March 2000

Economic Impacts of Requiring Post-Harvest Treatment of Oysters

Final Report

Prepared for

Interstate Shellfish Sanitation Conference
115 Atrium Way, Suite 117
Columbia, SC 29223

Prepared by

Mary K. Muth
Donald W. Anderson
Shawn A. Karns
Brian C. Murray
Jean L. Domanico
Research Triangle Institute
Center for Economics Research
Research Triangle Park, NC 27709

RTI Project Number 7466.000

RTI Project Number
7466.000

Economic Impacts of Requiring Post-Harvest Treatment of Oysters

Final Report

March 2000

Prepared for

Interstate Shellfish Sanitation Conference
115 Atrium Way, Suite 117
Columbia, SC 29223

Prepared by

Mary K. Muth
Donald W. Anderson
Shawn A. Karns
Brian C. Murray
Jean L. Domanico
Research Triangle Institute
Center for Economics Research
Research Triangle Park, NC 27709

DISCLAIMER

The results presented in this report are based on data and information provided by the companies that currently operate post-harvest treatment processes for oysters in their plants. The use or mention of any trade names, commercial products, or company names in this report does not constitute an endorsement or recommendation for use by Research Triangle Institute (RTI). Furthermore, RTI has no opinion on whether post-harvest treatment of oysters should be required, nor, if treatment was required, on which products in which regions should be included in a requirement.

Acknowledgements

We would like to acknowledge the contributions of Tayler Bingham, Sheryl Cates, Becky Durocher, and Heather Carter-Young at RTI and David Zorn at the Food and Drug Administration for providing insight on development of the economic model, assisting in the industry surveys and taste tests, and reviewing sections of the draft report. In addition, we would like to acknowledge the efforts of Susan Murchie in editing and preparing this report.

Contents

Appendix

Figures

Tables

Executive Summary

Three post-harvest treatment technologies for oysters, all of which are currently in use in Gulf region plants, eliminate *V. vulnificus* and may potentially result in reduced processing costs for shucked oysters and greater storability of raw halfshell oysters.

Research Triangle Institute (RTI) evaluated the economic impacts of requiring post-harvest treatment of oysters intended for the raw halfshell and shucked markets both for the Gulf region and for the entire United States. In considering the effects of treatment requirements, we evaluated three treatment technologies currently in use in the Gulf region that reduce the risks of consumers becoming infected with *Vibrio vulnificus* from consuming either raw halfshell or shucked oysters. These treatment technologies, which may also potentially reduce the levels of *Vibrio parahaemolyticus* in oysters, are the following: cryogenic individual quick freezing (IQF), a mild thermal process referred to as cool pasteurization, and hydrostatic pressure. In our economic analysis, we considered treatment requirement scenarios that included the Gulf only versus the entire United States and raw halfshell product only versus both raw halfshell and shucked product.

Based on our research findings, it appears that if post-harvest treatment was required for both raw halfshell and shucked oysters, the requirements would accelerate a process of technology adoption that is already beginning to occur in the industry. Some producers are becoming interested in these technologies not only because they eliminate *V. vulnificus*, but also because they may result in additional benefits such as reduced processing costs for shucked oysters or greater storability. However, a number of unresolved issues remain including

- whether small plants with low processing volumes and possibly limited resources would find it feasible to install treatment equipment,
- whether central treatment facilities would be able to provide treatment services to companies unable to install treatment equipment,
- whether the treatment processes would be adaptable to species of oysters other than the Eastern oyster (*Crassotrea virginica*), and
- how different types of consumers would ultimately react toward treated oysters.

E.1 SUPPLY-SIDE EFFECTS OF TREATMENT

Supply-side effects of treatment include the costs of the process and the feasibility of the technologies for individual plants.

RTI evaluated the supply-side effects of three post-harvest treatment technologies that are currently used in a few Gulf region plants that handle Eastern oysters. The cryogenic IQF process is currently used only for raw halfshell oysters, but the cool pasteurization and hydrostatic pressure processes are used for both raw halfshell and shucked oysters.

The costs of post-harvest treatment, which we use in the economic model as a proxy for the shift in supply of halfshell and shucked oysters as a result of treatment requirements, include annualized plant expansion costs, annualized capital equipment and installation costs, annual operating and maintenance costs, and per-unit royalties charged by the owners of the proprietary technologies. For two of the technologies we evaluated, the costs of the process for shucked oysters will be potentially offset by reduced shucking labor requirements and increased shucked oyster yields for plants that shuck oysters. Depending on the technology and the region of the country, the cost estimates for treatment of raw halfshell oysters range from 3.3 to 17.7 cents per oyster, and the cost estimates for treatment of shucked oysters range from –2.9 to 0.2 cents per oyster.

In addition to these costs, the feasibility of these treatment processes for individual plants will depend on whether a plant has the following: adequate space for installing treatment equipment, financial resources to purchase treatment equipment, sufficient volume of product relative to the size of the treatment equipment, and adequate technical capabilities to operate the treatment equipment. Central treatment facilities may potentially provide treatment services to plants unable to install their own treatment equipment. Whether the use of such facilities will be feasible for individual plants will depend on where the facilities would be located, who would build and operate the facilities, and how treatment services would be allocated to individual producers.

E.2 DEMAND-SIDE EFFECTS OF TREATMENT

> Demand-side effects of post-harvest treatment include (1) consumer reaction to changes in oyster prices and sensory and safety characteristics and (2) restaurant manager reaction to liability concerns and changes in quality characteristics.

RTI evaluated the potential demand-side effects of each of the post-harvest treatment technologies currently in use. In considering these demand-side effects, we conducted taste tests of treated oysters, interviewed restaurant managers regarding their perceptions of treated oysters, and interviewed the companies that currently market treated oysters. Participants in the taste tests of treated oysters in New Orleans, who normally eat raw oysters three or more times per year, indicated that if only treated oysters were available and treated oysters retailed for $1 to $2 more per dozen than untreated oysters, they would reduce the number of times they consume oysters per year by one-third to one-half. A small scale survey of 20 restaurant managers indicated the following:

- three of six restaurants that serve cooked oysters are at least somewhat likely to serve treated oysters, but the other three were either somewhat unlikely or unlikely;
- six of seven restaurants that serve untreated raw oysters expect that treatment would have no effect on sales if only treated oysters were available and treated oysters retailed for $1 more per dozen; and
- six of seven restaurants that currently serve either cool pasteurized or cryogenic IQF oysters report that their patrons do not seem to have noticed a difference in the oysters served.

Finally, all three companies report that they obtain higher prices for treated oysters relative to untreated oysters both because of increased safety and other quality-related characteristics of treated oysters. Specifically, the companies that produce oysters treated by cool pasteurization and by hydrostatic pressure report that they obtain prices of 10 to 20 percent more for both shucked and raw halfshell oysters that have been treated by their processes. The company that produces oysters treated by the cryogenic IQF process reports that it obtains approximately one-third more for treated raw halfshell oysters.

E.3 ESTIMATED ECONOMIC EFFECTS OF TREATMENT REQUIREMENTS

We combine supply-side and demand-side effects of post-harvest treatment requirements in an economic model of the oyster industry to estimate the effects on prices, volumes, revenues, costs, and employment.

Post-harvest treatment requirements would affect the wholesale (processing sector) markets for halfshell and shucked oysters both because of the costs of conducting post-harvest treatment activities (supply shifts) and the effects of post-harvest treatment on demand (demand shifts). We developed an interregional comparative statics model to estimate the effects of post-harvest treatment requirements under scenarios that include the Gulf only versus the entire United States and include supply shifts only versus supply and demand shifts. We considered these scenarios assuming first, that all producers would use the cool pasteurization process, and then second, that all producers would use the hydrostatic pressure process. We did not consider these scenarios assuming that producers would use the cryogenic IQF process because it appears that a company faced with a post-harvest treatment requirement is unlikely to consider IQF as an option.

In general, the overall economic effects of treatment requirements are greatest if requirements apply to the entire United States, rather than to only the Gulf region, and if demand shifts are included in the model in addition to supply shifts. Even when requirements are applied only to the Gulf, some effects occur in other regions because of the interregional shipment of oysters between regions. If requirements apply to the entire United States, prices and volumes are affected similarly across regions, except in the Northeast because the region shucks few oysters and thus would not experience the benefits of the treatment processes for shucked oysters.

Depending on the treatment requirement scenario, industry-wide treatment costs total a minimum of $14 million for the cool pasteurization treatment process and treatment savings total a minimum of $2 million for the hydrostatic pressure process. If demand shifts are included in the model in addition to supply shifts, then producers appear to benefit in the case of either treatment technology because revenues are estimated to rise more than the increase in costs associated with the treatment technologies.

If treatment requirements were to apply to only raw halfshell product processed in the Gulf, the results of the model differ from those presented above. However, due to the potential benefits of two of these processes for shucked oysters, producers that shuck oysters would likely use these processes for shucked oysters in addition to halfshell oysters and thus would treat shucked oysters even if not required to do so.

The economic model addresses the industry-wide effects but not the individual plant effects of post-harvest treatment requirements. Plants may shut down as a result of treatment requirements because either the revenue of the plant is not sufficient to cover its production costs plus the costs of treatment, or because it is technically infeasible for the plant to install treatment equipment. In particular, we know that the oyster industry is characterized by many small operations that may not have the resources or the management capacity to install and maintain treatment equipment. We can only speculate at this time on the extent to which central treatment facilities could provide treatment services to these plants.

E.4 QUALIFICATIONS OF THE ANALYSIS

Limitations of the analysis arise from the availability of data on the oyster industry, costs of post-harvest treatment, and demand effects of post-harvest treatment.

The analysis of the economic effects of requiring post-harvest treatment of oysters presented here was subject to several limitations. While we qualify the limitations throughout the report, we describe the basic categories of limitations here because an understanding of each will assist the reader in using the information presented and because they suggest future areas of research that may be of interest.

Baseline oyster industry data. Because of limitations in the data on oyster harvests, raw halfshell processing volumes and prices, and proportion of oysters to each of the raw halfshell and shucked product markets, we used available information from the National Marine Fisheries Service and from individuals in the industry to construct our best estimate of the baseline oyster industry data. In addition, because information on the product types and volumes produced by individual oyster plants was not available, our economic model methodology is based on the aggregate industry data.

Data on post-harvest treatment costs. The best available source of data on the actual costs of the treatment technologies is the companies that currently operate these processes. While we believe this information was provided to us in good faith, we acknowledge that the owners of the proprietary technologies for cool pasteurization and hydrostatic pressure have a financial stake in the perceptions of their technologies because they will collect royalties from other companies that adopt them. Furthermore, these companies are all located in the Gulf and thus far have only commercially applied the technologies to Eastern oysters.

Data on consumer acceptance of treated oysters. Because consumer acceptance data are costly and time-intensive to collect, our methodologies provide us with somewhat preliminary information on consumer acceptance of treated oysters. Specifically, the results of the taste tests for treated oysters provide us with information for only frequent oyster consumers in the Gulf region. The restaurant managers' survey was limited to a few metropolitan areas, and we were only able to obtain the names of restaurants that currently serve treated oysters from the companies that service these restaurants or by their distributors. Finally, the increased prices received for treated oysters as stated by the companies that currently market treated oysters are difficult to verify.

Economic impacts modeling methodology. Because we do not know the characteristics of individual plants, we adopted an aggregate industry economic model methodology. Thus, the model cannot predict which plants, if faced with a post-harvest treatment requirement, would adopt which technologies and which plants may potentially close instead of installing treatment equipment. If individual plant data were available, the economic model could more quantitatively address the effects of treatment requirements on individual plants.

E.5 POTENTIAL FUTURE RESEARCH

While we qualitatively address some of the limitations of the current analysis, it may be of interest to pursue additional areas of research to better estimate the effects of post-harvest treatment requirements. In particular, the following areas likely yield the greatest additional benefits:

- additional data on the characteristics of individual oyster plants including their products and volumes, physical sizes, numbers of employees, and proportion of oyster products to each of the raw halfshell and shucked markets;
- additional independently verified information on the costs of treatment for individual plants based on their characteristics;
- further evaluation of the feasibility of central treatment facilities including where they would be located, who would operate them, and the logistics of their use;
- further evaluation of consumer acceptance of treated oysters, including consumers in other regions of the country and for other species of oysters;
- further evaluation of the shelf-life of treated oysters and whether consumer acceptance of treated oysters is affected by shelf-life considerations; and
- the effect of higher wholesale costs for treated oysters on restaurant and retail prices.

1 Introduction

RTI evaluated the economic impacts of post-harvest treatment requirements for raw halfshell and shucked oysters both for the Gulf region and for the entire United States.

Research Triangle Institute (RTI) conducted a study of the economic impacts of requiring post-harvest treatment of oysters intended for the raw halfshell and shucked markets. In the analysis, RTI considered the following treatment requirement scenarios:

- requirements throughout the **United States**, for both **shucked** and **raw halfshell** oysters;
- requirements in the **Gulf only**, for both **shucked** and **raw halfshell** oysters; and
- requirements in the **Gulf only**, for **raw halfshell** oysters only.

If post-harvest treatment was required for both halfshell and shucked oysters, the requirements would accelerate a process of technology adoption that is already beginning to occur in the industry.

In considering the effects of treatment requirements, RTI evaluated the following three treatment technologies that reduce the risks of consumers becoming infected with *Vibrio vulnificus* from consuming either raw halfshell or shucked oysters: cryogenic individual quick freezing (IQF), a mild thermal process referred to as cool pasteurization, and hydrostatic pressure. These treatment technologies may also potentially reduce the levels of *Vibrio parahaemolyticus* in oysters, but verification data demonstrating this effect are currently unavailable or in the review process with state and federal regulatory agencies.

Based on our research findings, it appears that if post-harvest treatment was required for both raw halfshell and shucked oysters, the requirements would accelerate a process of technology adoption that is already beginning to occur in the industry. Some plants that handle and process oysters are becoming interested in using post-harvest treatment technologies because the processes eliminate *V. vulnificus* and result in additional benefits to the plants. Specifically, oysters treated by the cryogenic IQF process can be stored for several months so that better-quality winter-harvested oysters can be made available during other times of the year and in places where it would not otherwise be feasible to supply halfshell oysters. Oysters treated by the hydrostatic pressure process and the cool pasteurization process have higher shucking yields than untreated oysters. Finally, oysters treated by the hydrostatic pressure process also are more easily shucked resulting in a large reduction in the number of needed shuckers, who are in short supply in most areas of the country.

Two potential impediments to requiring post-harvest treatment of oysters are that small plants may not have the resources required to install and operate treatment equipment, and, if requirements apply to all of the United States, the processes we evaluated have only been applied to the Eastern oyster.

However, the capital equipment and plant modifications for these treatment processes are costly. In particular, small plants may not have the financial resources to invest in the required capital equipment, sufficient volume of product to make the process economically viable, or sufficient technical capabilities to operate the process. While central treatment facilities could potentially provide treatment services to small plants, there are a number of issues that would affect their feasibility for individual plants:

- where the facilities would be located, which affects the distance that oysters would need to be shipped for treatment;
- who would build and operate the facilities, which affects how much producers would be charged for treatment services; and
- how treatment services would be allocated to individual producers, especially during the peak harvest seasons.

The use of central treatment facilities would result in additional transportation costs, which may be substantial, in transporting oysters to and from the facility; thus, the producers that would use these facilities would incur a greater cost burden than plants that install their own treatment equipment.

Thus far, these processes have been applied only to the species of oyster *Crassostrea virginica*, which is commonly known as the Atlantic or Eastern oyster. This species of oyster is produced throughout the Gulf region and most of the Atlantic seaboard. If treatment requirements were imposed for areas outside the Gulf, the treatment technologies we evaluated must be determined to be suitable for other species. These other species include the following:

- the Pacific oyster (*Crassostrea gigas*) produced on the Pacific coast,
- the Kumamota oyster (*Crassostrea sikamea*) produced primarily on the Pacific coast,
- the Olympia oyster (*Ostrea lurida*) produced in the Northwest, and
- the European flat oyster (*Ostrea edulis*) produced both in the Northwest and Northeast.

Because these oyster species differ in size and shape from the Eastern oyster, we do not yet know whether the treatment processes would (1) eliminate the *V. vulnificus* bacteria and (2) result in acceptable product characteristics following treatment.

> The economic model estimates the quantitative effects of Gulf-only and U.S. treatment requirements for raw halfshell and shucked oysters. We also address how these results would differ for Gulf-only, raw halfshell-only treatment requirements.

In the economic model presented in this report, we estimated the effects of both Gulf-only and U.S. requirements for raw halfshell and shucked oysters. For tractibility of the model, we assumed that (1) the per-unit costs of treatment would be the same across plants, and (2) the treatment processes would be acceptable for all oyster species. We estimated the effects of treatment requirements assuming that the processes affect only the costs of producing oysters and both the costs of producing oysters and the demand for oysters. For each treatment scenario, we estimated changes in the

- raw halfshell, shucked, and shellstock prices and volumes;
- raw halfshell and shucked revenues and shellstock costs;
- treatment process costs or savings; and
- full-time equivalent plant employment.

The complete assumptions and results of the economic model for each treatment requirement scenario are summarized in Section 5 and detailed in Appendix B. In addition to the numerical results of the model, we also address qualitatively how the results would differ if treatment requirements applied only to raw halfshell oysters processed in the Gulf or if Gulf-harvested oysters were required to be treated prior to shipment from the Gulf.

We used a variety of information sources to conduct our analysis including both primary and secondary data sources. We would like to acknowledge the assistance of Steve Koplin at the National Marine Fisheries Service (NMFS) for providing data and insight on the oyster industry. We would also like to acknowledge the following individuals who provided information about the treatment processes currently in place in their plants:

- Clifford Hillman, Hillman Shrimp and Oyster Company, Dickinson, Texas (IQF process);
- John Schegan, Pat Fahey, and John Tesvich, AmeriPure Oyster Companies, Kenner, Louisiana (cool pasteurization process); and
- Mike Voisin, Motivatit Seafoods, Inc., Houma, Louisiana (hydrostatic pressure process).

Finally, we would like to thank the following individuals for providing insight on the characteristics of the oyster industry in their regions:

- Richard Daiger, industry consultant, Kinsale, Virginia;
- Bill Dewey, Taylor Shellfish Company, Shelton, Washington;
- Steve Fleetwood, Bivalve Packing Company, Inc., Port Norris, New Jersey;
- Lori Howell, Spinney Creek Shellfish, Inc., Eliot, Maine;
- Chris Nelson, Bon Secour Fisheries, Inc., Bon Secour, Alabama; and
- Karen Oertel, W.H. Harris Seafood, Inc., Grasonville, Maryland.

However, the findings in this report are not intended to reflect their views and opinions on post-harvest treatment of oysters.

In the remainder of this section, we provide background information on the *Vibrio* problem in the oyster industry and an overview of the contents of the report.

1.1 BACKGROUND

On June 29, 1998, the Center for Science in the Public Interest (CSPI) petitioned the Food and Drug Administration (FDA) to establish a regulation requiring nondetectable levels of *V. vulnificus* in oysters harvested from waters that have been linked to illnesses and deaths from these bacteria (CSPI, 1998). The petition notes the availability of a cool pasteurization process that can reduce the number of *V. vulnificus* bacteria to nondetectable levels. Although it was not noted in the petition, a cryogenic IQF process that reduces the number of *V. vulnificus* bacteria to nondetectable

> The Center for Science in the Public Interest (CSPI) petitioned FDA to establish a regulation requiring nondetectable levels of *Vibrio vulnificus* in oysters.

levels has been in use for some time. Since the time of the petition, a third treatment process—hydrostatic pressure—has also been developed.

The petition claims that to reduce *V. vulnificus* to nondetectable levels, treatment controls would need to be mandated year-round in affected areas. It claims that although most cases of *V. vulnificus* occur from oysters harvested from the Gulf region (Alabama, Florida, Louisiana, Mississippi, and Texas), a few cases occur from oysters harvested from the Northeast (Connecticut and New York) and Northwest (Washington state). Because *V. vulnificus* cases occur in many regions of the country, the petition suggests mandating treatment of shellfish harvested from waters linked to *V. vulnificus*.

In addition to controlling *V. vulnificus*, these treatments may potentially reduce the levels of *V. parahaemolyticus*. Although illnesses associated with *V. parahaemolyticus* are less severe and less likely to result in mortality, they occur with more frequency than illnesses from *V. vulnificus* throughout all regions of the United States.

CSPI claims in the petition that previous attempts to control *V. vulnificus* have been unsuccessful. Consumer education programs have been unsuccessful because they have not reached at-risk consumers or because at-risk consumers are not aware that they have the health conditions that make them vulnerable. Product label warnings have not been successful because retailers do not always choose to display the label's message and because the text of the label does not effectively communicate the information that would bring about a behavioral change by consumers. Finally, refrigeration controls instituted in 1996 provide for an allowable time before refrigeration that is long enough to allow *V. vulnificus* to multiply to unsafe levels.

CSPI also claims that FDA has legal grounds to regulate post-harvest treatment of oysters through the following vehicles:

- Food, Drug, and Cosmetic Act: to treat *V. vulnificus* as a food adulterant or as an added poisonous or deleterious substance;
- Public Health Service Act: to prevent the spread of communicable diseases from an infected animal to a person; and

- Seafood HACCP: to treat *V. vulnificus* as a hazard to be controlled.

In addition to the issues raised in the petition, consumer perception issues may also influence decisions regarding post-harvest treatment. News reports of *Vibrio* outbreaks may decrease demand for halfshell oysters that have not been treated. Thus, the industry may be interested in considering treatment options to avoid negative publicity and the resulting effect on consumption.

Recently, the FDA issued a *Federal Register* notice requesting information and views on CSPI's petition and questions related to the petition (FDA, 1999). They requested comments related to the following eight issues:

1. the employability of and barriers to adoption of the AmeriPure cool pasteurization process;
2. the availability of other technologies, including their effect on sensory qualities and their ability to reduce *V. vulnificus* to nondetectable levels;
3. the reliability and employability of these alternative technologies;
4. whether a nondetectable level is necessary;
5. whether the standard should apply to other shellfish;
6. the effect on costs, including who would bear the costs;
7. the benefits of the performance standard; and
8. whether the performance standard should apply to other *Vibrio* species that post-harvest treatment might be able to reduce.

We evaluated the feasibility, employability, and costs of three post-harvest treatment technologies.

This report provides information on issues 1, 2, and 3 in that we describe three post-harvest treatment processes, how the treatment processes affect product handling and distribution, and the factors that plants will evaluate when considering post-harvest treatment options. In addition, the report addresses the effects of the performance standard on costs (issue 6).

1.2 REPORT OVERVIEW

This report is organized as follows. Section 2 provides a profile of the oyster industry, focusing particularly on the processing sector for both halfshell and shucked oysters, and provides industry data that are used in the economic analysis. Section 3 describes the costs and technical feasibility of three treatment options that were considered. Section 4 provides information on potential consumer acceptance of treated oysters based on taste tests, restaurant manager surveys, and plant interviews that we conducted. Section 5 provides the summarized results of the economic impact analysis for several treatment scenarios. The economic methodology is described in Appendix A, and the complete economic model results are presented in Appendix B.

1.3 REFERENCES

Center for Science in the Public Interest (CSPI). June 29, 1998. "Citizen Petition." Submitted to the Dockets Management Branch, FDA, HHS.

Food and Drug Administration (FDA). January 21, 1999. "Performance Standard for *Vibrio vulnificus*; Request for Comments." *Federal Register* 64(13):3300-3301.

2 Profile of the Oyster Industry

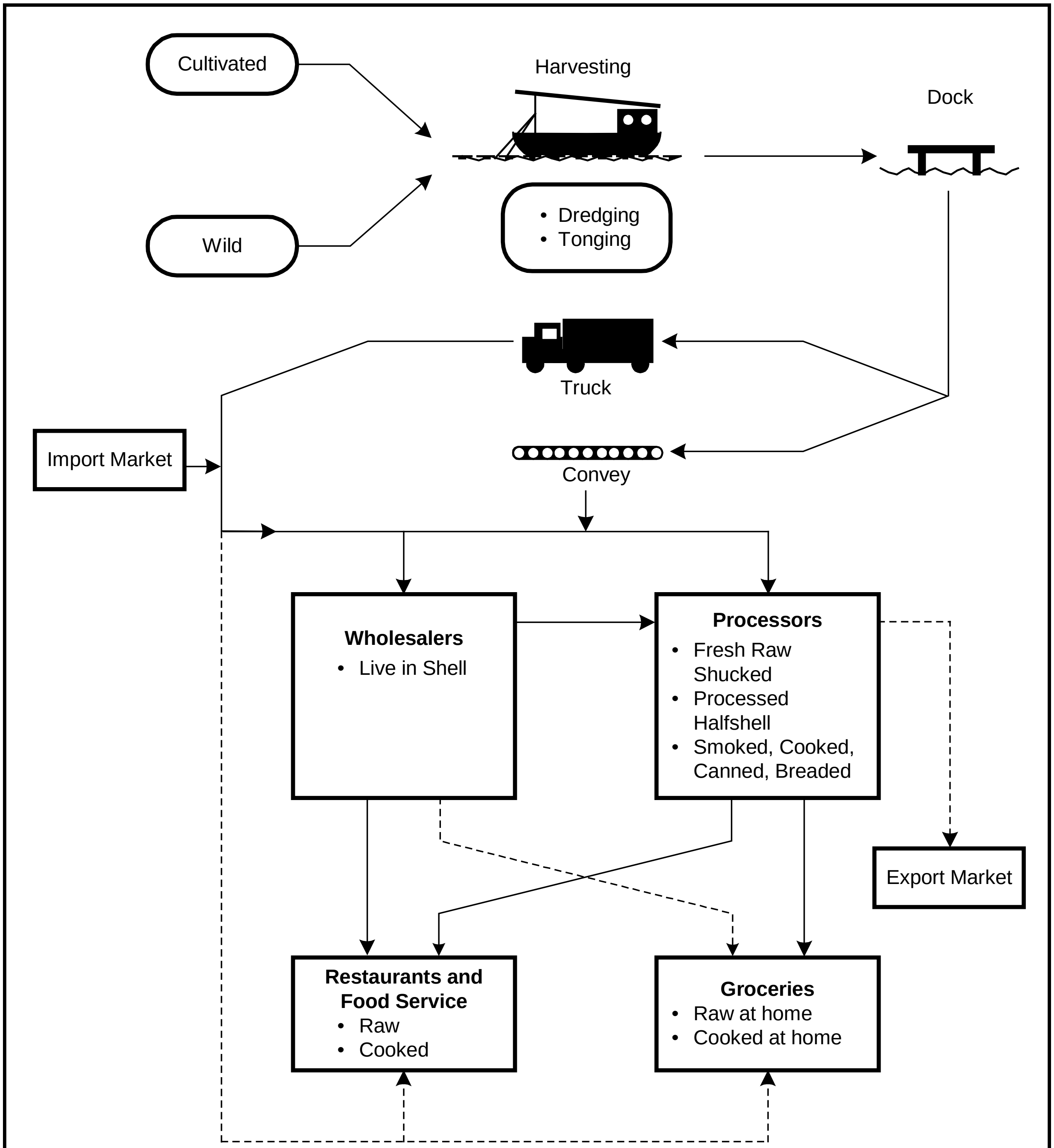
The industry profile identifies the stakeholders in the oyster industry, describes the factors affecting supply of and demand for oysters, and provides data on the industry.

