ECONOMIC ALTERNATIVES FOR GULF OF MEXICO OYSTER PROCESSING SECTOR

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ABSTRACT

A collaborative research and outreach program on oyster postharvest processing was jointly undertaken by the Mississippi State University-Coastal Research and Extension Center and the Mississippi Department of Marine Resources-Seafood Technology Bureau. The goal of this program was to evaluate the consumer acceptability of postharvest processed (PHP) raw oyster products and determine the economic viability of these systems for raw oyster products which would be in compliance with proposed federal regulations and satisfy market constraints imposed by individual states.

Federal regulatory mandates and market constraints set up by individual states would eventually require that a significant portion of raw oyster production in the Gulf of Mexico states would undergo postharvest processing, especially during summer months. The state of California imposed a ban on the sale of untreated raw oysters from the Gulf of Mexico states during summer months starting spring 2003. Earlier federal mandates require that individual oyster producing states establish postharvest processing capacity in relation to reported *Vibrio*-related cases. Recently, the U.S. Food and Drug Administration proposed new regulations that would require Gulf of Mexico oysters to undergo postharvest processing during warmer months.

Twelve commercial raw oyster postharvest processing plants operating in the United States are located in the Gulf of Mexico states. The three alternative postharvest processing systems that are commercially available include heat-cool pasteurization, high hydrostatic pressure and individually quick freezing oyster postharvest processing systems. In June 2009, the Florida Agriculture and Consumer Services licensed Food Technology Services Incorporated in Mulberry, Florida, to use low-dose irradiation to produce safer raw oyster products. These PHP technologies significantly reduce levels of certain bacteria that naturally occur in waters

where oysters are found, provide quality raw oysters, and enhance the shelf life of raw oysters.

The overall goal of this paper is to provide economic benchmarks for commercially viable postharvest processing systems for raw oyster products in the Gulf of Mexico. It is expected that these economic benchmark models would provide economic guidelines to oyster processors, distributors, and researchers in developing and promoting postharvest processed raw oyster products from the Gulf of Mexico states. Using the benchmark economic models, this paper would then assess the combined PHP capacity of the processing sector in the GOM states in relation to the recent monthly oyster landings of the region. The expansion in the regional, statewide or individual plant PHP capacity to comply with the proposed federal regulation and market constraint would have serious compliance, economic and marketing implications. This paper would attempt to outline the implications associated with the expansion of PHP capacity in the region.

INTRODUCTION

A collaborative research and outreach program on oyster postharvest processing was jointly undertaken by the Mississippi State University-Coastal Research and Extension Center (CREC) and the Mississippi Department of Marine Resources-Seafood Technology Bureau (DMR). The primary goal of this collaborative program was to evaluate the consumer acceptability of postharvest processed (PHP) raw oyster products (Posadas and Posadas, 2011; Posadas and Andrews, 2011; Posadas et al., 2011) and economic viability of PHP systems for raw oyster products which are in compliance with federal and state regulations (Posadas and Posadas, 2004). Earlier oyster collaborative efforts between CREC and DMR involved the two-year public relaying of oysters from conditional growing areas to approved growing waters in Mississippi (Burrage et al., 1991; Posadas et al., 1992; 1993).

The Gulf of Mexico (GOM) states have been supplying the Western states including California with shucked and halfshell oyster products for raw consumption. With the danger of illness or death associated with the consumption of raw oyster products contaminated with *Vibrio vulnifucus* by at-risk consumers (Fig. 1), the U.S. Food and Drug Administration (FDA) has specified that oyster producing states in the GOM process a certain percentage of their raw oyster production with approved postharvest processing methods.

Federal regulatory mandates and market constraints set up by individual states would eventually require that a significant portion of raw oyster production in the GOM states would undergo PHP, especially during summer months. Federal mandates require that individual oyster producing states establish postharvest processing capacity in relation to reported *Vibrio*-related cases. The state of California also required that all oyster products which were harvested from the GOM states from April 1 to October 1 must be subjected to approved postharvest processing before they can be sold for raw consumption in the state (Romney, et al. 2003). Intrafish (2009) reported in October 2009 that the FDA is proposing new regulations that would require U.S. Gulf of Mexico oysters to undergo treatment to kill potential bacteria during the warmer months, between May and October. An industry-wide estimate of the economic impact of mandatory postharvest processing of GOM raw shucked and halfshell oyster products conducted by Muth et al. (2002) showed that price increases would be less than 20 percent and that producer and consumer losses in the halfshell market are partially or more than offset by gains in the shucked market. Estimates made by Posadas and Posadas (2004) showed that PHP of oyster products for raw consumption, either by high pressure, heat-cool pasteurization or individually quick freezing would add between $0.11-$0.16 per oyster excluding the costs of harvesting and marketing and at full plant capacity.

