Southern Regional Aquaculture Center

SRAC Publication No. 4902
May 2010

Shellfish Handling Practices – Shrimp and Molluscs

Russell Miget[1]

Culture practices affect the safety of cultured shrimp and bivalve molluscan shellfish. Using correct practices in the culture, harvesting and processing of these species not only makes them safer for human consumption but also improves product quality.

Shrimp

Pre-harvest procedures

Warm-water penaeid (saltwater) shrimp are most commonly grown in earthen ponds 4 to 6 feet deep that range in size from less than an acre to tens of acres. Farmers routinely monitor shrimp size and condition and estimate survival by capturing live shrimp throughout the growing season. As harvest time nears, samples should also be checked for their quality and safety for human consumption. To do this, collect about 3 pounds of live shrimp (total) from different parts of the pond and place them in sterile (or new) plastic bags. Do not contaminate the shrimp with pond mud or insanitary equipment and handling. Chill the bags of shrimp in ice and take them to the certified lab.

It is assumed that shrimp will be cooked before consumption, so bacterial pathogens on raw product would not normally be considered a HACCP Critical Control Point to be monitored. However, because the pathogen *Salmonella* is widespread among warm-blooded animals and birds and is occasionally found in commercial animal feeds, it is "reasonably likely" (a HACCP term) that *Salmonella* may be present on, or in the intestinal tract of, farmed shrimp. The U.S. Food and Drug Administration (FDA) considers the mere presence of this pathogen an indication of poor sanitation during production, harvest or processing. Also, from a public health standpoint, there have been several highly publicized illnesses resulting from the cross-contamination of raw and cooked shrimp during preparation. So, raw shrimp should be tested for *Salmonella*.

Microbial identification may take up to a week. If the results are positive, the following options are available. First, since pond water is considered to be the source of contamination, attempt to keep both wild and domestic animals away from the ponds and then carry out a water exchange. If this does not eliminate the problem, it may be possible to treat harvested raw shrimp with a weak (10 ppm) chlorine solution either before or after further processing (e.g., heading, peeling, deveining.) Finally, *Salmonella*-contaminated product may have to be fully cooked and then rechecked for the bacterium before it is placed on the market.

If samples taken during the growing season repeatedly test negative for *Salmonella,* the farmer may conclude that it is not "reasonably likely" to expect the presence of this pathogen and discontinue, or limit, further microbial testing. Regulatory personnel will ultimately determine whether such a decision was justified.

Shrimp samples should also be evaluated for shell condition, texture, flavor and odor. If more than 5 percent of the shrimp have recently molted (have soft shells), the harvest should be delayed for a few days to allow the shells to harden. To evaluate for off odors or off flavors, shrimp samples should be either boiled or microwaved in a plastic bag until fully cooked, then smelled and tasted. (Off flavors most often occur when shrimp are grown in ponds with extremely low salinity, which allows the growth of the same blue-green algae that cause off flavors in cul-

[1]Texas AgriLife Extension Service, Sea Grant Program, The Texas A&M System

tured catfish.) To reduce the development of off colors in the cephalothorax (commonly referred to as "red head"), stop feeding shrimp, but no more than 2 days before harvest. While this condition does not affect flavor or product safety, it is a visual defect that will affect the price received for head-on shrimp.

Before harvest, all equipment that will come into contact with the shrimp should be washed with a detergent, rinsed, sanitized with a 200 ppm chlorine solution, and then rinsed again with potable water. This procedure will reduce bacterial contamination and increase shelf life, regardless of how the shrimp are subsequently processed. (This cleaning and sanitizing routine is part of a larger Standard Sanitation Operating Procedure, or SSOP, which is a prerequisite program that must be implemented along with a HACCP plan. Both an SSOP and a HACCP plan are necessary for processing shrimp.)

Harvest procedures

Ponds are harvested by draining water and shrimp into a net or catchment basin located outside of the pond levee. The pond is usually drained through a screened weir to approximately 30 percent of its operating volume 2 days before harvest. A more rapid drawdown, or merely fluctuating water levels, can induce molting and cause an unacceptably high percentage of soft-shell shrimp. As the shrimp are concentrated in a dwindling volume of water, monitor water temperature and dissolved oxygen (DO) frequently. If the DO level falls below 3 ppm, aerate to reduce stress and possible mortality before the shrimp are harvested. Dead shrimp do not drain well, must be hand collected from the muddy pond bottom, and often result in a lower price because of quality defects.

