The Steps Required to Produce Visually Perfect, Premium Quality, Great Tasting Wild Shrimp

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TAMU-SG-13-502

Note: If you downloaded this booklet and printed it, please read footnote[e] at the bottom of this page that addresses color differences that may occur with various printers.

[a] The development of this work was supported with funds provided by the U.S. Department of Agriculture to the Texas Sea Grant Program (Award Number H001344230) under the auspices of the Trade Adjustment Assistance for Farmers program. Funds from the National Sea Grant College Program Office, U.S. Department of Commerce, made the translation of this document into other languages possible (Award Number NA10OAR4170099).

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[e] There are 10 photographs of shrimp in this document. Some show premium-looking shrimp while others show various visual defects including the darkening of head and shell color over time. As original images, these photos accurately reflect both perfect and imperfect visual appearances. However, the color calibration of certain printers may specify more red, brown, and yellow tones which make otherwise great-looking shrimp appear off-colored and slightly darker. Where the visual quality of whole shrimp and tails shrimp have been judged and classified, please look at those photos on your monitor to see the most accurate colors.

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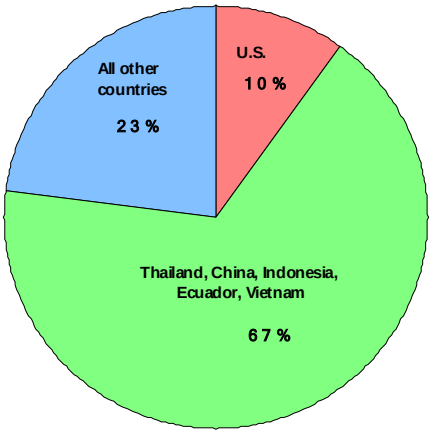
Introduction & Purpose

Twenty years ago the appearance of this shrimp tail would have been good enough for many buyers, but look closer. This tail, with no physical damage, has been exposed to temperature abuse – note the reddening along the top of the tail – and is also beginning to show signs of black spot. The days when this tail would have met quality expectations are behind us. Today, shrimp with such obvious visual defects are worth, at most, about half of what a same-sized, defect-free tail would bring.

Why have market expectations for the appearance and condition of shrimp increased while prices have dropped? The answer can be summed up in four words: imported, farm-raised shrimp. Today, imports account for 90% of total U.S. shrimp supplies while the shrimp you catch contribute to about 10% of what we eat. We import shrimp from over 100 countries. However, as the chart below shows, at least 67% of all the shrimp we eat are farmed and imported from just five countries.

Because imported, farmed shrimp **dominate** the U.S. market, the appearance and condition of your shrimp are now judged against the standards set by these farmed imports.

Farmed shrimp grown in ponds are drain-harvested, chill-killed in slush ice, processed, and blast frozen in less time than it takes you to make a single drag offshore. This makes the attributes of appearance and product condition easy to ensure. However, wild shrimp have a unique attribute that can distinguish them from a sea of imported, farmed shrimp: ***"built-in"* flavor**. The sweet taste results from the way shrimp maintain their very low body salt content, while the rich, savory flavors originate from the diet of plants and animals wild shrimp eat.



A new day has dawned for domestic shrimp fishermen. To earn the revenue necessary to succeed economically, your shrimp must meet new appearance and product condition expectations. But, when you meet appearance and product condition requirements you also preserve the flavor found in wild shrimp which can become a huge marketing advantage.

This booklet shows you how meet current market expectations with wild, flavorful shrimp.

Can Wild Shrimp Compete Against the Appearance and Condition of High-grade, Farm-raised Imports?

Every fisherman can meet the current market expectations for appearance and product condition! The shrimp in this photo were landed in August, treated on deck to prevent black spot, brine frozen, held frozen for 75 days, **then thawed and stored at refrigerated temperatures for four days.** These two market forms look great, show no signs of any quality defects, and are certainly equal to the appearance and condition of their farmed competitors. Routinely offloading shrimp that look like these require fishermen to make four operational changes while at sea:

1. shorten tow times,

2. use proven sorting, heading, rinsing, treating, and packaging procedures,

3. solidly brine freeze every batch of shrimp within 15 to 20 minutes, and

4. prevent black spot by using high-performing, approved food additives.

Step One – Shorten Tow Times

Remember, most imported, farmed shrimp die in slush ice as their body temperatures drop to 32° F. In contrast, most wild shrimp die in your nets or on deck. Once shrimp die, surface bacteria begin to attack their **freshness** at a rate dependent upon water temperature. The warmer the water, the faster freshness is lost and spoilage begins. The chemical chain reaction that darkens head and shell also gets a *"head start"* during long tows. As well, long tows often result in more obvious physical damage like broken tail fans. Once shrimp die, the best you can do is maintain their condition that existed when the catch was landed on deck.

Shorter tow times maintain the shrimp you land in a fresher condition and reduce the chemical changes that cause black spot. Shorter tows also allow you to pick shrimp from the catch, then head, rinse, treat, bag (or box) and freeze those shrimp as quickly as possible. In fact, shortening tow times is a key first step that helps to minimize defects in both product condition and appearance attributes. Shorter tows may also reduce shrimp loss from certain BRDs.

Several conditions influence the length of tows, such as the abundance of crabs (since they tend to tear up shrimp), the volume of by-catch while fishing, and time of year. One- to two-hour tows are common when crabs are present. Heavy by-catch requires more time to remove shrimp from the catch, so shorter tows during seasons of abundant by-catch will allow faster back-deck operations.

Shorter tows may slightly limit your production. But, let's remember three important facts. First, catch rates have mostly increased since 2006 because so many operators have left the shrimp fishery. Second, the prices you receive are lower and production costs are higher with the rise in fuel prices. Third, if your shrimp show any defects, you will **not** receive full market prices. Producing lots of shrimp with various defects may seem like the right move, but it's not. Offloading more sub-standard shrimp will reduce the money you earn because today, **buyers expect perfect-looking shrimp in top-notch condition**.

Shortening tow times is an important first step in minimizing defects, but you still need to use proven back-deck processing steps that prevent defects from occurring.