The purpose of the industry profile is to identify the stakeholders in the industry that would potentially be affected by a post-harvest treatment requirement, describe the factors affecting supply and demand for oysters, and provide data on the industry to be used in the economic model. In this profile, we emphasize the processing and wholesale sector because the initial burden of installing and operating treatment equipment would most logically and likely fall on existing shellstock processors. Harvesters and consumers will also be affected indirectly, however, so we also describe them briefly.

Figure 2-1 provides an overview of the oyster industry from harvesting to final consumption. The figure is necessarily a simplification of the process. The actual movement of oysters from harvest-to-consumers may differ from that shown in Figure 2-1 in subtle or significant ways, especially from region-to-region, depending on laws and customs.

Essentially there are three main “sectors” in the oyster industry: harvesters, processors, and retailers. Harvesting operations, which can vary anywhere from purely “wild” harvesting to highly-managed cultivating operations, bring mature oysters from waters to wholesalers/processors. Some harvesters deliver oysters directly to restaurants or other retail outlets, but it is more common for harvesters to sell their oysters either to wholesalers or processors. Wholesalers may repack shellstock into sacks, boxes, or bushels and sell them to other wholesalers or to processors. Wholesalers may also sell shellstock directly to restaurants or retailers.

Figure 2-1. Oyster Harvesting, Processing, and Distribution
Post-harvest treatment activities will occur at oyster wholesaling and processing plants.



Note: Dashed lines indicate less common channels.

Wholesalers and processors are generally located near water's edge with loading docks for conveying oysters from the boats into refrigerated trucks. All dealers must be certified under the National Shellfish Sanitation Program (NSSP) in order to receive or ship any shellfish products in interstate commerce (Anderson et al., 1996).

The remainder of this section is organized as follows. Section 2.1 discusses the harvesting sector of the industry, which could be indirectly affected by post-harvest treatment requirements as the derived demand for oysters changes. Section 2.2 describes the processing sector of the industry, which would be most directly affected by post-harvest treatment requirements. Section 2.3 describes interregional and international trade for oysters because trade flows may be affected by treatment requirements. Finally, Section 2.4 describes the demand or consumer side of the industry.

2.1 HARVESTING

Post-harvest treatment requirements would be expected to most immediately and directly affect oyster processing companies as they work to comply with the requirements. Oyster harvesters could also be affected, however, as the "derived demand" for shellstock changes. This section provides basic information about oyster harvesting in the United States and presents harvest data used in our economic model.

Shellstock oysters can be either natural, "managed natural," or cultivated. Natural oysters grow and reproduce without human intervention in naturally occurring oyster beds. Managed natural oyster beds are tended by harvesters, even in the off season, mainly by raking the beds periodically to reduce clustering. Cultivated oysters are transported while immature to man-made beds where they are allowed to mature. In some regions of the United States, particularly the Northwest, nearly all shellstock oysters are produced on cultivated beds. In the Northeast, a significant portion of shellstock oysters are produced on cultivated beds but some are harvested from wild reefs. In areas such as the Gulf, the majority of shellstock oysters are harvested from wild reefs.

Any harvester-level regional effects of post-harvest treatment requirements will depend on many factors, including the importance of the oyster industry in the region. Table 2-1 presents

Table 2-1. Nationwide Oyster Harvests by State, 1997
Oyster harvests are reported for 20 states in four regions of the country.

Region	State	Meat-Weight Pounds	Value ($)	($/lb)
Atlantic	FL East Coast	37,560	$93,191	$2.48
	GA	7,480	$18,428	$2.46
	MD	1,429,409	$4,507,620	$3.15
	NC	248,981	$1,010,935	$4.06
	SC	199,451	$770,829	$3.86
	VA	303,359	$959,368	$3.16
Atlantic Total		2,226,240	$7,360,371	$3.31
Gulf	AL	695,320	$1,397,908	$2.01
	FL West Coast	1,867,839	$2,718,855	$1.46
	LA	13,221,705	$29,770,615	$2.25
	MS	2,093,148	$2,671,554	$1.28
	TX	4,579,092	$11,200,249	$2.45
Gulf Total		22,457,104	$47,759,181	$2.13
Northeast[a]	CT	1,511,456	$5,103,618	$3.38
	ME	20,690	$76,771	$3.71
	NJ	592,870	$2,262,315	$3.82
	NY	528,917	$2,441,822	$4.62
	RI	256,325	$748,524	$2.92
Northeast Total		2,910,258	$10,633,050	$3.65
Pacific	AK	22,595	$357,100	$15.80
	CA	937,815	$3,586,000	$3.82
	OR	333,466	$1,333,852	$4.00
	WA	5,723,699	$14,263,258	$2.49
Pacific Total		7,017,575	$19,540,210	$2.78
Grand Total		34,611,177	$85,292,812	$2.46

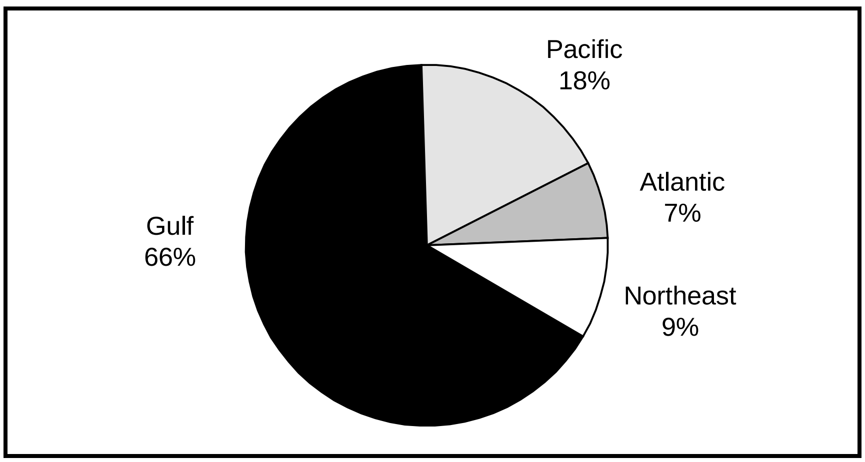
[a]Oysters are also harvested from Massachusetts, but NMFS data have not included a harvest number for the state since 1993. At the time this report was being finalized, we received data that indicated Massachusetts harvests of approximately 95,000 meat-weight pounds or 3 percent of Northeast harvests.

Sources: National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

Alaska Department of Fish and Game, Division of Commercial Fisheries. Statewide Aquatic Farming Production and Value. <http://www.cf.adfg.state.ak.us/geninfo/enhance/maricult/aqfarm_i/9698farm.htm>. As obtained on December 10, 1999. (Converted from in-shell weight to meat weight by multiplying by 0.02625.)

harvest data by state in 1997 in the Atlantic, Gulf, Northeast, and Pacific regions. These harvests are reported as meat-weight equivalents for which the amount of shellstock from the bushel, sack, or tub has been converted to its approximate meat-weight yield. Meat yield conversions vary by place and month and are determined by the individual state offices that report harvest data to NMFS. Based on these data, the Gulf dominates oyster harvests with 66 percent of harvests compared to the Northeast at nearly 9 percent, the Pacific at nearly 18 percent, and the Atlantic at 7 percent in 1997 (see Figure 2-2). Over the past few years, Gulf harvests have increased relative to 1992, Northeast and Pacific harvests have declined, and Atlantic harvests have been steady (see Figure 2-3).

Figure 2-2. Nationwide Oyster Harvests by Region, 1997
The Gulf region dominates U.S. oyster harvests.

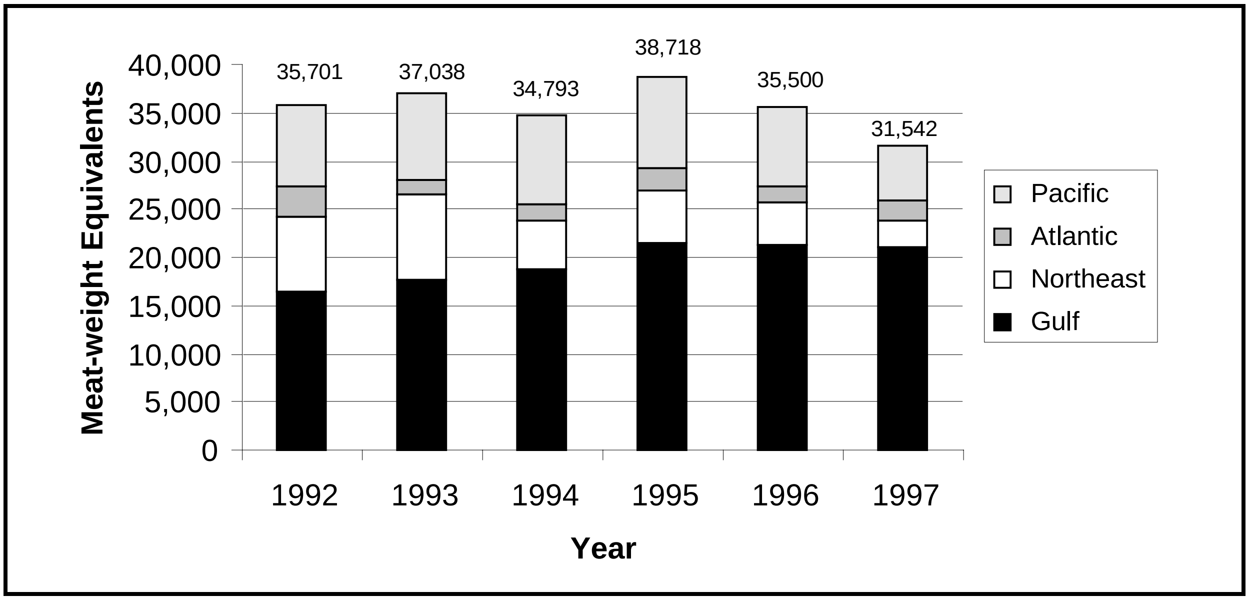


Source: National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

However, based on information provided to us by industry representatives, we believe NMFS harvest volumes are underreported in most regions of the United States for the following reasons:

- harvesters are taxed on volumes of harvests and associated profits and thus they may underreport their volumes,
- harvesters may in some states sell shellstock directly without going through a dealer (who reports the harvest volume),

Figure 2-3. Nationwide Oyster Harvests by Region (meat-weight equivalents), 1992–1997
Gulf oyster harvests have been increasing while oyster harvests in the other regions have decreased or remained steady.

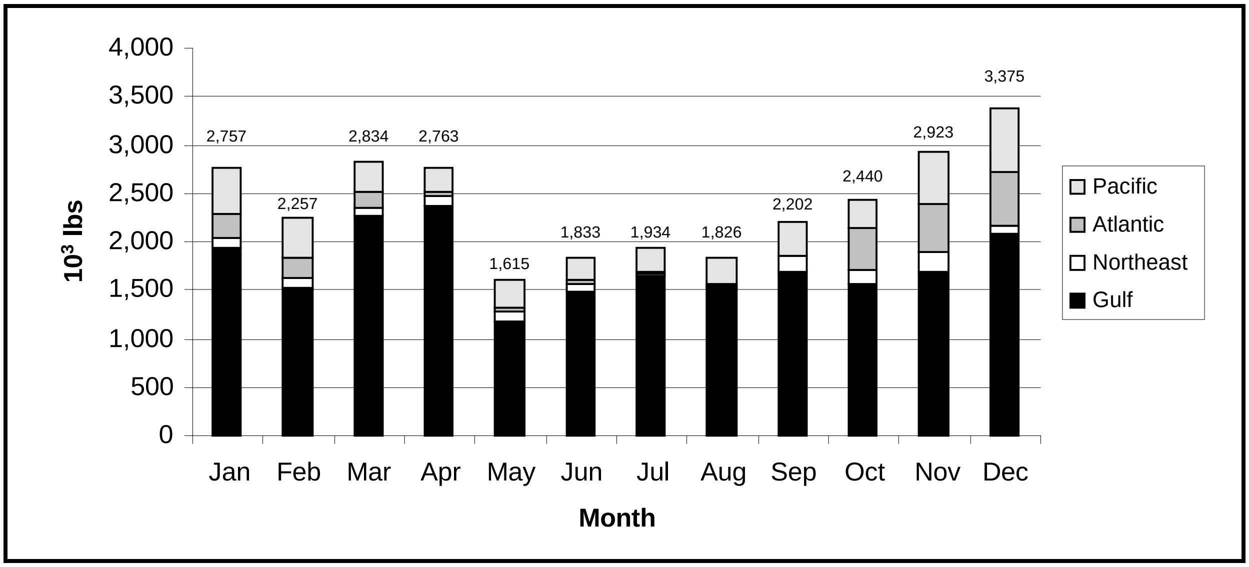


Source: National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

- the meat yield conversions used by the states may be outdated or inconsistent between regions, and
- the harvest containers used by individual harvesters may differ from the standard used by the states to calculate yields.

To the extent that the underreporting of harvests is consistent over the course of the year, the harvest data can provide us with some general information about seasonal harvests and prices. Figure 2-4 presents oyster harvests by month for 1997. As indicated by these data, nationwide harvests are at their peak in November, December, and January, and then again in March and April. The summer months from May through August, when oysters are spawning, yield lower harvest numbers. Prices for harvested oysters, based on meat-weight yields, are in the range of $2 to $3 per meat-weight pound over the course of the year with the exception of lower prices in March and April (Figure 2-5).

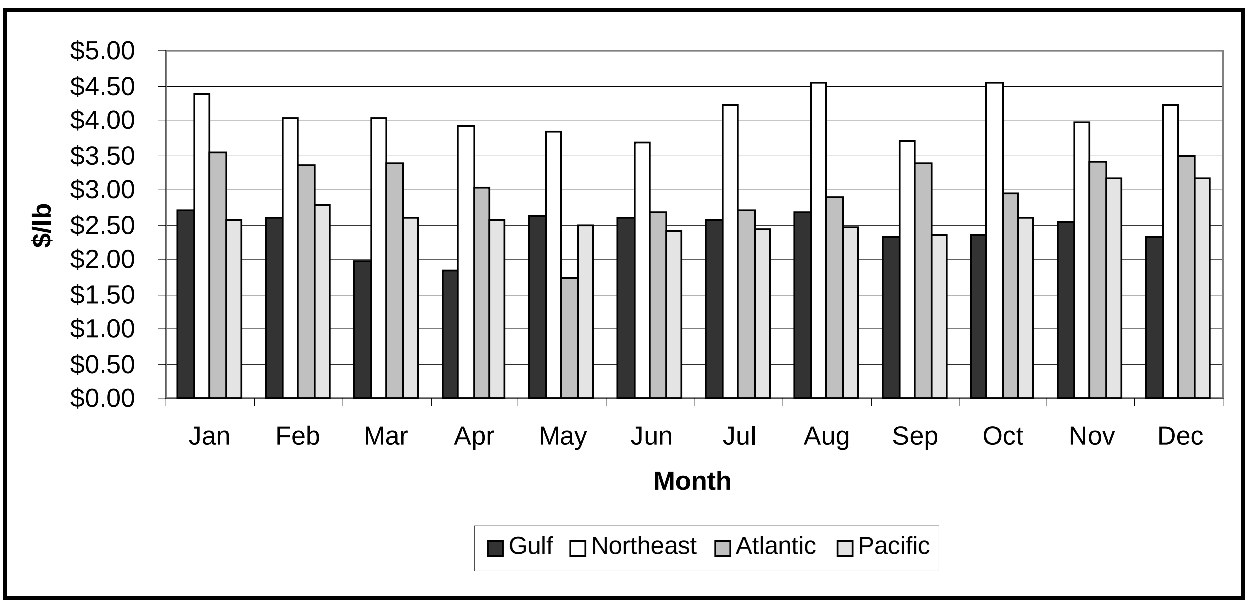
Figure 2-4. Regional Oyster Harvests by Month (meat-weight equivalents), 1997[a]
Oyster harvests are at their peak during the holiday months of November and December.



[a]A portion of the Northeast harvests (1.5 billion pounds) and Pacific harvests (1.3 billion pounds) are not specified by month.

Source: National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

Figure 2-5. Regional Oyster Harvest Values by Month (meat-weight equivalents), 1997
Prices for harvested oysters are in the range of $2 to $3 per meat-weight pound.



Source: National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

2.2 PROCESSING

The processing sector is the post-harvest industry that essentially transforms shellstock oysters into various consumer forms. Harvest and post-harvest operations occur with varying degrees of vertical integration depending on the region of the country. A fully-integrated company may do everything from managing their own "seed" operations, through growing and harvesting, to shucking-sorting and delivery to wholesalers or even retailers. Oyster processors may obtain shellstock directly from harvesters or from wholesalers (see Figure 2-1). Occasionally, processors purchase shucked oysters from other processors for use in prepared oyster products. Also, some facilities engage in both wholesaling and processing activities. Once oysters arrive at a processing plant, they are refrigerated as they await processing.

Processing plants may shuck the shellstock oysters and place them into any of several different sizes and types of containers for sale to restaurants, retailers, or other processors. Shucking is currently done by hand. Shuckers of Eastern oysters usually average about one gallon of oysters per hour, although an experienced shucker can produce twice that volume. Shuckers of Pacific oysters may open from 10 to 25 gallons per day depending on their experience and the size of the oysters and meat weight (Dewey, 2000). Some processing plants also conduct further processing of shucked oysters such as breading, stewing, or freezing (Anderson et al., 1996).

When oysters intended for the halfshell market are processed, they are usually placed on a conveyor belt where workers sort, grade, and wash them. Next, workers weigh or count them and pack them into cardboard boxes or burlap sacks. At this point, workers place a new tag on each batch of oysters. Processors must keep the original tags, which record the time and place of harvest, on file for 90 days. The new tags include information from the original tags plus additional information from the processor. Oysters are then shipped to another processor or the final customer (Chen, 1996).

Many oyster processors produce both shucked and halfshell oysters. The proportion of oysters used in each form is extremely difficult to determine given data limitations, and varies by plant, region, season, and year. Processors continually adjust the proportion of each form produced based on demand. In the Gulf, halfshell demand is generally higher in the summer while shucked demand is generally higher in the winter, but significant sales of each occur in all seasons. In this report, we assume that approximately half of Gulf shellstock goes to each market over the course of a year. In other regions, the relative proportions of the two product forms may vary considerably. Table 2-2 indicates the assumptions we used in our model about the proportion of shellstock going to each market by region as suggested by our industry contacts.

Table 2-2. Proportion of Shellstock to the Shucked and Halfshell Markets by Region
The proportion to each market varies by region.

Region	Shucked	Halfshell
Atlantic (mid-Atlantic and South Atlantic)	75%	25%
Gulf Coast	50%	50%
Northeast	10%	90%
Pacific	80%	20%

Processing plants that ship oysters are certified as interstate or intrastate shippers. As implied by their names, interstate certified plants may ship oysters across state lines while intrastate plants must market their oysters within their state borders. The interstate shippers are inspected and certified by individual states. Each state provides its list of certified dealers to the FDA, which publishes the Interstate Certified Shellfish Shippers List. The intrastate shippers are also inspected and certified by individual states, but the states maintain the intrastate lists themselves. Some states do not maintain a separate intrastate list and thus require all plants to be certified interstate shippers. The state agencies involved include departments of health, marine resources, agriculture (especially in states where all production is aquaculture), natural resources, or fisheries and wildlife.

Table 2-3 indicates the number of interstate certified shellfish in the shell (SS) and shucker/packer (SP) plants and all types of intrastate certified plants. Repackers (RP) and reshippers (RS), which are also included on the certified shippers list, are not included because they would be only indirectly affected by post-harvest treatment requirements.

Table 2-3. Locations of Shellfish Shippers in the United States by Region
The number of interstate and intrastate shellfish shippers provides an upper bound on the number of oyster plants.

Region	State	Interstate Shippers[a] Shellfish In Shell	Interstate Shippers[a] Shucker/Packer	Intrastate Shippers[b]	Grand Total
Atlantic	DC	3	0		3
	DE	14	2		16
	GA	8	11	23	32
	MD	57	31		88
	NC	44	9	77	130
	SC	40	3		43
	VA	66	66		132
Atlantic Total		232	112	100	444
Gulf	AL	0	41		41
	FL	72	43		115
	LA	63	41		104
	MS	17	11	7	35
	TX	21	25		46
Gulf Total		173	161	7	341
Inland	IL	22	0		22
	NM	4	0		4
	NV	2	0		2
	TN	1	0		1
Inland Total		29	0	0	29
Northeast	CT	61	0		61
	MA	94	18		112
	ME	84	26		110
	NH	10	9		19
	NJ	62	12		74
	NY	96	5		101
	PA	6	6	55	67
	RI	33	3		36
Northeast Total		446	79	55	580
Pacific	AK	9	7	9	25
	CA	55	1	176	232
	CO	6	0		6
	HI	7	0		7
	OR	15	7	8	30
	WA	178	25	114	317
Pacific Total		270	40	307	617
Grand Total		1,150	392	469	2,011

[a]Information on Interstate Shippers was obtained from the U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition. Interstate Certified Shellfish Shippers List. <http://vm.cfsan.fda.gov/~ear/shellfis.html>. Last updated on January 12, 2000. As obtained on February 11, 2000.

[b]Information on Intrastate Shippers was obtained from individual state offices. Blank cells indicate that the state does not maintain a separate intrastate shippers list.

Certified shellfish shippers may handle one or more of the following: oysters, clams, mussels, and scallops. Although the shippers list does not indicate the type of shellfish handled by these plants, it is believed that the majority handle oysters. The precise number of shellfish plants that handle oysters is not known; the certified interstate and intrastate shellfish shippers lists provide an upperbound on the number of oyster plants.

NMFS maintains confidential information on the numbers, locations, and volumes of processed product produced by plants that shuck or otherwise process oysters. These data, aggregated to preserve confidentiality, are presented by region for 1997 in Table 2-4. In 1997, there were 40 oyster shucking plants in the Atlantic region, 98 in the Gulf, and 24 in the Pacific region. These plants produced an average of 213,000 pounds of shucked meat and employed an average of nearly 20 employees. Nearly all of these plants probably also handle halfshell product. However, we believe that the number of oyster plants that handle only halfshell oysters greatly exceed the number of oyster shucking plants and that average production (on a meat-weight basis) and employment for these plants are lower than the averages for oyster shucking plants.

Based on the reported values for the output, we also calculated the average wholesale price per pound of output by state and region. Shucked product prices are highest in the Atlantic region, followed by the Gulf, and finally the Pacific. These differences may arise because the Pacific shucked oysters are a different species from those in the Gulf and Atlantic regions, because of regional variations in the costs of processing (primarily labor expenses), and because of the transportation costs involved in shipping shellstock from their harvest locations to their processing locations.

When compiling oyster processing data, NMFS converts gallons of shucked oysters to pounds of processed product by multiplying the number of gallons by 8.5 (representing 8.5 pounds of processed product per gallon of shucked oysters). However, industry representatives indicate that the actual volume of shucked oyster meat in a typical gallon of oysters is in the range of 6 to 8 pounds, but is most likely about 7 to 7.5 pounds. Thus, the shucked weights

Table 2-4. Oyster Processing and Shucking Plant Locations, Numbers, Employment Volumes, and Values, 1997
The Gulf region shucks the greatest volume of oysters followed by the Pacific and the Atlantic.

		Shucked				
Region	**State**	**No. of Plants**	**Employment**	**Pounds**	**Value ($)**	**($/lb)**
Atlantic	MD	11	249	1,202,601	5,417,668	4.50
	NC	5	112	1,508,080	5,345,255	3.54
	SC	3	64	27,913	141,500	5.07
	VA	21	389	3,675,667	16,256,992	4.42
Atlantic Total		40	814	6,414,261	27,161,415	4.23
Gulf	AL	41	584	5,326,819	22,441,717	4.21
	FL	14	162	2,323,248	7,864,506	3.39
	LA	24	357	4,546,859	14,561,140	3.20
	MS	10	164	2,765,910	9,168,770	3.31
	TX	9	155	1,908,646	7,655,798	4.01
Gulf Total		98	1,422	16,871,482	61,691,931	3.66
Pacific	CA	4	276	675,893	2,633,724	3.90
	OR	4	50	224,350	827,200	3.69
	WA	16	590	10,925,226	35,201,328	3.22
Pacific Total		24	916	11,825,469	38,662,252	3.27
Other States[a]		5	88	460,081	1,837,805	3.99
Grand Totals						
Shucked		167		35,571,293	129,353,403	3.64
Canned/Smoked/Processed[b]		19		1,277,596	5,428,682	4.25
Total Industry		186	3,240	36,848,889	134,782,085	3.66 (avg)

[a]"Other States" include Colorado, Delaware, Georgia, New Jersey, and Pennsylvania and are aggregated to protect plant confidentiality.

[b]Grand totals for canned, smoked, and processed oysters are aggregated to protect plant confidentiality.

Source: NMFS data provided by Steve Koplin.

indicated here are likely overstated relative to true oyster meat pounds; consequently, the price per pound of meat is likely higher than calculated based on these volumes.

