more suitable processing procedure for hard clams from leased, approved waters, this report will consider the cost of depurating clams as well as oysters. Since harvests can be made on leases throughout the year, sensitivity analysis which considers a greater number of depuration cycles per year can give an indication of the change in costs that depuration of hard clams may entail.

Oysters

At this time there are virtually no private oyster aquaculture activities in the two counties. Higher market prices for oysters could lead to greater interest in culture of oysters. Harbor Branch is conducting work on the development of a triploid oyster that could be cultured on leases. Triploid oysters have an advantage over "normal" oysters because they do not spawn: the energy expended by oysters on spawning during the summer results in smaller meats which reduce the salability and value of the oysters. Triploid oysters would make year-round harvests of oysters more economically attractive. While summer-harvested triploid oysters could be sold direct-to-market (since leases are all in AP or CA waters), depuration could be used to reduce levels of fecal coliforms which tend to be higher in summer months when oysters are subject to higher temperatures during transport.

PART TWO: THE DEPURATION FACILITY

NSSP AND THE FLORIDA ADMINISTRATIVE CODE

Regulations regarding the design and operation of depuration facilities are found in the Florida Administrative Code (FACb, 1993) and are largely adopted from the National Shellfish Sanitation Program (NSSP) manuals of operation. (The Florida Administrative Code is hereafter referred to as the "Code.") The NSSP is administered by the International Shellfish Sanitation Committee, which is a cooperative association between the individual states, the Environmental Protection Agency (EPA), FDA, NMFS, and the shellfish industry. The NSSP manuals serve as a guide for the preparation of state shellfish regulations for shellfish harvesting and processing (NSSPa, NSSPb).

States may elect not to adopt NSSP regulations verbatim. An example of differences in the NSSP recommendations for depuration and State of Florida regulations is that, while both require a minimum of 48 hours of depuration, the NSSP specifies that if product passes the 24-hour fecal coliform analysis of meat samples it would not have to be tested again at the 48-hour point. The Code requires both tests regardless of the count at 24-hours. A second example concerns the type of product that may be depurated within one plant. The NSSP recommends that product from approved and restricted areas not be processed within the same facility. The Code allows processing as long as the product is not commingled and storage facilities are separated. On issues where NSSP and state regulations do not agree, the possibility exists that product depurated under differing state regulations may not be accepted for sale in other states. This is true not only of regulations regarding depuration, but of those concerning harvesting, transport, and other aspects of shellfish processing.

With respect to the NSSP-associated State of Florida regulations, the prospective owner of the depuration facility will be most concerned with achieving successful verification of the facility operations from the state department which oversees shellfish processing.

REGULATORY ASPECTS: OPERATING PERMITS AND CERTIFICATION

State Verification of the Depuration Facility

As part of the certification process, a depuration permit application which describes the design and operation of the facility is submitted to Florida DEP. An example of the required information using a format of previous depuration and wet-storage applications is given in Appendix B. It is wise to contact regulatory personnel at DEP before beginning construction as they can point out potential problems in design and operation that would prevent certification.

Once the facility is ready to operate, officials at DEP will verify a Scheduled Depuration Process for the facility. Verification is complete when the facility demonstrates that normal operations result in successful depuration. An exact number of verification runs is not stated, but it is estimated that an average of three to four runs will be made. One unit in the depuration system must be loaded to capacity for each verification run. Shellfish which meet marketing standards at the end of the verification runs can be sold. Although the state does not collect any fees for the verification process, the economic costs of verification are equal to all operating costs incurred during the trials plus the costs of any shellfish not suitable for sale.

Depuration facilities are inspected monthly by officials from the Bureau of Marine Resources, DEP. If the depuration facility is not already part of an existing facility which is a certified wholesale dealer of shellfish, it obtains this license and becomes a dealer when it becomes certified as a depuration facility. Because depuration is considered to be a form of shellfish processing, the facility must meet certain standards of cleanliness. Wet-storage and depuration facility operators complain that, while this is a justifiable restriction for a facility handling raw oyster meats, as is the case with shucking/packing houses, these standards seem overly stringent for a facility where oysters remain in the shell. These regulations add additional expense to the costs of depuration.

Following is a summary of the most important considerations and implications of the Code and verification process (FACb).

Depuration cycle length: Shellfish must be depurated for a minimum of 48 hours.

Source of process water: Tank water that is pumped directly from the sea must originate from AP, CA, RE, or CR waters. The source of tank water is an approved or restricted area and is disinfected to drinking water standards. UV irradiation is the only method of water sterilization that is currently sanctioned by the FDA (FACb). Ozone is an alternative method of sterilization which is used in European and Australian depuration facilities. While ozone use in the U.S. is not "illegal," at present it is considered a food additive and thus subject to costly regulation (McNamara, 1991).

Source of shellfish: The Code defines depurated shellfish as originating from CR or RE waters only. Thus, shellfish from AP or CA water cannot be certified as depurated product. This differs from the NSSP definition, which allows shellfish from AP or CA areas to be depurated. Florida regulators indicate that they would like to change the Code to agree with the NSSP definition (Collins, 1994).

A depuration facility is certified to depurate a particular shellfish product from a particular geographic area. Based on the type and source of the shellfish, regulators decide on the minimum time period required for depurating the product. This would be a minimum of 48 hours, but could be longer.

For example, a facility in Cedar Key could be certified to depurate oysters from CR areas in Cedar Key. All certification runs would be carried out with oysters from this particular area. Based on the certification, regulators may decide that 48 hours is an adequate time period for depuration. Thus, the only shellfish that could be depurated in the facility are oysters from CR areas in Cedar Key. Any change in the type of shellfish, such as from oysters to clams, or the location of the product source, such as from Cedar Key to an out of state source, would entail re-certification of the facility. Re-certification may be required if the source of shellfish changes from one area to another within the two counties. For example if the product source changed from CR water in Cedar Key to RE waters in the Suwanee Sound. A facility can be certified to depurate or wet-store shellfish from several different areas, and may have different operating procedures for each (Collins, 1994).

Water volume and water flow per bushel of shellfish: Code regulations do not specify tank size or the number of shellfish per tank, but the NSSP manual calls for 8 cubic feet of water per bushel of shellfish, and Florida regulators generally call for this to be specified in the process. A water flow of 1 gpm per bushel is required.

Water quality in the process tanks: Water temperature and salinity must be "suitable" for depuration, meaning that water quality parameters should not be so different from harvest waters that shellfish pumping, and thus the effectiveness of depuration, would be lessened. Turbidity must be less than 20 JTU (Jackson Turbidity Units) and dissolved oxygen must be no less than 5 milligrams per liter. Tank waters must be tested for total coliforms every 24 hours (at 0, 24 and 48 hours for a 48 hour cycle), and this analysis must be carried out by a state certified lab.

Although not specifically required in the Code, regulators generally require that water from differing batches of depurated product (product that began the depuration cycle at different times) not be commingled, and that tank waters be discarded at the end of each cycle.

Shellfish meat quality: Meat samples are taken every 24 hours (at 0, 24, and 48 hours for a 48-hour cycle) and tested for fecal coliforms. The lab analysis from an FDA certified lab must demonstrate a fecal coliform count of less than 20 cells per 100 grams of meat before the shellfish may leave the facility. For shellfish harvested from the Suwanee Sound, analysis must also demonstrate that no salmonella is present in the meats.

Effluent Discharge

General Permit

The depuration facility will likely meet the criteria of the general permit for effluent discharge of marine bivalve facilities as specified in the Code (FACc). The general permit is a recent addition to the Code, and provides an exemption for depuration and wet-storage facilities, and hatcheries or nurseries that meet the criteria. It is important to meet the criteria; if the facility does not, it must apply for a permit for industrial wastewater discharge which is far more costly and time consuming to obtain. The facility would be excluded from the general permit if one of the following conditions existed: (1) the facility discharges more than one million gallons per day, (2) the facility uses non-native species, or (3) the facility adds supplemental algal cultures.

Operating under the general permit, the facility is only required to apply treatment to waters used for cleaning and rinsing the depuration tanks. Allowed methods of treatment include chlorination, filtration, gravity sedimentation, and discharge to a septic tank or public sewage system.

The cost of the general permit is $100 and is renewed every five years.

Wetland Resource Permit

The facility may need to obtain a Wetland Resource Permit. In the regulations of the general permit for effluent discharge, the facility is exempt from obtaining the Wetland Resource Permit as long as it does not violate the following conditions: (1) discharge pipes do not extend over submerged grass bed communities or more than 200 feet over waters of the state, (2) pipes are six inches or less in diameter, or (3) discharge pipes do not terminate within twenty feet of submerged grass bed communities or within fifty feet of a marked navigation channel (FACc, 1993). An outfall structure may be required to transport discharge away from submerged grass bed communities. The minimum one-time charge for the permit is $500.

Easement for Construction on State-Owned Lands

If shore-side land upon which the facility is built does not have title to submerged lands offshore, and the facility will be constructing an outfall structure, dock, or other structure on these lands, it will be necessary to obtain a private easement from the Department of State Lands. The charge for a 20 or 30 year private easement is based upon the enhanced value of the land that use of state submerged lands create. This enhanced value is based on the evaluation of a state-certified appraiser. Easements for commercial docks or other large structures can cost several thousand dollars. However, regulators indicate that for something as small as an outfall structure to support a discharge pipe, the cost of the easement could be based simply on the fee that an appraiser would charge to make the evaluation. This fee is not expected to be greater than $500.

SITING CONSIDERATIONS FOR A FACILITY IN DIXIE OR LEVY COUNTIES

The areas where depuration is most attractive from a marketing or resource-enhancement standpoint are often the areas where it is most difficult to site a depuration facility. Contaminated coastal water combined with the high cost of coastal land makes facility siting one of the most difficult aspects of planning a depuration facility. An optimal location would provide each of the following at the lowest cost: (1) a source of shellfish product, (2) a source of depuration tank waters, (3) a place to discharge effluent, (4) road access for deliveries and personnel, (5) utility access, (6) private ownership, (7) commercial zoning.

Product Source

As discussed above, depuration has the potential to significantly increase the size of the oyster resource in the two counties. The number of oysters in restricted waters that would be made available has been estimated at 13,600 bushels per year if waters of the Suwanee Sound are included, or 5,800 bushels excluding the Suwanee Sound. Water distances between harvest areas in Dixie and Levy counties are not so great as to rule out a depuration facility with a product source from anywhere within the two counties.

Assuming sufficient consumer demand, an alternative or supplement to local oyster landings is transport of oysters from other counties, such as Franklin County on Apalachicola Bay, or from other states, such as Louisiana or Mississippi. This would entail higher transport costs, but these might be offset by lower prices per bushel. However, oysters that are transported for long distances under refrigeration may have difficulty resuming pumping once placed in the depuration tanks, and there may be a greater likelihood of high mortalities. While no research has been done to verify or quantify this phenomenon, an operator of an oyster wet-storage facility in Louisiana reports that mortalities have been as high as 100% for oysters that were wet-stored after being transported nine hours in a 45-degree refrigerated truck. The operator of a facility in Florida which derives its oyster product for wet-storage from Louisiana, however, reports that mortality during the 72-hour wet-storage period is generally less than 10%.

Oyster landings also vary within any one year. This within-year variance is due to market strength and closure of harvest waters. Meat size is generally larger in the months November through February and consumer demand during these months is greater. Harvest waters close to harvesting in accordance with their management plans (Table 1), thus restricting supply. Any uncertainty of product supply makes it more difficult to consistently meet contracts with oyster buyers.

Tank Water Source

A depuration facility needs access to saltwater. Water may originate from the sea or be pumped from a saltwater well. Artificial seawater can be made by combining tap water with purchased seasalts.

The source of incoming water may be any water that is not unclassified, closed, or prohibited. Most of the coastal waters in Dixie and Levy counties are CR or prohibited (see maps in Appendix A).

Coastal land has the greatest potential for further contamination from urban runoff and sewage, and thus there is a greater possibility that near-shore CR waters may be reclassified as prohibited. However, those who conduct sanitary surveys indicate that the next surveys for the two counties (to take place in 1995) should not have great impacts on existing CR and CA areas (Harris, 1994).

Following is a general discussion of characteristics associated with different water sources. Costs of each water source is discussed in detail later in this study.

Ambient

The most obvious source of tank water is that pumped directly from the sea to a shore-side facility. However, virtually the only land in the two counties that is shore-side, commercially zoned, privately owned, and with road and utility access is located on prohibited waters. Even though depuration facilities filter and sterilize water to drinking water standards, they may not use seawater from prohibited areas. Therefore, the only way to use ambient waters is to transport water from nearby CA or CR waters to the facility by road or boat.

If the facility has nearby access to CA or CR waters, it is relatively inexpensive and logistically feasible to transport process waters in tanks on the bed of a pickup truck or on a trailer. Water transport is often done by soft-shell crab shedding operations.

The disadvantage of an ambient water source is that CA and CR waters are subject to closure. As an example of this restriction, the CA Zone B waters in Cedar Key, which border most land which is not on prohibited waters, were closed 148 days in 1993. Half of these closures occurred during the open harvesting season. (Twelve of these days occurred immediately after the March, 1993, storm). If a facility is depurating oysters from CA or CR waters in the same area, this water use restriction may not be the constraint to production, since the closure of waters and product source coincide. However, if the facility has access to a product source when local waters are closed, it could only continue operations by utilizing an alternative water source such as artificial seawater or water from a saltwater well.

Saltwater Well

A second source of tank water is a saltwater well. This option has the advantage of providing cool water with constant salinity, temperature, and water quality year-round, reducing the expertise that would be needed by the staff to adjust to changes in water quality. Unlike the option of transporting water, the facility would never be without a source of water.

One problem of a saltwater well is the possibility that the water from the well is unusable or may require costly treatment. Septic tank or other contamination could make water unusable. Artificial salts may be required to adjust the salinity. Well water may contain toxic levels of hydrogen sulfide which can be detrimental to shellfish pumping or cause mortality. However, hydrogen sulfide gas is naturally released from the water over time, and a degasser or "gas stripper" can be used to accelerate the removal of gas from water.

Well water may also contain high levels of iron. As the water contacts oxygen, iron in the water oxidizes and settles out. This oxidization can be accelerated through the use of aeration. A well providing water with a high iron content would thus require aeration and a settling tank. A degasser can also speed the settling out of iron. The possibility remains, however, that well water may contain such a high content of iron that the water cannot be used even after days of settling and aeration.

Any additional time required for iron settling negates one of the potential benefits of using a salt-water well–the cool temperatures of the water. During warmer months, 72 to 76 degree well water will heat to ambient temperatures during the settling period, and must be chilled. The chiller is the biggest fixed equipment expense of the facility.

It is very difficult to generalize water quality of wells in any area. Officials at the offices of the geologic survey and water management districts, as well as local well-diggers, were unable to predict the water quality of a well drilled in the two county area, or the depth to which the well would have to be drilled. Since it is very difficult to generalize water quality of wells in an area, it is advisable to drill the well as one of the first steps in constructing the depuration facility. Once the water quality of the well is evaluated, it becomes possible to precisely determine the quality of the well water, the time period needed for settling, and the size of chiller needed.

Artificial Seawater

A third source of tank water is artificial seawater. Purchased seasalts can be mixed with fresh water to create seawater.

Tap water containing chlorine will have to be aerated for approximately 24-hours to allow time for the chlorine to dissipate. A gas stripper can be used to accelerate this process.

A possible additional problem with well-water or artificial seawater stems from one of its advantages--the water is virtually free of bacteria. While this is a plus for water quality, it may detrimentally affect the health of the shellfish. Shellfish feed by filtering water, and if left in clean, nutrient-free water for long periods of time, meat quality may deteriorate and mortality increase. A facility that wet-stores oysters using artificial seawater indicates that they have seen mortality of 40% to 60% for oysters wet-stored greater than 24 hours. However, a Massachusetts facility which depurates soft-shell clams for 48 hours using water from a salt-water well indicates that they have not seen a deterioration in meat quality or high mortalities.

Tank Water Discharge

As discussed above, the depuration facility should qualify for the general permit for wastewater discharge for marine bivalve facilities. Under the general permit, the facility is not required to treat tank waters before discharge. The only waters that must be treated before discharge are those used to clean and rinse the process tanks (as discussed above, page 19).

Road and Utility Access, Ownership, and Zoning

Road and utility access is a major limiting factor in locating a site in Dixie and Levy counties. There are few roads to suitable areas and utility and sewer access does not extend far outside the city limits.

Most coastal area in the two counties is owned by the federal or state government. Much of the private land with road and utility access is zoned residential, or is costly due to its attractiveness for housing or tourist-oriented businesses.

Land outside the city limits is much less costly, but has limited utility and water access. There is also no land near towns that is zoned for facilities such as shellfish processing. Therefore, a petition to change the zoning would have to be made.

City power, telephone, sewer, and trash pickup are not absolutely necessary, but additional costs are incurred if they are not available. A generator could be purchased to supply power for the facility. Cellular telephones are an alternative to public lines. Trash can be delivered to the local landfill, and a septic tank could be installed. Tank water could be transported to and from the facility. Each of these increases the costs of depuration.

POSSIBLE LOCATIONS IN DIXIE AND LEVY COUNTIES

Land Based Facility

Much of the coastal land in the two counties is either state or federally owned, is marshy and thus unsuitable for the facility due to construction and regulatory costs, or is not located near a road. Based on product source, roads, and utility access, three likely locations for a commercial facility are the towns of Cedar Key, Horseshoe Beach, or Suwanee.

From a product source standpoint, at the current time Cedar Key and Horseshoe Beach are more promising than Suwanee. However, Suwanee would become very attractive if shellfish harvested from the Sound were not required to be tested for salmonella.

As for tank water source, any facility will be located on prohibited waters, and must either transport water, use a saltwater well, or make artificial seawater. At the present time, all near-shore waters near the towns of Horseshoe Beach and Suwanee are prohibited (Horseshoe Beach since the March, 1993, storm), and the closest source of seawater for Horseshoe Beach and Suwanee by road is more than 20 miles. Alternatively, water could be transported by boat from CA areas farther offshore. A facility located on prohibited water in Cedar Key could transport water by road from CA or CR waters within five miles of the facility. Facilities in any of the three towns could use a saltwater well or artificial seawater. It is not possible to predict whether a saltwater well would have a greater chance of containing iron or sulphur, or of being contaminated, in one area as opposed to another. Only the drilling of the well and testing of its water quality could determine this.

Water discharge permitting and easement for use of state lands depends on the particular site chosen. Any one town does not have an advantage over any other in this respect.

Commercially zoned land within the city limits is scarce in all three towns. Competition for land is greater in Cedar Key and land prices are higher there. The number of commercially-zoned sites within Horseshoe Beach is limited by the community's small size, but it is likely that the town would be more flexible in changing zoning to accommodate new business. Water-front commercially zoned land prices are lowest in Horseshoe Beach and Suwanee, at $25,000 or less for a 25*100 foot lot. Land costs in Cedar Key are two to four times higher. Information on land availability and prices was derived from discussion with real estate agencies and the zoning boards of both counties. Table 5 gives a summary of the availability and advantages and disadvantages of property in different locations.

Table 5. Characteristics, advantages, and disadvantages of possible locations for a depuration facility in Cedar Key, Horseshoe Beach, or Suwanee, Florida

	general notes	advantages	disadvantages
(1) within city limits--on conditionally restricted or conditionally approved waters	There is virtually no privately owned shore-side land within the city limits that is located on CR or CA waters.		
(2) within city limits--on prohibited waters	There are lots available within town and along the roads leading out of town, but many have existing structures that may prove unsuitable. Estimated cost for undeveloped land is $50,000 to $100,000 per 25 * 100 lot in Cedar Key and $25,000 or less in Suwanee and Horseshoe Beach.	Lots have utilities, telephone, and sewage. Shoreside location allows for effluent discharge. Shoreside facility can directly receive oysters from boats. Land is commercially zoned and areas already have some shellfish processing operations.	Water for use in the depuration facility cannot be from prohibited waters. Therefore, an alternative water source (artificial salt water, a saltwater well, or saltwater transported from an approved water source) would have to be used. Cost per lot is high. While land is zoned for commercial uses, there could be resistance from nearby residents. Existing structures may be unsuitable. Higher property taxes.
(3) outside of city limits--near town	There is commercially zoned land along highway 24 in Cedar Key, but this zoning (class B) does not allow for shellfish processing facilities. The advantages and disadvantages noted here would only be applicable if zoning changed to allow for a shellfish processing facility, of if the depuration plant was treated as a different type of facility than a processing plant is treated. The same restrictions hold for land outside the city limits of Horseshoe Beach and Suwanee.	Has utilities, telephone. Low cost of $10,000 or less per acre.	No sewage facilities so a septic tank would have to be built. No water access so an alternative water source would be needed. No water access for discharge, so discharge would have to be transported away from the facility or discharged to a private septic tank. Product source farther away from facility.
(4) outside of city limits--shoreside location far from town	In Cedar Key, areas north of Shell Mound have been mentioned as possible sites for a facility. However, these areas are not commercially zoned, and there is no road access. Most shoreside land is along marshy areas. For these reasons, this area is not considered suitable for a depuration facility, nor is land outside the city limits of Horseshoe Beach or Suwanee.		
(5) existing or previously operating shellfish processing facility operating within the city limits	Occasionally shellfish processing facilities are for sale. One could be converted into a depuration facility. The least expensive option would be the addition of a depuration component to an existing shellfish processing operation.	Same advantages of (2) above. Existing facility may have a pier and equipment for shucking/packing operation.	Same disadvantages as (2) above.

Information for this table was derived from discussions with real estate agencies and the zoning board in both counties.

Water Based Facility

An alternative to a land-based facility is one located on a boat or barge. This offers several advantages. The depuration facility could move to the source of the product and would not be restricted by water quality since it could be either semi-permanently moored in or could move to CA or AP waters. A used 14 X 50-foot houseboat with enough workspace for a 30 bushel/week facility and a motor, generator, and bathroom facilities could cost $50,000 - $75,000. While this is greater than the estimated 220 square foot building and property needed to accommodate a similar facility in Horseshoe beach, it is less than the combined cost of a building and land within the city limits of Cedar Key. One of the disadvantages of the facility would be that it is restricted from entering near-shore waters during poor weather or low tide, and only Suwanee has a marina large enough to accommodate this boat with entrance to the marina unrestricted by tides.

A host of new regulatory and operating considerations and their attendant costs accompany use of larger boats or barges. While a houseboat-size operation would incur relatively few regulatory problems, a larger barge moored offshore would be much more heavily regulated.

Operating costs can be great even for smaller boats. The owner of a 50-foot boat in Yankeetown that is used to harvest from aquaculture leases in Cedar Key indicates that equipment repair and replacement costs alone can be up to $150 per operating day. A boat is much more vulnerable to water and wind damage than a shore-side facility, and thus more costly to insure. Labor costs may be much higher if the boat is moored offshore and thus requires constant monitoring.

PART THREE: ECONOMIC ANALYSIS

DESIGN AND OPERATING ASSUMPTIONS

Several publications were reviewed for insight on design and operation of real and hypothetical depuration facilities (Neilson, et al. 1978; Bond and Truax, 1980; Williams, et al. 1980; Furfari, 1966; Howell, 1989; Furfari, 1991; Rhodes and Kaswek, 1991; Roberts et al. 1991). Three facilities were visited: an oyster wet-storage and hard clam depuration facility in Grant, Florida; an inoperative wet-storage and depuration facility in Apalachicola, Florida; and an oyster wet-storage facility in Cocodrie, Louisiana. The system design in this analysis is typical of facilities that operate currently and have operated in the past twenty years.