Final harvesting is usually begun in late afternoon and completed at night when water temperature is cooler and bird predation is minimal. Shrimp in the effluent are captured either in large harvest bags affixed to the effluent side of the weir gate culvert, or in screened catchment basins. Harvest bags typically are about 8 meters long, 2 meters in diameter, and made of 7 mm^2 mesh. Many ponds are being constructed with catchment basins designed to be screened and to accommodate a vortex pump that transfers water-slurried shrimp up to a dewatering tower and then into a container of ice water on the levee. Net-captured shrimp are transferred either to 10-gallon boxes and layered in ice or to 1-cubic-meter insulated containers that hold an ice-water slurry. These containers are similar to those used with mechanical harvest systems.

The quality of shrimp begins to deteriorate as soon as they are harvested. The speed of deterioration depends primarily on the temperature at which they are held, but also on whether the shrimp are physically damaged or covered with mud during harvest. Therefore, when net harvesting do not allow the bags to become too full and mash the shrimp. Likewise, keep shrimp that remain on the muddy pond bottom after harvest (and must be collected by hand) separate from the rest of the harvest.

Post-harvest procedures

Melanosis (Black Spot)

The darkening of pigments in membranes and meat just under the shrimp shell (melanosis) is commonly known as black spot, and it is a visual defect that compromises marketability. Black spot will eventually occur even under ideal refrigeration temperatures, but two chemicals are commonly used to delay its onset. The most common is sodium metabisulfite, a relatively inexpensive inorganic chemical that has been used for more than 40 years. The other, 4-hexylresorcinol (trade name EverFresh®), is an organic chemical that blocks the enzyme responsible for black spot. The sooner harvested shrimp are treated with one of these products the more effective they are in delaying the onset of melanosis. Thus, many farmers dip baskets of live shrimp in one of these solutions before storing the shrimp in ice or ice water for transport to the processing plant.

> Sodium metabisulfite powder releases toxic sulfur dioxide fumes when mixed with water, so the dry chemical should be stored in a sealed, water-tight container in a well-ventilated area. The 1.25 percent (w/v) solution used in treating shrimp is not dangerous, but it should be mixed in an open area that is upwind of any strong breeze to prevent eye and throat irritation.

Sulfites. Immerse baskets of shrimp for 1 to 3 minutes in a 1.25 percent solution of sodium metabisulfite (made by dissolving 3.1 pounds of sodium metabisulfite in 30 gallons of water). A cylindrical fiberglass or plastic tank holding 30 gallons of solution is convenient when using standard plastic "shrimp baskets." Each 30-gallon batch of sodium metabisulfite can treat about 500 pounds of shrimp before it should be discarded. However, if the dip water becomes muddy or frothy, a fresh solution should be used, otherwise the shrimp pick up a high bacterial load while being dipped and this reduces their shelf life. After dipping, drain shrimp and layer them in ice in boxes.

While this method works well for net-harvested shrimp, mechanically harvested shrimp are usually transferred to containers of ice water containing sodium metabisulfite, skipping the dip step. In this case, the soak time from levee to plant will be considerably more than a few minutes so the recommended concentration of sodium metabisulfite is 0.25 percent (w/v). The chemical will slowly leach out of treated shrimp, whether stored in ice water or melting ice. Therefore, prolonged storage of shrimp may make an additional treatment necessary during processing. Shrimp destined for the heads-on market are particularly prone to melanosis and should be treated pond side whenever possible. With so many variables in harvest techniques and in product form (i.e., head-on or headless), only experience can reveal the need and protocol for additional black spot treatment.

Because some consumers may be sensitive to sulfiting agents, the FDA has established a regulatory limit of 100 ppm for sulfite residue on shrimp. This level is adequate to prevent melanosis. Other countries have limits ranging from 60 to 100 ppm on raw shrimp and as low as 30 ppm for cooked product. Some hypersensitive asthmatics can have life-threatening allergic reactions to even small amounts of sulfites, so all treated products must be labeled with the sulfiting agent. If an aquaculture firm also processes the shrimp it grows, then labeling for sulfites would be a Critical Control Point (CCP) in their HACCP plan. There are test kits that provide a rough indication of the sulfite residue on shrimp, but it is strongly recommended that once an acceptable black spot prevention protocol is established, samples be submitted to a laboratory for sulfite analyses using the Monier-Williams Test, as described in the current edition of the official Methods of Analysis of the Association of Official Analytical Chemists.

