Analysis of the Economic Effects of Requiring Post-harvest Processing for Raw Oysters

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INTRODUCTION

In October 2009, the Food and Drug Administration (FDA) announced its intent to require post-harvest processing (PHP) of Gulf oysters harvested during the warm weather months that are intended for raw half-shell consumption. Consumption of raw oysters from the Gulf of Mexico is associated with *Vibrio vulnificus* illnesses in consumers. *Vibrio vulnificus* is a naturally occurring bacterium found in seawater along the Gulf, Atlantic, and Pacific Coasts, and can be transmitted to humans through the consumption of raw shellfish harvested from waters containing the organism. It does not normally affect healthy individuals, but persons who are immunocompromised, especially those with chronic liver disease, are at greater risk for contracting *Vibrio vulnificus* from oyster consumption. Although the annual number of reported *Vibrio vulnificus* illnesses associated with oyster consumption is low, generally in the range of 30 to 35 cases per year (CDC, 2011), the incidence of death among those individuals who contract the disease is high, at approximately 50%.

PHP methods can be applied to raw half-shell oysters and essentially eliminate the risk of illness due to *Vibrio vulnificus*. The methods determined to reduce *Vibrio vulnificus* to nondetectable levels (<30 MPN/gram) include cool pasteurization, cryogenic individual quick freezing (IQF) with extended frozen storage, high hydrostatic pressure (HHP) processing, and low-dose gamma irradiation. However, we excluded IQF from this analysis because use of IQF for summer-harvested oysters results in an unacceptable product from the perspective of the consumer (Muth et al., 2011).[1]

[1] Because oysters spawn during the summer, they are thinner and the freezing process results in poorer color and texture of IQF oysters.

Cool pasteurization is a mild thermal treatment of oysters in the shell, followed by a rapid cooling (Muth et al., 2000, 2002). This process raises the temperature of the oyster enough to kill *Vibrio vulnificus* bacteria but does not sterilize or cook the oyster. To treat oysters, the oysters are first washed, then individually banded with rubber bands and loaded onto trays. The trays are loaded onto carts, which are hoisted into a tank containing warm (126°F) water for 24 minutes. The trays are then hoisted into a cool water tank for 15 minutes at 40°F. The oysters are then packed for half shell or shucked. Currently, one operation in Franklin, Louisiana, uses the cool pasteurization process for raw oysters.

HHP is a method of inactivating microorganisms in foods by subjecting them to very high pressure. Prior to processing, oysters intended for the raw half-shell market are individually banded using a shrink wrap band. Workers load banded oysters for both raw half-shell and shucked uses into baskets, and a system of overhead rails conveys the baskets to the ultra high-pressure processor. The baskets are hoisted up and then lowered into the water-filled pressure chamber, which is then sealed and pressurized using an electric 60 horsepower pump. Pressures of 35,000 to 40,000 psi are applied for 3 to 5 minutes. The process can be used for both half-shell and shucked oysters. For oysters intended for shucking, the pressure helps release the adductor muscle from the shell, making it easy to remove the oyster from the shell. Currently, three operations in the Gulf (in Amite, Louisiana; Houma, Louisiana; and San Leon, Texas) use the HHP process for raw oysters.

Irradiation of oysters has been approved by FDA as a post-harvest process and validated by researchers at the University of Florida, although the process is not yet commercially used for oysters. Irradiation involves exposing oysters to ionizing energy, either gamma rays, machine-generated electrons, or X-rays. Gamma rays are more commonly used, specifically cobalt 60.

The gamma rays interact with water and other molecules in the oyster, thereby inactivating bacteria. Currently one irradiation facility operates in the Gulf, in Mulberry, Florida, but it has not irradiated oysters for the commercial market.

The Gulf States—Alabama, the west coast of Florida, Louisiana, Mississippi, and Texas—account for 60% of oyster harvests in the United States. According to the National Marine Fisheries Service, 20.6 million meat-weight pounds of oysters were harvested in 2008. Harvest volumes are highest October through March when oyster quality is higher; oyster quality declines when oysters begin to spawn during warmer months. Although precise estimates are unavailable, industry representatives estimate that approximately two-thirds of the harvest is was used for raw half-shell consumption.

To apply PHP to all summer-harvested Gulf oysters intended for raw half-shell consumption would require substantially greater capacity than is currently available in the industry. Although existing oyster processors could increase their processing capacities by operating more hours per week, installation of additional capacity will likely be needed to meet FDA requirements for PHP. However, smaller oyster processors may lack the resources or volume to install PHP equipment; thus, alternative methods of obtaining PHP services will likely be needed.