Step Two – Use Proven Back-Deck Processing Steps for Quickly Sorting, Heading, Rinsing, Treating, Bagging, and Freezing Shrimp

Once your short-tow shrimp are on deck, you begin a race to prevent defects that affect the appearance and condition of your catch. Black spot is an obvious appearance defect. Spoilage bacteria create off odors which hide the intense flavor of wild shrimp. Even though you freeze your shrimp, once they thaw, black spot and spoilage begin again and the length of time available to sell your product decreases.

Two technological advances help win the race against appearance and product condition defects. Black spot is an age-old problem in shrimp. Preventing black spot has become much easier with the development of EverFresh®, a high-performing, FDA-approved additive.[1] Proper treatment on deck with EverFresh® **permanently stops** the chain reaction which leads to darkening of head, shell, and in extreme cases, tail muscle. Regarding bacterial spoilage, the immersion brine freezing system aboard your trawler enables you to freeze every batch of shrimp at the peak of quality within 15 to 20 minutes. Rapid, solid freezing stops bacterial activity that leads to spoilage. These two technological advancements provide the tools necessary to offload flavorful, wild shrimp that look as good as high-grade, farm-raised imports.

[1] The mention of a trademark or proprietary product does not constitute a guarantee or warranty by the Texas A&M AgriLife Extension Service or Texas Sea Grant, and does not imply its approval to the exclusion of other products that also may be suitable.

In the quality improvement game, technology by itself is seldom enough. Human skill is also a key contributor to improved quality. Aboard shrimp trawlers, the way that certain steps are completed has a major influence on preventing defects such as discoloration from black spot and off-odors from spoilage.

Human skill is required to ensure that the *right things are correctly done* once the catch is landed. To determine what needs to be correctly done, we must begin with the last back-deck step – brine freezing – and work backward to when the catch was landed. The brine freezer is the best piece of technology you have for preserving your catch at the peak of quality, **but only if it is correctly used**. Let's see why the brine freezer should control your back-deck work.

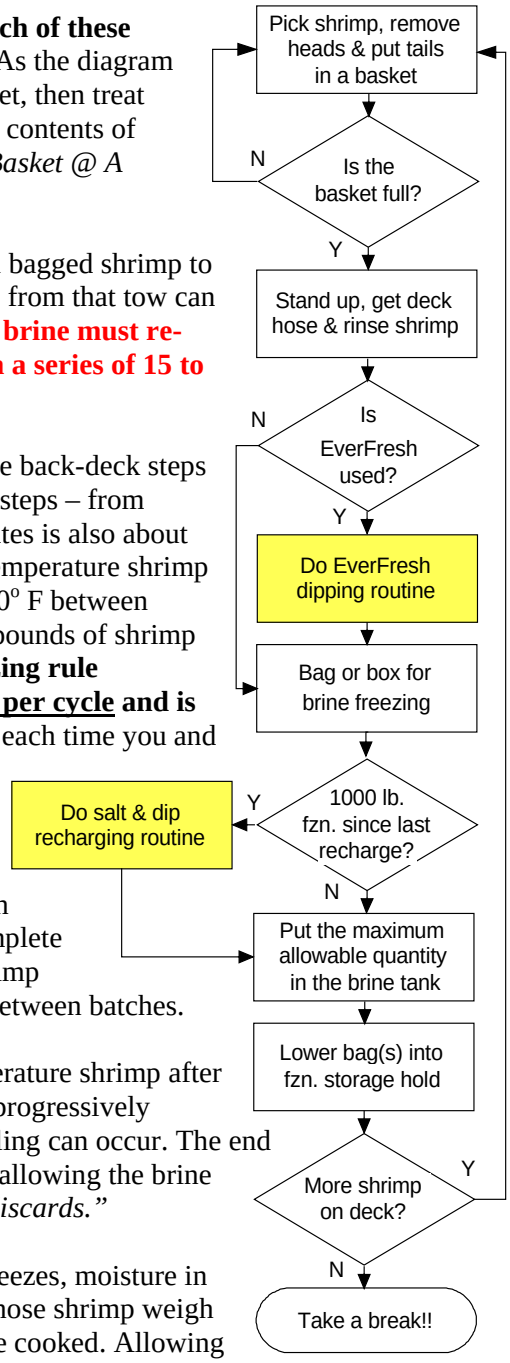
A refrigerated, 23% salt brine is the quickest, most cost-effective way to freeze shrimp at sea. **Experimentation shows that chilled brine can pull heat out of shrimp 37 times faster than <u>colder</u> air.** For example, refrigerated, liquid brine at 0° F (32° F colder than the freezing point of fresh water) reduced shrimp temperature by 43° F within **2 minutes**. On the other hand, a much colder, walk-in freezer at -16.6^o F took **75 minutes** to remove the same amount of heat from a single shrimp!

Brine systems are batch freezers. With a 23% salt concentration, the brine can be chilled to 0° F or lower. At around 0° F, a maximum temperature difference is created between the brine and deck-temperature shrimp. Once shrimp are immersed, heat is rapidly removed which, in turn, warms the brine. **To repeat the process of rapidly removing heat and solidly freezing the next batch of shrimp, brine needs to re-chill.** Re-chilling requires that warmed brine circulate across the cooling plates long enough to recover back to about 0° F **before** the next batch is immersed.

How much heat needs to be removed from shrimp for a solid freeze during peak production periods? In summer, offshore air temperatures are in the 90s. By the time shrimp are ready to be frozen, they may be in the 60° F to 70° F range. Solidly freezing each batch of deck-temperature shrimp within a series of 15 to 20 minute cycles requires removing at least 50 degrees of heat. S**olid freezing cannot occur unless the warmed brine re-chills to around 0° F. Therefore, re-chilling of brine is an inescapable requirement and one that must direct exactly how the back-deck processing steps are conducted.** What changes are required to ensure that brine re-chills between freezing cycles?

Neither the back-deck processing steps nor the order in which they are performed needs to change. Shrimp are still picked out of the catch, maybe headed, put in a basket, rinsed, perhaps treated on deck to prevent black spot, bagged or boxed, then brine frozen.

Basket @ A Time Routine



What needs to STOP is the historic focus on completing each of these steps <u>with the entire catch</u> before moving to the next step. As the diagram shows, once a basket is filled, stand up and rinse that full basket, then treat that full basket (if not done in the brine tank), bag (or box) the contents of that full basket, and freeze that container. This is called the *"Basket @ A Time"* routine.