4-hexylresorcinol (EverFresh®). 4-hexylresorcinol prevents melanosis by binding the enzyme responsible for brown pigment, which eliminates the need for retreatment after rinsing, soaking or thawing. The manufacturer claims that, as a processing aid, the product does not have to be labeled. However, some state regulatory agencies do require labeling of products treated with 4-hexylresorcinol. The chemical is used as a dip solution: 95 liters (25 gallons) of a 50 ppm solution of 4-hexylresorcinol is prepared using fresh water. Shrimp are dipped for 2 minutes with agitation, then drained and stored on ice or in ice water. Unlike sodium metabisulfite, however, 4-hexylresorcinol is ineffective when added directly to an ice-water slurry. It is most effective when used at ambient temperatures. The product is also ineffective in chlorinated water (sometimes used to eliminate pathogenic bacteria) or in concentrated salt brines used in some freezing systems.

Antibacterial treatment

Chlorine. Pond water has higher bacterial counts and dissolved organic loads than most waters from which wild shrimp are harvested. Cultured shrimp should be thoroughly washed during processing to reduce bacteria and increase shelf life. If the total aerobic plate count on harvested shrimp exceeds 1 million per gram and/or shrimp samples indicate the presence of *Salmonella,* a chlorine dip may be warranted. Chlorine solutions that directly contact food cannot exceed 10 ppm and the allowable contact time is 10 to 15 minutes. A 10 ppm solution can be prepared from calcium hypochlorite powder using the following formula: ppm chlorine desired divided by the percent chlorine in the powder times 0.1 equals grams of calcium hypochlorite per 1 liter of water. For example, to make a 10 ppm chlorine solution from calcium hypochlorite that has 35 percent chlorine:

$10 \div 35 = 0.28 \times 0.1 = 0.028$ grams powder per 1 liter of water (approximately 1 ounce per 270 gallons)

Chlorine and 4-hexylresorcinol should not be combined, as this diminishes the effectiveness of the anti-melanosis chemical. Since chlorine is active in ice-water slush, it often is added to the pond-side containers. Shrimp are then treated separately to control black spot once they arrive at the processing plant. Only fresh, potable water should be used to make up chlorine solutions. Concentrations higher than 10 ppm and exposure times longer than 15 to 20 minutes are not only illegal, but can discolor, create off odors, and alter the surface texture of shrimp. Chlorine residual decreases rapidly when exposed to organic materials, such as shrimp. However, the remaining "free chlorine" can be easily measured with chlorine test strips to maintain an effective bactericidal concentration.

Phosphate food additives. Any food additive or processing aid used must have an "intended effect" that is consistent with regulatory allowances. The use of phosphates in processing shrimp began in the 1960s with the intended effect of preventing moisture from migrating from peeled shrimp muscle into the breaded coatings. Later, phosphates were used with peeled, non-breaded shrimp to prevent the loss of moisture and water-soluble nutrients during frozen storage, thawing and cooking of peeled shrimp. Phosphate is now used to retain moisture in headless, shell-on shrimp as well.

Phosphate dips should be used to provide an acceptably moist cooked product without "adulterating" for the sake of "water weight gain." Phosphate is usually prepared as a 2 to 3 percent solution (w/v) of food-grade sodium tripolyphosphate, held at 41°F or colder. The soak time for phosphate uptake is about 2 hours. Wild American Shrimp, Inc. (WASI) guidelines require that peeled, raw shrimp contain 80 to 84 percent moisture and that cooked, peeled product contain 70 to 80 percent moisture. Raw, headless, shell-on shrimp should not contain more than 80 percent moisture after treatment with phosphate. All products treated with phosphates must be labeled as such (e.g., "phosphates used to retain moisture").