The objective of this paper was is to analyze the costs and economic feasibility of requiring PHP of Gulf state oysters harvested in the summer (April through October) and intended for raw half-shell consumption. We determined the resource requirements for installing and operating PHP equipment, estimated the costs of PHP on a per-oyster basis, and determined potentially economically feasible methods of applying PHP to all oysters harvested in the Gulf from April through October and intended for raw consumption. The results of the analysis can help guide FDA in determining the most economically feasible and efficient method of implementing PHP with the intent of eliminating illnesses associated with *Vibrio vulnificus*. The analysis updates and extends Muth et al. (2000, 2002) by obtaining new cost estimates for PHP processes, adding irradiation to the estimation of costs, considering the heterogenous nature of oyster processing establishments (size and products produced), and evaluating the feasibility of ensuring PHP can be applied to all oysters subject to PHP requirements in summer months.

The analysis of the effects of PHP requirements was subject to limitations resulting from two major events affecting the oyster industry:

- the Deepwater Horizon oil spill in April 2010, which resulted in numerous harvest area closures and significant death of oysters from freshwater diversions that were used to prevent oil from reaching shorelines and
- imposition of time-temperature requirements in Gulf states in May 2010, which for some states are as restrictive as a 1-hour limit from harvest to refrigeration in the summer months.[2]

Both of these events have caused and will cause substantial reductions in oyster harvests for several years into the future. However, use of a PHP technology will allow processors to use oysters that do not meet the May 2010 time-temperature requirements for raw half-shell consumption.

METHODS AND DATA

The methods used for the analysis focused on two areas: (1) determining resource requirements and costs of installing and operating PHP of oysters in the Gulf and (2) analyzing

2 Although it is too early to assess fully the effect of the more stringent time-temperature requirements implemented by the Gulf states in May 2010, illness data for 2010 reported to date do not indicate a reduction in illnesses even with decreased harvest volumes associated with the Gulf oil spill (ISSC, 2011).

the economic feasibility of post-harvest processing of all Gulf oysters harvested in the summer and intended for raw half-shell consumption (i.e., installing own equipment, toll processing using existing or potential private facilities, and toll processing using potential public facilities [or central PHP facilities]). In considering the possibility of central PHP facilities, we conducted a GIS analysis to determine the general locations that would minimize travel time and costs for operations that currently have no or insufficient treatment capacity.

To estimate the costs of installing and operating PHP equipment and conduct the cost analysis, we conducted in-depth on-site and telephone interviews and obtained detailed information from three HHP processors, one cool pasteurization processor, one irradiation processor, and one manufacturer of HHP equipment.[3] We used the information from the interviews to develop estimates of the initial purchase and installation and annual operating costs for HHP. There is only one source of information on the costs associated with the cool pasteurization process, so our estimates are based on the information provided by the company. The irradiation company provided information on toll-processing costs that need to be factored in with the costs of transportation and other handling charges associated with using irradiation.

We obtained data on individual oyster operations from the Interstate Certified Shellfish Shippers List (ICSSL), which includes the lists of certified dealers provided by the states to FDA. Processing plants that ship oysters across state lines must be certified as interstate shippers.

[3]We interviewed the following establishments: Motivatit Seafoods (HHP, site visit), Joey's Oysters (HHP, teleconference), Prestige Oysters (HHP, site visit), Avure Technologies, Inc. (HHP equipment manufacturer, teleconference); AmeriPure Oysters (cool pasteurization, site visit), and Food Technology Services, Inc. (FTSI) (irradiation, teleconference).

We assumed that the following types of operations from the ICSSL would be required to either install PHP equipment or identify another location that would offer toll-processing services:

- Shellstock shipper (SS): grows, harvests, buys, or repacks and sells shellstock. Shellstock shippers are not authorized to shuck shellfish or to repack shucked shellfish, but they may ship shucked shellfish.
- Repacker (RP): repacks shucked shellfish from a certified shucker-packer into other containers. Repackers may also repack and ship shellstock but may not shuck shellfish.
- Shucker-packer (SP): shucks and packs shellfish. Shucker-packers may act as shellstock shippers or reshippers or may repack shellfish originating from other certified dealers.

One additional type of oyster shipper, reshippers, is not likely to install PHP equipment or use toll-processing services because they are not engaged in processing. Instead, we assumed that reshippers would rely on shellstock shippers and shucker-packers to process oysters as required.