Processing Capacity

The processing capacity for the plant depends upon the demand for the depurated product, the supply of product, and the number of 48-hour tank cycles that can be made per year. It is not known if there would be a greater demand for depurated product than non-depurated. Estimates for possible plant sizes are based on estimated size of the resource, size of shellfish processors operating in the two-county area, and length of the operating year.

Wild-caught Oysters

The season for all classified open, unleased waters is September 1 to May 31. Thus, 13 of 52 weeks are not available to depuration of wild-caught oysters. During about 70 days (10 weeks) per year, CR areas are closed (in Cedar Key and Horseshoe Beach area classification areas). Assuming another two weeks lost to facility maintenance or other reasons, this leaves 27 weeks for depuration. If Suwanee waters are included, this adds an additional 10 weeks, 37 total weeks, for depuration since these waters would not close regularly due to rainfall or river discharge. If a non-local source of oysters is used, this could also increase the number of weeks available for depuration.

Each tank is used for 2.5 cycles per week. This accommodates the 48-hour depuration period, 6-hour pre-depuration period, and time needed post-depuration for unloading and cleaning tanks. A nine-month operating year is used because summer months are closed to wild harvesting. Assuming 2.5 cycles per week, the maximum number of cycles per tank per 9 month operating year is 67.5 per year for oysters harvested outside of Suwanee Sound (2.5 runs/tank/week * 27 weeks), and 92.5 if the Sound is open for harvesting (2.5 runs/tank/week * 37 weeks).

Resource assessment surveys indicate that there is sufficient resource to support a depuration facility. Assuming 5,800 bushels harvested from CR areas in the two counties (outside of the Sound), a facility of 214 bushels/week could be supported (5,800 annually / 27 weeks). Adding Suwanee Sound oysters brings the total to 368 bushels/week (13,600 annually / 37 weeks). (See the discussion of resource estimate, page 12).

Aquacultured Oysters or Hard Clams

Because hard clam aquaculture is a new activity in the area, it is difficult to predict the number of hard clams that will be harvested in coming years. Based on 7 million seed stocked in 1993 and a survival of 65%, nearly 4,550 bushels of one inch hard clams may be harvested in 1994 (1000 count per bushel). Using a nine-month operating year, this equates to 506 bushels per month. A 12-month operating year equates to a monthly supply of 379 bushels. Leases can be worked year-round, and only close based on area management plans.

Based on business plans of the current group of leaseholders, by 1996, 33 million clams per year could be stocked on leases. This could result in harvests of 21,450 bushels per year, or 1,788 to 2,383 bushels/month, depending on the length of the operating year. (Hard clam stocking and harvesting information from Sturmer, 1994).

A possible supply of triploid oysters for depuration cannot be predicted (see discussion page 16). Since aquacultured oysters may be smaller and more uniform in size, costs will be calculated using differing numbers of oysters per bushel.

For both hard clams and oysters, costs will be calculated assuming a longer operating year and thus a greater number of depuration cycles per year. This illustrates different per bushel costs that a year-round depuration facility could have.

Baseline Design Assumptions

A depuration facility for Dixie or Levy county would most likely be part of an existing or new shellfish processing facility. If a facility were to only provide the service of depuration, as opposed to buying the product to be depurated and then selling this product, the facility would need to have a large and steady supply of shellfish and market for the depurated product. The only facility in the U.S. today which depurates but does not market the depurated product is the state-owned facility in Massachusetts. The state provides the service for clam diggers at below cost.

This analysis treats the depuration facility as an addition to an existing or new shellfish operation which purchases the shellfish to be depurated. A separate building is constructed to house the depuration equipment and cooler, but an office and bathroom facilities are located in the existing shellfish operation. All cost analyses assume that the facility is located shoreside on prohibited waters within the city limits and has road, utility, and city sewer access.

Product source for oysters is CR waters in the two counties outside of the Suwanee Sound, and product source for hard clams are the aquaculture leases in the two counties. The baseline operating year is nine months, with 12 weeks of this time period non-operating due to 10 weeks closure of waters (based on past closure data) and two weeks down due to maintenance or other reasons. Product is delivered to the facility.

The source of tank water is an on-site saltwater well. For effluent discharge, it is assumed that process water is discharged by pipe directly to the sea, and that the fresh water used to clean tanks is discharged to the sewer system. A mortality of 6% is assumed. Counts per bushel of 280 oysters and 1000 hard clams is used. The number of operating weeks is 27 weeks per year, based on the discussion on page 26. The system is operated at capacity, with each tank used for 2.5 depuration cycles per week. Laboratory analysis is performed by a state-certified lab operated on-site by the facility.

Sensitivity analysis will examine the change in costs when several of the above baseline parameters are altered.

Design Options

Rather than calculate only one or two different sizes of facilities, this analysis estimates capital and operating costs for 12 different capacity facilities. While resource assessment surveys indicate the approximate size of facilities that could be supported, inability to predict the degree of demand for depurated product, or the potential number of aquacultured oysters or clams for depuration, warrants consideration of several different size facilities. The twelve facility designs are based on three different tank sizes and a range of one to four tanks per system. Table 6 gives information for each of the 12 design options.

All options keep tank waters distinct between tanks and batches of depurated shellfish. Options 1-3, 5-7, and 9-11 consider one to three tanks operating separately. Options 4, 8, and 12 have 4 tanks, but two tanks are joined as one and share tank waters. In effect, they act as two larger tanks.

Table 6. Design Options

weeks/yr operating = 27

option	number of tanks	tank size	Per Tank: available volume* (cu/feet)	Per Tank: capacity (bushels)	Per Tank: shellfish & tray volume (cu/feet)	Per Tank: water volume (cu/feet)	Per Tank: water usage (gallons)	System: production capacity (bushels)	System: capacity (bu) per week (2.5 cy./tank)	System: cycles per year	System: annual capacity (bu)
1	1	4.5'*8'*3.5'	117	12	16	101	753	12	30	67.5	810
2	2	4.5'*8'*3.5'	117	12	16	101	753	24	60	135.0	1,620
3	3	4.5'*8'*3.5'	117	12	16	101	753	36	90	202.5	2,430
4	4	4.5'*8'*3.5'	117	12	16	101	753	48	120	270.0	3,240
5	1	4.5'*16'*3.5'	234	24	32	202	1505	24	60	67.5	1,620
6	2	4.5'*16'*3.5'	234	24	32	202	1505	48	120	135.0	3,240
7	3	4.5'*16'*3.5'	234	24	32	202	1505	72	180	202.5	4,860
8	4	4.5'*16'*3.5'	234	24	32	202	1505	96	240	270.0	6,480
9	1	6'*24'*3.5'	468	48	64	404	3011	48	120	67.5	3,240
10	2	6'*24'*3.5'	468	48	64	404	3011	96	240	135.0	6,480
11	3	6'*24'*3.5'	468	48	64	404	3011	144	360	202.5	9,720
12	4	6'*24'*3.5'	468	48	64	404	3011	192	480	270.0	12,960

Options 4, 8, and 12 are two banks of two tanks (two tanks operate together)

*volume does not include 0.25' freeboard

One "cycle" = One 48-hour depuration period per tank plus 6 hours pre-depuration and 2-4 hours post-depuration for each tank.

EXPLANATION OF COSTS

Full cost budgets for all options are given in Appendix C. The budget for Option 6 is provided in Table 8. Note that Option 6 is used for reference purposes only and was not chosen because it was the "best" of all options. Worksheets used to calculate costs for each option are contained in Appendix D.

Water Supply Costs

Costs of water supply were calculated separately from those costs associated with depuration processing. A list of fixed and variable costs and the costs per gallon and per bushel depurated for transported ambient, wellwater, and artificial seawater are presented in Table 7. Appendix D contains the worksheet used to calculate water costs per design option.

A reservoir tank is used for all three systems: for transported seawater, the reservoir is used for settling of suspended solids such as mud and sand; for wellwater, it is used for iron settling and dissipation of hydrogen sulfide gasses; for artificial seawater it is used for aeration and dissipation of chlorine. Reservoir tank size is based on the volume of one tank for systems using one and two tanks. However, the reservoir must accommodate two tank's worth of water for systems using three and four tanks, since more than one tank will be stocked with shellfish within the 20-hour period allowed for settling. Costs of reservoir tanks are included in the calculation of water costs.

Transported seawater costs include labor costs and partial use of a truck for towing a trailer. The trailer holds a 3,000 gallon polyurethane tank purchased from an agricultural supply store. This type of tank is often used to transport liquid fertilizer. A gasoline pump is used to pump water into and out of the tank. Costs per gallon for the 12 options range from $0.0273/gal for Option 1 to $0.0074/gal for Option 12. This decrease in costs is due to more efficient use of fixed equipment and labor as the amount of water transported increases. While water usage is the same per bushel of shellfish depurated (62.7 gallons per bushel stocked), the resulting cost per bushel decreases as facility capacity increases. Transported water costs per bushel range from $1.82/bu for the smallest system to $0.49 for the largest (assumes 6% tank mortality).

Wellwater costs include capital costs for the settling tank, degasser, well-drilling for a 4-inch well, and pump. Variable costs are equal to the costs of electricity for pumping. Costs per gallon range from $0.009 for Option 1 to $0.0048 for Option 12. As with transported water, the cost per gallon decreases based on more efficient utilization of fixed equipment. Wellwater cost per bushel ranges from $0.60 to $0.32 based on system size.

The cost of **artificial seawater** includes costs for the reservoir, city water, and seasalts. The estimated cost per gallon is nearly constant at $0.10 per gallon, with cost per bushel ranging from $6.81 to $6.73 per bushel.

Water costs per cycle for the budgets presented below are based on the costs of wellwater. Sensitivity analysis will examine the change in total cost per bushel depurated based on each of the sources of tank water.

Table 7. Costs of alternative water sources.

Transported Ambient

Fixed costs:
- transport tank
- settling tank
- trailer
- pump

Variable costs:
- labor
- truck usage
- gas & oil

Saltwater Well

Fixed costs:
- well drilling
- settling tank
- degasser
- pump

Variable costs:
- electricity

Artificial Seawater

Fixed costs:
- de-clorination tank

Variable costs:
- city water
- seasalts

	Cost per Gallon			Cost per Bushel (6% mortality)		
System Options	transported	well	artificial	transported	well	artificial
1	$0.0273	$0.0090	$0.1024	$1.82	$0.60	$6.81
2	$0.0214	$0.0062	$0.1012	$1.42	$0.41	$6.73
3	$0.0202	$0.0061	$0.1016	$1.34	$0.40	$6.76
4	$0.0190	$0.0054	$0.1012	$1.27	$0.36	$6.73
5	$0.0160	$0.0074	$0.1024	$1.06	$0.49	$6.81
6	$0.0125	$0.0054	$0.1012	$0.83	$0.36	$6.73
7	$0.0121	$0.0055	$0.1016	$0.80	$0.37	$6.75
8	$0.0113	$0.0050	$0.1012	$0.75	$0.33	$6.73
9	$0.0104	$0.0066	$0.1024	$0.69	$0.44	$6.81
10	$0.0080	$0.0050	$0.1012	$0.53	$0.33	$6.73
11	$0.0080	$0.0053	$0.1016	$0.53	$0.35	$6.75
12	$0.0074	$0.0048	$0.1012	$0.49	$0.32	$6.73

* Cost per bushel based on water volume used per bushel of shellfish.

Table 8. Cost Budget, Option 6

cost per bushel =	$17.43	tank size =	4.5'*16'*3.5'	oyst/bushel =	280
cost per oyster =	$0.0623	number of tanks =	2	clams/bushel	1000
cost per clam =	$0.0174	bushels/tank or bank =	24	mortality =	6%
tank cycles/year =	135	(If number of tanks = 4,		bushels/week	120
		there are 2 banks of 2 tanks)		bushels/year	3,240

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$12,600	building and	$1,337	$9.90	2.51%
area, sq feet	450	property amortized			
Property	$18,000	over 30 years	$1,909	$14.14	3.58%
Processing Equipment**					
Depuration tanks	$3,600	10	$380	$2.81	0.71%
Sand Filter	$550	10	$58	$0.43	0.11%
UV sterilizer	$1,082	8	$143	$1.06	0.27%
Recirculating Pump	$863	6	$152	$1.12	0.28%
Blower	$333	6	$59	$0.43	0.11%
Chiller	$2,912	15	$205	$1.52	0.38%
Cooler (installed)	$3,605	15	$254	$1.88	0.48%
sq feet	40				
SUBTOTAL, Equipment	$12,945		$1,249	$9.25	2.34%
Materials**					
PVC tubing & materials and flow meters	$300	5	$63	$0.47	0.12%
oxygen meter	$530	5	$112	$0.83	0.21%
salinometer	$800	5	$169	$1.25	0.32%
tank trays	$640	3.5	$193	$1.43	0.36%
air diffusors	$112	1	$118	$0.88	0.22%
washing/culling table	$2,232	8	$294	$2.18	0.55%
UV replacement lights/sleeve	$372	1	$392	$2.91	0.74%
Pressure sprayer	$700	3	$246	$1.82	0.46%
SUBTOTAL, materials	$5,686		$1,588	$11.76	2.98%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$34	8.73%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,320	1	$1,320	$9.78	2.48%
liability (1% of sales)	$518	1	$518	3.84	0.97%
property taxes (3.12 millage)	$955	1	$955	$7.07	1.79%
labor for assembly	$1,280	30	$43	$0.32	0.08%
certification & permitting	$1,484	30	$49	$0.37	0.09%
SUBTOTAL, Other Fixed	$5,557		$2,885	$21.37	5.41%
SUBTOTAL FIXED	**$82,038**		**$13,619**	**$100.88**	**25.56%**
FIXED COSTS PER BUSHEL =	$4.46				

DESIGN OPTION = 6

VARIABLE COSTS	annual	per cycle	% of total
Assistant	$5,400	$40.00	10.13%
Hourly	$4,968	$36.80	9.32%
Owner/manager	$6,542	$48.46	12.28%
Lab technician	$6,480	$48.00	12.16%
SUBTOTAL, Labor	$23,390	$173.26	43.90%
Utilities			
Electricity			
UV	$2,519	$18.66	4.73%
pump	$743	$5.50	1.39%
blower	$99	$0.73	0.18%
cooler	$207	$1.53	0.39%
chiller	$956	$7.08	1.79%
lighting	$32	$0.24	0.06%
Water	$108	$0.80	0.20%
Sewage	$119	$0.88	0.22%
SUBTOTAL, Utilities	$4,782	$35.42	8.97%
Building maintenance	$280	$1.00	0.25%
Cleaning & misc supplies	$810	$6.00	1.52%
Laboratory Analysis, materials	$9,450	$70.00	17.73%
SUBTOTAL VARIABLE	**$38,712**	**$285.68**	**72.38%**

VAR. COSTS PER BUSHEL = $12.62

Water Supply Costs		cost per bushel(w/mortality)	annual	per cycle	% of total
Investment:	$3,468				
Costs per bushel		$0.3592			
Costs per cycle(excludes mortality)			**$1,098**	**$8.13**	**2.06%**

	initial investment	annual capital & operating costs		
	$85,506	$53,430		
TOTAL (includes mortality)			**$418.38**	100.00%
COST PER BUSHEL			**$17.43**	
COST PER OYSTER			**$0.0623**	
COST PER CLAM			**$0.0174**	

**An 11% operating capital interest cost is applied to 1/2 of the cost per year for equipment and matls.

Facility Costs

Fixed Costs

Fixed costs are incurred regardless of whether depuration occurs. Fixed costs are given in three forms: (1) initial investment cost (2) annual cost (3) cost per depuration cycle. Annual costs are calculated by dividing the initial investment cost by the number of years life for the item and adding an approximate cost of capital. Costs per cycle are calculated by dividing the yearly cost by the number of depuration cycles per year.

Building and Property

Building size is based on the area needed for tanks and workspace. No bathrooms, office, or storage space is included. An example facility layout for design option 6 is given in Figure 1. The building is screened with a metal roof. Fiberglass coated plywood comprise the walls from the floor to three feet so that these surfaces are easily cleaned. The cost of $28 per square foot includes the concrete slab, electrical wiring and plumbing, and fluorescent lighting. The walk-in cooler is on a concrete slab and is covered. The cooler opens into the building. The reservoir and degasser are covered.

Land cost is based on the average cost per square foot for waterfront land in Cedar Key, Horseshoe Beach, and Suwanee. Based on discussions with real estate agencies in each area, this average cost is estimated at $20 per square foot. Number of square feet of property purchased is equal to double the square footage of the building.

Building and property are amortized over a 30 year period at 10% interest.

Depuration Tanks

Depuration tanks are made of 2-inch insulated fiberglass. Tanks are intentionally oversized by 20% to allow for makeup water; makeup water is used to compensate for loss of tank water due to spillage or evaporation and loss when sand filters are backwashed. Makeup water could be kept in a separate reservoir, but a slightly larger depuration tank provides a better utilization of space, especially when multiple reservoirs would be required to service designs with multiple tanks. Tank sizes, volumes, and water and shellfish volumes are given in Table 6. Note that 3 inches of freeboard are allowed and the assumed shellfish and tray volume displaces approximately 2300 cubic inches of water per bushel.

Processing Equipment Specification: Pumps, Sandfilter, UV, Blower, Chiller, Cooler

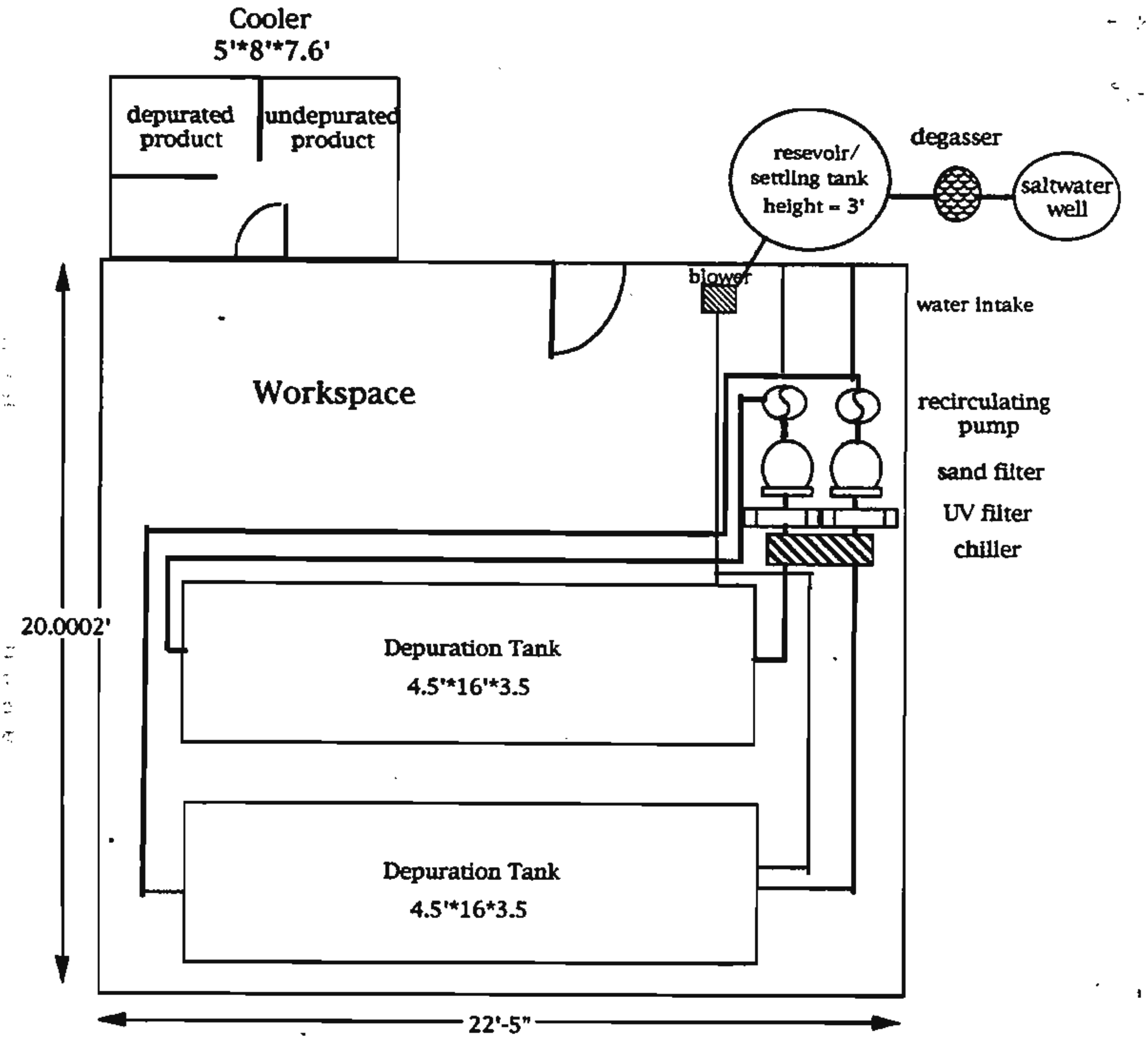
Jacuzzi recirculating pump size is based on system size, with horsepower ranging from 0.5 to 1.5. An electric pump (1 hp) is used for the saltwater well, and a gasoline powered pump (3.5 hp) is used for pumping seawater for transport.

Sandfilter and UV were chosen on the basis of the required gallons per minute flow. A separate filter and UV are required for each tank.

Figure 1.

DEPURATION FACILITY EXAMPLE LAYOUT

DESIGN OPTION 6



Building is screened, with fiberglass coated plywood to 3 feet on interior. Cooler is on a concrete slab and is covered. Reservoir and degasser are covered.

Pumps, sand filters, and UV units for systems with greater than one tank are simply replicates of these items for one tank. The combined pump, filter, and UV cost for Option 2 is, therefore, exactly double that of Option 1. This is an inefficient use of equipment, but is required if tank waters are to be kept separate.

A blower with 1/5 to 1/2 hp was chosen based on total water volume. The blower is used in conjunction with air stones for aeration of the depuration and reservoir tanks.

The chiller is the most costly component of the depuration equipment (other than the walk-in cooler). Unlike the pump, sandfilter, and UV unit, the specification of the chiller is not simply a replicate of the unit required per tank. Custom-made chillers are specified to accommodate more than one tank, and these chillers keep water distinct between tanks as required. Sharing a custom chiller among tanks reduces the cost of chilling water.

The size of the chiller is specified by BTU or hp size and is based on two major factors: (1) the difference between actual and desired water temperature and (2) the draw-down time to reach the desired temperature. Due to cooler temperatures, during three to six months of the facility's operating year it would not be necessary to use the chiller at full operation. In any case, the chiller size must be based on the maximum estimated chilling power needed. For sizing the chiller, a maximum 30 degree drawdown (as from 95 degrees to a standard 65 degrees used in depuration facilities) was used. The draw-down time used was 12 hours. A 12-hour time period is allowed for chilling because it is assumed that shellfish product is sourced from local areas and, even if stored for short periods in the cooler, is likely to be at a higher temperature than the 65 degrees to which the water will be cooled. Shellfish must be cooled slowly to avoid thermal shock which can detrimentally affect shellfish pumping and result in mortalities. This problem may be more pronounced in the summer months.

