Maximizing Revenues by Producing Top-quality Shrimp for the U.S. Market

Background Information

Quality improvement has been a topic within the domestic shrimp industry for decades. Yet, today quality improvement is essential since – as the title suggests – production of top-quality shrimp can maximize the revenues earned from shrimp fishing. In fact, improving the quality of shrimp may be the easiest way to improve the "bottom line" for owners and boost the earnings of Captain and crew. This has been the experience of other industries that have undertaken a dedicated quality improvement program.

Worldwide, shrimp quality standards have become more stringent. Today, farm-raised imported shrimp supplies roughly two-thirds of the billion-plus pound American market. The U.S. shrimp fleet and wild-harvested imports each supply about one-sixth of domestic market needs. Because of its dominance in the American market, farm-raised shrimp have become the standard by which all other shrimp products are judged. Specifically, the packs from high-grade exporters are considered all but perfect across the attributes of visual appearance and product condition. The implication for domestic producers and processors is clear. Quality standards developed 30 or 40 years ago by the domestic shrimp industry have been eclipsed by more aggressive standards created by the large integrated shrimp farming and processing operations across Central America and Southeast Asia. Therefore, if the domestic industry is to receive the price for its products necessary to ensure profitable operations, improving the quality of domestic shrimp is essential.

Many domestic producers, processors, and marketers feel as though they can no longer survive by producing shrimp for the commodity market. Rather, these industry leaders suggest that the U.S. shrimp industry must move toward producing a specialty shrimp product that can be marketed to the more exclusive segments of the larger, domestic market for a higher price. In other words, many believe it is time to position the wild-harvested, domestic shrimp as a distinctive-tasting, wholesome alternative that cannot be duplicated in ponds. Improved quality is essential if a premium, wild-harvested shrimp is to be created from the domestic harvest.

Fortunately, the primary attribute that cannot be duplicated in ponds is literally "built into" each wild shrimp. The most obvious inherent attribute of wild shrimp is its consistent, superior flavor over farm-raised product. "*This* [superior flavor] *is thought to be due primarily to the increased abundance of free amino acids which the animals utilize to counteract the large osmotic gradient which exists in salty offshore waters. Conversely, pond-raised shrimp are most efficiently raised during the rainy season when*

pond salinities may drop to one-tenth that of open ocean water. There is also speculation that the unique flavor of wild shrimp is due in part to their diet of high-protein, natural foods versus the cereal, grain-based feeds required to grow shrimp at high densities in ponds" [1].

Your own experience as well as recent taste tests have shown that wild shrimp have a distinguishable flavor compared with pond-raised shrimp. However, the wild caught shrimp used in the taste comparisons were headed within half an hour, solidly frozen in a brine tank within 20 minutes, then stored in an on-board freezer maintained at 0^o F to -10^o F . After offloading, the shrimp were stored between 0^o F and -10^o F for three to five months prior to use in the taste tests. These were high quality shrimp, both in taste as well as appearance. Therefore, it is important for owners and crews to understand that ocean-derived flavor – the primary attribute and hallmark of this niche program – is subtle and will not be distinguishable unless the shrimp are handled carefully once landed.

Undoubtedly, creating such a niche marketing program and proving its worth to targeted wholesale, retail, and consuming interests will take time, and require the steadfast commitment of interested, cooperating producers, processors, and marketers. Furthermore, such a directed effort to (a) create a premium shrimp product from the Gulf and South Atlantic fisheries, (b) carve a niche out of the billion-plus pound American shrimp market, and (c) supply it with relatively high-priced product is an ambitious goal with mostly long-term benefits. However, it is important to consider three inescapable facts:

- First, the U.S. is the high-cost producer and processor of tropical shrimp in the world, so it no longer makes economic sense to target wild, domestic shrimp toward the broader commodity market. In commodity markets, the low-cost producer and processor begins with a significant, comparative advantage. On the other hand, a high-cost producer or processor must spend proportionally more to meet the threshold expectations of the commodity market, but there is little reward or additional economic incentive for doing so.

- Second, participants in other commodity markets have realized long-run success with a similar niche-marketing approach that stressed a unique attribute that was unavailable from other sources. In particular, the Vidalia onion program in Georgia is a shining example of how a unique, mild-flavored product coupled with industry-wide adherence to stringent quality assurance requirements, legislation to protect the brand, and applied research to extend the marketing window has become successful at generating higher prices that are realized through the entire supply chain.

- Third, such a program will require complying with an upgraded set of quality standards. Importantly however, these standards are already in place among U.S. buyers due to the proliferation of farm-raised imports that supply about two-thirds of the American market.

Today, shrimp fishermen must do more than catch and land a superior-tasting product. The history of shrimp marketing suggests that there are numerous criteria that ultimately determine the value of shrimp. Today, the "built in" attribute of superior, consistent flavor is often eclipsed by other "conformance to specifications" criteria such as counts, weights, uniformity, physical damage, product condition, etc. The reason why these "conformance to specifications" criteria dominate in the determination of shrimp value is simple. Shrimp are still among the highest priced meat products on the market today, and buyers carefully scrutinize potential suppliers for numerous potential defects in both the product and the pack. As a result, processors have become more careful about what goes into their boxes. Regardless of taste, landed product that does not meet the numerous visual and product condition criteria are relegated to a lower tier within the market which, of course, sharply reduces the price paid to fishermen. Shrimp pieces are perhaps the best example of what happens to the price of an otherwise great-tasting product. In summer of 2003, a piece was worth about 38 percent of what a whole tail would fetch.

