Southern Regional Aquaculture Center

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Soft Shell Crab Shedding Systems

Albert "Rusty" Gaudé and Julie A. Anderson[1]

Since the early 1880s, the commercialization of soft blue crabs, *Callinectes sapidus,* from wild populations has increased, making it a stable and significant component of the crab industry. Although the production of soft crabs varies annually and seasonally, national production of this culinary specialty—focused in the East Coast and Gulf of Mexico states—is in the millions of pounds and worth millions of dollars. Price is variable and reacts to market pressure, as with any other commodity. Incoming product (live peeler crabs) will also vary in price, sometimes independently of landings (Fig. 1).

International supply and demand also play a role in the domestic production and price of soft shell crabs. An increase in imported crab within the last decade has created significant competition for blue crab production. The global harvest of other crabs within the blue crab family (Portunidae) has significantly increased, and the importation of alternative soft crab products (mangrove crab, *Scylla serrata*) from India, Thailand, Bangladesh and Australia has exploded into the American market. Although overseas consumers readily accept soft Callinectes, the volume exported abroad is poorly documented. However, even with this competition there is a demand for domestic soft shell crab shedding systems.

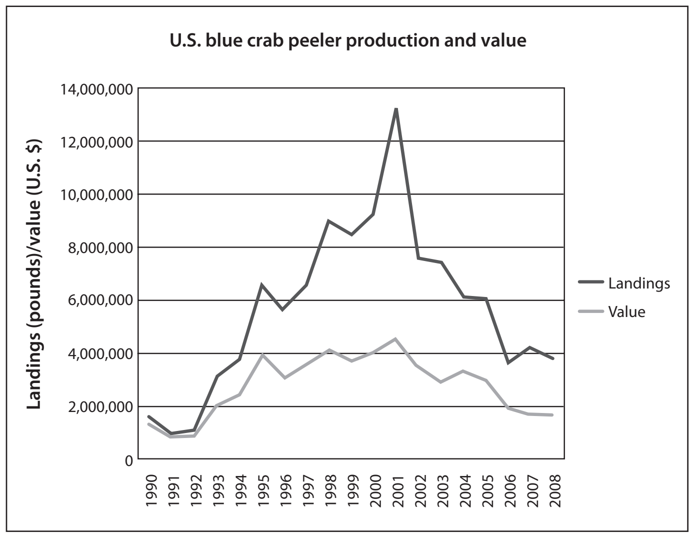

Figure 1: Blue crab peeler production and value in the United States. Source: National Marine Fisheries Service

Molting process

The physiology of molting crabs has been well documented. A crab responds to the lack of growth space within its shell by entering the pre-molt stage, also called the "peeler" or "buster" stage. At this stage the crab can absorb more water and ions into its circulatory system, dramatically swelling its body to crack its hard shell. Once it backs out of the old shell, or molts, the animal begins to harden its new carapace or shell using calcium from the water. A crab molts 20 to 25 times during its life.

The molting process is the most difficult and stressful time in the life of the crab and the time it is most vulnerable to cannibalization from other crabs. Even small mechanical, chemical or physiological problems during this time will result in near-certain death for a crab, so it is absolutely necessary to give peeler crabs the highest level of care before they are placed in the shedding system and throughout the shedding process. The difference between 50 percent molting success and 90 percent molting success significantly affects the profitability of any soft crab shedding system.