The walk-in cooler for storage of product begins with a minimum size of 5'*8' for the smallest system, increasing to a maximum size of 12' * 16' for the largest. Size is based on shellfish storage volume, but smaller systems have excess capacity because a walk-in cooler smaller than 5'*8' is not considered practical. The cooler has three compartments separated by dividers. This allows for separate storage of the following : (1) undepurated product, (2) depurated product waiting for the 48-hour lab analysis (3) depurated product ready for sale. It is important to note that while this method of storing depurated and undepurated product is currently allowed by Florida regulations, the NSSP manual does not allow depurated and undepurated product to be stored in units in close proximity. The NSSP requires that depurated product should be stored in a cooling unit in a separate building.

Equipment costs include an 11% interest which is charged on operating capital, charged to 1/2 of the yearly depreciated value.

Materials

The size and dimensions of PVC tubing, tank trays, air diffusors, UV bulb replacement, and size of the washing/culling tables is based on system capacity. PVC tubing is schedule 40, 1.5 inch for 4.5'*8' and 4.5'*16' tanks, and 2 inch for 6'*24' tanks. Fittings and flow meters are based on number of tanks and design. PVC elbow joints are threaded so that pipes may be disassembled for cleaning.

Plastic depuration trays are available at $13 to $15 per unit. This is an expensive option, but these trays interlock and thus stack easily. Plastic milk cartons could also be used as tank trays, or trays could be handmade from available materials. Coated galvanized wire can also be used to make trays costing approximately $8 each (materials & labor), which have a longer expected life (5 years compared to 1 to 3 years for plastic trays). However, wire trays may be difficult to stack in larger tanks. For the cost calculations, tray costs are estimated at an average $10 per unit, with each tray holding 3/4 bushel.

Airstones are used in conjunction with the blower for tank and reservoir aeration. Number of airstones is based on total water volume in the depuration tanks and reservoir.

All UV units use 30 watt bulbs. Bulbs are replaced annually. The replacement of one quartz sleeve is also allowed due to the possibility of breakage when cleaning.

The size of the washing/culling table is based on system capacity. Cost of the "do-it-yourself" washer/culler table is based on the description of a table in the Spinney Creek depuration facility manual (Howell, 1989).

Material costs include an 11% interest charge on operating capital, which is charged to 1/2 of the yearly depreciated value.

Laboratory Analysis

An outside laboratory can be used for sample analysis, or the facility can construct its own laboratory facility. This lab must be state certified. The cost of outside lab analysis per depuration batch is approximately $275 ($250 University of Florida cost plus a labor cost for transporting the samples). While a laboratory on the east coast of Florida quotes a cost of $150/batch, the logistics of transporting the sample may be prohibitive.

The estimated costs for a facility-owned lab for Option 6 are given in Table 9. The total cost per depuration cycle is estimated at approximately $152. Conversion of annual to per tank cost is based on 67.5 cycles per tank per year, multiplied by two tanks, which equals 135 tank cycles per year.

Building and property are amortized over 30 years at 10%. Equipment is depreciated over 10 years use and includes an 11% interest charge on one-half of total value. Labor charge is $12/hour, and is based on part-time (4 hours per day, 20 hours per week). Labor usages increase depending on the number of tank cycles: 20 hours per week for one and two tank or bank of tanks systems and 25 hours per week for the 3 tank system. Materials equals the cost of media, disposable petri dishes, other equipment, and electricity and water needed for each sample analysis. Seven dollars per analysis is multiplied by the three water samples and seven meat samples analyzed for each tank per depuration period. Quality assurance and control includes inspection and calibration of equipment required to maintain state certification.

The fixed portion of lab analysis costs is equal to all costs except labor and materials. Costs associated with the laboratory which vary depending upon the number of tank cycles per year are listed under the Variable Costs section of each cost budget.

Lab analysis costs per tank vary depending upon the size of the facility and number of cycles per year. Table 10 gives cost per option and the breakpoint in cycles per year where outside lab analysis is approximately equal to the costs of on-site analysis. Greater use of fixed equipment results in a lower cost per sample. Labor usage increases as more samples are tested, but the increase is proportionally less than the increase in samples analyzed, and thus relative costs per sample decrease. Materials costs, in contrast, increase proportionally to the number of samples tested.

Table 9. Estimated costs of depuration facility laboratory, design option 6

	initial investment	annual costs	per tank costs (135 tanks/yr)
building (15'*20' enclosed) (amortized, 30 yrs., 10%)	$5250	$557	$4.13
property (amortized, 30 yrs., 10%)	$15,000	$1591	$11.79
equipment	$7000	$739	$5.47
labor		$6480	$48.00
materials		$18,900	$70.00
quality assurance & control		$1014	$7.51
miscellaneous supplies		$750	$5.55
TOTAL	**$27,250**	**$30,031**	**$152.46**

In comparison to an outside lab charge of $275, it is more cost effective for the facility to do its own lab analysis no matter what the size. The limit to its ability to do the analysis is largely dependent on whether available technical expertise in the form of a trained microbiologist is available. Any decrease in the number of tank cycles per year will also increase costs of analysis from an on-site lab.

Table 10. On-site laboratory analysis costs per design option			
design option	maximum tank cycles per year	cost per cycle	number of tank cycles per year that result in an approximate cost of $275 per tank cycle[a]
1	67.5	$235	54
2	135	$152	54
3	202.5	$134	63
4	135	$156	56
5	67.5	$235	54
6	135	$152	54
7	202.5	$134	63
8	135	$156	56
9	67.5	$235	54
10	135	$152	54
11	202.5	$134	63
12	135	$156	56

[a]$275 is the approximate cost of using an outside laboratory for analysis

Other Fixed

The costs of property insurance are extremely site specific. Based on conversations with insurance agents, an estimate of 2.5% of the value of equipment and buildings was chosen as a reasonable estimate of yearly insurance costs.

Liability insurance is estimated at 1% of sales.

Property taxes of 0.0319% of appraised value are based on the average for Cedar Key, Horseshoe Beach, and Suwanee. Appraised value is constant at the beginning investment value.

Certification and permitting costs include the loss of oyster shellstock (two tanks lost during the certification process) plus a $500 wetland resource permit, $100 for the general permit for effluent discharge, and $500 for a state land easement. These one-time charges are depreciated over a 30 year period, as is labor required to assemble the components for each tank. (The general permit must be renewed every five years at a cost of $100, but is grouped with other one-time charges for ease of calculation).

Variable Costs

Variable costs are the cash expenses directly related to production. Variable costs are calculated per depuration cycle and annually.

Labor

Assistant, hourly, and owner/manager labor is calculated on the basis of the operating year. Therefore, the shorter the operating year, the lower the cost for this labor.

Assistant and Hourly Labor: A 20-hour per week assistant is used for all options. The assistant maintains the equipment and building and makes routine checks on the operation of the tanks. Additional labor is used on an hourly basis to assist with washing and culling shellfish and placing them in and removing them from the tanks. Labor costs per bushel decrease for larger facilities because the "fixed" labor required for the assistant is spread out over more bushels. Assistant's labor is calculated at $800 weekly for the 27 weeks of operation. Hourly labor is charged at $8.00 per hour.

Labor required in transporting water and transporting samples for laboratory analysis is calculated separately. The same $8.00 dollar charge per hour is used for all hourly labor except for the technician doing the lab analysis work, for whom a charge of $12/hour is made.

Owner/Manager labor: For smaller designs, only a fraction of owner/manager labor is required. As system size increases, more of the owner/manager's labor is used, with the largest design calling for a fulltime person. Compensation for the owner/manager is set at $35,000 annually. As noted above, the charge for labor only relates to the number of weeks that the facility actually operates.

Lab Technician: Labor for the lab technician is calculated as described above under "Laboratory Analysis."

Utilities

Electricity, water, and sewage costs are based on those of Cedar Key and are representative of the two-county area. Electricity utilization is based on equipment specifications and usage.

Building Maintenance

Building maintenance depends on a number of factors including location, weather, and operator diligence. Based on general estimates of building contractors and building owners, maintenance was estimated at $100 plus $0.40 per square foot. For Option 6, this calculates to $280 per year.

Cleaning and Miscellaneous Supplies

Miscellaneous supplies include cleaning agents, oil, tools, and other items. A per tank charge of $2 to $16 is used to account for these miscellaneous supplies.

Laboratory Analysis

Variable costs of laboratory analysis include the costs of materials required for the analysis of each sample as explained above.

Water Supply Costs

Costs of the saltwater well include both fixed and variable costs as explained in Table 7.

COMPARISON OF DESIGN OPTIONS

Costs per Bushel Compared

Costs per bushel and per shellfish unit decrease as the capacity of the facility increases. A summary of costs per design option is given in Table 11, and costs per bushel are represented in Figure 2. Full budgets for all options are given in Appendix C. Total costs per bushel range from $42.81/bushel for Option 1 to $9.25/bushel for Option 12. An increase in capacity lowers costs per unit by spreading out fixed costs over a greater number of units. Fixed costs do not increase at a rate equal to that of the increase in the production capacity, and thus the cost per unit decreases. However, fixed costs constitute less than one-third of total costs for each of the depuration design options. The decrease in costs per unit as system size increases is also attributable to more efficient use of labor and the spreading out of laboratory materials costs over a greater number of bushels when larger tanks are used. Labor cost and lab analysis costs combined constitute greater than 50% of total costs for all design options.

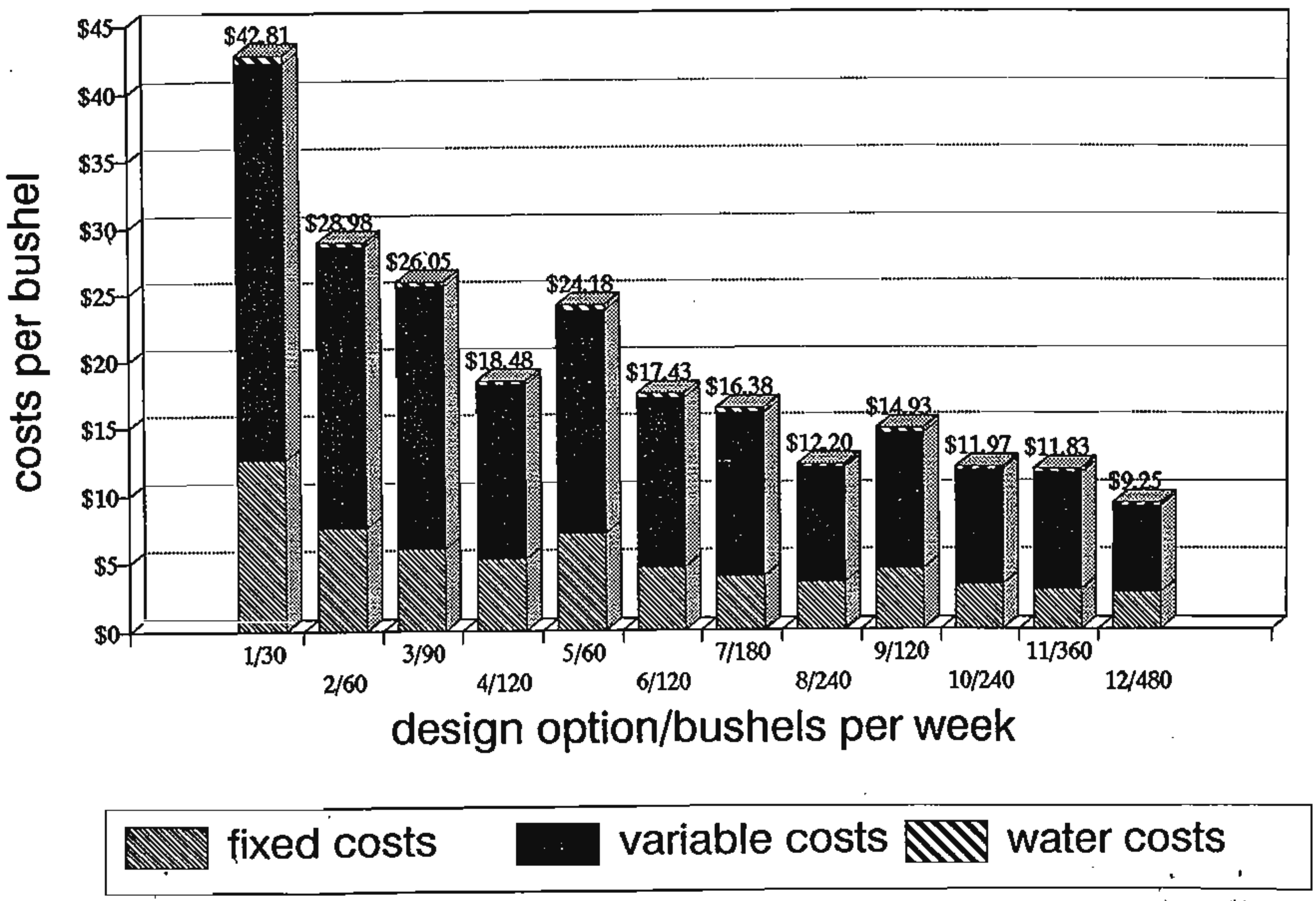
Labor: While systems with larger capacities entail significantly more labor hours to handle oysters before and after the depuration period, the assistant's, manager's, and lab technician's labor is used more efficiently and thus costs increase at a rate less than the increase in capacity. Labor time used to monitor the filling of tanks or to check in periodically to monitor dissolved oxygen or turbidity does not increase significantly based on larger tank sizes and number of tanks. Owner/manager and lab technician labor also increases at a rate less than the increase in capacity.

Lab materials: The cost for materials used for the analysis of each sample is a multiple of the number of tank cycles. The $70 charge (Table 9) per tank cycle is divided by the number of bushels per tank to calculate the cost per bushel, and thus this cost per bushel decreases the greater the capacity of each tank.

Table 11. Summary of costs per design option

design option	capacity/ week (bu)	fixed costs per bushel	variable costs per bushel	water source costs/bushel	total costs per bushel	total costs/ oyster	total costs/ clam
1	30	$12.50	$29.71	$0.60	$42.81	$0.153	$0.043
2	60	$7.46	$21.11	$0.41	$28.98	$0.104	$0.029
3	90	$5.99	$19.66	$0.40	$26.05	$0.093	$0.026
4	120	$5.16	$12.96	$0.36	$18.48	$0.066	$0.018
5	60	$7.07	$16.62	$0.49	$24.18	$0.086	$0.024
6	120	$4.46	$12.62	$0.36	$17.43	$0.062	$0.017
7	180	$3.79	$12.22	$0.37	$16.38	$0.059	$0.016
8	240	$3.35	$8.52	$0.33	$12.20	$0.044	$0.012
9	120	$4.38	$10.10	$0.44	$14.93	$0.053	$0.015
10	240	$3.17	$8.47	$0.33	$11.97	$0.043	$0.012
11	360	$2.88	$8.60	$0.35	$11.83	$0.042	$0.012
12	480	$2.59	$6.34	$0.32	$9.25	$0.033	$0.009

Figure 2. Costs per Bushel Depurated



Increasing Capacity: Larger Tanks vs. More Tanks

Assuming the same level of incoming raw product, lab costs and production scheduling make systems with larger tanks or smaller tanks operating in conjunction more cost efficient than the use of more numerous tanks.

Because of the scheduling of 48-hour depuration periods, systems with greater than two tanks do not provide any significant degree of flexibility, while costs for equipment and laboratory analysis increase. Based on the 48-hour depuration period and time required for pre- and post-depuration procedures, maximum usage of tanks and equipment is 2.5 cycles per week per tank. With any number of tanks greater than two tanks, the operator must load greater than one tank per day to achieve maximum use of equipment. By using larger tanks and equipment with greater gpm capacity, economics of scale are achieved and lab analysis costs per bushel decrease. For example, Options 6 and 9 have the same 120 bushel capacity per week, but the cost per bushel of Option 6, which has 2 tanks, is 17% greater than the cost per bushel for Option 9, which has 1 tank.

The disadvantage of using larger tanks is the possibility that the number of bushels available for depuration is less than anticipated. This will result in an increase in the costs per bushel. If the decrease in number of bushels is manifested in a <u>fewer number of bushels per tank</u>, fixed as well as the variable costs associated with each tank cycle are spread out over a fewer number of bushels, significantly increasing the costs per bushel. This is the same type of cost increase per bushel that would occur if significant mortalities were experienced in the tanks. If the decrease in number of bushels manifests itself in a <u>fewer number of cycles</u>, but with tanks loaded to capacity on those cycles, the increase in costs per bushel is somewhat less, because variable costs, like labor and lab materials costs, are not incurred.

SENSITIVITY ANALYSIS

Tables 12-16 illustrate the sensitivity of total cost to a change in a particular parameter, with all other parameters remaining constant. Each table gives costs per bushel, per oyster, and per clam. Numbers per bushel remain at 280 oysters and 1000 clams for all but Table 16.

Table 12 illustrates the change in costs due to a change in tank utilization which may result from (1) insufficient product stocked initially in tanks or (2) higher tank mortalities during the depuration cycle. Number of cycles per year, bushels stocked per tank, etc., remain constant. Changes in mortality have the greatest potential to increase costs per bushel, since almost 100% of costs are incurred for a smaller number of shellfish for sale. A smaller than expected number of shellfish per tank stocked (due to insufficient supply or weak demand) result in the same increase in costs. To minimize costs under conditions where supply is less than expected, it is preferable for the system to hold product or arrange for delivery of product so that tanks can be filled to capacity.

Table 13 gives the change in costs per bushel when a different number of cycles per year is used. The change in number of cycles is represented by the change in number of weeks operating per year. More operating weeks per year raises the annual operating capacity. A longer operating year implies a source of product from the Suwanee Sound, from aquaculture leases, or from non-local sources. Forty-five weeks may be a reasonable operating year if the facility has product available from various sources. Thirty-seven weeks is the operating year estimated for a facility receiving product from the Suwanee Sound. For Option 6, the cost per bushel falls by 11% when the operating year is lengthened from 27 to 37 weeks. With 37 operating weeks per year, capacity ranges from 1,110 bushels per year for Option 1 to 17,760 bushels for Option 12.

Fewer weeks operating per year could result from a smaller than expected supply of shellfish due to more attractive alternative enterprises for oysterman, or closure of harvest waters due to environmental conditions. As discussed above, a shorter operating year has less of an impact on costs per bushel than a change in mortality.

Table 14 gives the costs for different sources of water--transported, wellwater, and artificial. Wellwater is least expensive for all options. Because water costs only comprise a small percentage of total cost per shellfish unit, a change in water source does not have a significant impact on total cost for most options.

Table 15 lists the costs per bushel for each option if an outside laboratory were used for analysis. Costs per bushel using an outside lab are, on average, one-third greater than the costs of analysis performed at a facility-run lab. As stated previously, however, if the laboratory is utilized at less than capacity, it can become more efficient to use the services of an outside lab (see Table 10).

Table 16 gives the change in cost with a greater number of oysters and clams per bushel, as may be the case with aquacultured oysters and different sizes of aquacultured clams. Increasing the number of shellfish units per bushel decreases the depuration cost per unit.

ECONOMIC FEASIBILITY

The indicator of the feasibility of the depuration facility is whether the costs of depuration can be covered by either a premium on sales or a savings on the raw product used for depuration. While a processor may be willing to sell at cost or below cost in order to have a greater total volume of sales, it is unlikely that a potential investor would be willing to build a depuration facility if at least the cost of depurating could not be recuperated.

Wild-caught Oysters

Oystermen indicate that they would be willing to accept about 25% less for oysters harvested from CR or RE waters, since the higher yield per trip would be great enough to compensate them for a lower price per bushel. Calculated costs associated with oyster harvesting based on different catch rates support use of this lower price (Table 4). Based on a current price of $10.80 per bushel paid to oystermen for oysters from CA or AP areas, they would accept a minimum of $8.00 per bushel for oysters from CR or RE areas. Assuming no price premium for depurated oysters sold, this leaves no more than $2.80 per bushel to cover the costs of depuration before monitor charges are included. Assuming a monitor charge of $1.00 per bushel (this assumes 10 boats accompany one monitor and each boat reaches the 20 bushel daily limit), the total cost per bushel is $9.00, leaving $1.80 left to cover the costs of depuration. Since none of the options yields a cost per bushel less than $9.25 (Table 11), at current prices, oyster depuration does not appear to be economically feasible.

SENSITIVITY ANALYSIS

Table 12. Sensitivity of costs to changes in tank utilization/mortality

(see explanatory notes below)

PER BUSHEL

tank utili	Design Options 1	2	3	4	5	6	7	8	9	10	11	12	mortality
100%	$40.39	$27.34	$24.57	$17.43	$22.81	$16.45	$15.45	$11.51	$14.08	$11.30	$11.16	$8.73	0%
94%	$42.81	$28.98	$26.05	$18.48	$24.18	$17.43	$16.38	$12.20	$14.93	$11.97	$11.83	$9.25	6%
90%	$44.43	$30.08	$27.03	$19.18	$25.09	$18.09	$16.99	$12.66	$15.49	$12.42	$12.27	$9.60	10%
85%	$46.45	$31.44	$28.26	$20.05	$26.23	$18.91	$17.77	$13.24	$16.19	$12.99	$12.83	$10.04	15%
80%	$48.47	$32.81	$29.49	$20.92	$27.37	$19.74	$18.54	$13.81	$16.90	$13.55	$13.39	$10.47	20%
75%	$50.48	$34.18	$30.72	$21.79	$28.51	$20.56	$19.31	$14.39	$17.60	$14.12	$13.95	$10.91	25%
70%	$52.50	$35.54	$31.94	$22.67	$29.65	$21.38	$20.08	$14.96	$18.31	$14.68	$14.51	$11.35	30%
60%	$56.54	$38.28	$34.40	$24.41	$31.93	$23.02	$21.63	$16.11	$19.71	$15.81	$15.62	$12.22	40%
50%	$60.58	$41.01	$36.86	$26.15	$34.22	$24.67	$23.17	$17.27	$21.12	$16.94	$16.74	$13.09	50%
40%	$64.62	$43.75	$39.32	$27.90	$36.50	$26.31	$24.72	$18.42	$22.53	$18.07	$17.85	$13.96	60%

Explanation: Note that 100% tank utilization means that 100% of the tank was stocked and 100% of the oysters were live when removed from the tank. Thus, 100% tank utilization = 0% mortality. 40% tank utilization could mean that 60% of shellfish were lost to mortality, OR, the tank was only stocked to 60% of its capacity.