Objectives

To qualify for cash benefits under the Trade Adjustment Assistance Program, you are required to attend a Technical Assistance program hosted by Cooperative Extension. This is an excellent opportunity to revisit some harvesting and on-board handling procedures that will produce shrimp that meet both the visual quality and taste standards that are important to those segments of the American shrimp market who can appreciate and afford a distinctive-tasting, wholesome, higher-priced alternative that cannot be duplicated in ponds.

Wild-harvested shrimp destined for the niche-marketing program results from a team effort between producers and processors. To maintain its distinctive flavor, wild-harvested shrimp must be handled carefully aboard shrimp trawlers. To ensure that these distinctively-flavored shrimp are consistently packed with the same criteria used by high-grade foreign processors of farm-raised shrimp, both pack-style and product condition must be verified by scrupulous inspection during processing. Work is afoot throughout the Gulf and South Atlantic states to create a quality certification program for the domestic shrimp industry. The goal of this quality certification program is to create a premium product from the domestic harvest that meets the attributes important to the target market. Simply, these attributes are (a) a consistent, distinctive flavor and (b) product condition and pack style consistent with high-grade imports. Committed processors certainly play a key role in creating and servicing the premium niche, so rest assured that other industry-wide initiatives will also focus on processing requirements. However, only producers can qualify for the cash benefits offered by the Trade Adjustment Assistance Program, so this technical assistance focuses strictly on those quality improvement elements that fishermen can implement that will improve the quality of their catches. These quality management principles, when implemented, will enable producers to maximize the fraction of their catch that can be classified as premium quality.

The following production and on-board handling considerations will be reviewed: (a) tow times; why they are important and what they control, (b) on-deck work flows that prepare the shrimp for storage once they are landed (that is the steps of culling, heading, washing) and, (c) for freezer boats bagging or boxing, freezing on deck with brine systems, and moving frozen product to the frozen storage hold, or (d) in the case of ice boats, the use of dips and subsequent storing of fresh shrimp in the ice hold. Special emphasis will be given to management of brine systems since freezer boats comprise the greatest fraction of the offshore, domestic shrimp fleet.

Tow Times – The First Step in Producing Top-quality Shrimp

Two-thirds of the shrimp consumed in the American marketplace are produced on farms. Shrimp ponds are graded to slope toward a drain. When it is time to harvest the shrimp, the pond is slowly drained and the shrimp flow into a catchment basin. From there they are pumped into a slush-ice bath where they are chill-killed as their temperature drops to 32^{o} F. After arriving at the processing plant, which is often at the pond site, shrimp are headed, graded, and often further processed by being peeled, deviened, and perhaps cooked, then frozen within a matter of hours. Throughout processing shrimp rarely get above 40^{o} F before they are frozen.

By contrast, wild shrimp usually die in the net, allowing bacteria and enzymes to begin attacking their “freshness” at a rate dependent on the water temperature. Also, as shrimp are captured, they are subject to physical damage from the pressure exerted by the rest of the catch. These things happen even before the shrimp are hauled on board, and are unavoidable due to the nature of this fishery.

However, the impact of these unavoidable events can be somewhat controlled by shortened tow times. While more work is required to set and retrieve the gear, shorter tow times always result in a better quality product. Quality is directly improved from a shorter tow for two primary reasons. First, a shorter tow reduces the fraction of the catch that is physically damaged from being pulled through the water for extended time periods. Second, shrimp spend less time in the net which (a) minimizes the growth of spoilage bacteria and (b) reduces the accumulation of enzymes that discolor shrimp through black spot. The following tow times are recommended (Table 1). Of course, these suggested times should be shortened during peak production to avoid crushing the shrimp as well as to work the catch on deck faster so the quality of the catch can be preserved sooner (by freezing) or stabilized sooner (by storing it in crushed ice below deck).

Table 1. Recommended Number of Drags and Maximum Duration

Monthly Interval	Recommended number of drags and the maximum time
January through April	A maximum of three drags each night
May and June	No drag should last longer that three hours
July and September when surface water is above 80^{o} F	Only two-hour drags
October through December	No drags over three hours

Shorter tow times also create benefits that "spill over" to back-deck processing. On ice boats back-deck processing includes the steps of culling, heading, containerizing, washing, dipping in a sulfite solution, and moving shrimp below deck where they are stored under crushed ice. On freezer boats the steps of culling, heading, and containerizing are identical to an ice boat, but then baskets of shrimp are packaged in mesh bags or rigid, perforated plastic boxes, immersed in a brine freezing unit and when frozen, stored below deck in frozen storage. The catch resulting from shorter tow takes less time to process on the back deck. Ultimately this reduces the elapsed time between when the bag is opened and the last shrimp are processed and moved below deck.

From a psychological standpoint a smaller pile is less intimidating to the crew who must process it than a larger one. A smaller pile also suggests that each crew member will get a break sooner. On freezer boats, shorter tow times and a smaller pile mean that the shrimp will be frozen sooner, and without "heat shocking" the brine, an important issue which will be discussed in a later section.

