The Economics of Reducing Health Risk from Food

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9. Exploring the Supply of Safer Foods: A Case Study of Oyster Depuration in Dixie and Levy Counties, Florida

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Consumers face health risks from eating molluscan shellfish products, particularly raw or partially cooked, such as oysters and clams. With the increasing notoriety of shellfish-related illnesses and even deaths, the shellfish industry has suffered a decline in sales.

Some risks associated with raw or partially cooked oysters can be reduced by depuration. This is a process in which oysters are placed in tanks of sterilized, flowing seawater where their natural pumping action purges the animal of gut contents and pathogens (illness-causing microbes). The process can reduce the number of some pathogens found in oysters; it has been recognized by seafood safety regulators (e.g., U.S. FDA 1989) and the industry as a risk control strategy for shellfish products.

Currently, depuration is not widely practiced in the U.S. In order for depuration to have any significant impact on risk reduction, there must exist adequate economic incentives for the industry to adopt the technology and to offer the potentially safer product to the market. The economic incentives depend on tradeoffs between the costs of depuration and the benefits the process can generate. The major costs are on the processing sector to design and operate depuration facilities economically and according to standards. The benefits of depuration may include more landings and lower per unit harvesting cost for the fishermen and higher processor and retail prices for depurated products that are safer and aesthetically better. Ultimately, the profitability of the process also depends on the preferences of retailers and consumers.

This chapter reports a case study of the potential for oyster depuration in Dixie and Levy Counties, Florida. Our focus is on the costs that a processor would be likely to incur to set up and operate a depuration facility. We also explore how restaurant managers and consumers might react to depurated products.

Molluscan Shellfish and Human Health Risks

Molluscan shellfish (oysters, clams, and mussels) may cause human illnesses because: 1) their habitat in coastal estuaries and their immobility render them susceptible to fecal contamination and environmental pollution in the water; 2) they are filter feeders and their feeding behavior leads to pathogen concentration in their gastrointestinal tract and tissues; 3) consumers often eat the shellfish whole, including the gastrointestinal tract where pathogens are concentrated; and 4) consumers often eat them raw or partially cooked, thus allowing the pathogens to enter into and survive in human bodies and to cause illnesses (Klontz and Rippy 1991). According to a 1989 Food and Drug Administration estimate, 1 in 250 servings of raw or partially cooked molluscan shellfish results in illness, compared to 1 serving in 25,000 of cooked chicken, and 1 in 5,000,000 servings of cooked seafood (i.e., finfish and shellfish other than raw or partially cooked molluscan shellfish) (U.S. FDA 1989).

Molluscan Shellfish Related Illnesses, Pathogens, and Controls

Consumers may get ill from bacteria, vibrios, viruses, toxins, and chemical residues in molluscan shellfish (National Academy of Sciences (NAS) 1991).[2] Based on the most recent 20-year (1974-1993) data, however, Figure 9.1 shows most reported illnesses in the U.S. are attributable to bacteria, vibrios, and viruses (U.S. Food and Drug Administration, NTSU 1994). Though vibrios and viruses each accounted for about 45 percent of documented cases, all deaths have been associated with vibrios, particularly *Vibrio vulnificus*. The risk of *Vibrio vulnificus* is higher for some consumers who eat raw or undercooked oysters and have liver or kidney problems, diabetes, are immunocompromised, or are alcoholic. In addition, *Vibrio vulnificus* can be transmitted to humans through open wounds in contact with seawater.

As shown in Table 9.1, molluscan shellfish related pathogens either exist in the water (naturally occurring or due to fecal pollution in sewage discharge) or are introduced into the shellfish through improper food handling and preparation practices (NAS 1991). Thus, risk control strategies must address both sources to achieve effective reduction of human illnesses from these pathogens.