Twelve commercial raw oyster PHP plants operating in the United States are located in the GOM states. The three FDA-approved PHP systems already in commercial use during the last decade included heat-cool pasteurization (HCP), high hydrostatic pressure (HHP) and individually quick freezing (IQF). In August 2005, the FDA approved irradiation as a fourth postharvest process for oysters. Subsequently in June 2009, the Florida Agriculture and Consumer Services has licensed Food Technology Services Incorporated (FTSI) in Mulberry, Florida, to use low-dose irradiation (LDI) to produce safer oyster products. These PHP technologies significantly reduce levels of *Vibrio vulnificus* that naturally occur in waters where oysters are found, provide quality raw oysters, and enhance the shelf life of raw oysters (Andrews et al., 2000; Andrews et al., 2002; Cook, 1997; Cook and Ruple, 1992).

A Gulf-wide initiative was started by the GOM oyster industry with support from the GOM Sea Grant Programs in early 2010 to address the proposed FDA regulations that would require GOM oysters to undergo PHP during warmer months. Economists from the five GOM states Sea Grant programs met with oyster processors in April 2010 to discuss how to measure the aggregate cost of compliance of the new federal mandate. The collaborative industry-extension efforts to pursue the GOM oyster initiative was temporarily halted as a result of the Deepwater Horizon oil spill in April 20, 2010.

The overall goal of this paper was to provide economic benchmarks for commercially viable PHP systems for raw oysters in the Gulf of Mexico. It was expected that these economic models would provide economic guidelines to oyster processors, distributors, and researchers in developing and promoting postharvest processed raw oyster products from the GOM states. It should be noted that earlier versions of these deterministic models did not incorporate the elements of risks and uncertainty facing the domestic oyster industry (Posadas and Posadas, 2004). Since the economic-engineering approach was used in the earlier modeling process, the preliminary results were hypothetical in nature and needed to be validated by using industry-wide data. Using the benchmark economic models, this paper would then assess the combined PHP capacity of the processing sector in the GOM states in relation to the monthly oyster landings of the region during the past five years. The expansion in the regional, statewide or individual plant PHP capacity to comply with the proposed federal regulation and market constraint would have serious compliance, economic and marketing implications. This paper would attempt to outline the implications associated with the expansion of PHP capacity in the region.

POSTHARVEST PROCESSING SYSTEMS

As of April 2010, sixteen commercial raw oyster PHP plants are operating in the United

States, of which twelve plants are located in the GOM states. Since August 2005, the four PHP systems approved by FDA for raw oyster consumption included one HCP processing plant, four HHP plants, ten IQF plants and one LDI plant. Of the twelve PHP plants in the GOM states, one uses HCP, two use HHP, eight use IQF, and one uses LDI processing systems.

Posadas and Posadas (2004) developed deterministic spreadsheet models for HCP, HHP and IQF postharvest processing systems in the GOM states using templates prepared by Muth et al. (2000; 2002) and data collected during several visits with PHP plants in Mississippi, Louisiana and Texas. The understanding of the current technological processes involved in each PHP system for raw oyster products was vital in the economic modeling process. The postharvest processes observed during visits with processing plants were described in posters, leaflets and videos published by the Mississippi Department of Marine Resources, Seafood Technology Bureau (http://www.dmr.state.ms.us). These publications were widely distributed by DMR staff in several state and national outreach programs to promote awareness of these PHP technologies for raw oysters.

Until April 2010, the three types of commercial PHP systems operating in the GOM states proved to be economically viable systems given the resource constraints and prevailing market conditions during the past decade. It is uncertain as to the extent of the short-term and long-term damages of the Deepwater Horizon oil spill to the GOM oyster resources, especially those reefs which were oiled and affected by massive freshwater inflow. The expected impacts of the oil spill on the GOM oyster landings will be difficult to predict but the last five years monthly GOM data showed how landings were impacted by recent natural disasters. Due to the inherent nature of the oyster fishery, the monthly regional oyster landings in the GOM states showed significant seasonal fluctuations during the past five years. The monthly landings fluctuated from one million pounds in September to 2.3 million pounds in March (Fig. 2).

There are also risks and uncertainties in the markets for GOM seafood due to consumer perceptions associated with the oil spill. Several restaurants in different parts of the country were reported by Intrafish and Seafood News as refusing to serve seafood products harvested from the GOM waters. The negative perceptions of the safety and acceptability of the GOM seafood by seafood restaurants are eroding the market shares of individual states and producers of seafood products harvested from the GOM region. These market perceptions will further cause more fluctuations in the ex-vessel and plant-gate prices of oyster products. The monthly oyster ex-vessel prices fluctuated from month to month and from year to year during the most recent five harvesting seasons. The monthly oyster ex-vessel price averaged $3.04 per pound of meat (SD = standard deviation = ± $0.07) and ranged from $2.90 per pound in September to $3.15 per pound in November.