Bivalve molluscan shellfish

Cultured bivalve molluscan shellfish include oysters, clams, mussels and scallops. Cultured bivalves are usually spawned and reared to spat (seed) in a hatchery, then transferred to public waters for growout and harvest. Bacterial and viral pathogens are a significant risk in both cultured and wild bivalves for the following reasons:

- The brackish creeks and near-shore areas of bays and estuaries where bivalves are typically grown are susceptible to contamination with pathogens in raw sewage and runoff. These waters may also contain free-living potential pathogens.
- Bivalve shellfish are filter-feeders that concentrate pathogens from the environment. Concentrations of toxigenic micro-algae and pathogenic bacteria and viruses have been shown to be 100 times greater in bivalves than in the water column.
- Oysters are often consumed raw and other shellfish may be only partially cooked before consumption. Therefore, pathogens in the product may not be killed nor toxins inactivated. For these reasons, bivalve shellfish must be cultured, harvested and handled carefully.

Model Ordinance (2007 revision; *http://www.issc.org/nssptoc.aspx*) prepared by the Interstate Shellfish Sanitation Conference (ISSC), describes the National Shellfish Sanitation Program (NSSP), a federal/state cooperative program for the sanitary control of shellfish produced and sold for human consumption. This guide defines shellfish aquaculture as the culture of molluscan shellfish in natural and artificial growing areas, including the cultivation of molluscan shellfish with non-molluscan species in polyculture systems.

Particular attention should be paid to Chapter VI (Section II - Model Ordinance), entitled "Shellfish Aquaculture." This chapter describes the requirements a culturist must meet in growing bivalves. The requirements relate to permits, licenses, system design, and seed shellstock. In addition, there must be a written operational plan approved by the state shellfish authority. Particular attention is given to the quality of growing waters. Shellfish may not be grown in prohibited waters. Those grown in restricted, the closed status of conditionally approved, or the open status of conditionally restricted waters must be relayed or otherwise depurated before consumption. Shellfish grown in approved waters may be marketed immediately.

Harvesting, processing, storage and shipping requirements are the same for cultured and wild shellfish, and are detailed in the NSSP Model Ordinance. Records, which must be maintained for at least 2 years, include: 1) source of shellfish, including seed if the seed is from growing areas not in the approved classification; 2) dates of transplanting and harvest; and 3) in land-based systems, water source, its treatment method (if necessary) and its quality. The Guidance Documents (Section IV- Model Ordinance) contain bacterial water quality standards used to classify growing waters and a list of the Action Levels, Tolerances, and Guidance Levels for Poisonous or Deleterious Substances in Seafood. Action levels and tolerance represent the limits at or above which the FDA will take legal action to remove adulterated products from the market.

Pre-harvest

Microbial pathogens

Pathogens from the gut of humans and other warm-blooded animals include *Vibrio cholerae O1, Salmonella* spp., *Shigella* spp., *Campylobacter jejuni, hepatitis A virus,* and *Norovirus.* Free-living pathogens include *Vibrio vulnificus, Vibrio parahaemolyticus, Vibrio cholerae non-O1* and *Listeria monocytogenes.*

State shellfish control authorities classify public waters from which molluscan shellfish are harvested (either cultured or wild stock) as being open or closed to shellfish harvesting. These classifications are based on monitored levels of bacteria in water (and meats) and on models predicting bacterial loads from rainfall runoff. Classifications of growing areas are based on sanitary surveys and include the following: Approved, Conditionally Approved, Restricted, Conditionally Restricted and Prohibited. The status of a growing area is distinct from its classification, and may be Open, Closed or Inactive for the harvesting of shellstock.

Shellfish control authorities in each state not only control bivalve harvest times and locations, but also, through a system of identification tags, are able to trace shellstock through the marketing chain from harvester to consumer. This system is critical in tracing a confirmed illness back to its source (i.e., the harvester, the date, and the location) and preventing further illnesses.

Because bacteria can increase to hazardous numbers when exposed to high temperature, the goal is to reduce the internal temperature of the harvested shellstock to 50 °F or less as soon as possible. Shellfish control authorities therefore limit the time between harvest and refrigeration based on the average monthly maximum air temperature (AMMAT) for a particular location. These "time at temperature" critical limits are listed in Table 1 and in both the Model Ordinance and the *Fish and Fisheries Products Hazards and Controls Guidance, 3rd edition,* which describes the steps necessary to develop a HACCP plan. Such a plan is required if a grower also wishes to process molluscan shellfish. Notice that time/temperature vary somewhat depending on whether one is controlling for pathogens in general, for *Vibrio vulnificus,* or for *Vibrio parahaemolyticus.*

Table 1. Allowable time at average monthly maximum air temperature (AMMAT).				
	Water temperature			
Pathogens (general)	< 66 °F 36 hours	66-80 °F 24 hours	> 80 °F 20 hrs	
V. vulnificus[1]	< 65 °F 36 hrs	65-74 °F 14 hrs	74-84 °F 12 hrs	> 84 °F 10 hours
V. parahaemolyticus[2]	< 66 °F 36 hours	66-80 °F 12 hours	> 80 °F 10 hours	

[1]States with two or more confirmed *V. vulnificus* illnesses in oysters.
[2]Areas with two or more *V. parahaemolyticus* illnesses in the past 3 years.