To conduct the analysis, we estimated approximate oyster processing volumes for Gulf oyster processing establishments. We eliminated processors from the list obtained from the ISSCL that do not handle oysters or only shuck oysters using information obtained by the ISSC from the Gulf state agencies. We also augmented the ISCCL data with financial information from Dun & Bradstreet (D&B) (www.dnb.com) by matching the establishment name and address with records in the D&B dataset. We then converted the revenue estimates into estimated numbers of oysters processed by each establishment. For shellstock shippers, we divided the revenue estimate by an estimated wholesale value for half-shell oysters of $0.15 based on information provided by several industry interviewees. For shucker-packers and repackers, we divided the revenue estimate by a weighted average estimate for wholesale shucked and half-shell oysters according to the state in which the establishment is located assuming an estimated price for half-shell oysters of $0.15 and for shucked oysters of $0.12.[4]

To account for the fact that many shippers handle products other than oysters and, thus, their revenue estimates represent other types of products, we scaled back the volumes to account for other products. For processing operations with only “oysters” in the company name, we assumed 90% of the volume is oysters. For processing establishments with “oysters” and another term such as “seafood” or “fish,” we assumed 38% of the volume is oysters. Finally, for processing operations without “oysters” in the company name, we assumed 5% of the volume was oysters, and, for restaurant-type operations, we assumed 15% of the volume was oysters. These percentages were determined by calibrating the estimated volumes for operations on the shippers list to 2008 harvest volumes as reported by NMFS. We also adjusted the volumes produced by existing PHP processors by subtracting their PHP volumes from their total volumes to obtain an estimate of the remaining volume of oysters that would need to undergo a PHP process. Finally, we divided the estimated number of oysters by 12 to represent an average month in 2008.

Resource and Cost Estimation

Each of the PHP methods is associated with increased capital equipment, labor, or energy requirements and potential revenue changes due to changes in the type or nature of the product sold. For each PHP method, we used the information collected during the industry interviews to

[4] The weighted average values were $0.141 for Alabama, Louisiana, and Mississippi assuming 70% half shell; $0.147 for Florida assuming 90% half shell; and $0.144 for Texas assuming 80% half shell.

develop typical estimates of capital equipment costs (and life of capital equipment) and costs of labor, energy, and materials for representative size operations. Capital equipment and other initial costs were annualized and added to annual operating costs to develop a total annual cost estimate for each PHP process.

For calculations requiring conversion of oyster volumes, we applied the following assumptions obtained through discussions with industry participants:

- 250 oysters per 100-pound sack at harvest (actual numbers may range from 180 to 300 depending on harvest location and season)
- 7 pounds of oyster meat per 100-pound sack of oysters average over the course of the year (actual pounds may range from 3.5 to 10 pounds per sack depending on harvest location and season), which equates to approximately 36 oysters per meat-weight pound
- 4 pounds of oyster meat per 100-pound sack of oysters in the summer (actual pounds may range from 3.5 to 5 pounds per sack), which equates to approximately 62 oysters per meat-weight pound
- 60% of Gulf-harvested oysters are sold for half-shell use and 40% are sold for shucking over the course of a year

After applying these assumptions, we calculated total and per-oyster costs of PHP for shucked and half-shell oysters using the data provided by oyster processors and PHP vendors.

Economic Feasibility of PHP

Oyster processors seeking to maximize profits while adhering to requirements for PHP may consider the following options: install and operate PHP equipment within the establishment, obtain PHP services from a private or public operation (if available), or close during the summer months or permanently. Accurately modeling the economic effects of PHP requirements is challenging for a number of reasons. Oyster processors are maximizing profits based on a fixed short-run supply of the primary input, shellstock oysters. Depending on the location and season, shellstock oysters may or may not be available, and the quality of those supplies can vary considerably. Furthermore, oyster processors are maximizing profits over the course of the year rather than month to month. For example, oyster processors are willing to accept prices that are below their costs for shucked oysters in the summer because they are seeking to satisfy their customer needs over the course of the year to retain those customers for the months of the year when shucking yields are higher and, thus, shucking oysters is profitable.

Modeling the effects of PHP requirements is also complicated by the fact that depending on how the Gulf states choose to respond, some oyster processors may have the option of selling product only within the state of harvest. With the allowance of intrastate shipment of oysters that have not undergone a PHP process, the raw half-shell market becomes a differentiated product market but with one product substantially restricted by geographic location compared with the other. Furthermore, establishments that install PHP equipment would likely use the process for both half-shell and shucked oysters to reap the benefits associated with shucked oysters, while establishments that would have to rely on toll processing would likely use the process only for half-shell oysters. Thus, there will be differential industry responses because of the possibility of only intrastate shipments and the treatment of half-shell versus shucked oyster by different industry segments.