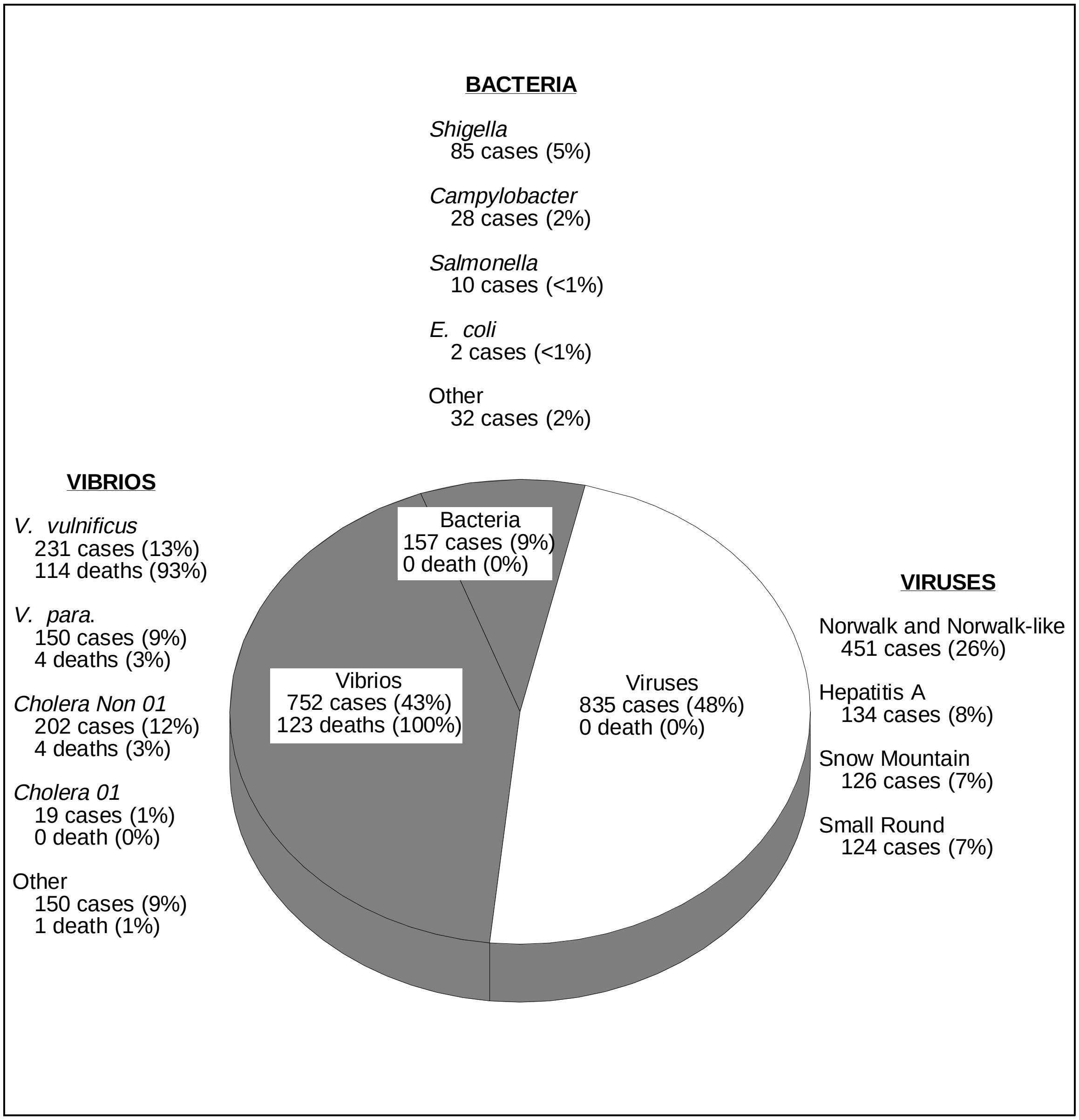
Depuration and relaying (to be discussed in detail later) are production processes used to prevent excessive levels of bacteria in raw shellfish products from entering into the market. Shellfish processors may perform depuration and relaying under guidelines established and enforced by the FDA and the states. Since improper handling and preparation practices may allow bacteria to survive and grow in shellfish, it is also important for the shellfish processing sector and seafood retailers (foodservice establishments and supermarkets) to adhere to Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) principles. FDA has promulgated a seafood inspection program based on HACCP, while the National Marine Fisheries Service (NMFS) of the Department of Commerce has already implemented a HACCP-based program. Furthermore, both the FDA and NMFS have been inspecting seafood producers' compliance with GMP. Finally, consumers can minimize the risk by avoiding eating raw or undercooked products as these bacteria can be killed by heat.

Shellfish Depuration

According to the National Shellfish Sanitation Program (NSSP), a voluntary shellfish inspection program, depuration is "the process of using a controlled aquatic environment to reduce the level of bacteria and viruses that may be present in shellfish harvested from moderately polluted waters to such levels that the shellfish will be acceptable for human consumption without further processing" (NSSP 1990). A water area is "moderately polluted" if the area's water quality does not meet stipulated microbiological standards. Harvesting in such an area is generally restricted and the harvests are prohibited from marketing without depuration or relaying. Presently, two categories of water are considered moderately polluted: the Restricted Area (RE) and Conditionally Restricted Area (CR). (See Appendix 9.A for details of water classification.)

Thus, depuration is **NOT** intended for shellfish from heavily polluted waters. Its purpose is to reclaim otherwise not-fit-for-marketing shellfish by reducing bacterial and viral contamination in them so they may be consumed raw or partially cooked. Moreover, the process needs stringent controls because the shellfish come from polluted waters.

FIGURE 9.1 Distribution of Molluscan Shellfish Related Illnesses, U.S., 1974-1993[a]



Source: *Seafood Borne Disease Outbreaks*, FDA/Northeast Technical Services Unit, May 1994.

[a]Notes: Includes only cases in which the agent and a single species have been identified. During the same time period, there were 263 cases of paralytic shellfish poisoning (PSP), associated with mussel, clam, and scallop consumption. Percentages in parentheses are each pathogen's share in total numbers of cases and deaths, respectively.