On-deck Procedures that Maintain Product Condition

Shrimp production would be easier if monthly production were more even. In reality, monthly harvests vary dramatically depending upon the time of year. Table 2, column 11 shows the average monthly production from the Gulf of Mexico off Texas computed over a twenty-year time frame. In just six weeks – the last two weeks in July and the month of August – 44 percent of the annual harvest occurs. This abundance is a welcome change from the six-month period between January and June when only 15 percent of the long run annual harvest is made. However, heavy production during the first six weeks of the summer season can compromise shrimp quality if the crew has not organized itself to undertake the most important job once shrimp come aboard. That job is completely processing segments of the catch as rapidly as possible so that shrimp remain in top condition. Also, the very asset designed to preserve shrimp at their quality peak – the brine freezing system – becomes the limiting factor between mid-July and early September when production is heaviest. Back-deck processing must be organized so that the brine system is not overloaded. This will allow the highest fraction of the catch to be preserved in top condition.

Table 2. The monthly percentage contribution made by Texas offshore shrimp harvests to each count size between 1981 and 2000 using a May through April annual operating cycle

	Number of Shrimp Tails Per Pound									
Month	1-15	16-20	21-25	26-30	31-40	41-50	51-67	>67	Unsized	Monthly Total
May	4%	5%	3%	2%	2%	2%	3%	9%	3%	3%
June	2%	3%	2%	2%	2%	4%	6%	14%	3%	4%
July	22%	10%	9%	17%	32%	35%	33%	24%	18%	23%
August	15%	11%	19%	26%	26%	24%	26%	16%	21%	21%
September	10%	15%	18%	16%	12%	12%	9%	6%	13%	13%
October	13%	17%	17%	12%	8%	8%	7%	7%	11%	11%
November	10%	13%	12%	9%	7%	7%	7%	8%	9%	9%
December	10%	10%	9%	7%	5%	4%	4%	5%	13%	7%
January	3%	4%	4%	2%	2%	1%	1%	2%	2%	2%
February	5%	4%	3%	2%	2%	1%	1%	3%	2%	2%
March	3%	3%	2%	2%	1%	1%	1%	3%	2%	2%
April	3%	3%	2%	2%	1%	1%	1%	3%	3%	2%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Avg. Yearly Harvest	1,326,859	5,317,789	5,270,863	4,393,269	8,735,851	4,488,600	4,495,271	2,685,492	435,022	37,149,015
Size Count Percent	4%	14%	14%	12%	24%	12%	12%	7%	1%	100%

Through customary practices, back-deck processing has centered around completely finishing one step, like heading, before moving to the next step like washing. This "one big job" approach during the warm months sets the stage for (a) product condition defects like dehydration, off odor, and soft texture that affects edibility and (b) accelerating the progression of cosmetic-oriented defects like blackspot. The preferred approach would be to make a basket of *"just-headed"* shrimp the control that triggers subsequent jobs with those tails. In other words take that basket of tails and perform the all subsequent steps until those tails are stored below deck. Using an ice boat as a example, after a basket is filled with shrimp tails, that basket of tails should be washed, dipped in the sulphite or Everfresh® solution, then stored below deck under crushed ice. For freezer boats, once a basket is filled with *"just-headed"* shrimp, those shrimp should be washed, then sacked or boxed, and put in the brine freezing unit. Generally, the basket of shrimp tails that has been packaged for brine freezing should freeze solidly within 20 minutes, about the same time it takes to head enough shrimp to fill a basket.

Management of Brine Freezing Operations

Many Gulf boats now use brine tanks to freeze their catch before placing it in frozen storage in the hold. This technology allows vessels to remain at sea for extended cruises, saving both time and fuel in returning to port every week to ten days to offload the catch, which is the common practice of traditional ice boats. This section begins by discussing several "myths" about using brine tanks, then addresses the three considerations essential to produce premium quality, frozen-at-sea shrimp. These considerations include: (a) properly charging the brine tank before each cruise, (b) knowing when and how to

recharge the brine tank with salt and dip (sodium metabisulfite), and (c) managing the quantity of bagged or boxed shrimp placed in the freezer at any given time.

Myths Surrounding Brine Freezing Operations

Although brine freezing is a fairly simple procedure, a considerable body of *misinformation* has developed over the years which should first be laid to rest if high-quality shrimp is to be produced from this system. This section addresses three "myths" about the operation, purpose, and management of brine freezing systems.

- "The longer my shrimp stay in the brine tank the more weight they will gain." Wrong!!!! The brine solution is about 25 times saltier than the body fluids in a shrimp so *water will move out of the shrimp* into the brine, and *salt will move out of the brine into the shrimp.* This process will occur until the *outside of the shrimp is solidly frozen*. Therefore the faster freezing can occur, the less chance there will be for (a) losing weight from water loss and (b) manufacturing salty-tasting shrimp due to salt uptake. We can taste salt at a concentration which is only twice the normal salt content of shrimp, so only a little salt uptake from the brine, combined with water loss, will make a shrimp salty-tasting and tough.

- "Putting my shrimp directly in the freezer (hold) is all that's necessary to ensure good quality shrimp." Wrong again! When deck-temperature shrimp are simply placed in the vessel's below-deck freezer they freeze very slowly. The problem with a slow freeze is that the body fluids, which make up about 70 percent of the weight of shrimp, tend to freeze into large ice crystals which break cells open as the shrimp body fluids expand upon freezing. When these shrimp are thawed, much of the cell fluids leak out, resulting in losses in both weight as well as flavor. Since there is no protective glaze on each shrimp, they also dehydrate during extended frozen storage. This leaves them weighing less and uncharacteristically chewy.

- "Brine units were never designed to freeze shrimp, only to chill them so they will freeze faster in the hold." Historically accurate, but wrong today!!! When brine freezers were first installed on shrimp trawlers they were not as efficient, but today immersion brine systems can freeze shrimp solidly in about 20 minutes. As mentioned above, so long as shrimp remain unfrozen in the brine they are losing water and taking up salt. So, if you are using brine simply to chill shrimp you would be better off using chilled fresh water or a fresh water ice slush rather than a concentrated salt solution.