As a first step in considering the economic feasibility of applying PHP to Gulf oysters, we evaluated the extent to which the Gulf industry currently has sufficient PHP capacity. From industry-provided data, we calculated maximum processing volumes for existing and planned HHP and cool pasteurization equipment in the Gulf assuming two different operating scenarios:

- Scenario 1: 2,000 hours of PHP processing per year (equivalent to 8 hours of processing time per shift with one shift per day and operating 250 days per year)
- Scenario 2: 4,800 hours of PHP processing per year (equivalent to 8 hours of processing time per shift with two shifts per day and operating 300 days per year)

(In actual operation, processing volumes would be less than these calculated estimates because of inevitable equipment breakdowns or occasional unavailability of raw oysters.) We then compared the maximum available capacity with estimated Gulf oyster volumes. Because a large percentage of oysters are shipped across state lines for processing, we estimated the percentage availability at the total Gulf oyster industry level.

The second step in the analysis determined the extent to which individual oyster operations would be able to install PHP equipment within their operations. Specifically, we compared estimated oyster product volumes relative to the capacity of PHP equipment available in the marketplace. Because the cool pasteurization and HHP processes provide benefits in terms of reduced shucking labor or increased shucked oyster yields, operations that install these processes will likely apply PHP to both half-shell and shucked oysters. However, operations could decide to apply PHP only to half-shell oysters shipped interstate. Thus, we compared total oyster volumes and half-shell oyster interstate shipment volumes for each oyster processing establishment against the estimated capacity for the smallest process operating 2,000 hours per year.

The final step in the analysis focused on determining the feasibility of developing central PHP facilities to offer services to processors that are unable to install their own PHP equipment.

If the Gulf oyster industry made the decision to develop central PHP facilities, one of the first issues of concern would be where to locate the facilities. Thus, we conducted a geographic information system (GIS) analysis to identify locations for potential consideration. In conducting the GIS analysis, we assumed that oysters would be shipped from a processor location to a central PHP facility to allow for preprocessing activities (cleaning, sorting, and banding) at the processor location. Oysters would then be either shipped back to the processor location for final packaging and order fulfillment or directly to a buyer. Oyster processors would, therefore, incur costs for refrigerated shipping to and from the central PHP facility in addition to the costs of PHP services. Furthermore, the central facility may need to include an additional fee to compensate investors depending on how the operation is financed.

The analysis was based on the assumption that all summer-harvested Gulf half-shell oysters shipped interstate would be treated using cool pasteurization or HHP. We assumed that a central PHP facility would have at most a monthly treatment capacity of 7 million oysters per month based on the highest capacity HHP processor operating 4,800 hours per year or the equivalent of two of the highest capacity cool pasteurization units also operating for 4,800 hours per year. To determine the optimal locations for central PHP facilities, we used ESRI's Network Analyst software within ArcMap with the following optimization criteria: minimize the travel distance from the original establishment to the central PHP facility using major highways, and require that the central PHP facility be within a 4-hour drive from the original establishment to allow for drivers to return in the same day.

RESULTS

Resource and Cost Estimation

Installing and beginning to operate PHP processes within a plant will require several steps. These include

- developing plans for expanding the plant or altering the plant layout;
- obtaining building permits;
- securing financing for purchasing equipment;
- constructing the expanded facility;
- modifying electrical, natural gas, and water hookups;
- purchasing and installing equipment;
- validating and verifying the process;
- training workers on operation and maintenance of the equipment;
- updating the operation's Hazard Analysis and Critical Control Point (HACCP) plan to address PHP;
- updating recordkeeping systems; and
- updating product labeling and notifying buyers.

Each of the PHP methods is associated with increased capital equipment, labor, or energy requirements and potential revenue changes due to changes in the type or nature of the product sold.

Cool Pasteurization

Cost estimates for the cool pasteurization process are based on the following volumes: 18,000 sacks of oysters per year for a small process and 145,600 sacks per year using holding tanks with capacity of 7,500 gallons (hot tank) and 5,500 gallons (cold tank) for a large process. Capital equipment requirements for cool pasteurization include a boiler, chilling and condensing unit, computer-monitored hot and cold exchange unit, holding tanks (7,500 gallons for the hot water tank and 5,500 gallons for the cold water tank), conveyers, hoists for lifting oysters in and out of water tanks, an ultraviolet water purification system, stainless steel racks, and delivery and installation including plumbing and electrical hookups. Estimates of the costs of plant expansion to house the equipment were calculated assuming $150 per square foot (200 square feet for the small process and 1,750 square feet for the large process). For both the small and large processes, capital equipment and installation costs were estimated by applying a net inflation factor of 1.31 obtained from the Bureau of Labor Statistics for the period 1999 to 2009 (2010 is not yet available) to original cost estimates provided by AmeriPure in 1999 (Muth et al., 2000).