TABLE 9.1 Molluscan Shellfish Related Pathogens, Sources, Species, and Controls

Pathogen[a]	Source[b] Pre-harvest (Water) Naturally Occurring	Source[b] Pre-harvest (Water) Fecal Pollution	Source[b] Post-Harvest Handling/ Preparation	Species[a]	Control (By Whom)[c]
BACTERIA					Depuration (FDA, states, industry);
Shigella		X	X	Oysters, Clams	Relaying (FDA, states, industry);
Campylobactor		X	X	Oysters, Clams	HACCP[d] (FDA, NMFS, states, industry, retail);
Salmonella		X	X	Oysters, Mussels	
E. coli		X	X	Oysters	GMP[d] (FDA, NMFS, states, local, industry, retail);
					Avoiding consumption of raw or undercooked products (consumers)
VIBRIOS					Water and harvest controls (FDA, states);
Vibrio vulnificus	X			Oysters	Refrigeration (FDA, NMFS, states, local, industry);
Vibrio parahaemolyticus	X			Oysters, Clams	
Vibrio cholerae O1	X			Oysters	Low-dose gamma irradiation;
Vibrio cholerae non-O1	X			Oysters	Avoiding cross-contamination, time/temperature abuse, consumption of raw or undercooked products (states, local, industry, retail, consumers)
Other	X			Oysters, Clams	
VIRUSES					Water controls (FDA, states);
Norwalk & Norwalk-like		X		Oysters, Clams	Relaying (FDA, states, industry);
Hepatitis A		X		Oysters, Clams	Personal hygiene (industry, foodservice, consumers);
Snow Mountain		X		Clams	
Small Round Viruses		X		Oysters	HACCP (FDA, NMFS, states, industry, retail);
					GMP (FDA, NMFS, states, industry, retail)

(continues)

TABLE 9.1 Molluscan Shellfish Related Pathogens, Sources, Species, and Controls (continued)

[a]Pathogens and species were based on illnesses reported in *Seafood Borne Disease Outbreaks*, FDA/Northeast Technical Services Unit, May 1994. Only the 1974-1993 data with identified pathogen and species were included here.

[b]The source classification was based on *Seafood Safety*, National Academy of Sciences, 1991.

[c]Information on controls was based on *Seafood Safety*, National Academy of Sciences, 1991; information provided by the Department of Commerce/National Marine Fisheries Service (NMFS); and the *Food Code*, FDA, 1993.

[d]HACCP—Hazard Analysis Critical Control Point; GMP—Good Manufacturing Practices.

In the process, the shellfish are placed in tanks of ultraviolet (UV) light treated, flowing (or recirculating) saltwater for a minimum of 48 hours. As the water contains little food, at the end of the 48 hours, the shellfish purge themselves of gut contents which may include pathogens. The shellfish are tested at 0, 24, and 48 hours to ensure that the depuration works and they meet the specified microbiological standard—an ending fecal coliform count of < 20 cells/100 grams of shellfish meat. This compares to a standard of < 230 cells/100 grams for oysters harvested from approved waters.

Relaying is a similar process which involves transferring shellfish from contaminated growing areas to approved areas for a minimum of 15 days to allow biological cleansing in natural environmental conditions.

Depuration **CANNOT** eradicate all pathogens, especially viruses and vibrios, in molluscan shellfish (Richards 1988, Sobsey and Jaykus 1991). The process has not been proven to be effective for total elimination of viruses and vibrios. Research suggests that pathogens weakly attached to tissues (bacteria) are depurated first, while more firmly attached organisms are depleted more slowly or decline to die off. Also, naturally-acquired *Salmonella* in oysters may not be removed with depuration.

In addition, fecal coliform is found to be a poor indicator of the existence of viruses and vibrios in shellfish and in waters (Regan et al. 1993). An oyster may pass the 48-hour fecal coliform test and still cause illness as a result of viruses or vibrios remaining in the shellfish's tissues. Moreover, pathogens may still survive and grow in depurated shellfish if the foods are not handled or cooked properly.

In the U.S., active depuration facilities are located in California, Connecticut, Florida, Maine, and Massachusetts.

Shellfish Industry May Gain Economically from Depuration

In this chapter, the shellfish industry refers to the harvesting sector (the fishermen) and the processing sector (processors/wholesalers). To the harvesting sector, depuration would provide them with access to previously-closed waters (i.e., CR and RE), more quantity per harvest trip, lower per unit harvesting costs, and additional revenue. As mentioned earlier, potentially contaminated waters may not be open to direct-to-market harvesting. With depuration, however, shellfish in these waters could become available. With access to more or richer areas, the fishermen would be able to harvest a greater quantity of shellfish per harvest trip, thus lowering the per unit cost of production (assuming the same level of harvesting effort). Moreover, additional revenue would be generated with more harvests.

Whether depuration is beneficial to the shellfish processing sector depends on the difference between the sum of the costs of obtaining shellfish (from restricted waters) and depuration and the revenue generated by depurated shellfish. Harvests from restricted areas are potentially contaminated and have to be depurated before they can be marketed. Processors, therefore, may be able to purchase the shellfish from these areas at a discount. On the other hand, because depurated products are considered safer and perhaps more palatable, due to lower grittiness and higher salinity, the products may command a price premium in the retail market (Richards 1988). Also, it has been suggested that some buyers of shellfish may feel there is less liability (toward users) if they obtain "cleansed" products; some foodservice buyers also prefer depurated products (Arnold 1991). Naturally, the cost savings (of raw product) and additional revenue would have to be weighed against the costs of designing, operating, and maintaining a depuration facility according to regulations.