Peelers obtained by different collection methods will yield crabs in various stages of the pre-molt cycle. Pre-molt stages are indicated by subtle (yet obvious to the trained eye) physical changes to certain body parts,

[1]Louisiana Sea Grant College Program and LSU Agricultural Center

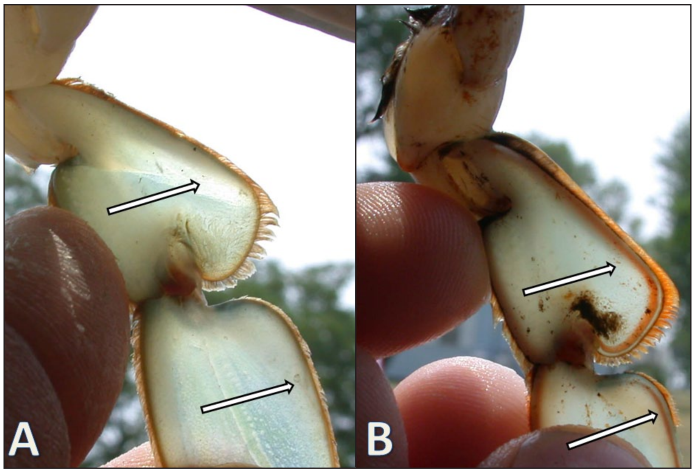

Figure 2. Paddle leg of blue crab. The line (arrow) between shell and tissue changes from white (A) to red (B) as the crab gets closer to molting. Photographer: Donald W. Webster

primarily the lower two segments of the swimming legs ("paddles") (Fig. 2). Stages are distinguished by the color of the line between the old and new shell at the edge of the swimming paddles. This line turns from white to pink, then to red just before molting.

Segregating pre-molt crabs based on these stages is standard practice. Earlier stage crabs are much more likely to cannibalize late-stage molting crabs. Not separating the stages will result in higher mortality.

Harvesting peelers

Hard crabs are harvested by several methods:

Fisherman harvested

Crabs may be hand-collected, dip netted, or dredged from habitats favored by pre-molt crabs.

Trap harvested

Peeler or jimmy traps use the hormonal draw of mature males ("jimmys") to lure near-mature, pre-molt females into modified, traditional crab pots.

Bush lines are long, submerged lines baited with wax myrtle leaves that attract pre-molt crabs of both sexes to the reclusive protection of the vegetative clump. Clinging crabs are collected with dip nets.

Crab "pounds" use flexible wire or netting to guide pre-molt crabs into entrapments as they seek a reclusive shoreline refuge for molting.

Ordinary crab pots collect all stages of crabs that are still feeding. The percentage of late pre-molt crabs caught with this method is thus smaller than with the methods described above. Currently, most peelers are obtained with crab pots.

Trawl capture uses crabs from the incidental bycatch during shrimping season. It has limitations because of the harvest trauma it causes. Bycatch often contains a lower percentage of late pre-molt crabs.

Note: Always check with state and federal regulatory agencies to verify the legality of peeler collection methods, sizes, season, and catch limits!

Soft crab systems

Water quality

Proper water quality parameters (Table 1) are essential to the survival of both crabs and the bacteria colonies that serve as a living part of the filtration process. A successful shedding system maintains two biological populations: crabs and bacteria. Operators should use good water quality analysis kits and instruments and test water often. The time and cost involved may be a nuisance, but keeping records of water quality is vital for maintaining the system and for diagnosing problems that may arise.

Table 1: Water quality parameters that must be tested during operation.

Parameter	*Safe range*
Nitrite	0.0 to 0.5 mg/L (ppm)
Temperature	75 to 80 °F with 77 °F ideal
pH	6.5 to 8
Alkalinity	> 100 mg/L (ppm)
Salinity	5 to 30 ppt within 5 ppt of harvesting waters
Dissolved oxygen	> 5.0 mg/L (ppm)
Total ammonia	below 1.0 mg/L (ppm)
Nitrate	< 500 mg/L (ppm) in sump

At a minimum, the following parameters should be recorded regularly.

Salinity—the amount of dissolved salt in the water. Avoid changes of more than 5 ppt at any point, such as from capture to the shedding system or within the shedding system.

Dissolved oxygen—the oxygen saturation, or the amount of oxygen in the water and available for the crabs and bacteria. Oxygen is essential for survival.

Ammonia—a form of nitrogen that can be very toxic to marine life. Bacteria break it down to nitrite.