In developing a HACCP plan, it should be considered "reasonably likely" that unsafe levels of pathogens from the harvest area will be introduced at the receiving step. Thus, receiving is a CCP in the HACCP plan. These are ways pathogens can be eliminated or reduced to an acceptable level at the receiving step.

- Check incoming molluscan shellfish for proper tags or labels and verify that the harvested shellfish are from open waters. This includes cultured products.
- Check for proper licenses from harvester or dealer.
- Minimize outgrowth of naturally occurring pathogens (*V. cholerae, V. vulnificus, V. parahaemolyticus*, and *Listeria monocytogenes*) by adhering to time/temperature critical limits.
- Kill pathogens by cooking or retorting. (Note: This process will not eliminate chemical contaminants or natural toxins in shellfish harvested from closed waters.)
- On shellstock intended for raw consumption, include warning tags that instruct retailers to inform customers that consuming raw or partially cooked bivalve molluscs may increase their risk of foodborne illness, especially in individuals with compromised immune systems. (No such warning tags are required on products that are generally cooked before consumption, such as scallop adductor muscle only or shucked oysters).

There are other molluscan shellfish treatments a culturist can use.

Relaying (Model Ordinance, Section II Chapter V). Relaying allows shellstock to naturally purge themselves of pathogenic microorganisms. It involves harvesting shellstock from growing areas classified as conditionally approved, restricted or conditionally restricted (but not prohibited) and then moving them to areas that are approved or conditionally approved (open status). Relaying is effective if the level of contamination in the shellstock is such that it can be reduced to levels safe for human consumption. The contaminated shellstock are held in clean waters long enough to reduce the pathogens (as measured by the coliform group of indicator organisms in the water) or the poisonous or deleterious substances that may be present to acceptable levels. Relocated shellstock must remain in place for at least 14 consecutive days in environmental conditions suitable for shellfish feeding and cleansing, unless shorter time periods are demonstrated to be adequate.

Post-harvest and processing

Wet storage (Model Ordinance, Section II Chapter VII)

Wet storage may be used to store, condition, remove sand from or add salt to bivalve shellstock. It is considered a processing activity. Shellstock to be "wet stored" may be harvested only from areas classified as approved or conditionally approved (open status). Shellstock must be harvested, identified and shipped to the wet storage area in accordance with the requirements of Chapters VIII and IX of the Model Ordinance.

Wet storage of depurated product can occur only in the facility in which the shellstock were depurated. If product is to be wet stored in natural waters offshore, a sanitary survey of the waters must be conducted and only approved or conditionally approved waters (open status) can be used.

Depuration (Model Ordinance, Section II Chapter XV)

Depuration, which is carried out in a land-based facility, allows shellstock to naturally eliminate pathogenic microorganisms in water that is either naturally pathogen-free (i.e., a flow-through system) or is treated to remove pathogens. Oysters harvested from restricted or conditionally restricted areas that carry the "open status" designation must be depurated for a minimum of 44 hours and then assayed for pathogenic fecal coliform bacteria. Then, if the indicator bacterial Critical Limit is met, the oysters can be released for sale.

Post-harvest processing (Model Ordinance, Section II Chapter XVI)

Post-harvest processing is a procedure that reduces the number of specific pathogenic microorganisms to non-detectable levels. Such processes typically target naturally occurring pathogenic *Vibrio* species, which can cause life-threatening illness in certain immune-compromised individuals. Currently there are four approved post-harvest processes: 1) heat-cool pasteurization; 2) high hydrostatic pressure; 3) individual quick freezing (IQF) followed by a period of frozen storage; and 4) recently approved low-dose gamma irradiation.