Ultimately, the economic feasibility of shellfish depuration depends on market demand. Consumer concerns with eating molluscan shellfish is one possible factor alleged to have depressed sales of these products. Since depuration can reduce the number of some pathogens in molluscan shellfish, the process has been recognized as one way to increase consumer confidence in these products. It has also been suggested that depurated shellfish may be more palatable than regular products because of lower grittiness and higher salinity. Consumer confidence and preferences for depurated products may lead to a recovery of lost markets, an overall increase in demand, and a higher price for depurated products.

This chapter focuses primarily on the costs of a hypothetical depuration facility and provides limited information on potential restaurant and consumer demand for depurated oysters.[3] As such, the chapter is a partial analysis of the economics of depuration.

A Case Study of the Economics of Depuration: Oyster Depuration in Dixie and Levy Counties, Florida

Market Conditions

There is a considerable interest in Dixie and Levy Counties, Florida, in exploring the possibility that depuration can revive the local oyster industry. Local shellfish wholesalers estimate that their sales of oysters are 50 percent or less of what they were five years ago (Deadrick 1994, Viele 1994). Public concerns with eating raw molluscan shellfish is one possible factor that has depressed the demand. Oyster landings in the area also have declined considerably in recent years. This has been due to a combination of factors. In addition to lower demand for the product, the profitability of alternative enterprises, most notably aquaculture of hard clams, has provided a profitable alternative to the harvest of wild oysters. Harvesting costs have also risen because permanent and temporary water closures have reduced average catch rates per trip.

Figure 9.2 shows the water classifications effective April 30, 1993 in the two counties. Prior to mid-1992, most of the coastal waters in the two counties were in the AP status (i.e., oyster harvests could be sold directly to market). Since mid-1992, however, many of these areas were reclassified to be CA or CR.

The effects of water re-classifications and closures can be observed in changes in oyster landings. Table 9.2 shows the oyster landings in Dixie and Levy Counties for the 1985-1993 period. The quantities of landings varied between years; these figures cannot be used as definitive estimates of the size of the resources because the quantity of oysters harvested in any area depends on many factors. Nevertheless, landings do give a sense of the quantity of oysters "worth harvesting" if most of the coastal waters in the area remained in AP classification as they had been prior to mid-1992. Compared to the 1990-1992 average landings (26,215 bushels in the two counties), the 1993 landings were significantly lower.

FIGURE 9.2 Shellfish Harvesting Areas and Water Classification, Dixie and Levy Counties, Florida