Why make this change? The **<u>historic work pattern</u>** pushes all bagged shrimp to the brine freezer with the expectation that every bag of shrimp from that tow can be frozen one right after another. **This approach <u>forgets</u> that brine must re-chill <u>between batches</u> if each batch is to be solidly frozen in a series of 15 to 20 minute cycles.**

How does working a basket full of shrimp through the first five back-deck steps support a quick, solid freeze of the entire catch? The first five steps – from picking to bagging – will take about 20 minutes. Twenty minutes is also about how long it will take to solidly freeze those processed, deck-temperature shrimp if (a) your brine contains 23% salt and has re-chilled to about 0° F between batches, and (b) you use the rule of freezing no more than 15 pounds of shrimp for every 100 gallons of brine. **This fundamental brine-freezing rule establishes the <u>maximum allowable quantity (lb.) to freeze per cycle</u> and is based on the gallon capacity of your brine tank.** Therefore, each time you and others arrive at the brine tank with another batch ready to be frozen, the maximum allowable quantity immersed in the brine will have solidly frozen and is ready to be stored below deck. As an added bonus, the brine will have recovered to 0° F or below. Working a basket at a time through all five steps helps you coordinate the minutes required to complete these steps with (a) the time necessary for solidly freezing shrimp currently in the brine tank as well as (b) re-chilling the brine between batches.

What happens when you try to freeze one batch of deck-temperature shrimp after another without allowing the brine to re-chill? The brine gets progressively warmer to the point where limited, partial freezing or just chilling can occur. The end result of immersing bag after bag in the freezing tank without allowing the brine to re-chill between batches will either be *"downgrades"* or *"discards."*

<u>Downgrades.</u> Until the outside layer of each shrimp solidly freezes, moisture in shrimp is replaced by salt from the brine. In turn, this makes those shrimp weigh less at the dock, and creates a tough, salty-tasting product once cooked. Allowing the brine to re-chill before the next batch is immersed rapidly freezes the outside layer of each shrimp. Once the outside layer is frozen, moisture in shrimp is locked in and salt is locked out.

<u>Discards.</u> Just chilling shrimp in the brine tank and expecting them to solidly freeze below deck often leads to spoilage. **Spoiled shrimp are discards with terrible economic consequences!** Two years ago a dock stopped payment on a $70,000 check because shrimp in the center of bags did not freeze in the brine tank and were never frozen in the freezer hold. By the time they were offloaded after the cruise, unfrozen shrimp in the center of the bags had completely spoiled. If just the outside surfaces freeze (in other words, a partial-freeze) this effectively **insulates** the center of each shrimp so the middle may never freeze during below-deck storage.

Step Three – Solidly Brine Freeze All Shrimp Within 20 Minutes

Brine-freezing technology represents a major breakthrough that enables fishermen to offload a greater percentage of defect-free, premium-quality shrimp from extended cruises. But routinely achieving a solid freeze within 20 minutes requires proper management of the brine solution.

In the last section, you learned that completing back-deck processing with each **basket of shrimp picked from the catch** was the best way to ensure that brine temperatures return to their lowest levels between freezing cycles. This allows each batch of shrimp to freeze solidly within 15 to 20 minutes. You also learned a fundamental rule for proper brine freezing: ***"Figure the maximum allowable quantity (lb.) that can be frozen per cycle and freeze no more than that amount at a time."*** The maximum allowable quantity is found by multiplying 0.15 by the gallon capacity of your tank. So, if your tank holds 533 gallons of brine, then the maximum allowable quantity you can freeze at a time is 80 pounds (0.15 lb./~~gal.~~ x 533 ~~gal.~~ ≈ 80 lb.). There are two other fundamental rules you will soon learn.

This section addresses the two important steps of **creating and maintaining saturated brine solutions**. Just as we found in the previous section on back-deck processing, human skill also ensures that brine tanks are routinely cleaned and sanitized, and each cruise always begins with a 23.3% brine solution.

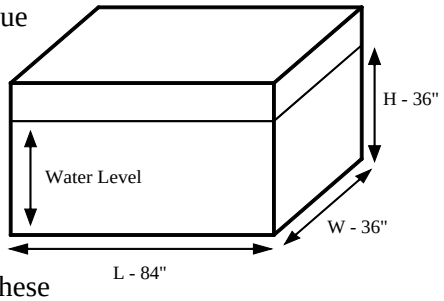
In immersion freezing operations, salt is added to water to keep the brine liquid at temperatures far below the freezing point of fresh water. "Water" for use in immersion brine freezers can either be clean, offshore sea water or fresh water suitable for drinking. When refrigeration is introduced to a **saturated** salt brine that contains 23.3% salt by weight, the temperature at which liquid salt brine turns to solid ice drops from 32° F to at least 0° F, but in theory the freezing point is actually lower. Therefore, a 23.3% salt solution reduces the freezing point of liquid brine by at least 32° F below the freezing point of water. This low temperature is only achievable when you have 23 lb. of salt for every 100 lb. of liquid brine. **The *fundamental rule* about creating saturated brine solutions is this: *"Begin your cruise with a 23.3% brine solution."***

Initial Brine Tank Charging Routine at the Dock

How much salt should be added to the brine tank before getting underway? For each gallon of water, 2.53 lb. of salt should be added. But, how many gallons are there in your rectangular tank? To determine the gallon capacity of your brine tank, you first need to know the **cubic inch volume of your tank.** Here is how to figure it.

1. Permanently mark the water depth (in other words, the "full" line), then measure and write down the inside length, inside width, and water depth in inches. You only need to make these measurements once. But if you change the size of your tank, you will need to re-measure the length, width, and depth to find the new cubic inch volume. The cubic inch volume of your tank is found by multiplying these three dimensions. Using the dimensions shown in the drawing on the next page, the cubic inch capacity of the tank would be 108,864 cubic inches (84" x 36" x 36").

2. With the cubic inch capacity of your tank figured, divide that value by 231. A brine tank with the dimensions shown in the drawing would hold 471 gallons [(84" x 36" x 36") ÷ 231].