NMFS does not maintain data on the volume of halfshell product handled by plants that shuck oysters and does not maintain data on plants that handle *only* halfshell product. Thus, data on halfshell oysters plants are not presented here. However, some information on prices of both halfshell and shucked oyster products by region is reported for the Fulton Fish Market (U.S. Department of Commerce, 1997). These prices are for product at the public market and thus include transportation costs, which may be substantial, from the plant to the market. In 1997, the prices per oyster (assuming a 100-count container) were as follows:

- Connecticut: 38 cents
- Florida: 20 to 22 cents
- Louisiana: 19.5 to 20.5 cents
- Massachusetts: 24 to 24.25 cents
- Maryland: 22 cents
- Mississippi: 20 to 21 cents
- New Jersey: 21.67 cents
- New York (Long Island): 27.25 to 35.85 cents
- Rhode Island: 38 cents
- Texas: 20 to 21.2 cents
- Virginia: 18 to 22 cents

Thus, some Northeastern oysters sell for double the delivered price of oysters from the mid-Atlantic and Gulf regions.

Similarly, Northeast shucked oyster prices were higher than mid-Atlantic shucked oysters (many of which likely originated from the Gulf). The reported shucked oyster prices per gallon (assuming 8 pints to the gallon) were as follows:

- Maryland: $22.80 to $24.00
- New York (Long Island): $55.00 to $60.00
- Virginia: $22.72 to $23.20
- Washington: $40.00 to $42.00

2.3 INTERREGIONAL AND INTERNATIONAL TRADE

Data on interregional and international trade in oyster products are included here because post-harvest treatment requirements may potentially alter trade flows of oyster products. This would be especially true if certain regions or countries of origin were not covered by the requirement.

Based on information provided by industry representatives, shellstock may be transported between states and between regions for processing, and processed product may be shipped elsewhere for consumption. In addition to domestic trade flows, some shellstock is imported from Canada. The predominate trade flows appear to be the following:

- Gulf shellstock is shipped to California (for halfshell use) and to the mid-Atlantic (mostly for shucking);
- Connecticut shellstock is shipped to New Jersey for processing for halfshell use;
- Connecticut, Rhode Island, and New Jersey shellstock are shipped to the mid-Atlantic for processing for halfshell use;
- New Jersey shellstock is shipped to the mid-Atlantic for shucking;
- California shellstock is shipped to Washington state for shucking;
- Northwest shucked oysters are shipped to California, the Gulf, the major metropolitan areas in the Midwest and Northeast, and Canada;
- Northwest halfshell oysters are shipped to California and the major metropolitan areas in the Midwest and Northeast; and
- Both eastern and western Canadian shellstock is shipped to many parts of the country for halfshell consumption.

Trade flows between regions have in recent years been affected by

- concerns about *V. vulnificus* in Gulf harvested oysters resulting in more Gulf oysters being used for shucked product, particularly in the mid-Atlantic;
- MSX and Dermo disease problems that have at times virtually eliminated harvests from the mid-Atlantic states, causing plants in these areas to import all the shellstock they process from the Gulf and Northeast;
- greater production of oysters for halfshell consumption in the Northwest particularly for the Pacific, Olympia, Kumamoto, and European flat oyster; and
- the influx of laborers from Mexico and Central America to the mid-Atlantic.

In general, it appears that interregional shipments of oysters are substantial and are likely to continue to be substantial in the future.

Table 2-5 provides data on imports of oyster products from 1994 to 1998 for the top five countries from which we import and overall import totals. The volumes presented are for pounds of oysters in the shell, shucked, or otherwise processed and thus can only be used as a general indication of the volume of oyster product imported. If these were all oyster meat volumes, international

Table 2-5. Imports of Oyster Products, 1994–1998
Import volumes for oyster products have been increasing over the past five years with Canada and South Korea accounting for the vast majority of imports.

Country	Pounds of Oysters 1994	1995	1996	1997	1998
Canada	1,898,668.20	1,987,449.20	2,097,917.80	2,040,572.60	2,168,762.20
China	268,191.00	68,266.00	67,124.20	2,591.60	73,449.20
Japan	190,179.00	264,684.20	173,155.40	328,378.60	246,796.00
New Zealand	80,603.60	71,359.20	101,978.80	107,841.80	132,294.80
South Korea	1,271,078.60	1,770,850.40	1,465,521.20	1,798,187.60	1,524,408.60
All Other	90,981.00	97,152.00	115,667.20	309,810.60	293,640.60
Total Volume	3,799,701.40	4,259,761.00	4,021,364.60	4,587,382.80	4,439,351.40
Total Value	$9,363,951.00	$11,892,349.00	$9,584,432.00	$11,817,363.00	$10,096,745.00

Note: Import volumes combine farmed and wild oysters that are live, fresh, frozen, dried, salted, and brined.

Source: National Oceanic and Atmospheric Administration. National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division. FOREIGN TRADE INFORMATION—Annual By Product For All Countries. <http://www.st.nmfs.gov/ows-trade/trade_prdct_cntry.sh>. As obtained on November 10, 1999.

imports would be approximately 15 percent of the U.S. harvest volume. According to the intrastate shippers list, only plants in Canada, New Zealand, and South Korea are certified to ship shellfish in the shell to the United States; and only plants in Canada, Chile, Mexico, and New Zealand have been certified to ship shucked shellfish to the United States. The number of certified shippers of each type for each country is provided in Table 2-6.

Table 2-7 provides data on exports of oyster products from 1994 to 1998 for the top five countries to which we export and overall export totals. As for imports, the indicated volumes may be for in the shell, shucked, and otherwise processed oysters. If all volumes were oyster meats, exports would account for less than 10 percent of the U.S. harvest volume.

Table 2-6. Certified Foreign Shellfish Shippers
Foreign shellfish plants that export oysters to the United States must be certified interstate shippers.

Country	Shellfish in Shell	Shucker/Packer	Total
Canada	65	60	125
Chile	2	1	3
Mexico	1	0	1
New Zealand	8	38	46
South Korea	0	5	5
Total	76	104	180

Source: U.S. Food and Drug Administration. Center for Food Safety and Applied Nutrition. Interstate Certified Shellfish Shippers List. <http://vm.cfsan.fda.gov/~ear/shellfis.html>. Last updated on January 12, 2000. As obtained on February 11, 2000.

Table 2-7. Exports of Oyster Products, 1994–1998
Export volumes for oyster products have remained fairly constant over the past 5 years with Canada accounting for more than half of exports.

	Pounds of Oysters				
Country	1994	1995	1996	1997	1998
Canada	1,477,493.60	1,573,442.20	1,362,088.20	1,561,892.20	1,506,029.80
Hong Kong	15,835.60	101,428.80	141,801.00	398,004.20	302,515.40
Japan	304,999.20	211,646.60	40,990.40	129,291.80	59,987.40
Spain	25,891.80	28,109.40	36,333.00	68,653.20	59,892.80
Taiwan	584,865.60	489,854.20	293,574.60	360,071.80	125,793.80
All Other	221,084.60	123,571.80	218,462.20	365,530.00	435,930.00
Total Volume	2,630,170.40	2,528,053.00	2,093,249.40	2,883,443.20	2,490,149.20
Total Value	$6,893,149.00	$6,582,878.00	$5,710,206.00	$6,128,566.00	$5,941,022.00

Note: Export volumes combine live, fresh, frozen, dried, salted, and brined oyster products.

Source: National Oceanic and Atmospheric Administration. National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division. FOREIGN TRADE INFORMATION—Annual By Product For All Countries. <http://www.st.nmfs.gov/ows-trade/trade_prdct_cntry.sh>. As obtained on November 10, 1999.

2.4 CONSUMPTION

The product characteristics that influence consumer perceptions of raw halfshell oysters include appearance (size, shape, color), odor, flavor (sweetness and saltiness), and texture (firmness). Consumers prefer cup-shaped oysters and meat that fits the shell (i.e., that is not shrunken). Color may be less important to consumers since there is a great deal of natural variation in the color of raw oysters. Raw oysters should not emit any unpleasant odor because consumers regard off-odor as an indication of spoilage. Fresh oysters should have a mild, salty flavor with no off-flavor, and their texture should be very tender but not mushy (Chen, 1996). The sensory characteristics of halfshell oysters vary depending on the season in which they are harvested, the location from which they are harvested, and the species of the oysters.

Five different species of oysters make up the majority of harvests in the United States (Rex-Johnson, 1997; Taylor Shellfish, 1999; CuisineNet, 1999):

- ***Crassostrea virginica.*** These oysters are known as the Atlantic oyster or the Eastern oyster or may be named for the area where they are harvested (e.g., Bluepoint, Apalachicola, Wellfleet). They are grown on the Gulf Coast and the entire Atlantic Seaboard. They are consumed both raw and shucked.
- ***Crassostrea gigas.*** These oysters are known as the Pacific oyster and are also sold under a variety of names depending on where they are harvested. They are usually shucked but may also be served on the halfshell if they are harvested when small (2 to 3 inches long).
- ***Ostrea lurida.*** These oysters are known as the Olympia oyster and are native to the Northwest. They are extremely small, approximately the size of a quarter, and are most often served on the halfshell. If shucked, 250 meats make up a pint.
- ***Crassostrea sikamea.*** These oysters, known as the Kumamoto oyster, originated in Japan and are cultivated in the Northwest. They are small oysters, though larger than the Olympia oyster, and are almost always served on the halfshell.

- ***Ostrea edulis.*** These oysters are known as the European flat oyster and are sometimes referred to as the Belon oyster, after the region of France where they originated. They are cultivated in both the Northeast and the Northwest. They have a flat, round shape, are usually harvested when smaller than the Eastern oyster, and are nearly always served on the halfshell.

2.4.1 Uses and Consumers

Consumers enjoy oysters both in their homes and in restaurants. Most often, oysters consumed at home are cooked, and oysters consumed in restaurants are served both raw and cooked. Consumers purchase oysters from grocery stores or fresh seafood markets for in-home consumption. Oyster processors report that most oysters sold to grocery stores are shucked and shipped in a variety of different size containers for stewing or frying. Although restaurants also purchase shucked oysters, wholesalers and processors report shipping significant quantities of shellstock to restaurants. Consumers order these oysters in restaurants as raw halfshell oysters or in cooked halfshell dishes such as steamed oysters or Oysters Rockefeller (Anderson et al., 1996).

Although oyster bars and seafood restaurants serving oysters are located in all areas of the country, they are concentrated in coastal regions near oyster landings. During the summer travel and vacation season, consumer demand is high for in-shell oysters suitable for raw or cooked halfshell consumption. Oyster industry representatives report a high consumer demand for shucked oyster meats during the winter holiday season in November and December (Anderson et al., 1996).

In 1994, the Florida Agricultural Market Research Center conducted a telephone survey on seafood consumption with over 1,000 randomly selected Florida households (Degner and Petrone, 1994). They found that seafood consumption was greatest among middle-aged consumers (ages 35 to 64) and those with a college education. About 47 percent of those interviewed indicated that they like oysters. However, only about a quarter of those who like oysters reported that they are frequent consumers who eat oysters at least once a month. Nearly a third of respondents had not eaten any oysters within the last year, and the remainder had eaten them four times or less in the previous year. About half of those who like oysters but had not eaten any in the previous year cited “fear of illness” as their reason for avoiding them.

According to this study, 53 percent of respondents reported that they usually eat cooked oysters, 41 percent generally eat oysters raw on the halfshell, about 4 percent eat raw oysters from a jar, and the remaining respondents eat canned oysters. The preferred form of oyster appears to be unrelated to factors such as age, income, gender, education, or race. About 23 percent of respondents who had eaten oysters in the previous year reported that the proportion of oysters they ate raw was decreasing. Only 2 percent of oyster consumers mentioned price or expense as a reason for not eating them in the past year.

2.4.2 Substitution Possibilities in Consumption

When a consumer chooses among protein sources to consume, they may compare shucked to halfshell oysters, or compare oysters to other shellfish, seafood, or protein sources such as meat and poultry. Although oyster consumers may have a strong preference for oyster products compared to these other products, they must be price competitive. According to a study by Hanson, Herrmann, and Dunn (1995), which reviewed literature on the determinants of seafood purchasing behavior, “the most critical marketing problem faced by fisheries and aquaculture businesses is how to compete on price with poultry and red meats” (page 1304). Cheng and Capps (1988) also considered how changes in the prices of poultry and red meat affect consumption of seafood. They found that the consumption of seafood was more sensitive to changes in its own price than to changes in the prices of poultry and red meat. Their results suggest that an increase in the price of oysters could cause consumers to consume fewer oysters and more of other types of seafood, poultry, and red meat.

2.5 REFERENCES

Alaska Department of Fish and Game, Division of Commercial Fisheries. Statewide Aquatic Farming Production and Value. <http://www.cf.adfg.state.ak.us/geninfo/enhance/maricult/aqfarm_i/9698farm.htm>. As obtained on December 10, 1999.

Anderson, D.W. R.C. Lindrooth, B.C. Murray, and J.L. Teague. 1996. "Cost of Restrictions on Gulf Oyster Harvesting for Control of *Vibrio vulnificus*-Caused Disease." Research Triangle Park, NC: Research Triangle Institute.

Chen, Y.-P. 1996. *Reduction and Management of Vibrio Vulnificus in Gulf Coast Oyster (Crassostrea virginica).* Doctoral dissertation. Louisiana State University. Department of Food Science.

Cheng, H.-T., and O. Capps, Jr. August 1988. "Demand Analysis of Fresh and Frozen Finfish and Shellfish in the United States." *American Journal of Agricultural Economics* 70(3):533-542.

CuisineNet. 1999. "Oysters on the Halfshell." wysiwyg://34/http://match.cuisinet/digest/ingred/oyster/eating.shtml. As obtained on December 8, 1999.

Degner, R.L., and C. Petrone. 1994. "Consumer and Restaurant Manager Reaction to Depurated Oysters and Clams." Florida Agricultural Market Research Center, Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, Industry Report 94-1.

Dewey, B., Taylor Shellfish Company, Inc. February 6, 2000. "Economic Impacts of Requiring Post-Harvest Treatment of Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

Hanson, G.D., R.O. Herrmann, and J.W. Dunn. December 1995. "Determinants of Seafood Purchase Behavior: Consumers, Restaurants, and Grocery Stores." *American Journal of Agricultural Economics* 77(5):1301-1305.

Koplin, S., National Marine Fisheries Service. 1999. Oyster processing plant data provided to Mary Muth, Research Triangle Institute.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Marine Commercial Landing Statistics. <http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html>. As obtained on November 10, 1999.

National Oceanic and Atmospheric Administration. National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division. FOREIGN TRADE INFORMATION—Annual By Product For All Countries. <http://www.st.nmfs.gov/ows-trade/trade_prdct_cntry.sh>. As obtained on November 10, 1999.

Rex-Johnson, B. 1997. *Pike Place Public Market Seafood Cookbook.* Ten Speed Press: Berkeley, California.

Taylor Shellfish. 1999. "Product Catalog, Oysters—Taylor Shellfish." <www.taylorshellfish.com/oysters.html>. As obtained on December 7, 1999.

U.S. Department of Commerce. 1997. "Fresh Prices at Fulton Fish Market." New York, NY. <www.st.nmfs.gov/st1/market_news/nyfu97.pdf>.

U.S. Food and Drug Administration. Center for Food Safety and Applied Nutrition. 2000. Interstate Certified Shellfish Shippers List. <http://vm.cfsan.fda.gov/~ear/shellfis.html>. Last updated on January 12, 2000. As obtained on February 11, 2000.

3 Treatment Technologies and Costs

RTI evaluated three post-harvest treatment technologies that are intended to eliminate *Vibrio vulnificus* from raw oysters. These treatment technologies are individual quick freezing (IQF), cool pasteurization, and hydrostatic pressure. All three of the treatment technologies are currently in use in the Gulf, and products from plants with these treatment technologies are already being sold to restaurants, grocery stores, and other food service establishments. Thus far, these treatment technologies have only been applied to Gulf-harvested oysters of the species *C. virginica*, otherwise known as the Eastern oyster. We do not have information on their effectiveness or practicality for other species of oysters, which may differ in size and shape from the Eastern oyster.

These three processes are in different stages of demonstrating their effectiveness in reducing *Vibrio* in Gulf-harvested oysters to nondetectable levels. For the IQF process, the data to support nondetectable levels of *V. vulnificus* have been compiled only for winter-harvested oysters. The Food and Drug Administration (FDA) has requested additional data to support nondetectable levels of *V. vulnificus* in oysters with levels of the bacteria typically found in summer-harvested oysters (Distefano, 1999). For the cool pasteurization process, the data to support nondetectable levels of *V. vulnificus* have been submitted to and accepted by the FDA; the data to support nondetectable levels of *V. parahaemolyticus* have also been submitted to FDA. Finally, for the hydrostatic pressure process, preliminary data suggest that the process reduces

V. vulnificus to nondetectable levels. However, as with the IQF process, the FDA has requested additional data to support nondetectable levels of *V. vulnificus* in oysters with levels of the bacteria typically found in summer-harvested oysters (Distefano, 1999). Preliminary evidence suggests that all three of these processes may also have effects on the levels of *V. parahaemolyticus*.

Two other post-harvest treatment technologies—heat shock and depuration—are included in NSSP's "Guide for the Control of Molluscan Shellfish" (1997). Although they may reduce the levels of *V. vulnificus*, they have not been documented to achieve nondetectable levels. Thus, we did not evaluate these processes in this study. Another potential post-harvest treatment technology that was not evaluated in this study, but which may become available in the future, is irradiation. In September 1999, the FDA was petitioned by the National Fisheries Institute and the Louisiana Department of Agriculture to allow irradiation of fresh or frozen molluscan shellfish for control of *Vibrio* and other foodborne pathogens (FDA, 1999). We did not evaluate irradiation as an alternative because it is not currently in use, and thus we had no means of assessing costs and feasibility of the technology for treatment of raw oysters.

In this section, we describe equipment and resource requirements, costs, and post-treatment handling and distribution. We then evaluate the feasibility of treatment for individual oysters plants. The information in this section is provided irrespective of potential consumer acceptance of oysters treated by each of these methods.[1] Furthermore, the numerical cost estimates provided in this section are based primarily on treatment of Eastern oysters with labor, energy, and other input costs that are applicable to the Gulf region.

---

[1]Consumer acceptance of post-harvest treated oysters is addressed in Section 4.

3.1 TREATMENT COSTS AND REQUIREMENTS

> We evaluated three post-harvest treatment technologies for oysters:
> - individual quick freezing,
> - cool pasteurization, and
> - hydrostatic pressure.

When evaluating a technology, we are interested in the potential effects of that technology on both the supply and demand for the product that will be treated. In this section, we describe the factors that will affect supply and distribution of both raw halfshell and shucked oysters that are treated with each technology. Specifically, we describe what will be required for plants to install the technology (preparation of the space, capital equipment purchases, and process modifications), the cost per unit for treatment of oysters using the technology (including royalties to be paid to the owners of the technology), and how product handling differs once the product is treated. While differences in product handling following treatment are a factor in the demand for treated oysters, the effects of treatment on consumer and restaurant acceptance of treated oysters are addressed in more detail in Section 4.

The information on the technologies described in this section was obtained by RTI from the following companies:

- Individual quick freezing: Hillman Shrimp & Oyster Company, Dickinson, Texas;
- Cool pasteurization: AmeriPure Oyster Companies, Kenner, Louisiana; and
- Hydrostatic pressure: Motivatit Seafoods, Inc., Houma, Louisiana.

Each treatment technology is addressed below.

3.1.1 Individual Quick Freezing

Two types of IQF processes are currently in use in the oyster industries: cryogenic freezing and mechanical freezing.[2] Preliminary data suggest that the cryogenic process, which has been in use in the Gulf for over a decade, achieves nondetectable levels of *V. vulnificus* in winter-harvested oysters. In contrast to the cryogenic process, mechanical freezing of oysters using a blast freezer is done for ease of handling and storage and has not been documented to reduce levels of *V. vulnificus*. Neither IQF process

[2]We are aware of three companies doing cryogenic freezing of oysters and perhaps a dozen more companies doing mechanical freezing in the Gulf (Nelson, 1999), and a few companies doing mechanical freezing in the Pacific region (Dewey, 2000).

for oysters is patented, and thus use of either process does not require payment of royalties.

The IQF process is fundamentally different from the cool pasteurization process and the hydrostatic pressure process because (1) it has, to our knowledge, only been developed and used for oysters to be served on the halfshell and not for shucked oysters; (2) once treated, the oysters must be kept frozen until just prior to serving; and (3) the data to document nondetectable levels of *V. vulnificus* have been compiled only for winter-harvested oysters in the Gulf.

In this section, we describe the cryogenic IQF process, the required plant modifications and capital equipment needed for the process, the variable inputs used in the process (e.g., labor, water, energy), the per-unit costs of treatment, and changes in the handling of the product once it has been treated.

Process Description

After incoming shellstock has been received, rinsed, and prepared for treatment, oysters are shucked and placed on the halfshell. Workers load the oysters onto a conveyor belt that transports the oysters through the freezer tunnel where they are rapidly frozen using liquid CO_2. Next, they travel on the conveyor belt through a glazing machine that sprays them with a fine mist of water, which freezes into a glaze of ice. Workers then pack the frozen oysters into wax-coated corrugated boxes using sheets of plastic to separate layers, and bubble wrap to add cushioning. The entire process takes approximately 9 minutes from start to finish. Once treated, the oysters are stored in a freezer.

Plant Modifications and Capital Equipment

We considered two different size IQF processes: a small process that would treat approximately 50,000 cases per year (12 dozen oysters per case) and a large process that would treat approximately 100,000 cases per year. The small process requires approximately 1,200 square feet (30 feet by 40 feet), and the large process requires approximately 2,000 square feet. For both sizes, the required ceiling height is 9 to 10 feet and the flooring is concrete.

The following capital equipment is needed:

- a cryogenic freezer tunnel (10 feet for a small process and 20 feet for a large process),
- a cryogen receiver tank,
- a glazing (or mister) machine and conveyer, and
- a freezer truck for transporting the product to cold storage.

Total capital equipment and installation costs for the small process are approximately $408,000, and for the large process are approximately $620,000. The expected life of the processing equipment is 12 to 15 years, and the expected life of the freezer truck is 5 years.

Processing Inputs

To operate the IQF process, the following variable inputs are needed:

- liquid CO_2 (60 pounds per case of oysters);
- additional water;
- additional electricity;
- labor for shucking oysters prior to entering the freezer tunnel;
- additional labor for preparing the oysters prior to freezing, loading the freezer belt, guiding the oysters from the freezer tunnel into the glazing machine, and packing the oysters into cases;
- cold storage space;
- packaging; and
- a driver, fuel, and upkeep for the freezer truck.

Note that part of the costs for these inputs (particularly shucking labor) would normally fall on the restaurant or food service establishment that serves raw halfshell oysters. However, to cryogenically freeze oysters, they must be placed on the halfshell; thus, the costs of shucking are a cost of the IQF process.

Per-Unit Costs of Treatment

Table 3-1 summarizes the per-unit costs of treatment for a small and large IQF treatment process. To calculate these per-unit costs, we added the following treatment specific costs:

Table 3-1. Per-Unit Treatment Costs for the Cryogenic IQF Process
We estimated treatment costs for a small and large cryogenic IQF process operating 2,500 hours per year.

	Small Process	Large Process
Cost Estimates		
Per raw halfshell oyster	$0.141	$0.138
Per case of raw halfshell oysters[a]	$20.35	$19.94
Throughput Assumptions		
Oysters per year	7,200,000	14,400,000
Cases per year[a]	50,000	100,000

[a]One case holds 12 dozen oysters.

- annualized plant expansion costs for the space required to house the treatment equipment,
- annualized capital equipment and installation costs, and
- annual operating and maintenance costs (e.g., liquid CO_2, labor, energy, water, and replacement parts).

These total annual costs are then divided by the annual throughput of the treatment process to calculate the per-unit (i.e., per oyster and per case) cost.

The cost per unit is slightly lower for the large process compared to the small process because the larger size equipment is less costly on a per-unit capacity basis than the smaller size equipment. We assume that plants will purchase rather than lease the required equipment; however, the costs do not vary substantially in either case.[3]

The treatment costs are based on the following assumptions: the plant operates one 10-hour shift per day, 5 days per week, 50 weeks per year; interest rates are 10 percent per year; construction costs average $65 per square foot; wages including benefits average $10 per hour; and CO_2 gas prices are 5.5 cents per pound.[4] In addition, we assume an average storage time of 3 months per case at 60 cents per case.

---

[3]According to Hillman Oyster Companies, the freezer tunnel and cryogen receiver tank can be leased (Hillman, 1999).

[4]Liquid CO_2 prices vary substantially by region; the estimate we used applies to the Gulf region.

Post-Treatment Handling and Distribution

Once the oysters have been through the IQF process and packaged, cold storage space must be available to keep the product frozen prior to its distribution. Because oyster plants may not have sufficient freezer capacity on site to store all of the oysters that are treated, they may need to lease cold storage space to keep the product frozen until it is distributed.[5] If they are leasing cold storage space, oyster plants must also own and maintain a freezer truck for transporting the product to and from cold storage.

One of the benefits of the IQF process is that oysters can be stored from the winter harvest, which yields higher quality oysters (particularly in the Gulf), and then offered for sale during other times of the year.[6] More importantly, however, raw halfshell oysters can be served at restaurants and other food service establishments without a shucker on staff. The oysters are removed from their packaging and brought up to the desired serving temperature before they are served on the halfshell. This means that raw halfshell oysters can be made available in locations where they otherwise would not be. For these reasons, IQF oysters may retail at prices higher than raw, untreated oysters without regard to the safety attributes of either product.

3.1.2 Cool Pasteurization

The cool pasteurization process for oysters is a patented process developed by AmeriPure Oyster Companies that has been in use for approximately 3 years. It is a mild thermal treatment of oysters in the shell, followed by a rapid cooling. This process raises the temperature of the oyster enough to kill *V. vulnificus* bacteria, but does not sterilize or cook the oyster. The same process is used for both raw halfshell and shucked oysters, except that shucked oysters are not banded prior to processing. AmeriPure Oyster Companies claims that shucking yields for pasteurized oysters increase by 15 to 30 percent relative to untreated oysters because the process results

---

[5]Because the market for cold storage is fairly competitive, we expect the cost of rented storage space not to differ substantially from the cost of storage space at the plant.

[6]However, freezing oysters alters the texture of the meat and thus IQF oysters are somewhat of a different commodity than fresh oysters. In addition, summer-harvested oysters in the Gulf may not freeze well in comparison to winter-harvested oysters (Nelson, 2000).

in greater moisture retention in the oyster meat (Tesvich and Fahey, 2000). Shucking yield increases of 10 to 20 percent, with the greatest increases occurring in the summer when oysters are "skinnier," were confirmed by food scientists from Louisiana State University (Andrews, 2000).