Why is Brine Freezing So Effective?

The essence of proper brine freezing is getting the shrimp to freeze in the shortest amount of time possible, and with the least amount of physical damage defects like pieces, broken or damaged shrimp, broken tails, and blackspot. The *rate of freezing* is directly related to the temperature difference between the shrimp and the coolant. The colder the coolant the faster the freeze. Concentrated salt water (brine) is the most common coolant used on fishing boats because it is the least expensive way to lower the freezing point of water. Water is a key ingredient because cold water removes heat from shrimp ten times *faster* than cold, circulating air. Specifically, it takes water chilled to 36^{o} F 30 minutes to chill a 52^{o} F product to 37^{o} F, while it takes air chilled to 30^{o} F about 300 minutes to remove the same 15^{o} F. (Figure 1.) Also, think about how fast your body loses heat if you fall overboard in the winter as compared to being on deck when the air is colder than seawater. The same principle applies when chilling and ultimately freezing shrimp.

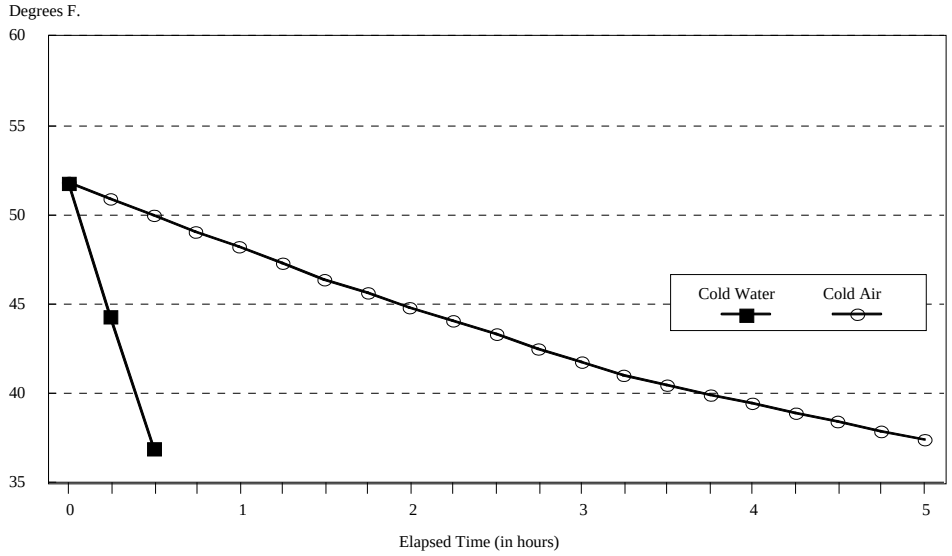

Figure 1. The efficiency of removing heat from whole fish with cold water and slowly circulating cold air

Initial Brine Mix

The first objective in properly using the brine freezer is to create a brine solution that lowers the freezing point of water to about -6^{o} F; the lowest temperature achievable by adding salt. The following procedure will enable you to begin each trip with the same concentration of brine that will result in the lowest operational temperature.

Step 1. Determine how many gallons your brine tank holds.

- To begin, mark the "Full Line" with a waterproof marker inside the tank. Measure this distance in inches. It will become the height. Remember that the ingredients you will add will increase the volume slightly, so keep this in mind when marking the full line so the tank does not overflow.

- Next, measure the inside length and width of the brine tank in inches.

- Multiply length times width times height to determine the volume of your tank, then divide by 231 to determine the number of gallons your tank holds. For example, if your tank is 7 feet (84 inches) long, 3 feet (36 inches) wide, and you generally fill it 3 feet (36 inches) deep, then your tank holds 471 gallons ([84" x 36" x 36"] ÷ 231 = 471 gallons). Record the gallon capacity of the brine tank because the initial charge of salt, dip powder, and corn syrup or corn syrup solids is based on the number of gallons the tank holds.

- Once the capacity of the brine tank has been calculated, fill the tank with fresh water to the full line marked in the previous step. Using fresh, potable water instead of seawater reduces the initial bacterial load in the water resulting in shrimp with a longer shelf life when thawed.

Step 2. Add ingredients to the brine tank.

- The next step is to add the salt, dip, and corn syrup (or corn syrup solids) to the water. As stated, salt is an economical way to reduce the freezing point of water; so its role is essential. Likewise, dip (sodium metabisulfite) is an agent that serves to prevent discoloration (blackspot) of shrimp shells.

- Alternatively, if a buyer specifies that the shrimp cannot contain any residue of dip powder (sodium metabisulfite), Everfresh® (4-hexylresorcinol) can be used as a pre-freeze dip. **Everfresh® cannot be used in the brine tank itself for two reasons: (a) the compound is ineffective when used at temperatures below 35^{o} F and (b) the product is ineffective when mixed with strong salt brines on in the presence of chlorinated (city) water.** To prepare a solution of Everfresh®, use clean seawater from the deck hose once offshore. Everfresh® works best at deck temperature. One 200 gram pouch should be dissolved in 25 gallons of seawater. This solution will treat 500 to 600 pounds of shrimp, after which it should be dumped and a fresh batch made up. This will prevent the solution from becoming so contaminated with bacteria that it hastens the onset of spoilage, thereby shortening the trip length. Baskets of shrimp should be agitated for 2 minutes, then drained, and iced.