Nitrite—highly toxic form of nitrogen in the water. Bacteria break it down to nitrate.

Nitrate—a more stable form of nitrogen that is less toxic to aquatic animals.

Temperature—often similar to ambient air temperature. It affects the rate of molting and even crab survival at extremes.

pH—a measure of how acidic the water is because of hydrogen. It is measured on a scale of 1 to 14, with 7.0 being neutral.

Alkalinity—a measure of resistance to pH changes due to the amount of $CaCO_3$ (calcium carbonate). A sudden drop may not affect the crabs, but it may indicate a pH problem, which can cause mortality.

Chlorine—a chemical added by water treatment plants that can be harmful or fatal to crabs and bacteria

Shedding systems can use **natural water** from local bayous, estuaries or marshes. While this water source may already be saline, it also contains bacteria and parasites that may be harmful. Water from **wells or municipal sources** also can be used. It will need to have salt added to reach a salinity similar to the water from which the crabs came. Also, chlorine or chloramine will need to be removed from the water before it enters the system; this is done with chemical removers (chloramine) or overnight aeration (chlorine). Chlorine is harmful to crabs and to beneficial bacteria in the system.

Types of systems

What all forms of soft crab production have in common is the confinement of pre-molt animals. Anything else is not production, but wild harvest. There are three basic types of confinement systems.

Floating systems

Stationary boxes (also known as "cars" or "floats") are floating boxes made of wood or fiberglass anchored and attached to a fixed point in open water habitats such as bays, inlets or tidal streams. The well-being of confined crabs depends on surrounding water conditions and water flow. This traditional method has a very low start-up cost but is limited by variable water quality, weather conditions, and site accessibility.

Onboard shedding trays are found on the decks of shrimp vessels. Peelers harvested in bycatch are placed in them and supplied with natural water pulled onboard. Deck space is at a premium, but the captive labor force of the crew makes sorting and retrieving soft crabs an integral part of routine duties.

Land-based open loop water systems

Soft crab operations using open loop water are similar to floating systems, as they often use the variable but inexpensive water of an adjacent water body. Start-up and operation are economically attractive to many producers who have waterfront access and live within a reasonable distance of the shedding system. Trays are a standard design, as in Fig. 3, and are often used in multiples of four for each stage. Electricity for the pump(s) and material costs for the all-weather covering add to the costs.

Land-based closed loop water systems

Closed loop or recirculating systems are different from other system designs because they **hold and reuse water,** which circulates through the series of trays (Fig. 3) before being purified and used again. The initial source of this water can be suitable surface water from adjacent waterways, well water, or municipal water systems (after appropriate water treatment). Closed loop systems have the advantage of being completely self-contained without exposure to the highly variable water quality conditions of many estuarine water bodies. The most appealing attribute of the closed loop system is the ability to locate the shedding operation away from any surface water. Water quality can also be managed more easily than in other set-ups. Land cost and proximity to the operator's home are often strong factors in deciding to use this type of system.

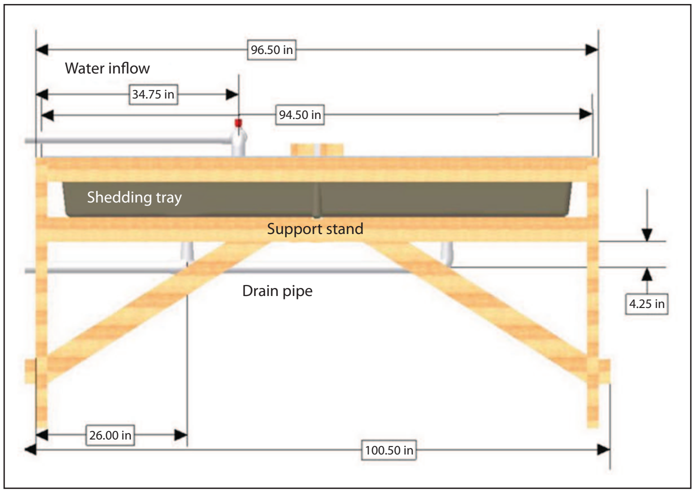

Figure 3. Example of a standard soft crab shedding tray with sample dimensions. Courtesy of Jack Perry and Dr. Ronald Sheffield