As mentioned previously, the process has been demonstrated as effective in reducing *V. vulnificus* to nondetectable levels. Data to document nondetectable levels of *V. parahaemolyticus* have also been compiled.

In this section, we describe the cool pasteurization process, the required plant modifications and capital equipment needed for the process, the variable inputs used in the process (e.g., labor, water, energy), the per-unit costs of treatment, and changes in the handling of the product once it has been treated.

Process Description

After shellstock is received at the plant and prior to the cool pasteurization process, workers place a rubber band around each oyster intended for the raw halfshell market. Banding may be done manually or using a banding machine. Oysters to be shucked are not banded. Workers load both types of oysters into racks and submerge them in a bath of warm water. During this process, the internal temperature of the oysters is raised to a level that varies with the season because levels of *V. vulnificus* are higher in summer months. The length of time that the internal oyster temperature is maintained at the specified temperature is adjusted based on the size of the batch of oysters (Andrews, 1999).

After the heating process, the oysters are transferred to a bath of sanitized cold water for rapid chilling. During both the heating and cooling stages of the process, water temperatures must be closely monitored. The water is replaced on a daily basis (Schegan and Fahey, 1999).

The technology is available to automate the process to a continuous line system, which will eliminate the need for separate tanks and for manually lifting the oysters in and out of the hot and cold water baths separately (Schegan and Fahey, 1999). A continuous line system may be more appropriate for large rather than small plants, but a particular plant would weigh the costs of automation versus the labor costs of the manual system in choosing which to install.

Plant Modifications and Capital Equipment

We evaluated both a small- and a large-scale cool pasteurization treatment process. However, AmeriPure Oyster Companies states that the size of the process can be adjusted to fit the needs of the individual processing plant (Tesvich and Fahey, 2000). The small-scale process we evaluated requires approximately 200 square feet and handles approximately 18,000 100-pound sacks per year. The large-scale process we evaluated requires 1,500 to 2,000 square feet of space within the plant and handles approximately 225,000 100-pound sacks per year. The ceiling height requirement for the treatment process is 12 feet. In addition to the space within the plant, the following capital equipment is needed:

- a boiler,
- a chilling and condensing unit,
- a computer monitored hot and cold exchange unit,
- holding tanks (5,800 gallons for the hot water tank and 3,700 gallons for the cold water tank),
- conveyer units,
- hoists for lifting oysters in and out of the water baths,
- an ultra-violet water purification system, and
- banding machines, particularly for large plants.

Installation of the equipment requires plumbing connections and electrical hook-ups. Without the costs of the banding machines, the total capital and installation costs for the small process are approximately $45,000, and for the large process are approximately $230,000. The cost of the banding machine is approximately $15,000; the large plant we evaluated would require two machines. The expected life of capital equipment is 20 to 25 years with proper maintenance.

Processing Inputs

To operate the cool pasteurization treatment process, the following variable inputs are needed:

- additional electricity and/or natural gas;
- additional water;

- additional workers to operate the process;
- UV filters and other replacement parts such as tank probes, nuts and bolts, and thermometers; and
- oyster bands and the additional labor expenses to put the bands on oysters intended for the raw halfshell market.

In addition, an oyster plant would pay a license fee to AmeriPure Oyster Companies to cover the set up of the treatment process and a royalty based on the volume processed.

Per-Unit Costs of Treatment

Table 3-2 summarizes the per-unit costs of the cool pasteurization treatment process. To calculate these per-unit costs, we added the following treatment specific costs:

- annualized plant expansion costs for the space required to house the treatment equipment,
- annualized capital equipment and installation costs,
- annual operating and maintenance costs (e.g., labor, energy, water, replacement parts, bands for raw halfshell oysters), and
- per-unit royalties that will be imposed by AmeriPure Oyster Companies.[7]

These total annual costs are then divided by the annual throughput of the treatment process to calculate the per-unit treatment cost.

Table 3-2. Per-Unit Treatment Costs for the Cool Pasteurization Treatment Process
We estimated treatment costs for a small and large cool pasteurization treatment process operating 2,500 hours per year.

	Small Process	Large Process
Cost Estimates		
Per shucked oyster	$0.002	-$0.003
Per raw halfshell oyster	$0.042	$0.028
Per sack[a]	$6.09	$3.39
Throughput Assumptions[b]		
Oysters per year	5,000,000	61,875,000
Shellweight pounds per year	1,800,000	22,500,000
Sacks per year	18,000	225,000

[a]We assumed that half of each sack would be shucked and half would be banded for the raw halfshell market.

[b]We assumed 275 oysters per 100 pound sack.

[7]The royalty fees are confidential information provided to RTI; thus, while royalties are included in the cost estimates, they are not disclosed here.

The costs per sack for the small process are approximately double the costs of the large process primarily because the capital equipment costs are higher on a per-unit basis. Specifically, the equipment costs for the small process are approximately one-fifth of the equipment costs for the large process, yet the large process handles 12 times the volume of the small process. In addition, we assume the small process requires one additional worker whereas the large process requires three additional workers. Thus, the labor costs to run the treatment process are proportionally higher for the small process.

The treatment costs are based on the following assumptions: the plant operates one 10-hour shift per day, 5 days per week, 50 weeks per year; interest rates are 10 percent per year; construction costs average $65 per square foot; and wages including benefits average $10 per hour. In addition, based on claims by AmeriPure Oyster Companies (Tesvich and Fahey, 2000; Andrews, 2000), we estimated and assumed shucked yield increases of 1 pound per 100 pounds of shellstock oysters.[8]

Post-Treatment Handling and Distribution

Once oysters are treated with the cool pasteurization process, they are generally handled as they are for untreated raw oysters. The label for the AmeriPure product states that it must be kept refrigerated at 38° Fahrenheit or lower.[9] Oysters to be served on the halfshell are distributed in their banded shells and are shucked at the time they are served. Oysters to be cooked are shucked and placed into containers.

3.1.3 Hydrostatic Pressure

The hydrostatic pressure process for raw oysters, which has been developed by Motivatit Seafoods and in use since the summer of 1999, applies to both raw halfshell and shucked oysters (Voisin, 1999). The process pops open the oyster and separates the muscle of the oyster from the shell. Thus, Motivatit Seafoods claims that

[8]If yield increases were not factored into the costs of treating shucked oysters, the estimated per-unit costs of treatment would be 2 cents per shucked oyster for the small process and 1.5 cents per shucked oyster for the large process.

[9]This temperature requirement may be lower than the requirement to which some distributors, wholesalers, and food service establishments are accustomed (Nelson, 2000).

shucking a pressure-treated oyster is easier and faster than an untreated oyster. In addition, because the muscle of the oyster is not cut, the oyster retains all of its moisture. They also claim yield increases of 25 to 50 percent (averaging 37 percent over the course of the year) both because the moisture is retained and because all of the oysters in a sack, including the smallest ones, are shucked (Voisin, 1999).

As noted previously, Motivatit Seafoods is still in the process of compiling the data needed to establish that the hydrostatic pressure process achieves nondetectable levels of *V. vulnificus*.

In this section, we describe the hydrostatic pressure process, the required plant modifications and capital equipment needed for the process, the variable inputs used in the process (e.g., labor, water, energy), the per-unit costs of treatment, and changes in the handling of the product once it has been treated.

Process Description

Once shellstock oysters are received at the plant, they are prepared for treatment. Oysters intended for the raw halfshell market are individually banded shut using a banding machine that shrink-wraps the band onto the oyster. Workers then load oysters for both raw halfshell 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. At present the chamber is loaded from the top, but the equipment industry is working on developing a system that could load horizontally. Following treatment, oysters intended for the raw halfshell market are packaged with their bands on and oysters intended for shucking are shucked and packed in containers.

Plant Modifications and Capital Equipment

We considered three different size hydrostatic pressure processes:

➤ a small-size process that would treat approximately 5,000 shellweight pounds per day running at 60 pounds per cycle, 8.3 cycles per hour, 10 hours per day;

- a medium-size process that would treat approximately 14,000 shellweight pounds per day running at 200 pounds per cycle, 7 cycles per hour, 10 hours per day; and
- a large-size process that would treat approximately 21,000 shellweight pounds per day running at 300 pounds per cycle, 7 cycles per hour, 10 hours per day.

The treatment equipment requires from 1,500 to 2,000 square feet of space within the plant. For all sizes, the required ceiling height is 16 feet so that the product can be hoisted into the processor. The bottom of the enclosure that houses the processor is 6 feet below floor level to make the process more functional.

In addition to the plant modifications, the following capital equipment is needed:

- an overhead rail system with support beams, the processor enclosure, conveyors, and hoists; and
- an ultra high-pressure processor.

The expected life of the overhead rail system, conveyors, and hoists is 20 years. The processor unit will be available for sale or lease from equipment suppliers in cooperation with Motivatit Seafoods. An oyster plant would pay an equipment lease cost that covers delivery, installation, and maintenance of the processor and a per-pound basis royalty. The costs for the capital equipment that is not part of the leased equipment are approximately $40,000 for the small process, $50,000 for the medium process, and $60,000 for the large process.

Processing Inputs

To operate the hydrostatic pressure process, the following variable inputs are needed:

- additional electricity,
- additional water,
- additional labor expenses for higher skilled workers (two for a small plant, three for a medium or large plant), and
- oyster bands and the additional labor expenses to put the bands on oysters intended for the raw halfshell market.

For shucked oyster products, however, Motivatit Seafoods claims fewer workers are needed to shuck the oysters because the oysters are already popped open, and the oyster meat is already separated from the shell. Thus, the number of shuckers needed at a plant is expected to decrease by 60 percent. Also, the costs of the process are further offset by increased yields for shucked product.

Per-Unit Costs of Treatment

Table 3-3 summarizes the per-unit costs of treatment for a small, medium, and large hydrostatic pressure process. We based the cost calculations on Motivatit Seafoods' expected charges for leasing the processor unit. Thus, we added the following treatment specific costs:

- annualized plant expansion costs for the space required to house the processor,
- annualized capital equipment costs for the equipment not included in the lease,
- annual processor lease cost (which includes maintenance),
- annual operating costs (e.g., labor, energy, water, and bands for raw halfshell oysters), and
- per-unit royalties that will be imposed by Motivatit Seafoods.[10]

Table 3-3. Per-Unit Treatment Costs for the Hydrostatic Pressure Process
We estimated treatment costs for a small, medium, and large high-pressure processor operating 2,500 hours per year.

	Small Process	Medium Process	Large Process
Cost Estimates			
Per shucked oyster[a]	–$0.025	–$0.029	–$0.030
Per raw halfshell oyster	$0.037	$0.033	$0.032
Per sack[b]	$1.68	$0.51	$0.25
Throughput Assumptions[c]			
Oysters per year	3,437,500	9,625,000	14,437,500
Shellweight pounds per year	1,250,000	3,500,000	5,250,000
Sacks per year	12,500	35,000	52,500

[a]Negative numbers indicate that it will be less costly to produce shucked oysters with the hydrostatic pressure process relative to untreated oysters.

[b]We assumed that half of each sack would be shucked and half would be banded for the raw halfshell market.

[c]We assumed 275 oysters per 100 pound sack.

[10]The royalty fees are confidential information provided to RTI; thus, while royalties are included in the cost estimates, they are not disclosed here.

These total annual costs are then divided by the annual throughput of the treatment process to calculate the per-unit treatment cost.

The cost per unit is lowest for the largest processor and highest for the smallest processor because the plant modifications cost essentially the same for all three sizes of processors even though the processor will process different volumes, and the costs of the overhead rail system, conveyers, and hoists do not increase substantially as the size of the processor increases.

The treatment costs are based on the following assumptions: the plant operates one 10-hour shift per day, 5 days per week, 50 weeks per year; interest rates are 10 percent per year; and wages including benefits average $10 per hour. In addition, based on information provided by Motivatit Seafoods (Voisin, 1999), we assume shucker labor savings of 60 percent and increased shucked product yields of approximately 2 pounds per 100 pounds of shellstock.[11,12]

Post-Treatment Handling and Distribution

As with untreated oysters, pressure-treated oysters must be kept refrigerated throughout their distribution process. The handling of shucked product coming out of the hydrostatic pressure process is the same as for untreated shucked oysters except that the oysters are more easily shucked for packing in containers. However, once raw halfshell oysters are treated with the hydrostatic pressure process, their handling differs from raw untreated oysters because they are easier to shuck. Thus, restaurants and food service establishments can serve pressure-treated oysters without a shucker on staff.

3.2 TREATMENT TECHNOLOGY FEASIBILITY

In deciding which, if any, post-harvest technology to adopt, individual plants will compare not only the per-unit costs of

[11]If yield increases were not factored into the costs of treating shucked oysters, the estimated per-unit costs of treatment would be 1.2 cents per shucked oyster for the small process, 0.7 cents per shucked oyster for the medium process, and 0.6 cents per shucked oyster for the large process.

[12]Taylor Shellfish, Inc. has been testing the hydrostatic pressure process on Pacific oysters and is finding overall yield decreases (Dewey, 2000). Thus, it is uncertain whether these yield increases apply to oysters other than the Eastern oyster.

treatment but also the feasibility of a particular technology for their plant. Specifically, small plants with limited capacity may be unable to undertake the process changes to use a particular technology. In this section, we describe the factors that will affect each plant's ability to adopt post-harvest treatment. We also describe the potential construction and use of central post-harvest treatment facilities.

3.2.1 Factors Affecting Treatment Feasibility

The primary factors affecting the feasibility of installing treatment equipment within an oyster plant include space requirements, availability of financial resources, and size of the plant relative to the treatment equipment capacity.

The primary factors affecting the feasibility of installing treatment equipment within an oyster plant include space requirements, the availability of financial resources, the size of the plant relative to the treatment equipment capacity, and the management capabilities of the plant. To learn more about the characteristics of oyster plants, we distributed a one-page questionnaire in mid-October 1999 to a randomly selected sample of plants on the Interstate Shellfish Shippers List. The list of plants was provided to us by the FDA through the Interstate Shellfish Sanitation Conference and included plants from all states on the shippers list. Of the 158 questionnaires we mailed, 20 were completed and 10 were returned by the postal service as undeliverable. Five additional questionnaires were returned with responses indicating that the plant does not handle oysters or will not be affected by post-harvest treatment requirements. We received no responses from any of the plants located in the Gulf states. While the response rate was low, the questionnaire provides us with a preliminary indication of the ability of oyster plants to install treatment equipment.

In evaluating its ability to install treatment technology, a plant may consider the following:

1. *Is space available within the plant to install treatment equipment, and is the ceiling high enough to install and run the equipment? If the answer to either of these questions is no, can the plant be expanded to accommodate the equipment? Also, if the plant needs to be expanded, is adjacent land available?*

   Based on responses to the questionnaire, most oyster plants (85 percent) have no unoccupied floor space within the plant to install the treatment equipment. Of those that do, three have 2,000 or more square feet available, which is sufficient for the large-size processes for all three treatment technologies. Of the plants with insufficient space within the plant to accommodate treatment equipment, none have adjacent land available to expand their plants.

Of the 16 plants that provided information on ceiling height, six have ceiling heights of 8 feet or less, which is too low for any of the treatment processes. An additional six plants have ceiling heights of 9 to 10 feet, which is sufficient only for the IQF process. The remaining four plants have ceiling heights of 12 or more feet, which is sufficient for the cool pasteurization process but not the hydrostatic pressure process.

2. *Does the plant have the financial resources or ability to borrow the funds needed to purchase and install the capital equipment for post-harvest treatment?*

   We did not question plants about their financial resources, but in general, we believe smaller plants are less likely to have the ability to borrow the funds necessary for equipment installation. However, regardless of their financial resources it is unlikely that plants would be able to borrow funds to install a treatment process that is designed for a capacity much greater than the plant's normal operating throughput, which is addressed in the following question.

3. *For small plants, does the plant handle a sufficient volume of product relative to the size of the treatment equipment?*

   The oyster plants that responded to the survey indicate that they process between 1 and 750 tons of shellstock per year with an average of 142 tons per year. Of the processes we evaluated, the smallest cool pasteurization process is designed for 900 shellstock tons per year and the smallest hydrostatic pressure process is designed for 625 shellstock tons per year.[13]

   If the plant handles a volume much smaller than the minimum size equipment, then their per-unit costs of

[13] AmeriPure Oyster Companies claims that the cool pasteurization process can be adapted for any size plant (Tesvich and Fahey, 2000).

processing will likely be much greater than those presented in Section 3.1. Thus, the impact of post-harvest treatment requirements will be much greater for these plants compared to larger plants. Furthermore, plants that handle a low volume of product may not have the technical capabilities required to install and operate treatment equipment.

4. *Finally, for plants that may consider installing IQF equipment, can the plant maintain the product in its frozen state throughout its storage and distribution and what kind of operational changes would be required to do so?*

   If plants do not have a means for keeping the product frozen after treatment, then IQF is not a viable option. While raw halfshell oysters are normally refrigerated throughout their distribution, they are not normally kept frozen unless they have been treated by either a cryogenic or mechanical IQF process. In addition, to market IQF oysters, a plant must be able to secure customers for the product who are likely different from their current customers to whom they sell their fresh product.

If installation of treatment equipment is technically infeasible for individual plants for any of the reasons noted above, one possible solution is the use of central treatment facilities, which are discussed in the following section.

3.2.2 Central Treatment Facilities

Central treatment facilities for post-harvest treatment of oysters could potentially evolve through two different routes. The first route would be through private companies that provide post-harvest treatment of oysters to plants on a per-unit cost basis. The second route would be through the formation of cooperatives by groups of oyster plants. At this stage in the development of the technologies, we can only speculate about whether either of these options would evolve and what kind of effects they could have on the structure of the oyster industry.

> For plants that do not install treatment equipment, post-harvest treatment services could potentially be provided to them by private companies or by cooperatives.

In evaluating either possibility, one would need to consider the effects of (1) additional transportation costs in shipping oysters to and from the central treatment facility and (2) potential effects on product quality of delays in oysters reaching their final market. Furthermore, if cooperatives form, they may take on marketing and distribution activities in addition to the treatment process and thus may also have effects on costs and product quality.

The use of central post-harvest treatment facilities could result in additional transportation costs and delays in oysters reaching the market.

When we asked plants what factors would affect their decisions to use central post-harvest treatment facilities, they responded with the following:

- confidentiality and security at the facility;
- cost or fee for the service;
- logistics, scheduling, and convenience of the service;
- transportation distance and costs to ship oysters to the facility;
- quality control at the facility; and
- the effect of the particular treatment process on the acceptability of the oysters or the demand for treated oysters.

These factors would depend on where and by whom treatment facilities would be constructed and how the institutional arrangements for treating oysters would evolve. However, based on previous experiences with central treatment facilities, some individuals in the industry believe that it is very unlikely that "dealers and harvesters will join forces and build centralized treatment facilities, or even *use* central treatment facilities if provided for them" (Howell, 2000, p. 2).[14] Scheduling the use of facilities, especially during the peak harvest season, would be particularly difficult (Howell, 2000). In addition, "Washington State growers had a bad experience with a cooperative processing facility several decades ago that has biased the industry" against these types of facilities (Dewey, 2000, p. 8). Thus, while we suggest the possibility of central treatment facilities, predicting the acceptance and level of use of central treatment facilities is beyond the scope of this study.

3.3 REFERENCES

AmeriPure Oyster Companies. Undated. Promotional brochure. Kenner, Louisiana.

[14]The state of Massachusetts operates a subsidized central depuration plant. Due to limited capacity, the plant must ration the days when harvesters can work (Howell, 2000).

Andrews, L., Sugar Processing Research Institute, New Orleans, LA. December 13, 1999. Personal communication with Mary Muth, Research Triangle Institute.

Andrews, L., Sugar Processing Research Institute, New Orleans, LA. February 4, 2000. Personal communication with Mary Muth, Research Triangle Institute.

Dewey, B., Taylor Shellfish Company, Inc. February 6, 2000. "Economic Impacts of Requiring Post-Harvest Treatment of Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

Distefano, P., Office of Seafood, Center for Food Safety and Applied Nutrition, Food and Drug Administration. November 18, 1999. Personal communication with Mary Muth, Research Triangle Institute.

Food and Drug Administration, Department of Health and Human Services. *Federal Register*. October 19, 1999. "National Fisheries Institute and Louisiana Department of Agriculture and Forestry; Filing of Food Additive Petition." 64(201):56351.

Hillman, C., Hillman Shrimp and Oyster Company, Dickinson, Texas. October 6, 1999. Teleconference with Mary Muth and Don Anderson, Research Triangle Institute.

Howell, L., Spinney Creek Shellfish, Inc. February 9, 2000. "Review of Economic Impacts of Requiring Post-Harvest Treatment for Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

National Shellfish Sanitation Program (NSSP). 1997. "Guide for the Control of Molluscan Shellfish." Produced jointly by the Interstate Shellfish Sanitation Conference and the U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration.

Nelson, C., Bon Secour Fisheries, Inc., Bon Secour, Alabama. September 29, 1999. Teleconference with Mary Muth, Research Triangle Institute.

Nelson, C., Bon Secour Fisheries, Inc., Bon Secour, Alabama. February 5, 2000. "Economic Impacts of PHT." Memorandum to Mary Muth, Research Triangle Institute.

Schegan, J., and P. Fahey, AmeriPure Oyster Companies, Inc., Kenner, Louisiana. October 5, 1999. Teleconference with Mary Muth and Don Anderson, Research Triangle Institute.

Tesvich, J., and P. Fahey, AmeriPure Oyster Companies. February 7, 2000. "RTI Draft Report on Oysters." Facsimile to Mary Muth, Research Triangle Institute.

Voisin, M., Motivatit Seafoods, Inc., Houma, Louisiana. October 6, 1999. Teleconference with Mary Muth and Don Anderson, Research Triangle Institute.

4 Potential Effects of Treatment on Demand for Oysters

Post-harvest treatment of oysters affects the demand for shucked and raw halfshell products because it affects both the physical characteristics (e.g., sensory, safety, or other quality characteristics) and the economic attributes (e.g., where and when it is sold and at what price) of each product. In this section, we briefly describe potential consumer reaction to treatment, potential restaurant and food service manager reaction to treatment, and information provided to us by the companies that currently market treated oysters. Because the treatment processes we evaluated are currently operating only in the Gulf, nearly all of the information in this section pertains to Eastern oysters harvested in the Gulf. We follow with a summary of our conclusions about the overall potential effect of treatment on demand for each treatment technology.

4.1 POTENTIAL CONSUMER REACTION TO POST-HARVEST TREATMENT

Safety, sensory, and other quality characteristics will affect the demand for post-harvest treated oysters relative to untreated oysters.

Ultimately, the effects of post-harvest treatment on oyster demand depend on whether consumers prefer or dislike treated oysters compared to untreated oysters. Consumers' specific reactions depend on the following:

- whether consumers are concerned about safety,
- whether changes in the sensory characteristics are acceptable or possibly even preferred, and

- whether there are other quality changes associated with treatment (e.g., how the oyster muscle is separated from the shell).

Their responses to each of these factors affect their willingness-to-pay for treated oysters relative to untreated oysters. In general, we expect these effects to be greater for halfshell oysters intended for raw consumption than for shucked oysters intended for cooked consumption. Without regard to changes in the safety or sensory attributes of oysters, consumers of raw halfshell oysters "have been trained to discard shellfish that are dead, gaped, and unresponsive" (Dewey, 2000, p. 2). Thus, consumer acceptability may be affected until consumers become accustomed to these changes resulting from treatment. Because cooking kills *V. vulnificus and V. parahaemolyticus* bacteria, safety is less of a consideration for shucked oysters.[1] Furthermore, sensory changes as a result of treatment are more likely to be noticeable for raw halfshell oysters than for shucked oysters that are cooked.

To evaluate potential consumer reaction to treated oysters, RTI conducted taste tests of treated and untreated raw halfshell oysters in New Orleans on August 5, 1999. The participants were not professional tasters but were individuals who normally eat raw oysters three or more times per year. None of the participants believed that they or anyone in their household had ever become sick from eating oysters, and most felt the risk of illness was either somewhat or very unlikely.

The logistics of the taste tests involved purchasing shellstock at the dock; shipping it to each of the plants that currently have treatment processes in place (Dickinson, Texas; Houma, Louisiana; and Kenner, Louisiana); treating the oysters in a timely manner; reshipping them to New Orleans by the date of the taste tests; and finally, transferring the oysters to a lab for testing. Due to the difficulties we encountered in conducting the taste tests, we do not feel confident that we can make meaningful comparisons of sensory characteristics between the treatment options or between treated and untreated oysters. However, we do feel that we can state some

[1]However, safety is still a consideration for shucked oysters because anecdotal evidence suggests that some consumers eat them raw. Seven of 19 participants in RTI's taste tests (discussed below) consume shucked oysters raw. In addition, 16 of 20 restaurant managers and chefs that we surveyed know of individuals who consume shucked oysters raw.

general conclusions about the attitudes of the taste test participants toward treatment of oysters.

About one-fourth of the participants indicated that they would not change the frequency with which they consume oysters as a result of mandatory treatment and increased retail price of $1 to $2 per dozen. Most of the remaining participants indicated that they would continue to eat raw oysters but would do so less frequently. Overall, their responses indicated that they would reduce the number of times they consume oysters per year by 35 to 52 percent if only treated oysters were available and the price of treated oysters was $1 to $2 per dozen higher than untreated oysters. In considering these results, it is important to keep in mind that all of the participants in this study regularly consume raw, untreated Gulf oysters, which they generally consider to be safe. Results may have differed if participants included individuals who do not currently consume oysters due to safety concerns. Furthermore, the responses from the taste test panel may be due to one or more of the following factors: increased price for treated oysters, changes in the sensory characteristics of treated oysters, and the perception that treated oysters are no longer a raw, live product. We cannot disaggregate the effects of these factors in their responses.

The results of the taste tests we conducted are generally opposite those of two studies on consumer responses to safer oysters.[2] The first study was a telephone survey of approximately 1,000 individuals in Florida by Degner and Petrone (1994) on potential consumer response to depurated oysters.[3] The responses to their survey are based entirely on perceived changes in the safety characteristics of raw oysters and not on any perceived changes in sensory characteristics. Their survey found that 55 percent of respondents who consume oysters would be willing to buy depurated oysters. Of this group, 70 percent would be willing to pay a premium (relative to 50 cents per oyster) ranging from 1 to 50 cents per oyster for the "safer" depurated oysters. At a retail price of 55 cents per depurated oyster, they project that the number of oyster consumers would increase by 30 percent, and the number

[2]Neither of these studies identify the pathogens that affect the safety of the oysters.