PER OYSTER

tank utili	Design Options 1	2	3	4	5	6	7	8	9	10	11	12	mortality
100%	$0.144	$0.098	$0.088	$0.062	$0.081	$0.059	$0.055	$0.041	$0.050	$0.040	$0.040	$0.031	0%
94%	$0.153	$0.104	$0.093	$0.066	$0.086	$0.062	$0.058	$0.044	$0.053	$0.043	$0.042	$0.033	6%
90%	$0.159	$0.107	$0.097	$0.068	$0.090	$0.065	$0.061	$0.045	$0.055	$0.044	$0.044	$0.034	10%
85%	$0.166	$0.112	$0.101	$0.072	$0.094	$0.068	$0.063	$0.047	$0.058	$0.046	$0.046	$0.036	15%
80%	$0.173	$0.117	$0.105	$0.075	$0.098	$0.070	$0.066	$0.049	$0.060	$0.048	$0.048	$0.037	20%
75%	$0.180	$0.122	$0.110	$0.078	$0.102	$0.073	$0.069	$0.051	$0.063	$0.050	$0.050	$0.039	25%
70%	$0.188	$0.127	$0.114	$0.081	$0.106	$0.076	$0.072	$0.053	$0.065	$0.052	$0.052	$0.041	30%
60%	$0.202	$0.137	$0.123	$0.087	$0.114	$0.082	$0.077	$0.058	$0.070	$0.056	$0.056	$0.044	40%
50%	$0.216	$0.146	$0.132	$0.093	$0.122	$0.088	$0.083	$0.062	$0.075	$0.061	$0.060	$0.047	50%
40%	$0.231	$0.156	$0.140	$0.100	$0.130	$0.094	$0.088	$0.066	$0.080	$0.066	$0.064	$0.050	60%

PER CLAM

tank utili	Design Options 1	2	3	4	5	6	7	8	9	10	11	12	mortality
100%	$0.040	$0.027	$0.025	$0.017	$0.023	$0.016	$0.015	$0.012	$0.014	$0.011	$0.011	$0.009	0%
94%	$0.043	$0.029	$0.026	$0.018	$0.024	$0.017	$0.016	$0.012	$0.015	$0.012	$0.012	$0.009	6%
90%	$0.044	$0.030	$0.027	$0.019	$0.025	$0.018	$0.017	$0.013	$0.015	$0.012	$0.012	$0.010	10%
85%	$0.046	$0.031	$0.028	$0.020	$0.026	$0.019	$0.018	$0.013	$0.016	$0.013	$0.013	$0.010	15%
80%	$0.048	$0.033	$0.029	$0.021	$0.027	$0.020	$0.019	$0.014	$0.017	$0.014	$0.013	$0.010	20%
75%	$0.050	$0.034	$0.031	$0.022	$0.029	$0.021	$0.019	$0.014	$0.018	$0.014	$0.014	$0.011	25%
70%	$0.053	$0.036	$0.032	$0.023	$0.030	$0.021	$0.020	$0.015	$0.018	$0.015	$0.015	$0.011	30%
60%	$0.057	$0.038	$0.034	$0.024	$0.032	$0.023	$0.022	$0.016	$0.020	$0.016	$0.016	$0.012	40%
50%	$0.061	$0.041	$0.037	$0.026	$0.034	$0.025	$0.023	$0.017	$0.021	$0.017	$0.017	$0.013	50%
40%	$0.065	$0.044	$0.039	$0.028	$0.036	$0.026	$0.025	$0.018	$0.023	$0.018	$0.018	$0.014	60%

Baseline assumptions are highlighted.

Table 13. Sensitivity of costs to changes in depuration cycles per year.

PER BUSHEL

	Design Options											
weeks operating	1	2	3	4	5	6	7	8	9	10	11	12
45	$32.28	$23.03	$21.26	$14.67	$18.32	$13.93	$13.44	$9.75	$11.39	$9.62	$9.75	$7.43
37	$35.70	$24.96	$22.81	$15.90	$20.22	$15.07	$14.39	$10.55	$12.54	$10.38	$10.43	$8.02
27	$42.81	$28.98	$26.05	$18.48	$24.18	$17.43	$16.38	$12.20	$14.93	$11.97	$11.83	$9.25
25	$44.92	$30.17	$27.00	$19.24	$25.35	$18.13	$16.96	$12.69	$15.63	$12.44	$12.24	$9.62
23	$47.39	$31.57	$28.13	$20.14	$26.73	$18.96	$17.65	$13.27	$16.46	$13.00	$12.73	$10.04
21	$50.33	$33.23	$29.47	$21.21	$28.37	$19.93	$18.47	$13.95	$17.45	$13.66	$13.31	$10.55
19	$53.89	$35.25	$31.09	$22.50	$30.35	$21.12	$19.47	$14.78	$18.65	$14.45	$14.01	$11.17
17	$58.29	$37.73	$33.09	$24.09	$32.80	$22.58	$20.69	$15.80	$20.12	$15.44	$14.88	$11.93
15	$63.87	$40.88	$35.63	$26.11	$35.90	$24.44	$22.25	$17.10	$21.99	$16.68	$15.97	$12.89
13	$71.16	$45.00	$38.94	$28.75	$39.96	$26.86	$24.28	$18.80	$24.44	$18.32	$17.41	$14.15

PER OYSTER

	Design Options											
weeks operating	1	2	3	4	5	6	7	8	9	10	11	12
45	$0.115	$0.082	$0.076	$0.052	$0.065	$0.050	$0.048	$0.035	$0.041	$0.034	$0.035	$0.027
37	$0.153	$0.089	$0.081	$0.057	$0.072	$0.054	$0.051	$0.038	$0.045	$0.037	$0.037	$0.029
27	$0.153	$0.104	$0.093	$0.066	$0.086	$0.062	$0.058	$0.044	$0.053	$0.043	$0.042	$0.033
25	$0.160	$0.108	$0.096	$0.069	$0.091	$0.065	$0.061	$0.045	$0.056	$0.044	$0.044	$0.034
23	$0.169	$0.113	$0.100	$0.072	$0.095	$0.068	$0.063	$0.047	$0.059	$0.046	$0.045	$0.036
21	$0.180	$0.119	$0.105	$0.076	$0.101	$0.071	$0.066	$0.050	$0.062	$0.049	$0.048	$0.038
19	$0.192	$0.126	$0.111	$0.080	$0.108	$0.075	$0.070	$0.053	$0.067	$0.052	$0.050	$0.040
17	$0.208	$0.135	$0.118	$0.086	$0.117	$0.081	$0.074	$0.056	$0.072	$0.055	$0.053	$0.043
15	$0.228	$0.146	$0.127	$0.093	$0.128	$0.087	$0.079	$0.061	$0.079	$0.060	$0.057	$0.046
13	$0.254	$0.161	$0.139	$0.103	$0.143	$0.096	$0.087	$0.067	$0.087	$0.065	$0.062	$0.051

PER CLAM

	Design Options											
weeks operating	1	2	3	4	5	6	7	8	9	10	11	12
45	$0.032	$0.023	$0.021	$0.015	$0.018	$0.014	$0.013	$0.010	$0.011	$0.010	$0.010	$0.007
37	$0.036	$0.025	$0.023	$0.016	$0.020	$0.015	$0.014	$0.011	$0.013	$0.010	$0.010	$0.008
27	$0.043	$0.029	$0.026	$0.018	$0.024	$0.017	$0.016	$0.012	$0.015	$0.012	$0.012	$0.009
25	$0.045	$0.030	$0.027	$0.019	$0.025	$0.018	$0.017	$0.013	$0.016	$0.012	$0.012	$0.010
23	$0.047	$0.032	$0.028	$0.020	$0.027	$0.019	$0.018	$0.013	$0.016	$0.013	$0.013	$0.010
21	$0.050	$0.033	$0.029	$0.021	$0.028	$0.020	$0.018	$0.014	$0.017	$0.014	$0.013	$0.011
19	$0.054	$0.035	$0.031	$0.022	$0.030	$0.021	$0.019	$0.015	$0.019	$0.014	$0.014	$0.011
17	$0.058	$0.038	$0.033	$0.024	$0.033	$0.023	$0.021	$0.016	$0.020	$0.015	$0.015	$0.012
15	$0.064	$0.041	$0.036	$0.026	$0.036	$0.024	$0.022	$0.017	$0.022	$0.017	$0.016	$0.013
13	$0.071	$0.045	$0.039	$0.029	$0.040	$0.027	$0.024	$0.019	$0.024	$0.018	$0.017	$0.014

Baseline assumptions are highlighted.

Table 14. Sensitivity of costs to changes in water source

PER BUSHEL

	Design Options 1	2	3	4	5	6	7	8	9	10	11	12
wellwater	$42.81	$28.98	$26.05	$18.48	$24.18	$17.43	$16.38	$12.20	$14.93	$11.97	$11.83	$9.25
transported	$44.03	$29.99	$26.99	$19.39	$24.75	$17.90	$16.81	$12.62	$15.18	$12.17	$12.01	$9.42
artificial	$49.02	$35.30	$32.40	$24.85	$30.50	$23.80	$22.77	$18.60	$21.30	$18.37	$18.23	$15.66

PER OYSTER

	Design Options 1	2	3	4	5	6	7	8	9	10	11	12
wellwater	$0.153	$0.104	$0.093	$0.066	$0.086	$0.062	$0.059	$0.044	$0.053	$0.043	$0.042	$0.033
transported	$0.157	$0.107	$0.096	$0.069	$0.088	$0.064	$0.060	$0.045	$0.054	$0.043	$0.043	$0.034
artificial	$0.175	$0.126	$0.116	$0.089	$0.109	$0.085	$0.081	$0.066	$0.076	$0.066	$0.065	$0.056

PER CLAM

	Design Options 1	2	3	4	5	6	7	8	9	10	11	12
wellwater	$0.043	$0.029	$0.026	$0.018	$0.024	$0.017	$0.016	$0.012	$0.015	$0.012	$0.012	$0.009
transported	$0.044	$0.030	$0.027	$0.019	$0.025	$0.018	$0.017	$0.013	$0.015	$0.012	$0.012	$0.009
artificial	$0.049	$0.035	$0.032	$0.025	$0.030	$0.024	$0.023	$0.019	$0.021	$0.018	$0.018	$0.016

Baseline assumptions are highlighted.

Table 15. Sensitivity of costs to a change in the source of laboratory analysis

PER BUSHEL

Design Options

	1	2	3	4	5	6	7	8	9	10	11	12
on-site	$42.81	$28.98	$26.05	$18.48	$24.18	$17.43	$16.38	$12.20	$14.93	$11.97	$11.83	$9.25
outside	$46.35	$39.81	$38.49	$28.98	$25.95	$22.84	$22.60	$17.45	$15.82	$14.68	$14.94	$11.87

PER OYSTER

Design Options

	1	2	3	4	5	6	7	8	9	10	11	12
on-site	$0.153	$0.104	$0.093	$0.066	$0.086	$0.062	$0.059	$0.044	$0.053	$0.043	$0.042	$0.033
outside	$0.166	$0.142	$0.137	$0.103	$0.093	$0.082	$0.081	$0.062	$0.056	$0.052	$0.053	$0.042

PER OYSTER

Design Options

	1	2	3	4	5	6	7	8	9	10	11	12
on-site	$0.043	$0.029	$0.026	$0.018	$0.024	$0.017	$0.016	$0.012	$0.015	$0.012	$0.012	$0.009
outside	$0.046	$0.040	$0.038	$0.029	$0.026	$0.023	$0.023	$0.017	$0.016	$0.015	$0.015	$0.012

W

Baseline assumptions are highlighted.

Table 16. Sensitivity of costs based on differing counts of oysters and clams per bushel.

OYSTERS

count per bushel	Design Options 1	2	3	4	5	6	7	8	9	10	11	12
220	$0.195	$0.132	$0.118	$0.084	$0.110	$0.079	$0.074	$0.055	$0.068	$0.054	$0.054	$0.042
250	$0.171	$0.116	$0.104	$0.074	$0.097	$0.070	$0.066	$0.049	$0.060	$0.048	$0.047	$0.037
280	$0.153	$0.104	$0.093	$0.066	$0.086	$0.062	$0.058	$0.044	$0.053	$0.043	$0.042	$0.033
310	$0.138	$0.093	$0.084	$0.060	$0.078	$0.056	$0.053	$0.039	$0.048	$0.039	$0.038	$0.030
340	$0.126	$0.085	$0.077	$0.054	$0.071	$0.051	$0.048	$0.036	$0.044	$0.035	$0.035	$0.027
370	$0.116	$0.078	$0.070	$0.050	$0.065	$0.047	$0.044	$0.033	$0.040	$0.032	$0.032	$0.025

CLAMS

count per bushel	Design Options 1	2	3	4	5	6	7	8	9	10	11	12
600	$0.071	$0.048	$0.043	$0.031	$0.040	$0.029	$0.027	$0.020	$0.025	$0.020	$0.020	$0.015
800	$0.054	$0.036	$0.033	$0.023	$0.030	$0.022	$0.020	$0.015	$0.019	$0.015	$0.015	$0.012
1000	$0.043	$0.029	$0.026	$0.018	$0.024	$0.017	$0.016	$0.012	$0.015	$0.012	$0.012	$0.009
1200	$0.036	$0.024	$0.022	$0.015	$0.020	$0.015	$0.014	$0.010	$0.012	$0.010	$0.010	$0.008

Baseline assumptions are highlighted.

If depurated product is more attractive to consumers based on a more appealing appearance or perception of enhanced safety, a price premium on depurated product could cover the costs of depuration. Based on the $17.43 cost per bushel for depurated product for Option 6 and the $1.80 in savings made for each bushel paid to harvesters, the premium would have to be equal to $0.056 per oyster to cover the costs of depuration (($17.43 - $1.80) / 280 oysters per bushel). This would be a 35% to 45% price increase over the current $0.12 to $0.15 wholesale price per oyster. For the largest capacity option, Option 12, the premium required is $0.027 per oyster, or 20% of the current wholesale price.

Aquacultured Hard Clams

In April 1993, 1-inch clams were being sold by producers for $0.08 to $0.10 each, with product costs estimated to be between $0.05 and $0.077 per clam (Adams, et al 1993). The costs of depurating clams range from $0.043 to $0.009 per clam. As previously noted, aquacultured shellfish are grown in AP or CA waters, and thus there is no possible savings on purchase price as there is for wild-caught oysters. Based on current marketing information, it is impossible to predict if the costs could be covered by a premium on depurated clams. For Option 6, a premium of $0.017 would be required to cover the costs of depuration ($17.43 / 1000 clams per bushel). For Option 12, the premium required is $0.009 per clam. Because the depuration cost per clam is a much smaller percentage of the clam wholesale price, it may be easier to secure a premium to cover the costs of depuration.

THE REAL WORLD

In the "real world," circumstances may reduce the costs of depuration significantly in several ways. A saltwater well may not contain iron and thus a chiller and reservoir would not be needed. The owner may have existing property or buildings, thus reducing initial investment costs. The owner's family may be able to supply some of the labor. Used equipment may be purchased at a discount from Florida east coast clam depuration operations which are no longer operating. On the marketing side, it may be possible to make contracts with retail outlets or restaurants to market a steady supply of depurated product at a premium price.

It is equally as likely, however, that conditions or unforeseen events lead to an increase in the costs of depuration. Skilled labor to do laboratory analysis may not be available, and the more expensive services of an outside lab may have to be used. Environmental or marketing conditions may result in significantly fewer depuration cycles per year, thus increasing costs per cycle. Months may be required to refine the facility operations, with costly short-term mortalities the result.

LARGER SYSTEMS

The costs per bushel, oyster, and clam will decrease as system size increases. It may be possible to reduce costs to less than the $9.25 per bushel calculated if systems of 1,000 or more bushels per week are used. While it does not appear that the oyster resource in the Dixie and Levy county area could support such a facility, the number of hard clams grown in the area has the potential to increase to an amount sufficient to support a facility of an economically feasible size, where costs are less than $0.01 per clam depurated.

SUMMARY AND CONCLUSIONS

This economic analysis determined the approximate investment and capital and operating costs for a depuration facility. A partial budgeting approach was used to construct cost budgets for 12 design options with varying operating capacities. Costs were then estimated on a per year, tank cycle, bushel, and oyster and clam basis.

Total investment costs range from $60,308 to $203,958 for capacities ranging from 30 bushels per week to 498/bu week. Capital and operating costs per bushel range from $42.81 for the smallest capacity facility to $9.25 for the largest. This is equal to $0.153 to $0.33 per oyster and $0.043 to $0.009 per hard clam.

The cost of depuration can be recuperated in one of two ways. Depuration may enhance the salability of shellfish and recuperate lost markets by improving consumer perceptions of shellfish safety, or simply by providing a product with a better appearance. The premium paid for depurated shellfish could cover the costs of depuration. Based on baseline assumptions for the 12 different facility options, the premium required is from $9.25 to $42.81 per bushel depending upon the operating capacity of the facility. At wholesale prices of $8 per bushel for oysters, it seems unlikely that depurated product will be able to garner the premium required. Hard clams, at $80 per bushel, have a better chance of attaining the premium, simply because the percentage increase in the total cost of the clam is smaller than that for oysters.

The second means by which the cost of depuration can be recovered is by purchasing shellfish to be depurated for a lower price than shellfish destined for direct-to-market sales. Oystermen indicate that they would be willing to accept a lower price per bushel if they had access to the more abundant resource in restricted waters. At current purchase prices, harvesting costs, and monitor costs, it is estimated that approximately $1.80 is available to cover the costs of depuration. Because the cost budgets for each of the facilities indicate a cost several times higher than this, the cost of depuration cannot be recuperated by this second means. If oyster prices rose significantly, depuration could become a more attractive means to obtain resource. High clam prices in the late 1980's, accompanied by abundant resource in restricted waters, led to construction of several facilities on the east coast of Florida which depurated wild product from restricted waters. During this period the cost of clam depuration was recovered by purchasing wild clams from restricted waters at a lower price (Adams, 1985).

The costs of depuration decrease with the size of the facility. The estimated increase in the oyster fishery in Dixie and Levy counties could support a facility of up to 500 bushels per week (assuming a 27 week operating year and use of Suwanee Sound oysters). While there is virtually no aquaculture of oysters, hard clam aquaculture has the potential to provide over 2,000 bushels per month, dependent upon the harvest and length of the operating year. However, hard clams are all grown in approved waters, and thus the costs of depuration must be recovered by a price premium. At the present time, it is impossible to say if any premium could be earned.

For hard-clams, wet-storage is an alternative means by which the value of the product can be increased. A wet-storage cycle can be completed in as little as eight hours, and lab analysis of meat samples is not required, thus the costs per cycle and bushel are less than that of depuration. Since aquacultured hard clams are from approved waters, wet-storage may be a more economically feasible way to enhance product value.

Relaying may provide an alternative means to enlarge the oyster resource. Relaying can act as a form of "natural" depuration, and when relays are carried out with a number of participants, the cost per participant is minimal. The recent introduction of aquaculture leases in the two counties combined with restrictions on the resource in the Suwanee Sound and other areas seems to provide an opportunity for profitable use of relaying.

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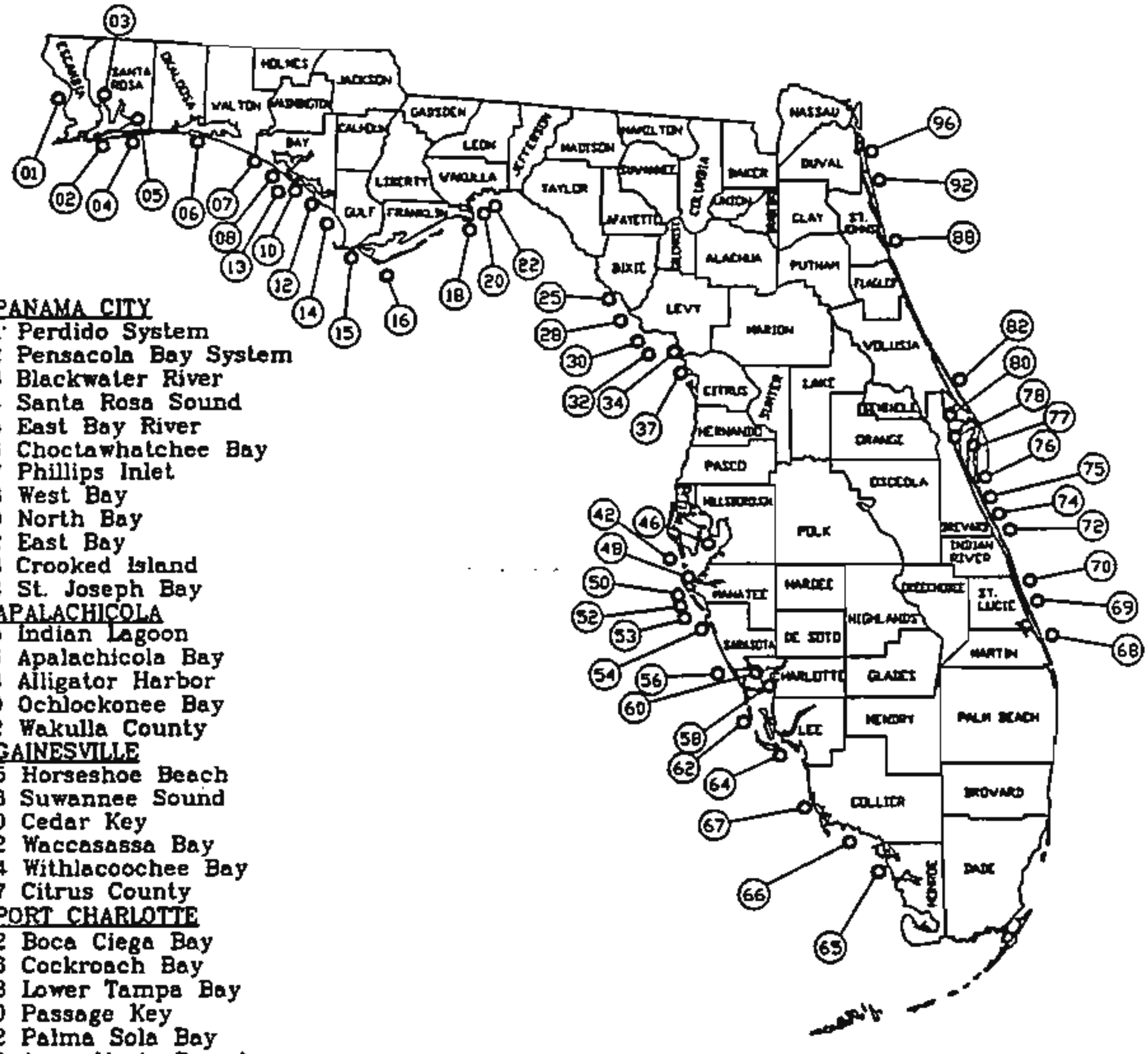
APPENDIX A

Shellfish Harvesting Area Classification Maps



PANAMA CITY
1 Perdido System
2 Pensacola Bay System
3 Blackwater River
4 Santa Rosa Sound
5 East Bay River
6 Choctawhatchee Bay
7 Phillips Inlet
8 West Bay
10 North Bay
12 East Bay
13 Crooked Island
14 St. Joseph Bay

APALACHICOLA
15 Indian Lagoon
16 Apalachicola Bay
18 Alligator Harbor
20 Ochlockonee Bay
22 Wakulla County

GAINESVILLE
25 Horseshoe Beach
28 Suwannee Sound
30 Cedar Key
32 Waccasassa Bay
34 Withlacoochee Bay
37 Citrus County