However, these advantages are somewhat offset by the added start-up and operating costs, the increased labor, and the technical skill required to set them up and run them. By design, these recirculating systems require filtration to maintain water quality. These filters must deal with physical and chemical contaminants constantly generated by crabs in the shedding trays. The four types of filters listed below all use some means of dealing with the physical (i.e., particulates) and chemical (i.e., nitrogen waste) reconditioning of the water. See SRAC Publications 451 and 452.

Some operators use a hybrid of the open loop and closed, recirculating system by saving the initial surface water for an extended period but exchanging a large amount of the held water during any one 24-hour period. These hybrid systems usually have some filtration and treatment components. Hybrid systems can be used with surface water and well water systems.

Design of land-based systems

Land-based systems have several major components. The first is holding trays. Typically, a system has at least four holding trays, one for each stage of peeler crab. Second is the pump, which pulls water from the sump or local water supply and moves it back into the holding trays. Pumps must be large enough to accommodate the system. For recirculating systems, a reservoir and sump provide water for volume dilution to help maintain water quality. No crabs are placed in the sump. The sump should be as large as is feasible, as a larger volume of water will allow for more crabs. Water drums, concrete septic tanks, or any water storage container can be used as a sump. Recirculating systems have a final major component—the filter. Both mechanical and biological filtration are important.

Mechanical filtration involves the separation and removal (by elimination or degradation) of unwanted particulates such as crab waste. Batting or other non-toxic materials can be used to catch waste particles in the water. Something inexpensive and easy to swap out or clean is ideal. Screens are used primarily to capture larger particulates; these filters can be disposable or cleanable. Screens can be used at any step of the operation where solids are observed. Many materials are available, but pore/screen size should be small enough to capture particles without hindering water flow. Screens also prevent large particles from getting into closed portions of the system and causing damage to pumps or other filters. Protein skimmers are useful for mechanical and chemical filtration. They remove protein waste from the top of the water and prevent suspended or dissolved organic matter from progressing any farther down the water pathway, which would burden more critical components.

Biological filtration (reconditioning) is accomplished when bacteria (*Nitrosomonas* and *Nictobacter*) living on the surface of filter media break down nitrogenous waste products from ammonia to nitrite to the less toxic nitrate form. Oxygen is essential, as it is the addition of oxygen molecules to nitrogen that converts it to nitrate. Aeration will help the bacteria break down the waste. The larger the total surface area of filter media, the greater the population of bacteria available to convert toxic forms of nitrogen waste. Because of the living nature of biological filtration systems, it takes time to build up bacteria populations before large numbers of crabs are added. In new systems this can take 4 to 6 weeks, which can be accelerated by using biological and/or chemical catalysts to pre-load the media and establish suitable bacterial colonies. As living creatures, bacteria also are sensitive to water quality. Poor water quality and chemicals such as chlorine may not kill crabs directly, but may result in eventual mortality if bacteria are killed off, ending the biological filter.

Closed loop systems are characterized by the design of the filter components, such as the following types (often used in combination).

Submerged bed filters

Normally held in large, open containers, these media-filled filters can have gravel, rock, sand, shell (oyster or clam), or any combination thereof. These very popular filters have large surface areas for the colonization of beneficial bacteria. There are established population loads of shedding crabs that correspond to certain volumes of this media. Systems that include calcareous shells or minerals can buffer the entire system. Filters with submerged rocks have the lowest carrying capacity (Fig. 4).