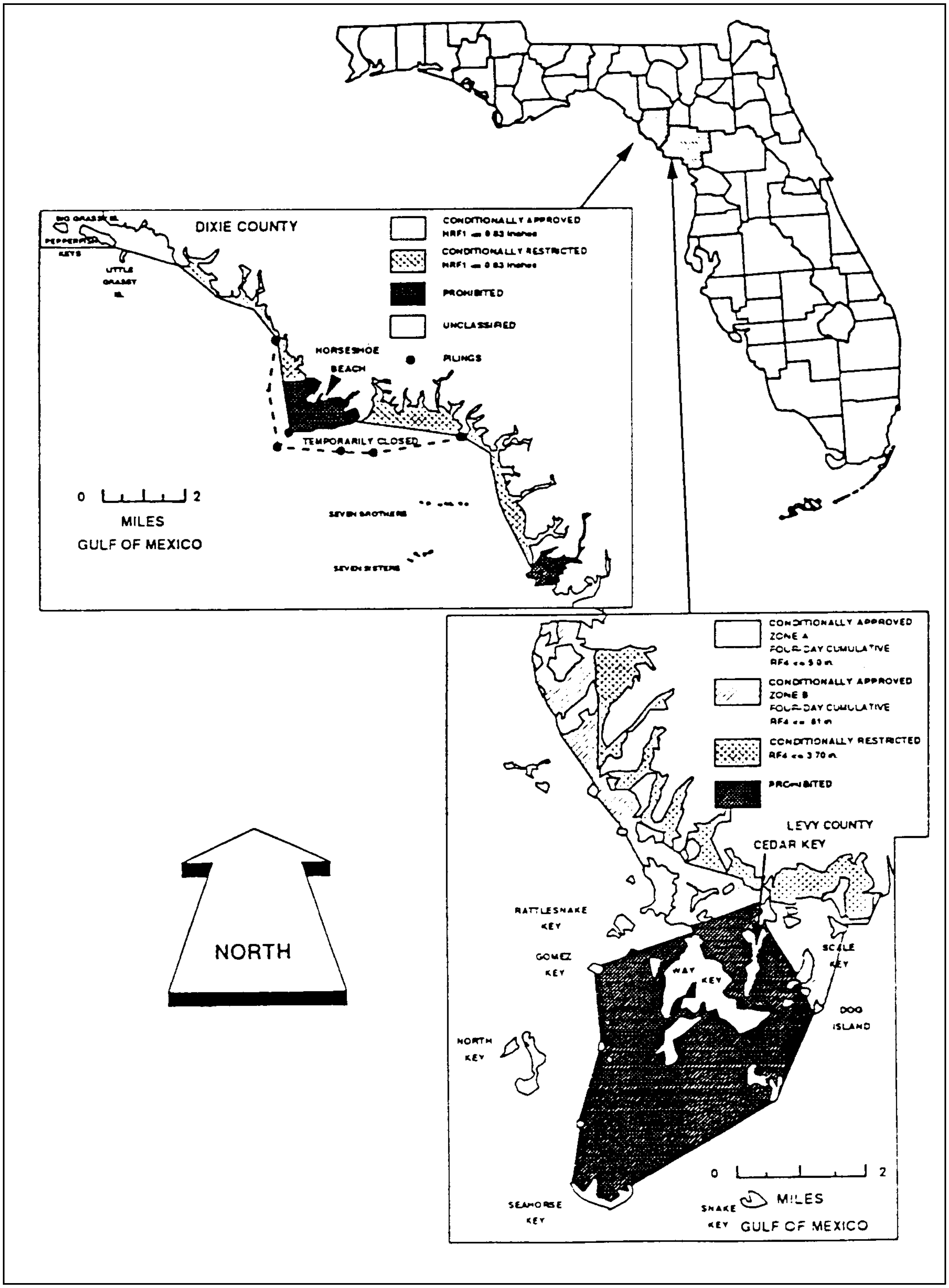


TABLE 9.2 Commercial Oyster Landings (Bushels) in Dixie and Levy Counties, and the State of Florida, 1985-1993

Year	Dixie County	Levy County	Dixie and Levy Counties	Florida
1993	916	7,882	8,798	354,286
1992	4,076	8,147	12,223	256,803
1991	15,228	4,468	19,696	236,129
1990	33,498	13,230	46,726	285,450
1989	72,355	20,227	92,582	236,080
1988	53,409	10,491	63,900	281,549
1987	52,501	10,584	63,085	481,423
1986	107,205	29,626	136,831	279,503
1985	2,674	15,809	18,483	559,316

Source: Florida Department of Natural Resources, Marine Fisheries Information System, Annual Landings Summary.

Potential Resource Available to Depuration

It is estimated that the additional landings per year that would be available if some restricted waters were open are 5,800 bushels, including 4,800 bushels at Horseshoe Beach and 1,000 bushels at Cedar Key (both areas classified as CR). Compared to the average number of bushels landed in the 1990-1992 period (26,215 bushels), depuration may increase the quantity of oysters harvested annually by 22 percent for the two counties.

Lower Harvesting Costs and Additional Revenue to Fishermen

Currently, oyster harvesting in Dixie and Levy Counties costs $5.21 per bushel. This estimate is based on a 1983 study in Franklin County, Florida (Prochaska and Keithly 1986) and recent discussions with oystermen and managers of shellfish processing facilities in Cedar Key. The estimate reflects adjustments for inflation. It is assumed that 1) harvests occur four days a week throughout the nine-month season, 2) the oysterman travels 16 miles per trip and harvests 8 bushels per trip, and 3) a monitor is hired at a daily charge of $100 and can accompany an average of 12 boats at one time.

What would happen to the cost estimate if there were an increase in the number of oysters available for harvest? It is difficult to estimate the exact increase in the number of bushels harvested per trip if CR areas were available for harvesting to supply a depuration facility. Nevertheless, fishermen indicated that they expect the cost per bushel to drop.

As such, the fishermen have mentioned that they would be willing to accept a discount for oysters harvested from the CR waters, since the higher yield per trip would be great enough to compensate them for a lower price per bushel. Given a current price of $10.80 per bushel paid to fishermen for harvests from AP or CA areas, they would accept a minimum of $9.00 per bushel for oysters from CR areas.

Estimates of Depuration Costs

The operating and capital cost estimates of a hypothetical depuration facility are based on literature reviews of the design and operation of actual and hypothetical depuration facilities and site visits of operative and inoperative facilities. The estimates do not include shellstock costs.

Operation Requirements. In Florida, regulations regarding the design and operations of depuration facilities are found in the Florida Administrative Code (FAC) which is largely adopted from the NSSP Manuals of Operation. Among the requirements of the Code, state certification of the facility operations is of primary importance. A summary of the key certification requirements is as follows (FAC 1993).

Depuration Cycle Length: Shellfish must be depurated for a minimum of 48 hours.

Source of Process Water: Must be from an approved or restricted area and is UV-disinfected to drinking water standards.

Source of Shellfish: Must be from CR or RE waters only.

Water Volume and Flow: 8 cubic feet of water per bushel of shellfish should be provided and a water flow of 1 gallon per minute per bushel is required.

Quality of Process Water: Water temperature and salinity must not be so different from harvest waters; turbidity must be < 20 JTU (Jackson Turbidity Units) and dissolved oxygen must be > 5 ml per liter; the water should be tested by a state-certified lab for total coliform at 0, 24, 48 hours for a 48-hour cycle; water used in each cycle must be discarded.

Shellfish Meat Quality: Meat samples are taken every 24 hours (at 0, 24, 48 hours) and tested by an FDA-certified lab for fecal coliforms; the lab analysis must demonstrate a fecal coliform count of < 20 cells per 100 grams of meat before the shellfish may leave the facility.

Effluent Discharge Permit: Private easement for construction on state-owned lands and zoning permits may be necessary.

Cost Items: The costs of operating a depuration facility include:

Fixed: Building, land, equipment (depuration tanks, sand filter, UV sterilizer, recirculating pump, blower, chiller, cooler), materials (PVC tubing and materials, flow meters, oxygen meter, salinometer, tank trays, air diffusors, washing/culling table, UV replacement lights/ sleeve, pressure sprayer), lab tests, other (insurance, taxes, labor to assemble tanks, certificate, and permits).