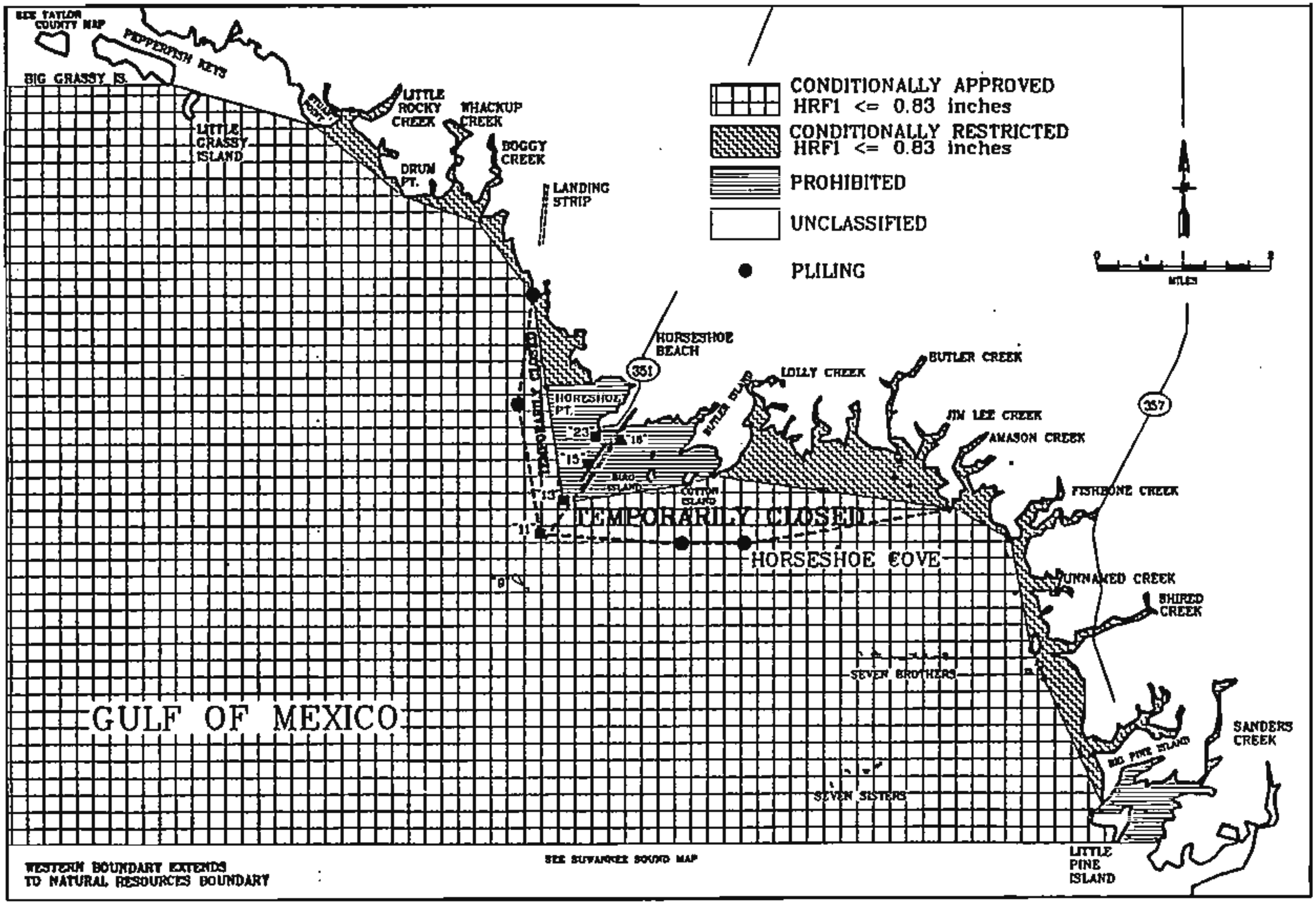
PORT CHARLOTTE
42 Boca Ciega Bay
46 Cockroach Bay
48 Lower Tampa Bay
50 Passage Key
52 Palma Sola Bay
53 Anna Maria Sound
54 Sarasota Bay
56 Lemon Bay
58 Gasparilla Sound
60 Myakka River
62 Pine Island Sound
64 Estero Bay
65 Everglades
66 Ten Thousand Islands
67 Rookery Bay

PALM BAY
68 Martin County
69 South St. Lucie
70 Indian River/St. Lucie
72 North Indian River
74 Body F
75 Body E
76 Body D
77 Body C
78 Body B
80 Body A
82 Volusia
88 St. Johns, South
92 St. Johns, North
96 Duval County

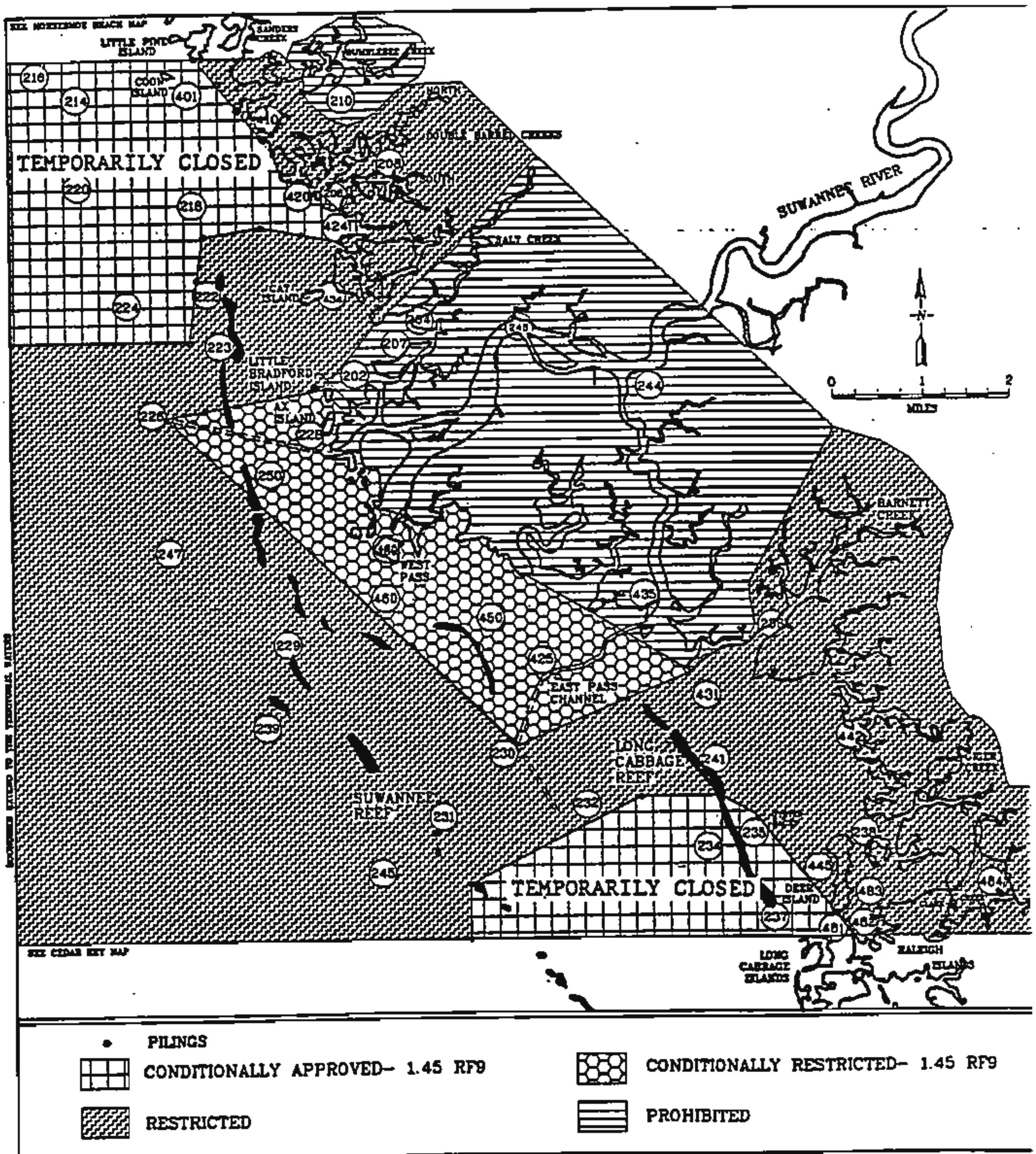
-N-

LOCATION OF SHELLFISH HARVESTING AREAS

Horseshoe Beach Shellfish Harvesting Area Classification
(Effective April 30, 1993)



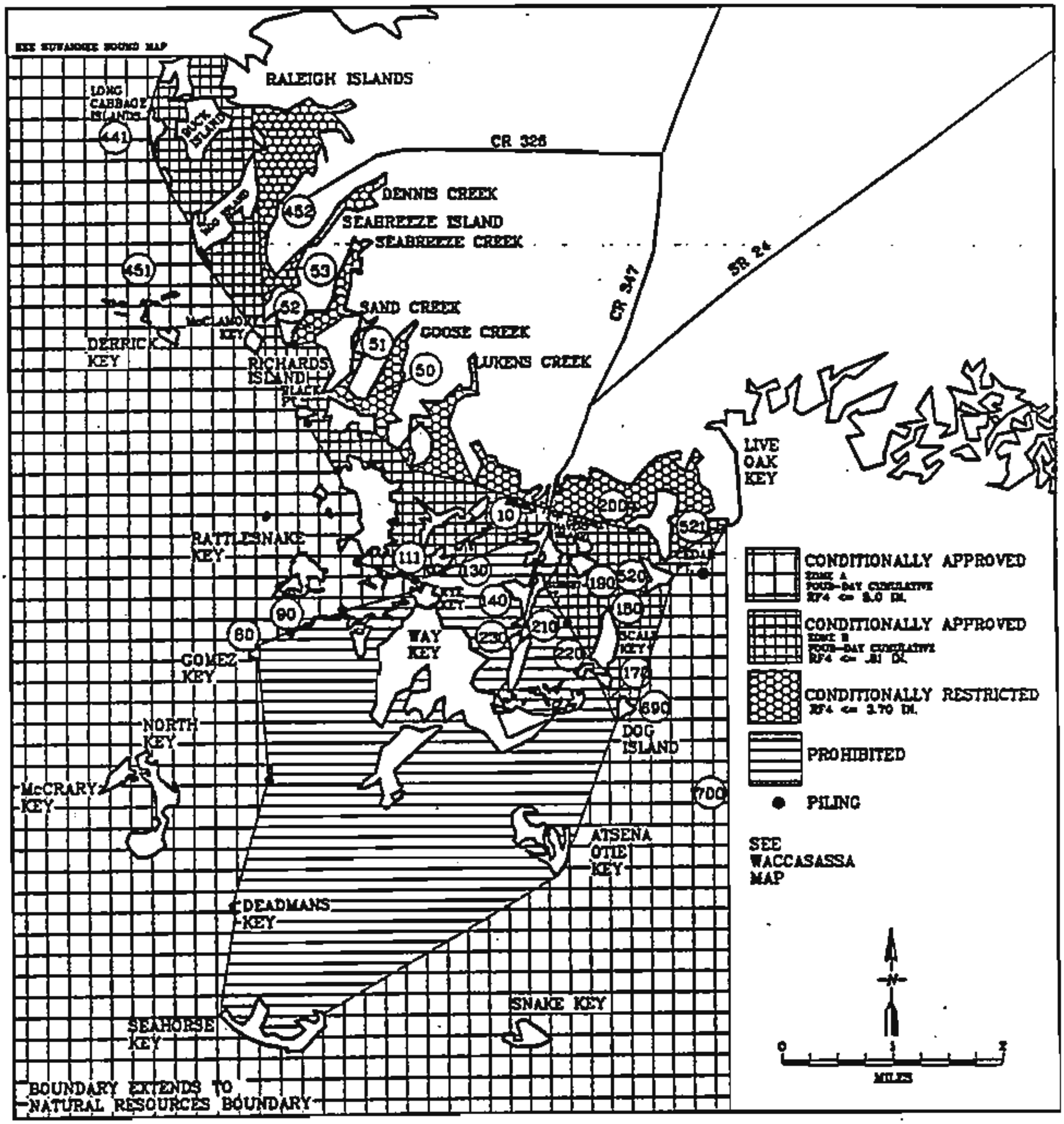
MAP 11-1 LEVY COUNTY
SUWANNEE SOUND



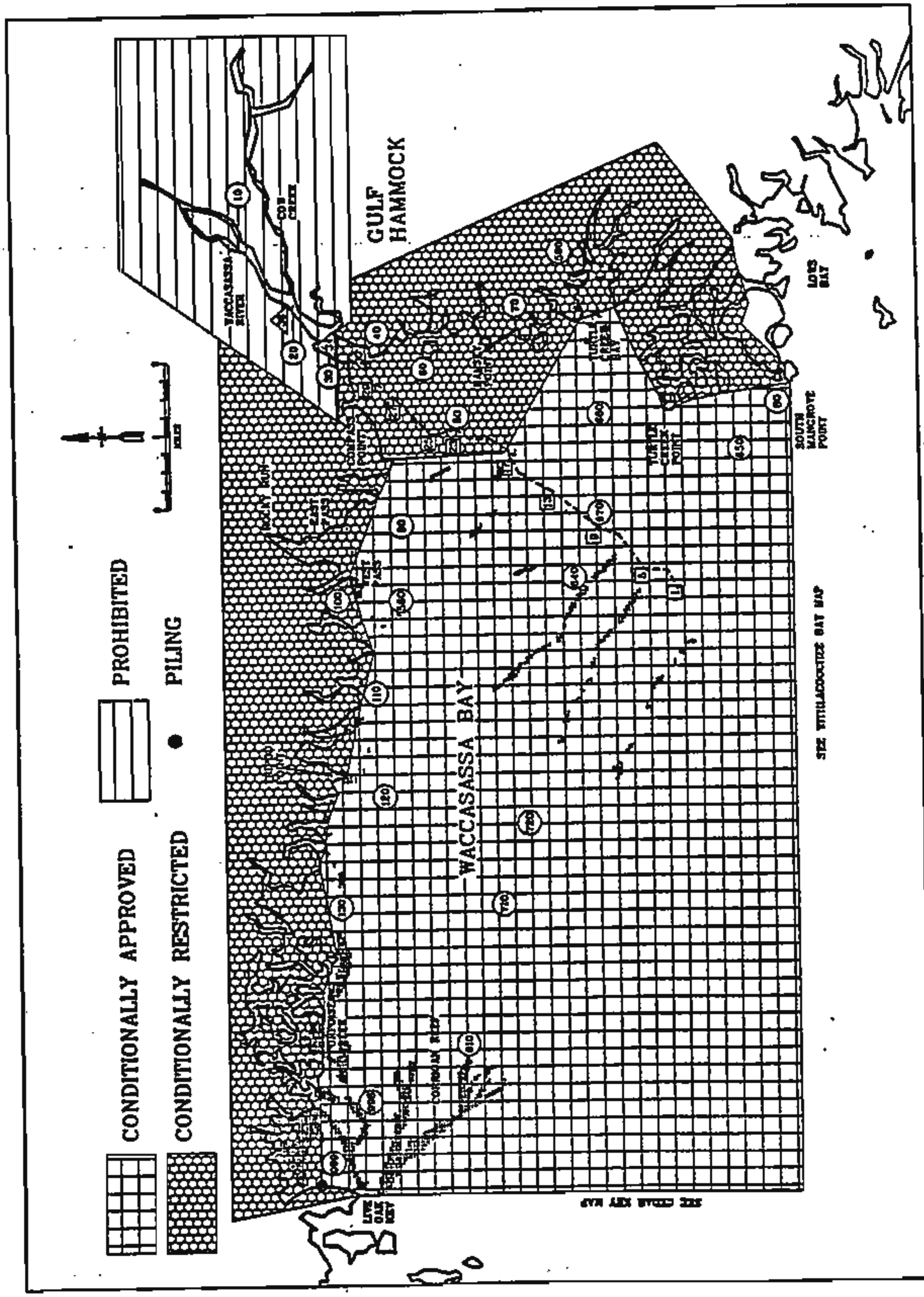
SUWANNEE SOUND SHELLFISH HARVESTING AREA

FLORIDA DEPARTMENT OF NATURAL RESOURCES
SHELLFISH ENVIRONMENTAL ASSESSMENT SECTION
3900 COMMONWEALTH BOULEVARD
TALLAHASSEE FLORIDA, 32399
TELEPHONE (904) 488-5471
REVISED AUGUST 31, 1991

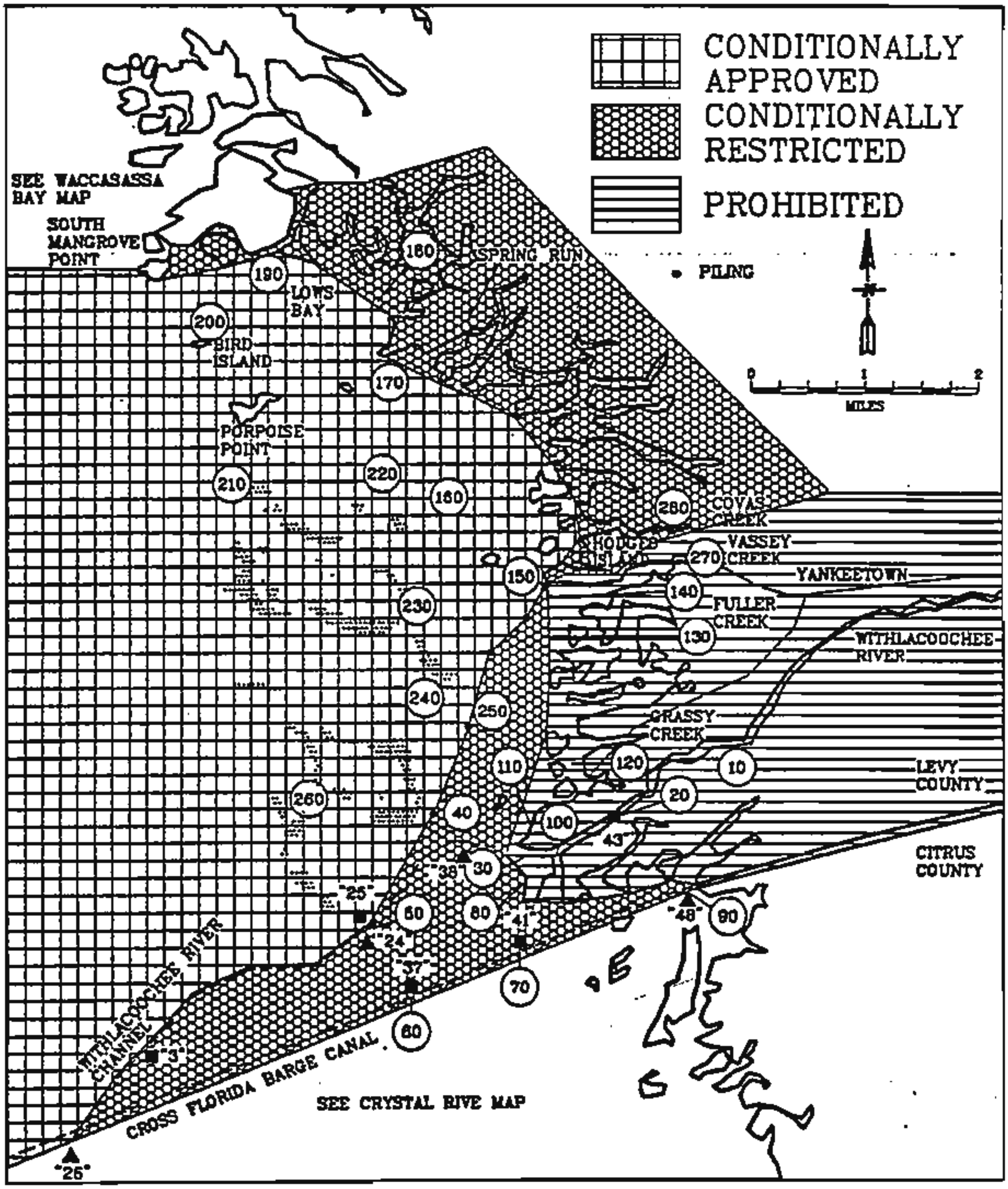
MAP 11-2 LEVY COUNTY
CEDAR KEY



MAP 11-3 LEVY COUNTY
WACCASASSA BAY



MAP 11-4 LEVY COUNTY
WITHLACOOCHEE BAY



APPENDIX B

Example Depuration Facility Permit Application

Example Depuration Permit Application

A. Plant Identification

Levy/Dixie Depuration Facility, Option 6
shore-side location

Number of plant employees: 2

Plant Quality Control Laboratory: Levy/Dixie Depuration Facility

Source of Shellfish: conditionally restricted waters in Dixie and Levy counties, Florida

B. Plant Description

1. Equipment

a) Processing Tanks:
construction materials: 2 inch polyurethane insulated fiberglass tanks
number of tanks: 2
tank dimensions: 4.5'*16'*3.50'
water capacity per tank: 1505 gallons (3" freeboard)
(24 bushels per tank)

b) Settling tank
tank construction material: 2 inch polyurethane
tank dimensions: 3' height, 4.6 diamter
water capacity: 1505 gallons
used for sediment and iron removal

c) filtration
flow rate required: 24 bushels * 1.5 gpm/bushel = 36 gpm

sand filter (per tank): Aquanetics L225-6, max flow gpm = 53

d) UV Sterilization

flow rate required: 13 bushels * 1.5 gpm/bushels = 36 gpm

UV sterilization (per tank): Aquanetics Q90IL, max flow gpm = 50

e) recirculation

recirculating pump: 1, 3/4 HP Jacuzzi pump

f) flow meters- 1 per tank

g) plumbing

all system plumbing uses 1.5 inch diameter 40 PVC pipe

h) drainage

mid-level drains used to recirculate water during processing, bottom drains used to dispose of sediments and cleaning liquids to alternative discharge

2. System Loading

a) tray description:
construction material: impervious plastic
dimensions: 28" * 14" * 7"
Tray design allows for 3" of oysters plus 4 inches clearance between trays

b) tray capacity = 3/4 bushel

c) tank capacity = 32 trays, 24 bushels

d) system capacity, 2 tanks = 64 trays, 48 bushels

3. Source and Treatment of Process Water

a) Source: saltwater well

b) pretreatment:

Source saltwater is aerated (if needed) in the settling tank for 20 hours, then recirculated for 6 hours through the sand filter and UV unit prior to loading of shellfish.

c) bacteriological quality of source water meets that approved for depuration (Florida Comprehensive Shellfish Control Code)*

d) bacteriological quality of process water meets that approved for depuration (Florida Comprehensive Shellfish Control Code)*

e) process water treatment during depuration cycle

1) all recirculated water passes throught the sand filter and UV

sterilization unit

2) aeration with air stones keeps level of DO saturation above the 50% required minimum

3) Plant Operations

1) see depuration process flow-chart

2) see depuration facility maintenance schedule

4) Cold Storage

Shellfish are stored in a 45 F degree cooler divided into three compartments by 3 foot dividers. Compartment A holds undepurated product, compartment B holds depurated product held for 48-hour fecal coliform test, and compartment C holds depurated product approved for sale.

*In an actual application, this information must be provided verbatim.

Depuration Plant Maintenance & Cleaning Procedures

Maintenance Schedule*					
	cycle	weekly	monthly	bimonthly	annually
inspect UV unit	X				
inspect UV bulbs				X	
replace UV bulbs					X
clean purification tanks	X				
clean resevoir tank			X		
clean inside PVC recirculating pipes				X	
chlorox inside PVC recirculating pipes			X		
backwash sand filter	X				
inspect sand filter media					X
wash and scrub cooler			X		
wash work area floor	X				
wash and scrub walls					X
wash trays	X				
wash washer/culler	X				
paint interior walls, patch					X

* Schedule is adapted from (Howell, 1989).