The initial fixed investment required (IFIR) to establish an HCP processing system would be $0.90 million. The annual operating capital required (AOCR) to operate the HCP system at full capacity would be $4.04 million. The HCP system would generate annual gross sales amounting to $5.22 million with an annual production at full capacity (APFC) of 0.21 million cases of HCP processed raw oysters. Discounted investment indicators showed that HCP processing system had an internal rate of return (IRR) of 40 percent and a net present value (NPV) amounting to $4.52 million. Considering the fluctuations in the GOM oyster landings and ex-vessel prices, and fuel prices, the probabilities of the HCP system to generate positive NPV was calculated by using Simetar© (2008). The simulation results showed that the HCP system will have a very good chance to be an economically viable processing system (Fig. 3).

Establishing an HHP processing system for raw oysters could be considered an economically viable alternative. The HHP processing system would require IFIR = $2.55 million and AOCR = $5.36 million. With APFC = 0.29 million cases of HHP raw oysters, annual gross sales at full capacity were projected to reach $7.34 million. The HHP processing system had an IRR = 26 percent and NPV = $6.59 million. The HCP system will have a very good chance to be an economically viable processing system based on simulation results of the NPV values using Simetar© (2008), as shown in Fig. 4.

The IQF processing system proved to be an economically viable raw oyster processing system. It could potentially produce 0.18 million cases of frozen halfshell oysters per six-month processing period at 100% capacity use. It would require IFIR = $0.75 million to establish the processing system, and AOCR = $5.22 million to operate the system. With an expected annual gross sales reaching $6.43 million, the IQF system was a viable processing system with NPV = $5.13 million and IRR = 52 percent. Simulations of the CDF approximations of the NPV values using Simetar© (2008) showed that the HCP system will have a very good chance to be an economically viable processing system (Fig. 5).

The total initial investment required to build and operate an LDI processing system in the GOM region could range from $8 to $12 million. The processing capacity of the LDI system operating in the GOM region at its current Cobalt level is about 40,000 pounds per processing hour. It could devote about 50 hours per week for oyster irradiation and pre- and post-LDI processing. The average costs of oyster irradiation that the plant would charge its customers would range from 6 to 8 cents per pound of oyster shellstock.

POSTHARVEST PROCESSING CAPACITY

The ability of the GOM oyster industry to comply with the combined market constraint and federal regulation to PHP process oysters harvested from April 1 to October 1 was measured by comparing the combined PHP capacity of existing GOM plants to the region's monthly oyster landings. The stochastic combined PHP capacity measures the percent of monthly oysters landings that the entire GOM region or individual state can postharvest process under federal, state and industry guidelines.

The stochastic PHP capacity of the five GOM states was estimated from the combined processing capacity reported or assumed for the twelve PHP facilities operating in the region. The stochastic processing capacity was expressed in terms of pounds or sacks of oyster shell stock or cases/boxes of PHP oysters on an hourly, per shift, daily, weekly, and monthly basis. The stochastic individual plant monthly PHP capacity was measured as follows:

$$\text{PLANT} = [\text{POUNDS x HOURS x SHIFTS x DAYS}],$$

where PLANT = individual plant PHP capacity per month,

POUNDS = equivalent pounds of shellstock processed per hour,

HOURS = number of hours operating per shift,

SHIFTS = number of shifts operating per day,

DAYS = number of days operating per month.

The state-wide PHP capacity was computed from the individual processing capacity of every PHP plant located in the state. The state percent PHP capacity was measured as follows:

$$\text{STATE} = \sum \text{PLANTS} / \text{LANDINGS x 100},$$

where STATE = percent of state PHP capacity per month,

∑PLANTS = sum of the PHP capacity per month of all plants operating in the state,

LANDINGS = state oyster landings in equivalent pounds of shellstock per month.

The region-wide PHP capacity was calculated from the individual processing capacity of all PHP plants located in the GOM region. The regional percent PHP capacity was estimated as follows:

$$REGION = \sum PLANTS / LANDINGS \times 100,$$

where REGION = percent of region PHP capacity per month,

∑PLANTS = sum of the PHP capacity per month of all plants operating in the region,

LANDINGS = regional oyster landings in equivalent pounds of shellstock per month.

The region-wide PHP capacity fluctuated from month to month due the differences in the operating periods of different PHP systems (Fig. 6). All of the IQF plants operate for about six months during colder months due to differences in the quality of oysters between seasons. The IQF plants generally do not operate between May and October due to market dislike for summer IQF raw oysters. The HCP, HHP and LDI can operate year-round depending on the availability of shellstock, storage space, and market demand for raw oysters.