- Corn syrup, or corn syrup solids are not used aboard all freezer boats, but this type of sugar is an essential component of premium quality shrimp. Corn syrup or corn syrup solids provide two important benefits that impact upon shrimp quality. First, the sugar forms a glaze that keeps shrimp from dehydrating during extended time in the frozen storage hold. Dehydration slowly removes weight from the frozen shrimp which reduces the quantity that is packed out. Second, the sugar glaze prevents the shell from becoming rough and pitted. A rough, pitted shell is generally a telltale sign of improper use of dip powder, and the sugar glaze helps frozen-at-sea shrimp maintain their fresh-caught appearance. Standard proportions for each ingredient are specified for each gallon of water in the tank (Table 3).

Table 3. Required proportions of each ingredient per gallon of water

Ingredient	Pounds per gallon	Total amount for the 471 gallon tank
Salt	2.53 lb. / gal.	1,192 lb. salt = (2.53 lb. / gal.) x 471 gal.
Dip powder (sodium metabisulfite)	0.074 lb / gal.	34.8 lb. dip powder = (0.074 lb. / gal.) X 471 gal.
Corn syrup or Corn syrup solids (CSS)	0.12 gal. / gal. or 1.19 lb. / gal.	56.5 gal. corn syrup = (0.12 gal.) x 471 gal. or 560 lb. CSS = (1.19 lb. / gal.) x 471 gal.

These ingredients will increase the volume of the brine slightly, so keep this in mind when marking the "Full Line" (mentioned above) so the tank does not overflow. Thoroughly mix these three ingredients **before cooling**. Use a submersible pump or a drum mixer to hasten the salt into solution. When freezing shrimp, run the submersible pump or drum mixer to circulate the brine. Circulating the brine during freezing operations eliminates "hot spots" in the brine tank and ensures that shrimp are frozen at the fastest rate possible.

A refractometer can be used to confirm the concentration of your brine. Figure 2 shows the actual instrument (upper left) while the circle shows what the viewer sees when looking through the device. After adding the salt and thoroughly mixing for an hour or so the reading should be about 23 percent. After adding the dip and corn syrup, the overall concentration will increase slightly, and the reading with all ingredients added should be between 29 and 30 percent. Make a note of this reading as you will need to refer to it when periodically recharging the brine during each cruise.

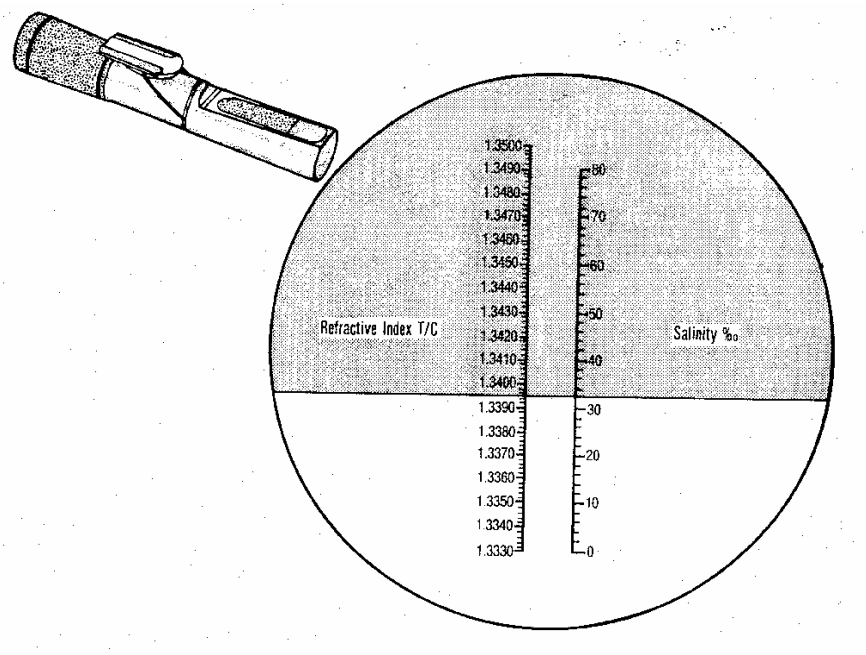

Figure 2. Use a refractometer to determine the exact concentration of brine

Step 3. Begin cooling the brine mixture.

- Once the salt and sugar have dissolved, start the compressor to begin cooling the brine. If the brine was mixed correctly the temperature should approach the lowest temperature possible, - 6^{o} F. An actual *working temperature* between 5^{o} F and 0^{o} F will freeze shrimp within the recommended 20 minutes.

- If the brine cannot be maintained at a temperature lower than 10^{o} F, recheck your salt calculations and make sure your compressor is operating properly.

Recharging the Brine Tank

Even with the system operating between 5^{o} F and 0^{o} F, a certain amount of salt, dip and sugar remain on the shrimp after they are drained. This means that as shrimp are frozen in the brine tank, the salt concentration is gradually diluted. As the brine becomes less concentrated with use, the minimum achievable temperature increases.
The practical effect of a higher operating temperature is a longer soak time necessary to freeze the shrimp. (Remember, that until the shrimp solidly freeze, body fluids migrate out of the tail which creates weight loss, and salt migrates into the tail muscle which results in a noticeable salty flavor.) The concentration of dip powder also drops with repetitive use. The practical effect of a diluted dip concentration is blackspot formation as the product is thawed. Therefore the system should periodically be recharged with salt and dip powder. One ingredient that does not have to be recharged is the corn syrup or corn syrup solids. The initial charge of sugar should be sufficient for the entire trip.