Variable: Wages, utilities, building maintenance, cleaning and supplies, materials for lab tests.

Water: Well drilling, settling tank, degasser, pump, electricity.

Design and Operation Assumptions: The following assumptions are used in the analysis:

Processing Capacity: The facility operates at capacity; 27 weeks per year are available for depuration, excluding season closure, water closures, and maintenance; 2.5 depuration cycles can be accomplished per week.

Location: The facility is located shoreside within city limits and has road, utility, and city sewer access.

Source of Oysters and Process Water: Oysters are from CR waters in the two counties; tank water is obtained from an on-site saltwater well.

Effluent Discharge: Process water is discharged by pipe directly to sea; fresh water used to clean tanks is discharged to the sewer system.

Other: The facility is considered as an addition to an existing or new shellfish processing operation which purchases the oysters to be depurated; the oysters are delivered to the facility.

Design Options: To cover a wide range of facility sizes, 10 different options are used to estimate the costs. The options vary in the number of tanks in the facility (1-4 tanks) and the capacity of the tank (12, 24, and 48 bushels/tank).

TABLE 9.3 Estimates of Depuration Costs, By Design Option

Option	Tank Size (Bu.)	# of Tanks	Capacity Per Year (Bu.)	Fixed Cost/ Bu.	Variable Cost/ Bu.	Water Cost/ Bu.	Total Cost/ Bu.	Cost/ Oyster
1	12	1	810	$12.50	$29.71	$0.60	$42.81	$0.153
2	12	2	1,620	7.46	21.11	0.41	28.98	0.104
3	12	3	2,430	5.99	19.66	0.40	26.05	0.093
4	12	4	3,240	5.16	12.96	0.36	18.48	0.066
5	24	1	1,620	7.07	16.62	0.49	24.18	0.086
6	24	2	3,240	4.46	12.62	0.36	17.43	0.062
7	24	3	4,860	3.79	12.22	0.37	16.38	0.059
8	24	4	6,480	3.35	8.52	0.33	12.20	0.044
9	48	1	3,240	4.38	10.10	0.44	14.93	0.053
10	48	2	6,480	3.17	8.47	0.33	11.97	0.043

Cost Estimates

The cost estimates of the hypothetical depuration facility are shown in Table 9.3. The depuration costs per oyster decrease as the capacity of the facility increases, by using either larger or more tanks. At the smallest capacity with one 12-bushel tank (Option 1), it costs $42.81 per bushel ($0.153 per oyster) to depurate the product. In contrast, the cost is only $12.20 per bushel ($0.044 per oyster) for Option 8 (four 24-bushel tanks) and $11.97 per bushel ($0.043 per oyster) for Option 10 (two 48-bushel tanks). An increase in capacity lowers average cost by spreading out fixed costs over a greater output. In addition, larger capacity permits more efficient use of labor and the spreading out of laboratory materials costs. Labor cost and laboratory analysis costs combined constitute more than 50 percent of total costs for all design options.

Economic Feasibility of Depuration in Dixie and Levy Counties, Florida

Supply of Depurated Oysters

Whether the depuration process can benefit the oyster processing sector depends on cost savings of oysters from restricted waters, marginal costs of depuration, and marginal returns from depurated products. As mentioned earlier, fishermen would be willing to accept a minimum of $9.00 per bushel of oysters from CR areas. Compared to the current price of $10.80 per bushel paid for oysters from AP or CA areas, this leaves no more than $1.80 per bushel to cover the costs of depuration. Since none of the options in Table 9.3 yields a depuration cost per bushel of lower than $11.97, oyster depuration does not appear to be economically feasible, given the cost savings of raw product and marginal costs of depuration.

If depurated product is more attractive to consumers based on perception of enhanced product safety or a more appealing appearance, a price premium on depurated oysters could make the process feasible. Given the depuration costs per bushel in Table 9.3, the premium would have to be at least $10.17 per bushel ($11.97-$1.80) or $0.036 per oyster. This amounts to 67 percent of the current price received by processors. In addition, this premium reflects the most optimistic conditions in that Option 10 (Table 9.3) assumes all the additional quantity of oysters from the restricted waters are harvested and marketed.

Demand for Depurated Oysters

The profitability of setting up a depuration facility ultimately would depend on 1) the acceptability of depurated oysters to retailers (especially restaurants) and consumers; 2) the size of the potential market for depurated oysters; and 3) the price premiums that the product can receive. As mentioned in the preceding discussions, potential resources are available; nevertheless, a processor may not be able to cover its depuration costs if the price or quantity demanded is not high enough. Below, we report some information with respect to restaurants' and consumers' attitude toward depurated oysters.

What Do Restaurants Think About Selling Depurated Oysters? It appears the potential size of restaurant demand for depurated oysters is limited. A random sample of independent restaurants in seven metropolitan statistical areas (MSAs) within approximately 100 miles of Cedar Key was drawn from listings in the 1994-1995 Florida Business Directory. The sample included only those listings that had a seafood-oriented name or were known to serve seafood. Staff of the Florida Agricultural Market Research Center at the University of Florida called approximately 100 restaurants and successfully interviewed 35 managers responsible for menu selection and purchasing decisions. Telephone calls were made during non-rush hour periods, i.e., mid-mornings and mid-afternoons. Most interviews required 15 minutes each.