APPENDIX C

Cost Budgets for Each Design Option

COST BUDGET, OPTION =	**1**	tank size =	4.5'*8'*3.5'	oyst/bushel =	280
cost per bushel =	$42.81	number of tanks =	1	clams/bushel =	1000
cost per oyster =	$0.1529	bushels/tank or bank =	12	mortality =	6%
cost per clam =	$0.0428	(If number of tanks = 4,		bushels/week	30
tank cycles/year =	67.5	there are 2 banks of 2 tanks)		bushels/year =	810

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$6,188	building and	$656	$9.72	2.01%
area, sq feet	221	property amortized			
Property	$8,840	over 30 years	$938	$13.89	2.87%
Processing Equipment**					
Depuration tanks	$1,050	10	$111	$1.64	0.34%
Sand Filter	$207	10	$22	$0.32	0.07%
UV sterilizer	$360	8	$47	$0.70	0.15%
Recirculating Pump	$408	6	$72	$1.06	0.22%
Blower	$333	6	$59	$0.87	0.18%
Chiller	$1,816	15	$128	$1.89	0.39%
Cooler (installed)	$3,506	15	$247	$3.65	0.75%
sq feet	40				
SUBTOTAL, Equipment	$7,680		$685	$10.14	2.09%
Materials**					
PVC tubing & materials and flow meters	$134	5	$28	$0.42	0.09%
oxygen meter	$530	5	$112	$1.66	0.34%
salinometer	$800	5	$169	$2.50	0.52%
tank trays	$160	3.5	$48	$0.71	0.15%
air diffusors	$28	1	$30	$0.44	0.09%
washing/culling table	$1,800	8	$237	$3.52	0.73%
UV replacement lights/sleeve	$124	1	$131	$1.94	0.40%
Pressure sprayer	$700	3	$246	$3.65	0.75%
SUBTOTAL, materials	$4,276		$1,001	$14.83	3.06%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$69	14.22%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,028	1	$1,028	$15.23	3.14%
liability (1% of sales)	$65	1	$65	0.96	0.20%
property taxes (3.12 millage)	$469	1	$469	$6.95	1.43%
labor for assembly	$480	30	$16	$0.24	0.05%
certification & permitting	$1,292	30	$43	$0.64	0.13%
SUBTOTAL, Other Fixed	$3,334		$1,621	$24.01	4.95%
SUBTOTAL FIXED	**$57,567**		**$9,552**	**$141.51**	**29.20%**
FIXED COSTS PER BUSHEL =	**$12.50**				

DESIGN OPTION = 1

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$80.00	16.51%
Hourly	$1,242	$18.40	3.80%
Owner/manager	$3,635	$53.85	11.11%
Lab technician	$6,480	$96.00	19.81%
SUBTOTAL, Labor	$16,757	$248.25	51.22%
Utilities			
Electricity			
UV	$420	$6.22	1.28%
pump	$124	$1.84	0.38%
blower	$49	$0.73	0.15%
cooler	$94	$1.39	0.29%
chiller	$119	$1.77	0.37%
lighting	$8	$0.12	0.02%
Water	$108	$1.60	0.33%
Sewage	$119	$1.76	0.36%
SUBTOTAL, Utilities	$1,042	$15.43	3.18%
Building maintenance	$188	$0.67	0.14%
Cleaning & misc supplies	$135	$2.00	0.41%
Laboratory Analysis, materials	$4,725	$70.00	14.44%
SUBTOTAL VARIABLE	**$22,847**	**$336.35**	**69.40%**

VAR. COSTS PER BUSHEL = $29.71

Water Supply Costs		cost per bushel(w/mortality)	annual	per cycle	percent of total
Investment:	$2,741				
Costs per bushel		$0.6003			
Costs per cycle(excludes mortality)			$458.71	$6.80	1.40%

	initial investment	annual capital & operating costs		
	$60,308	$32,857		
TOTAL (includes mortality)			**$513.73**	100.00%
COST PER BUSHEL			**$42.81**	
COST PER OYSTER			**$0.1529**	
COST PER CLAM			**$0.0428**	

COST BUDGET, OPTION =	2	tank size =	4.5'*8'*3.5'	oyst/bushel =	280
cost per bushel =	$28.98	number of tanks =	2	clams/bushel =	1000
cost per oyster =	$0.1035	bushels/tank or bank =	12	mortality =	6%
cost per clam =	$0.0290	(If number of tanks = 4,		bushels/week	60
tank cycles/year =	135	there are 2 banks of 2 tanks)		bushels/year =	1,620

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$9,016	building and	$956	$7.08	2.16%
area, sq feet	322	property amortized			
Property	$12,880	over 30 years	$1,366	$10.12	3.08%
Processing Equipment**					
Depuration tanks	$2,100	10	$222	$1.64	0.50%
Sand Filter	$414	10	$44	$0.32	0.10%
UV sterilizer	$720	8	$95	$0.70	0.21%
Recirculating Pump	$816	6	$143	$1.06	0.32%
Blower	$333	6	$59	$0.43	0.13%
Chiller	$2,487	15	$175	$1.30	0.39%
Cooler (installed)	$3,506	15	$247	$1.83	0.56%
sq feet	40				
SUBTOTAL, Equipment	$10,376		$984	$7.29	2.22%
Materials**					
PVC tubing & materials and flow meters	$288	5	$61	$0.45	0.14%
oxygen meter	$530	5	$112	$0.83	0.25%
salinometer	$800	5	$169	$1.25	0.38%
tank trays	$320	3.5	$96	$0.71	0.22%
air diffusors	$56	1	$59	$0.44	0.13%
washing/culling table	$1,944	8	$256	$1.90	0.58%
UV replacement lights/sleeve	$248	1	$262	$1.94	0.59%
Pressure sprayer	$700	3	$246	$1.82	0.56%
SUBTOTAL, materials	$4,886		$1,261	$9.34	2.85%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$34	10.50%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,166	1	$1,166	$8.64	2.63%
liability (1% of sales)	$259	1	$259	1.92	0.59%
property taxes (3.12 millage)	$683	1	$683	$5.06	1.54%
labor for assembly	$960	30	$32	$0.24	0.07%
certification & permitting	$1,292	30	$43	$0.32	0.10%
SUBTOTAL, Other Fixed	$4,360		$2,183	$16.17	4.93%
SUBTOTAL FIXED	**$68,768**		**$11,402**	**$84.46**	**25.74%**
FIXED COSTS PER BUSHEL =	$7.46				

DESIGN OPTION = 2

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$40.00	12.19%
Hourly	$2,484	$18.40	5.61%
Owner/manager	$4,604	$34.10	10.39%
Lab technician	$6,480	$48.00	14.63%
SUBTOTAL, Labor	$18,968	$140.50	42.82%
Utilities			
Electricity			
UV	$1,679	$12.44	3.79%
pump	$497	$3.68	1.12%
blower	$99	$0.73	0.22%
cooler	$188	$1.39	0.43%
chiller	$478	$3.54	1.08%
lighting	$23	$0.17	0.05%
Water	$108	$0.80	0.24%
Sewage	$119	$0.88	0.27%
SUBTOTAL, Utilities	$3,191	$23.64	7.20%
Building maintenance	$229	$0.82	0.25%
Cleaning & misc supplies	$540	$4.00	1.22%
Laboratory Analysis, materials	$9,450	$70.00	21.34%
SUBTOTAL VARIABLE	$32,378	$238.96	72.83%

VAR. COSTS PER BUSHEL = $21.11

Water Supply Costs		cost per bushel(w/mortality)	annual	per cycle	percent of total
Investment:	$2,741				
Costs per bushel		$0.4132			
Costs per cycle(excludes mortality)			$631.44	$4.68	1.43%

	initial investment	annual capital & operating costs		
	$71,509	$44,411		
TOTAL (includes mortality)			$347.78	100.00%
COST PER BUSHEL			$28.98	
COST PER OYSTER			$0.1035	
COST PER CLAM			$0.0290	

COST BUDGET, OPTION =	**3**	tank size =	4.5'*8'*3.5'	oyst/bushel =	280
cost per bushel =	$26.05	number of tanks =	3	clams/bushel =	1000
cost per oyster =	$0.0930	bushels/tank or bank =	12	mortality =	6%
cost per clam =	$0.0260	(If number of tanks = 4,		bushels/week	90
tank cycles/year =	202.5	there are 2 banks of 2 tanks)		bushels/year =	2,430

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$12,180	building and	$1,292	$6.38	2.16%
area, sq feet	435	property amortized			
Property	$17,400	over 30 years	$1,846	$9.11	3.09%
Processing Equipment**					
Depuration tanks	$3,150	10	$332	$1.64	0.56%
Sand Filter	$621	10	$66	$0.32	0.11%
UV sterilizer	$1,080	8	$142	$0.70	0.24%
Recirculating Pump	$1,224	6	$215	$1.06	0.36%
Blower	$333	6	$59	$0.29	0.10%
Chiller	$2,800	15	$197	$0.97	0.33%
Cooler (installed)	$3,506	15	$247	$1.22	0.41%
sq feet	40				
SUBTOTAL, Equipment	$12,714		$1,258	$6.21	2.11%
Materials**					
PVC tubing & materials and flow meters	$467	5	$98	$0.49	0.16%
oxygen meter	$530	5	$112	$0.55	0.19%
salinometer	$800	5	$169	$0.83	0.28%
tank trays	$480	3.5	$145	$0.71	0.24%
air diffusors	$84	1	$89	$0.44	0.15%
washing/culling table	$2,088	8	$275	$1.36	0.46%
UV replacement lights/sleeve	$372	1	$392	$1.94	0.66%
Pressure sprayer	$700	3	$246	$1.22	0.41%
SUBTOTAL, materials	$5,521		$1,526	$7.54	2.56%
Laboratory Analysis, fixed	$27,250	(various)	$4,901	$24	8.21%
Other Fixed					
Insurance					
property (2.5% of eq + building)	$1,304	1	$1,304	$6.44	2.18%
liability (1% of sales)	$583	1	$583	2.88	0.98%
property taxes (3.12 millage)	$923	1	$923	$4.56	1.55%
labor for assembly	$1,440	30	$48	$0.24	0.08%
certification & permitting	$1,292	30	$43	$0.21	0.07%
SUBTOTAL, Other Fixed	$5,542		$2,901	$14.32	4.86%
SUBTOTAL FIXED	**$80,606**		**$13,724**	**$67.77**	**22.98%**
FIXED COSTS PER BUSHEL =	$5.99				

DESIGN OPTION = 3

VARIABLE COSTS			annual	per cycle	percent of total
Assistant			$5,400	$26.67	9.04%
Hourly			$3,726	$18.40	6.24%
Owner/manager			$5,573	$27.52	9.33%
Lab technician			$8,100	$40.00	13.57%
SUBTOTAL, Labor			$22,799	$112.59	38.18%
Utilities					
Electricity					
UV			$3,779	$18.66	6.33%
pump			$1,118	$5.52	1.87%
blower			$148	$0.73	0.25%
cooler			$282	$1.39	0.47%
chiller			$1,075	$5.31	1.80%
lighting			$47	$0.23	0.08%
Water			$108	$0.53	0.18%
Sewage			$119	$0.59	0.20%
SUBTOTAL, Utilities			$6,676	$32.97	11.18%
Building maintenance			$274	$0.98	0.33%
Cleaning & misc supplies			$1,215	$6.00	2.03%
Laboratory Analysis, materials			$14,175	$70.00	23.74%
SUBTOTAL VARIABLE			$45,139	$222.53	75.47%
VAR. COSTS PER BUSHEL =	$19.66				
Water Supply Costs		cost per			
Investment:	$3,468	bushel(w/mortality)			
Costs per bushel		$0.4036			
Costs per cycle(excludes mortality)			$925.32	$4.57	1.55%
	initial investment		annual capital & operating costs		
	$84,074		$59,788		
TOTAL (includes mortality)				$312.57	100.00%
COST PER BUSHEL				$26.05	
COST PER OYSTER				$0.0930	
COST PER CLAM				$0.0260	

COST BUDGET, OPTION =	4	tank size =	4.5'*8'*3.5'	oyst/bushel =	280
cost per bushel =	$18.48	number of tanks =	4	clams/bushel =	1000
cost per oyster =	$0.0660	bushels/tank or bank =	24	mortality =	6%
cost per clam =	$0.0185	(If number of tanks = 4,		bushels/week	120
tank cycles/year =	135	there are 2 banks of 2 tanks)		bushels/year =	3,240

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$15,680	building and	$1,663	$12.32	2.94%
area, sq feet	560	property amortized			
Property	$22,400	over 30 years	$2,376	$17.60	4.21%
Processing Equipment**					
Depuration tanks	$4,200	10	$443	$3.28	0.78%
Sand Filter	$828	10	$87	$0.65	0.15%
UV sterilizer	$1,440	8	$190	$1.41	0.34%
Recirculating Pump	$1,632	6	$287	$2.13	0.51%
Blower	$333	6	$59	$0.43	0.10%
Chiller	$2,912	15	$205	$1.52	0.36%
Cooler (installed)	$3,605	15	$254	$1.88	0.45%
sq feet	40				
SUBTOTAL, Equipment	$14,950		$1,524	$11.29	2.70%
Materials**					
PVC tubing & materials and flow meters	$677	5	$143	$1.06	0.25%
oxygen meter	$530	5	$112	$0.83	0.20%
salinometer	$800	5	$169	$1.25	0.30%
tank trays	$640	3.5	$193	$1.43	0.34%
air diffusors	$112	1	$118	$0.88	0.21%
washing/culling table	$2,232	8	$294	$2.18	0.52%
UV replacement lights/sleeve	$496	1	$523	$3.88	0.93%
Pressure sprayer	$700	3	$246	$1.82	0.44%
SUBTOTAL, materials	$6,187		$1,798	$13.32	3.18%
Laboratory Analysis, fixed	$27,250	(various)	$5,151	$38	9.12%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,447	1	$1,447	$10.72	2.56%
liability (1% of sales)	$518	1	$518	3.84	0.92%
property taxes (3.12 millage)	$1,188	1	$1,188	$8.80	2.10%
labor for assembly	$1,920	30	$64	$0.47	0.11%
certification & permitting	$1,484	30	$49	$0.37	0.09%
SUBTOTAL, Other Fixed	$6,557		$3,267	$24.20	5.78%
SUBTOTAL FIXED	**$93,024**		**$15,780**	**$116.89**	**27.94%**
FIXED COSTS PER BUSHEL =	$5.16				

DESIGN OPTION = 4

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$40.00	9.56%
Hourly	$4,968	$36.80	8.79%
Owner/manager	$6,542	$48.46	11.58%
Lab technician	$6,480	$48.00	11.47%
SUBTOTAL, Labor	$23,390	$173.26	41.41%
Utilities			
Electricity			
UV	$2,939	$21.77	5.20%
pump	$869	$6.44	1.54%
blower	$99	$0.73	0.17%
cooler	$177	$1.31	0.31%
chiller	$956	$7.08	1.69%
lighting	$40	$0.30	0.07%
Water	$216	$1.60	0.38%
Sewage	$238	$1.76	0.42%
SUBTOTAL, Utilities	$5,534	$40.99	9.80%
Building maintenance	$324	$1.16	0.28%
Cleaning & misc supplies	$1,080	$8.00	1.91%
Laboratory Analysis, materials	$9,450	$70.00	16.73%
SUBTOTAL VARIABLE	**$39,778**	**$293.41**	**70.12%**

VAR. COSTS PER BUSHEL = $12.96

Water Supply Costs		cost per bushel(w/mortality)	annual	per cycle	percent of total
Investment:	$3,468				
Costs per bushel		$0.3592			
Costs per cycle(excludes mortality)			**$1,098.06**	**$8.13**	**1.94%**

	initial investment	annual capital & operating costs		
	$96,492	$56,656		
TOTAL (includes mortality)			**$443.54**	100.00%
COST PER BUSHEL			**$18.48**	
COST PER OYSTER			**$0.0660**	
COST PER CLAM			**$0.0185**	

COST BUDGET, OPTION =	5	tank size =	4.5'*16'*3.5'	oyst/bushel =	280
cost per bushel =	$24.18	number of tanks =	1	clams/bushel =	1000
cost per oyster =	$0.0864	bushels/tank or bank =	24	mortality =	6%
cost per clam =	$0.0242	(If number of tanks = 4,		bushels/week	60
tank cycles/year =	67.5	there are 2 banks of 2 tanks)		bushels/year =	1,620

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$8,428	building and	$894	$13.24	2.42%
area, sq feet	301	property amortized			
Property	$12,040	over 30 years	$1,277	$18.92	3.46%
Processing Equipment**					
Depuration tanks	$1,800	10	$190	$2.81	0.51%
Sand Filter	$275	10	$29	$0.43	0.08%
UV sterilizer	$541	8	$71	$1.06	0.19%
Recirculating Pump	$432	6	$76	$1.12	0.21%
Blower	$333	6	$59	$0.87	0.16%
Chiller	$2,487	15	$175	$2.59	0.47%
Cooler (installed)	$3,605	15	$254	$3.76	0.69%
sq feet	40				
SUBTOTAL, Equipment	$9,473		$853	$12.64	2.31%
Materials**					
PVC tubing & materials and flow meters	$139	5	$29	$0.43	0.08%
oxygen meter	$530	5	$112	$1.66	0.30%
salinometer	$800	5	$169	$2.50	0.46%
tank trays	$320	3.5	$96	$1.43	0.26%
air diffusors	$56	1	$59	$0.88	0.16%
washing/culling table	$1,944	8	$256	$3.80	0.69%
UV replacement lights/sleeve	$186	1	$196	$2.91	0.53%
Pressure sprayer	$700	3	$246	$3.65	0.67%
SUBTOTAL, materials	$4,675		$1,164	$17.25	3.15%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$69	12.59%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,129	1	$1,129	$16.72	3.05%
liability (1% of sales)	$130	1	$130	1.92	0.35%
property taxes (3.12 millage)	$639	1	$639	$9.46	1.73%
labor for assembly	$640	30	$21	$0.32	0.06%
certification & permitting	$1,484	30	$49	$0.73	0.13%
SUBTOTAL, Other Fixed	$4,021		$1,968	$29.15	5.33%
SUBTOTAL FIXED	**$65,887**		**$10,807**	**$160.11**	**29.25%**
FIXED COSTS PER BUSHEL =	$7.07				

DESIGN OPTION = 5

VARIABLE COSTS		annual	per cycle	percent of total
Assistant		$5,400	$80.00	14.61%
Hourly		$2,484	$36.80	6.72%
Owner/manager		$4,604	$68.21	12.46%
Lab technician		$6,480	$96.00	17.54%
SUBTOTAL, Labor		$18,968	$281.01	51.33%
Utilities				
Electricity				
UV		$630	$9.33	1.70%
pump		$186	$2.75	0.50%
blower		$49	$0.73	0.13%
cooler		$103	$1.53	0.28%
chiller		$239	$3.54	0.65%
lighting		$11	$0.16	0.03%
Water		$108	$1.60	0.29%
Sewage		$119	$1.76	0.32%
SUBTOTAL, Utilities		$1,445	$21.40	3.91%
Building maintenance		$220	$0.79	0.14%
Cleaning & misc supplies		$203	$3.00	0.55%
Laboratory Analysis, materials		$4,725	$70.00	12.79%
SUBTOTAL VARIABLE		**$25,560**	**$376.19**	**68.72%**
VAR. COSTS PER BUSHEL =	$16.62			

Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$3,468				
Costs per bushel		$0.4924			
Costs per cycle(excludes mortality)			**$752.59**	**$11.15**	**2.04%**

	initial investment	annual capital & operating costs		
	$69,354	$37,120		
TOTAL (includes mortality)			**$580.30**	**100.00%**
COST PER BUSHEL			**$24.18**	
COST PER OYSTER			**$0.0864**	
COST PER CLAM			**$0.0242**	

COST BUDGET, OPTION =	6	tank size =	4.5'*16'*3.5'	oyst/bushel =	280
cost per bushel =	$17.43	number of tanks =	2	clams/bushel =	1000
cost per oyster =	$0.0623	bushels/tank or bank =	24	mortality =	6%
cost per clam =	$0.0174	(If number of tanks = 4,		bushels/week	120
tank cycles/year =	135	there are 2 banks of 2 tanks)		bushels/year =	3,240

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$12,600	building and	$1,337	$9.90	2.51%
area, sq feet	450	property amortized			
Property	$18,000	over 30 years	$1,909	$14.14	3.58%
Processing Equipment**					
Depuration tanks	$3,600	10	$380	$2.81	0.71%
Sand Filter	$550	10	$58	$0.43	0.11%
UV sterilizer	$1,082	8	$143	$1.06	0.27%
Recirculating Pump	$863	6	$152	$1.12	0.28%
Blower	$333	6	$59	$0.43	0.11%
Chiller	$2,912	15	$205	$1.52	0.38%
Cooler (installed)	$3,605	15	$254	$1.88	0.48%
sq feet	40				
SUBTOTAL, Equipment	$12,945		$1,249	$9.25	2.34%
Materials**					
PVC tubing & materials and flow meters	$300	5	$63	$0.47	0.12%
oxygen meter	$530	5	$112	$0.83	0.21%
salinometer	$800	5	$169	$1.25	0.32%
tank trays	$640	3.5	$193	$1.43	0.36%
air diffusors	$112	1	$118	$0.88	0.22%
washing/culling table	$2,232	8	$294	$2.18	0.55%
UV replacement lights/sleeve	$372	1	$392	$2.91	0.74%
Pressure sprayer	$700	3	$246	$1.82	0.46%
SUBTOTAL, materials	$5,686		$1,588	$11.76	2.98%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$34	8.73%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,320	1	$1,320	$9.78	2.48%
liability (1% of sales)	$518	1	$518	3.84	0.97%
property taxes (3.12 millage)	$955	1	$955	$7.07	1.79%
labor for assembly	$1,280	30	$43	$0.32	0.08%
certification & permitting	$1,484	30	$49	$0.37	0.09%
SUBTOTAL, Other Fixed	$5,557		$2,885	$21.37	5.41%
SUBTOTAL FIXED	**$82,038**		**$13,619**	**$100.88**	**25.56%**
FIXED COSTS PER BUSHEL =	$4.46				

DESIGN OPTION = 6

VARIABLE COSTS			annual	per cycle	percent of total
Assistant			$5,400	$40.00	10.13%
Hourly			$4,968	$36.80	9.32%
Owner/manager			$6,542	$48.46	12.28%
Lab technician			$6,480	$48.00	12.16%
SUBTOTAL, Labor			$23,390	$173.26	43.90%
Utilities					
Electricity					
UV			$2,519	$18.66	4.73%
pump			$743	$5.50	1.39%
blower			$99	$0.73	0.18%
cooler			$207	$1.53	0.39%
chiller			$956	$7.08	1.79%
lighting			$32	$0.24	0.06%
Water			$108	$0.80	0.20%
Sewage			$119	$0.88	0.22%
SUBTOTAL, Utilities			$4,782	$35.42	8.97%
Building maintenance			$280	$1.00	0.25%
Cleaning & misc supplies			$810	$6.00	1.52%
Laboratory Analysis, materials			$9,450	$70.00	17.73%
SUBTOTAL VARIABLE			**$38,712**	**$285.68**	**72.38%**
VAR. COSTS PER BUSHEL =	$12.62				
Water Supply Costs		cost per			
Investment:	$3,468	bushel(w/mortality)			
Costs per bushel		$0.3592			
Costs per cycle(excludes mortality)			$1,098.06	$8.13	2.06%
	initial investment		annual capital & operating costs		
	$85,506		$53,430		
TOTAL (includes mortality)				$418.38	100.00%
COST PER BUSHEL				$17.43	
COST PER OYSTER				$0.0623	
COST PER CLAM				$0.0174	