Knowing when to recharge the brine tank can be determined by two monitoring methods: the “pounds” method and the “refractometer” method. Either method can signal when a recharge is due. Regardless of the method, someone on board the vessel needs to be responsible for this monitoring step. With the pounds method, a count needs to be kept of the boxes or bags which pass through the brine tank. Alternatively, the concentration can be periodically checked with a refractometer.

The count method requires that the system be recharged after freezing approximately 1,000 pounds (10 boxes) of shrimp. Once 1,000 pounds have been frozen, the crew should add 28 pounds of salt and one cup of dip powder. (For reference, 28 pounds of granulated salt will fill a five gallon plastic pail to a depth of 6½ inches.)

The refractometer provides a clear read-out of the concentration in the brine tank (Figure 2 above). When the concentration drops 2 percentage units from its original dockside reading of 29 to 30 percent, it is time to add more salt and dip. Recharging with the refractometer method is also based on throughput, but the calculations are a bit different than when using the “count” method.

To determine the pounds of salt that need to be added to restore the brine to a 29 to 30 percent concentration as indicated after the initial charge, convert the gallon capacity of your brine tank to an equivalent weight in pounds, then multiply that value by 0.02, or the increase needed to restore the concentration to its original strength. Thus, to add 2

percentage points back to the salt concentration when it was originally charged, you will need to add 78 pounds of salt using the following formula: [(471 gallon capacity of the brine tank) x (8.3 lb. per gallon of brine) x 0.02]. To restore the concentration of dip powder, add about three cups of sodium metabisulfite.

Ensuring Peak Freezing Performance from the Brine Tank

Two things should be kept in mind. During heavy production periods such as the beginning of the summer season off Texas it's easy to overload the brine freezer by trying to run too much shrimp through it in too short a time. Too much throughput never allows the brine to get below 20^{o} F, when it should be operating somewhere between 5^{o} F and 0^{o} F. Even though 20^{o} F is still below the freezing point of fresh water (32^{o} F), at 20^{o} F it may take the shrimp an hour to freeze, all the while losing water and taking up salt. In this case you really are using the brine to simply chill the shrimp before placing them in the freezer. This practice will not result in a quality product! If your production exceeds the capacity of your brine unit; that is,you cannot maintain the brine solution in the 5^{o} F to 0^{o} F range, you have several options:

- *Do not wait until the whole pile is headed before you wash, bag and freeze the catch*, as this will overload the brine system and the shrimp will not freeze solidly within the recommended 20 minutes. As soon as a basket of shrimp is headed, wash it, bag it, tag it with a numbered float and place it in the brine unit. Keep track of the immersion time for each bag using the numbered floats. Freezing as soon as possible after heading is especially important during the summer since enzymes and bacteria that *destroy the fresh quality* we are attempting to maintain become active within the first hour after the shrimp hit the deck! Freezing almost completely stops this action.

  A 5 hp compressor chilling a 450 gallon brine unit should freeze up to 60 pounds of unchilled shrimp in 20 minutes. **Never place more than 15 pounds of shrimp per 100 gallons of brine, even if it is operating at 0^{o} F, or it will "heat shock" the brine, raising the temperature enough to prevent solid freezing within 20 minutes.** These, however, are engineering calculations to "get us in the capacity ballpark." Each brine system is somewhat unique and recommendations will vary depending on system design, compressor efficiency, insulation, air temperature, etc. **Whatever the system, the crew needs to adjust their heading and freezing activities so that the brine is maintained between 0^{o} F and 5^{o} F and the shrimp are frozen as soon as possible after heading.**

  Obviously a thermometer of some sort is needed to monitor the brine temperature. Digital thermometers with a temperature sensor attached to a wire can be purchased for under $20. Make sure it will read temperatures in the -10^{o} F to $+80^{o}$ F range.

- The above recommendations can be exceeded if shrimp are pre-chilled in slush ice or chilled *fresh water* to get the shrimp close to 32^{o} F before freezing. This

means the brine will have to remove only the heat necessary to *freeze* the shrimp, not the heat to get them down to 32^{o} F. Since shrimp are about 75% water, roughly 1 Btu is needed to lower the temperature of one pound of shrimp one degree F down to 32^{o} F. This means it would take about 300 pounds of ice to cool 1,000 pounds of shrimp tails from a summertime deck temperature of about 80^{o} F to 32^{o} F. Once at this temperature, an additional 144 Btu per pound must be removed to freeze the shrimp.

If your experience indicates that shrimp production at the start of the season may be too heavy for the crew to meet the above recommendations consider carrying ice, either in insulated containers on deck where it can be easily handled, or in the freezer, if moving it around is not too dangerous. Use the ice to cool *fresh water* in a separate container on deck. When production exceeds the crews' ability to head and freeze in the time recommended above, keep the shrimp in chilled water until they can be worked. If necessary, carry an extra deck hand for the first trip or two at the season opening just to help cull and head the catch.

Use of plastic boxes vs. mesh vegetable sacks

From the time that brine freezers were installed aboard Gulf shrimp trawlers, operators have used mesh vegetable bags as the container of choice when freezing shrimp in brine. Beginning in the late eighties, some operators noticed that physical damage defects (no tail, inadvertently peeled shrimp, pieces, broken or damaged, blackspot, or broken tail) were less of a problem when rigid, perforated, plastic boxes were used in lieu of the more traditional "*onion sack*". A detailed study initiated in 1987 compared the levels of physical damage defects. This study demonstrated that the plastic boxes resulted in a 12 percent reduction in physical damage defects [2]. Subsequent work with this data set last summer (2003) demonstrated that the use of the plastic box would result in a 7.67 percent increase in a vessel's gross revenue which would be shared between the vessel owner and the crew!