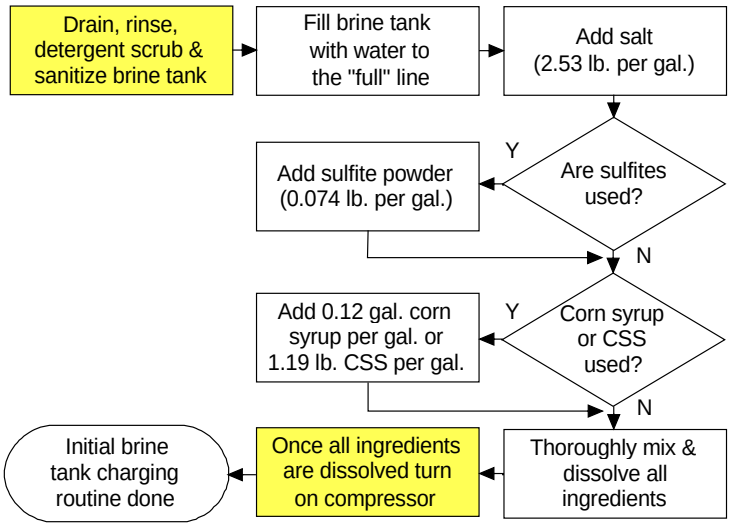
The most important ingredients in a brine freezer are water and salt, but most operators use other products too. Virtually all fishermen who use sulfites add it to their brine units. Although less popular today, some operators add corn syrup or corn syrup solids (CSS) which is thought to glaze the shrimp as they freeze. Each of these ingredients is listed in the table below, first as the amount to be added per gallon of water, and second as the total amount for a 471-gallon tank.

Ingredient	Proportion	Quantity for a 471 gal. tank
Salt	2.53 lb. per gal.	**1,192 lb.** (2.53 x 471 gal.)
Dip Powder	0.074 lb. per gal.	**34.8 lb.** (0.074 x 471 gal.)
Corn syrup or	0.12 gal. per gal.	**56.5 gal.** (0.12 x 471 gal.)
Corn syrup solids (CSS)	1.19 lb. per gal.	**560 lb.** (1.19 x 471 gal.)

So far you have learned how to figure the cubic inch capacity of your brine tank, how to convert those cubic inches to gallons, and the proportion of each ingredient to add so you begin your cruise with a 23.3% salt solution.

The final set of skills required to begin your cruise with a cleaned, sanitized, correctly-charged brine tank is shown in the diagram. This is the sequence of steps required to prepare the tank and create a saturated brine solution before leaving the dock. The two yellow boxes highlight important steps sometimes forgotten. The first is to drain, rinse, detergent scrub, and sanitize the tank with a bleach solution before filling it with water and adding other ingredients. This process ensures that spoilage organisms in the tank are removed or killed which will improve the shelf life of shrimp once thawed. The second highlighted step indicates that only when all ingredients are added, mixed, and **dissolved** should the compressor be turned on.

Initial Brine Tank Charging Routine



Recharging the Brine Tank During the Cruise

What about recharging while at sea? As shrimp are frozen, both salt and sulfite concentrations change (if you use sulfites in the brine freezer). Remember, **only if** your brine is a 23.3% saturated solution can the liquid be chilled to 0° F or below. Further, periodically restoring sulfite concentration is essential to control black spot.

While fishing, brine volume drops as bags are removed from the tank or when brine splashes out in rough seas. As the volume of refrigerated brine is reduced, the capacity to remove heat from shrimp is also reduced. In an 84" x 36" x 36" tank, every inch of brine lost decreases brine volume by 13 gallons. Lose 6" of brine depth, and freezing capacity has been reduced by 78 gal. With 393 gallons of brine in a 471-gallon tank, this also means that the maximum allowable quantity (lb.) to freeze each cycle is no longer 71 lb. (0.15 x 471) but is reduced to 59 lb. (0.15 x 393).

Recharging the brine tank with the correct amounts of water, salt and sulfite powder (if you use it) should be done after every 1,000 pounds of shrimp are frozen. When catches are high, recharging will need to occur several times each day or night. A key step in the recharge procedure is to keep track of the number of pounds or standard-weight bags or boxes frozen so you and your fellow crew members will know **when** to recharge the tank. Use a dry-marker and a small, coated clip board, or whatever method you choose as long as everyone knows when 1,000 lb. (25 40-lb. bags) have been frozen.

The idea of recharging seems simple. But do it incorrectly and you will not restore the **concentration** of salt to the brine solution. Again this is where human skill determines the outcome. **The final *fundamental rule* of proper brine freezing management is this: *"Never add dry salt to cold brine!"*** Why not? The salt will not dissolve and will not restore the salt concentration to 23.3%.

Here is the correct way to restore both the brine level and salt percentage, one pail at a time. The recharging routine begins at the dock with the one-time step of setting up a *recharge pail* by marking two lines in a five-gallon bucket. As shown in the top photo, permanently mark a line 2" from the bottom and another line 9½" from the bottom. This can be done using a C-clamp to hold a wooden stake off the bottom at those distances so lines can be traced around the inside circumference of the pail with a permanent marker (bottom photo). Once the *recharge pail* is marked, the recharge steps at sea are:

1. Add salt to the 2" line. This equals 7½ pounds.

2. Add either fresh water or clean sea water to the 9½" line. This equals 3 gallons.

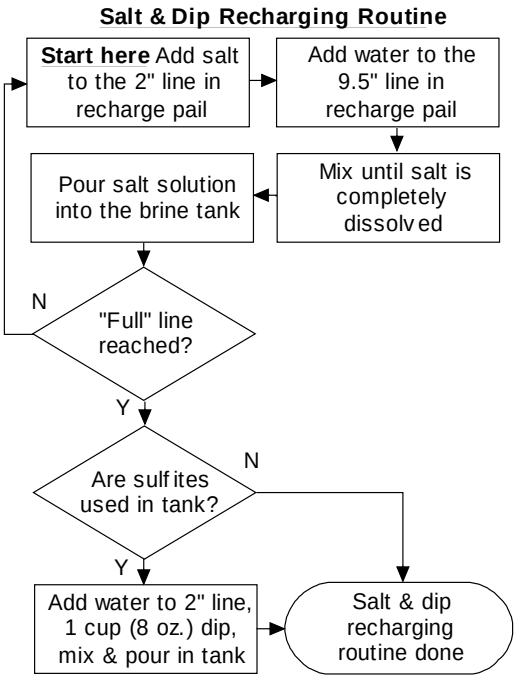
3. Stir until the salt is **<u>completely</u>** dissolved.