The combined GOM states PHP capacity averaged about 43 percent of the region's oyster landings during the recent five years. When the monthly landings are broken down by individual states and linked with the regional dispersion of existing PHP plants, a complex transportation problem emerges among the individual states and oyster processors, wholesalers and distributors. The regional dispersal of the plants and the monthly differences in the volumes of oyster landings in individual states present a major challenge to the industry to supply its markets and reduce transportation costs from sources, plants and to market destinations. As a result of the regional dispersal of facilities, some states have low monthly PHP capacities. The level of analysis of PHP capacity, however, was limited to regional in scope since in some states the number of PHP plants were less than three plants.

In order to comply with the proposed FDA regulations that will require postharvest processing of all oysters harvested from the GOM states from April 1 to October 1, the combined PHP capacity in the GOM region will need to be increased by two to three times the present capacity. The oyster processors serving the current and future markets for raw oyster consumption have the options of expanding their existing PHP capacities within the region or accessing PHP capacities in nearby regions. Expanding plant capacities using alternative PHP systems have complicated compliance implications. Each new plant location, equipment, workers and new owners using PHP systems have to undergo a thorough FDA approved validation process. The validation process requires technical expertise and takes time to be completed.

The short-term alternative that oyster processors can undertake to double PHP capacity is by increasing the number of shifts from one to two shifts per day and increasing the number of processing days. This alternative will require additional manpower to be recruited, trained and validated. The logistics involved in the procuring, preparing, processing, storing and transporting the additional shellstock will increase the need for additional operating capital, equipment and storage space. The increased usage of the plant equipment will add more to the annual costs of repair and maintenance. The doubling of the number of daily shifts in all PHP facilities in the GOM region, however, will provide adequate PHP capacity during some colder months but will still be inadequate mostly during the warmer months (Fig. 7).

The expansion in capacities by accessing excess capacities within the region and nearby regions requires the transport of suitable oyster shellstock from the base plants to the PHP plants, to storage facilities and to final market destinations. These tasks can be accomplished by buying and operating refrigerated trucks or by hiring refrigerated trucking space. Additional building space and manpower will be required to handle the preparation of additional incoming shellstock for further postharvest processing in distant facilities. These activities will require additional capital investment, and operating capital. At the current investment climate, would investors and processors be able to access sufficient funds to finance these investment decisions? Will there be enough manpower to operate these additional PHP capacities?

The expansion in existing PHP capacities in current locations or nearby locations will require construction and operation of additional PHP facilities. These activities will require additional capital investment, and operating capital to handle the additional volume of oyster shellstock. These added capacities would also require the hiring, training and validation of new workers.

The marketing issue that every oyster processor, wholesaler and distributor would like to consider in making these complicated investment decisions would be that given these added PHP capacities, will there be markets for the added supply of PHP raw oysters? What are the markets shifts that can be expected when added PHP oysters are brought into the PHP pipelines?

RAW OYSTER MARKET SEGMENTS

To better understand the characteristics, needs and demographics of consumers and non-consumers of raw oyster products, market segmentation analysis was conducted to identify the specific oyster consuming market segments in oyster producing and consuming regions (Jepson and Jamison, 2007; Posadas, 2007; Posadas et al., 2011; Posadas and Posadas, 2011). The geographical locations included in different market segments for PHP raw oyster products were

Coastal Mississippi and Southern California. Data were collected from personal and telephone interviews of consumers in the two regions and used to develop market segments for PHP raw oyster products.

The willingness to buy models were estimated using survey results with the dependent variable consisting of a scale or binary variable stating interest in buying or willingness to buy PHP raw oyster products. The empirical models were estimated by using logit and tobit methods with the binary or scale variable stating the respondent's willingness to buy as the dependent variable. The choice of logit and tobit methods was prompted by the type of data used in estimating the models since the dependent variable consisted of binary or scale variable.

The segmentation analysis indicated several variables may have an influence upon an individual's willingness to buy PHP oysters (Table 1). For most individuals in the study, price did not seem to be a factor in willingness to buy a PHP product. There was some indication that those with higher education were more willing to buy PHP products as were those who were in the upper income brackets. There was slight evidence that males were more willing to buy PHP product.

Seafood markets seemed to be the preferred source of product with oyster bars being preferred in some instances. While race did not seem to affect willingness to buy, age did seem to play a role with older individuals less willing to purchase PHP product. Residence did seem important as residents from Pascagoula, Mississippi were also less willing to buy PHP products. Respondents who viewed the appearance, smell and taste of oysters adversely were less willing to buy PHP.

Those who had health and safety concerns about raw oysters were also less likely to buy PHP oysters. For those respondents who perceived raw oysters to taste good and were fun to eat, their willingness to buy was positively enhanced. Respondents who were aware of the health risks and methods to reduce risks seem to be positively influenced in their willingness to buy PHP products.

The results of the segmentation analysis also showed that those individuals who were aware of the risks and methods for reducing them seem to be more willing to buy product that addresses those risks. This perception of risks strengthened the continued need for education campaigns to identify the risks and ways to reduce them to the oyster consuming public. Those individuals with higher income and those with more education are one market segment that seems to be more willing to buy PHP products among those who participated in the surveys. However, older respondents and those from Pascagoula were less willing to buy PHP oyster products.