These boxes, which hold 18 pounds of shrimp, cost about $5 apiece. Therefore six boxes are required for every 100 pounds of shrimp. Crews who have used the boxes say they last several seasons. Although the boxes are stackable, the freezer needs to have racks or shelves installed so they do not slide around or fall off each other and spill shrimp onto the floor of the hold.

In addition to the documented reduction in physical damage, the rigid plastic boxes also facilitate a quick freeze in the brine because the configuration of these containers creates a high surface area to volume ratio. Shrimp packaged in onion sacks, particularly if the sacks are completely filled with shrimp, may take much longer to freeze because (a) the weight of shrimp is greater and thus more heat must be removed prior to freezing and (b) mesh bags tend to maintain a low surface area to volume ratio; thus, the distance to the center of the sack is greater than with a box.

If *"onion sacks"* are used, shrimp should be left *loose* in the sack so they have room to expand when they freeze. Freezing should never result in sacks with a solid mass of shrimp that has to be broken apart. Loose packing and the use of corn syrup in the brine will help prevent this, even if the shrimp thaw *slightly* then refreeze while in the hold. Boxes (or bags) should be drained then immediately placed in the freezer.

Both bags and boxes should be handled carefully when being moved below deck, stowed in the freezer, and offloaded. Individually quick frozen shrimp are especially vulnerable to breakage when tossed around.

A Summary of Important Considerations for Freezer Boats

Brine systems are very effective freezing systems for the offshore industry. However, like all assets, brine freezers need to be managed before, during, and after the cruise. When creating the initial brine mix prior to leaving the dock, mix brine using fresh city water. During the cruise, be sure to wash headed shrimp thoroughly before placing them in the brine tank. This step effectively removes much of the surface bacteria from the shrimp and keeps the brine solution cleaner. It is essential that the brine drops to a temperature of at least 5^{o} F and preferably 0^{o} F before freezing shrimp. During the cruise, freeze shrimp a few boxes (or sacks) at a time while the rest are still being headed. This will ensure that the shrimp will freeze in less than 20 minutes. Importantly, do not overload the tank with shrimp. Overloading will increase the temperature of the brine to between 20^{o} F and 30^{o} F. At this higher temperature freezing will require well in excess of 20 minutes. Unfortunately, a long soak time the brine tank will reduce the weight of shrimp as water migrates out of the muscle and increase the salty taste as salt migrates into the tail muscle. **Use the ratio of no more than 15 pounds of shrimp per 100 gallons of brine.** For example, the brine tank used in previous discussions had a capacity of 471 gallons. If containerized shrimp start at **deck temperature**, you should put no more than 70 pounds in the tank. Alternatively, if you have pre-chilled shrimp in slush ice, the 15 pounds of shrimp per 100 gallons of brine ratio could be exceeded. After every 1,000 pounds of shrimp have been frozen, or after the concentration of the brine tank drops by 2 percentage points according to the refractometer, recharge the solution with salt and dip powder. Once frozen, handle shrimp carefully to avoid breakage. Remember that a piece is worth less than half the price of the equivalent whole tail. Finally, do not make a second trip using the same brine. Upon returning to port at the end of a cruise, drain the tank, then clean and sanitize it. Used brine harbors bacteria which coat the shrimp and reduces their shelf life once they are thawed.

Quality Management Aboard Ice Boats

The first two steps of back-deck processing – culling and heading – are identical whether the trawler is a freezer or an ice boat. Aboard an ice boat however, the containers of headed shrimp must be washed thoroughly and should be pre-chilled in an ice slush bath for about 15 minutes with agitation before stowage below deck in crushed ice. If dip (sodium metabisulfite) is used in this **pre-chill ice bath**, it should be mixed at a rate of 1 cup dip powder for every 10 gallons of water. Alternatively, if the shrimp are to be

immersed in a solution of sodium metabisulfite at **deck temperature**, use 1.5 cups of dip per 10 gallons of water and agitate for only one minute before draining. Remember, there is a maximum allowable dip residue of 100 parts per million. Shrimp will be checked at the dock for this chemical and rejected if this level is exceeded. If shrimp are not pre-chilled they should be iced down as soon as possible. Do not work the entire catch before getting the shrimp on ice.

The hold temperature should not exceed 35^{o} F. Shrimp should be layered in ice (two pounds of ice for each pound of shrimp) and maintained at 33^{o} F. Of course, a thermometer should be used to assure these conditions are being met.

Headed shrimp should be thoroughly washed then pre-chilled in an ice slush bath for about 15 minutes (with agitation) before being placed in the fish hold.

If Everfresh® (4-hexylresorcinol) is used to prevent blackspot it should be used at a rate of one 200 gram pouch per 25 gallons of water. This solution will treat 500 to 600 pounds of shrimp, after which it should be dumped and a fresh batch made up. This will prevent the solution from becoming so contaminated with bacteria that it hastens the onset of spoilage, thereby shortening the trip length. Baskets of shrimp should be agitated for 2 minutes, then drained and iced. Everfresh® works best at deck temperature. It is best to make up each batch with seawater from the deck hose once offshore in clean water.