4. **Once completely dissolved**, pour the mixture into the brine tank.

5. Repeat this process until the "full" line marked inside of the brine tank is reached.

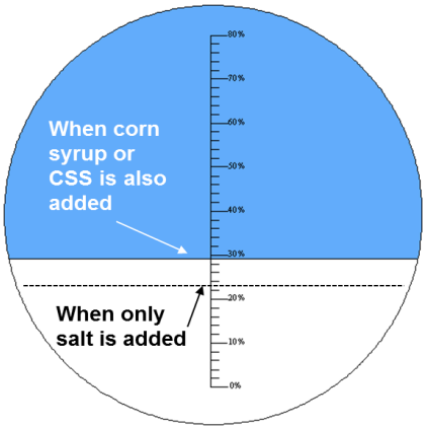
6. If sulfites are used, add water to the 2" line and dissolve 1 cup (8 oz.) of sulfite powder before pouring that solution into the brine tank.

The sequence of these six steps is shown in the following diagram. Using the *recharge pail*, the amount of salt dissolved in water (that is, 7½ pounds in 3 gallons of water) is a constant 23.3% **so every addition to the tank maintains a saturated brine solution** in quantities of about 30 pounds per pail. This process also restores the volume of brine to the "full" line, which re-establishes the stated gallon capacity of your brine tank.



Ignoring the recharge step after every 1,000 lb. have been frozen at sea could mean having the product down-graded at the dock for darkening (if you use sulfites to control black spot) or excessive saltiness. Worse yet, if the salt concentration gets too low in the tank, the minimum achievable temperature of the brine solution will **increase** no matter how hard the compressor works, and the shrimp will not solidly freeze. Remember, unfrozen or partially-frozen shrimp can actually spoil below-deck during extended cruises.

Some operators confirm the concentrations of their salt brines with a refractometer. As the photo shows, once you put a few drops of the brine solution on the refractometer, look through the eye-piece, and you will see two distinctive colors that make up the circle. The drawing shows what appears when looking through the eyepiece. The line that divides the circle into two parts intersects with the vertical scale and shows the percent concentration. When the correct weight of salt is added, the reading will be 23%. If corn syrup or corn syrup solids are also added, the reading will be between 28 and 30%.



Step Four – Permanently Prevent Black Spot with High-Performance Additives

Purpose

So far, this booklet has examined every step required aboard the trawler that contributes to a visually-perfect, great-tasting catch. You have learned about the benefits of shorter tows, working a basket of shrimp through each back-deck step of picking, heading, rinsing, perhaps treating, bagging or boxing, as well as proper management of brine freezing systems.

Black spot which darkens the shell (and muscle in extreme cases) is a defect in shrimp, whether they are wild or farmed. This section addresses the fourth operational change necessary to offload visually-perfect shrimp.

Control of black spot is compared using sulfites or EverFresh® applied to short-tow shrimp which were handled using the proven back-deck processing steps outlined earlier, then rapidly brine frozen. This segment photographically shows which black spot-preventing treatment generated the best looking result for both whole shrimp and tails once the shrimp were thawed and held at refrigerated temperatures over four days.

Whole shrimp and tails were either (a) treated on deck in an EverFresh® solution and **then** brine frozen or (b) treated with sulfites in the brine tank **while** being brine frozen. After brine freezing, these shrimp remained in frozen storage for 75 days. On the 76th day, shrimp were thawed and kept refrigerated over four days. The photo sequences beginning on page 12 show the same shrimp that were randomly-selected from each treatment on day 0, the 76th day, and repetitively photographed on days 2 and 4.

Background Information about Approved Additives

In the Gulf and South Atlantic shrimp fishery, the two most common FDA-approved chemicals used to control black spot are sodium metabisulfite (also known as "dip" or "sulfites") and EverFresh®.

Sulfites. Sulfites are relatively inexpensive, and can be added directly to brine solutions. Care must be taken when mixing up the solution because when sulfite powder is added to water, toxic sulfur dioxide gas is released. When used correctly, the sulfite treatment adds about ¼¢ per pound to the cost of producing shrimp. Sulfites are widely used in the food industry but a fraction of the population is allergic to sulfites. Therefore, any product treated with them must show that ingredient on the label. The FDA has established a maximum residual level of sulfites in shrimp of 100 parts per million. Exceed that level and a market or regulatory response may occur.

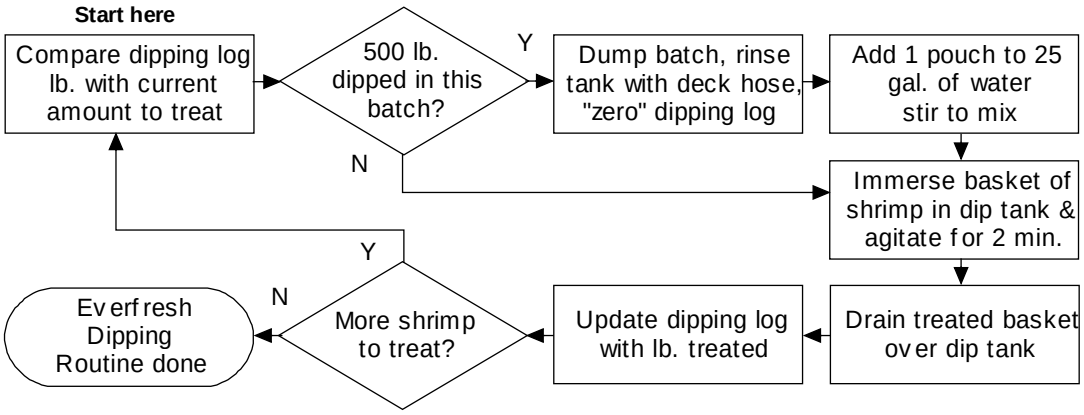
Sulfites compete for oxygen with the natural chemical compounds found in shrimp that are responsible for black spot. As long as a residual level of sulfite remains on shrimp, black spot can be controlled. However, once sulfites are washed off shrimp, the chemical chain reaction that causes black spot begins again. Importantly, the chemical compounds responsible for the black spot chain reaction are **not** modified when frozen. Therefore, **if** the sulfite treatment has been rinsed off prior to grading and re-freezing, this chain reaction can continue as soon as the shrimp are thawed. For this reason, sulfites are often re-applied in the processing plant.