It is recommended that further research into these issues and other geographical locations are needed to provide more details as to why these market segments are averse to buying PHP products. The need for additional research on consumers willingness to buy raw oyster products was further reinforced in order to better understand their perceptions of safety and willingness to consume seafood products harvested from the GOM states especially after the Deepwater Horizon oil spill. Earlier studies conducted by Swartz and Starnd (1981) showed that negative media coverage about the kepone incidence in the James River significantly reduced demand for safe oysters from the Baltimore area. The massive media coverage of the oil spill have surely created conflicting perceptions about the safety of Gulf seafood including raw oysters.

SUMMARY AND IMPLICATIONS

Even before the Deepwater Horizon oil spill, the Gulf of Mexico oyster processing sector had been confronted by proposed federal regulations to postharvest process oysters harvested from the region's growing waters between April 1 and October 1. The damages of the oil spill to the region's oyster resources and the negative market perceptions of the safety of oyster products harvested from the Gulf waters added more to the uncertain future of the oyster industry. The risk and uncertainty besetting the oyster processing sector due to the combined pressures from recent natural disasters, economic recession, and massive oil spill have made it extremely difficult for them to make investment decisions about their postharvest processing capacities in response to the proposed federal regulations.

On aggregate terms, the region's oyster processing sector has limited alternatives to effectively address the proposed regulations. These economic alternatives require decisions to invest in additional postharvest processing, storage, and transport capacities which are dependent on the uncertain recovery of the region's oyster resources. It is recommended that detailed assessments of the postharvest processing capacities of individual plants and states be implemented in order to better understand the responses of processing plants to the proposed federal regulations and recent disasters.

Marketing decisions are also risky since the markets for oyster products have been adversely affected by the negative market perceptions about their safety. It is recommended that additional research on willingness to buy in broader geographical locations be conducted in order to better understand perceptions of safety and willingness to consume seafood products harvested from the Gulf states especially after the Deepwater Horizon oil spill.

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Table 1. Factors Affecting Willingness to Buy Postharvest Processed Oysters

Decision Attribute	Price	Education	Gender	Income	Age	Race	Residence	Appearance Gritty Slimy Taste Bad Smell	Taste good Fun to eat Aphrodisiac	Preferred Place of Purchase	Health & Safety Concerns	Aware of Health Risks	Known Methods to Reduce Risks
Buy HHP (Survey)	↓	-	-	↑ 60-80K	30-39↑ 50 up↓	-	MS ↓	-	↑	Seafood market	↑	↑	↑
Buy HHP (Interview)	-	-	-	↑ 75K up	-	-	-	↓	-	Seafood market	↓	-	-
Buy HCP (Survey)	-	↑ Some College	-	↑ 40-59K	50 up ↓	Caucasian, African American↓	MS ↓	-	↑	-	-	-	↑
Buy HCP (Interview)	-	-	↑ Males	↑ 100K up	-	-	-	↓	-	-	↓	-	-
Buy IQF (Survey)	-	↑ College Degree	-	-	59 up ↓	-	MS ↓	-	↑	Oyster bars Seafood market	↓	-	↑
Buy IQF (Interview)	-	-	-	↑ 100K up	-	↑ Hispanic	↑ MS	↓	-	Seafood market	↓	-	-

Sources: Jepson and Jamison, 2007; Posadas, 2007.

Figure 1. Shellfish-related *Vibrio vulnificus* cases and death. Source: Personal communication from the Food and Drug Administration.

Figure 2. Regional GOM states monthly oyster landings, in pounds of meat, 2005-2009. Source of raw data: Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, MD.