To land top quality shrimp ice boats should limit their trips to 6 days for head on, and 9 days for tails. As with freezer boats, when production is heavy limit the tow times, hire extra crew to help cull and head, wash thoroughly and ice as soon as possible to assure maximum “freshness.”

Summary and Conclusions

Leadership in the Gulf and South Atlantic shrimp industry suggests that industry stability and vessel profitability may best be ensured by producing a premium, high-priced, specialty shrimp with attributes that cannot be duplicated in a pond. Wild shrimp have a flavor which distinguishes them from the vast majority of shrimp available in the U.S., but flavor alone will not establish domestic shrimp as a top-tier, specialty product. In addition to its unique *ocean-derived* flavor, the premium processed and packaged product will also have to compare favorably with shrimp from high-grade processors who export farmed shrimp from Southeast Asia and Central America. The vast majority of shrimp fishermen and processors in the Gulf and South Atlantic shrimp industry are capable of delivering such a premium product.

The objective of this report has been to revisit some harvesting and on-board handling procedures that will produce shrimp that meet both the visual quality and taste standards that will appeal to those segments of the American shrimp market who can appreciate and afford a distinctive-tasting, wholesome, higher-priced alternative that cannot be duplicated in ponds. **These procedures, when implemented, will enable producers to maximize the fraction of their catch that can be classified as premium quality.**

Tow Times

While more work is required to set and retrieve the gear, shorter tow times always result in a better quality product. Shorter tows improve quality because (a) less of the catch is physically damaged from being pulled through the water, (b) shrimp spend less time in the net which minimizes the growth of spoilage bacteria and (c) less time in the net also reduces the accumulation of enzymes that discolor shrimp through black spot. The catch from a shorter tow takes less time to process on the back deck. Ultimately this reduces the elapsed time between when the bag is opened and the last shrimp are processed and moved below deck.

Back-deck Processing

Heavy production during the first six weeks of the summer season can compromise shrimp quality if the crew has not organized itself to undertake the most important job once shrimp come aboard. Specifically, that job is completely processing segments of the catch as rapidly as possible so that shrimp remain in top condition. Using the customary approach of completing each step before moving to the next one during the warm months sets the stage for (a) product condition defects like dehydration, off odor, and soft texture that affects edibility and (b) the acceleration of some of the cosmetic-oriented defects like blackspot. Freezing as soon as possible after heading is especially important during the summer since enzymes and bacteria that *destroy the fresh quality* we are attempting to maintain become active within the first hour after the shrimp hit the deck! Freezing almost completely stops this action.

Brine Freezing

A brine concentration of 23 percent will enable brine temperatures to remain between 0^{o} F and 5^{o} F. At this temperature range, shrimp will freeze within the recommended 20 minutes. If the brine cannot be maintained at a temperature lower than 10^{o} F, recheck salt calculations and make sure the compressor is operating properly. The original charge with salt and dip powder depends upon the volume of water in the brine tank. However, recharging is strictly dependent upon the volume of shrimp that passes through the brine unit. Two monitoring methods are available so crew will know when to recharge the unit. Crew can count the pounds that go through the brine system, and recharge after each 1,000 pounds. Alternatively, the system can be recharged when the refractometer shows a 2 percent reduction from the original concentration. Regardless of the method, someone on board the vessel needs to keep track of the number of boxes or bags which pass through the brine tank or periodically check the concentration of the brine tank with a refractometer.

Ice Boats

To maintain shrimp quality aboard an ice boat, containers of headed shrimp should be washed thoroughly then pre-chilled in an ice slush bath for about 15 minutes with agitation before stowage below deck under crushed ice. If dip (sodium metabisulfite) is used in this pre-chill ice bath, it should be mixed at a rate of 1 cup dip powder for every 10 gallons of water. Alternatively, if shrimp are to be dipped at deck temperature, use 1.5 cups of dip per 10 gallons and agitate for only one minute before draining.

If Everfresh® is used to prevent blackspot instead of dip powder (sodium metabisulfite) it should be used at a rate of one 200 gram pouch to 25 gallons of water. This solution will treat 500 to 600 pounds of shrimp, after which it should be dumped and a fresh batch made. Everfresh® works best at deck temperature. It is best to make up the Everfresh® solution with seawater from the deck hose once offshore in clean water. Baskets of shrimp should be agitated for 2 minutes in the solution, then drained and iced.

In the hold, shrimp should be layered in ice, with two pounds of ice to one pound of shrimp and maintained at 33^{o} F. To land top-quality shrimp, ice boats should limit their trips to six days for head-on product, and nine days for tails.

Final Thoughts

Because of the upgraded quality expectations that have resulted from our dependence on farm-raised imports, today only a few buyers pay extra when they offload premium quality shrimp. On the other hand, the boat *always gets penalized* for shrimp which contain too many physical damage defects (like no tail, pieces, broken or damaged shrimp, blackspotted product, or broken tails) or poor product condition (like strong off-odor, mushy texture, etc.).

Throughout the Gulf and South Atlantic shrimp industry there is talk of creating a niche for premium-quality, distinctive-tasting, wild, domestic shrimp, and work is underway to support that objective. As this niche marketing program gains traction, a higher price should be expected. Until that happens, it is essential that the greatest fraction of your catch be classified as premium quality. Spending days offshore only to have the value of your hard work down-graded for various quality defects costs both the boat and you money. More than anything, producing a premium-quality product requires that everyone use the procedures outlined in this report to work smarter, not harder.

References

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