[3]Depurated oysters have been processed to reduce the number of pathogenic organisms by putting the oysters in tanks of disinfected water for a minimum of 44 hours (NSSP, 1997).

of occasions upon which oysters would be eaten would increase by nearly 60 percent, resulting in a total projected increase in oyster consumption of 39 percent. At a retail price per depurated oyster of 65 to 75 cents, they project total increases in oyster consumption of nearly 25 percent.

The second study was a survey by Lin and Milon (1995) on willingness-to-pay for safer oysters. They surveyed approximately 1,000 individuals in the mid-Atlantic and Southeastern states about their potential reactions to a *hypothetical* government inspection program that would decrease the incidence of illness from consuming oysters. They found that frequent oyster consumers, as were the taste test participants, were less willing to pay a price premium for safer oysters than infrequent consumers. Furthermore, their willingness-to-pay responses were higher if they had had a personal experience with illness from eating unsafe oysters, which was not the case for any of the taste test participants. Including participants who were not willing to pay anything more for safer oysters, they found increased willingness-to-pay averaged 18 to 20 percent more (72 to 80 cents more for a dozen oysters with a retail price of $4.00 in 1990 dollars).

Consumers who currently consume raw oysters may be less willing to pay for safer oysters compared to consumers who do not currently consume raw oysters for safety reasons.

In conclusion, we expect different responses to treatment of raw halfshell oysters based on whether an individual consumer is currently consuming raw oysters (“in-the-market”) or is not currently consuming raw oysters due to safety considerations (“out-of-the-market”). For “in-the-market” consumers, perceived sensory changes or the perception that treated oysters are no longer truly raw may cause them to reduce their consumption of raw oysters. These consumers are not likely to be willing to pay more for treated oysters. For “out-of-the-market” consumers, safety considerations may override perceived sensory changes, and they may be willing to pay more for treated oysters relative to current prices for untreated oysters. Based on the evidence presented above, the net effect of treatment on demand for oysters from these two groups of consumers is unknown; demand for treated oysters relative to untreated oysters may increase or decrease. In presenting these results, we acknowledge that all of the information we have on consumer willingness-to-pay for safer oysters is based on consumers in the Southern areas of the country where *V. vulnificus* is most prevalent.

In contrast to the raw halfshell market, we expect the effects of treatment on the demand for shucked oysters to be primarily due to changes in other quality characteristics of the oysters. However, we expect these effects to be small because these changes are less noticeable in cooked oysters.

4.2 POTENTIAL RESTAURANT MANAGER REACTION TO POST-HARVEST TREATMENT

Restaurant manager reaction to treated oysters will depend on product liability concerns, quality issues, and the practicality of serving treated oysters.

In addition to consumer perceptions regarding treatment, the effects of post-harvest treatment on oyster demand depend on whether and where oysters are available as a result of treatment. A restaurant or food service operation's decision to carry oysters is and will continue to be affected by whether or not the oysters are treated. Their specific reactions depend on the following:

- whether they are concerned about safety from a product liability viewpoint,
- whether they have other quality concerns about the product,
- whether it is feasible from a practical standpoint for the establishment to offer treated oysters (i.e., due to shelf life, storage requirements, and the need for a shucker on staff), and
- the cost of treated oysters relative to untreated oysters and the effects of the increased cost on menu prices.

Their responses to each of these factors affect whether or not they will begin to offer or discontinue offering oysters as a result of treatment. The decision to offer treated oysters may be made by the corporate headquarters of hotel and chain restaurants or by restaurant managers and chefs at individual restaurant locations. We describe our findings with regard to each of these types of restaurants below.

4.2.1 Corporate Headquarters' Decisions to Offer Treated Oysters

For restaurants owned by a corporate entity, the decision to carry treated oysters is likely to be driven by liability and reputation concerns. To learn more about the decisions by particular corporate headquarters to carry treated oysters, we interviewed individuals at the corporate headquarters of Marriott and Red Lobster. Both of these entities offer AmeriPure treated oysters at their restaurants and appear to have similar experiences with treated oysters.

Restaurants that are owned by Marriott International, Inc. and Host Marriott Corporation began serving raw halfshell and shucked pasteurized AmeriPure oysters approximately 2 years ago due to concerns about safety and liability (Grim, 1999). All of the Gulf-harvested oysters that they sell are treated; however, they also serve untreated oysters harvested from other regions because some chefs prefer oysters from particular geographical regions from which treated oysters are not currently available. They would prefer that all of the oysters they serve be treated, regardless of harvest location. The menus at restaurants that serve treated oysters do not state that the oysters are treated, and consumers appear to have reacted favorably to treated oysters.

Similarly, Red Lobster restaurants began offering raw halfshell and shucked pasteurized AmeriPure oysters a few years ago in response to *Vibrio* outbreaks (Karppe, 1999). Not all Red Lobster restaurants serve raw oysters, but those that do serve only treated raw oysters. Although Red Lobster restaurants do not state on their menu that the raw halfshell oysters are treated, they do display the AmeriPure advertising banner. Treated oysters appear to be selling well at Red Lobster restaurants (Karppe, 1999). All of the restaurants that have begun serving AmeriPure oysters, which totaled 60 by October 1999, continue to serve them.

4.2.2 Individual Restaurants' Decisions to Offer Treated Oysters

To learn more about the experiences and perceptions of individual restaurant managers and chefs regarding treated oysters, we conducted a small-scale survey of 20 restaurants over the 4-week period of October 22 through November 19, 1999. We selected restaurants in the following categories:

- restaurants that serve cooked but not raw oysters (6 restaurants),
- restaurants that serve untreated raw oysters (7 restaurants), and
- restaurants that serve post-harvest treated oysters (7 restaurants).

Based on information from restaurant managers, it appears that post-harvest treatment may either have little effect on or potentially increase availability and sales of raw oysters.

Restaurants that serve cooked but not raw oysters and restaurants that serve untreated raw oysters were randomly selected from restaurant listings in each city. Restaurants that serve post-harvest treated oysters were suggested to us by the plants that produce treated oysters or the distributors that handle their product. In all, we surveyed restaurants in the following cities: San Antonio, TX (2); New Orleans, LA (3); Gulfport, MS (1); various cities in Florida (5); Washington, DC (2); New York, NY (2); Chicago, IL (3); and Seattle, WA (2).

In general, we found that half of restaurants that *currently serve only cooked oysters* are at least somewhat likely to begin offering raw oysters if treated oysters retail for an additional price of $1 per dozen compared to untreated raw oysters. Six of the seven restaurants that *currently serve untreated raw oysters* expect that a post-harvest treatment requirement would have no effect on their sales of oysters (assuming a $1 per dozen additional retail price). Furthermore, six of the seven restaurants that *currently serve either pasteurized or IQF oysters* report that their patrons do not seem to have noticed a difference in the oysters served (5 restaurants) or actually seem to prefer treated oysters (1 restaurant). Overall, it appears from these results that post-harvest treatment could either have little effect on or potentially increase availability and sales of raw oysters. In the following sections, we describe the findings for each group of restaurants in more detail.[4]

Restaurants That Serve Only Cooked Oysters

Restaurants that serve only cooked oysters mostly serve fried or poached oysters. They do not serve raw oysters for one or more of the following reasons:

- ➤ short shelf life,
- ➤ customer safety and liability concerns,
- ➤ too labor intensive, and
- ➤ low consumer demand.

To learn about their likelihood of serving treated raw oysters, we asked the following question:

---

[4]The complete results of the restaurant manager surveys are available in Durocher, Cates, and Muth (1999).

Assuming that treated oysters would retail for an additional $1.00 ($2.00) per dozen compared to untreated oysters, within the next 12 months how likely would you consider offering them as a menu option for customers who prefer raw oysters?

Their responses indicate that half of the restaurants would be somewhat likely to offer raw treated oysters at either additional retail price, but that the other half would be very unlikely, somewhat unlikely, or neither likely nor unlikely to offer raw untreated oysters (Table 4-1).

Table 4-1. Likelihood of Restaurants that Serve Only Cooked Oysters Offering Treated Oysters
Half of restaurants that serve only cooked oysters are somewhat likely to offer treated raw oysters.

Likelihood of Serving Treated Raw Oysters	Additional Retail Price for Treated Oysters: $1 Per Dozen	$2 Per Dozen
Very unlikely	1	2
Somewhat unlikely	1	1
Neither likely nor unlikely	1	0
Somewhat likely	3	3
Very likely	0	0

Restaurants That Serve Untreated Raw Oysters

Six of the seven restaurants we surveyed that serve untreated raw oysters serve them year round. One restaurant does not serve them year round due to safety concerns.

To learn about their potential responses to post-harvest treatment, we asked them questions about the following:

- ➤ whether they would be likely to offer treated oysters *in addition to* or *instead of* untreated oysters at an additional retail price of $1.00 per dozen (assuming that post-harvest treatment is optional, not required), and
- ➤ whether they expect raw oyster sales to be affected by treatment (assuming that post-harvest treatment is required).

In response to the first question, three of the seven restaurants reported that they would be at least somewhat likely to offer treated oysters *in addition to* untreated oysters, and two of the seven restaurants reported that they would be at least somewhat likely to offer treated oysters *instead of* untreated oysters.

To address the second question, we specifically asked the following:

Assume that regulations were in place that would require raw oyster shellstock to be treated to kill bacteria and that you could no longer sell untreated oysters. Assume that treated oysters would retail for an additional cost of $1.00 ($2.00) per dozen. How would you expect this to affect your sales of raw oysters?

Their responses indicate that nearly all of the restaurants expect required post-harvest treatment of oysters at an additional retail price of $1 per dozen to have no effect on raw oyster sales (Table 4-2). At an additional retail price of $2 per dozen, most of the restaurants expect a decrease in sales, and one restaurant reported it would not sell treated oysters.

Table 4-2. Perceived Effect of Post-Harvest Treatment Requirements on Sales of Raw Oysters by Restaurants that Currently Serve Untreated Raw Oysters
Most restaurants expect no effect on sales at an additional retail price of $1 per dozen compared to untreated oysters.

	Additional Retail Price for Treated Oysters	
Perceived Effect on Raw Oyster Sales	**$1 per Dozen**	**$2 per Dozen**
Increase sales greatly (more than 25%)	0	0
Increase sales slightly (less than 25%)	0	0
No change in sales	6	1
Decrease sales slightly (less than 25%)	0	4
Decrease sales greatly (more than 25%)	1	1
I would not sell treated oysters	0	1

Restaurants That Serve Treated Raw Oysters

Of the restaurants we interviewed that serve treated oysters, five serve pasteurized AmeriPure oysters and two serve Hillman IQF oysters.[5] Six of the seven restaurants are located in the Gulf and

[5]We were unable to obtain names of restaurants that serve pressure-treated oysters from the distributor.

the seventh is located in Chicago. Their stated reasons for serving treated oysters include the following:

- ➤ reduced risk and liability concerns,
- ➤ extended shelf life, and
- ➤ customer demand for treated oysters.

As noted above, six of the seven restaurants that currently serve either pasteurized or IQF oysters report that their patrons do not seem to have noticed a difference in the oysters served (5 restaurants) or actually seem to prefer treated oysters (1 restaurant).[6] Nearly all of the restaurants charge either the same or up to $1 per dozen more for treated oysters compared to what they previously charged for untreated oysters.

We also asked the respondents how they believe their customers perceive differences in the sensory attributes of treated oysters compared to untreated oysters. Nearly all of the respondents believe that treated oysters compare favorably to untreated oysters in appearance, odor, and flavor (Table 4-3).

Table 4-3. Perceived Customer Comparisons of Sensory Attributes of Treated Oysters
Managers and chefs of restaurants that serve treated oysters believe that treated oysters compare favorably to untreated oysters.

	Oyster Attributes		
Customer Perceptions of Treated Oysters	**Appearance**	**Odor**	**Flavor**
Treated about the same as untreated	4	2	4
Treated better than untreated	2	5	2
Treated not as good as untreated	1	0	1

[6]Other restaurant responses to AmeriPure treated oysters were documented by the members of the Louisiana Oyster Task Force (1999).

4.3 COMPANY EVIDENCE OF THE EFFECTS OF POST-HARVEST TREATMENT ON DEMAND

The companies with treatment processes in place claim they are able to obtain a higher price for treated oysters compared to untreated oysters either because of increased safety or other changes in the attributes of the product.

Because all three treatment technologies are currently in use, we have evidence of the effects of post-harvest treatment on demand from our interviews with the companies in the Gulf that currently treat oysters. These three companies handle and treat Gulf-harvested oysters. In general, the companies with treatment processes in place claim they are able to obtain a higher price for treated oysters compared to untreated oysters. For two of these processes, the effects on price result not only from increased safety but also from the fact that oysters intended to be served raw on the halfshell are either pre-shucked or more easily shucked than untreated oysters. The effects on prices are described below based on information provided by the companies with treatment processes.[7]

The IQF treatment process applies only to raw halfshell oysters since the treatment technology is not currently available for shucked oysters. For raw halfshell oysters, oyster processors currently receive higher prices than for untreated oysters because the oysters are already shucked and on the halfshell, and thus the restaurant does not need to have a shucker on staff. Furthermore, because the oysters are frozen, they can be shipped further distances and kept for longer periods of time. For all of these reasons, raw halfshell oysters can be made available in locations where they otherwise may not be (e.g., inland casinos). Thus, IQF oysters generally retail for higher prices than untreated oysters in the locations where they are served. However, in coastal areas where oysters are harvested, such as the Gulf region, it is unlikely that most consumers would be willing to pay a higher price for IQF oysters than untreated oysters (Hillman, 1999).

For the cool pasteurization process, AmeriPure obtains a 10 to 20 percent price premium for treated shucked oysters relative to untreated shucked oysters from the Gulf (Dickenson, 2000). One retailer in particular, Kroger, carries only post-harvested treated oysters from the Gulf. In addition, pasteurized raw halfshell oysters sell for prices above those of untreated raw halfshell oysters

[7]In considering this evidence, we acknowledge that if all oysters were required to be treated, and thus plants could not differentiate their product because it was treated, plants may be less able to obtain higher prices for treated product.

primarily because they are perceived as safer. The convenience and other quality attributes of pasteurized raw halfshell oysters are similar to those of untreated oysters because the treatment process does not change how the oysters are shucked, handled, and stored. As reported in the *Wall Street Journal* (Chase, 1999) and the *New York Times* (St. George, 1998), pasteurized AmeriPure oysters sell at wholesale prices of 6 to 8 cents per oyster more than untreated oysters.

For the hydrostatic pressure process, both shucked and raw halfshell oysters sell for higher prices than untreated oysters because of quality, convenience, and safety differences. Pressure-treated shucked oysters sell for approximately 10 percent more than untreated shucked oysters due to quality differences in the oysters (Voisin, 1999). In particular, the muscle of the oyster separates from the shell cleanly during the process. Pressure-treated raw halfshell oysters sell for approximately 10 cents per oyster more than untreated raw halfshell oysters due primarily to convenience and safety differences (Voisin, 1999). Because the raw halfshell oysters have already been opened by the process (and kept shut with a band), they are easily reopened and prepared for serving on the halfshell.

4.4 SUMMARY OF POTENTIAL TREATMENT EFFECTS ON DEMAND

Based on the evidence presented in the preceding sections, which applies mostly to Eastern oysters harvested in the Gulf, it appears that demand for treated raw halfshell oysters could potentially increase relative to untreated raw halfshell oysters. We are less able to draw conclusions about oysters harvested from other regions of the country.[8]

Table 4-4 summarizes the evidence we have on potential effects of post-harvest treatment of oysters on demand for raw halfshell oysters harvested from the Gulf. For each information source, we

[8]Because of the uncertainties regarding the effects of post-harvest treatment on demand for oysters, the economic model presented in Section 5 presents the estimated effects of treatment requirements both *with* and *without* demand effects.

Table 4-4. Summary of the Potential Effects of Post-Harvest Treatment on Demand for Raw Halfshell Oysters
With the exception of the taste test results, post-harvest treatment of raw halfshell oysters indicates positive effects of treatment on oyster demand.

Treatments	Taste Test Results	Restaurant Survey	Plant Experience
Cryogenic IQF	–	+	+
Cool Pasteurization	–	+	+
Hydrostatic Pressure	–	NA[a]	+

[a]We were unable to contact restaurants serving pressure-treated raw halfshell oysters.

indicate whether the information we have indicates that consumers will increase consumption and/or be willing to pay more (indicated by +) or decrease consumption and/or be unwilling to pay more (indicated by –) for treated relative to untreated oysters. While the taste tests indicate negative effects, the restaurant survey and plant experience, which are indirect measures of consumer acceptance, indicate positive effects.

In comparison to raw halfshell oysters, we have relatively less information on the potential effects of treatment on shucked oyster demand. We did not include shucked oysters in the taste tests and restaurant survey; thus, the only information we have on shucked oyster demand is from plant experience. As noted previously, the IQF process does not apply to shucked oysters. For the other two processes, plant experience indicates positive effects of treatment on demand for shucked oysters.

4.5 REFERENCES

Chase, M. February 8, 1999. "Eating Raw Shellfish Is Risky for Everyone But Lethal for Some." *Wall Street Journal.* 233(26):B1.

Degner, R.L., and C. Petrone. 1994. "Consumer and Restaurant Manager Reaction to Depurated Oysters and Clams." Florida Agricultural Market Research Center, Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, Industry Report 94-1.

Dewey, B., Taylor Shellfish Company, Inc. February 6, 2000. "Economic Impacts of Requiring Post-Harvest Treatment of Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

Dickenson, B., Marketing Specialists, Smyrna, Georgia. February 7, 2000. Letter to Pat Fahey, AmeriPure Oyster Companies, Kenner, Louisiana.

Durocher, B., S. Cates, and M. Muth, Research Triangle Institute. November 24, 1999. “Restaurant Manager Survey Results.” Memorandum prepared for Ken Moore, Interstate Shellfish Sanitation Conference.

Grim, D., Marriott Corporation. September 29, 1999. Telephone conversation with Mary Muth, Research Triangle Institute.

Hillman, C., Hillman Shrimp and Oyster Company, Dickinson, Texas. October 6, 1999. Teleconference with Mary Muth and Don Anderson, Research Triangle Institute.

Karppe, M., Red Lobster Corporation. October 7, 1999. Telephone conversation with Mary Muth, Research Triangle Institute.

Lin, C.-T. Jordan, and J.W. Milon. 1995. “Contingent Valuation of Health Risk Reductions for Shellfish Products.” Chapter 5 in *Valuing Food Safety and Nutrition*, J. Caswell, ed. Westview Press: Boulder, CO.

Louisiana Oyster Task Force. May 12, 1999. “Formal Comments and Supporting Documents.” Submitted to the Louisiana Department of Health and Hospitals, Office of Public Health.

National Shellfish Sanitation Program (NSSP). 1997. “Guide for the Control of Molluscan Shellfish.” Produced jointly by the Interstate Shellfish Sanitation Conference and the U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration.

St. George, D. February 17, 1998. “A Harvest of Risk and Burden for Oystermen.” *The New York Times.* A1.

Voisin, M., Motivatit Seafoods, Inc., Houma, Louisiana. October 6, 1999. Teleconference with Mary Muth and Don Anderson, Research Triangle Institute.

5 Estimated Effects of Post-Harvest Treatment Requirements

The economic model estimates the effects of post-harvest treatment requirements on prices and output in the halfshell, shucked, and shellstock markets and on plant employment in the processing sector.

Using information and data from our profile of the oyster industry, we developed a model to estimate the economic impacts of requiring post-harvest treatment of oysters. We use information from Section 3 on the costs of the treatment technologies in conjunction with information from Section 4 on the expected effects of treatment on demand for oysters to estimate changes in prices and output in the halfshell, shucked, and shellstock markets and to estimate changes in plant employment in the processing sector. We also investigate the potential distributional effects of treatment requirements on international trade and on plants of different sizes.

This section presents the results of our analysis. We begin by describing the assumptions of the analysis and the baseline data used in constructing the model. We present the estimated shifts in supply and demand for halfshell and shucked oysters for each of the treatments. Finally, we provide our estimates of the economic effects of the treatment technologies. The methodology we used to obtain these results is described in Appendix A, and detailed model results are provided in Appendix B.

5.1 ASSUMPTIONS AND BASELINE INDUSTRY DATA

In this section, we describe the assumptions of the economic model and the baseline data used in constructing the model. The assumptions are required for tractability and application of the model, and the baseline data are used to calibrate the model.

5.1.1 Assumptions of the Analysis

Assumptions of the model include those that define how treatment requirements will be imposed and the structure of the oyster industry.

In developing a model of the national oyster industry, we made several assumptions regarding the treatment requirements and the structure of the oyster industry. These assumptions are listed and briefly described below.

- **Both the harvesting and processing sectors of the oyster industry are perfectly competitive.** Perfect competition means that individual producers of shucked and halfshell oysters and harvesters of shellstock receive the going market price for similar quality products rather than influence market prices.
- **Treatment requirements would be imposed year-round.** According to CSPI (1999), levels of *V. vulnificus* are higher in summer-harvested oysters, but it has been detected in oysters harvested during most months of the year.
- **The per-unit costs of treatment will be the same for all plants.** Because we have little information on the size distribution of oyster plants, we are not able to assign different cost estimates to different size plants in the economic model.[1]
- **Shellstock may be harvested from any region of the country to satisfy processing needs in any of the other regions.** Based on information provided to us by industry representatives (described in Section 2.3), shellstock is frequently shipped to other regions for processing.
- **International trade flows of oysters will be unaffected by treatment requirements.** Treatment requirements for exported and imported oysters would cause changes in

[1] Per-unit treatment costs would actually differ across plants depending at least in part on their size, with smaller plants likely incurring higher per-unit costs and larger plants likely incurring lower per-unit costs (see Section 3 for cost estimates for different size processes). If plants were to use a central treatment facility, transportation costs to and from the facility would raise their per-unit costs even higher. Because the existence and location of central treatment facilities is only speculative at this time, we do not have estimates of these transportation costs.

international trade that cannot be addressed in the economic model.[2]

- **The Atlantic, Gulf, Northeast, and Pacific oyster processing regions can each be considered distinct markets with interregional trade flows between them.** Based on information from industry representatives, the characteristics of the oyster markets in each of these areas differ considerably. However, trade flows of products between regions are substantial.

Finally, we assume three possible treatment requirement scenarios. From most restrictive to least restrictive, they are as follows:

- requirements throughout the **United States**, for both **shucked** and **raw halfshell** oysters;
- requirements in the **Gulf only**, for both **shucked** and **raw halfshell** oysters; and
- requirements in the **Gulf only**, for **raw halfshell** oysters only.

In Section 5.3, we present the results of the economic model for the first two types of requirements. For the Gulf-only requirements for raw halfshell oysters, we describe why the economic model is less appropriate and the qualitative differences we expect compared to Gulf-only requirements for both shucked and raw halfshell oysters.

5.1.2 Baseline Oyster Industry Data

We use 1997 data as the baseline in the economic impacts model for two primary reasons: (1) 1997 is the most recent year for which complete data are available for the industry; and (2) with the exception of the cryogenic IQF process, post-harvest treated oysters were not yet widely available, and thus the 1997 data were mostly unaffected by changes in the marketplace resulting from post-harvest treatment.[3] By assuming 1997 as the baseline, we are projecting the effects of treatment requirements as if 1997 was a typical year for the industry. To the extent that 1997 was better or worse than a typical year, the model may understate or overstate the potential effects of treatment requirements.

---

[2]The reasons why post-harvest treatment may affect international trade in oysters are described in Section 5.3.4.

[3]Because the cryogenic IQF process was in use for a significant portion of the Gulf market, we adjust our data for its effects as noted later.

We compiled baseline oyster industry data from NMFS datasets and adjusted the data based on information from industry sources.

Table 5-1 presents the 1997 baseline data as used in the economic impacts model. Note that we express halfshell and shellstock volumes on a meat-weight basis, in addition to a per-oyster basis, so that our data are consistent across product forms in the economic impacts model. These data were obtained and adjusted as follows:

- **Shucked product volumes** were obtained from NMFS shucking plant data.
  - ✓ NMFS converts from gallons to pounds by multiplying by 8.5; thus, we adjusted the data to reflect 7 pounds of meat per gallon (see Section 2.2 for further discussion).
- **Halfshell product volumes** were estimated based on the proportion of shellstock used for shucked and halfshell uses as suggested to us by industry representatives.
  - ✓ We assumed halfshell volumes of 25 percent in the Atlantic, 50 percent in the Gulf, 90 percent in the Northeast, and 20 percent in the Pacific.
  - ✓ To translate meat-weight pounds to number of oysters, we assumed 7 pounds of meat per 275 oysters, except for the Pacific where we assumed 7 pounds of meat per 150 oysters.
- **Shellstock input volumes** were estimated by adding shucked and halfshell volumes, without distinguishing from which region the shellstock are harvested.[4]
- Halfshell and shellstock volumes treated and marketed as cryogenic IQF product were subtracted from the Gulf totals because IQF halfshell oysters are marketed differently than untreated oysters (see Section 5.3.1 for more explanation).
  - ✓ We assumed 10 percent of the halfshell volume in the Gulf is marketed as cryogenic IQF product based on information provided to us by industry sources.
- **Wholesale shucked product prices** were obtained from NMFS shucking plant data.
  - ✓ We adjusted the prices to reflect 7 pounds of meat per gallon rather than 8.5 as noted above.
- **Wholesale halfshell product prices** were estimated based on the relationship between shucked prices and halfshell prices, on a meat-weight basis, as reported at the Fulton Fish Market (U.S. Department of Commerce, 1997).

[4]Note that our estimate of shellstock volume implies that national NMFS harvest data are understated by approximately 43 percent. As described in Section 2.1, this is not inconsistent with statements by industry representatives.

Table 5-1. Baseline Wholesale Oyster Industry Data, 1997
Baseline oyster industry data were obtained from NMFS and augmented with information from industry sources.