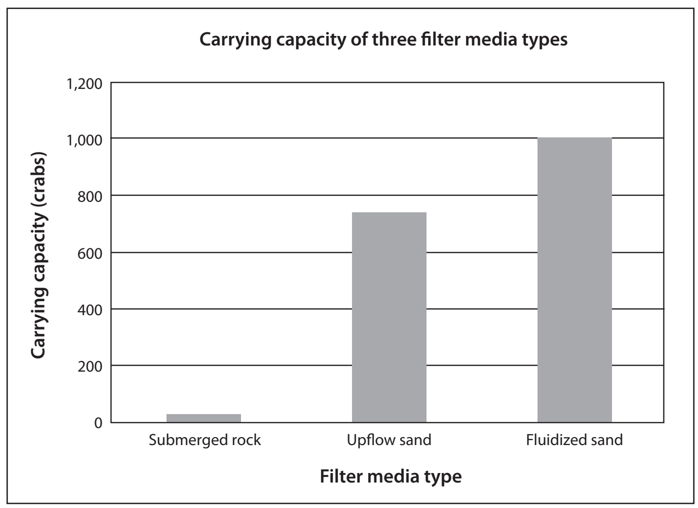

Figure 4. Carrying capacity (per cubic foot of media) of three types of filter media. Upflow and fluidized sand filters are based on 8/16 filter sand. Source: Malone and Burden, 1988

Upflow sand filter

Technically advanced and operationally more complex is the sealed, upflow sand filter, which combines the mechanical filtration and biological reconditioning of recirculating water. A major advantage of the upwelling sand filter is the ability to "back flush" the filter system at regular intervals, an option not available in submerged rock systems. This runs water in the opposite direction into a wastewater system to rinse the filter. This type of system requires daily maintenance. Carrying capacity is many times greater than that of the submerged rock system on a volume basis, but that advantage comes with additional infrastructure costs and electrical consumption.

Fluidized sand bed filter

Since the closed system soft crab operation has a living colony of bacteria within its grains of media, anything one does to enhance the living conditions of those bacterial communities will increase filter effectiveness. The fluidized sand bed filter keeps the entire sand mass slightly suspended in a controlled upflow of well-oxygenated and conditioned water. The peeler carrying capacity of the fluidized sand bed is more than 30 percent higher than that of the more compacted upflow sand filter. However, as the fluidized sand grains are constantly rolling because of controlled water pressure, the mechanical filtration capacity of this filter is greatly reduced. In effect, the fluidized sand bed becomes solely a bacterial water "conditioner," and the filtration of particulates must be done by another means, sometimes with an upflow sand filter. These combined systems, although powerful metabolite processors, have higher operational costs and are more complicated to operate. Mechanical, electrical and operating mishaps can cause water system failure, production delays, and/or mortalities in the peeler population.

Low-density bead filters

Filter packages that use the combined principals of all known, closed-loop water treatment systems are now available. These pressurized containers house manufactured synthetic media. Containers like these, commonly called "bead filters," combine the nitrogen breakdown by bacterial colonies with mechanical filtration (with backflush options to routinely rinse out captured waste). These units are easy to operate and biologically efficient. Their application in the field of aquaculture is widespread and growing. The carrying capacity of peeler crabs per cubic foot of media is very good, but these systems are very costly to start up and require routine attention.

Moving bed reactors

Optimizing the media surface for bacteria will increase carrying capacity. Artificial media has been developed to do this. These moving bed reactors can be used in conjunction with other components that are equally or less technical. For example, moving beds can be used with less expensive oyster shell.

Economics and business

The vast majority of soft crab operations are run as family or small businesses, but there are many factors that determine the size of a business and how profitable it will be. From harvesting to holding soft shell crabs, the process is time-intensive. When crabs are molting, they must be checked regularly every few hours, 24 hours a day, to prevent molted crabs from beginning to harden. Too much hardening reduces their value. They will stop hardening when removed from the water.