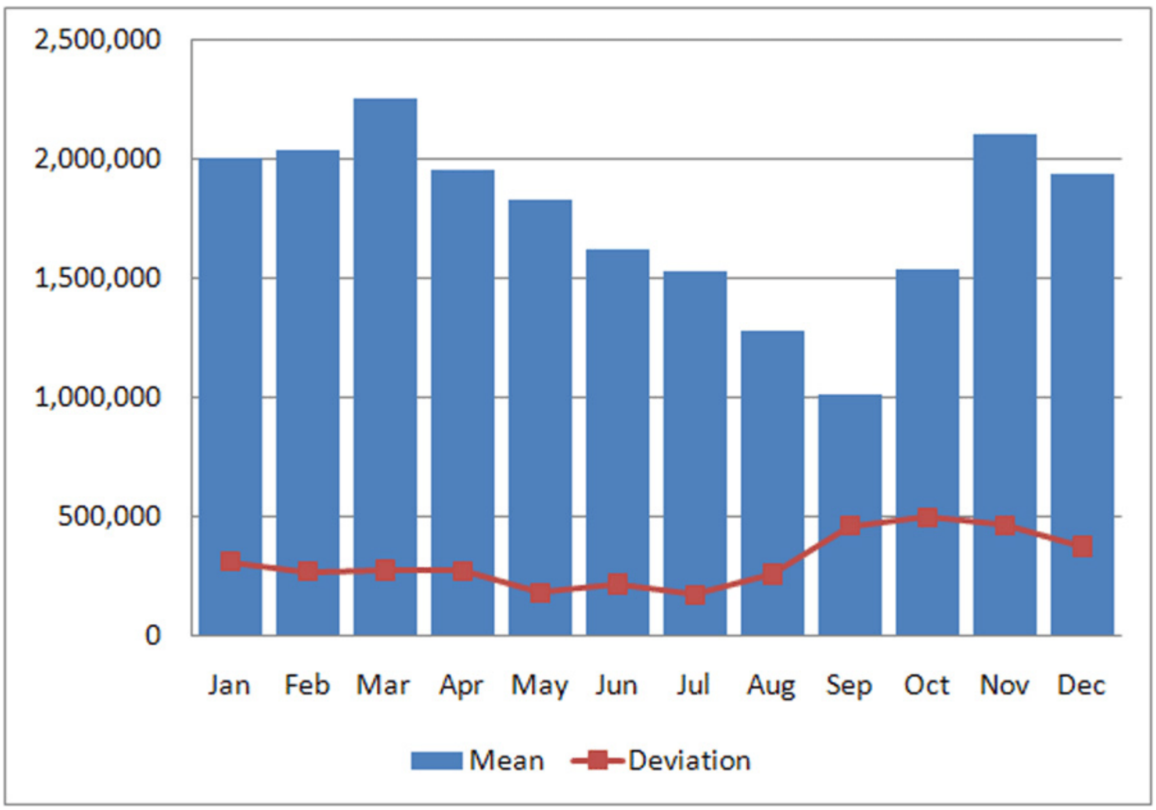

Figure 3. CDF approximations of NPV for HCP system

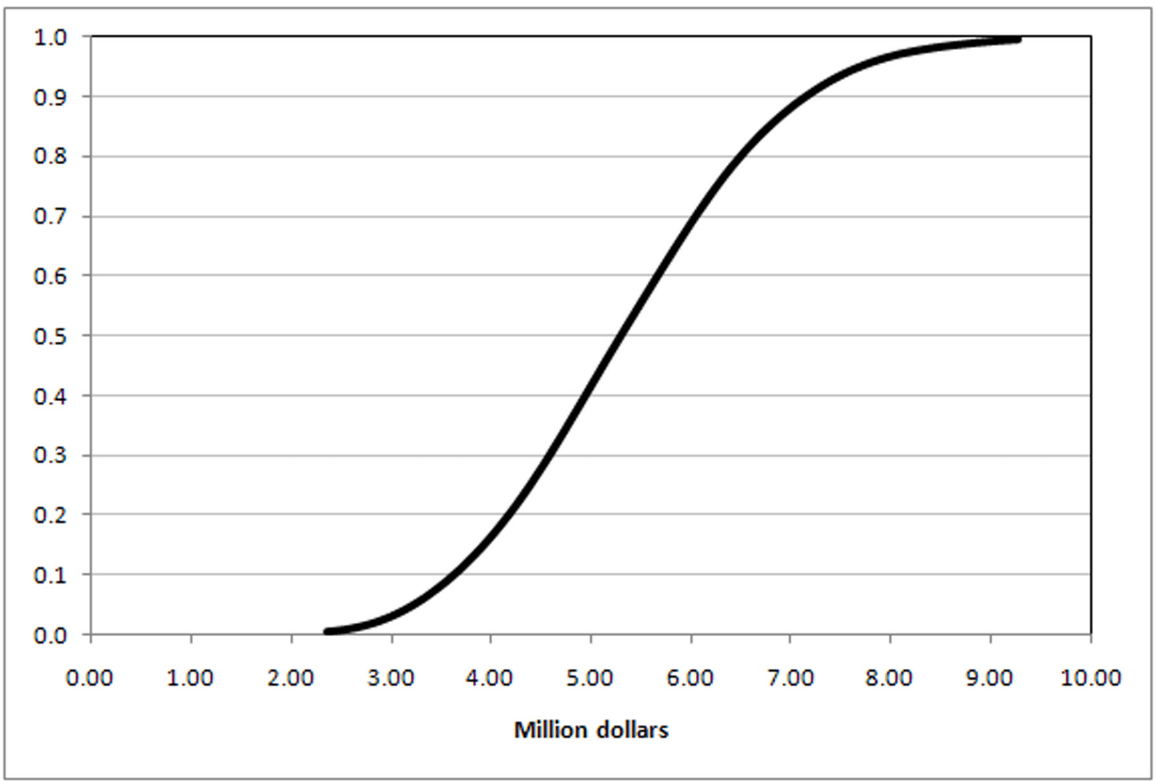

Figure 4. CDF approximations of NPV for HHP system