	U.S. Total	Atlantic	Gulf[a]	Northeast	Pacific
Halfshell volume (output)					
Meat-weight pound	17,727,374	1,776,342	11,115,330	2,384,226	2,451,476
No. of oysters[b]	652,656,187	69,784,874	436,673,663	93,666,021	52,531,629
Shucked volume (output)					
Meat-weight pound	29,294,007	5,329,027	13,894,162	264,914	9,805,904
Shellstock volume (input)					
Meat-weight pound	47,021,381	7,105,369	25,009,492	2,649,140	12,257,380
No. of oysters[b]	1,628,386,738	279,139,496	982,515,741	104,073,357	262,658,143
Halfshell price (output)					
Per meat-weight pound	$7.33	$7.70	$5.55	$9.56	$7.94
Per oyster[b]	$0.20	$0.20	$0.14	$0.24	$0.37
Shucked price (output)					
Per meat-weight pound	$4.42	$5.13	$4.44	$5.31	$3.97
Shellstock price (input)					
Per meat-weight pound	$2.57	$3.41	$2.13	$3.61	$2.74
Per oyster[b]	$0.07	$0.09	$0.05	$0.09	$0.13
Halfshell revenue	$129,941,650	$13,677,835	$61,690,079	$22,793,201	$19,464,719
Shucked revenue	$129,479,511	$27,337,909	$61,690,079	$1,406,693	$38,929,439
Shellstock cost	$120,844,948	$24,229,308	$53,270,217	$9,563,395	$33,585,221
No. of plants[c]					
Shucker/packer	392	112	161	79	40
In-shell	1,150	232	173	446	270
No. of FTE plant workers[d]	1,953	398	1,098	42	416

[a]Gulf shellstock and halfshell volumes do not include the 10 percent of the market that we estimate are processed by cryogenic IQF.

[b]We assumed 7 pounds of meat per 275 oysters, except in the Pacific where we assumed 150 oysters.

[c]The number of plants listed is the number of shellfish shippers and shucker/packers on the Interstate Shellfish Shippers List and is an upperbound on the number of oyster plants. Because inland plants are not included above, U.S. totals shown here are less than U.S. totals on the Shippers List.

[d]FTE = full time equivalent. We estimated the number of FTE workers based on annual volumes.

- ✓ We assumed that halfshell prices were higher than shucked prices by 50 percent in the Atlantic, 25 percent in the Gulf, 80 percent in the Northeast, and 100 percent in the Pacific.

➤ **Harvest shellstock prices** were obtained from NMFS harvest data.

➤ **Numbers of plants** were obtained from the Interstate Certified Shellfish Shippers List. Not all of these plants handle oysters, but the number of plants on the Shippers List provides an upperbound to the number of plants affected by post-harvest treatment requirements.

➤ **Shucker employment** and **halfshell worker employment** numbers were estimated based on the volume that a full-time employee can process on an annual basis.

- ✓ We assumed that a full-time shucker can shuck 14,000 meat pounds per year (except in the Pacific, for which we assumed 25,000 meat pounds per year for the larger Pacific oyster), and a full-time halfshell worker can handle shellstock equivalent to 105,000 meat pounds per year.

5.2 COST AND DEMAND CHANGES FOR THE TREATMENT TECHNOLOGIES

To determine how the baseline data on volumes, prices, and employment may change as a result of post-harvest treatment requirements, we obtained estimates of the costs of post-harvest treatment on a per-unit basis (i.e., how supply of oysters shifts) and how the demand for oysters may change due to changes in preferences for treated oysters.[5] We describe each of these shifts below.

5.2.1 Cost Shifts for Post-Harvest Treatment Process

> Supply of halfshell and shucked oysters will shift by the per-unit costs of post-harvest treatment.

We estimated the costs of post-harvest treatment processes using data and information provided by the plants with treatment processes in place. We use these costs as a proxy for the shift in supply of halfshell and shucked oysters as a result of treatment requirements (see Appendix A for more explanation). Thus, the costs on a per-unit basis are expressed as a proportion relative to the market price to obtain the supply shifts used in the model. The

[5]As described in Section 5.3, we estimated the model with both effects of treatment on supply (costs) and demand and with effects of treatment on supply (costs) only.

cost estimates, which are described in detail in Section 3.1, include the following:

- annualized plant expansion costs for the space required to house the treatment equipment,
- annualized capital equipment and installation costs,
- annual operating and maintenance costs (e.g., labor, energy, water, replacement parts, and oyster bands for halfshell product), and
- per-unit royalties charged by the owners of the technologies for the cool pasteurization and hydrostatic pressure processes.

Table 5-2 lists the per-unit treatment costs for medium-size (or average-size) processes for each treatment technology. We provide the estimates based on $10 per hour wage rates (including benefits) as in Section 3 and also on $15 per hour wage rates (including benefits) to reflect higher wage rates in the Northeast region. The estimates on a per-meat pound are used in the model, but we provide the estimates on a per-oyster basis for comparison. Two of these estimates in the table bear some explanation. First, negative treatment costs for shucked product result from either yield increases or reduced shucking labor from the treatment process. Second, the treatment costs for IQF halfshell product are very large primarily because the oysters must be shucked and prepared on the halfshell prior to treatment and because the oysters must be kept frozen once they are treated.

5.2.2 Demand Shifts for Treated Oysters

> The demand for halfshell and shucked oysters will shift if consumers prefer, or potentially dislike, treated oysters relative to untreated oysters.

Demand for oysters may change as a result of treatment both because current consumers of oysters adjust their consumption or because consumers not currently consuming oysters begin to consume oysters. We based our estimates of changes in demand for treated shucked and halfshell oysters primarily on the increases in wholesale prices that the plants with treatment processes in place claim they are able to obtain. The reasons for these shifts in demand, which are described in detail in Section 4 and may or may not apply to each treatment, include the following:

- reduced concerns about safety by consumers of halfshell oysters,
- reduced concerns about liability by restaurants and food service operations serving halfshell oysters,

Table 5-2. Per-Unit Treatment Cost Estimates (medium or average size processes)[a]
Treatment costs vary by product type and treatment method and depend, in part, on wage rates.

	Shucked		Halfshell	
	$10/Hour Wage Rates	$15/Hour Wage Rates	$10/Hour Wage Rates	$15/Hour Wage Rates
Cryogenic IQF				
Cost per oyster	na[b]	na[b]	$0.139	$0.177
Cost per pound (meat)[c]	—	—	$5.461	$6.954
Cool Pasteurization				
Cost per oyster	–$0.001	$0.002	$0.035	$0.043
Cost per pound (meat)[c]	–$0.039	$0.079	$1.375	$1.689
Hydrostatic Pressure				
Cost per oyster	–$0.029	–$0.028	$0.033	$0.036
Cost per pound (meat)[c]	–$1.139	–$1.100	$1.296	$1.414

[a]We calculated treatment cost estimates based on data provided by the plants with treatment processes in place.

[b]The cryogenic IQF process has not been adopted for use on shucked oysters.

[c]Cost per pound of meat was calculated based on the assumption that 275 oysters yield 7 pounds of meat. In the Pacific, the cost per oyster would be higher than these estimates but the number of oysters per pound would be lower such that the per pound estimates would be similar.

- greater feasibility of serving halfshell oysters in particular locations (particularly in inland areas),
- changes in the sensory characteristics of the halfshell oysters, and
- other quality changes that occur in halfshell and shucked oysters as result of treatment.

Table 5-3 lists the estimated proportionate shift in demand (i.e., the percentage change in willingness-to-pay) for shucked and halfshell product treated by each method. We estimated these shifts based on claims by the plants that currently market treated oysters (see Section 4.3). Because these demand shifts are somewhat speculative, we consider the impacts of post-harvest treatment requirements both with and without the demand shifts. In the case without demand shifts, we are assuming that consumers are indifferent between treated and untreated oysters.

Table 5-3. Proportionate Demand Shift Estimates Resulting from Post-Harvest Treatment[a]
Willingness-to-pay for treated oysters at the wholesale level is estimated to be between 0 and 33 percent greater than untreated oysters.

Process	Shucked	Halfshell
Cryogenic IQF	na[b]	33%
Cool Pasteurization	15%	15%
Hydrostatic Pressure	10%	20%

[a]We based our estimates on claims by the plants that have treatment processes in place.

[b]The IQF process has not been adopted for use on shucked oysters.

5.3 ECONOMIC EFFECTS OF POST-HARVEST TREATMENT REQUIREMENTS

We estimated the economic effects of post-harvest treatment requirements by incorporating the supply and demand shifts described above into an economic model of the oyster industry. The model, which is described in Appendix A, estimates the plant-level effects of the requirements on

- output volumes for halfshell and shucked oysters,
- input volumes for shellstock,
- output prices for halfshell and shucked oysters,
- input prices for shellstock oysters,
- revenue generated from halfshell and shucked oysters,
- total costs of shellstock,
- total costs of the treatment process, and
- changes in oyster plant employment (process workers).

The potential effects on plant closures, which are not estimated from the economic model, are discussed in Section 5.3.5.

Because the cryogenic IQF treatment process is substantially different from the cool pasteurization and hydrostatic pressure processes, we address it separately prior to describing the results for the other two processes.

5.3.1 The Cryogenic IQF Treatment Process

Based on our discussions with industry representatives, we believe cryogenic IQF-treated halfshell oysters are essentially in a different market than halfshell oysters that are untreated or treated by either of the other two treatment methods. The oysters are packaged on the halfshell (i.e., shucking costs are incurred at the oyster plant) and are kept frozen in storage and distribution once treated. The costs of treating IQF oysters, as indicated in Table 5-2, are three to five times higher than for either of the other two processes. The market for these oysters is in locations where halfshell oysters would normally not be available for consumption such as inland casinos, cruise ships, and similar types of venues. In areas where there are no impediments to serving halfshell oysters, particularly in coastal areas, it is unlikely that consumers would be willing to pay the additional costs associated with IQF oysters.

A plant faced with the decision about which post-harvest treatment method to choose is unlikely to consider cryogenic IQF as an option unless the plant is prepared to market halfshell oysters differently than they have in the past.

Thus, a plant faced with the decision about which post-harvest treatment method to choose is unlikely to consider cryogenic IQF as an option unless the plant is prepared to market halfshell oysters differently than they have in the past. However, the cryogenic IQF market is substantial in the Gulf region; we estimate that approximately 10 percent of the halfshell oysters processed in the Gulf are treated by the cryogenic IQF process (three plants are currently operating, and one is coming on-line shortly).[6] We expect the cryogenic IQF halfshell market to be essentially unaffected by treatment requirements. For this reason, and because the IQF treatment method has not been adapted for use on shucked oysters, we exclude the IQF proportion of the Gulf market by subtracting 10 percent of the halfshell and shellstock volumes from the baseline data. We estimate the effects of post-harvest treatment on the remaining portion of the Gulf market for each of the other two treatments.

[6] An industry representative informed us that two cryogenic plants are also operating in Virginia, but we were unable to confirm the relative sizes of these plants.

5.3.2 Economic Effects of Treatment Requirements for Both Shucked and Raw Halfshell Oysters (Gulf Only and United States)

> We considered scenarios in which treatment requirements would apply to both shucked and halfshell product or only halfshell product, to the Gulf region or to all of the United States, and with and without demand shifts for treated product.

We estimated the effects of post-harvest treatment requirements assuming that the entire industry would adopt either the cool pasteurization process or the hydrostatic pressure process.[7] In estimating these effects, we considered scenarios in which

- ➤ treatment requirements would apply to
  - ✓ the entire United States, for both raw halfshell and shucked product;
  - ✓ the Gulf only, for both raw halfshell and shucked product; or
  - ✓ the Gulf only, for raw halfshell product only; and
- ➤ treatment requirements would affect
  - ✓ only the costs of producing oysters (supply shifts—see Table 5-2) or
  - ✓ both the costs and willingness-to-pay for oysters (supply shifts and demand shifts—see Table 5-3).

Because the economic model is less appropriate in considering the effects of *Gulf only, raw halfshell only* treatment requirements, we address this scenario separately in Section 5.3.3.[8] Also, because the demand shifts are somewhat speculative, we estimated the economic impacts both with and without them.

In this section, we focus on the effects of treatment requirements that apply to *both raw halfshell and shucked product* and consider the following four scenarios for each treatment process:

- ➤ Gulf-only requirements with supply shifts,
- ➤ Gulf-only requirements with supply and demand shifts,
- ➤ U.S. requirements with supply shifts, and
- ➤ U.S. requirements with supply and demand shifts.

---

[7]We assumed that all plants adopt either one technology or the other because we do not have information on the characteristics of individual oyster plants and thus cannot predict the proportion of plants that may adopt one technology versus the other.

[8]Because the treatment processes yield benefits, such as increased yields and reduced shucking labor, for shucked oysters products, plants that install treatment equipment are likely to run the processes for both raw halfshell and shucked product.

The results of these four scenarios for each treatment process are summarized in Table 5-4 for the cool pasteurization process and in Table 5-5 for the hydrostatic pressure process. These tables summarize the estimated effects of treatment requirements on prices, volumes, revenues, shellstock costs, treatment costs (or savings), and plant employment. In addition to these summaries, the complete results of each scenario are presented in Appendix B.

In general, the overall economic effects of treatment requirements are greatest when requirements apply to the entire United States, rather than to only the Gulf region, and when demand shifts are included in the model in addition to supply shifts. Even when requirements are applied only to the Gulf, some effects occur in other regions because of the interregional shipment of oysters between regions. If requirements apply to the entire United States, prices and volumes are affected similarly across regions, except in the Northeast because the region shucks few oysters and thus would not experience the benefits of the treatment processes for shucked oysters. Depending on the scenario, total FTE employment in the industry increases by a minimum of 28 percent for the cool pasteurization process but decreases by a minimum of 23 percent for the hydrostatic pressure process. Industry-wide treatment costs total a minimum of $14 million for the cool pasteurization treatment process and treatment savings total a minimum of $2 million for the hydrostatic pressure process. If demand shifts are included in the model in addition to supply shifts, then producers appear to benefit in the case of either treatment technology because revenues are estimated to rise more than the increase in costs associated with the treatment technologies.

The effects of a Gulf-only treatment requirement that would require shellstock oysters harvested in the Gulf to be treated prior to shipment out of the Gulf would have even greater economic effects than estimated by the economic model.

In the scenario with Gulf-only controls, the effects on both the Gulf and other regions would likely be greater than those estimated by the economic model if treatment requirements imply that shellstock oysters may not leave the region prior to treatment. Shellstock oysters are currently shipped from the Gulf to other regions, particularly the Atlantic and Pacific regions, primarily for shucking but also for raw halfshell use. If Gulf oysters were required to be treated in the Gulf, then the volume of product processed in the Gulf would increase greatly. Plants in regions that depend on Gulf shellstock may then have difficulties in purchasing sufficient shellstock inputs to ensure their economic viability. Predicting the

Table 5-4. Summary of Results Assuming All Plants Adopt the Cool Pasteurization Treatment Process

We considered four combinations of treatment requirements and supply and demand shifts.[a]

Scenario: Gulf-only controls, supply shifts only	Scenario: U.S. controls, supply shifts only
➤ In the Gulf, **prices** for raw halfshell oysters increase by 10 percent, shucked oysters increase by 1 percent, and shellstock oysters decrease by 2 percent. Price changes in other regions are 1 percent or less for raw halfshell and shucked oysters and 1 percent or less for shellstock. ➤ In the Gulf, **volumes** for raw halfshell oysters decrease by 5 percent, shucked oysters increase by 2 percent, and shellstock oysters decrease by 1 percent. Volume increases in other regions are 2 percent or less for all products. ➤ In the Gulf, **revenues** increase by 5 percent for raw halfshell oysters and 3 percent for shucked oysters, shellstock costs decrease 3 percent, and **treatment costs** are $14.0 million. In other regions, revenues and shellstock costs both increase by much lesser amounts. ➤ In the Gulf, **FTE plant workers** increase by 30 percent primarily due to a large increase in halfshell handlers for the banding operation. Employment changes in other regions are 2 percent or less.	➤ Across the U.S., **prices** for raw halfshell oysters increase by 8 to 12 percent, shucked oysters increase by 2 percent in all regions, and shellstock oysters change by –2.5 to 2.2 percent. ➤ Across the U.S., **volumes** for raw halfshell oysters decrease by 1 to 2 percent, shucked oysters increase by 1 to 3 percent, and shellstock oysters change by –1.5 to 1.3 percent. ➤ For all regions in the U.S. combined, **revenues** increase by 8 percent for raw halfshell oysters and 4 percent for shucked oysters, which is offset by an increase in shellstock costs of 1.4 percent and **treatment costs** of $22.7 million ($14.4 million in the Gulf). ➤ For all regions in the U.S. combined, **FTE plant workers** increase by 28 percent primarily due to a large increase in halfshell handlers for the banding operation.
Scenario: Gulf only, supply and demand shifts	**Scenario: U.S. controls, supply and demand shifts**
➤ In the Gulf, **prices** for raw halfshell oysters increase by 22 percent, shucked oysters increase by 11 percent, and shellstock oysters increase by 16 percent. Price increases in other regions are 3 percent or less for raw halfshell and shucked oysters and 5 percent or less for shellstock. ➤ In the Gulf, **volumes** for raw halfshell oysters increase by 7 percent, shucked oysters decrease by 12 percent, and shellstock oysters increase by 10 percent. Volume increases in other regions are 4 percent or less for all products. ➤ In the Gulf, **revenues** increase by 31 percent for raw halfshell oysters and 24 percent for shucked oysters, which is offset by an increase in shellstock costs of 27 percent and **treatment costs** of $15.8 million. In other regions, revenues and shellstock costs both increase by much lesser amounts. ➤ In the Gulf, **FTE plant workers** increase by 44 percent primarily due to a large increase in halfshell handlers for the banding operation. Employment changes in other regions are 3 percent or less.	➤ Across the U.S., **prices** for raw halfshell oysters increase by 22 to 29 percent, shucked oysters increase by 13 to 16 percent, and shellstock oysters increase by 20 to 27 percent. ➤ Across the U.S., **volumes** for raw halfshell oysters increase by 12 to 16 percent, shucked oysters increase by 13 to 17 percent, and shellstock oysters increase by 12 to 16 percent. ➤ For all regions in the U.S. combined, **revenues** increase by 43 percent for raw halfshell oysters and 34 percent for shucked oysters, which is offset by an increase in shellstock costs of 43 percent and **treatment costs** of $26.4 million ($16.8 million in the Gulf). ➤ For all regions in the U.S. combined, **FTE plant workers** increase by 46 percent primarily due to increases in production volumes and a large increase in halfshell handlers for the banding operation.

[a]Complete numerical results are provided in Appendix B.

Table 5-5. Summary of Results Assuming All Plants Adopt the Hydrostatic Pressure Process
We considered four combinations of treatment requirements and supply and demand shifts.[a]

Scenario: Gulf-only controls, supply shifts only	Scenario: U.S. controls, supply shifts only
➤ In the Gulf, **prices** for raw halfshell oysters increase by 8 percent, shucked oysters decrease by 6 percent, and shellstock oysters increase by 3 percent. Prices change in other regions by –1 to 0 percent for all products. ➤ In the Gulf, **volumes** for raw halfshell oysters decrease by 6 percent, shucked oysters increase by 8 percent, and shellstock oysters increase by 2 percent. Volumes change in other regions by –1 to 1 percent for all products. ➤ In the Gulf, **revenues** increase by 1.5 percent for raw halfshell oysters and 2 percent for shucked oysters, which is offset by increases in shellstock costs of 5 percent. **Treatment process savings total** $3.7 million. In other regions, absolute changes in revenues and shellstock costs are generally smaller than in the Gulf. ➤ In the Gulf, **FTE plant workers** decrease by 28 percent due to a large decrease in the number of shuckers, which is partially offset by an increase in halfshell handlers for the banding operation. Employment changes in other regions are –1 percent or smaller.	➤ Across the U.S., **prices** for raw halfshell oysters increase by 4 to 9 percent, shucked oysters decrease by 6 to 7 percent, and shellstock oysters increase by 2 to 8 percent except in the Northeast where they decrease by 3 percent. ➤ Across the U.S., **volumes** for raw halfshell oysters decrease by 3 to 5 percent, shucked oysters increase by 4 to 7 percent, and shellstock oysters increase by 1 to 5 percent except in the Northeast where they decrease by 2 percent. ➤ For all regions in the U.S. combined, **revenues** increase by 3 percent for raw halfshell oysters and decrease by 2 percent for shucked oysters, and shellstock costs increase by 6 percent. **Treatment process savings** total $13.2 million. Treatment costs are positive only in the Northeast. ➤ For all regions in the U.S. combined, **FTE plant workers** decrease by 33 percent due to a large decrease in the number of shuckers, which is partially offset by an increase in halfshell handlers for the banding operation. However, FTE plant workers in the Northeast increase by 145 percent.
Scenario: Gulf only, supply and demand shifts	**Scenario: U.S. controls, supply and demand shifts**
➤ In the Gulf, **prices** for raw halfshell oysters increase by 22 percent, shucked oysters increase by 3 percent, and shellstock oysters increase by 20 percent. Prices increase in other regions by less than 3 percent for all products. ➤ In the Gulf, **volumes** for raw halfshell oysters increase by 9 percent, shucked oysters increase by 15 percent, and shellstock oysters increase by 12 percent. Volumes increase in other regions by less than 4 percent for all products. ➤ In the Gulf, **revenues** increase by 34 percent for raw halfshell oysters and 18 percent for shucked oysters, which is offset by increases in shellstock costs of 35 percent. **Treatment process savings** total $2.4 million. In other regions, absolute changes in revenues and shellstock costs are much smaller than in the Gulf. ➤ In the Gulf, **FTE plant workers** decrease by 20 percent due to a large decrease in the number of shuckers, which is partially offset by an increase in halfshell handlers for the banding operation. Employment changes in other regions are less than 1 percent.	➤ Across the U.S., **prices** for raw halfshell oysters increase by 21 to 27 percent, shucked oysters increase by 3 to 6 percent, and shellstock oysters increase by 23 to 26 percent. ➤ Across the U.S., **volumes** for raw halfshell oysters increase by 14 to 18 percent, shucked oysters increase by 14 to 16 percent, and shellstock oysters increase by 14 to 16 percent. ➤ For all regions in the U.S. combined, **revenues** increase by 44 percent for raw halfshell oysters and 21 percent for shucked oysters, which is offset by increases in shellstock costs of 45 percent. **Treatment process savings** total $12.1, but treatment costs are positive in the Northeast. ➤ For all regions in the U.S. combined, **FTE plant workers** decrease by 23 percent due to a large decrease in the number of shuckers, which is partially offset by an increase in halfshell handlers for the banding operation. However, FTE plant workers in the Northeast increase by 188 percent.

[a]Complete numerical results are provided in Appendix B.

economic effects of such a requirement is beyond the capabilities of the model because the model focuses on the processing rather than the harvesting sector of the industry, and because we do not have reliable data on the volume of shellstock oysters shipped for processing outside of the Gulf.

5.3.3 Economic Effects of Treatment Requirements for Only Gulf, Raw Halfshell Oysters

Because of the benefits of the treatment processes for shucked oysters, producers that shuck oysters would likely use these processes for both shucked and halfshell oysters even if not required to treat shucked oysters.

If treatment requirements were to apply to only raw halfshell product processed in the Gulf, the results of the model differ from those presented above. While our economic model can be used to estimate the potential effects of this scenario, we believe the results of such an analysis would be less useful because of the nature of the treatment technologies we evaluated. In particular, both the hydrostatic pressure process and the cool pasteurization process appear to yield benefits to plants that shuck oysters due to increased yields and, in the case of the hydrostatic pressure process, shucker labor savings. Thus, producers that shuck oysters would likely use these processes for shucked oysters in addition to halfshell oysters and thus would treat shucked oysters even if not required to do so.

If we estimate the economic effects of treatment requirements for *Gulf only, raw halfshell oysters only*, it appears that we should include treatment cost savings for shucked oysters as we have done for the scenario of treatment requirements that apply to both shucked and raw halfshell oysters in the Gulf. However, the economic model cannot account for the fact that some producers may stop producing raw halfshell product entirely or for the potential effect of requiring that Gulf oysters must be treated before being shipped out of the region.

If we did consider the case in which Gulf region producers treat *raw halfshell oysters only* regardless of any potential benefits from treating shucked oysters, we would expect to see the following effects of post-harvest treatment requirements as compared to the results we presented for *the Gulf region only* including *both raw halfshell and shucked oysters*:

- In the Gulf, production of raw halfshell oysters would be lower and the production of shucked oysters would be higher. Some producers would choose to shuck all the oysters they process to avoid installing treatment equipment, while other producers would shift a portion of their production from raw halfshell to shucked oysters to avoid a portion of the costs of treating oysters.

- In the Gulf, prices of raw halfshell oysters would rise less (and perhaps fall) because some consumers would likely switch to shucked oysters rather than pay more for raw halfshell oysters and other regions would likely purchase fewer Gulf raw halfshell oysters. With lower prices for raw halfshell oysters, producers would be less able to recoup the costs of treatment.
- In the Gulf, prices of shucked oysters may rise or fall depending on how much consumers switch from raw halfshell oyster to shucked oyster consumption (causing prices to increase) and how much producers switch from raw halfshell to shucked oyster production (causing prices to decrease).
- Total treatment costs would increase because they would no longer be offset by treatment savings for shucked product.
- FTE plant workers would be higher for both processes as a result of greater shucked volumes, and FTE workers would increase rather than decrease for the hydrostatic pressure process because shucking labor reductions would not be realized.

As described in the previous section for the case of Gulf-only requirements for both shucked and raw halfshell oysters, the interregional trade effects of treatment requirements will depend on how the treatment requirements are imposed. In particular, if Gulf oysters were required to be treated in the Gulf, then the volume of product processed in the Gulf would increase greatly. As mentioned previously, modeling the effects of such a requirement is beyond the scope of the economic model.

5.3.4 Potential International Trade Effects of Treatment Requirements

As mentioned in Section 5.3.2, oysters imported into or exported from the United States may also be required to be treated. Industry representatives believe that treatment requirements for imported and exported oysters will greatly reduce international trade of oysters (Howell, 2000; Dewey, 2000). For U.S. oysters intended for the export market, post-harvest treatment may reduce the market for U.S. oysters because foreign consumers are likely to be

- sensitive to changes in sensory characteristics resulting from treatment, particularly in Asian markets;
- concerned that the need for treatment (as indicated on the label) insinuates that something may be wrong with the product; and
- not accepting of additional processing of oysters, particularly in European countries.