The survey asked about the restaurants' practices and experiences in selling raw and cooked oysters. In addition, anticipated sales and purchases were elicited for oysters that would be treated by a process that "reduces the number of bacteria and viruses in oysters...by flushing with clean water."

One of the most interesting results from the survey is the strong relationship between a restaurant's concern for the safety of the product and its sales practice and experiences. Managers were asked whether they carried raw oysters (which pose higher risk to some population subgroups) at the time of the survey; if not, whether they had carried raw oysters before, and why they did not carry the product or discontinued it. Seven restaurants never had raw oysters on their menu; all of them cited product safety as the primary reason for not selling raw oysters. Similarly, 8 of the 9 restaurants who discontinued the product attributed the decision to safety concerns. In addition, 11 of the 19 restaurants who were selling raw oysters stated that they had seen a decline in the sales of the product; by comparison, only 3 of 24 restaurants selling cooked oysters felt the same way.

These results suggest that safer oysters should have a strong appeal to the restaurant managers. Nevertheless, as shown in Table 9.4, only 12 of the 35 managers said they would purchase the depurated oysters. The lack of interest among restaurants corresponds with current menu practices. Specifically, most of those restaurants who cited safety concerns for not carrying or having discontinued oysters (either raw, cooked, or both) would still not buy the safer product.

In terms of anticipated sales, respondents who expressed interest in the safer oysters were asked "what percentage effect, if any, would the availability of safer oysters have on your gross sales of oysters" if the treated oysters cost $30.00 per bushel and regular oysters cost $15.00 per bushel. Eight of the 12 respondents felt a safer product would have positive impact on their gross sales, while the other four foresaw a decrease or no change at all. The anticipated increases in sales vary from 10 to 30 percent above current sales.

The lack of interest in the safer oysters is a troubling finding in that safety apparently is one of the primary reasons, if not the only reason, some restaurants have avoided either raw or cooked oysters. A possible explanation is the stated wholesale price for the depurated product was too high relative to the perceived worth of the risk reduction. Our survey could not shed light on this possibility. Nevertheless,

TABLE 9.4 Would a Restaurant Manager Purchase the Treated Oysters?

Current Menu Practice	Yes	No	Total
Carries both RAW and COOKED oysters	8	11	19
Carries only COOKED oysters	1	4	5
Does not carry any oysters			
Due to safety reasons	3	6	9
Due to other reasons	0	2	2
ALL SAMPLE	12	23	35
Other Breakdowns:			
Never carried RAW oysters (all due to safety)	2	5	7
Discontinued RAW oysters			
Due to safety reasons	1	7	8
Due to other reasons	0	1	1
Never carried COOKED oysters			
Due to safety reasons	1	3	4
Due to other reasons	0	2	2
Discontinued COOKED oysters			
Due to safety reasons	2	3	5
Due to other reasons	0	2	2

this explanation may be expected if the respondents were not fully aware of the merits of depurated products, based on the description of the process and the potential change in the level of oysters' risk. Hence, restaurant managers could not value the safer products adequately. Alternatively, some respondents could be risk-averse in that they would not be interested in a product unless it is 100 percent risk-free. Given the publicity of oyster-related deaths (from *Vibrio vulnificus*) in recent years, the restaurant managers could have a valid concern about potential liabilities.

Another possible explanation of the restaurants' lack of interest in depurated oysters is that they were uncertain of consumer demand. Some business managers prefer to take a follower's rather than a leader's stance when it comes to new and more expensive products. The conservative attitude may be particularly relevant in the present case because neither the restaurant managers nor their customers can observe or verify the product's risks, let alone a reduction in the risks. As such, the managers may question whether a significant number of consumers would order treated oysters or would pay a premium for the product.

The next sub-section suggests, however, that consumers may be interested in the safer product and may be willing to pay a premium for it.

What is the Marketability of Depurated Oysters to Consumers? To examine consumers' willingness to eat depurated oysters and their willingness to pay for the safer product, a stratified sample of 1,012 adults (age 18 or older) in the same 7 MSAs covered by the restaurant survey was selected for a telephone survey. Households were randomly selected by using a random digit dialing technique; within each household, an adult was randomly selected using the "last birthday" technique.

Interviews were done by a commercial field service using a computer assisted telephone interviewing (CATI) program. The average interview lasted approximately 10 minutes. The sample contained somewhat greater proportions of older, female, and white individuals as well as high-income households than the target population.

The survey covered topics on risk perceptions of oysters, clams, and chicken; consumption practices of oysters; reasons for any changes in oyster consumption habits; willingness to eat depurated oysters; and willingness to pay for the product. Here, we limit the reporting to respondents' consumption intentions of depurated oysters and the price premiums they would be willing to pay for the safer product.

Though product safety does not appear to have inhibited many respondents from ever eating oysters, it has caused some respondents to reduce their oyster consumption. An overwhelming majority (85 percent) of those who had never eaten oysters cited non-safety reasons such as appearance and taste. Nevertheless, half of those who had not eaten oysters last year reported they did so because of doctor's advice or personal concerns about product safety. Moreover, 45 and 27 percent of those who had oyster consumption experience said they had reduced the frequency and quantity of consumption, respectively; the main reason cited for the change is product safety.