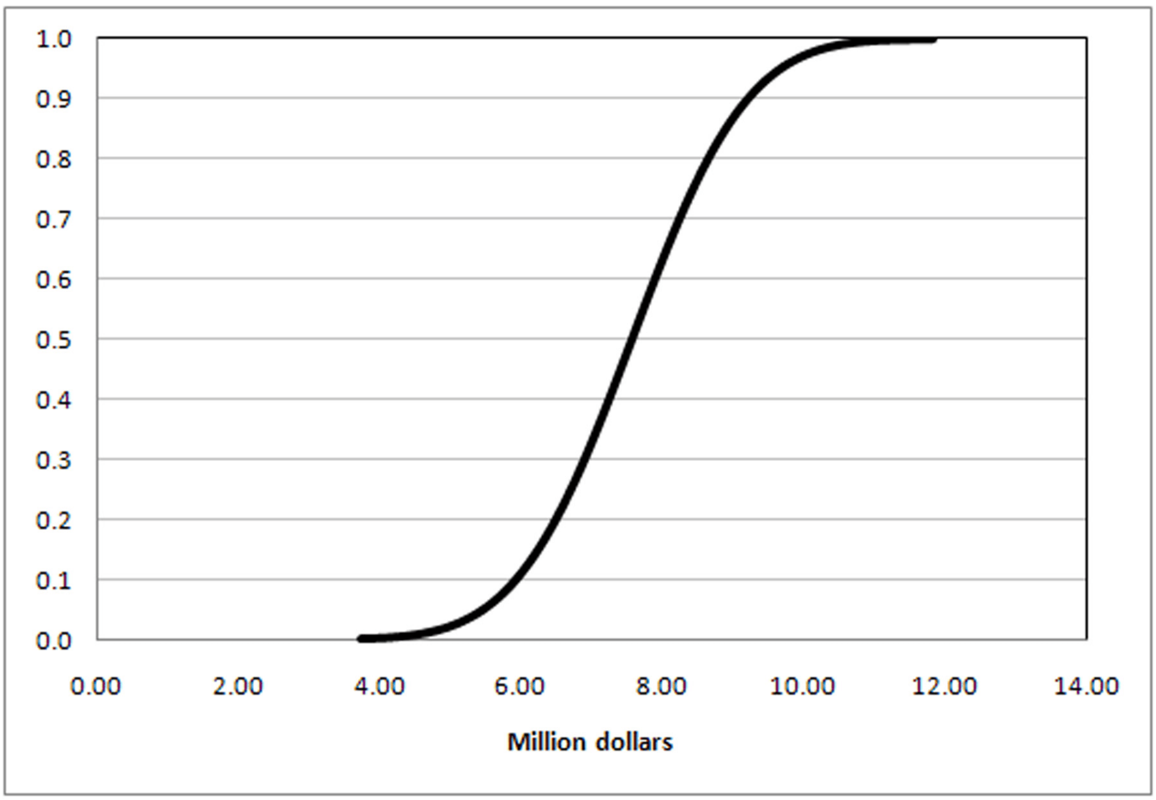

Figure 5. CDF approximations of NPV for IQF system

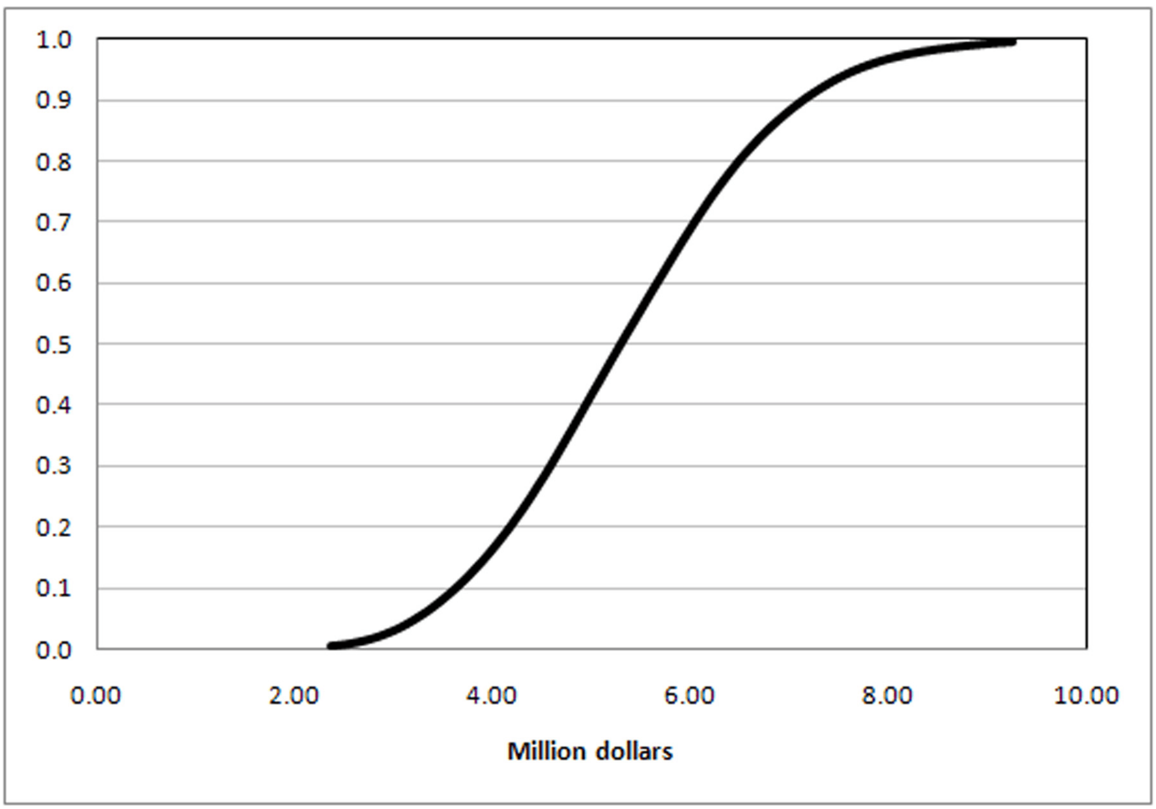

Figure 6. Estimated monthly combined GOM states