To use one of these processes a dealer must have a HACCP plan for the process approved by the shellfish control authority. The plan must ensure that the target pathogen(s) are at safe levels for the at-risk population. The dealer must demonstrate that the process reduces the level of *Vibrio vulnificus* in the processed product to a non-detectable level (<30 MPN/gram) and that the process achieves a minimum 3.52 log reduction, to be determined by the *Vibrio vulnificus* FDA-approved EIA procedure of Tamplin, et al. (as described in Chapter 9 of the FDA *Bacteriological Analytical Manual, 7th edition,* 1992) or other method approved for NSSP use. The dealer must demonstrate that the process reduces the level of *Vibrio parahaemolyticus* in the processed product to non-detectable levels (<30 MPN/gram) and also achieves a minimum 3.52 log reduction. For processes that target other pathogens, the dealer must demonstrate that the levels of those pathogens in processed product have been reduced to levels below the appropriate FDA action level, or, in the absence of such a level, below the appropriate level as determined by the ISSC. The ability of the process to reliably reduce the target pathogen(s) shall be validated by a study as outlined in Guidance Documents, Chapter IV: Naturally Occurring Pathogens, Section .04, approved by the authority, with the concurrence of the FDA.

The HACCP plan shall include: 1) process controls to ensure that the end point criteria are met for every lot, and 2) a sampling program to periodically verify that the end point criteria are met.

All post-harvest processed shellfish must be packaged and labeled in accordance with all requirements of the Model Ordinance. This includes labeling all molluscan shellfish that have been subjected to the process but are not frozen in accordance with applicable shellfish tagging and labeling requirements in Chapter X.05 and X.06.

Records must be kept in accordance with Chapter X.07.

A dealer who meets the requirements of this section may label the treated product in one of four ways: 1) "Processed for added safety" if the process reduces the levels of all pathogens of public health concern to safe levels for the at-risk population; 2) "Processed to reduce (name of target pathogen(s)) to nondetectable levels" if the process reduces one or more, but not all, pathogens of public health concern to safe levels for the at-risk population, and if that level is nondetectable; or 3) "Processed to reduce (name of target pathogen(s)) to nondetectable levels for added safety" if the process reduces one or more, but not all, pathogens of public health concern to safe levels for the at-risk population, and if that level is nondetectable; or 4) the name of the process used (e.g., "pasteurized," "individually quick frozen," "pressure treated," "low-dose gamma radiation") instead of the word "processed" in the options listed above.

For the purposes of refrigeration, dead product is treated as shucked product and live product as shellstock.

Summary

Most post-harvest procedures for shrimp are designed to maintain the quality of the product, not protect consumer health. However, food safety is not a big concern with shrimp because shrimp do not concentrate toxins and normally are not eaten raw (cooking destroys pathogenic microorganisms). On the other hand, the post-harvest handling of bivalves requires greater vigilance because these products can concentrate pathogenic microorganisms and/or toxins from the water to harmful levels and are often eaten raw or only partially cooked.

References and additional literature

http://www.issc.org/nssptoc.aspx – Model Ordinance

http://www.cfsan.fda.gov/~comm/haccp4.html – HACCP guidance document

http://info1.cfsan.fda.gov/shellfish/sh/shellfis.cfm – Certified shellfish shippers

http://www.floridaaquaculture.com/seas/seas_intro.htm

http://www.floridaaquaculture.com/processing/handleintro.htm

http://www.floridaaquaculture.com/publications/hard%20clam%20handle_harvest.pdf

http://www.floridaaquaculture.com/publications/VVriskreduction.pdf

http://www.issc.org/client_resources/Education/VvFactSheet.pdf

The Risk of Eating Raw Oysters or Clams. Interstate Shellfish Sanitation Conference, 115 Atrium Way, Suite 117, Columbia SC 29223 E-mail: ISSC142@IBM.NET

Haby, M.G., R.J. Miget, T.E. Rippen and C.W. Coale, Jr., 1999. Improving the Performance of Full-service Retail Seafood Departments. Texas Sea Grant Publication TAMU-SG-99-502. College Station, TX.

SRAC publications:

Shrimp	Publications 260, 2600, 2601, DVD 18
Oysters	Publications 432, 434, 4300
Clams	Publication 433
HACCP issues	Publication 4900

USDA United States Department of Agriculture | National Institute of Food and Agriculture

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 2007-38500-18470 from the United States Department of Agriculture, National Institute of Food and Agriculture.