Capital equipment costs (including installation) and plant expansion costs were amortized assuming a 20-year life and 7% interest rate. Current estimates for operating costs—water, electricity, natural gas, labor, replacement parts, and maintenance—were added to banding costs and adjusted for shucking labor savings to develop total annual operating costs. In addition, a licensing fee of $0.0125 per oyster was included.[5]

Table 1 provides estimates of throughput, total costs, and per-unit costs associated with two process sizes for the cool pasteurization process based on a 2,080-hour annual operating schedule. Assuming that the process is applied to both half-shell and shucked oysters, the resulting per-oyster PHP cost, including both amortized capital equipment costs and annual operating costs, is 4.9 cents per half-shell oyster and −1.1 cents per shucked oyster for the large process and 5.2 cents per half-shell oyster and −0.8 cents per shucked oyster for the small process (not including transportation costs if a toll-processing facility is used).

<u>High Hydrostatic Pressure</u>

The sole equipment manufacturer for HHP equipment, Avure, produces four sizes of machinery that can process oysters:

- 100-liter horizontal machine operating at 11 cycles per hour with 120 shell-weight pounds per cycle (requiring space of 12 by 12 feet)

[5] When the patents on the process expire in approximately 5 years, the licensing fee will no longer apply.

- 320-liter vertical machine operating at 12 cycles per hour with 450 shell-weight pounds per cycle (requiring space of 30 by 20 feet)
- 350-liter horizontal machine operating 12 cycles per hour with 500 shell-weight pounds per cycle (requiring space of 50 by 20 feet)
- 687-liter horizontal machine operating 10 cycles per hour and with 700 shell-weight pounds per cycle (requiring space of 40 by 30 feet)

Capital equipment requirements for HHP are the HHP unit and enclosure, chiller, compressor, overhead rail system, conveyers, hoists, and delivery and installation costs, including electrical hookups.

Licensing fees for HHP are built into the capital equipment costs and, thus, are not separately incurred on a per-oyster basis. Plant expansion costs were estimated assuming the minimum required square footage would be twice the footprint of the HHP equipment. However, the 320 L vertical system requires 23 feet of vertical clearance, which would be difficult in many facilities, in contrast to the horizontal system, which is 6 to 7 feet in height. Thus, plant expansion costs may be higher for installing a vertical process.

Avure provided estimates of the base equipment costs; additional costs for installation, rail system, conveyors, and building expansion; and operation costs per shell-weight pound, including labor, electricity, water, building expansion, conveyors, and depreciation costs (using a straight-line method). To provide consistency in estimating the costs of plant expansion per square foot and amortizing costs using a 7% interest rate, we decomposed the per-pound operation costs provided by Avure and then reconstructed the plant expansion, installation, and annual per-oyster costs of HHP. We estimated plant expansion costs by multiplying $150 per square foot times twice the square footage requirements provided by Avure. Capital equipment costs were included as provided by Avure. We estimated additional equipment and installation costs assuming that the costs are 10% of capital equipment costs based on detailed information provided by HHP processors that use a 215 L machine and a 350 L machine each. Per-oyster operating costs were calculated by subtracting our estimate of the portion of Avure's per-oyster operating costs that is attributable to plant expansion, capital equipment, and installation and adding back our annualized estimate of each of these portions of costs assuming a 20-year life for plant expansion, 10-year life for capital equipment and installation, and a 7% interest rate.[6] We then adjusted the per-oyster operating costs to account for banding costs for half-shell oysters and shucking labor savings and increased yields for shucked oysters.[7]

Following these calculations, we compared the resulting cost estimates to cost estimates calculated using detailed information provided by HHP processors based on their recent experience installing HHP processes. The estimates based on the data from the HHP processors were somewhat higher than but generally similar to the estimates provided by Avure. The cause of the differences is unknown but could be due to a variety of factors, including differences in the wages and energy prices, imprecision in the method we used to deconstruct Avure's cost estimates, or differences in assumptions used.

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[6] We estimated the portion of Avure's per-oyster costs that are attributable to plant expansion, capital equipment, and installation by calculating the annual costs of each assuming a straight-line depreciation method and 20-year life for plant expansion and installation (these are grouped in Avure's data) and 10-year life for capital equipment and dividing the result by the number of oysters processed each year.

[7] The costs of banding are estimated to be 3 cents per half-shell oyster, yield increases for shucked oysters are estimated to result in a 3 cents per oyster increase in revenue, and labor savings are estimated at 1.3 cents per shucked oyster (Muth et al., 2011).