For foreign oysters intended for import into the United States, post-harvest treatment requirements may reduce the volume of imports because foreign firms will export to other countries rather than comply with U.S. treatment requirements. Treatment requirements would likely affect oysters that enter the United States as IQF product, if they are mechanically frozen, and as live product intended for the halfshell market (e.g., from Canada and Chile).

5.3.5 Potential Effects of Treatment Requirements on Individual Plants

Individual plants will be affected by treatment requirements both through the effects of treatment costs on market prices and output and because of the changes in their processes that are required to conduct post-harvest treatment activities.[9] A decline in output that occurs as a result of treatment may result from several individual plants reducing their level of output and from the less efficient plants shutting down (e.g., if it is too small relative to the capacity of the treatment equipment or they cannot borrow sufficient funds for purchasing capital equipment). However, in cases in which one observes increases in output as a result of treatment requirements, the reduction in output from plants that shut down is more than offset by increases in output by plants that remain in the market.

> Plant shut-downs may occur because the revenue of the plant is not sufficient to cover its production costs plus the costs of treatment, or because it is technically infeasible for the plant to install treatment equipment.

Plants may shut down as a result of treatment requirements because either the revenue of the plant is not sufficient to cover its production costs plus the costs of treatment, or because it is technically infeasible for the plant to install treatment equipment. However, in cases where the treatment technology actually results

[9]Given sufficient information on the characteristics of individual plants (e.g., their size, access to financial resources, proportion of product to the halfshell and shucked market), one could model the decisions of individual plants to choose one technology versus the other. Then, based on changes in their own production costs and in market prices, one could estimate which plants may potentially close as a result of post-harvest treatment. However, detailed data of this nature could not be obtained for this industry.

in cost savings for the industry (i.e., through reductions in the costs of shucking), we expect plant closures primarily because it is technically infeasible for the plant to install treatment equipment. In particular, we know that the oyster industry is characterized by many small operations that may not have the financial resources or the technical capacity to install and maintain treatment equipment.

While central treatment facilities may become available for small facilities to treat oysters, many in the industry have concerns about their feasibility for widely dispersed producers in an industry that does not have a history of successful cooperative efforts involving other shellfish-related activities (Howell, 2000; Dewey, 2000).[10] In addition, the use of central treatment facilities may substantially increase the costs of producing oysters due to the costs of transporting product to the facility. Transportation costs are already a substantial portion of the costs of producing oysters (Nelson, 2000).

5.4 REFERENCES

Center for Science in the Public Interest (CSPI). June 29, 1998. "Citizen Petition." Submitted to the Dockets Management Branch, FDA, HHS.

Dewey, B., Taylor Shellfish Company, Inc. February 6, 2000. "Economic Impacts of Requiring Post-Harvest Treatment of Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

Howell, L., Spinney Creek Shellfish, Inc. February 9, 2000. "Review of Economic Impacts of Requiring Post-Harvest Treatment for Oysters—January 2000." Comments delivered to Mary Muth, Research Triangle Institute.

Nelson, C., Bon Secour Fisheries, Inc., Bon Secour, Alabama. February 4, 2000. Personal communication with Mary Muth, Research Triangle Institute.

Tesvich, J., and P. Fahey, AmeriPure Oyster Companies. February 7, 2000. "RTI Draft Report on Oysters." Facsimile to Mary Muth, Research Triangle Institute.

[10]These cooperative efforts include a depuration plant currently operating in Massachusetts and a shucked oyster repacking and marketing facility that operated in the 1960s and 1970s in Washington state.

U.S. Department of Commerce. 1997. “Fresh Prices at Fulton Fish Market.” New York, NY. <www.st.nmfs.gov/st1/market_news/nyfu97.pdf>.

Appendix A: Economic Impacts Methodology

> The economic effects of each treatment technology depend on
> - which products in which regions are required to be treated,
> - the relative sizes and directions of the shifts in supply and demand for halfshell and shucked oysters, and
> - the effects of adjustments in wholesale halfshell and shucked oyster market quantities on the shellstock oyster market.

The results of the model that we presented in Section 5 were obtained from a comparative statics model of the U.S. and regional oyster markets. Post-harvest treatment requirements would affect the wholesale (processing sector) markets for halfshell and shucked oysters both because of the costs of conducting post-harvest treatment activities (supply shifts) and the effects of post-harvest treatment on willingness-to-pay for oysters (demand shifts). As described in Section 5, we estimated the effects of post-harvest treatment requirements under four scenarios:

- treatment requirements would affect halfshell and shucked oysters in the **Gulf only,** and treatment would shift only the **supply** curves for oysters;
- treatment requirements would affect halfshell and shucked oysters in all of the **United States**, and treatment would shift only the **supply** curves for oysters;
- treatment requirements would affect halfshell and shucked oysters in the **Gulf only**, and treatment would shift both the **supply** curves and the demand curves for oysters; and
- treatment requirements would affect halfshell and shucked oysters in all of the **United States**, and treatment would shift both the **supply** curves and the **demand** curves for oysters.

We addressed qualitatively how the results would differ if treatment requirements applied only to **Gulf halfshell oysters**, but do not present the results of the model under this scenario because it appears likely that producers would treat shucked oysters even if not required to do so.

In this appendix, we describe the graphical and mathematical representations of the model, provide the elasticity estimates used in the model, and indicate how each result in the model was obtained.

A.1 GRAPHICAL REPRESENTATION OF THE ECONOMIC MODEL OF THE OYSTER INDUSTRY

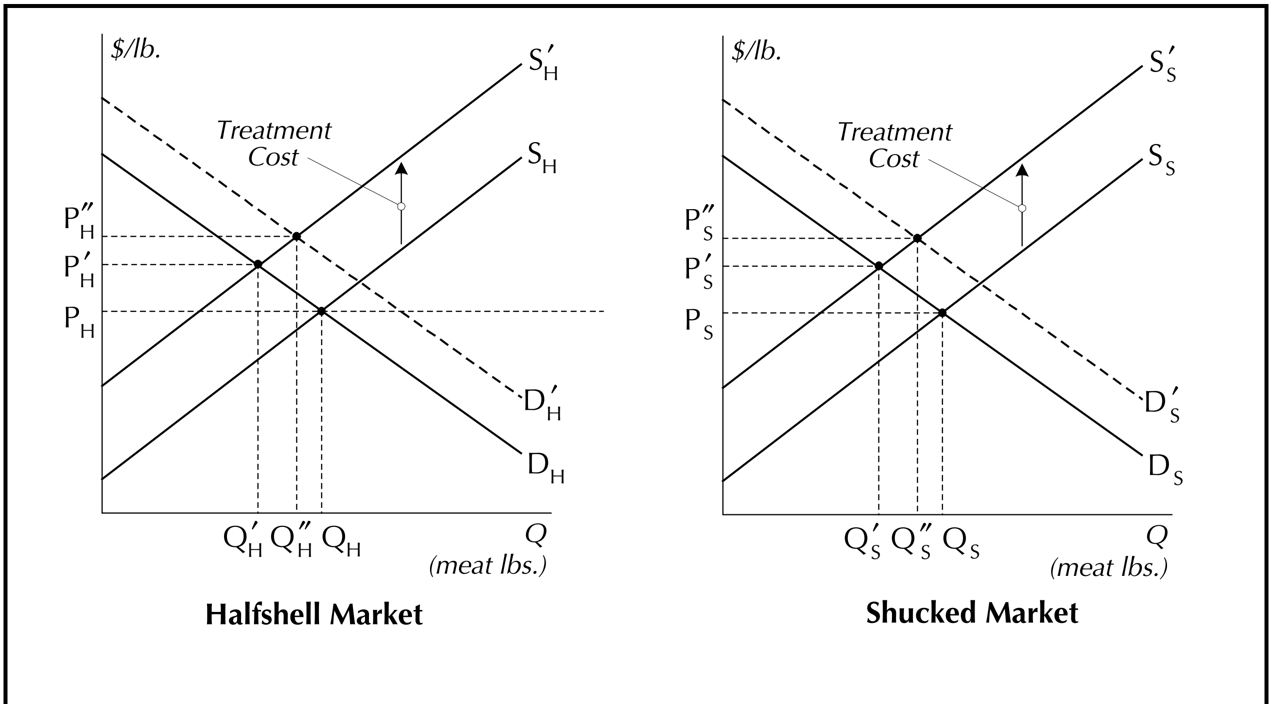
In this section, we demonstrate graphically the effects of supply and demand shifts in the wholesale halfshell and shucked oyster markets and the resulting effects on the shellstock oyster market. Each of the treatment technologies we considered has different expected effects on supply and demand as described in Sections 3 and 4. Use of a treatment technology may affect the costs of producing oysters in one of the following ways:

- costs of producing halfshell and shucked oysters may both increase, or
- costs of producing halfshell oysters may increase while the costs of producing shucked oysters may decrease.

The economic effects of these alternative scenarios are illustrated in the following set of figures:

- **Figure A-1a illustrates the effects of a treatment technology that increases the costs of producing halfshell and shucked oysters when treatment requirements apply to both products.** In the halfshell and shucked markets, the costs of treatment shift the supply curves upward (from S_H to S_H' in the halfshell market and from S_S to S_S' in the shucked market). The shift is greater in the halfshell market than in the shucked market because the costs of treatment are higher for halfshell oysters primarily due to costs of banding oysters intended for the halfshell market. If demand is unchanged, then the prices of halfshell and shucked oysters rise relative to the prices for untreated oysters (from P_H to P_H' in the halfshell market and from P_S to P_S' in the shucked market), and the market-clearing quantities decrease (from Q_H to Q_H' in the halfshell market and from Q_S to Q_S' in the shucked market). If, however, demand for each type of oyster increases (e.g., due to increased safety and other

Figure A-1a. Wholesale Market Effects of a Treatment Process that Increases the Costs of Producing Halfshell and Shucked Oysters
The supply curves shift up due to the increase in production costs. The demand curves may or may not shift due to changes in product characteristics following treatment.

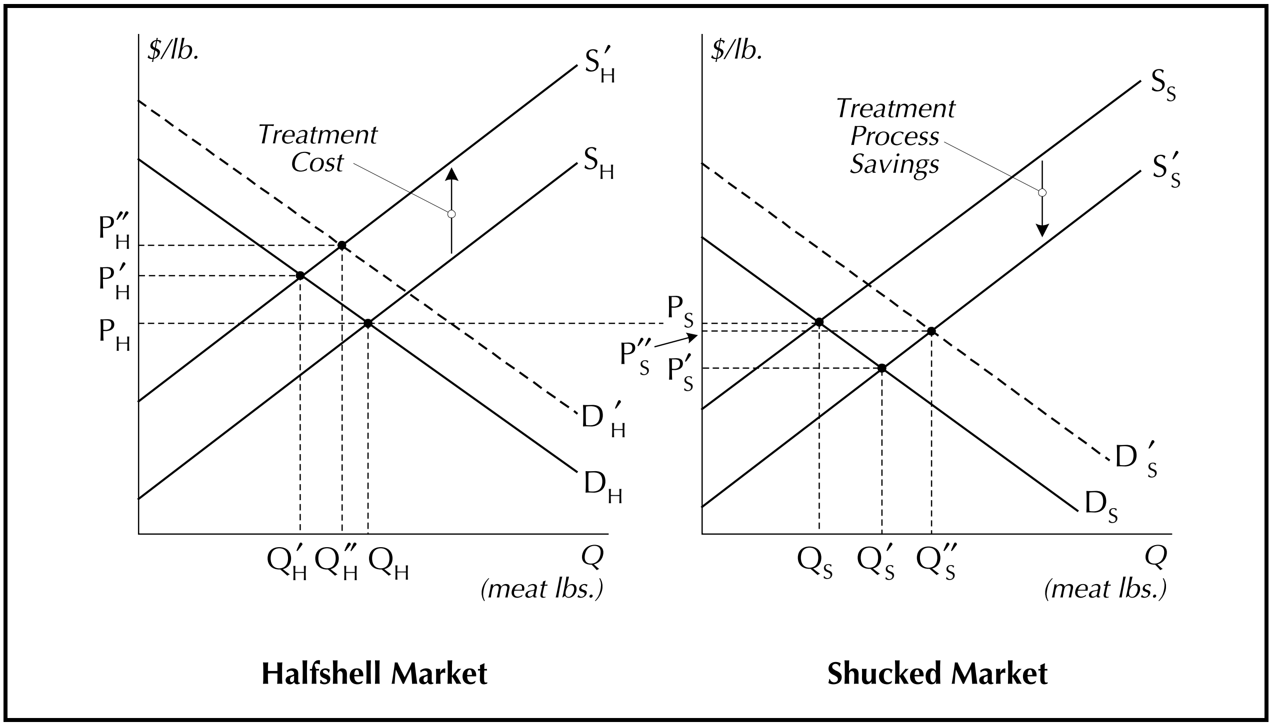


quality changes), then the price of halfshell oysters increases to P''_H, and the price of shucked oysters increases to P''_S. The market-clearing quantities of halfshell and shucked oysters may increase or decrease compared to the market-clearing quantities for untreated oysters depending on the relative sizes of the supply and demand shifts (shown as decrease to Q''_H and Q''_S in the figure). In addition to the shifts in supply and demand due to the direct effects of the treatment process, supply and demand for each product may also shift due to the changes in relative prices of each. In other words, if the price of halfshell oysters rises more than the price of shucked oysters as a result of treatment effects, consumers may substitute shucked oysters for halfshell oysters, and producers may shift some production from shucked oysters to halfshell oysters. These general equilibrium market effects are not illustrated here but are included in the mathematical model.

- **Figure A-1b illustrates the effects of a treatment technology that increases the costs of producing halfshell oysters and reduces the costs of producing shucked oysters when treatment requirements apply to both products.** In the halfshell market, the costs of treatment shift the supply curve upward from S_H to S_H', and in the shucked market, the cost savings from treatment shift the supply curve downward from S_S to S_S'. (The cost savings from producing shucked oysters are obtained either because yields increase or because treated oysters are more easily shucked than untreated oysters.) If demand is unchanged, then the price of halfshell oysters rises relative to the price for untreated oysters from P_H to P_H', and the price of shucked oysters falls from P_S to P_S'. Correspondingly, the market-clearing quantity of halfshell oysters decreases from Q_H to Q_H', and the market-clearing quantity of shucked oysters increases from Q_S to Q_S'. If, however, demand for each type of oyster increases (e.g., due to increased safety and other quality changes), then the price of halfshell oysters increases to P_H'', and the price of shucked oysters may increase or decrease compared to the price of untreated shucked oysters depending on the relative size of the supply and demand shifts (shown as a decrease to P_S'' in the figure). The market-clearing quantity of halfshell oysters may increase or decrease compared to the market-clearing quantity for untreated oysters depending on the relative sizes of the supply and demand shifts (shown as a decrease to Q_H'' in the figure), and the market-clearing quantity of shucked oysters will increase to Q_S''. As in Figure A-1a, the general equilibrium market effects of the relative price changes in each market are not illustrated here but are included in the mathematical model.

As noted in the above discussions, the market-clearing quantities of halfshell and shucked oysters will change for each treatment technology, and thus the quantity of shellstock purchased by processors from harvesters must adjust. The expected effects of treatment on the shellstock market are summarized in the following figure:

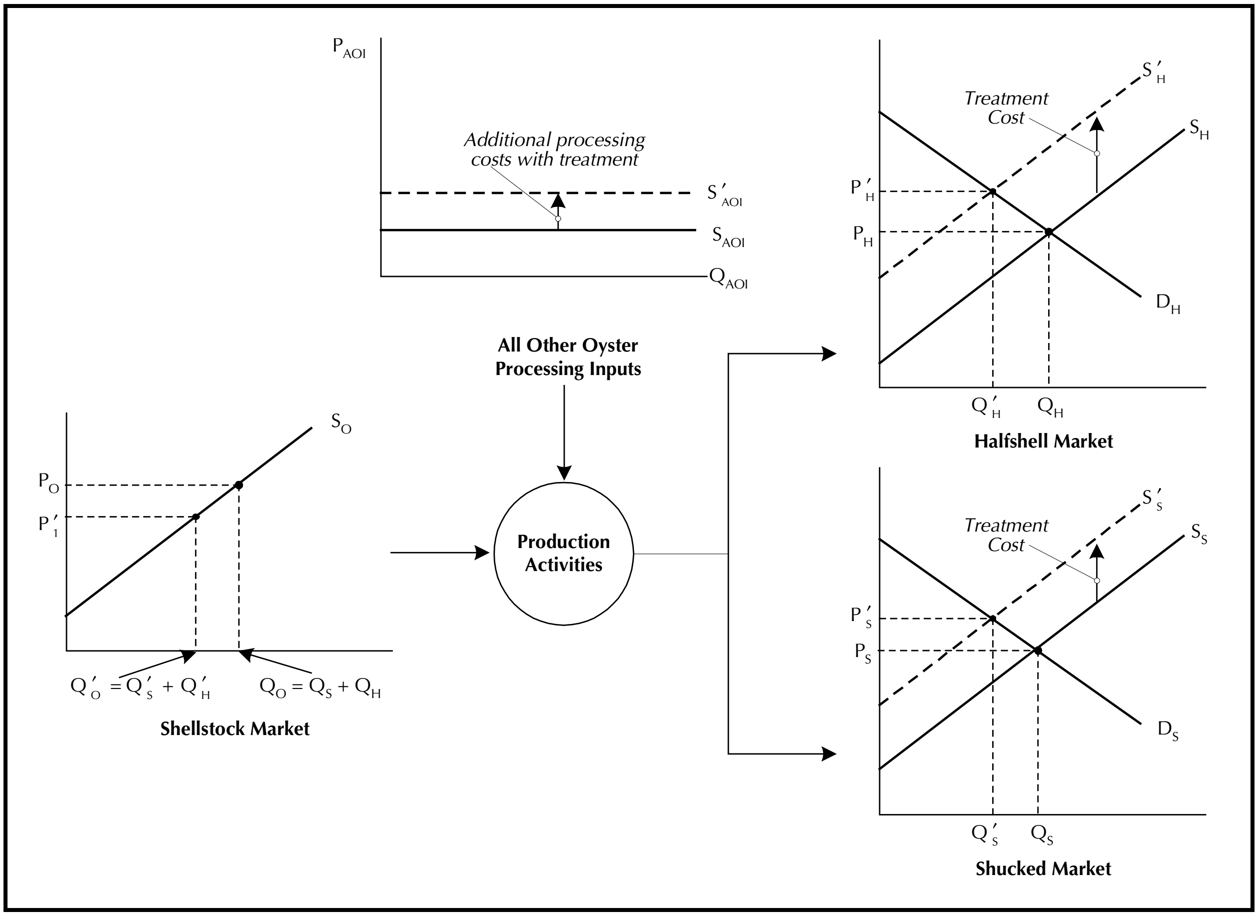
Figure A-1b. Wholesale Market Effects of a Treatment Process that Increases the Costs of Producing Halfshell Oysters but Decreases the Costs of Producing Shucked Oysters
The halfshell oyster supply curve shifts up and the shucked oyster supply curve shifts down due to changes in the costs of producing oysters. The demand curves may or may not shift due to changes in product characteristics following treatment.



- **Figure A-2 illustrates the effects on the shellstock market for the case in which a treatment process increases the costs of producing both halfshell and shucked oysters and has no effect on demand.** As shown, shellstock and all other inputs (S_{AOI}) such as labor, water, and energy are combined during the production process to produce halfshell and shucked oysters. If we assume that all other inputs are competitively supplied at a constant market price (i.e., supplied perfectly elastically corresponding to the supply curve S_{AOI}), then decreases in the market quantities of halfshell and shucked oysters correspond to a decrease in the market quantity of shellstock along the upward-sloping supply curve for shellstock and thus a decrease in the price of shellstock. If, however, the market quantities of halfshell or shucked oysters increase either because the demand curve shifts out by more than the shift in the supply curve

Figure A-2. Effects of the Post-Harvest Treatment Requirements on the Market for Shellstock Oysters

Post-harvest treatment requirements at the processing level will affect the volume of shellstock oysters purchased from harvesters.



or the treatment process reduces the costs of producing shucked oysters, then the market quantity of shellstock will increase and thus the price of shellstock will increase. In a general equilibrium framework, changes in the price of shellstock affect the costs of producing halfshell and shucked oysters; thus, supply of each product will shift even further. Although not illustrated here, these market effects are included in the mathematical model. Similarly, the effects of a treatment process that increases the costs of producing halfshell oysters but decreases the costs of producing shucked oysters can also be illustrated.

The above set of figures was used as the basis for developing the mathematical model of the oyster industry described in the following section.

A.2 MATHEMATICAL REPRESENTATION OF THE ECONOMIC MODEL OF THE OYSTER INDUSTRY

The following assumptions were used in developing the economic model (see Section 5.1.1 for more detail):

- Both the harvesting and processing sectors of the oyster industry are perfectly competitive.
- Treatment requirements will be imposed year-round.
- The per-unit costs of treatment will be the same for all plants regardless of size, location, or oyster species processed, except that labor costs are 50 percent higher in the Northeast.
- Shellstock may be harvested from any region of the country to satisfy processing needs in any of the other regions.
- International trade flows of oysters will be unaffected by treatment requirements.
- The Atlantic, Gulf, Northeast, and Pacific oyster processing regions can each be considered distinct markets with interregional trade flows among them. We assume the Gulf region is linked to the Atlantic and Pacific regions and the Atlantic market is linked to the Northeast market.
- Both shucked and halfshell oysters will be required to be treated.

For consistency in the model, all prices and quantities are expressed in meat-weight pound equivalents. In developing the model we first describe the equilibrium conditions in each market, then totally differentiate these expressions to determine the effects of treatment requirements, and finally obtain the comparative static solutions. Each step is described below.

In each region, market equilibrium for each product can be expressed by equating the demand equation with the supply equation. For example, in the Gulf region, market equilibrium in the shucked oyster market can be expressed as

$$Q^D_S\,(P^G_S, P^A_S, P^P_S, P^G_H, TP^G_S) = Q^S_S\,(P^G_S, P^G_H, P^G_O, TC^G_S).$$

The economic model begins with equilibrium expressions for the following markets:

- wholesale shucked oysters,
- wholesale halfshell oysters, and
- shellstock oysters at the harvest level.

On the left side of the equation, Q_S^D is the demand for shucked oysters in the Gulf, P_S^G is the price of shucked oysters in the Gulf, P_S^A is the price of shucked oysters in the Atlantic, P_S^P is the price of shucked oysters in the Pacific, P_H^G is the price of halfshell oysters in the Gulf, and TP_S^G is a demand shifter for consumer preferences toward treatment of shucked Gulf oysters. On the right side of the equation, Q_S^S is the supply of shucked oysters in the Gulf, P_O^G is the price of shellstock oysters in the Gulf, and TC_S^G is a supply shifter for the costs of treatment of Gulf shucked oysters. We have assumed that shucked oyster prices in the Gulf are affected by shucked oyster prices in the Atlantic and Pacific regions and by halfshell oyster prices in the Gulf. Thus, shucked oyster prices in the Gulf are assumed to be unaffected by halfshell oyster prices in the other regions. Note also that this expression assumes that prices of other food products (e.g., other shellfish, seafood, protein sources) do not affect the demand for shucked oysters; in other words, the demand for shucked oysters is separable from these other products. Because our model uses a single year as the baseline, we assume that treatment requirements will not be affected by other demand factors such as income and population. Furthermore, we assume that other supply factors, such as wages and energy costs, will not be affected by treatment requirements.

Next, market equilibrium in the Gulf halfshell oyster market can be expressed as

$$Q_H^D\,(P_H^G, P_H^A, P_H^P, P_S^G, TP_H^G) = Q_H^S\,(P_H^G, P_S^G, P_O^G, TC_H^G).$$

On the left side of the equation, Q_H^D is the demand for halfshell oysters, P_H^G is the price of halfshell oysters in the Gulf, P_H^A is the price of halfshell oysters in the Atlantic, P_H^P is the price of shucked oysters in the Pacific, P_S^G is the price of shucked oysters in the Gulf, and TP_H^G is a demand shifter for consumer preferences toward treatment of Gulf halfshell oysters. On the right side of the equation, Q_H^S is the supply of halfshell oysters, P_O^G is the price of shellstock oysters in the Gulf, and TC_H^G is a supply shifter for the costs of treatment of Gulf halfshell oysters. The assumptions of this equilibrium expression are the same as for the shucked market equilibrium expression noted above.

Finally, because the demand for shellstock is derived from the demand for shucked and halfshell oysters, equilibrium in the shellstock market is determined based on the quantity demanded from each of these markets. That is,

$$Q_O^G = Q_S^G + Q_H^G$$

where Q_O^G is the quantity of shellstock oysters, Q_S^G is the quantity of shucked oysters, and Q_H^G is the quantity of halfshell oysters. The equilibrium price in the shellstock market is determined based on the elasticity of supply for shellstock oysters.

We developed this set of equilibrium conditions for each of the four regions considered in the analysis. By totally differentiating the equilibrium conditions in the shucked and halfshell oyster markets and expressing each in elasticity form, we obtained a set of five equations for each region that describes the following:

- ➤ price changes in the wholesale shucked market,
- ➤ price changes in the wholesale raw halfshell market,
- ➤ quantity changes in the wholesale shucked market,
- ➤ quantity changes in the wholesale halfshell market, and
- ➤ price changes in the shellstock harvest market.

As noted above, because we assume the shellstock market adjusts completely to changes in the shucked and halfshell markets, we obtain the change in the quantity of shellstock oysters by adding the quantity changes in the shucked and halfshell markets.

We put the set of 20 equations with 20 unknowns (five equations for each of four markets) into a matrix format and programmed the model in Microsoft Excel. The percentage shifts in the supply and demand for oysters resulting from treatment are used as inputs into the model.

The elasticity estimates used in the model, which are listed in Table A-1, are based on estimates in the economics literature and on RTI's previous study of the effects of *Vibrio* controls in the oyster industry (see Anderson et al., 1996). These elasticity estimates include those for the own-price, cross-price, and interregional cross-price elasticities of demand for oysters and the own-price and cross-price elasticities of supply for oysters.

Table A-1. Oyster Demand and Supply Elasticity Estimates Used in the Economic Impacts Model
The elasticity estimates include both within region and interregional relationships.