PHP capacity with one processing shift per day

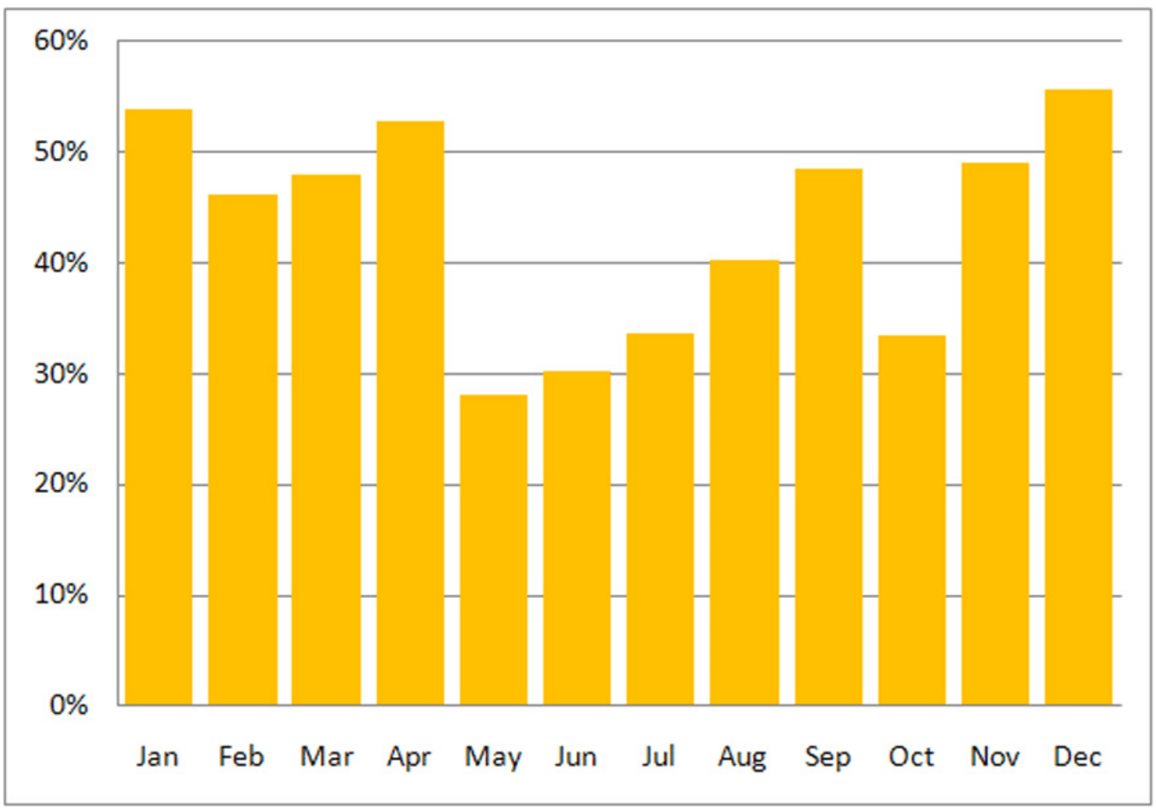

Figure 7. Estimated monthly combined GOM states PHP capacity with two processing shifts per day