Each step of the crab shedding system must be considered in the overall economic analysis. Whichever physical/business scale the operation uses, the top concerns of the soft crab operator are the supply, price and quality of peelers; distance to the shedding facility; cost of property; flexibility to sell soft crabs as preferred; a reliable pumping (filter/water) system; and a cost-effective labor supply. Permitting and other regulatory requirements vary; minimum peeler size, gender, harvest techniques, and possession details for shedders and fisherman are all subject to changing regulations. Likewise, the source of peelers and their method of capture can affect the value of the final soft crab product. A good, cost-effective source of peelers is crucial for the business to be profitable. Size class alone can make some soft crabs double in value. Handling and processing also are important.

The overall profitability of the business will be determined by the number of times the shedding cycle is completed (system turns), the survival rate of peeler crabs, capacity use of the facility, market price, and the overall size of the system. Consider the impacts depicted in Figure 5, where a 1,200 crab per turn, closed-system, soft crab operation is shown to be sensitive to various factors. Many of these factors are the result of management decisions or

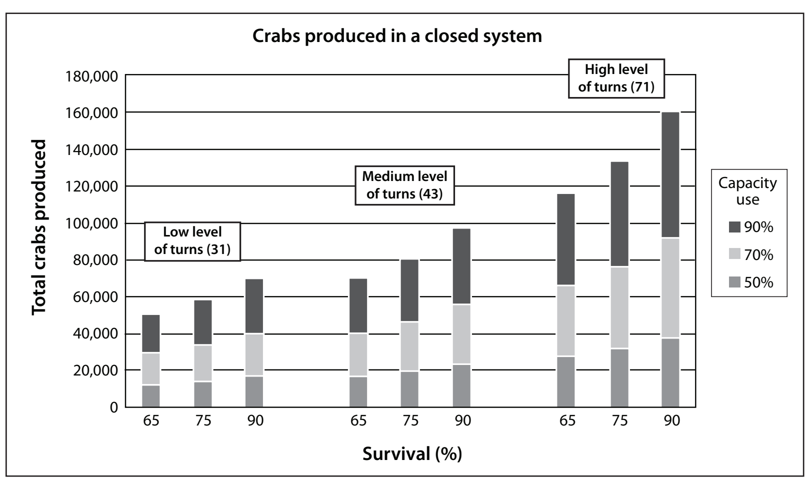

Figure 5. Annual soft crab production as influenced by operations management. Source: Roberts, 1985

actions such as peeler sources and treatment, water quality, and the facility's capacity. Overall quality of the crabs will also significantly affect profitability. An operator with 65 percent molting success, 50 percent tray capacity, and 31 seasonal turns per tray will produce 4,750 dozen fewer crabs annually than an operator with 90 percent molt, 90 percent capacity, and 71 turns. For larger crabs, this can result in a loss of tens of thousands of dollars in income. The burden of overhead and capital costs is obviously more taxing to the operator on the low side of production.

Since the actual molting procedure is dependent on such a wide array of variables (water temperature, water quality, stage of peeler, treatment/injuries to peeler, etc.), the actual time the peeler spends in the shedding tray, or turn time, fluctuates. Generalized projections can be made using 5-day averages (each tank will turn 1.5 times each week). Likewise, an 80 percent survival rate (from tray entry until completed molt) usually represents a well-operated shedding facility. After molting, the general policy is to freeze individually wrapped crabs to allow for small quantity consumption, rather than bulk freezing.

Individual assistance

All coastal states have university-based Sea Grant Programs in addition to state Extension services. Field agents of either program will be able to provide more detailed local information about the soft crab industry. While labor intensive, blue crab shedding systems can be a significant component of the crab industry if managed correctly.

Suggested references

This fact sheet describes only the basics of shedding operations. The sources below are excellent supplemental references.

Jackson and Sweat. 1997. Crab Shedding-System Designs. *http://nsgl.gso.uri.edu/flsgp/flsgpg97003.pdf*

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

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