Elasticity	Assigned Value
Within region own-price elasticities of demand:	
Halfshell	–0.56
Shucked	–1.13
Within region cross-price elasticities of demand:	
Halfshell-shucked	0.31
Shucked-halfshell	0.31
Interregional cross-price elasticities of demand:	
Halfshell	0.20
Shucked	0.40
Within region own-price elasticities of supply:	
Halfshell	1.97
Shucked	2.30
Shellstock	1.64
Within region cross-price elasticities of supply:	
Halfshell-shucked	–0.30
Shucked-halfshell	–0.30
Halfshell-shellstock	–0.50
Shucked-shellstock	–0.50

For the demand side of each market, the elasticity values were based primarily on estimates in the economics literature. The elasticity of demand for shucked oysters is assumed to be –1.13, which is the elasticity estimate obtained by Cheng and Capps (1988) for retail oysters and similar to the –1.1 elasticity estimate obtained in RTI's previous study for shellstock oysters. The elasticity of demand for halfshell oysters is assumed to be half as elastic as for shucked oysters with a value of –0.56 because the results of the taste tests and restaurant manager surveys suggested that consumers are relatively insensitive to price changes for halfshell oysters. The cross-price elasticities between shucked and halfshell oysters are assumed to be 0.31 based on Cheng and Capps estimate of the cross-price elasticity between oysters and poultry. The interregional cross-price elasticities were chosen to be inelastic with the halfshell oyster value half that of the shucked oyster value.

For the supply side of each market, the elasticity values were based primarily on RTI's previous estimates. The average shellstock supply elasticity estimate across the Gulf regions in RTI's previous study was 1.64. We assumed for this study that the elasticity of supply is 20 percent greater than this value for halfshell oysters and 40 percent greater for shucked oysters to reflect the higher costs of processing respectively for each product.[1] The cross-price elasticity of supply between shucked and halfshell product was assumed to be low at –0.30 based on our belief that the proportion of shucked versus halfshell oysters produced is relatively insensitive to price changes in each market. Furthermore, the cross-price elasticities of supply between the shellstock and halfshell markets and between the shellstock and shucked markets were both assumed to be –0.50 based on the assumption that approximately half of the value of shellstock price changes is reflected in wholesale market supply adjustments.

A.3 OBTAINING THE ECONOMIC MODEL RESULTS

Using the model solution described above, we obtained estimates of price and quantity changes in each market, plant revenue changes, plant cost changes, and plant employment changes if post-harvest oyster treatment requirements were imposed. These estimates are provided in Tables 5-4 and 5-5 and Appendix B. In this section, we reiterate the method by which each estimate was obtained.

- Percentage changes for the following values were obtained directly from the matrix solution described in Section A.2

[1] The elasticity of supply for processed oysters must be greater than for shellstock oysters if the slopes of the respective supply curves are the same. For example, if P_H is greater than P_0 at a given market quantity, and processing costs are a constant per unit cost at all output levels (implying equal supply slopes), then $\varepsilon^S_H > \varepsilon^S_O$ based on the elasticity definition $\varepsilon^S = \frac{\partial Q}{\partial P} \bullet \frac{P}{Q}$.

and applied to baseline values in Table 5-1 to calculate post-treatment values:

- ✓ **wholesale halfshell oyster volume**,
- ✓ **wholesale shucked oyster volume**,
- ✓ **wholesale halfshell oyster price**,
- ✓ **wholesale shucked oyster price**, and
- ✓ **harvest-level shellstock oyster price**.

➤ Absolute changes in the **harvest-level shellstock volume** were obtained by adding the absolute changes in the shucked and halfshell volumes as predicted from the model.

➤ Post-treatment revenues from products were calculated by multiplying post-treatment prices by post-treatment volumes for the following:

- ✓ **halfshell oyster revenue**, and
- ✓ **shucked oyster revenue**.

➤ **Total shellstock costs** were calculated by multiplying the post-treatment price by the post-treatment volume.

➤ **Total treatment costs** were calculated by multiplying the volume of halfshell and shucked products by their respective treatment costs as indicated in Table 5-2.

➤ The number of **FTE plant workers** includes adjustments in the number of workers due to changes in the volume of products handled and increases or decreases in the number of workers due to the treatment process itself. The adjustments in the number of workers due to changes in product volume were based on the values noted in Section 5.1 (14,000 meat pounds per year for each shucker in the Atlantic, Gulf, and Northeast and 25,000 for each shucker in the Pacific and 105,000 meat pounds per year for each halfshell handler in all regions). The adjustments in the number of workers due to the treatment processes themselves were assumed to be as follows:

- ✓ For the cool pasteurization process, we assumed that one additional worker per 525,000 meat pounds is required to run the treatment process for both halfshell and shucked product, and one additional worker per 39,375 meat pounds is required to band halfshell oysters.
- ✓ For the hydrostatic pressure process, we assumed that no additional workers are required to run the treatment process (although we do include additional costs for higher skilled laborers in the treatment cost estimates); one additional worker per 31,500 meat pounds is required to band halfshell oysters using a banding machine in all regions; and one less shucker is required per 21,000 meat pounds of shucked oysters in the

Atlantic, Gulf, and Northeast and per 38,000 meat pounds in the Pacific.

A.4 REFERENCES

Anderson, D.W., R.C. Lindrooth, B.C. Murray, and J.L. Teague. 1996. "Cost of Restrictions on Gulf Oyster Harvesting for Control of *Vibrio vulnificus*-Caused Disease." Research Triangle Park, NC: Research Triangle Institute.

Cheng, H.-T., and O. Capps, Jr. August 1988. "Demand Analysis of Fresh and Frozen Finfish and Shellfish in the United States." *American Journal of Agricultural Economics* 70(3):533-542.

Appendix B: Detailed Economic Model Results

Table B-1. Results for the Pasteurization Treatment Process with Supply Shifts: Gulf-Only Requirements

We estimated changes in the oyster industry assuming all Gulf producers adopt the pasteurization process, and demand for oysters would be unaffected by treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	17,273,630	–2.6%	1,803,983	1.6%	10,592,213	–4.7%	2,388,318	0.2%	2,489,116	1.5%
No. of oysters	634,158,390	–2.8%	70,870,766	1.6%	416,122,656	–4.7%	93,826,774	0.2%	53,338,194	1.5%
Shucked volume										
Meat-weight pounds	29,614,812	1.1%	5,348,054	0.4%	14,162,560	1.9%	265,229	0.1%	9,838,969	0.3%
Shellstock volume										
Meat-weight pounds	46,888,442	–0.3%	7,152,037	0.7%	24,754,773	–1.0%	2,653,547	0.2%	12,328,085	0.6%
No. of oysters	1,621,901,556	–0.4%	280,972,886	0.7%	972,508,937	–1.0%	104,246,479	0.2%	264,173,254	0.6%
Halfshell price										
Per meat-weight pounds	$7.04	6.0%	$7.79	1.1%	$6.10	10.0%	$9.58	0.2%	$8.03	1.1%
Per oyster	$0.19	6.0%	$0.20	1.1%	$0.15	10.0%	$0.24	0.2%	$0.37	1.1%
Shucked price										
Per meat-weight pounds	$4.46	0.9%	$5.16	0.5%	$4.50	1.4%	$5.32	0.1%	$3.99	0.5%
Shellstock price										
Per meat-weight pounds	$2.56	–0.4%	$3.45	1.1%	$2.09	–1.7%	$3.62	0.3%	$2.77	0.9%
Per oyster	$0.07	–0.4%	$0.09	1.1%	$0.05	–1.7%	$0.09	0.3%	$0.13	0.9%
Halfshell revenue	$121,606,354	3.3%	$14,049,762	2.7%	$64,650,918	4.8%	$22,872,680	0.3%	$19,979,967	2.6%
Shucked revenue	$132,082,063	2.0%	$27,583,338	0.9%	$63,757,740	3.4%	$1,410,253	0.3%	$39,254,088	0.8%
Shellstock cost	$120,034,411	–0.7%	$24,651,147	1.7%	$51,846,945	–2.7%	$9,605,437	0.4%	$34,098,507	1.5%
Treatment cost	$14,007,704	N/A	$0	N/A	$14,007,704	N/A	$0	N/A	$0	N/A
No. of FTE plant workers	2,287	17.1%	399	0.4%	1,429	30.1%	42	0.1%	417	0.4%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-2. Results for the Pasteurization Treatment Process with Supply Shifts: U.S. Requirements

We estimated changes in the oyster industry assuming all U.S. producers adopt the pasteurization process, and demand for oysters would be unaffected by treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	17,368,181	–2.0%	1,763,107	–0.7%	10,858,495	–2.3%	2,340,274	–1.8%	2,406,304	–1.8%
No. of oysters	639,351,673	–2.0%	69,264,929	–0.7%	426,583,728	–2.3%	91,939,349	–1.8%	51,563,667	–1.8%
Shucked volume										
Meat-weight pounds	29,924,513	2.2%	5,437,828	2.0%	14,250,502	2.6%	268,547	1.4%	9,967,636	1.6%
Shellstock volume										
Meat-weight pounds	47,292,694	0.6%	7,200,935	1.3%	25,108,997	0.4%	2,608,822	–1.5%	12,373,940	1.0%
No. of oysters	1,636,964,046	0.5%	282,893,892	1.3%	986,424,871	0.4%	102,489,416	–1.5%	265,155,867	1.0%
Halfshell price										
Per meat-weight pounds	$7.32	10.2%	$8.44	9.6%	$6.21	11.9%	$10.29	7.7%	$8.62	8.5%
Per oyster	$0.20	10.2%	$0.22	9.6%	$0.16	11.9%	$0.26	7.7%	$0.40	8.5%
Shucked price										
Per meat-weight pounds	$4.51	2.0%	$5.25	2.3%	$4.55	2.4%	$5.40	1.7%	$4.04	1.7%
Shellstock price										
Per meat-weight pounds	$2.59	0.8%	$3.49	2.2%	$2.14	0.7%	$3.52	–2.5%	$2.78	1.6%
Per oyster	$0.07	0.8%	$0.09	2.2%	$0.05	0.7%	$0.09	–2.5%	$0.13	1.6%
Halfshell revenue	$127,135,085	8.0%	$14,878,431	8.8%	$67,459,445	9.4%	$24,086,176	5.7%	$20,733,026	6.5%
Shucked revenue	$134,959,555	4.2%	$28,533,637	4.4%	$64,809,301	5.1%	$1,450,171	3.1%	$40,258,652	3.4%
Shellstock cost	$122,488,078	1.4%	$25,096,824	3.6%	$53,831,137	1.1%	$9,182,777	–4.0%	$34,433,354	2.5%
Treatment cost	$22,705,215	N/A	$2,210,566	N/A	$14,370,386	N/A	$3,207,323	N/A	$2,916,941	N/A
No. of FTE plant workers	2,493	27.6%	464	16.6%	1,445	31.6%	106	154.3%	479	15.1%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-3. Results for the Pasteurization Treatment Process with Supply and Demand Shifts: Gulf-Only Requirements
We estimated changes in the oyster industry assuming all Gulf producers adopt the pasteurization process, and demand for oysters would increase with treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	18,703,749	5.5%	1,837,697	3.5%	11,935,331	7.4%	2,396,575	0.5%	2,534,146	3.4%
No. of oysters	689,537,520	5.7%	72,195,225	3.5%	468,888,006	7.4%	94,151,155	0.5%	54,303,134	3.4%
Shucked volume										
Meat-weight pounds	31,287,124	6.8%	5,471,182	2.7%	15,493,256	11.5%	266,558	0.6%	10,056,127	2.6%
Shellstock volume										
Meat-weight pounds	49,990,873	6.3%	7,308,878	2.9%	27,428,587	9.7%	2,663,133	0.5%	12,590,274	2.7%
No. of oysters	1,739,100,820	6.8%	287,134,499	2.9%	1,077,551,650	9.7%	104,623,094	0.5%	269,791,578	2.7%
Halfshell price										
Per meat-weight pounds	$7.45	12.2%	$7.96	3.3%	$6.77	22.0%	$9.61	0.6%	$8.20	3.2%
Per oyster	$0.20	12.2%	$0.21	3.3%	$0.17	22.0%	$0.24	0.6%	$0.38	3.2%
Shucked price										
Per meat-weight pounds	$4.71	6.6%	$5.26	2.6%	$4.93	10.9%	$5.34	0.5%	$4.07	2.5%
Shellstock price										
Per meat-weight pounds	$2.79	8.6%	$3.57	4.7%	$2.47	15.9%	$3.64	0.9%	$2.86	4.5%
Per oyster	$0.08	8.6%	$0.09	4.7%	$0.06	15.9%	$0.09	0.9%	$0.14	4.5%
Halfshell revenue	$139,342,929	18.4%	$14,623,452	6.9%	$80,822,626	31.0%	$23,040,420	1.1%	$20,769,562	6.7%
Shucked revenue	$147,362,354	13.8%	$28,801,713	5.4%	$76,314,927	23.7%	$1,422,952	1.2%	$40,920,129	5.1%
Shellstock cost	$139,474,534	15.4%	$26,093,976	7.7%	$67,690,658	27.1%	$9,697,195	1.4%	$36,033,867	7.3%
Treatment cost	$15,802,195	N/A	$0	N/A	$15,802,195	N/A	$0	N/A	$0	N/A
No. of FTE plant workers	2,452	25.6%	408	2.7%	1,576	43.5%	42	0.6%	426	2.6%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-4. Results for the Pasteurization Treatment Process with Supply and Demand Shifts: U.S. Requirements

We estimated changes in the oyster industry assuming all U.S. producers adopt the pasteurization process, and demand for oysters would increase with treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	20,123,869	13.5%	2,051,554	15.5%	12,651,136	13.8%	2,670,923	12.0%	2,750,256	12.2%
No. of oysters	741,468,868	13.6%	80,596,783	15.5%	497,008,900	13.8%	104,929,132	12.0%	58,934,052	12.2%
Shucked volume										
Meat-weight pounds	33,938,531	15.9%	6,221,975	16.8%	16,274,520	17.1%	299,533	13.1%	11,142,503	13.6%
Shellstock volume										
Meat-weight pounds	54,062,400	15.0%	8,273,529	16.4%	28,925,656	15.7%	2,970,456	12.1%	13,892,759	13.3%
No. of oysters	1,875,795,017	15.2%	325,031,500	16.4%	1,136,365,040	15.7%	116,696,493	12.1%	297,701,984	13.3%
Halfshell price										
Per meat-weight pounds	$8.36	25.9%	$9.72	26.2%	$7.14	28.6%	$11.68	22.2%	$9.73	22.5%
Per oyster	$0.23	25.9%	$0.25	26.2%	$0.18	28.6%	$0.29	22.2%	$0.45	22.5%
Shucked price										
Per meat-weight pounds	$5.10	15.4%	$5.96	16.2%	$5.17	16.4%	$6.03	13.5%	$4.49	13.2%
Shellstock price										
Per meat-weight pounds	$3.19	24.1%	$4.33	27.0%	$2.68	25.7%	$4.33	19.9%	$3.34	21.9%
Per oyster	$0.09	24.1%	$0.11	27.0%	$0.06	25.7%	$0.11	19.9%	$0.16	21.9%
Halfshell revenue	$168,235,547	42.9%	$19,942,885	45.8%	$90,296,050	46.4%	$31,198,287	36.9%	$26,759,048	37.5%
Shucked revenue	$173,086,508	33.7%	$37,101,355	35.7%	$84,092,845	36.3%	$1,805,924	28.4%	$50,071,587	28.6%
Shellstock cost	$172,459,056	42.7%	$35,819,583	47.8%	$77,433,693	45.4%	$12,856,401	34.4%	$46,395,369	38.1%
Treatment cost	$26,336,536	N/A	$2,576,364	N/A	$16,755,723	N/A	$3,660,748	N/A	$3,343,701	N/A
No. of FTE plant workers	2,848	45.8%	532	33.8%	1,659	51.1%	120	189.0%	536	29.1%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-5. Results for the Hydrostatic Pressure Process with Supply Shifts: Gulf-Only Requirements

We estimated changes in the oyster industry assuming all Gulf producers adopt the hydrostatic pressure process, and demand for oysters would be unaffected by treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	17,069,014	–3.7%	1,799,538	1.3%	10,400,850	–6.4%	2,384,793	0.0%	2,483,833	1.3%
No. of oysters	626,214,244	–4.1%	70,696,124	1.3%	408,604,825	–6.4%	93,688,294	0.0%	53,225,001	1.3%
Shucked volume										
Meat-weight pounds	30,268,143	3.3%	5,257,289	–1.3%	15,068,066	8.4%	264,348	–0.2%	9,678,440	–1.3%
Shellstock volume										
Meat-weight pounds	47,337,156	0.7%	7,056,826	–0.7%	25,468,916	1.8%	2,649,141	0.0%	12,162,273	–0.8%
No. of oysters	1,642,490,556	0.9%	277,232,453	–0.7%	1,000,564,562	1.8%	104,073,404	0.0%	260,620,136	–0.8%
Halfshell price										
Per meat-weight pounds	$6.98	5.1%	$7.72	0.3%	$6.02	8.5%	$9.56	0.0%	$7.96	0.2%
Per oyster	$0.19	5.1%	$0.20	0.3%	$0.15	8.5%	$0.24	0.0%	$0.37	0.2%
Shucked price										
Per meat-weight pounds	$4.27	–3.4%	$5.09	–0.8%	$4.19	–5.7%	$5.31	–0.1%	$3.94	–0.8%
Shellstock price										
Per meat-weight pounds	$2.58	0.4%	$3.37	–1.1%	$2.19	3.0%	$3.61	0.0%	$2.71	–1.3%
Per oyster	$0.07	0.4%	$0.09	–1.1%	$0.05	3.0%	$0.09	0.0%	$0.13	–1.3%
Halfshell revenue	$119,141,719	1.2%	$13,892,101	1.6%	$62,622,312	1.5%	$22,798,144	0.0%	$19,765,672	1.5%
Shucked revenue	$129,244,969	–0.2%	$26,755,399	–2.1%	$63,076,398	2.2%	$1,402,382	–0.3%	$38,111,150	–2.1%
Shellstock cost	$122,129,864	1.1%	$23,794,160	–1.8%	$55,883,134	4.9%	$9,563,407	0.0%	$32,900,572	–2.0%
Treatment cost	–$3,683,025	N/A	$0	N/A	–$3,683,025	N/A	$0	N/A	$0	N/A
No. of FTE plant workers	1,633	–16.4%	393	–1.2%	788	–28.3%	42	–0.1%	411	–1.2%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-6. Results for the Hydrostatic Pressure Process with Supply Shifts: U.S. Requirements
We estimated changes in the oyster industry assuming all U.S. producers adopt the hydrostatic pressure process, and demand for oysters would be unaffected by treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	16,999,445	–4.1%	1,719,966	–3.2%	10,619,506	–4.5%	2,313,193	–3.0%	2,346,779	–4.3%
No. of oysters	625,928,566	–4.1%	67,570,100	–3.2%	417,194,881	–4.5%	90,875,453	–3.0%	50,288,132	–4.3%
Shucked volume										
Meat-weight pounds	30,979,684	5.8%	5,532,939	3.8%	14,671,490	5.6%	281,151	6.1%	10,494,103	7.0%
Shellstock volume										
Meat-weight pounds	47,979,129	2.0%	7,252,905	2.1%	25,290,996	1.1%	2,594,344	–2.1%	12,840,883	4.8%
No. of oysters	1,655,592,877	1.7%	284,935,567	2.1%	993,574,857	1.1%	101,920,676	–2.1%	275,161,777	4.8%
Halfshell price										
Per meat-weight pounds	$7.14	7.5%	$8.23	6.8%	$6.05	9.0%	$9.96	4.1%	$8.50	7.1%
Per oyster	$0.19	7.5%	$0.21	6.8%	$0.15	9.0%	$0.25	4.1%	$0.40	7.1%
Shucked price										
Per meat-weight pounds	$4.11	–7.0%	$4.80	–6.4%	$4.12	–7.1%	$4.96	–6.5%	$3.70	–6.8%
Shellstock price										
Per meat-weight pounds	$2.66	3.5%	$3.53	3.4%	$2.17	1.8%	$3.49	–3.4%	$2.95	7.8%
Per oyster	$0.07	3.5%	$0.09	3.4%	$0.05	1.8%	$0.09	–3.4%	$0.14	7.8%
Halfshell revenue	$121,376,038	3.1%	$14,148,112	3.4%	$64,224,343	4.1%	$23,029,402	1.0%	$19,949,494	2.5%
Shucked revenue	$127,326,502	–1.7%	$26,579,125	–2.8%	$60,483,842	–2.0%	$1,395,283	–0.8%	$38,826,875	–0.3%
Shellstock cost	$127,624,483	5.6%	$25,574,621	5.6%	$54,864,243	3.0%	$9,047,882	–5.4%	$37,930,868	12.9%
Treatment cost	–$13,254,580	N/A	–$4,072,942	N/A	–$2,947,948	N/A	$2,677,667	N/A	–$8,911,358	N/A
No. of FTE plant workers	1,303	–33.3%	203	–49.0%	788	–28.3%	102	145.4%	210	–49.4%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-7. Results for the Hydrostatic Pressure Process with Supply and Demand Shifts: Gulf-Only Requirements
We estimated changes in the oyster industry assuming all Gulf producers adopt the hydrostatic pressure process, and demand for oysters would increase with treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	18,922,470	6.7%	1,837,712	3.5%	12,156,557	9.4%	2,393,099	0.4%	2,535,103	3.4%
No. of oysters	698,113,067	7.0%	72,195,828	3.5%	477,579,009	9.4%	94,014,598	0.4%	54,323,632	3.4%
Shucked volume										
Meat-weight pounds	31,447,860	7.4%	5,364,782	0.7%	15,949,696	14.8%	265,552	0.2%	9,867,831	0.6%
Shellstock volume										
Meat-weight pounds	50,370,330	7.1%	7,202,493	1.4%	28,106,252	12.4%	2,658,650	0.4%	12,402,934	1.2%
No. of oysters	1,757,353,431	7.9%	282,955,096	1.4%	1,104,174,192	12.4%	104,446,984	0.4%	265,777,159	1.2%
Halfshell price										
Per meat-weight pounds	$7.42	11.7%	$7.89	2.5%	$6.78	22.2%	$9.60	0.4%	$8.13	2.4%
Per oyster	$0.20	11.7%	$0.20	2.5%	$0.17	22.2%	$0.24	0.4%	$0.38	2.4%
Shucked price										
Per meat-weight pounds	$4.50	1.8%	$5.19	1.1%	$4.55	2.6%	$5.32	0.3%	$4.01	1.0%
Shellstock price										
Per meat-weight pounds	$2.81	9.3%	$3.49	2.2%	$2.56	20.3%	$3.63	0.6%	$2.79	1.9%
Per oyster	$0.08	9.3%	$0.09	2.2%	$0.06	20.3%	$0.09	0.6%	$0.13	1.9%
Halfshell revenue	$140,404,729	19.3%	$14,502,841	6.0%	$82,417,297	33.6%	$22,965,269	0.8%	$20,607,668	5.9%
Shucked revenue	$141,515,370	9.3%	$27,825,148	1.8%	$72,645,994	17.8%	$1,414,061	0.5%	$39,570,296	1.6%
Shellstock cost	$141,540,628	17.1%	$25,111,085	3.6%	$72,023,394	35.2%	$9,654,236	0.9%	$34,645,868	3.2%
Treatment cost	–$2,411,806	N/A	$0	N/A	–$2,411,806	N/A	$0	N/A	$0	N/A
No. of FTE plant workers	1,743	–10.8%	401	0.8%	881	–19.7%	42	0.3%	419	0.8%

Note: Percentage changes are relative to the baseline data in Table 5-1.

Table B-8. Results for the Hydrostatic Pressure Process with Supply and Demand Shifts: U.S. Requirements

We estimated changes in the oyster industry assuming all U.S. producers adopt the hydrostatic pressure process, and demand for oysters would increase with treatment.

	U.S. Total		Atlantic		Gulf		Northeast		Pacific	
	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact	Post-Treatment	% Impact
Halfshell volume										
Meat-weight pounds	20,473,314	15.5%	2,088,959	17.6%	12,864,269	15.7%	2,728,009	14.4%	2,792,077	13.9%
No. of oysters	754,450,260	15.6%	82,066,243	17.6%	505,382,013	15.7%	107,171,784	14.4%	59,830,220	13.9%
Shucked volume										
Meat-weight pounds	33,923,420	15.8%	6,135,689	15.1%	16,133,584	16.1%	300,835	13.6%	11,353,312	15.8%
Shellstock volume										
Meat-weight pounds	54,396,734	15.7%	8,224,648	15.8%	28,997,853	15.9%	3,028,844	14.3%	14,145,389	15.4%
No. of oysters	1,884,418,308	15.7%	323,111,166	15.8%	1,139,201,380	15.9%	118,990,290	14.3%	303,115,473	15.4%
Halfshell price										
Per meat-weight pounds	$8.29	24.8%	$9.62	24.9%	$7.06	27.3%	$11.62	21.5%	$9.70	22.2%
Per oyster	$0.22	24.8%	$0.25	24.9%	$0.18	27.3%	$0.29	21.5%	$0.45	22.2%
Shucked price										
Per meat-weight pounds	$4.62	4.5%	$5.43	5.8%	$4.67	5.1%	$5.57	4.8%	$4.08	2.8%
Shellstock price										
Per meat-weight pounds	$3.22	25.3%	$4.29	25.8%	$2.69	26.2%	$4.46	23.5%	$3.43	25.3%
Per oyster	$0.09	25.3%	$0.11	25.8%	$0.06	26.2%	$0.11	23.5%	$0.16	25.3%
Halfshell revenue	$169,723,776	44.2%	$20,092,791	46.9%	$90,855,411	47.3%	$31,693,520	39.0%	$27,084,301	39.1%
Shucked revenue	$156,726,198	21.0%	$33,299,846	21.8%	$75,282,581	22.0%	$1,674,210	19.0%	$46,321,379	19.0%
Shellstock cost	$175,157,482	44.9%	$35,291,530	45.7%	$77,919,386	46.3%	$13,504,332	41.2%	$48,549,108	44.6%
Treatment cost	–$12,105,359	N/A	–$4,281,259	N/A	–$1,704,059	N/A	$3,192,849	N/A	–$9,312,890	N/A
No. of FTE plant workers	1,501	–23.1%	232	–41.6%	915	–16.7%	120	187.7%	234	–43.7%

Note: Percentage changes are relative to the baseline data in Table 5-1.