It follows, therefore, that depurated oysters received somewhat positive reactions from the respondents. After hearing a description of the depuration process (the same description as used in the restaurant survey), respondents were asked whether they would buy the product if it were available. Fifty-five percent of those asked said they would ("potential buyers"), 38 percent said no, and 7 percent did not answer or could not decide. A chi-square analysis (at the 5 percent significance level) indicates the potential buyers tend not to perceive a high risk in either raw or cooked oysters, have eaten oysters more often, or have not reduced the proportion of oysters eaten in raw form.

It is also interesting to note that among those who liked oysters but did not eat any in the past year, 49 percent of them would be enticed by the depurated oysters. Further analysis indicates 41 percent of the respondents who did not eat oysters last year due to safety reasons would be willing to try treated oysters and 50 percent of them would not.

If there is a market for depurated oysters, would consumers be willing to pay more for the product? The survey asked potential buyers "If oysters now sell for $0.50 each in a seafood shop or restaurant, how much would you be willing to pay for oysters treated in this manner to make them safer?" The mean and median of the reported willingness to pay are $0.21 and $0.10, respectively. Twenty percent would pay up to 5 cents (or one-tenth) above the price for regular oysters ($0.50). Most others would pay from 10 to 25 cents more than the current price. Only 13 percent were not ready to pay any price premium for the safer product. On the other hand, there were also some respondents (15 percent) who could not decide the price or did not answer the question. A correlation analysis (at the 5 percent significance level) suggests the more likely a respondent thought he/she would be to get sick from a serving of raw or cooked oysters, the higher price he/she would be willing to pay for the safer product.

The findings on willingness to buy and willingness to pay thus suggest that the safer product would be appreciated by at least some consumers, especially those who avoided oysters for fear of getting ill from the food.

Summary

This study examines the cost to reduce some human foodborne health risks using depuration, a post-harvest process that removes some pathogens in molluscan shellfish products. The case study of a hypothetical oyster depuration facility at Dixie and Levy Counties, Florida, suggests the process may not be economically feasible to a processor under the given conditions. The price premium required by the facility to cover its marginal costs is about 67 percent of the price a processor currently receives. Restaurant managers may lack confidence in consumer demand for the depurated product. Nevertheless, a consumer survey suggests there may be a market for the safer oysters and some consumers would be willing to pay a price premium for depurated oysters.

Notes

[1]Lin is a Research Assistant Professor, Food and Resource Economics Department (FRED), University of Florida (UF) and a Visiting Agricultural Economist, Economic Research Service, USDA; Adams and Degner are Professors, FRED, UF; and Dunning is an Agricultural Economist with the North Carolina Department of Agriculture and was a Research Assistant at FRED, UF when this research was conducted. The authors thank Buck Brooks and Nedra Williams for technical assistance. The views expressed in this chapter are the authors' and do not necessarily reflect the views of the U.S. Department of Agriculture.

[2] Vibrios are spiral-shaped bacteria. In this chapter, we use the term "bacteria" to indicate all non-vibrio bacteria.

[3]For details of the cost, consumer, and restaurant analyses, see Dunning and Adams (1995) and Degner and Petrone (1994).

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Appendix 9.A

Classification of Water Quality

States participating in the National Shellfish Sanitation Program (NSSP), a cooperative program between FDA, states, and industry (state and industry participation is voluntary), attempt to control pathogens by regulating the waters from which molluscan shellfish may be harvested. Pollution points surveys are conducted to identify potential pollution sources (sewage treatment systems, areas prone to agricultural runoff, and areas with wild animal populations). In addition, states carry out bacteriological surveys to detect the presence of pathogens, using fecal coliform as the "indicator" bacterium.

Based on the pollution points and bacteriological surveys, water areas and shellfish harvests sales are classified and regulated as follows:

Approved Area (AP)	Meets 14/43 fecal coliform standard; normally open to harvesting; harvests are permitted for direct marketing; the area may be closed temporarily under extraordinary circumstances such as sewage spills.
Conditionally Approved Area (CA)	Meets 14/43 standard; periodically closed to harvestingbased on pollution events such as increased rainfall or river flow; harvests from CA may be sold for direct marketing.
Restricted Area (RE)	Meets 88/260 standard; normally open to regulated depuration or relaying; harvests may not be marketed without depuration or relaying.
Conditionally Restricted Area (CR)	Meets 88/260 standard; depuration, relaying, and sales of harvests are periodically suspended during pollution events.
Prohibited Area	Harvesting not permitted due to failure to meet water standard.
Unclassified	Harvesting not permitted pending bacteriological survey.

Note: The "14/43" and "88/260" are water standards adopted by the NSSP. The former refers to median or geometric mean of the fecal coliform indicator does not exceed 14 MPN (mean probable number) per 100 ml (milliliters) of water, and MPN not to exceed 43/100 ml of water more than 10 percent of the time. The "88/260" standard refers to median or geometric mean of the indicator does not exceed 88 MPN per 100 ml of water, and MPN not to exceed 260/100 ml of water more than 10 percent of the time.

Source: Florida Department of Environmental Protection, Shellfish Environmental Assessment Section, 1993.