COST BUDGET, OPTION = 7

cost per bushel =	$16.38	tank size =	4.5'*16'*3.5'	oyst/bushel =	280
cost per oyster =	$0.0585	number of tanks =	3	clams/bushel =	1000
cost per clam =	$0.0164	bushels/tank or bank =	24	mortality =	6%
tank cycles/year =	202.5	(If number of tanks = 4,		bushels/week	180
		there are 2 banks of 2 tanks)		bushels/year =	4,860

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$17,108	building and	$1,815	$8.96	2.42%
area, sq feet	611	property amortized			
Property	$24,440	over 30 years	$2,593	$12.80	3.45%
Processing Equipment**					
Depuration tanks	$5,400	10	$570	$2.81	0.76%
Sand Filter	$825	10	$87	$0.43	0.12%
UV sterilizer	$1,623	8	$214	$1.06	0.29%
Recirculating Pump	$1,295	6	$228	$1.12	0.30%
Blower	$390	6	$69	$0.34	0.09%
Chiller	$5,190	15	$365	$1.80	0.49%
Cooler (installed)	$4,683	15	$329	$1.63	0.44%
sq feet	60				
SUBTOTAL, Equipment	$19,405		$1,861	$9.19	2.48%
Materials**					
PVC tubing & materials and flow meters	$490	5	$103	$0.51	0.14%
oxygen meter	$530	5	$112	$0.55	0.15%
salinometer	$800	5	$169	$0.83	0.22%
tank trays	$960	3.5	$289	$1.43	0.39%
air diffusors	$168	1	$177	$0.88	0.24%
washing/culling table	$2,520	8	$332	$1.64	0.44%
UV replacement lights/sleeve	$558	1	$589	$2.91	0.78%
Pressure sprayer	$700	3	$246	$1.22	0.33%
SUBTOTAL, materials	$6,726		$2,018	$9.96	2.69%
Laboratory Analysis, fixed	$27,250	(various)	$4,901	$24	6.53%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,594	1	$1,594	$7.87	2.12%
liability (1% of sales)	$1,166	1	$1,166	5.76	1.55%
property taxes (3.12 millage)	$1,296	1	$1,296	$6.40	1.73%
labor for assembly	$1,920	30	$64	$0.32	0.09%
certification & permitting	$1,484	30	$49	$0.24	0.07%
SUBTOTAL, Other Fixed	$7,461		$4,170	$20.59	5.55%
SUBTOTAL FIXED	$102,390		$17,358	$85.72	23.12%
FIXED COSTS PER BUSHEL =	$3.79				

DESIGN OPTION = 7

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$26.67	7.19%
Hourly	$7,452	$36.80	9.92%
Owner/manager	$8,481	$41.88	11.29%
Lab technician	$8,100	$40.00	10.79%
SUBTOTAL, Labor	$29,433	$145.35	39.20%
Utilities			
Electricity			
UV	$5,668	$27.99	7.55%
pump	$1,671	$8.25	2.22%
blower	$247	$1.22	0.33%
cooler	$333	$1.64	0.44%
chiller	$2,151	$10.62	2.86%
lighting	$66	$0.33	0.09%
Water	$108	$0.53	0.14%
Sewage	$119	$0.59	0.16%
SUBTOTAL, Utilities	$10,362	$51.17	13.80%
Building maintenance	$344	$1.23	0.33%
Cleaning & misc supplies	$1,823	$9.00	2.43%
Laboratory Analysis, materials	$14,175	$70.00	18.88%
SUBTOTAL VARIABLE	**$56,137**	**$276.75**	**74.64%**

VAR. COSTS PER BUSHEL = $12.22

Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$4,921				
Costs per bushel		$0.3677			
Costs per cycle(excludes mortality)			$1,685.81	$8.32	2.25%

	initial investment	annual capital & operating costs		
	$107,312	$75,180		
TOTAL (includes mortality)			**$393.04**	**100.00%**
COST PER BUSHEL			**$16.38**	
COST PER OYSTER			**$0.0585**	
COST PER CLAM			**$0.0164**	

COST BUDGET, OPTION =	8	tank size =	4.5'*16'*3.5'	oyst/bushel =	280
cost per bushel =	$12.20	number of tanks =	4	clams/bushel =	1000
cost per oyster =	$0.0436	bushels/tank or bank =	48	mortality =	6%
cost per clam =	$0.0122	(If number of tanks = 4,		bushels/week	240
tank cycles/year =	135	there are 2 banks of 2 tanks)		bushels/year =	6,480

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$21,952	building and	$2,329	$17.25	3.12%
area, sq feet	784	property amortized			
Property	$31,360	over 30 years	$3,327	$24.64	4.46%
Processing Equipment**					
Depuration tanks	$7,200	10	$760	$5.63	1.02%
Sand Filter	$1,100	10	$116	$0.86	0.16%
UV sterilizer	$2,164	8	$285	$2.11	0.38%
Recirculating Pump	$1,726	6	$303	$2.25	0.41%
Blower	$390	6	$69	$0.51	0.09%
Chiller	$7,468	15	$525	$3.89	0.70%
Cooler (installed)	$5,954	15	$419	$3.10	0.56%
sq feet	80				
SUBTOTAL, Equipment	$26,002		$2,477	$18.35	3.32%
Materials**					
PVC tubing & materials and flow meters	$716	5	$151	$1.12	0.20%
oxygen meter	$530	5	$112	$0.83	0.15%
salinometer	$800	5	$169	$1.25	0.23%
tank trays	$1,280	3.5	$386	$2.86	0.52%
air diffusors	$224	1	$236	$1.75	0.32%
washing/culling table	$2,808	8	$370	$2.74	0.50%
UV replacement lights/sleeve	$744	1	$785	$5.81	1.05%
Pressure sprayer	$700	3	$246	$1.82	0.33%
SUBTOTAL, materials	$7,802		$2,455	$18.19	3.29%
Laboratory Analysis, fixed	$27,250	(various)	$5,151	$38	6.91%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,880	1	$1,880	$13.93	2.52%
liability (1% of sales)	$1,037	1	$1,037	7.68	1.39%
property taxes (3.12 millage)	$1,663	1	$1,663	$12.32	2.23%
labor for assembly	$2,560	30	$85	$0.63	0.11%
certification & permitting	$1,868	30	$62	$0.46	0.08%
SUBTOTAL, Other Fixed	$9,008		$4,728	$35.02	6.34%
SUBTOTAL FIXED	**$123,374**		**$20,466**	**$151.60**	**27.44%**
FIXED COSTS PER BUSHEL =	$3.35				

DESIGN OPTION = 8

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$40.00	7.24%
Hourly	$9,936	$73.60	13.32%
Owner/manager	$10,419	$77.18	13.97%
Lab technician	$6,480	$48.00	8.69%
SUBTOTAL, Labor	$32,235	$238.78	43.22%
Utilities			
Electricity			
UV	$4,408	$32.66	5.91%
pump	$1,299	$9.63	1.74%
blower	$165	$1.22	0.22%
cooler	$290	$2.15	0.39%
chiller	$1,912	$14.16	2.56%
lighting	$56	$0.42	0.08%
Water	$216	$1.60	0.29%
Sewage	$238	$1.76	0.32%
SUBTOTAL, Utilities	$8,585	$63.59	11.51%
Building maintenance	$414	$1.48	0.27%
Cleaning & misc supplies	$1,620	$12.00	2.17%
Laboratory Analysis, materials	$9,450	$70.00	12.67%
SUBTOTAL VARIABLE	**$52,303**	**$385.85**	**69.84%**

VAR. COSTS PER BUSHEL = $8.52

Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$4,921				
Costs per bushel		$0.3323			
Costs per cycle(excludes mortality)			$2,031.28	$15.05	2.72%

	initial investment	annual capital & operating costs		
	$128,295	$74,801		
TOTAL (includes mortality)			$585.65	100.00%
COST PER BUSHEL			$12.20	
COST PER OYSTER			$0.0436	
COST PER CLAM			$0.0122	

COST BUDGET, OPTION =	9	tank size =	6'*24'*3.5'	oyst/bushel =	280
cost per bushel =	$14.93	number of tanks =	1	clams/bushel =	1000
cost per oyster =	$0.0533	bushels/tank or bank =	48	mortality =	6%
cost per clam =	$0.0149	(If number of tanks = 4,		bushels/week	120
tank cycles/year =	67.5	there are 2 banks of 2 tanks)		bushels/year =	3,240

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$12,096	building and	$1,283	$19.01	2.81%
area, sq feet	432	property amortized			
Property	$17,280	over 30 years	$1,833	$27.16	4.02%
Processing Equipment**					
Depuration tanks	$5,000	10	$528	$7.81	1.16%
Sand Filter	$635	10	$67	$0.99	0.15%
UV sterilizer	$1,312	8	$173	$2.56	0.38%
Recirculating Pump	$449	6	$79	$1.17	0.17%
Blower	$390	6	$69	$1.02	0.15%
Chiller	$2,912	15	$205	$3.03	0.45%
Cooler (installed)	$4,234	15	$298	$4.41	0.65%
sq feet	48				
SUBTOTAL, Equipment	$14,931		$1,418	$21.00	3.11%
Materials**					
PVC tubing & materials and flow meters	$177	5	$37	$0.55	0.08%
oxygen meter	$530	5	$112	$1.66	0.25%
salinometer	$800	5	$169	$2.50	0.37%
tank trays	$640	3.5	$193	$2.86	0.42%
air diffusors	$112	1	$118	$1.75	0.26%
washing/culling table	$2,232	8	$294	$4.36	0.65%
UV replacement lights/sleeve	$372	1	$392	$5.81	0.86%
Pressure sprayer	$700	3	$246	$3.65	0.54%
SUBTOTAL, materials	$5,563		$1,562	$23.14	3.42%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$69	10.19%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,357	1	$1,357	$20.10	2.97%
liability (1% of sales)	$292	1	$292	4.32	0.64%
property taxes (3.12 millage)	$917	1	$917	$13.58	2.01%
labor for assembly	$800	30	$27	$0.40	0.06%
certification & permitting	$1,868	30	$62	$0.92	0.14%
SUBTOTAL, Other Fixed	$5,233		$2,654	$39.32	5.82%
SUBTOTAL FIXED	**$82,354**		**$13,401**	**$198.53**	**29.37%**
FIXED COSTS PER BUSHEL =	$4.38				

DESIGN OPTION = 9

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$80.00	11.84%
Hourly	$4,968	$73.60	10.89%
Owner/manager	$6,542	$96.92	14.34%
Lab technician	$6,480	$96.00	14.20%
SUBTOTAL, Labor	$23,390	$346.52	51.27%
Utilities			
Electricity			
UV	$1,260	$18.66	2.76%
pump	$255	$3.78	0.56%
blower	$82	$1.22	0.18%
cooler	$112	$1.67	0.25%
chiller	$478	$7.08	1.05%
lighting	$16	$0.23	0.03%
Water	$108	$1.60	0.24%
Sewage	$119	$1.76	0.26%
SUBTOTAL, Utilities	$2,430	$36.00	5.33%
Building maintenance	$273	$0.97	0.14%
Cleaning & misc supplies	$270	$4.00	0.59%
Laboratory Analysis, materials	$4,725	$70.00	10.36%
SUBTOTAL VARIABLE	**$31,088**	**$457.49**	**67.69%**

VAR. COSTS PER BUSHEL = $10.10

Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$4,921				
Costs per bushel		$0.4385			
Costs per cycle(excludes mortality)			$1,340.34	$19.86	2.94%

	initial investment	annual capital & operating costs		
	$87,275	$45,829		
TOTAL (includes mortality)			**$716.44**	100.00%
COST PER BUSHEL			**$14.93**	
COST PER OYSTER			**$0.0533**	
COST PER CLAM			**$0.0149**	

COST BUDGET, OPTION = 10

cost per bushel =	$11.97	tank size =	6'*24'*3.5'	oyst/bushel =	280
cost per oyster =	$0.0428	number of tanks =	2	clams/bushel =	1000
cost per clam =	$0.0120	bushels/tank or bank =	48	mortality =	6%
tank cycles/year =	135	(If number of tanks = 4, there are 2 banks of 2 tanks)		bushels/week	240
				bushels/year =	6,480

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$19,208	building and	$2,038	$15.09	2.78%
area, sq feet	686	property amortized			
Property	$27,440	over 30 years	$2,911	$21.56	3.98%
Processing Equipment**					
Depuration tanks	$10,000	10	$1,055	$7.81	1.44%
Sand Filter	$1,270	10	$134	$0.99	0.18%
UV sterilizer	$2,624	8	$346	$2.56	0.47%
Recirculating Pump	$897	6	$158	$1.17	0.22%
Blower	$390	6	$69	$0.51	0.09%
Chiller	$7,468	15	$525	$3.89	0.72%
Cooler (installed)	$6,814	15	$479	$3.55	0.65%
sq feet	96				
SUBTOTAL, Equipment	$29,463		$2,766	$20.49	3.78%
Materials**					
PVC tubing & materials and flow meters	$392	5	$83	$0.61	0.11%
oxygen meter	$530	5	$112	$0.83	0.15%
salinometer	$800	5	$169	$1.25	0.23%
tank trays	$1,280	3.5	$386	$2.86	0.53%
air diffusors	$224	1	$236	$1.75	0.32%
washing/culling table	$2,880	8	$380	$2.81	0.52%
UV replacement lights/sleeve	$744	1	$785	$5.81	1.07%
Pressure sprayer	$700	3	$246	$1.82	0.34%
SUBTOTAL, materials	$7,550		$2,396	$17.75	3.27%
Laboratory Analysis, fixed	$27,250	(various)	$4,651	$34	6.35%
Other Fixed					
insurance					
property (2.5% of eq + building)	$1,898	1	$1,898	$14.06	2.59%
liability (1% of sales)	$1,166	1	$1,166	8.64	1.59%
property taxes (3.12 millage)	$1,455	1	$1,455	$10.78	1.99%
labor for assembly	$1,600	30	$53	$0.40	0.07%
certification & permitting	$1,868	30	$62	$0.46	0.09%
SUBTOTAL, Other Fixed	$7,988		$4,635	$34.34	6.33%
SUBTOTAL FIXED	**$118,899**		**$19,397**	**$143.68**	**26.50%**
FIXED COSTS PER BUSHEL =	$3.17				

DESIGN OPTION = 10

VARIABLE COSTS			annual	per cycle	percent of total
Assistant			$5,400	$40.00	7.38%
Hourly			$9,936	$73.60	13.58%
Owner/manager			$10,419	$77.18	14.24%
Lab technician			$6,480	$48.00	8.85%
SUBTOTAL, Labor			$32,235	$238.78	44.04%
Utilities					
Electricity					
UV			$5,038	$37.32	6.88%
pump			$1,021	$7.56	1.39%
blower			$248	$1.84	0.34%
cooler			$323	$2.39	0.44%
chiller			$1,912	$14.16	2.61%
lighting			$49	$0.37	0.07%
Water			$108	$0.80	0.15%
Sewage			$119	$0.88	0.16%
SUBTOTAL, Utilities			$8,818	$65.32	12.05%
Building maintenance			$374	$1.34	0.25%
Cleaning & misc supplies			$1,080	$8.00	1.48%
Laboratory Analysis, materials			$9,450	$70.00	12.91%
SUBTOTAL VARIABLE			**$51,958**	**$383.44**	**70.72%**
VAR. COSTS PER BUSHEL =	$8.47				
Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$4,921				
Costs per bushel		$0.3323			
Costs per cycle(excludes mortality)			**$2,031.28**	**$15.05**	**2.78%**
	initial investment		annual capital & operating costs		
	$123,820		$73,386		
TOTAL (includes mortality)				**$574.69**	100.00%
COST PER BUSHEL				**$11.97**	
COST PER OYSTER				**$0.0428**	
COST PER CLAM				**$0.0120**	

COST BUDGET, OPTION =	11	tank size =	6'*24'*3.5'	oyst/bushel =	280
cost per bushel =	$11.83	number of tanks =	3	clams/bushel =	1000
cost per oyster =	$0.0422	bushels/tank or bank =	48	mortality =	6%
cost per clam =	$0.0118	(If number of tanks = 4,		bushels/week	360
tank cycles/year =	202.5	there are 2 banks of 2 tanks)		bushels/year =	9,720

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$26,796	building and	$2,842	$14.04	2.62%
area, sq feet	957	property amortized			
Property	$38,280	over 30 years	$4,061	$20.05	3.74%
Processing Equipment**					
Depuration tanks	$15,000	10	$1,583	$7.81	1.46%
Sand Filter	$1,905	10	$201	$0.99	0.19%
UV sterilizer	$3,936	8	$519	$2.56	0.48%
Recirculating Pump	$1,346	6	$237	$1.17	0.22%
Blower	$433	6	$76	$0.38	0.07%
Chiller	$12,024	15	$846	$4.18	0.78%
Cooler (installed)	$9,170	15	$645	$3.19	0.59%
sq feet	140				
SUBTOTAL, Equipment	$43,814		$4,106	$20.28	3.79%
Materials**					
PVC tubing & materials and flow meters	$656	5	$139	$0.68	0.13%
oxygen meter	$530	5	$112	$0.55	0.10%
salinometer	$800	5	$169	$0.83	0.16%
tank trays	$1,920	3.5	$579	$2.86	0.53%
air diffusors	$336	1	$354	$1.75	0.33%
washing/culling table	$3,528	8	$465	$2.30	0.43%
UV replacement lights/sleeve	$1,116	1	$1,177	$5.81	1.09%
Pressure sprayer	$700	3	$246	$1.22	0.23%
SUBTOTAL, materials	$9,586		$3,241	$16.01	2.99%
Laboratory Analysis, fixed	$27,250	(various)	$4,901	$24	4.52%
Other Fixed					
insurance					
property (2.5% of eq + building)	$2,446	1	$2,446	$12.08	2.26%
liability (1% of sales)	$2,624	1	$2,624	12.96	2.42%
property taxes (3.12 millage)	$2,030	1	$2,030	$10.03	1.87%
labor for assembly	$2,400	30	$80	$0.40	0.07%
certification & permitting	$1,868	30	$62	$0.31	0.06%
SUBTOTAL, Other Fixed	$11,369		$7,244	$35.77	6.68%
SUBTOTAL FIXED	**$157,096**		**$26,395**	**$130.35**	**24.34%**
FIXED COSTS PER BUSHEL =	$2.88				

DESIGN OPTION = 11

VARIABLE COSTS		annual	per cycle	percent of total
Assistant		$5,400	$26.67	4.98%
Hourly		$14,904	$73.60	13.74%
Owner/manager		$14,296	$70.60	13.18%
Lab technician		$8,100	$40.00	7.47%
SUBTOTAL, Labor		$42,700	$210.86	39.37%
Utilities				
Electricity				
UV		$11,336	$55.98	10.45%
pump		$2,296	$11.34	2.12%
blower		$373	$1.84	0.34%
cooler		$562	$2.77	0.52%
chiller		$4,301	$21.24	3.97%
lighting		$103	$0.51	0.10%
Water		$108	$0.53	0.10%
Sewage		$119	$0.59	0.11%
SUBTOTAL, Utilities		$19,198	$94.80	17.70%
Building maintenance		$483	$1.72	0.32%
Cleaning & misc supplies		$2,430	$12.00	2.24%
Laboratory Analysis, materials		$14,175	$70.00	13.07%
SUBTOTAL VARIABLE		$78,986	$389.39	72.71%
VAR. COSTS PER BUSHEL =	$8.60			

Water Supply Costs		cost per bushel(w/mortality)			
Investment:	$7,829				
Costs per bushel		$0.3497			
Costs per cycle(excludes mortality)			$3,206.79	$15.84	2.96%

	initial investment	annual capital & operating costs		
	$164,925	$108,587		
TOTAL (includes mortality)			$567.71	100.00%
COST PER BUSHEL			$11.83	
COST PER OYSTER			$0.0422	
COST PER CLAM			$0.0118	

COST BUDGET, OPTION =	12	tank size =	6'*24'*3.5'	oyst/bushel =	280
cost per bushel =	$9.25	number of tanks =	4	clams/bushel =	1000
cost per oyster =	$0.0330	bushels/tank or bank =	96	mortality =	6%
cost per clam =	$0.0093	(If number of tanks = 4,		bushels/week	480
tank cycles/year =	135	there are 2 banks of 2 tanks)		bushels/year =	12,960

	Investement	estimated life	cost/ year	cost/ cycle	percent of total
FIXED COSTS					
Building (30 years, 10%)	$34,860	building and	$3,698	$27.39	3.27%
area, sq feet	1245	property amortized			
Property	$49,800	over 30 years	$5,283	$39.13	4.67%
Processing Equipment**					
Depuration tanks	$20,000	10	$2,110	$15.63	1.87%
Sand Filter	$2,540	10	$268	$1.98	0.24%
UV sterilizer	$5,248	8	$692	$5.13	0.61%
Recirculating Pump	$1,794	6	$315	$2.34	0.28%
Blower	$433	6	$76	$0.56	0.07%
Chiller	$16,580	15	$1,166	$8.64	1.03%
Cooler (installed)	$12,349	15	$869	$6.43	0.77%
sq feet	192				
SUBTOTAL, Equipment	$58,944		$5,496	$40.71	4.86%
Materials**					
PVC tubing & materials and flow meters	$985	5	$208	$1.54	0.18%
oxygen meter	$530	5	$112	$0.83	0.10%
salinometer	$800	5	$169	$1.25	0.15%
tank trays	$2,560	3.5	$772	$5.72	0.68%
air diffusors	$448	1	$473	$3.50	0.42%
washing/culling table	$4,176	8	$551	$4.08	0.49%
UV replacement lights/sleeve	$1,240	1	$1,308	$9.69	1.16%
Pressure sprayer	$700	3	$246	$1.82	0.22%
SUBTOTAL, materials	$11,439		$3,838	$28.43	3.39%
Laboratory Analysis, fixed	$27,250	(various)	$5,151	$38	4.55%
Other Fixed					
insurance					
property (2.5% of eq + building)	$3,026	1	$3,026	$22.42	2.68%
liability (1% of sales)	$2,333	1	$2,333	17.28	2.06%
property taxes (3.12 millage)	$2,641	1	$2,641	$19.57	2.34%
labor for assembly	$3,200	30	$107	$0.79	0.09%
certification & permitting	$2,636	30	$88	$0.65	0.08%
SUBTOTAL, Other Fixed	$13,837		$8,195	$60.70	7.24%
SUBTOTAL FIXED	**$196,130**		**$31,661**	**$234.53**	**27.99%**
FIXED COSTS PER BUSHEL =	$2.59				