Table 2 provides estimates of throughput, total costs, and per-unit costs associated with four process sizes for HHP based on 2,000-hour and 4,800-hour annual operating schedules. Assuming the same processing time for half-shell and shucked oysters, the resulting per-oyster PHP costs, including both amortized capital equipment costs and annual operating costs, range from 5.3 to 7.0 cents per half-shell oyster and −1.9 to 0.0 cents per shucked oyster based on 2,000 operating hours per year and from 4.2 to 5.0 cents per half-shell oyster and −2.3 to −3.1 cents per shucked oyster based on 4,800 operating hours per year (not including transportation costs if a toll-processing facility is used).[8]

Low-Dose Gamma Irradiation

Large quantities of oysters can be irradiated quickly within packaged boxes. It would be the last step in the process before oysters are introduced into commerce. In trials, oysters are cleaned, packaged, and labeled, and then shipped to the irradiation facility on pallets in refrigerated trucks.[9] The irradiation facility does not need to hold oysters, because they can process an entire truckload in only 1 hour. Thus, the oysters are transported to and from the irradiation facility on the same truck. Oysters have an expected 7- to 10-day shelf life after irradiation.

The sole irradiation facility, FTSI, in the Gulf operates on a toll-processing basis and would charge 7 cents per pound. FTSI estimates there are 3.8 oysters per pound, which would work out to be less than 2 cents per oyster for irradiation processing. However, based on the assumptions used in our analysis of 2.5 half-shell oysters per pound (250 oysters per 100-pound

[8] Anecdotal information suggests that some processors may process oysters intended for shucking for a shorter process than half-shell oysters to facilitate the shucking process rather than to reduce *Vibrio vulnificus* to nondetectable levels.

[9] Banding the oysters would likely be needed for commercially irradiated product.

sack), the cost would be 2.8 cents per oyster. As with the other processes, irradiated oysters would require banding. Thus, the total cost per oyster would be 5.8 cents per oyster, not including refrigerated transportation costs to the irradiation facility. Although the process could, in theory, be applied to shucked oysters, there are no advantages related to shucked oyster yields or shucking labor as there are for the other process.

Because of the location of the facility, use of irradiation will only be feasible for a portion of the Gulf region. However, the majority of Gulf oyster harvests are processed at operations more than a day's drive from the FTSI facility. For example, the distance from New Orleans, Louisiana, to Mulberry, Florida, is nearly 700 miles, which equates to approximately 11 hours of driving time according to Google Maps (maps.google.com).

Economic Feasibility Analysis

Table 3 provides a summary of key assumptions regarding oyster industry volumes in the Gulf. Based on information obtained from state agencies and industry participants, an estimated 40% of Florida-West Coast, 70% of Louisiana, and 75% of Texas oysters harvested from the Gulf in the summer months (April through October) are used for half-shell consumption. Essentially no oysters harvested from Alabama and Mississippi during the summer are used for half-shell consumption. Overall, for half-shell and shucked oysters, an estimated 30% of Florida-West Coast, 75% of Louisiana, and 50% of Texas oysters harvested from the Gulf in the summer and intended for half-shell consumption are shipped interstate (and thus are specifically subject to PHP requirements). Estimates of interstate shipments are not included for Alabama and Mississippi because shucked product will not be subject to PHP requirements.

Based on calculations of maximum processing volumes for existing and planned HHP and cool pasteurization equipment in the Gulf, existing PHP capacity during the summer (April through October) is approximately 70 million oysters assuming a PHP operating schedule of one 8-hour shift per day for 5 days per week or 167 million assuming a PHP operating schedule of two 8-hour shifts per day for 6 days per week. Assuming 5 days of operating one 8-hour shift per day each week, PHP capacity relative to total Gulf summer harvest is 11% relative to total summer harvest, 19% relative to half-shell summer harvest, and 27% relative to interstate half-shell summer harvest. Assuming 6 days of operating two 8-hour shifts per day each week, PHP capacity relative to total Gulf summer harvest is 27% relative to total summer harvest, 45% relative to half-shell summer harvest, and 66% relative to interstate half-shell summer harvest. Thus, even if we assume that oysters could be transported without cost to existing PHP processors, existing capacity is insufficient to post-harvest process the majority of oysters under most scenarios.

Based on comparison of processing volumes to equipment capacity, we estimate that 6 to 11 establishments beyond those already operating post-harvest processes have sufficient volume to install PHP equipment. Of the remaining 122 to 127 establishments with insufficient product volumes to warrant installation of PHP equipment, their estimated product volumes would account for only 10 to 19% of the capacity of the smallest size equipment. Therefore, many smaller oyster operations in the Gulf would be unable to install PHP equipment in their facilities for a number of reasons, including that they have insufficient product volume relative to the smallest available PHP equipment, lack sufficient floor space to install PHP equipment without costly plant expansion (and possibly land purchase), lack financial resources or access to credit to purchase processing equipment and expand plant floor space, and lack a labor force with required skills to operate PHP equipment. Shifting to only shucked production in the summer is not economically feasible given the substantially lowered yields for shucked oysters in the summer.