EverFresh®. On the other hand, 4-hexylrescorcinol (the active ingredient in EverFresh®) permanently binds to – but does not react with – those chemical compounds responsible for the black spot chain reaction. It never has to be re-applied, even after repeated freeze/thaw cycles or multiple rinses. In most states (not Texas however), EverFresh® does not have to be labeled since shrimp cannot be *"overtreated"* with this product and this compound **does not** cause allergic reactions.

EverFresh® is extremely effective, but it is more expensive than sulfite powder. It is also safer to use aboard the vessel than sulfites because no toxic gas is produced. When used correctly, the EverFresh® treatment adds about 1¢ per pound to the cost of producing shrimp.

Importantly, EverFresh® cannot be added to the brine tank because a high salt concentration and a brine temperature far below freezing make it ineffective. Instead, shrimp must be dipped in an EverFresh® solution for 2 minutes on deck prior to brine freezing as illustrated in the following diagram. The solution is made with cool, not cold, water. The solution is prepared by dissolving one 200-gram pouch in a 30-gallon dip tank that contains 25 gallons of fresh water or clean, offshore sea water. This 25-gallon solution will treat 500 pounds of shrimp (about 12 to 13 40-lb. bags). Just like the brine-tank recharge step, you will need to keep track of the amount of shrimp dipped in each batch of EverFresh®, and prepare a new batch once 500 pounds have been treated.

Everfresh Dipping Routine



Appearance Differences Between Shrimp Treated with Sulfites or Everfresh®, Brine Frozen At Sea, Held in Frozen Storage for 75 Days, Thawed and Held Refrigerated for Four Days

Shrimp appearance was scored by evaluating black spot development and the change in head/shell color. "Premium," highlighted in green, indicates a perfect-looking shrimp with no observable defects. "Marginal," highlighted in yellow, suggests the formation of at least one visual defect. "Marginal" means the shrimp could be purchased and eaten that day, but may not be visually appealing enough to hold for next-day sale. An "Unacceptable" score, shown in red, means that the visual defects had developed to such an extent that the product was visually unappealing the day the photograph was taken**. It is important to note that at-sea treatments with either sulfites or EverFresh® did <u>not</u> result in either whole shrimp or tails receiving an Unacceptable appearance score, even after four days under refrigeration.**

<u>Thawed appearance when sulfites are used in brine freezer.</u> On day 0, both market forms were very impressive, with a pearly *"just caught"* sheen on both the whole shrimp and the tail. Beginning on day 2, the head of the whole shrimp darkened slightly but did not blacken, so visual quality remained at "Premium." The shrimp tail also retained its "Premium" appearance. On day 4, the head of the whole shrimp had darkened around the eyes, and for that reason was slightly downgraded to the intermediate score between "Premium" and "Marginal" (we called this "Prem-Marg") meaning that the whole shrimp did not quite meet "Premium" status but had not depreciated to "Marginal" status either. Note too that there is no discoloration in the tail muscle of the whole shrimp. Shrimp tails treated with sulfites retained their "Premium" status over the fourth day.

Visual Appearance and Score of Thawed Shrimp Previously Treated
With Sulfites in the Brine Tank: Day 0 through Day 4

Day	Form	Visual appearance score and photograph of thawed product	
0	Whole	Premium	
	Tail	Premium	
2	Whole	Premium	
	Tail	Premium	
4	Whole	Prem-Marg	
	Tail	Premium	

<u>Thawed appearance using an EverFresh® dip before brine freezing.</u> The EverFresh® treatment created the only instance when both market forms maintained their "Premium" status over the entire four-day, refrigerated interval. These results should not be surprising. EverFresh® permanently stops the chain reaction that darkens shrimp. While EverFresh® adds about ¾¢ more per pound to the production cost of shrimp than when sulfites are used, the effectiveness provides additional time for retail interests to sell a premium-looking product.

Visual Appearance and Score of Thawed Shrimp Previously Treated With EverFresh® at Sea then Brine Frozen: Day 0 through Day 4

Day	Form	Visual appearance score and photograph of thawed product	
0	Whole	Premium	
	Tail	Premium	
2	Whole	Premium	
	Tail	Premium	
4	Whole	Premium	
	Tail	Premium	

<u>Discussion of results.</u> Either chemical treatment resulted in a **shrimp tail** that retained its "Premium" score and could be displayed under retail conditions for up to four days. For head-on shrimp, use of EverFresh® resulted in the **only instance** where the visual appearance of head-on shrimp was judged "Premium" over the four days of simulated retail conditions. Once shrimp are treated on the back-deck

with EverFresh®, it never has to be re-applied. If head-on shrimp are what you produce, EverFresh® should be your first choice among black-spot-preventing products.

What Contributed to Visually-Perfect, *"Right out of the Water"* Appearance? This segment documented and compared the appearance of whole shrimp and tails when two additives were used to control black spot. Initially it may seem that the technology contained in these two products was mostly responsible. In fact, ensuring visual perfection and top-notch condition from harvest to the retail end of the supply chain resulted from a mix of technology and skill. One question remains: *"What was the relative contribution of technology and skill?"*

Visually-perfect, *"right out of the water"* appearance after harvest, back-deck processing, brine freezing, two months in cold storage, and holding under refrigeration resulted from achieving eight objectives. These eight objectives are listed on the left side of the following diagram. Each objective corresponds to one of the four steps discussed in this booklet: (a) shortened tow times, (b) back-deck processing, (c) managing and ensuring the correct use of brine freezers throughout the cruise, and (d) preventing black spot with approved food additives.