DESIGN OPTION = 12

VARIABLE COSTS	annual	per cycle	percent of total
Assistant	$5,400	$40.00	4.77%
Hourly	$19,872	$147.20	17.57%
Owner/manager	$18,173	$134.62	16.07%
Lab technician	$6,480	$48.00	5.73%
SUBTOTAL, Labor	$49,925	$369.82	44.14%
Utilities			
Electricity			
UV	$8,817	$65.31	7.79%
pump	$1,786	$13.23	1.58%
blower	$248	$1.84	0.22%
cooler	$514	$3.81	0.45%
chiller	$3,823	$28.32	3.38%
lighting	$90	$0.66	0.08%
Water	$216	$1.60	0.19%
Sewage	$238	$1.76	0.21%
SUBTOTAL, Utilities	$15,732	$116.53	13.91%
Building maintenance	$598	$2.14	0.25%
Cleaning & misc supplies	$2,160	$16.00	1.91%
Laboratory Analysis, materials	$9,450	$70.00	8.35%
SUBTOTAL VARIABLE	$77,865	$574.48	68.56%

VAR. COSTS PER BUSHEL = $6.34

Water Supply Costs		cost per bushel(w/mortality)	annual	per cycle	percent of total
Investment:	$7,829				
Costs per bushel		$0.3188			
Costs per cycle(excludes mortality)			$3,897.73	$28.87	3.45%

	initial investment	annual capital & operating costs		
	$203,958	$113,423		
TOTAL (includes mortality)			$888.15	100.00%
COST PER BUSHEL			$9.25	
COST PER OYSTER			$0.0330	
COST PER CLAM			$0.0093	

APPENDIX D

Worksheets Used to Calculate Costs per Design Option

WELL

master	gals	settling tank cost	well pump degasser	pump electricity	TOTAL COST CYCLE	TOTAL COST BUSHEL STOCKED	TOTAL COST GALLON wellwater
1	753	$1.83	$2.41	$2.56	$6.80	$0.57	$0.00903
2	753	$0.91	$1.20	$2.56	$4.68	$0.39	$0.00621
3	753	$1.21	$0.80	$2.56	$4.57	$0.38	$0.00607
4	753	$0.91	$0.60	$2.56	$4.07	$0.34	$0.00540
5	1505	$3.62	$2.41	$5.12	$11.15	$0.46	$0.00741
6	1505	$1.81	$1.20	$5.12	$8.13	$0.34	$0.00540
7	1505	$2.40	$0.80	$5.12	$8.32	$0.35	$0.00553
8	1505	$1.80	$0.60	$5.12	$7.52	$0.31	$0.00500
9	3011	$7.21	$2.41	$10.24	$19.86	$0.41	$0.00660
10	3011	$3.61	$1.20	$10.24	$15.05	$0.31	$0.00500
11	3011	$4.80	$0.80	$10.24	$15.84	$0.33	$0.00526
12	3011	$3.60	$0.60	$10.24	$14.44	$0.30	$0.00480

Well drilling costs/annual = $1500/20 years.	75
Pump = $300/8 years	37.5
degasser, $200/4	50
	162.5

Pump electricity based on 1 hp at 20 gpm.

settling tank costs annual = cost/6 years

ARTIFICIAL SEAWATER

master	gals	sea salts cost 0.1	resevoir cost/gallon	TOTAL COST PER GALLON
1	752.6569	$75.27	$0.0024	0.10243
2	752.6569	$75.27	$0.0012	0.10122
3	752.6569	$75.27	$0.0016	0.10160
4	752.6569	$75.27	$0.0012	0.10120
5	1505.314	$150.53	$0.0024	0.10241
6	1505.314	$150.53	$0.0012	0.10120
7	1505.314	$150.53	$0.0016	0.10160
8	1505.314	$150.53	$0.0012	0.10120
9	3010.628	$301.06	$0.0024	0.10240
10	3010.628	$301.06	$0.0012	0.10120
11	3010.628	$301.06	$0.0016	0.10159
12	3010.628	$301.06	$0.0012	0.10120

*Although tap water costs vary with design size, they are minimal costs and are not included here.

WATER COSTS

weeks/year = 27
utilization = 100.0%

TRANSPORTED

DESIGN OPTIONS	GALS/ TANK	6 year life settling tank costs per cycle	trips per tank	tanks per week	trips per year	truck maint per trip $2.00	(1 trip = 1 gal) gas/oil per trip $1.20	annual trailer costs per trip 8 yr life	.125% per tri percent truck usage 0.1250%	15 yr life truck cost per trip $1,600
1	753	$1.83	1	2.5	67.5	2	$1.20	$5.19	8.438%	$2.00
2	753	$0.91	1	5	135	2	$1.20	$2.59	16.875%	$2.00
3	753	$1.21	1	7.5	202.5	2	$1.20	$1.73	25.313%	$2.00
4	753	$0.91	1	10	270	2	$1.20	$1.30	33.750%	$2.00
5	1505	$3.62	1	2.5	67.5	2	$1.20	$5.19	8.438%	$2.00
6	1505	$1.81	1	5	135	2	$1.20	$2.59	16.875%	$2.00
7	1505	$2.40	1	7.5	202.5	2	$1.20	$1.73	25.313%	$2.00
8	1505	$1.80	1	10	270	2	$1.20	$1.30	33.750%	$2.00
9	3011	$7.21	1	2.5	67.5	2	$1.20	$5.19	8.438%	$2.00
10	3011	$3.61	1	5	135	2	$1.20	$2.59	16.875%	$2.00
11	3011	$4.80	1	7.5	202.5	2	$1.20	$1.73	25.313%	$2.00
12	3011	$3.60	1	10	270	2	$1.20	$1.30	33.750%	$2.00
		(per trip)								

Pump works at 120 gals/minute. With 75% efficiency, = 30 cents per hour.
3000 gal tank = $3000, 5 yr life, trailer = $2800, 8 year life
Multiply times number of tanks per system = trips per cycle
(recall a cycle = use of all tanks one time)

options	$381 pump, 3 yr life, cost per trip	minutes pumping*	(cost = 30 cent gas for pump $0.0067	labor = $8 labor/trip = 30 min/trip plus pumping time	TOTAL COST PER TRIP, CYCLE	TOTAL COST PER BUSHEL	bu	TOTAL COST PER GALLON Transported
1	$1.88	17.54	$0.12	$6.34	$20.55	$1.71	12	$0.02731
2	$0.94	17.54	$0.12	$6.34	$16.10	$1.34	12	$0.02140
3	$0.63	17.54	$0.12	$6.34	$15.22	$1.27	12	$0.02022
4	$0.47	17.54	$0.12	$6.34	$14.33	$1.19	12	$0.01904
5	$1.88	30.09	$0.20	$8.01	$24.10	$1.00	24	$0.01601
6	$0.94	30.09	$0.20	$8.01	$18.76	$0.78	24	$0.01246
7	$0.63	30.09	$0.20	$8.01	$18.17	$0.76	24	$0.01207
8	$0.47	30.09	$0.20	$8.01	$16.98	$0.71	24	$0.01128
9	$1.88	55.18	$0.37	$11.36	$31.20	$0.65	48	$0.01036
10	$0.94	55.18	$0.37	$11.36	$24.06	$0.50	48	$0.00799
11	$0.63	55.18	$0.37	$11.36	$24.08	$0.50	48	$0.00800
12	$0.47	55.18	$0.37	$11.36	$22.29	$0.46	48	$0.00740

BUILDING AREA

cost per square foot = $28

Design Options	# of tanks	width (feet)	length (feet)	total area (feet)	TOTAL COST
1	1	13	17	221	$6,188
2	2	14	23	322	$9,016
3	3	15	29	435	$12,180
4	4	16	35	560	$15,680
5	1	14	21.5	301	$8,428
6	2	20	22.5	450	$12,600
7	3	26	23.5	611	$17,108
8	4	32	24.5	784	$21,952
9	1	16	27	432	$12,096
10	2	24.5	28	686	$19,208
11	3	33	29	957	$26,796
12	4	41.5	30	1245	$34,860

Building cost includes the cost of plumbing, electrical work, and light fixtures.

TANKS

Resevoir tanks

3 & 4 tank modules require double-sized resevoirs.

Design Options	# of tanks	resevoir size needed (gals)	resevoir height (feet)	volume (cu/feet)	solve for needed radius squared	diameter	RESEVOIR TOTAL COST
1	1	753	3	101.03	10.72	3.27	$741
2	2	753	3	101.03	10.72	3.27	$741
3	3	1505	3	202.06	21.45	4.63	$1,468
4	4	1505	3	202.06	21.45	4.63	$1,468
5	1	1505	3	202.06	21.45	4.63	$1,468
6	2	1505	3	202.06	21.45	4.63	$1,468
7	3	3011	4	404.11	32.17	5.67	$2,921
8	4	3011	4	404.11	32.17	5.67	$2,921
9	1	3011	4	404.11	32.17	5.62	$2,921
10	2	3011	4	404.11	32.17	5.62	$2,921
11	3	6021	5	808.22	51.48	7.1	$5,829
12	4	6021	5	808.22	51.48	7.1	$5,829

Depuration Tanks

4.5*8*3.5 = $1,050
4.5*16*3.5 = $1,800
6*24*3.5 = $5,000

Design Options	# of tank	DEPURATION TOTAL COST
1	1	$1,050
2	2	$2,100
3	3	$3,150
4	4	$4,200
5	1	$1,800
6	2	$3,600
7	3	$5,400
8	4	$7,200
9	1	$5,000
10	2	$10,000
11	3	$15,000
12	4	$20,000

PROCESSING EQUIPMENT AND ASSOCIATED COSTS

Equipment Specifications & Cost

	Design Option	gpm	w/ 1 tank	w/ 2 tanks	w/3 tanks	w/2 banks of 2 tanks
sand filter	1	33/66	$207	$207	$414	$621
	5	50/100	$275	$275	$550	$825
	9	100/166	$635	$635	$1,270	$1,905
UV	2	SAME	$360	$360	$720	$1,080
	6	AS	$541	$541	$1,082	$1,623
	10	ABOVE	$1,312	$1,312	$2,624	$3,936
pump	3	1/2 TO 3/4	$408	$408	$816	$1,224
	7	3/4 TO 1	$432	$432	$863	$1,295
	11	1 TO 1.5	$449	$449	$897	$1,346
blower	4	1/3 to 1/5 hp	$333	$333	$333	$333
	8	1/5 hp to 1/2	$333	$333	$390	$390
	12	1/5 hp to 1/2	$390	$390	$433	$433

Electrical lighting costs are calcuated using 2 hours use per cycle of 1, 4" florescent fixture (2 bulbs) per 60 ft of space for 1/2 of cycle's hours. Minimal lighting is required because building is open.

EQUIPMENT COSTS

Design Options	sand filter	UV	pump	blower
1	$207	$360	$408	$333
2	$414	$720	$816	$333
3	$621	$1,080	$1,224	$333
4	$828	$1,440	$1,632	$333
5	$275	$541	$432	$333
6	$550	$1,082	$863	$333
7	$825	$1,623	$1,295	$390
8	$1,100	$2,164	$1,726	$390
9	$635	$1,312	$449	$390
10	$1,270	$2,624	$897	$390
11	$1,905	$3,936	$1,346	$433
12	$2,540	$5,248	$1,794	$433

ELECTRICAL COSTS

uv	pump	blower
$6.22	$1.84	$0.73
$12.44	$3.68	$0.73
$18.66	$5.52	$0.73
$21.77	$6.44	$0.73
$9.33	$2.75	$0.73
$18.66	$5.50	$0.73
$27.99	$8.25	$1.22
$32.66	$9.63	$1.22
$18.66	$3.78	$1.22
$37.32	$7.56	$1.84
$55.98	$11.34	$1.84
$65.31	$13.23	$1.84

CHILLER

design options	system gallons	BTU required for 12 hour, 20 degree drawdown	HP needed	install.=$500 TOTAL EQUIP. COST PLUS INSTALLATION & DELIV
1	753	10,412	0.9	$1,816
2	1,505	20,824	1.7	$2,487
3	2,258	31,235	2.6	$2,800
4	3,011	41,647	3.5	$2,912
5	1,505	20,824	1.7	$2,487
6	3,011	41,647	3.5	$2,912
7	4,516	62,471	5.2	$5,190
8	6,021	83,294	6.9	$7,468
9	3,011	41,647	3.5	$2,912
10	6,021	83,294	6.9	$7,468
11	9,032	124,941	10.4	$12,024
12	12,043	166,588	13.9	$16,580

Electricity costs

design options	12 hrs electricity for drawdown	36 hrs electricity for maintenance	Total electricity costs/cycle
1	$0.71	$1.06	$1.77
2	$1.42	$2.12	$3.54
3	$2.12	$3.19	$5.31
4	$2.83	$4.25	$7.08
5	$1.42	$2.12	$3.54
6	$2.83	$4.25	$7.08
7	$4.25	$6.37	$10.62
8	$5.66	$8.50	$14.16
9	$2.83	$4.25	$7.08
10	$5.66	$8.50	$14.16
11	$8.50	$12.74	$21.24
12	$11.33	$16.99	$28.32

COOLER SIZES AND COSTS

Equipment Costs: Cost of box based on $50/sq foot.
Draw-down horsepower based on 1 tank's bushels.
Maintenance hp based on maximum volume required.

Design Options	# bushels	maximum bushels held	maximum volume required	realistic volume required	pounds from 1 tank	BTU's for 6 hour drawdown	HP required	COST OF COOLER EQUIPMENT PLUS INSTALLATION
1	12	30	40	60	720	2,400	0.2	$1,296
2	24	60	40	60	720	2,400	0.2	$1,296
3	36	90	40	60	720	2,400	0.2	$1,296
4	48	120	40	60	1,440	4,800	0.4	$1,395
5	24	60	80	120	1,440	4,800	0.4	$1,395
6	48	120	80	120	1,440	4,800	0.4	$1,395
7	72	180	80	120	1,440	4,800	0.4	$1,395
8	96	240	80	120	2,880	9,600	0.8	$1,594
9	48	120	160	239	2,880	9,600	0.8	$1,594
10	96	240	160	239	2,880	9,600	0.8	$1,594
11	144	360	160	239	2,880	9,600	0.8	$1,594
12	192	480	160	239	5,760	19,200	1.6	$1,993

Box specifications:

height = 7.6
usable height = 6'

box cost per sq foot = $50
slab cost per sq foot = $3

Design Options	width (feet)	length (feet)	box size (sq foot)	box size (cubic feet)	cost for box	concrete slab cost	TOTAL COST FOR COOLER
1	5	8	40	240	$2,000	$210	$3,506
2	5	8	40	240	$2,000	$210	$3,506
3	5	8	40	240	$2,000	$210	$3,506
4	5	8	40	240	$2,000	$210	$3,605
5	5	8	40	240	$2,000	$210	$3,605
6	5	8	40	240	$2,000	$210	$3,605
7	6	10	60	360	$3,000	$288	$4,683
8	8	10	80	480	$4,000	$360	$5,954
9	6	8	48	288	$2,400	$240	$4,234
10	8	12	96	576	$4,800	$420	$6,814
11	10	14	140	840	$7,000	$576	$9,170
12	12	16	192	1152	$9,600	$756	$12,349

MATERIALS & SUPPLIES COSTS

		1.5 inch PVC, additional feet required per system						
Design Options	number of tanks	from blower to tanks	resevoir to tanks	return from tanks	intake to pump and between equip	well to resevoir and resevoir to blower	SYSTEM TOTAL FEET PVC TUBING	TOTAL COST PVC TUBING PER SYSTEM** $0.30
1	1	8	4	9	4.5	30	55.5	$16.65
2	2	20	12	26	4.5		118	$52.05
3	3	28	20	32	4.5		202.5	$112.80
4	4	34	28	38	4.5		307	$204.90
5	1	8	4	25	4.5	30	71.5	$21.45
6	2	20	12	36	4.5		144	$64.65
7	3	28	20	42	4.5		238.5	$136.20
8	4	34	28	53	4.5		358	$243.60
9	1	8	4	33.3	4.5	30	79.8	$31.92
10	2	20	12	53.5	4.5		169.8	$99.84
11	3	28	20	73	4.5		295.3	$217.96
12	4	34	28	93	4.5		454.8	$399.88

	Miscellanous PVC material & flow meter, additional material required per system									PER TANK
Design Options	couplings + ball valves	cost $36.95	threaded elbows	elbow cost $1.54	tee joints	tee cost $1.04	SYSTEM COST FOR PVC MATERI	flow meter	system meter cost $35.00	TOTAL COST PVC TUBING, MATERIALS, AND FLOW METER PER SYSTE
1	2	$73.90	5	$7.70	1	$1.04	$82.64	1	$35.00	$134.29
2	2	$73.90	6	$9.24	0	$0.00	$165.78	1	$70.00	$287.83
3	2	$73.90	6	$9.24	0	$0.00	$248.92	1	$105.00	$466.72
4	2	$73.90	6	$9.24	0	$0.00	$332.06	1	$140.00	$676.96
5	2	$73.90	6	$9.24	0	$0.00	$83.14	1	$35.00	$139.59
6	2	$73.90	6	$9.24	0	$0.00	$166.28	1	$70.00	$300.93
7	2	$73.90	6	$9.24	0	$0.00	$249.42	1	$105.00	$490.62
8	2	$73.90	6	$9.24	0	$0.00	$332.56	1	$140.00	$716.16
9	2	$96.50	5	$12.50	1	$0.00	$109.00	1	$35.00	$175.92
	2	$96.50	6	$15.00	0	$0.00	$220.50	1	$70.00	$390.34
11	2	$96.50	6	$15.00	0	$0.00	$332.00	1	$105.00	$654.96
12	2	$96.50	6	$15.00	0	$0.00	$443.50	1	$140.00	$983.38

**Last 4 options are using 2" PVC materials and the costs below:

tubing	valves	elbows	tee jts.
$0.40	$48.25	$2.50	$1.52

MATERIALS & SUPPLIES COSTS, continued

Design Option	bushels/ system	# of air diffusors	cost per diffusor	total cost, diffusors	number of tank trays	tray cost $10	oxygen meter $530
1	12	2	$14	$28	16	$160	$530
2	24	4	$14	$56	32	$320	$530
3	36	8	$14	$112	48	$480	$530
4	48	10	$14	$140	64	$640	$530
5	24	3	$14	$42	32	$320	$530
6	48	6	$14	$84	64	$640	$530
7	72	9	$14	$126	96	$960	$530
8	96	12	$14	$168	128	$1,280	$530
9	54	4	$14	$56	64	$640	$530
10	108	8	$14	$112	128	$1,280	$530
11	162	12	$14	$168	192	$1,920	$530
12	216	16	$14	$224	256	$2,560	$530

Size and number of diffusors based on water volume of tank and reservoir.

washing/ table $1,800	UV bulbs, # per system (30 watt bulbs)	UV replacement, lights & sleeve $62	cleaning and misc. supplies/tank
$1,800	2	$124	$2
$1,944	4	$248	$4
$2,088	6	$372	$6
$2,232	8	$496	$8
$1,944	3	$186	$3
$2,232	6	$372	$6
$2,520	9	$558	$9
$2,808	12	$744	$12
$2,232	6	$372	$4
$2,880	12	$744	$8
$3,528	18	$1,116	$12
$4,176	20	$1,240	$16

LABORATORY COSTS

Values in columns below are annual costs.

	for 1 or 2 tanks	for 3 tanks	for 2 banks of 2 tanks
property	$557.03	$557.03	$557.03
building	$1,591.50	$1,591.50	$1,591.50
equipment	$738.50	$738.50	$738.50
labor	$6,480.00	$8,100.00	$6,480.00
quality control	$1,014.00	$1,014.00	$1,014.00
basic supplies	$750.00	$1,000.00	$1,250.00
TOTAL ANNUAL COST	$11,131.03	$13,001.03	$11,631.03

materials costs/cycle = $70

Design Option	runs/ year	cost/run	# of tank cycles per year that results in an approximate lab cost of $275/tank cycle: cycles/year	cost/cycle
1	67.5	$234.90	54	$276.13
2	135	$152.45	54	$276.13
3	202.5	$134.20	71	$253.11
4	135	$156.16	56	$277.70
5	67.5	$234.90	54	$276.13
6	135	$152.45	54	$276.13
7	202.5	$134.20	71	$253.11
8	135	$156.16	56	$277.70
9	67.5	$234.90	54	$276.13
10	135	$152.45	54	$276.13
11	202.5	$134.20	71	$253.11
12	135	$156.16	56	$277.70

Lab cost per tank cycle is equal to total annual cost divided by the total number of tanks sampled for during the year, plus the materials cost per cycle ($70).

Property and building costs are amortized over 30 years at 10%. Equipment is depreciated over 10 years and includes an 11% interest charge on 1/2 of the annual value.

Original investment costs:

property	$15,000
building	$5,250
equipment	$7,000
TOTAL	$27,250

CERTIFICATION & PERMITTING

Design Option	wetland resource	easement	general permit	loss of shellfish	TOTAL COSTS
1	$500	$500	$100	$192	$1,292
2	$500	$500	$100	$192	$1,292
3	$500	$500	$100	$192	$1,292
4	$500	$500	$100	$384	$1,484
5	$500	$500	$100	$384	$1,484
6	$500	$500	$100	$384	$1,484
7	$500	$500	$100	$384	$1,484
8	$500	$500	$100	$768	$1,868
9	$500	$500	$100	$768	$1,868
10	$500	$500	$100	$768	$1,868
11	$500	$500	$100	$768	$1,868
12	$500	$500	$100	$1,536	$2,636

*assumes a loss of two tanks' worth of oysters during certification

LABOR COSTS

Assistants labor:

Assistants labor is fixed at 20 hours weekly, $10 per hour.

Hourly labor:

10 minutes is required per bushel for culling and loading or unloading shellfish into/from tank.

	cost/hour = $8		Tank Assembly Labor		
Design Options	culling and loading and unloading	hours w/ slack time 15%	HOURLY LABOR COST/cycle	hours for assembly	cost for assembly
1	120	2.30	$18.40	60	$480
2	240	4.60	$36.80	120	$960
3	360	17.25	$138.00	180	$1,440
4	480	20.70	$165.60	240	$1,920
5	240	12.65	$101.20	80	$640
6	480	18.40	$147.20	160	$1,280
7	720	24.15	$193.20	240	$1,920
8	960	29.90	$239.20	320	$2,560
9	480	18.40	$147.20	100	$800
10	960	29.90	$239.20	200	$1,600
11	1440	41.40	$331.20	300	$2,400
12	1920	52.90	$423.20	400	$3,200

LABOR COSTS, continued

Managerial labor:

Even the smallest operation will require 1/5 time of manager.
The largest operation requires a full-time manager and a half-time operations person.
Managerial labor time increases with the system capacity.

Design Option	Cost/yr = fraction of time	$35,000 cost	MANAGERIAL L PER OPERATING
1	0.20	$7,000	$3,635
2	0.25	$8,867	$4,604
3	0.31	$10,733	$5,573
4	0.36	$12,600	$6,542
5	0.25	$8,867	$4,604
6	0.36	$12,600	$6,542
7	0.47	$16,333	$8,481
8	0.57	$20,067	$10,419
9	0.36	$12,600	$6,542
10	0.57	$20,067	$10,419
11	0.79	$27,533	$14,296
12	1.00	$35,000	$18,173

**The manager is compensated for only the weeks during which the facility is operating.