However, one option might be for smaller oyster operations to obtain PHP services on a toll basis through a central PHP facility operated by an agency.[10] The results of the GIS analysis identified the optimal locations for PHP facilities by zip code as listed in Table 4 and as shown in Figure 1. Mean driving distances from processor locations to the optimal locations range from 21 miles for the Apalachicola, Florida, location to 149 miles for the San Antonio, Texas, location. In Alabama and Louisiana, the mean driving distances are approximately 40 miles. Maximum driving distances range from 75 miles for the Apalachicola, Florida, location to 284 miles for the San Antonio, Texas, location. In addition to all of the activities required to install PHP equipment in a private facility, a central PHP facility would also require determining the legal and operating structure of the operation, identifying a specific property with the intent of modifying an existing facility or building a new facility, and conducting outreach and education to the industry to develop the clientele.

DISCUSSION

Use of central PHP facilities may be the only viable option, other than closure in the summer, for smaller oyster operations that lack the volume and resources to install their own

[10] Although there is the potential for existing cool pasteurization and HHP processors to provide toll processing services, we concluded this is unlikely to occur because none of the other PHP operations in the Gulf (cool pasteurization and HHP) currently have sufficient capacity to offer more than a relatively minor volume of toll processing if PHP requirements are applied to all summer-harvested Gulf oysters. By operating more shifts or more days of the week, existing PHP operations would likely only be able to ensure that all of their own product was post-harvest processed, which would have to be above and beyond what they currently process.

PHP equipment. For oyster processors located within a cost-effective transportation distance from the irradiation facility in Florida, toll processing could be established in a relatively short period of time assuming that consumer acceptability issues are not a concern. To use toll-processing services, oysters will need to be shipped from a processor location to a central PHP facility rather than from a harvest location. Prior to PHP, harvested oysters must be cleaned, sorted, and banded. Oyster processors would most likely conduct these initial activities within their establishment to maintain quality and oversight of their products. Oyster processors might also transport oysters back to the original facility for final packaging and shipping orders to buyers. Thus, oyster processors will have to purchase containers for shipping to and from the toll-processing facility and obtain additional refrigerated transportation by purchasing trucks or using a trucking company. As a result, the costs associated with using a toll-processing facility will be substantially higher than the per-oyster PHP costs calculated for individual establishments.

Furthermore, it is likely that oyster processors would only use toll-processing services for half-shell oysters and, therefore, would not receive the yield increases or shucking labor savings associated with applying the process to oysters intended for shucking. In addition to incurring costs of using toll-processing services, the time required for transportation and conducting PHP activities will reduce the saleable time period for raw oysters. Because small oyster operations will more likely need to rely on using a central PHP facility, they will require more time to comply with the requirements for PHP compared with larger operations. Furthermore, our analysis assumes that the equipment manufacturers could fulfill all orders as they are received and have sufficient staff available to support the delivery and installation of the equipment and training of staff. It is currently unknown whether the equipment manufacturers could satisfy these needs.

A number of issues affecting the analysis are currently unknown, such as whether states will allow intrastate shipments of oysters that have not undergone PHP and which oyster processors would elect to ship only intrastate if that were the case, whether the industry or Gulf oyster agencies will be in a position to establish central PHP facilities to provide PHP services for establishments that are unable to install PHP equipment, and how consumers would respond if only oysters that had undergone PHP were available. Although some consumers may prefer post-harvest processed oysters or be indifferent between post-harvest processed and traditional oysters, others may elect to no longer consume oysters if only post-harvest processed oysters are available or only consume traditional oysters if Gulf states allow for intrastate shipments of half-shell oysters that have not been post-harvest processed. Of those consumers who prefer or are indifferent about post-harvest processed oysters, it is uncertain whether consumers are willing to pay more for these oysters if only post-harvest processed oysters are available.

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Table 1. Throughput Assumptions and Costs for the Cool Pasteurization Treatment Process: 2,080 Operating Hours per Year

	Small Process	Large Process
Annual throughput assumptions		
Half-shell oysters	2,700,000	21,840,000
Shucked oysters	1,800,000	14,560,000
Total oysters	4,500,000	36,400,000
Total shell-weight pounds	1,800,000	14,560,000
Total sacks	18,000	145,600
Total cost estimates		
Total plant expansion and capital equipment costs	$74,740	$386,245
Total annual operating costs, including banding costs and yield increases for shucked oysters	$85,075	$555,096
Per-unit cost estimates		
Per half-shell oyster	$0.052	$0.049
Per shucked oyster[a]	−$0.008	−$0.011
Per sack	$7.00	$6.25

[a] Negative cost values for shucked oysters mean that processors incur "savings" resulting from increased yields for shucked oysters.