Objectives that Ensure Visually Perfect Shrimp in Top Notch Condition	The Mix of Technology and Skill Necessary to Achieve Each Objective				
1. Use short-duration tows in hot months.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	**All Skill**
2. Prevent black spot with approved additives.	**All Technology**	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	All Skill
3. Treat no more than 500 pounds in each batch of EverFresh.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	**All Skill**
4. Create a 23.3% salt solution in the brine tank.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	**All Skill**
5. Restore salt, sulfite concentrations, and water depth after every 1,000 lb. has been frozen.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	**All Skill**
6. Freeze no more than 15 pounds of shrimp for each 100 gallons of brine per batch.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	Mostly Skill some Tech.	**All Skill**
7. Between batches, brine temperature should re-chill to around 0 F.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	**Mostly Skill some Tech.**	All Skill
8. Ensure all pounds from each tow can be solidly frozen in a series of 15 to 20 min. batches.	All Technology	Mostly Tech. some Skill	Equal Amounts of Tech. & Skill	**Mostly Skill some Tech.**	All Skill

Opposite each of the eight objectives are five possible combinations of technology and skill that **could have** achieved each objective. **The highlighted boxes show the actual combinations of technology and skill required to meet each objective.** Five of the eight objectives are strictly dependent upon skill in implementing the steps, procedures, and routines we have specified. Two objectives are mostly dependent upon skill, but refrigeration technology obviously plays a role. The only objective completely dependent upon technology is the second one: *Prevent black spot with approved additives*. Interestingly, objectives three, four, and five ensure that black-spot technology (either sulfites or EverFresh®) is correctly used. As the diagram shows, ensuring proper use of black spot technology is completely driven by skill. **From this review of objectives and the mix of technology and skill necessary to achieve them, the appearance results achieved at the retail end of the supply chain were dominated by the skill and ability of Captain and crew.**

No chemical treatments can undo errors made during towing, back-deck processing, or freezing. The shrimp used in this evaluation did not spend too much time in the net, were handled rapidly once on deck, properly treated to prevent black spot and were solidly frozen in a well-managed brine freezing system within 20 minutes.

Summary and Conclusions

Imported, farmed shrimp account for at least 67% of all shrimp the U.S. consumes. If the appearance and condition of your shrimp are not on par with farm-raised imports from high-grade foreign processors, they will not command top prices, regardless of their **"built-in" flavor.** To maximize the volume of visually-perfect, premium-quality shrimp from every tow, **each step** aboard the trawler – from tow times to back-deck processing to brine freezing – needs to be **correctly** done. Letting any step "slide" will ultimately result in unintended defects and lower prices.

This booklet reviewed the procedures that enable you to maximize the volume of visually-perfect, premium-quality, great-tasting shrimp from every cruise. Using proven quality improvement procedures can ensure that virtually all of the shrimp you offload will retain their *"right out of the water"* appearance and condition, and will command full market prices. A review of these four changes is presented below.

Shorten Tow Times

Most wild shrimp die in the nets or on deck. Once shrimp die, the best you can do is maintain their condition that existed when the catch was landed on deck. Shorter tows limit chemical changes that create black spot, maintain freshness, allow quick back-deck processing and treatment with approved additives, and reduce physical damage.

Back-Deck Processing

Completing each back-deck step **with the entire catch** pushes all shrimp to the brine freezer for the last back-deck step. Historically, the brine tank was filled with deck-temperature shrimp, and this practice continued until all shrimp from the tow had passed through the brine unit. Without time for the brine to re-chill, this approach progressively warmed the brine as more bags were immersed. This practice resulted in two types of defects. First, until the surfaces of shrimp freeze, salt migrates into the muscle. Second, without an approach that builds in time to re-chill the brine, the unit will ultimately just chill shrimp and these chilled shrimp may not solidly freeze below deck. Eliminating these defects requires that the back-deck processing routine support the brine unit for its intended purpose as a **batch freezer**. This segment stressed the need to work **each basket of shrimp** through the first-five back-deck steps of picking, heading, rinsing, treating, and bagging. There are two primary benefits in using the *"Basket @ A Time"* method for completing the first-five back-deck steps.

1. This method coordinates the manpower and time required to perform the first five back-deck processing steps – about 20 minutes – with the time necessary for solidly freezing the **maximum allowable quantity (lb.)** in the brine tank within a series of 15 to 20 minute cycles. With this minor change, the just-processed maximum allowable quantity is ready to enter the freezing unit just as the current, solidly-frozen batch is being removed for below-deck storage.

2. This approach also includes time for the brine to re-chill to 0° F or below between batches. Re-chilling is essential since solidly freezing the **next** batch (where "batch" is the **maximum allowable quantity** of deck-temperature shrimp which can be frozen within 15-20 minutes) requires a very low brine temperature at the **beginning** of the next freezing cycle!

Managing the Brine Freezer

Brine freezers can preserve the catch at the peak of quality, but only if the system is charged with enough salt to begin with, and only if the tank is recharged with water and salt after every 1,000 pounds are frozen. Guessing about the proper salt concentration or the quantity of shrimp frozen between recharges can result in reduced brine volume as well as lower salinity. Fewer gallons reduce the maximum allowable quantity (lb.) that can be frozen per cycle. A weak brine solution will never reach the low temperatures required to freeze shrimp within 15 to 20 minutes (if at all) even though the compressor constantly runs. Managing brine freezing operations were summarized as three fundamental rules.

1. ***The maximum allowable quantity (lb.) that can be solidly frozen per freezing cycle is based upon the gallon capacity of the brine tank.*** To figure this maximum value, multiply 0.15 by the gallon capacity. Placing no more than the maximum allowable quantity in the brine tank per freezing cycle (a) prevents overloading the unit with too much deck-temperature shrimp, (b) allows solid freezing within 15 to 20 minutes, and (c) gives the brine a chance to re-chill to the essential low temperature of at least 0° F. (See page 5.)

2. ***Begin each cruise with a 23.3%, saturated brine solution.*** This brine strength ensures that the liquid brine can be chilled to 0° F or below. (See pages 6-7.)

3. ***During recharging at sea, never add dry salt to cold brine.*** After every 1,000 lb. are frozen, **dissolve** 2" of salt (7½ lb.) in 9 ½" of water (3 gal.) in the marked *recharge pail*, then add that mixture to the brine tank. Repeat this procedure until the "full" line on the brine tank is reached. If sulfites are used, add water to the 2" salt line, **dissolve** 1 cup (8 oz.) of sulfite powder, and pour in the tank. (See pages 8-9.)