Assumptions:

- Each 100-pound sack holds 250 oysters.
- 60% of oysters are sold to the half-shell market and 40% are sold to the shucked market.
- Half-shell oysters incur banding costs of $0.015 per oyster.
- Shucked oysters have labor savings of $0.03 per oyster.
- Plant expansion has a 20-year life and equipment has a 20-year life.
- Interest rates for bank loans to processors are 7%.

Table 2. Throughput Assumptions and Costs for the HHP Process: 2,000 and 4,800 Operating Hours per Year

	100 L Horizontal	320 L Vertical	350 L Horizontal	687 L Horizontal
2,000 Operating Hours per Year				
Annual throughput assumptions				
Half-shell oysters	3,960,000	16,200,000	18,000,000	21,000,000
Shucked oysters	2,640,000	10,800,000	12,000,000	14,000,000
Total oysters	6,600,000	27,000,000	30,000,000	35,000,000
Total shell-weight pounds	2,640,000	10,800,000	12,000,000	14,000,000
Total sacks	26,400	108,000	120,000	140,000
Total cost estimates				
Total plant expansion and capital equipment costs	$1,280,000	$2,050,000	$2,406,250	$3,110,000
Total annual operating costs, including banding costs and yield increases for shucked oysters	$270,662	$637,877	$698,124	$886,320
Per-unit cost estimates				
Per half-shell oyster	$0.070	$0.053	$0.052	$0.054
Per shucked oyster[a]	−$0.003	−$0.020	−$0.021	−$0.019
Per sack	$10.25	$5.91	$5.82	$6.19
4,800 Operating Hours per Year				
Annual throughput assumptions				
Half-shell oysters	15,840,000	38,880,000	43,200,000	50,400,000
Shucked oysters	6,336,000	25,920,000	28,800,000	33,600,000
Total oysters	22,176,000	64,800,000	72,000,000	84,000,000
Total shell-weight pounds	8,870,400	25,920,000	28,800,000	33,600,000
Total sacks	88,704	259,200	288,000	336,000
Total cost estimates				
Total plant expansion and capital equipment costs	$1,280,000	$2,050,000	$2,406,250	$3,110,000
Total annual operating costs, including banding costs and yield increases for shucked oysters	$330,854	$830,117	$993,324	$1,062,320
Per-unit cost estimates				
Per half-shell oyster	$0.050	$0.042	$0.043	$0.042
Per shucked oyster	−$0.023	−$0.031	−$0.030	−$0.031
Per sack	$5.22	$3.20	$3.45	$3.16

[a] Negative cost values for shucked oysters mean that processors incur “savings” resulting from increased yields for shucked oysters.

Table 3. Oyster Industry Assumptions and Volume Estimation

	Alabama	Florida-West Coast	Louisiana	Mississippi	Texas	Total
Percentage of total harvest used for half-shell consumption in the summer[a]	0%	40%	70%	0%	75%	
Percentage of total harvest shipped interstate (applies to half-shell oysters)[a]	NA	30%	75%	NA	50%	
Harvest volumes: Summer 2008 (April–October)						
Meat-weight (pounds)[b]	30,929	1,297,429	6,779,514	1,009,136	914,152	10,031,160
Meat-weight per 100-pound sack[c]	4	4	4	4	4	
100-pound sacks	7,732	324,357	1,694,879	252,284	228,538	2,507,790
No. of oysters per sack[c]	250	250	250	250	250	
No. of oysters	1,933,063	81,089,313	423,719,625	63,071,000	57,134,500	626,947,500
Estimated half-shell volume in summer	—	32,435,725	296,603,738	—	42,850,875	371,890,338
Estimated interstate half-shell volume summer	—	9,730,718	222,452,803	—	21,425,438	253,608,958

[a] Percentages were obtained through discussions with state agencies and industry experts, all of which were generally in agreement.

[b] Harvest data were obtained from NMFS.

[c] Estimated meat-weight pounds per sack for summer-harvested oysters were based on estimates provided by several industry participants.

Table 4. Results of GIS Analysis to Determine Optimal Locations for Central PHP Facilities Assuming Half-Shell Oysters Shipped Interstate are Post-harvest Processed

Approximate Location	Required Monthly PHP Capacity (million oysters)	Average Miles from Oyster Processors to Central PHP Facility	Maximum Miles from Oyster Processors to Central PHP Facility
Houma, LA 70361	3.0	43	220
San Antonio, TX 78279	2.6	149	284
New Orleans, LA 70142	2.5	43	190
Bayou La Batre, AL 36509	2.4	40	95
St. Augustine, FL 32086	1.4	86	206
Apalachicola, FL 32329	0.7	21	75

Figure 1. Results of GIS Analysis Identifying Optimal Locations for Central PHP Facilities to Process Gulf-Harvested Oysters Assuming Half-Shell Oysters Shipped Interstate Are Post-harvest Processed