Permanently Preventing Black Spot

The final segment illustrated changes in appearance that occur once shrimp arrive at their final destination and are thawed. Regardless of the additive used, shrimp tails retained their "Premium" designation across all four days. Whole shrimp dipped in an EverFresh® solution and **then** brine frozen maintained their *"right out of the water"* appearance and "Premium" designation during four days under refrigeration. Whole shrimp treated with sulfites **in** the brine tank were judged "Premium" on days zero and two, but slipped to "Prem-Marg" by day 4.

Final Thoughts...

Four operational changes, four diagrammed procedures, and eight objectives necessary to offload visually-perfect, premium-quality, great-tasting, wild shrimp have been presented. Each change positively affects shrimp appearance and condition, while preserving the natural, *"built-in"* flavor of wild shrimp. All suggested changes are minor, but following them will help meet expectations for visually-perfect shrimp so full prices are paid. Above all, remember that the objectives necessary to offload wild shrimp with that *"right out of the water"* appearance are dominated by human skill. Technology is of course important, but correctly using the technological tools aboard your trawler requires human skill and ability. You spend too much time at sea to get *"docked at the dock"* for **preventable** quality defects!

The Secrets of Success

1. Complete the required preliminary work.
2. Reduce tow times, especially in hot months.
3. Manage brine solutions.
   a. Initial Brine Tank Charging Routine
   b. Salt & Dip Recharging Routine (at sea)
4. Correctly use sulfites or EverFresh

\+ 5. "Basket @ A Time" Back-deck Routine

= Perfect-looking shrimp in top-notch condition

Required, Preliminary Work (One Time)

Determine Gallon Capacity of the Brine Tank

1. Measure inside length, width, and height of the brine tank in inches.

2. Multiply all three values together. This is the cubic inch (cu.") volume of the tank.
   (84" x 40¼" x 36½") = 123,123.2 cu."

3. Divide cu" volume by 231. This equals the gallon capacity of the tank.
   (123,123.2 cu. " ÷ 231) = 533 gal.

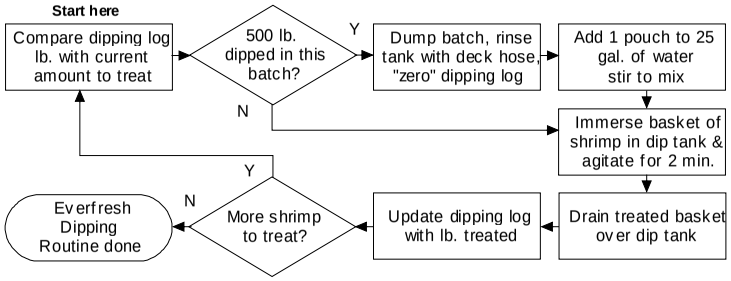
Figure the Maximum Allowable Quantity (lb.) to Freeze per Cycle

1. The rule: freeze no more than 15 lb. of shrimp for each 100 gal. of brine in the tank

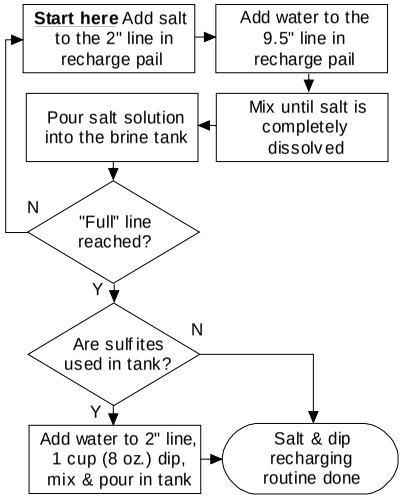
2. To find the max. number of lb. to freeze multiply 0.15 by the gallon capacity
   (0.15 x 533) = 80 lb.

3. Therefore, only two 40-lb. sacks should be put in the brine freezer at a time.

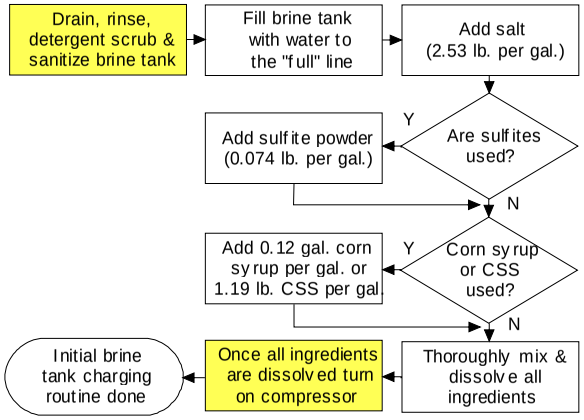
Everfresh Dipping Routine



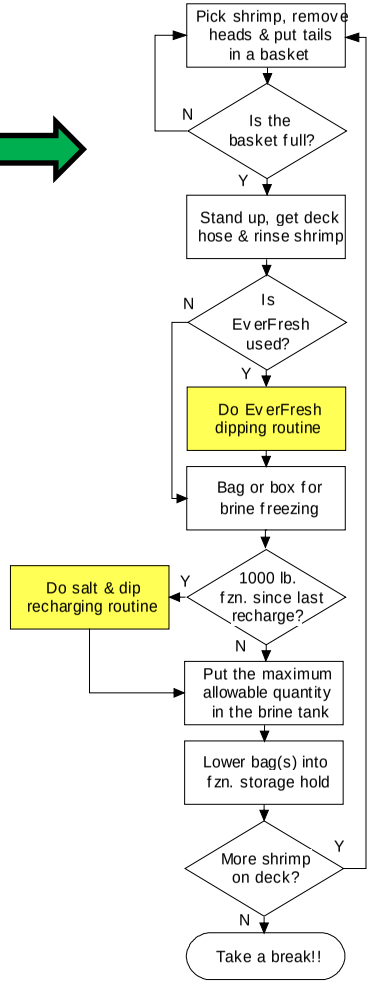
Salt & Dip Recharging Routine



Initial Brine Tank Charging Routine



Basket @ A Time Routine



Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Douglas L. Steele, Director, Texas A&M AgriLife Extension Service,The Texas A&M University System. 07-13